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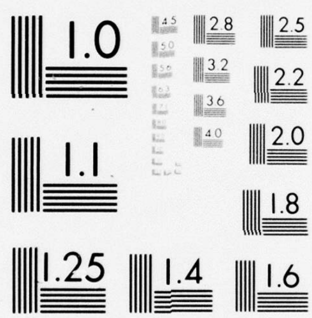

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The proposed network will not supplant the present systems but merely augment them in such a manner as to increase the availability of international circuits while at the same time effecting a reduction in cost for their usage.

GLOBAL TELECOMMUNICATIONS NETWORKS

A thesis presented to the Faculty of the U.S. Army Command and General Staff College in partial fulfillment of the requirements for the degree

MASTER OF MILITARY ART AND SCIENCE

by

ROBERT E. GRAY, MAJ, USA
B.A., Ohio State University, 1973

Fort Leavenworth, Kansas
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MASTER OF MILITARY ART AND SCIENCE

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The opinions and conclusions expressed herein are those of the individual student author and do not necessarily represent the views of either the U.S. Army Command and General Staff College or any other governmental agency. (References to this study should include the foregoing statement.)

GLOBAL TELECOMMUNICATIONS NETWORKS

ABSTRACT

The present international telecommunications system is a mosaic of different and separate telecommunications systems, each providing services of a limited nature to a specialized community of users All too frequently these international systems are too poorly interconnected to provide telecommunications services on a world-wide basis. The growth pattern of the present international telecommunications systems has been on an incremental basis, characterized by point-to-point telegraph and telephone circuits.

This study traces the growth and evolution of international telecommunications and analyzes the impact of recent technological advances in electronics on the cost and capacity of present international telecommunications systems. The study concludes that a Global Telecommunications Network (GTN), with the capacity to interconnect each of the existing international systems is economically and technically feasible. A proposal to establish such a network is put forth. The proposed network will not supplant the present systems but merely augment them in such a manner as to increase the availability of international circuits while at the same time effecting a reduction in cost for their usage.

By applying the current telecommunications networking technology of automatic circuit and message switching demand assigned transmission channels as well as circuit preemption options, to the design of a GTN, the study has determined that

the necessary channelization can be made available to establish specialized subsystems. One subsystem proposed for establishment in this manner is the Global War Avoidance Telecommunications Subsystem (GLOWATS). As a result of an analysis of the impact of the current model of a war avoidance telecommunications system (the Washington-Moscow direct communications link) on relations of the United States and the Soviet Union, the study concluded that such systems may aid in stabilizing crises in international relations.

The technical parameters and network design requirements proposed by the study are based on the use of a communications satellite as the primary transmission medium. Costs of the proposed GTN are analyzed and derived in terms of the cumulative costs of the earth terminal stations, leased satellite channels, leased submarine cable channels and the computerized switches. The proposed system is achievable within the next five years.

TABLE OF CONTENTS

CHAPTER I

INTRODUCTION TO THE PROBLEM

BACKGROUND

The recent advances in the state-of-the-art in telecommunications and electronic technology has made possible a truly global telecommunications network that offers; "international communications on a scale and of a scope significantly greater than has been considered possible until very recently."[1] These new advances in telecommunications technology will not supplant present day telecommunications systems but may complement them by providing additional capabilities for interconnection of present day national and international telecommunications systems. The advances in technology that may prove to have the greatest impact on global telecommunications are the development of a small transportable satellite terminal and the computerized switch. Through the use of these inventions the present international system may be extended to provide service to even the most remote regions of the world.

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[1] Mickelson, Sig. "Communications by Satellite." Foreign Affairs, October 1969.

HYPOTHESIS

It is possible with minor augmentation to the present international telecommunications system to provide a world-wide telecommunications network.

TASKS

To test the hypothesis, the following questions will be answered:

a. What will be the cost of the augmentation package in terms of present day dollars?

b. What is the traffic requirements expressed in terms of voice grade channels of three kilohertz bandwidth?

c. What areas of the world are presently without the capability to access the international telecommunications system?

d. What is the optimum design criteria for the added systems in terms of bandwidth and power levels?

METHODOLOGY

Chapter I gives the background, states the hypothesis, and establishes the criteria and objectives for this study. Chapter II deals with the evolution of global telecommunications networks in terms of growth and development from a service, facility and cost point of view. Chapter III proposes the establishment of a Global Telecommunications Network and describes its operational concepts and capabilities. Chapter IV details the technical design parameters required for the augmentation packages to transition from the present day international telecommunications system to a global telecommunications network. Chapter V summarizes and analyzes the material discussed in chapters II, III, and IV. While no new material will be introduced in this chapter, significant aspects of the material covered in the previous chapters will be explored in an attempt to isolate data and information on which to base conclusions.

SCOPE

This study is limited to the following areas:

a. Research and analysis of the international telecommunications systems present and planned capabilities.

b. Assessing the impact of recent advances in telecommunications technology on global telecommunications systems.

c. The application of telecommunications networking technology to design a global telecommunications network, that affords each nation of the world the capability to access the worldwide telecommunications system.

DEFINITIONS

Definitions germane to this study are consistent with Department of the Army Regulation 310-25, Dictionary of United States Army Terms, 1 June 1972. The following definitions also apply to this research effort.

a. TELECOMMUNICATIONS NETWORK - A composite system of interconnected telephone, telegraph, radio and video subsystems for the transmission and reception of information.

LIMITATIONS

The research shall be restricted solely to unclassified sources. This approach will facilitate the wide dissemination of the paper and provide for less restrictive document handling procedures. Because of the amount of source material available and time constraints, only those reference materials available at Fort Leavenworth will be used in this research effort.

CHAPTER II

EVOLUTION OF GLOBAL TELECOMMUNICATIONS NETWORKS

INTRODUCTION

Among the many factors that have an effect on peace and stability in the international environment are communications contacts and interdependence among major powers. While all communications contacts may not involve telecommunications directly, tangentially they create an environment which adds impetus to the demand for telecommunications links and services.

In addressing the United Nations General Assembly in 1961, Jawaharlal Nehru, President of India, stated that he "thought it might be more helpful if more attention were directed to the cooperative activities being pursued by the nations of the world, 'even between countries which are opposed to each other in the political and other fields'."[1] That these cooperative activities alluded to by Mr. Nehru, have become increasingly less difficult is possibly the result of the growth in international communications. Note how closely the

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[1] Colin, Cherry. World Communications: Threat or Promise. (Bath, U.K.; Wiley-Interscience, 1971), p. 121.

rate of growth of international organizations (Figure 1) parallels that of the rate of growth of transatlantic telephone circuits shown in (Figure 2).

The rise of global telecommunications also parallels and reflects the growing interpenetration between the economies of the developed societies. It is in the area of economics that the world may show its maximum amount of communications contacts and interdependence. During periods of international crises, military relationships and military power are emphasized, but economic factors, relationships and power are crucial in peace. "Developed economies must progress together or the entire edifice of economic growth may collapse. Strategic polarities may be less relevant than economic interrelationships which are increasingly uniting developed polities."[2]

This chapter will examine the growth of and development of global telecommunications from a service, facility and cost point of view. While, at the same time assessing the impact of this growth and its attending technological advances on the design of a truly worldwide telecommunications network and a proposed design for a Global War Avoidance Telecommunications Subsystem (GLOWATS).

In addressing the United Nations on 25 September 1961, President John F. Kennedy declared:

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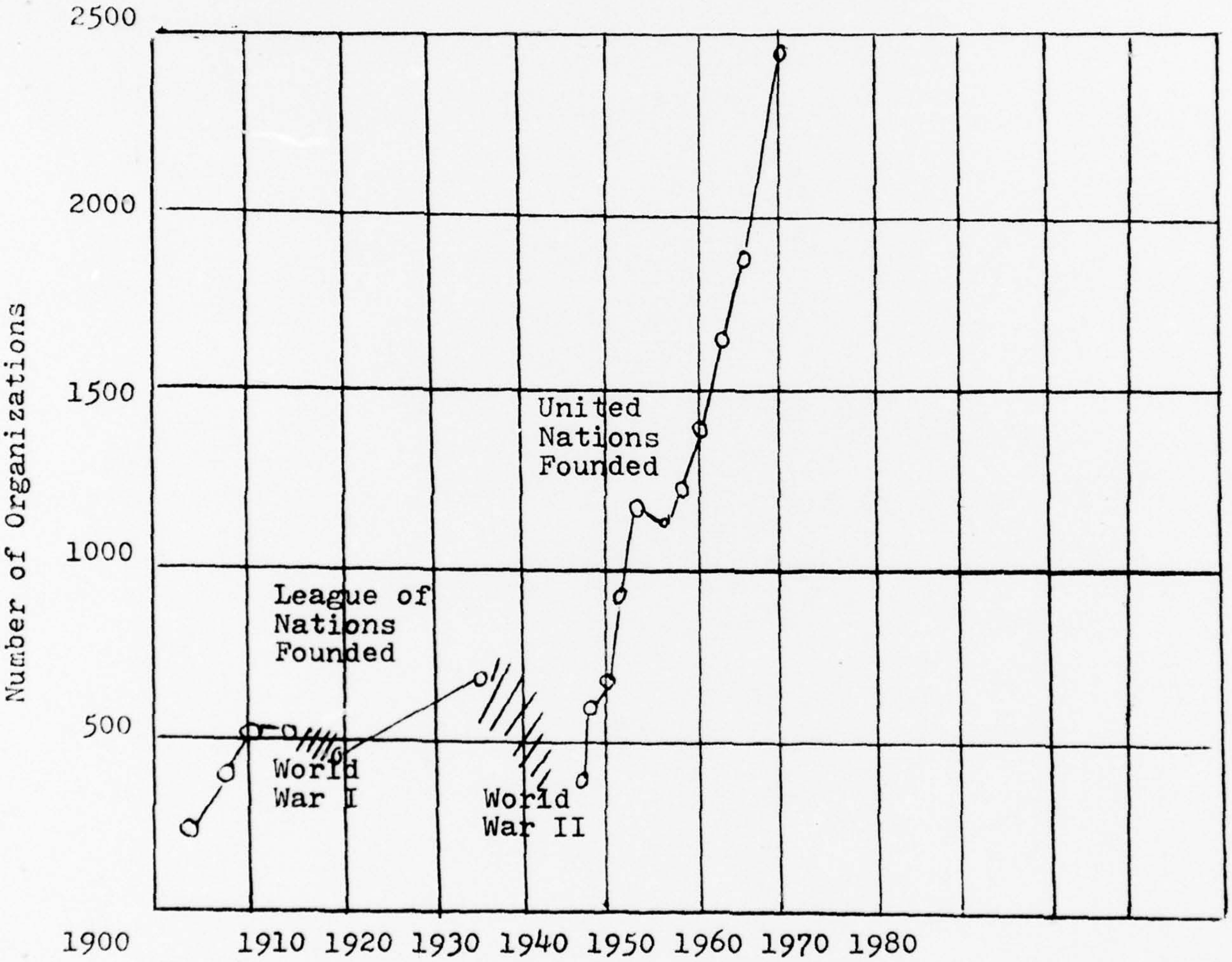
[2]Richard Rosecrance. International Relations: Peace or War? (New York: McGraw-Hill Book Company, 1973), p. 49.

Figure 1

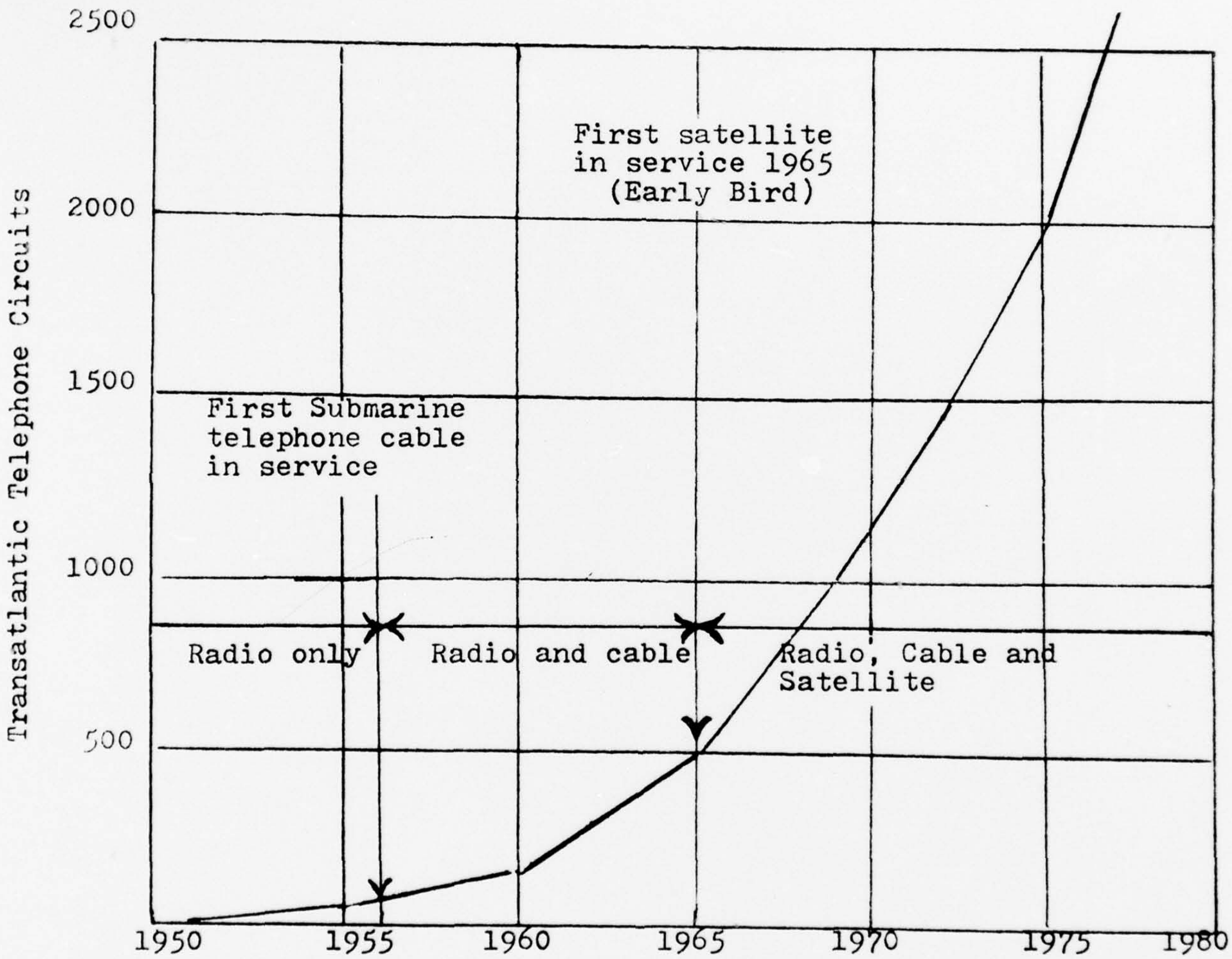
Growth of International Organizations



Source: Adapted from <u>World Communications: Threat or Promise</u>? (Bath, U.K.; Wiley-Interscience, 1971)

Figure 2

Official prediction of telephone circuits across the North Atlantic



(Adapted from World Communications: Threat or Promise?
(Bath, U.K.; Wiley-Interscience, 1971)

> We shall propose a global system of communications satellites linking the whole world in telegraph and telephone and radio and television. The day need not be far away when such a system will televise the proceedings of this body to every corner of the world for the benefit of peace.[3]

The global telecommunications systems that have evolved since President Kennedy spoke those words, do indeed, make it possible to transmit television to every corner of the globe.

GROWTH OF GLOBAL TELECOMMUNICATIONS SYSTEMS

On the eve of the first attempt to bridge the Atlantic ocean by telegraphy, The Times of London published an article headed "Shrinking World", in which these sentences appeared:

> So far as human foresight can judge, the Old and New World will be in telegraphic communication before tomorrow night. The prospect opened to the world by this achievement is so marvellous that any attempt to describe it must give only a faint and feeble picture. The two most active and energetic nations of the globe are placed in hourly communication. The Governments of England and the United States will be able to converse rapidly and freely, removing misconceptions should they arise, and transacting their affairs without delay of a voyage during which the face of events may be changed. . . . By bridging the Atlantic these two great systems are brought into connexion.[4]

In printing this article, The Times of London recognized the potential of international telecommunications links to serve as a means for intergovernmental coordination. Since that

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[3] Orrin E. Dunlap Jr. Communications in Space. (New York: Harper & Brothers, Publishers, 1962), p. 103.

[4] Colin Cherry. World Communications: Threat or Promise. (Bath, U.K.; Wiley-Interscience, 1971), p. 103.

event the entire world has experienced tremendous growth in international telecommunications but for the countries of the North Atlantic region it has been explosive.

Because of differences in societies and relative levels of economic advancement the demand for international telecommunications varies from one area of the world to another. Britain is considered to be the world's busiest telegraph center. The United States on the other hand either originates or terminates over 80 percent of all "international communications traffic."[5] Although, the first trans-Atlantic telephone cable was installed only 20 years ago, by "1970, about 1322 telephone circuits (or equivalent) could be carried across the Atlantic by cable and about 600 more by satellite. Both methods have continued to expand their capacities."[6] Figure 2 shows the effect of this growth in capacity on trans-Atlantic telephone traffic, since the first submarine cable was installed in 1956. As the number of international circuits have risen, the cost of using this service has been reduced. These falling costs are due to the relatively new developments in electronics that permit the carrying of more and more messages over the same bandwidth. Figures 3 and 4, illustrate the falling cost of telecommunications and projects a trend

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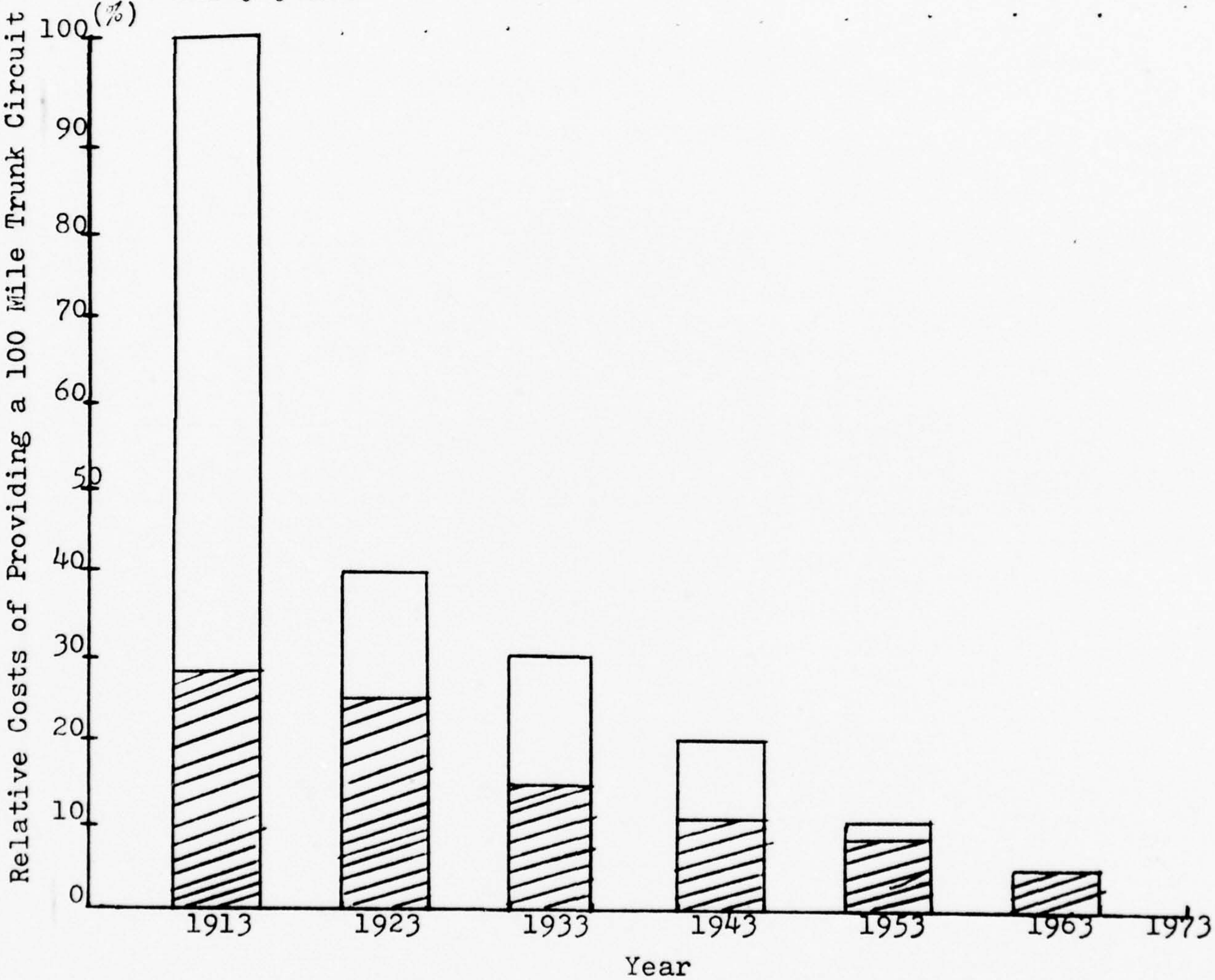
[5]Judith T. Kidlow. Intel<u>Sat</u>: Studies in International Relations and Foreign Policy. (Lexington, Mass., D.C. Heath and Co., 1973), p. 14.

[6]Colin Cherry. World Communications: Threat or Promise. (Bath, U.K.; Wiley-Interscience, 1971), p. 84.

Figure 3

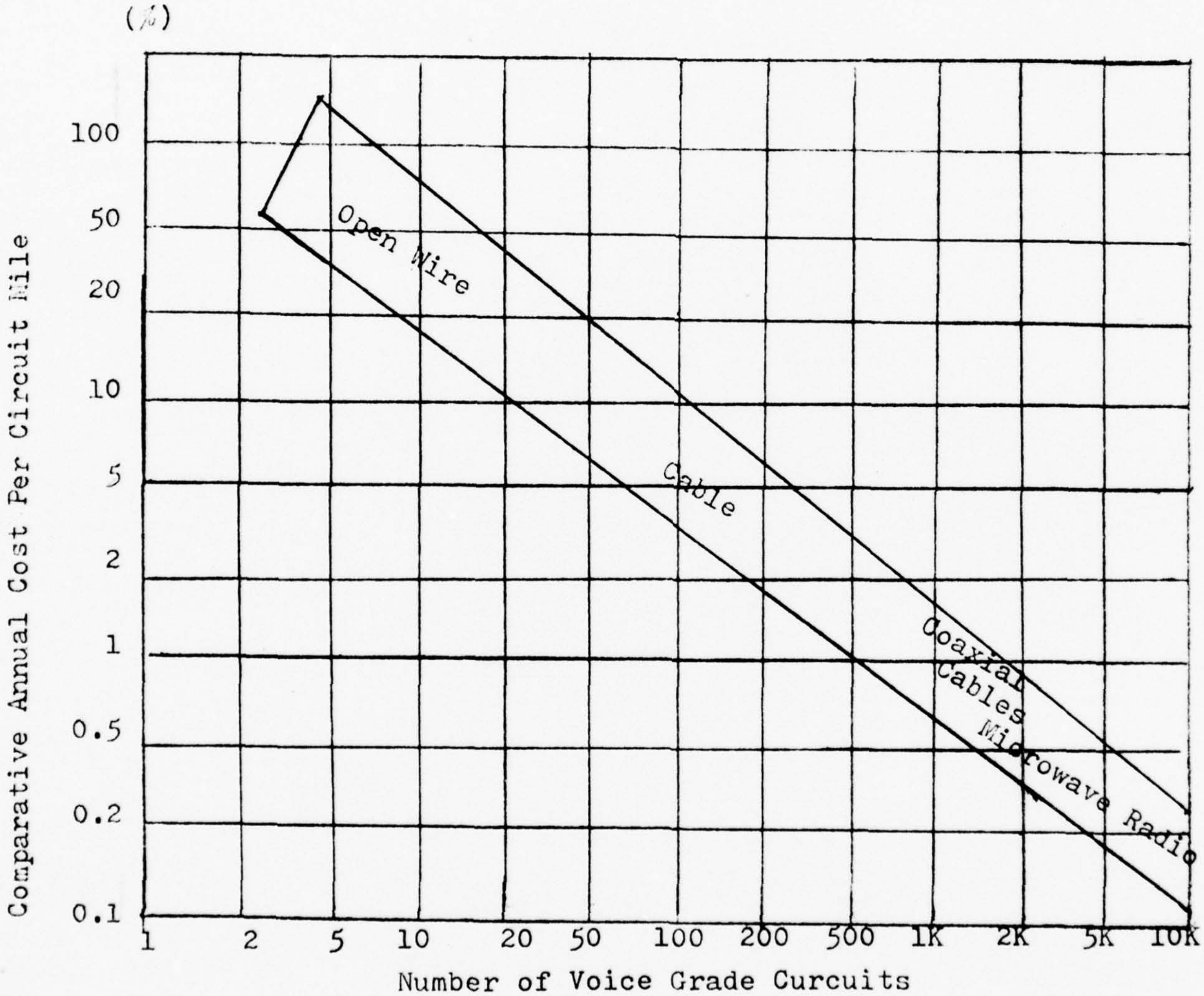
The falling cost of telephone trunk circuits over the last fifty years



Source: Adapted from <u>World Communications: Threat or Promise</u>? (Bath, U.K.; Wiley-Interscience, 1971)

Figure 4

Decreasing costs of Telecommunications



Source: Adapted from World Communications: Threat or Promise? (Bath, U.K.; Wiley-Interscience, 1971)

for the future. Recent advances should reduce these costs further. For example, waveguide, coaxial cables and microwave methods now under development may carry up to and over 100,000 circuits simultaneously across the country. Figure 5 depicts the "relative costs of twisted pair-wire cables, coaxial cables, microwave radio relay and helical waveguides."[7] Advances in LASER and Fibre Optic technology should reduce these costs even more.

Now, even with a satellite system that promises many thousands of telephone circuits, submarine cables still remain an integral part of international telecommunications systems. "Additional undersea cable systems are under construction, despite the fact that satellite systems hold the promise of lower circuit cost for large volumes of traffic."[8] Figure 6, again indicates how the costs of circuits go down as the number of circuits over a given means increase (in this case the means is a transoceanic cable system). Telephone and telegraph circuit cost over the North Atlantic route is expected to decline because of increased cable and satellite circuit capacity.

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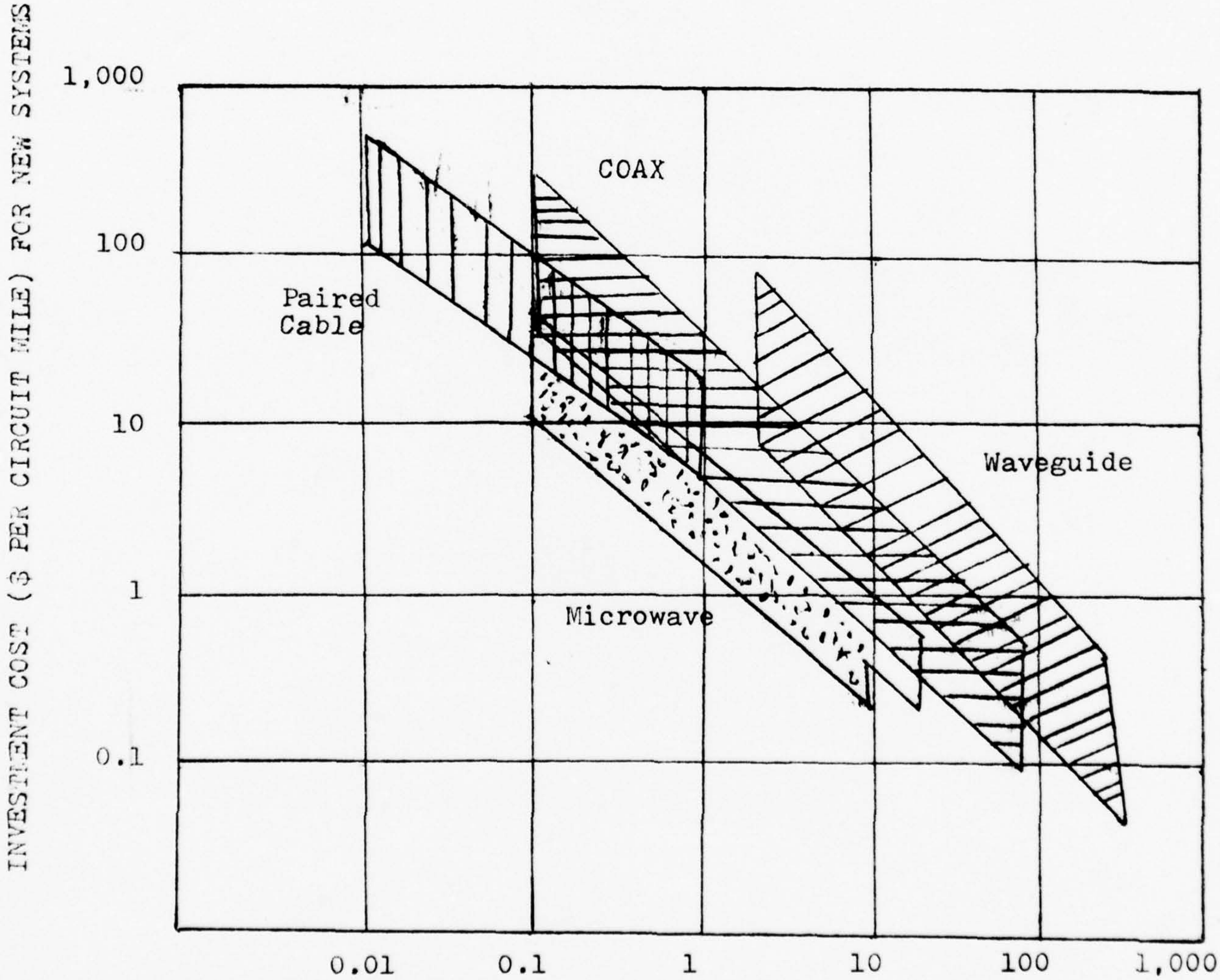
[7]James Martin. Future Developments in Telecommunications. (Englewoods Cliff, N.J., Printice-Hall Inc., 1971)

[8]Orrin E. Dunlap Jr. Communications in Space. (New York: Harper & Brothers, Publishers, 1962), p. 160.

Figure 5

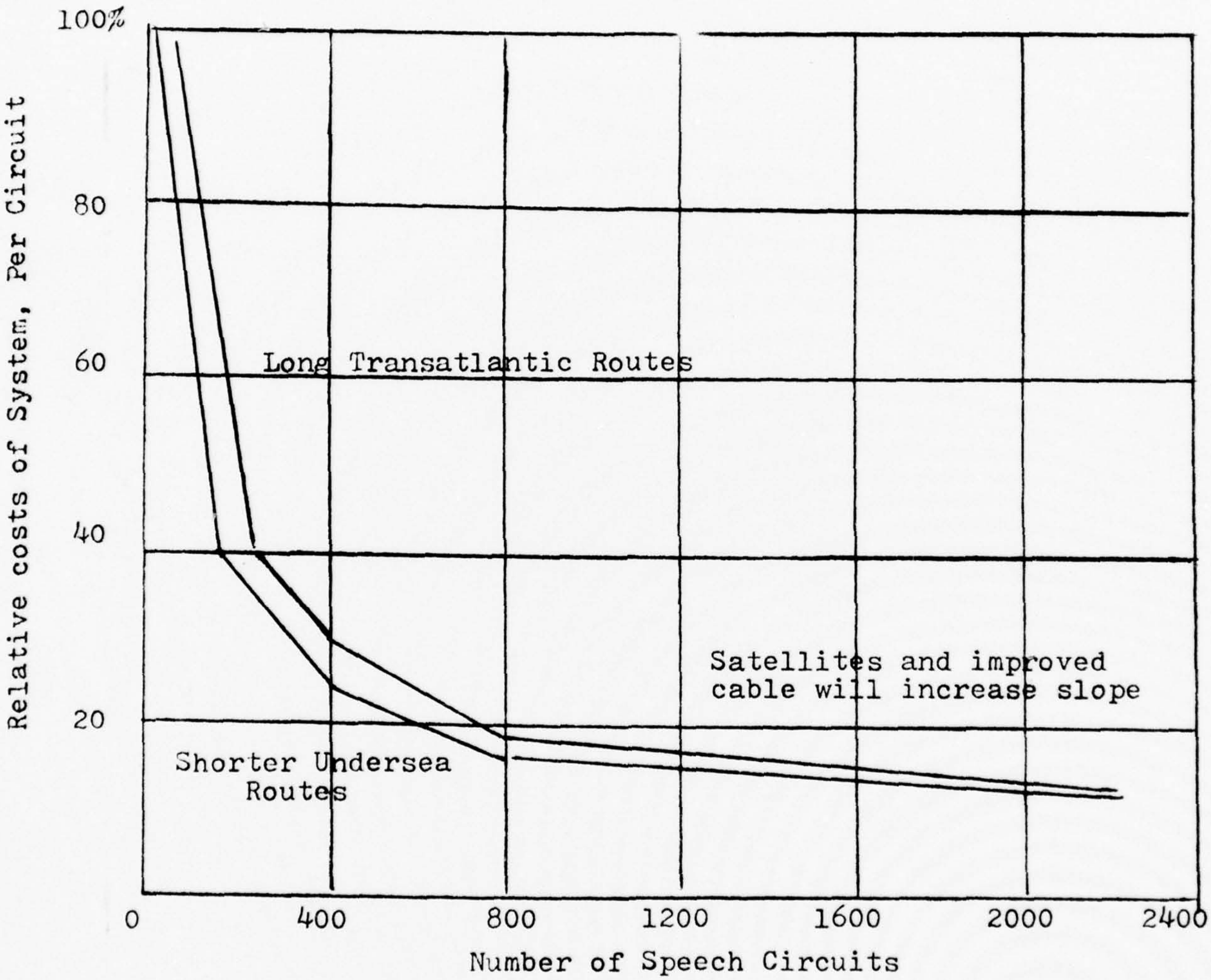
Cost trends in terrestrial transmission



Source: Future Developments in Telecommunications. (Englewood Cliffs, N.J.: Prentice-Hall Inc., 1971)

Figure 6

Decreasing Cost Relative to Capacity



Source: Adapted from World Communications: Threat or Promise? (Bath, U.K.: Wiley-Interscience, 1971)

PLANNING OF INTERNATIONAL TELECOMMUNICATIONS

The planning of all international telecommunications is the responsibility of a United Nations special agency, namely the International Telecommunications Union (ITU).[9] At the same time, certain aspect of international telecommunications may only concern a single continent or a group of countries or an individual country. Thus, there are three levels at which planning must proceed: Global or International, Regional and National. An international committee meeting in Rome under the auspices of the I.T.U., was the first to start planning for a worldwide telecommunications system capable of carrying telephone, telegraph and other services. The committee "studied the needs of the developing areas of the world (e.g., Africa, Asia, and South America) with regard to relating these needs to the existing and projected networks of Europe and North America."[10] Specifically, the committee was charged with determining the flow of telecommunications between the various areas of the globe in order to provide an estimate of how many telephone channels were required to link the whole world. A second conference held in Mexico City, Mexico in 1967 took up the question of; What is the most feasible technical method to

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[9]Colin Cherry. World Communications: Threat or Promise. (Bath, U.K.; Wiley-Interscience, 1971), p. 124.

[10]Ibid., p. 132.

make this a viable system, and was the refinement of the original estimate circuit requirements necessary? Figure 7, shows the principal international and global flow of telephone or equivalent telegraph traffic; numbers indicate an estimate of voice grade telephone circuits in years 1962, 1968, and in 1975.

There are three teographical regions for which global cable systems for telegraph and telephone services have been planned (see Figure 8): first, the North Atlantic for common American, Canadian, British, European and Middle Eastern connection; second, the British Commonwealth system and third, is the Pacific system which serves the United States' interests.[11] A joint American-British enterprise was responsible for the first of these cables to be laid across the North Atlantic. "A second and similar cable was laid between Britain, Paris and Frankfurt, in 1959 and a third in 1963 was laid between Britain and Canada."[12] The second planning area was for an overseas cable system to serve the British Commonwealth. A Commonwealth telecommunications conference held in London during July of 1958 concluded and recommended that a global submarine cable system be installed to link the commonwealth countries.[13] Figure 8, shows the planned global submarine cable system. Figure 9, shows how much of this system

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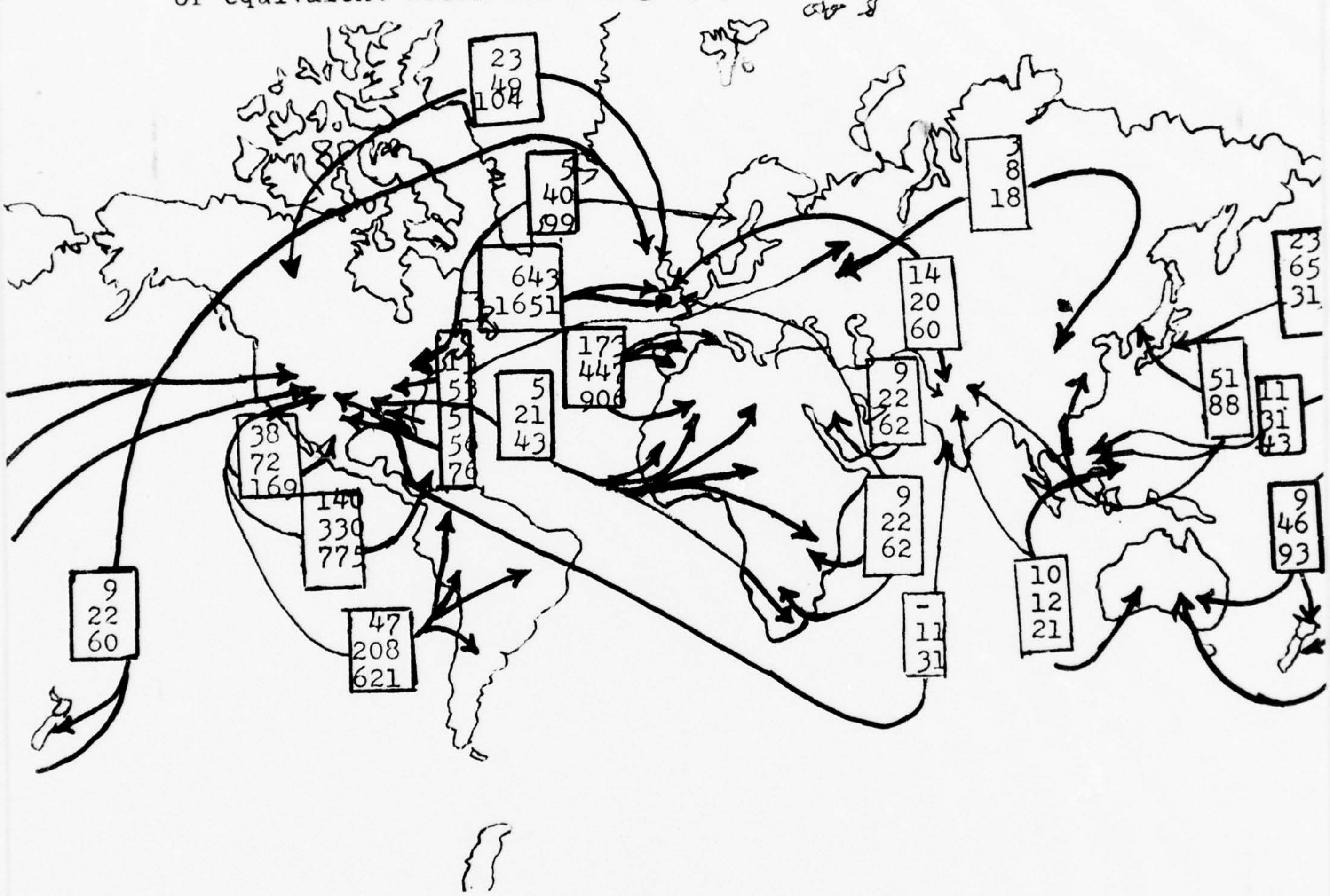
[11] Ibid., p. 87.

[12] Ibid

[13] Ibid., p. 88.

Figure 7
The principal intercontinental flows of telephone traffic, or equivalent Telex and telegraphy



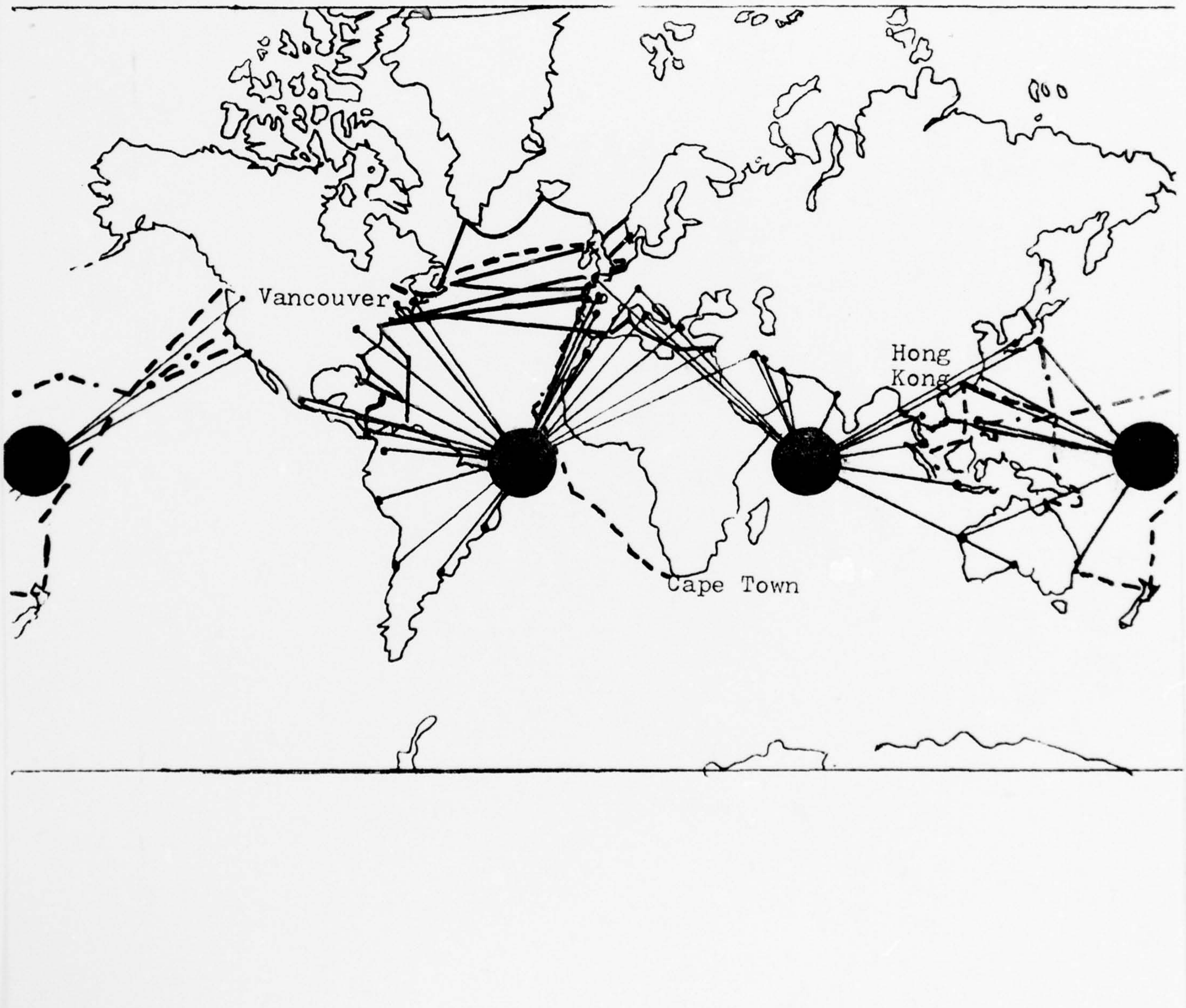
Source: Adapted from <u>World Communications</u>: <u>Threat or Promise</u>? Bath, U.K.; Wiley-Interscience, 1971)

Figure 8
'Round-the-World' Telephone Cable System as conceived
Commonwealth Communications Conference

Source: Adapted from World Communications: Threat or Promise? (Bath, U.K.; Wiley-Interscience, 1971)

Figure 9

The World's Principal Intercontinental Trunk Routes (cables and satellite for telecommunications (telephony, telegraphy, etc.) as of April, 1970



Source: Adapted from Microwave Journal. Vol. 19, no. 7, July 1976, Horizon House has been installed to date, as well as the communications satellite systems serving the Atlantic, Pacific, and Indian ocean basins. The third area of planning was for the Pacific cable system installed by the United States, it too is shown on Figure 10.

IMPACT OF COMMUNICATIONS SATELLITES ON INTERNATIONAL TELECOMMUNICATIONS

The rapidly expanding capacity of communications satellites has had a revolutionary effect on international global telecommunications. The emphasis now is on satellites to improve domestic and regional communications. Projections by the National Aeronautics and Space Administration (NASA) as shown in Table II-1, indicates the growth in terms of space communications segments of satellite communications systems. "French space officials estimate that by the year nineteen-ninety, 37 international and 37 domestic communications satellites will have been launched with 16 to be placed in orbit by their own Ariane booster."[14] The global market for civil communications satellites, earth terminal stations and peripherals is expected to be $4 billion by 1980.[15] "Between 1980 and 1990, the market for satellites alone is seen as

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[14]Lee Farnham. The Changing Market For Communications Satellites. (Microwave Journal, Vol. 19, no. 7, July 1975), p. 14. See also the report on "Who will Dominate the Next Generation Satellite Communications Market?", Dr. Paul Polishuk, same journal on page 16.

[15]Ibid.

TABLE II-1

Communications Satellite Launches 1980-2000

COUNTRY	NUMBER
Arab League	2
Australia	2
Brazil	3
Canada	3
China	3
Europe	5
India	1
Japan	3
Mexico	1
U.S.A.	20

Extracted from Microwave Journal, Vol. 19, no. 7, July 1976
Horizon House

$2.8 billion, much of this money will be spent for domestic and regional satellites."[16] Figure 10, illustrates the expected rise in sales and investments in satellite communications systems. In this figure "Peripherals" refer to the equipment of the terrestrial system.

With the trend toward smaller antennae and greater satellite output power, the cost of the Earth Terminal Station (ETS) portion of a satellite communications system is expected to decline. This fact should make satellite communications more available to the less developed countries (LDCs). Thus, a major share of the international satellite communications systems will service installations in the LDCs. Many of these nations will acquire extensive national communications networks including access to regional distribution networks. Table II-2 shows the present and planned distribution of ETSs by country.[17] Using these earth terminal stations along with the planned domestic and regional satellite communications system, it is hoped that the majority of the membership of the United Nations will have access to the international telecommunications system by 1980.

"Communications satellite circuit cost within one continent is essentially independent of distance, whereas those for terrestrial links are proportional to distance."[18]

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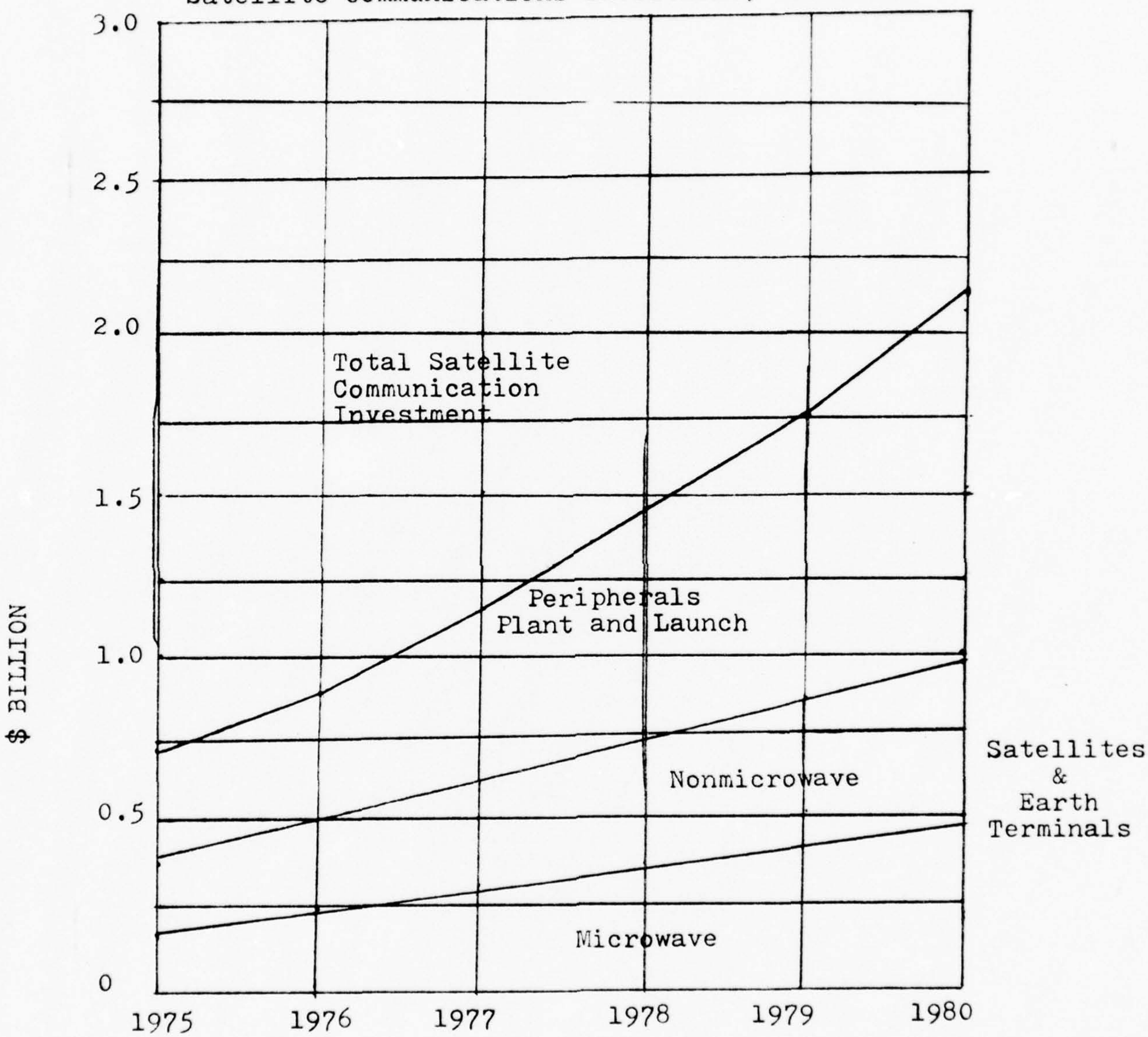
[16] Ibid.

[17] Ibid.

[18] James Martin. Future Developments in Telecommunications. (Englewood Cliffs, N.J.: Prentice-Hall Inc., 1971), p. 232.

Figure 10
Satellite communications investment, worldwide



Source: Microwave Journal, Vol. 19, no. 7, July 1976, Horizon House

TABLE II-2

EARTH TERMINAL STATION (ETS) RESOURCES*

COUNTRIES	INTELSAT	DOMSAT or OTHER
Algeria	2	16
Argentina		
Australia	3	4
Bahrain	1	
Bangladesh	2	
Barbados	1	
Belgium	2	
Brazil	3	
Camaroon	1	
Canada	3	63
Ceylon	1	
Chile	2	
Colombia	2	
Dominican Republic	1	
Dubai	1	
Dubay	1	
Ecuador	1	
Fiji	1	
France	5	
French Territories	3	
Gabon	1	
Germany	3	
Greece	2	
Holland	2	
Hong Kong	2	
India	2	
Indonesia	1	
Iran	1	
Iraq	2	
Israel	1	
Italy	3	
Ivory Coast	1	
Jamaica	1	
Japan	2	
Jordan	1	
Kuwait	1	
Lebanon	1	
Malagasy	1	
Malaysia	1	
Mexico	1	
Morocco	1	
New Zealand	1	

*Adapted from Microwave Journal, Vol. 19, no. 7, July 1976, Horizon House

COUNTRIES	INTELSAT	DOMSAT OR OTHER
Nicaragua	1	
Nigeria	2	
Norway		5
Panama	1	
Pakistan	2	
Peru	1	
Phillipines	1	
Portugal	3	
Quatar	1	
Romania	1	
Saudi Arabia	2	
Senegal	1	
Singapore	2	
South Africa	2	
South Korea	1	
Spain	3	
Sudan	1	
Sweden	1	
Switzerland	1	
Syria	1	
Taiwan	1	
Thailand	1	
Tobago	1	
Trinidad	1	
Uganda	1	
United Kingdom	3	
U.S.A.	8	8
U.S.S.R.	3	2
Venezuela	1	
Yugoslavia	1	
Zaire	1	
Zambia	1	

However, as satellite capacity becomes larger, traffic volume rises and as ETS costs drop, the breakeven point between terrestrial links occur at shorter distances. The cost of voice grade circuits between various American cities, via satellite are shown in Table II-3 to illustrate the above points. Figure 11, indicates how the cost per circuit decreases as a function of route density and satellite capacity. Because of the traffic carrying capacity of satellites, the cost per circuit is generally lower than circuits offered by submarine cables. Look again at Figure 6, and note the economic advantage to be gained as technology improves the message carrying capability of cable systems. This is important to the global telecommunications, in that future satellite communications will rely on submarine cable systems to provide a backup grid of international telecommunications. In some areas of the world the submarine cable may provide the primary links between some countries. Tables II-4 through II-7 indicate the number of existing and planned satellite communications systems. These systems will have the capability to provide 84,562 telephone circuits or 218 television circuits by the year 1980.

TABLE II-3

TYPICAL AMERICAN SATELLITE RATES

FOR

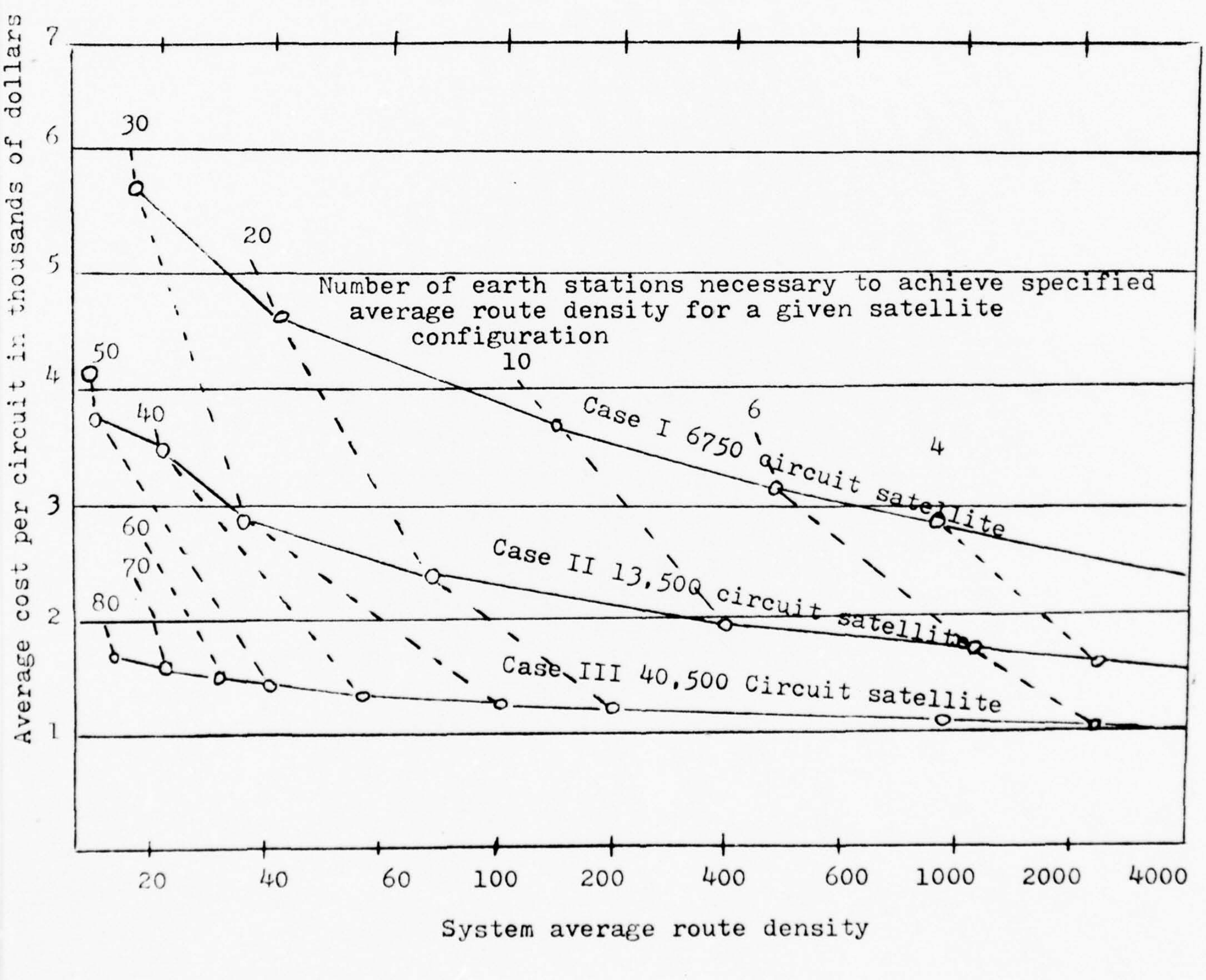
VOICE GRADE CHANNEL*

BETWEEN	AND	PRICE
Chicago	New York	$ 500
Chicago	Los Angeles	750
Dallas	New York	700
Dallas	Los Angeles	700
Dallas	San Francisco	750
New York	Los Angeles	1,000
New York	San Francisco	1,000
Washington	Los Angeles	1,000
Washington	San Francisco	1,000

*Adapted from Telecommunications; May 1975, Horizon House-Microwave, Inc.

Figure 11

Satellite systems cost trends



Source: Future Developments in Telecommunications. (Englewood Cliffs, N.J.: Prentice-Hall Inc., 1971)

TABLE II-4

BROADCAST SATELLITES

NAME	ORG.	DATE	FREQ (GHz)	BEAM (DEGREE)	FFD (dBW/M)	ETS CHARACTERISTICS DIA (M)	G/T (dB/K)	COST $
ATS-6	NASA	1974	0.86	2.60	-116	3	1	800
ATS-6	NASA	1974	2.6	0.9	-112	3	3	5,000
STASIONAR	USSR	1975	0.714	2.0	--104	3.4	-7.8.+1	?
CTS	NASA/ CRC	1976	12.0	2.5	-110	3,2.5, 1.2	16	10K
JBS	NASDA NHK	1978	12.0	1x3	-108	1.5	15	350
EBU/GBS	ESA/FRG	1985	12.0	1.2	-100	0.5	4	200
INTELS V	INTELSAT	1980	11	2.2	-116	0.7	4	

Source: Microwave Journal, Vol. 19, no. 7, July 1976, Horizon House

TABLE II-5

Present Communications Satellites

NAME	ORG.	FREQ BAND	XPNDRS	CAP. TV/vox	ETS DIA (M)	OPER DATE
INTELSAT IV	INTELSAT	C	12	12 or 16,000	30	1971
ANIK	TELESAT	C	12	12 or 6,000	98,30,	1972
WESTAR	WESTERN	C	12	12 or 6,000	10	1974
STATSIONAR	USSR	C	21	1+20	25,12	1974
SYMPHONIE	FRANCE/ Germany	C	2	2 or 1,200	16,8,4	1975
INTELSAT IVA	INTELSAT	C	20	20 or 10,000	30	1975
SATCIN	RCA	C	24	24 or 12,000	13,10	1975
ALGERIA	PTT(LEASE OF XPN)		1	1-30	11	1975
N.SEA OFF-SHORE	NORWAY(LEASE OF PTT XPNDR)			94	13,8	1975

Source: Microwave Journal, Vol. 19, no. 7, July 1976, Horizon House

TABLE II-6

PLANNED COMMUNICATIONS SATELLITES

NAME	ORG.	FREQ BAND	XPNDRS	CAP. TV/VOX	ES/DIA (M)	OPER DATE
COMSTAR	AT&T COMSAT	C	24	24 or 4,000	12.8 9.8	1976
INDONESIA	PERMUTEL	C	12	12/ 1200	9.8,7.3 4.0	1976
SIRIO	ITALY	Ku	1	1+12	14,5,4	1976
ETS-11	JAPAN NASDA	S,X,K			13,10	1977
OTS/ECS	EUROPEAN SP.AGCY	Ku	3	2 18,000	13,3	1977
BRAZIL	PTT	C			10	1977
JAPANESE CS	NASDA/MPT	C,K	8	8 18,000	13,10, 2.5	1979
ECS	NASDA/MPT NTT	C,K			13,10	1980
INTELSAT V	INTELSAT	C,Ku	27	2280 MHz BW		1980
IRAN	PTT				8,1,2	1980
ARAB LEAGUE	PTT	C			18,3	
CCS-1	NAD NASDA	C,K			10,3	1979

Source: Microwave Journal, Vol. 19, no. 7, July 1976, Horizon House

TABLE II-7

SPECIALIZED COMMUNICATIONS SATELLITES (MOBILE ETS)

NAME	ORG.	FREQ (GHz)	XPNDRS	CAPACITY VOICE	TTY	ETS CHAR DIA (M)	OPER DATE
MARISAT	COMSAT/ GEM	.254 .806	3			US NAVY	1975
		1.539 1.640	1			M/S	1975
		4/6	1	15	132	E/S 12.	1975
MARCOTS	ESA	1.54 1.64	2	50-60		M/S 0.6	1977
		11.70 14.50	2	50-60		ETS/13	
IMARSAT	IMCO	4/6, 11.7 14.5		14-160		ETS 10	1980
		1.54 1.64		14-160		M/A	
AEROSAT	ESA+ COMSAT GEN+ CANADA	0.126/ 0.131		2-4			1978
		1.55/ 1.65 5.0625/ 5.1375		2-7			

Source: Adapted from World Communications: Threat or Promise? (Bath, U.K.; Wiley-Interscience, 1971)

TABLE II-7

SPECIALIZED COMMUNICATIONS SATELLITES (MOBILE ETS)

NAME	ORG.	FREQ (GHz)	XPNDRS	CAPACITY VOICE	CAPACITY TTY	ETS CHAR DIA (M)	OPER DATE
MARISAT	COMSAT/ GEM	.254 .806	3			US NAVY	1975
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		4/6	1	15	132	E/S 12.	1975
MARCOTS	ESA	1.54 1.64	2	50-60		M/S 0.6	1977
		11.70 14.50	2	50-60		ETS/13	
IMARSAT	IMCO	4/6, 11.7 14.5		14-160		ETS 10	1980
		1.54 1.64		14-160		M/A	
AEROSAT	ESA+ COMSAT GEN+	0.126/ 0.131		2-4			1978
		1.55/ 1.65		2-7			
	CANADA	5.0625/ 5.1375					

Source: Adapted from World Communications: Threat or Promise? (Bath, U.K.; Wiley-Interscience, 1971)

CHAPTER III

PROPOSAL FOR A GLOBAL TELECOMMUNICATIONS NETWORK AND GLOBAL WAR AVOIDANCE TELECOMMUNICATIONS SUBSYSTEM

Having considered in Chapter II the growth and demand for international communications which have been in part, created by business and commerce, the economic progress of the LDCs, and the growth of international organizations, it is clear that the usefulness of the satellite communications systems and the technology discussed in Chapter II, will depend on their integration into the existing national, regional, and international telecommunications facilities. At the present time the international telecommunications system is a mosaic of different and separate communications systems each providing services to a local area. These islands of telecommunication service all too frequently are still poorly interconnected for international and intercontinental communication. The interconnection of local telecommunications systems by radio and cable has increased as the demand for long distance service has grown, but this has been accomplished largely through the incremental evolution of point-to-point circuits that benefit only those on each end of the circuit. Even the present submarine cable systems are nothing but coupling devices that interconnect two particular areas on a direct basis. Many of the nations that today still have relatively poor communications access to the global telecommunication system are those with a prospect for rapid growth over this decade and beyond. To gain the most economical use of the increased circuit capacities discussed in Chapter II, and the already existing extensive international telecommunications systems, will require the establishment of a world-wide telecommunications network. A network of global telecommunications systems that will serve civil and economic interest, and if used properly may serve as an aid in controlling hostilities. It could be designed to provide ample capacity for both civil traffic and intergovernmental communications in international crises. To organize and route traffic in such a way as to get the maximum use from a minimum number of circuits, such a network should provide for shared use by private citizens, businesses, and by civil and international agencies of the United Nations, and world governments. The proposed Global Telecommunications Network should also meet the following criteria:

a. It should be within the present state of the art;

b. It should be highly reliable and continue to function even if one of the primary circuit paths should fail;

c. It should offer communications services at least equal in quality to those presently provided by the international telecommunications systems.

OPERATIONAL CONCEPT

The heart of the proposed Global Telecommunications Network will be the transmission system (communication satellites, submarine cables, etc.), and the automatic or electronic switching system. The transmission system will provide the circuit paths or channels for the network, whereas the automatic switching system selects the circuit paths for interconnecting users of the network. Recent advances in technology has produced automatic computerized switches which can concentrate communications traffic and route it through a maze of interconnected systems according to predetermined precedence and preemption requirements. This flexibility also makes it possible to switch to another circuit if one fails.

The proposed network will not only serve high density traffic routes, but will also have the flexibility to serve points with smaller requirements. The transmission system will use broadband channels that can be subdivided into narrower bandwidths. This is of great importance in allowing the lesser developed countries with relatively small requirements access to the Global Telecommunications Network. In addition, the transmission system offers the advantage that the Earth Terminal Stations (ETSs) required at low traffic locations can be of simpler and cheaper design than those used on high density routes. Such a system will be uniquely suited to expanding service to the developing areas of the world. It would provide added security and reliability, both by making available alternate routes and by giving direct access to areas that until recently could only be reached by radio or by intermediate terrestrial systems of other countries.

The demand for additional, more versatile (in terms of services provided) global communications is growing tremendously. Table II-1, shows the ratio of domestic telephone calls in selected countries. On balance it appears that many of the LDCs have a higher ratio of overseas telephone calls to domestic calls than most of the highly industrialized countries. This also probably indicates that the requirement for international telecommunications services will have a higher growth rate in the LDCs. The volume of overseas telephone calls is expected to increase from 20 million in 1970 to nearly 30 million by 1980.[1] This means that overseas telephone circuits may also have to be increased by a corresponding number. It seems obvious that one or more satellite communications systems, in addition to the present undersea cable systems, will be required to provide all of the services and transmission capacity to accommodate this expected growth in demand.

COMPUTERIZED SWITCHING SYSTEM

Activation of the computerized switches in the proposed Global Telecommunications Network, should produce economies by elimination or integration of previously dedicated communications

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[1]Communication Satellites, Part 1. (House Committee on Science and Astronautics, 1961), p. 227.

TABLE III-1

Ratio of international (local and trunk) telephone calls to international calls

1-50	50-500	500-2000	2000-5000	Over 5000
Dominican	Rep. of Ireland	Cameroons	United States	Singapore
Monaco	Belgium	Austria	Portugal	Japan
Lebanon	Switzerland	Ivory Coast	Spain	Australia
Luxembourg	Netherlands	Granada	South Africa	Polynesia
Sudan	France	Antigua	Israel	
Pakistan	German F.R.	Denmark	German D.R.	
Libya	Indonesia	Norway	Argentine	
Thailand	Central Africa	Mali	Trinidad	
	Egypt	Belgian Congo	New Zealand	
	St. Thome & Principe	Ethiopia	New Caledonia	
	Somaliland	Greece	Nigeria	
	Syria	Sweden	Malaya	
	Mauritania	Turkey	Vietnam	
	Angola	Italy	Ghana	
	Dahomey	United Kingdom	East Africa	
	India	Burma		
	Bermuda	Mozambique		
		Upper Volta		
		Niger		
		Yugoslavia		
		Macao		
		Iceland		
		Madagascar		

Source: Adapted from World Communications: Threat or Promise? (Bath, U.K.; Wiley-Interscience, 1971)

systems. The switches will accept and switch two different types of traffic; telephone traffic and traffic in the form of teletypewriter, data card and magnetic tape.[2] The switch, under the control of a software and hardware program, will accept these messages in different formats and convert them into a common format for transmission between switching centers, where they will be again converted into the original format and passed to their designated addressee.

The switching concept provides for circuit allocation only as there is a demand for a circuit path. Path selection is automatically made through a special control module. On a demand for service, an idle circuit is selected and automatically routed from the calling party or station to the called station. Hence, any particular circuit path may at one moment be selected for use between terminal A and B, for example; at another time this same circuit path may be selected for use between entire different terminal stations, perhaps C and D. Thus, it is unnecessary to allocate specific circuits to individual terminal stations. Groups of circuits or individual circuits, may of course, be leased to serve special requirements. This service of leased circuits is in addition to the concept of "Demand Service" described above.

One of the measures of any communications systems' effectiveness is its reliability of service. The reliability

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[2] Government Use of Satellite Communications. (U.S. Congress House Committee on Government Operations, 1968) p. 18. See also the TRI-TAC discussion by Majors John Randt and John C. Smith, The Army Communicator, Fall 1976, Vol 1, no. 7, July 1976.

of this conceptual global telecommunications network is greatly enhanced by using the many circuit paths afforded by the computerized switch. If, between a particular pair of terminal stations, there are always several circuit paths, failure of one path would not put the network out of business. The demand for a circuit to connect those particular terminal stations would simply be switched to another transmission system.

GEOSTATIONARY SATELLITE COMMUNICATIONS SYSTEM

This concept of a global telecommunications network relies to a great extent on the use of large capacity, synchronous satellites as a primary transmission system. From Figure 12 one can see that by stationing one satellite over the Atlantic, one over the Pacific and one over the Indian Ocean every inhabited part of the world could be connected in a global telecommunications network. Each communications satellite would carry either 24 television circuits or 14,000 individual telephone circuits in master groups of up to 600 circuits.[3] These broadband channels can be used in a 24 channel mode, thus permitting those countries and regions with relatively small requirements to be connected into the Global Telecommunications Network.

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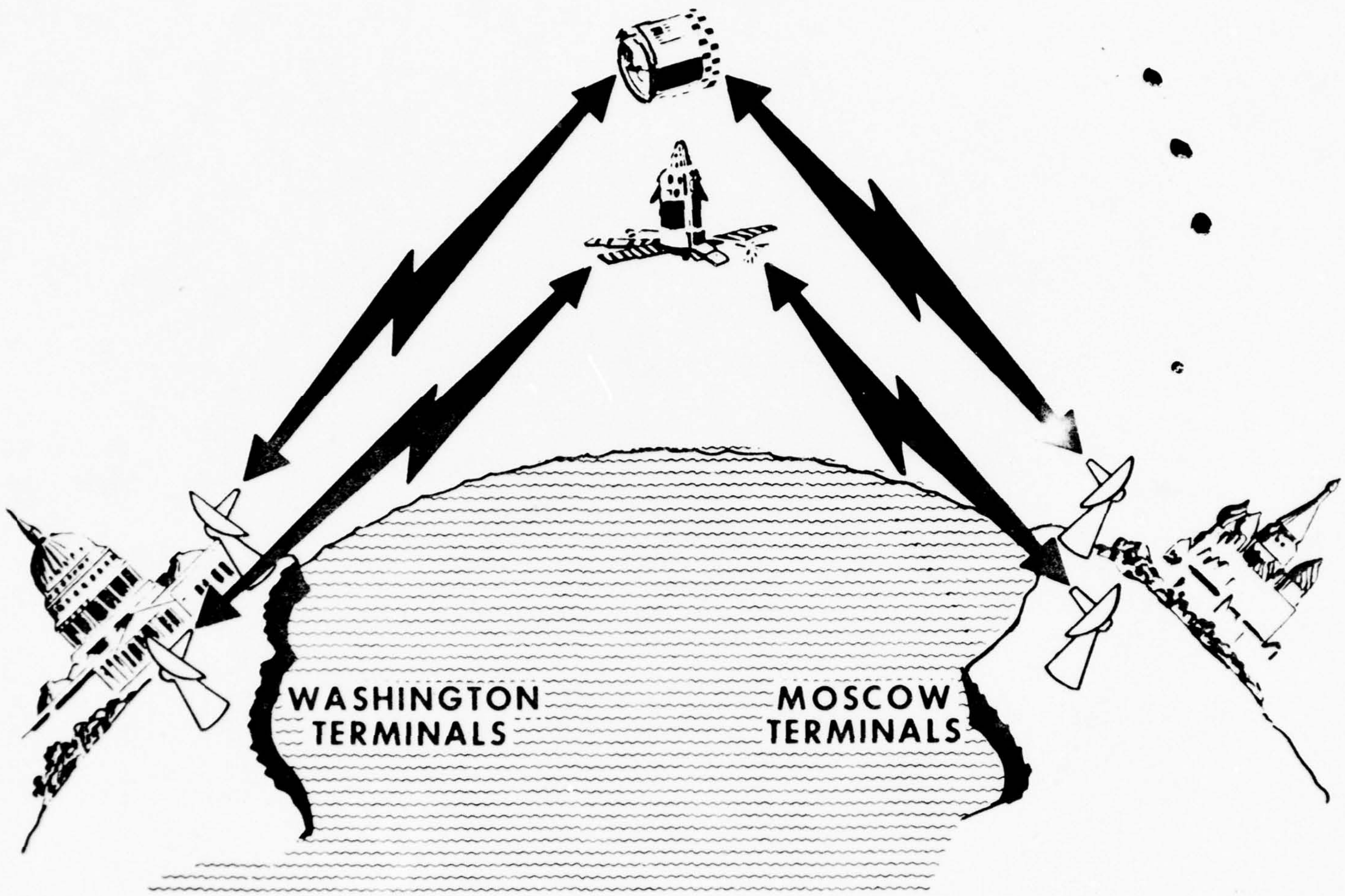
[3]This is based on the use of the COMSTAR Communications satellite, presently in service, and belonging to AT&T/COMSTAT. Description of this communications satellite is at page 18, _Microwave Journal_, Vol. 19, no. 7, July 1976.

Figure 12

USA-USSR SATELLITE DIRECT COMMUNICATIONS LINK (DCL)



Source: Major General Jack A. Albright. *C^3 for Crisis Management.* 29th AFCEA Convention, Wash, D.C., 5 June 1975.

An international system of communications satellites has two parts: first, there are the satellites themselves, used in common by all parties and not standing on any nation's territory, and second, the earth terminal station which is owned and controlled separately by the various nations or commercial communications carriers who are sharing in the system.[4] The satellites are thus shared while the earth terminal stations are either leased, nationally owned, or perhaps owned under international agreements by a group of nations or communications carriers on a regional basis. One of the benefits that accrues from such an arrangement is the degree of cooperation required among the various nations and commercial communications entities to make it work. President Johnson in a message to Congress in 1967, reaffirmed America's support of INTELSAT; "he stressed that America sought no domination of satellite communications and urged the Soviet Union and the nations of Eastern Europe to join INTELSAT. The message concluded: 'the challenge of this new technology is simple--it is to encourage men to talk to each other rather than fight one another. Historians may write that the human race survived or faltered because of how well it mastered the technology of this age'."[5]

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[4]Colin Cherry. World Communications: Threat or Promise? (Bath, U.K.; Wiley-Interscience, 1971), p. 165.

[5]Judith T. Kidlow. INTELSAT: Studies in International Relations and Foreign Policy. (Lexington, Mass., D.C. Heath and Co., 1973), p. 63.

GLOBAL WAR AVOIDANCE TELECOMMUNICATION SUBSYSTEM

"Many of the most tragic aberrations of history are attributable to messages that failed to arrive, arrived too late or were misunderstood when they did arrive."[6] Conflict/General War avoidance in recent times have also been highly dependent on rapid, reliable global communications. Perhaps, no single event in the past 25 years has brought the world closer to a General War than the Cuban Missile crisis of 1962. Telecommunications probably played a key role in reducing the chances for a General War. "It was the nightmare of the U.S. Administration during the Cuban Crisis that something would interrupt the flow of messages between Moscow and Washington."[7] Within the next year, both Moscow and Washington agreed to establish a "Hot Line" so that future crises and misunderstandings which might lead to war may be resolved. The Washington-Moscow Hot Line, currently referred to as the Direct Communications Link (DCL), is entering the space age.

> The giant technological leap is being made in order to create a more foolproof method of emergency communication in a nuclear age. Until now, the Hot Line has been a maze of undersea cables, radio links and land lines, all vulnerable to mishap. Several mishaps have in fact occurred. For example, a manhole fire north of Baltimore once knocked out the primary line. A farmer in Finland severed the cable with his tractor, a deep-sea fishing trawler cut the line and so did a

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[6] Alstair Buchan, et al.,1 The Atlantic Papers, (Cambridge, Mass.: Dunellen Inc., 1970), p. 335.

[7] Ibid., p. 336.

> bulldozer operator near Copenhagen. Concern over the accidents led to a U.S.-Soviet agreement to create a pair of 'independent but parallel circuits' over separate satellite systems for the Hot Line.[8]

A new earth terminal station costing $6.8 million has been built to establish one of those circuits, in the DCL.[9] This facility which is located near Fort Detrick, Maryland, uses four non-synchronous Molniya satellites to establish direct communications between Washington and Moscow, without crossing the borders of a third country (see Figure 12). "The other circuit goes from a COMSAT terminal at Etam, W. Va., and then to an INTELSAT mid-Atlantic satellite. Signals pass through a leased channel, and are relayed directly to the Soviet Union."[10]

In order to insure accuracy, messages between the American President and the Soviet Premier are transmitted in their native language using teletype format. Even though the system has been in existence since 1963, it has only been used 15 times to pass operational traffic. The Hot Line was first used at the start of the Vietnam War when the U.S. Navy's ship Maddox was reported to have been attacked by the North Vietnamese in the Gulf of Tonkin. On several occasions later in the war, President Johnson used the system to advise the U.S.S.R. on critical developments. Messages were exchanged during the Three Day War of 1967. When the Pueblo was seized

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[8] L.H. Whittemore. U.S.-Soviet Hot Line Begins Operating by Satellite. (Parade Magazine, December 1976), p. 10.

[9] Ibid.

[10] Ibid.

by the North Koreans, President Johnson used the system to advise the U.S.S.R., that the U.S. naval units dispatched to the Sea of Japan were not a threat to U.S.S.R. security interest.

Whether or not the thaw that ensued in U.S.-Soviet relations after the installation of the Hot Line can be directly related to the Hot Line, itself, is debatable. But, there has been perceptible changes in the nature of those relations. Prior to the Hot Line the relationship between the U.S. and the Soviet Union was referred to as the "Cold War," which produced the Berlin Blockade of 1949, the Berlin Wall of 1961 and the Cuban Missile Crisis itself. Since, the installation of the Hot Line the relationship has undergone fundamental changes from "Cold War" to "Peaceful Coexistence" which has produced a Limited Nuclear Test Ban Treaty and led to an agreement to ban the employment of nuclear weapons in space.[11] This changing behavior pattern has created a climate of "Detente" which has produced the Nuclear Non-proliferation Treaty, the banning of biological weapons in warfare, Strategic Arms Limitation Talks (SALT), and an increase in intercultural communications.

From the foregoing it appears that the slender thread of telecommunications (the Hot Line) that exists between Moscow and Washington has tended to have a stabilizing effect on relations between the U.S.S.R. and the U.S., and that

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[11] John Spanier. Games Nations Play. (New York: Praeger Publishers, 1972), p. 84.

telecommunications may play an equally fundamental role in achieving understanding and harmonizing conflict among the other nations of the world. To that end, this study proposes that a Global War Avoidance Telecommunications Subsystem (GLOWATS) be established as a subsystem of the Global Telecommunications Network (GTN). The design of the proposed GLOWATS should be guided by the following considerations:

a. Although, the least complicated design approach would be to establish a new global telecommunications network using dedicated communications satellites and terrestrial links for the express purpose of serving as a dedicated GLOWATS, the dollar cost associated with such an approach is prohibitive. If such a system is to come about, cost dictates the use of those international telecommunications systems that are existing presently or planned for implementation in the future. Utilizing these facilities which the trends outlined in Chapter II indicates will have more than adequate channel capacity, is not only cheaper but will allow more flexible and diverse routing, thus enhancing the survivability of the GLOWATS through redundancy.

b. Frequency spectrum is the basic commodity used in satellite communications systems (the major transmission medium of the proposed GLOWATS). It is scarce. The system to be designed should make efficient use of the available frequency spectrum.

c. The basic communications transmission system, both cable and satellites, must be highly reliable. It must continue to work even if individual segments of the system fail.

d. The Subsystem should provide the capability to transmit interchangeably different types of signals, that is, large numbers of telephone, telegraph and data circuits on a switched basis or television and other signals requiring wide-band service on a call up basis.

e. During stable non-crisis periods GLOWATS need not be distinguishable from the larger Global Telecommunications Network. During times of crises and hostilities users of the GLOWATS (i.e., the world governments), have a priority that would give them first call on any non-busy circuit and would preempt lesser priority users if all circuits were busy.

Operation of GLOWATS will require close cooperation with the communications agencies and administrations of the many countries, who will share in the use of the global telecommunications network. The large body of experience already acquired by the I.T.U. and the various international communications carriers indicate that they have been able to resolve differences and work together harmoniously and effectively.[12] This fact gives assurance that the technology now under development and that already developed can be quickly made into an operable global telecommunications network serving the people of many lands. This proposal is not only a method for acquiring better and cheaper communications facilities on a worldwide basis, but also an opportunity to improve communications of all types to and between all nations, with the hope and expectation that this may advance the cause for lasting peace.

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[12]See discussion of international Telecommunications planning on page 12.

CHAPTER IV

NETWORK DESIGN AND IMPLEMENTATION

INTRODUCTION

The preceding chapters have examined the growth of global telecommunications and very briefly analyzed the potential for reductions in cost for communications services, made possibly by the recent advances in telecommunications technology. Chapter III, explored a proposal to establish a Global Telecommunications Network (GTN), by augmenting the present international telecommunication systems with computerized switches and additional communications satellite terminals. Such a network will, with minimum cost in network resources, afford the necessary circuits and facilities to establish a Global War Avoidance Telecommunications Subsystem (GLOWATS). A subsystem that may have potential for promoting peace and stability in international relations. The host of social, economic, and technical factors to be considered in designing a system to implement the proposals advanced in Chapter III, will be considered in this chapter.

ECONOMIC IMPACT OF GLOBAL TELECOMMUNICATIONS

One of the major hindrances to a developing country's economic progress is the lack of adequate communications facilities. Wilbur Schramm has argued that investments in communications facilities in general should be slightly ahead, and never behind, investments in the other institutions of a developing country's economy.[1] A country's communications facilities, both internal and external, and its economic appear to be correlated. Figures 13 and 14 examines the relationship between telephone instruments and per capita Gross National Product (GNP). A comparison of the telephone facilities available to citizens of countries with a per capita GNP above $1,000 and those available in the Lesser Developed Countries (LDCs) indicates that telephones and other modern telecommunications facilities are associated with a trend toward rising per capita GNP. Whether the increasing rise in per capita GNP creates a demand for additional telecommunications facilities or whether the additional communications tend to increase the rate of growth in the wealth of a nation is not clear. There is, however, a close correlation between the number of telephones in a country and the per capita GNP of that country.

The International Bank for Reconstruction and Development have stated that "the future of small countries depends to a critical degree on their external economic relationships, including the extent to which they can combine with each other to rationalize production and create large markets."[2] To

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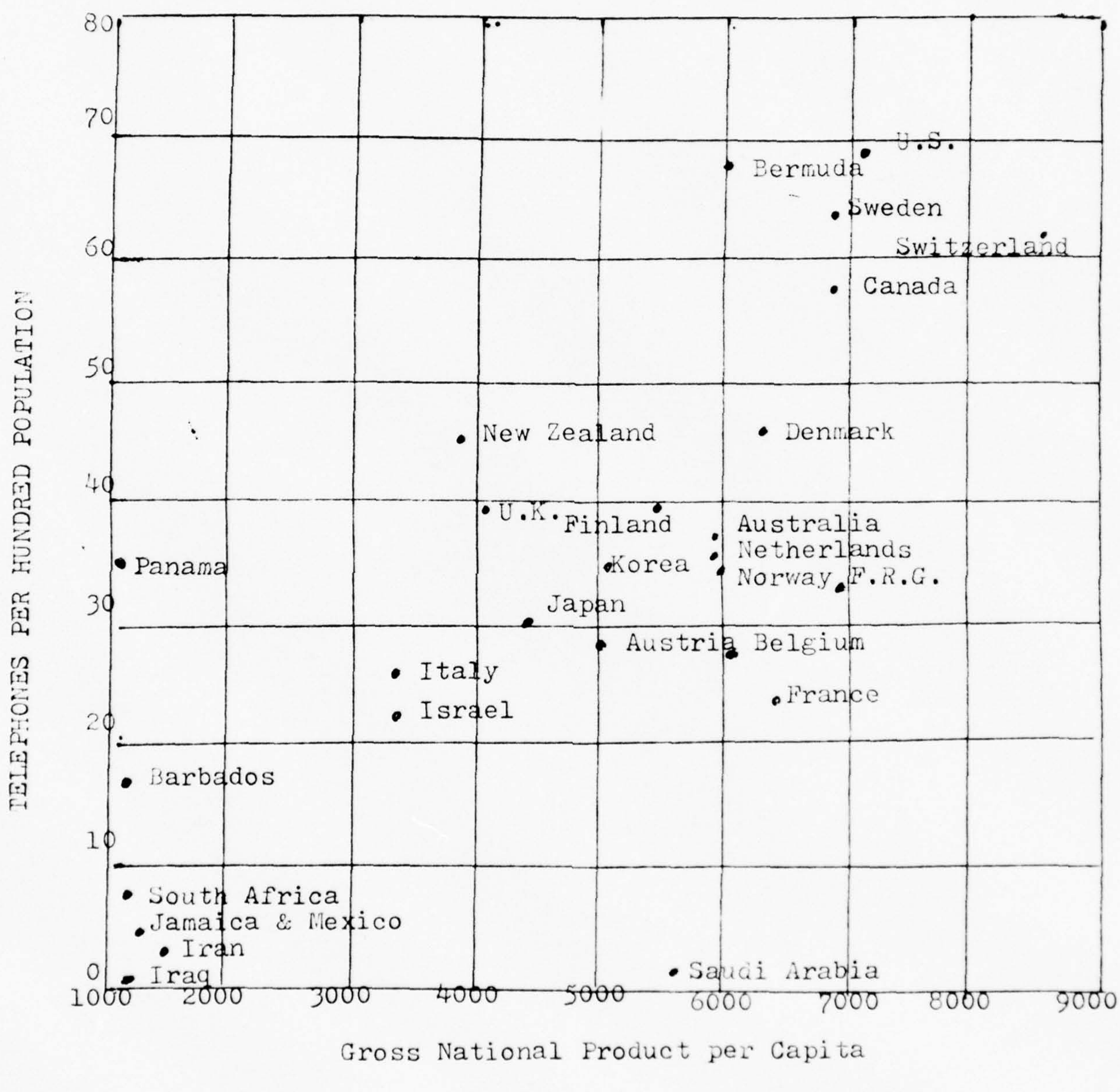
[1] Wilbur Schramm. Mass Media and National Development. (Stanford, Calif.: Stanford University Press and UNESCO, Paris, 1964), p. 206.

[2] World Bank Atlas of per capite Production and Population. (Geneva,: International Bank for Reconstruction and Development, 1969), p. 263.

Figure 13

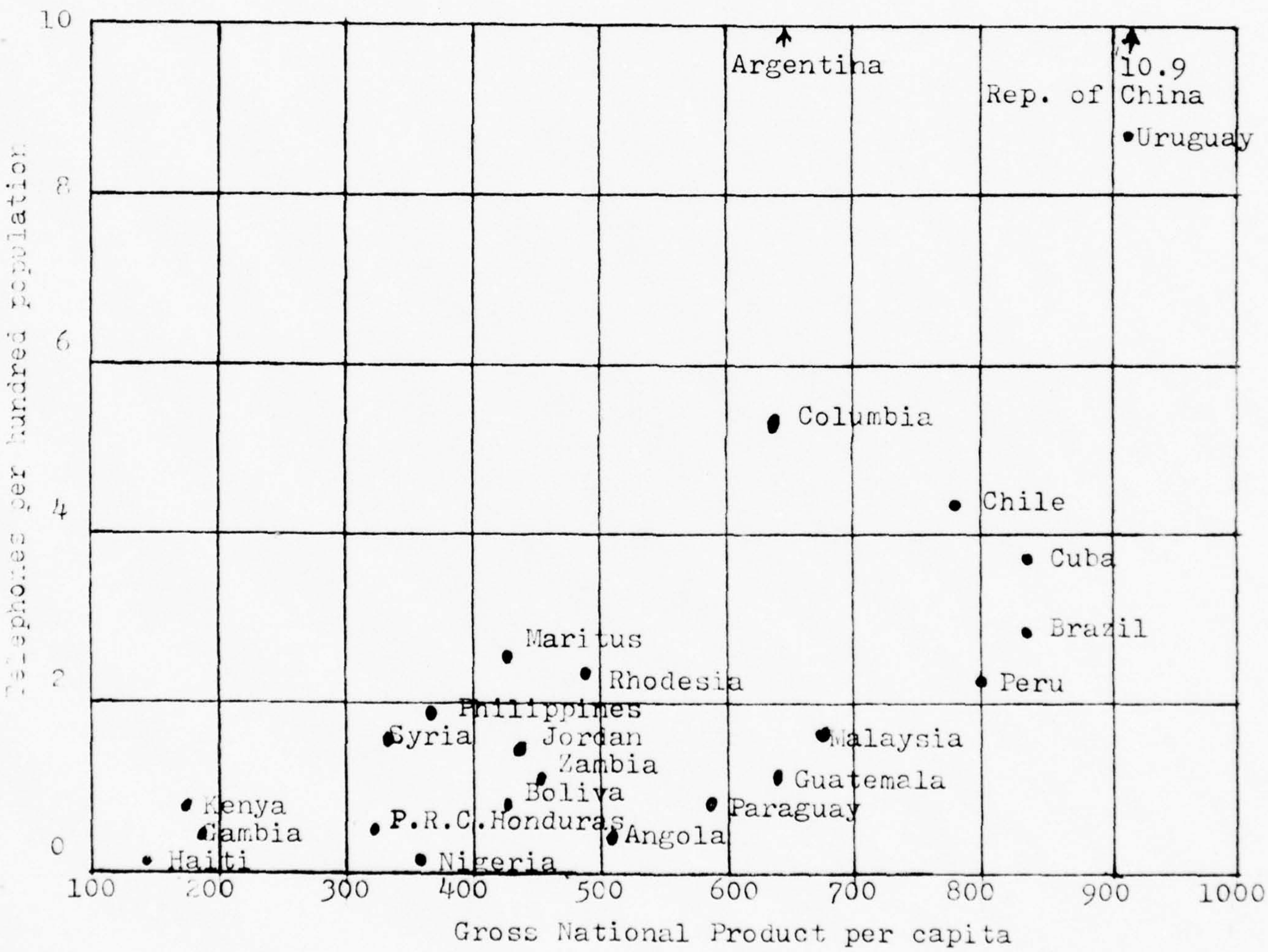
Correlation between telephones and Gross National Product (GNP) in Countries with GNP per capita above $1,000 (U.S. Dollars).



Adapted from C. Cherry. World Communications; Data from The National Basic Intelligence Fact Book, Central Intelligence Agency

Figure 14

Correlation between telephones and Gross National Product (GNP) in countries with GNP below $1,000 (U.S. Dollars)



Adapted from C. Cherry. World Communications. Data from Central Intelligence Agency's: Basic Intelligence Fact Book; January 1977 develop these economic relationships the new and lesser developed countries need to improve their telecommunications facilities and services both for internal and international communications. The proposed GTN should lower the cost of international telecommunications services by making them available to the lesser developed countries.

The dilemma facing the lesser developed countries is, how much of the meager resources of the country should be expended in upgrading the international communications facilities, and how much to devote to upgrading internal communications and developmental programs. While, financial resources are a major problem, there are other impediments that prevent or retard the developing countries in their attempt to improve telecommunications facilities and services. Among these are the politics of the area or region which may prevent them from making use of the international telecommunications facilities of a neighboring country. In order to reduce cost it will be necessary under the proposed network to process the international communications traffic for some of the smaller countries on an area basis, using the facilities of a single country for entry into the GTN.

DEMAND FOR GLOBAL TELECOMMUNICATIONS NETWORKS AND SERVICES

The fate of a global telecommunications network is intimately tied to the demand for the services that may be provided by that network. For any particular telecommunications system, cost per channel is inversely proportional to utilization rates. To get significantly lower cost per circuit, reasonably high rates of circuit utilization is required. The needs of the various countries for international telecommunications vary. The highly developed western industrial countries have an immediate requirement for many circuits to all areas of the globe, the less developed countries require only a few. Consequently, the countries that have direct access to global telecommunications systems, share those facilities on a service basis with those countries who do not. The sharing of facilities is to become more important as the international system transitions to a network of regional and area systems, tied to centrally located computerized switches so that any available transmission path may be used regardless of what country owns the transmission system. Annex I, shows those countries with access to global telecommunications.

Problems may arise in competition between countries desiring to become nodes in the GTN. There are a finite number of nodal points needed and the number of primary switching stations, satellite terminals and submarine cable systems will be limited. If different countries request ground terminals, to be located in close proximity to each other, the network may have to be enlarged or a choice made between the competiting countries as to which will become the nodal point responsible to the world community for providing global telecommunications service to that area. In choices such as these, delicate political issues may arise.

A review of the graphs in Chapter II, indicate that because of the explosive growth in international telecommunications traffic, very careful and elaborate forecasting is needed in order to predict future needs accurately. Predictions of international telecommunications growth are made by the International Telecommunications Union's, Commite' Consultaif de Telephonie et Telegraphie, in their Manual on National Telephone Networks.[3] There are many difficulties in accurately predicting international traffic flow. In the present age of increasingly shorter lead times for dramatic breakthroughs in the electronic and telecommunications fields, there is no way to prove that a newly designed system will not be out of date and un-economic to use before it has paid for itself. Nor is it known just how the introduction of some new system, such as the Videophone, may affect the traffic demands.[4] International political difficulties such as a war may affect the volume of message traffic, both telephone and telegraph. Note the relative reduction in international telephone traffic during the war years of 1940 through 1945 as shown in Figure 15.

Based on the predictions of the requirements for intercontinental telephone channels predicted by the "Rome Plan", of 1963, Table IV-1 shows the estimate of the telephone circuits

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[3]Colin Cherry. World Communications: Threat or Promise? (Bath, U.K.; Wiley-Interscience, 1971), p. 94.

[4]James Martin. Future Developments in Telecommunications (Englewood Cliffs, N.J., Prentice-Hall Inc., 1971), p. 37.

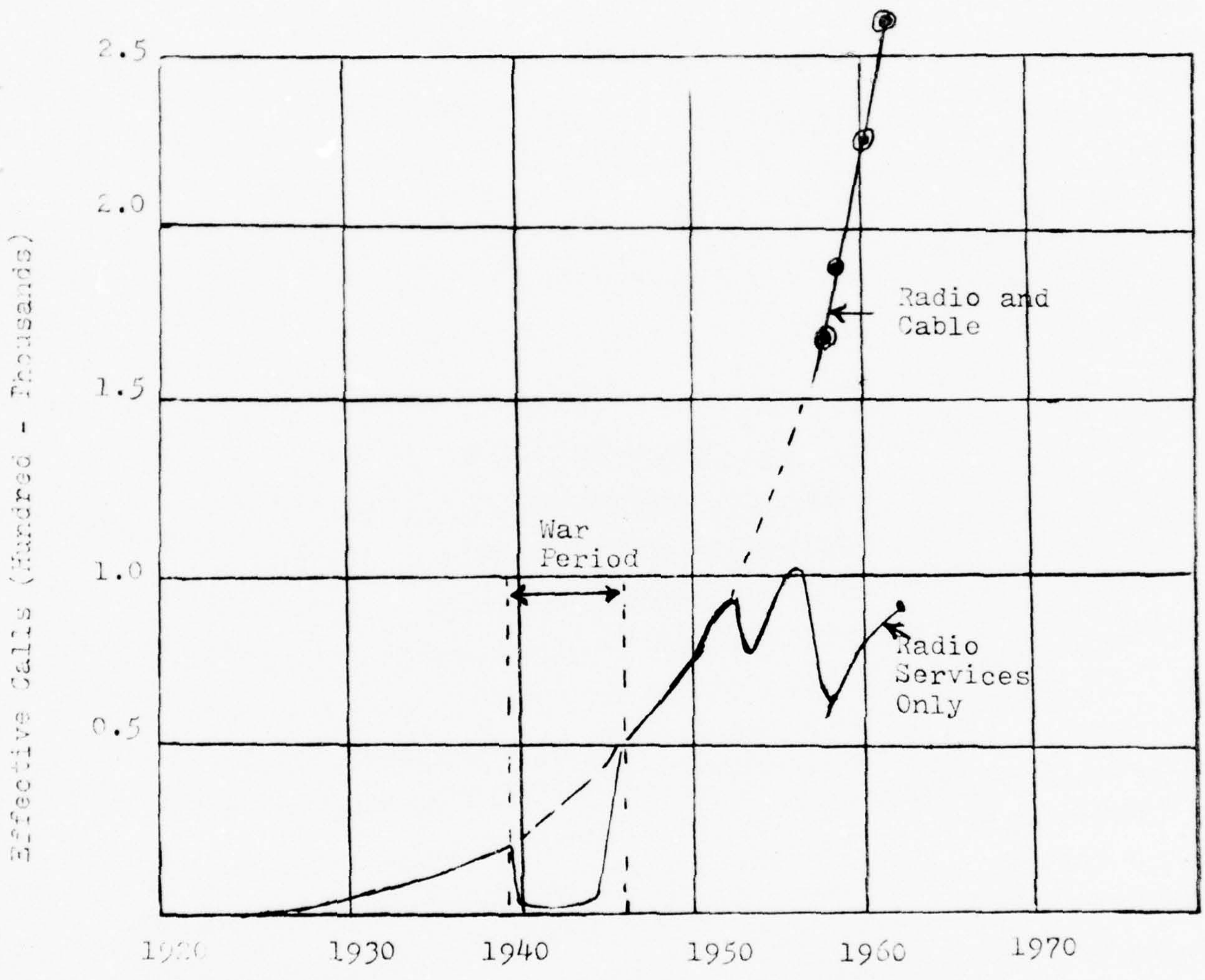
TABLE IV-1

CONNECTING COUNTRIES	ESTIMATED CIRCUITS REQUIRED
North America--Africa	194
North America--Europe	10,480
North America--South America	1,880
North America--Far East (China, Japan, etc.)	400
North America--Australia	60
Europe--South America	300
Europe--Africa	1,122
Europe--Far East (China, Japan, etc.)	800
Europe--Australia	400
South America--Far East (China, Japan, etc.)	300
South America--Australia	50
South America--Africa	30
Africa--Australia	40
Africa--Far East (China, Japan, etc.)	100
Far East (China, Japan, etc.)--Australia	120

Figure 15

WAR TIME DROP IN INTERNATIONAL

TELEPHONE CALLS



Source: Adapted from World Communications: Threat or Promise? (Bath, U.K.; Wiley-Interscience, 1971)

needed to accommodate the demands for intercontinental telecommunications for the year 1980. Based on this rate of increase and the principle of saturation, the demand between the industrialized countries is expected to level off but the demand from the lesser developed countries will continue to rise. Predictions about any of these factors, especially over the next decade are subject to much incertainty. This is particularly true of those demands involving the developing countries. In the face of these uncertainties there will be no attempt here to be definite about their traffic demands. The demand profile shown in Figure 16, is on an area basis and does not indicate definite requirements.

GEOGRAPHICAL CONSIDERATIONS

There are certain geographical regions throughout the world between which telecommunications have traditionally occurred. These regions are most easily typified by population density, individual classifications, past, present and future communications facilities, and trends. As such, they have influenced the areas in which the present earth terminal stations and intercontinental submarine cables are located. Figure 17 shows that the larger part of the world population is spread logitudinally around the world in a belt between 60° north and 40° south latitude.[5] Very little of the earth's

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[5]Communications Satellites Part 1. (General Electric's Comments Before a hearing of the House Committee on Science and Astronautics, 1961), p. 220.

Figure 16

Predicted Demand Profile

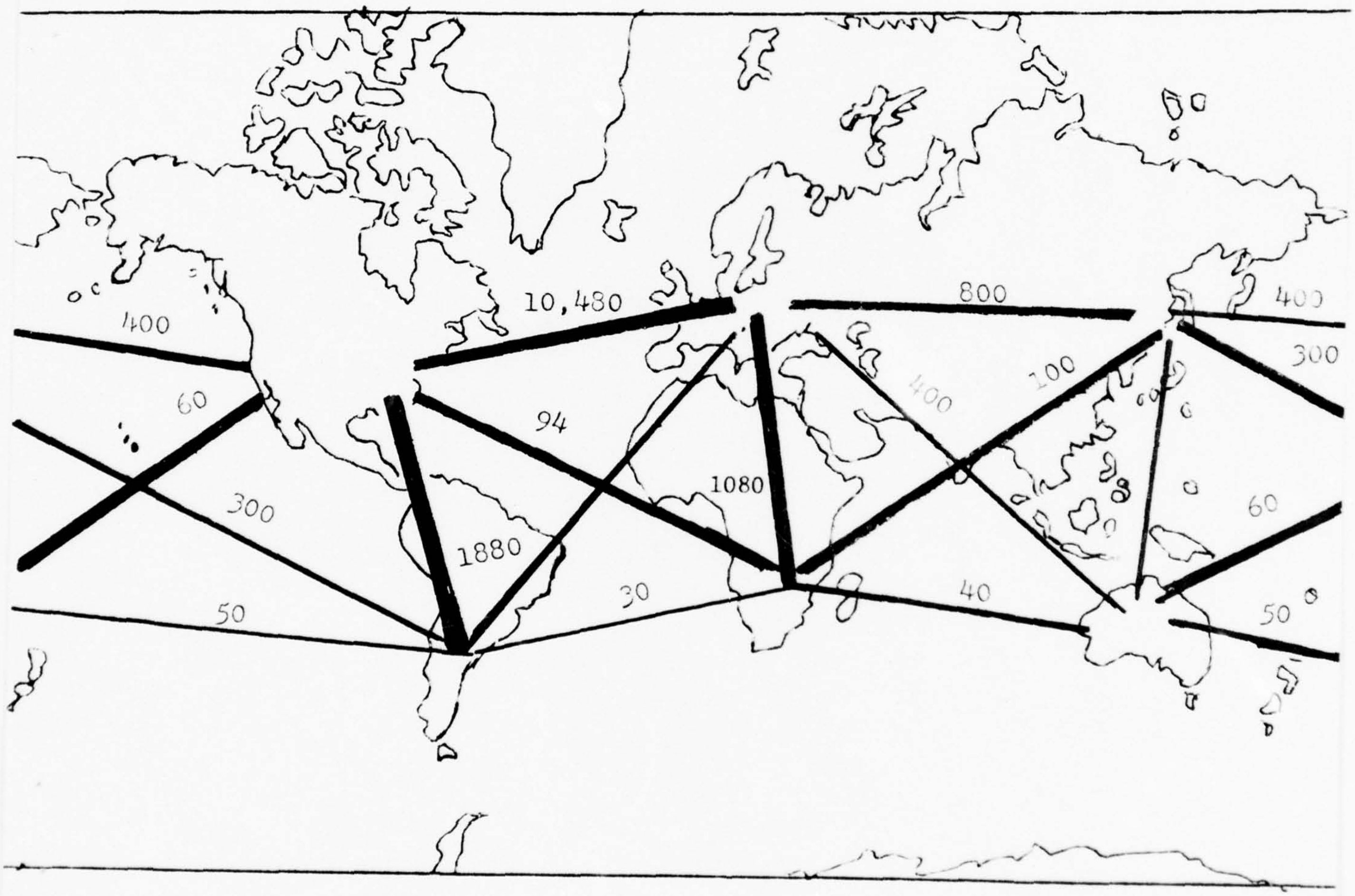
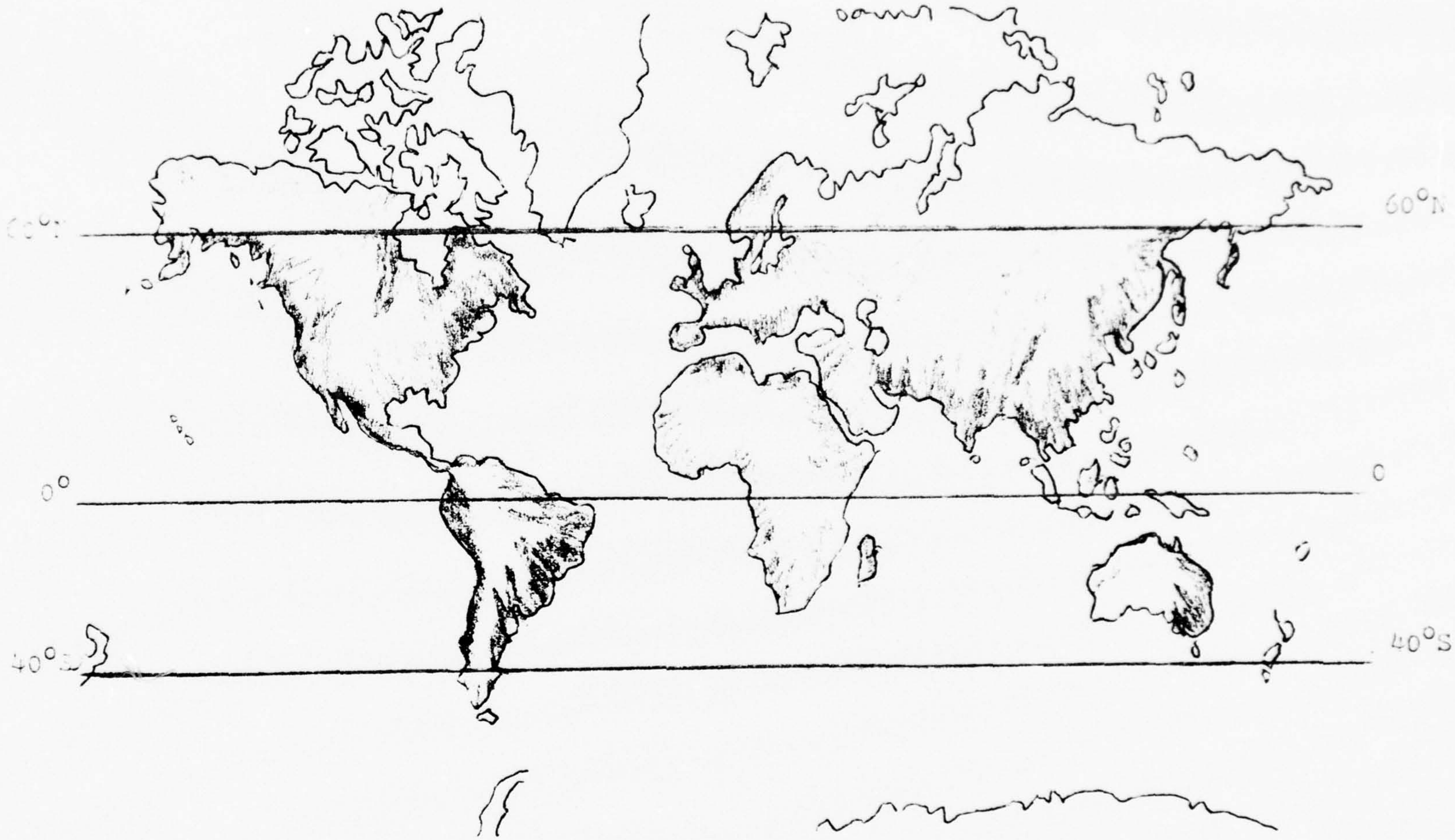


Figure 17

Principal Distribution of World Population



population lives beyond these extremities. Further major concentrations of population exist along the eastern and western coasts of United States and South America, the coast of China, along the eastern coast of Australia and western coast of Africa, and in Europe, India, Japan, and Indochina. Annex I, shows the present distribution of the international telecommunications transmission resources worldwide. Note that the majority of the terminal stations for both communications satellites and submarine telephone cables are along the coastal areas.

Because of geographical and topographical differences, not all areas of the world are equally promising for potential application of the GTN's transmission systems. There are several reasons for this:

a. Because of the differences in climate, distance, terrain, level of economic development, etc., telecommunications transmission systems vary from one geographical area to another. For example, tropospheric scatter is an ideal method for communicating between Whoa Yai (Green Mountain), Thailand and Vung Tau, Vietnam, it cannot however, be used to communicate in a direct link between Thailand and Japan.[6] On the other hand, in some land areas the use of communications satellites could, because of the difficult terrain, turn out to be less expensive than microwave relays or cable systems.

b. The geographic pattern of demand dictates the requirements for locating the ETSs, and the computerized

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[6]Rienzi, Matthew. Vietnam Studies Communications-Electronics 1962-1970. Department of the Army, 1972, p. 30.

switches of the GTN. To be economic the volume of traffic in any area within the scope of a particular transmission system would have to be large enough to support the construction and operation of the necessary earth terminal stations and switches or the interconnecting terrestrial systems, even if it is assumed that the satellites or submarine cable systems are already in operation.

The routes of world communications of various kinds have not evolved haphazardly but are closely related to international trade and political relations.[7] Much of the present telecommunications traffic follows the general trade routes of international commerce. There are three principal routes (see Figure 18), first, is the North Atlantic; second, is the European-Far East route through the Suez Canal; third, is the Europe to South America leg.[8] Submarine cables (see Figure 8), now connects mainly those areas of the world which already had some form of communications, because of trade or political relations.[9] These three major trade routes are also the primary routes for intercontinental telecommunications, as such they form the architectural framework for the Global Telecommunications Network.

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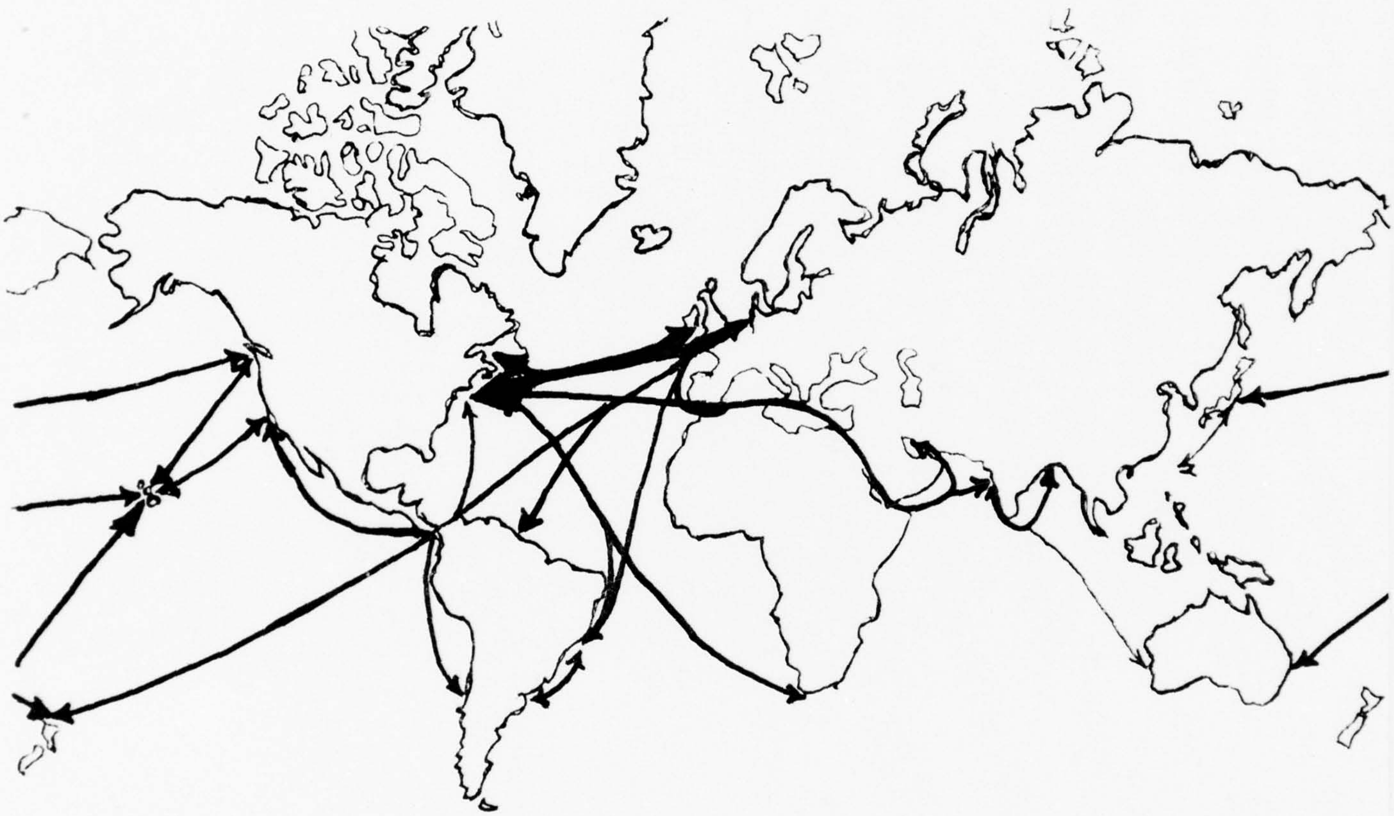
[7]Colin, Cherry. World Communications: Threat or Promise? (Bath, U.K.; Wiley-Interscience, 1971), p. 90.

[8]Ibid., p. 90 and 93 for a discussion of correlation between Ship and Airline traffic routes and message traffic routes.

[9]Ibid., p. 88 for a discussion of "Commonwealth Telephone Cable System"

Figure 18

The World's Main Shipping Lanes



Adopted from World Communications: Threat or Promise?
(Bath, U.K.; Wiley-Interscience)

DESIGN CALCULATIONS FOR A TYPICAL SATELLITE SYSTEM

The communications satellite transmission system will be the primary circuit path for the GTN, as such it must meet rigorous technical standards. This section presents the radio link design calculations which provide the basis for the determination of the transmission systems characteristics and further demonstrated the feasibility of the proposed Global Telecommunications Network. The equations and assumptions that are used are shown and the results are tabulated. These calculations are based on present knowledge which can be supported by, textbooks, technical papers, and various engineering references, and components that are presently available on a commercial basis.

a. Determination of required Carrier-to-Noise (C/N) - ETS transmitter to satellite receiver.[10]

Assume this is a frequency Modulated (FM) system using single sideband multiplex techniques for a 600 channel system. The signal-to-noise (S/N) in the worst channel is established as 47 db unweighted (Weighting factor is 3 db) which is comparable to the transcontinental system and is in accord with the CCIR recommendation.[11]

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[10] Formulae were adapted from the: Technical Appendix to Comments by the Microwave Section of the Electronic Industrial Association; to the House Committee on Science and Astronautics, contained in Communications Satellites, Part 2, 1961, p. 803.

[11] International Telephone and Telegraph. Reference Data for Radio Engineers. (New York; Howard W. Sams & Co., Inc., 1968), p. 2-1.

$$S/N = C/N + 20 \log \frac{\sqrt{2}\, D_c}{h_f} + 10 \log \frac{B}{2b}$$

$$C/N = S/N - 20 \log \frac{\sqrt{2}\, D_c}{h_f} - 10 \log \frac{B}{2b}$$

Where:

D_c = RMS channel deviation = 200 khz

h_f = To the highest frequency for 600 voice channels
= 2540 khz (6 mhz baseband for TV)

B = IF bandwidth (for 600 voice channels or TV)
= 16000 khz

b = channel bandwidth = 3 khz

$$C/N = 47 - 20 \log \frac{\sqrt{2} \times 200 \text{ khz}}{2540 \text{ khz}} = 10 \log \frac{1600 \text{ khz}}{2 \times 3 \text{ khz}}$$

C/N = 32 db

Determination of satellite receiver noise level[12]

Noise power of the receiver (P_N) = N_F + 10 log KTB

Where:

N_F = excess noise factor of the receiver = 8 db

K = Boltzmann's constant = 1.38×10^{-23}

T = Effective noise temperature = 290°K

B = IF bandwidth = 16 mhz

P_N = 8 db + 10 log $(1.38 \times 10^{-23} \times 290 \times 16 \times 10^{6})$

P_N = -124 dbw

Antenna Gain Determination[13]

G_T = Gains of transmitting antenna (a 60' diameter dish)

G_T = 59 db (at 6.5 kmhz)

G_T = 59 db (at 6.5 kmhz)

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[12] Formulae were adapted from the: Technical Appendix to Comments by the Microwave Section of the Electronic Industrial Association; to the House Committee on Science and Astronautics, contained in Communications Satellites, Part 2, 1961, p. 803.

[13] Ibid.

G_R = Gain of the satellite receiving antenna (the earth subtends an angle of 17° from the height of 22,300 miles)

G_R = 20 db (for 6.5 kmhz) to give a 17° beam angle.

Power Output from the ETS's Transmitter[14]

$P_T = A + C/N + L_C - G_R + P_N$

Where:

A = Space attenuation (at 22,300 miles)

A = 200 db at 6.5 kmhz

L_C= Miscellaneous coupling losses = 1.0 db

P_T= 200 + 32 - 1 - 59 - 20 - 124 = 30 dbw (at 6.5 kmhz)

P_T= 1.0 kw

b. Determination of required Carrier-to-noise (C/N) - Satellite transmitter to ETS receiver[15]

In the satellite to earth system a different technique will be used. This technique is known as wide deviation FM. Again the base band will be 6 mhz, to accommodate the TV.

$$C/N = S/N - 20 \log \frac{\sqrt{2}\, D_c}{h_f} - 10 \log \frac{B}{2b}$$

D_c = RMS channel deviation (peak deviation of 40 mhz)

= 2.0 mhz based on CCIR recommendations for Loading

h_f = 2.54 mhz

B = Receiver Bandwidth = 12 mhz (twice the baseband)

$$C/N = 47 - 20 \log \frac{\sqrt{2} \times 2 \text{ mhz}}{2.54 \text{ mhz}} = 10 \log \frac{12000 \text{ khz}}{2 \times 3 \text{ khz}}$$

C/N = 14 db (which will allow a fade margin of 4 db)

Determination of ETS Receiver Noise Level[16]

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[14] Ibid.

[15] Ibid.

[16] Ibid.

The Earth Terminal's receiver will have a Noise temperature of $30^{o}K$

$P/N = 10 \log KTB$

$P/N = 10 \log (1.38 \times 10^{-23} \times 30 \times 10 \times 10^{6})$

$P_N = -144$ dbw

Determination of Satellite transmitter Power Output[17]

$P_T = A + C/N + L_C - G_T - G_R + P_N$

$G_T = 20$ db (at 6.5 kmhz)

$G_R = 49$ db (at 6.5kmhz)

$P_T = 190 + 14 - 1 - 20 - 49 - 144$

$P_T = 8$ dbw

$P_T = 160$ milliwatts

c. Conclusions

The earth terminal station will use conventional techniques to transmit 600 voice channels or one TV channel to the Geo-stationary satellite receiver. The power required will be one (1) kilowatt into a 60-foot diameter dish. The satellite transmission system will use wide deviation techniques to transmit the 600 voice channels or the TV channel back to earth receiver. The satellite will have an output power of 160 milliwatts to be received on the earth station in a 60-foot diameter antenna.

EFFECTS ON NOISE AND INTERFERENCE ON DESIGN CONSIDERATIONS

Communications satellite systems are subject to the phenomena of Radio Frequency (RF) and noise interference,

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[17] Ibid.

effects that may degrade overall system quality. The major sources of interference and noise that may affect the satellite system are:

a. Radio frequency signals from the transmitting antenna of the earth terminal station interfering with other satellite and terrestrial systems.

b. Radio frequency signals from terrestrial radio communications systems interfering with the receiving antenna of the earth terminal.

c. Noise "that occurs when the sun passes directly behind the satellite. The sun, being of such a high noise temperature, is an extremely powerful noise source", that tends to blind the earth terminal's receiver to the satellite transmitter.[18]

d. Radio frequency signals from the satellite's transmitter interfering with receivers of terrestrial systems.

e. RF signals from terrestrial microwave telecommunications and other electromagnetic systems interferring with the satellite receiver.

The type interference identified in subparagraphs a, and b, above can be protected against by initial planning. Design plans should insure that Earth Terminal Stations are located

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[18] James Martin. Future Developments in Telecommunications. (Englewood Cliffs, J.J.; Prentice-Hall Inc., 1971) p. 240.

away from concentrations of terrestrial radio frequency emitters. Antenna design should insure that side lobes are nulled. Remedial actions will include as an option changing frequencies of either the satellite or terrestrial system. The sun noise phenomenon is not expected to cause grave problems in that it only occurs twice each year and then only lasts for about five minutes.[19] Figure 19 depicts these cases of interference, except for the Sun noise problem.

To discuss acceptable interference levels and criteria, the CCIR recommendations regarding frequency of accuracy and intensity of acceptable degradation of telephone channel performance should be used.[20] The design objectives for average overall system poise per channel is a normalized S/N ratio of 51 db psophmetrically weighted. This is equal to 48 db weighted over a 3 khz band. The CCIR recommends that this noise level not be exceeded more than 50 percent of the time.[21] The noise per circuit mile then can be computed as follows:

S/N (50% of the time per mile) = 48 + 10 log 16000 = 80 db[22] For a typical microwave system, the acceptable

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[19] Ibid.

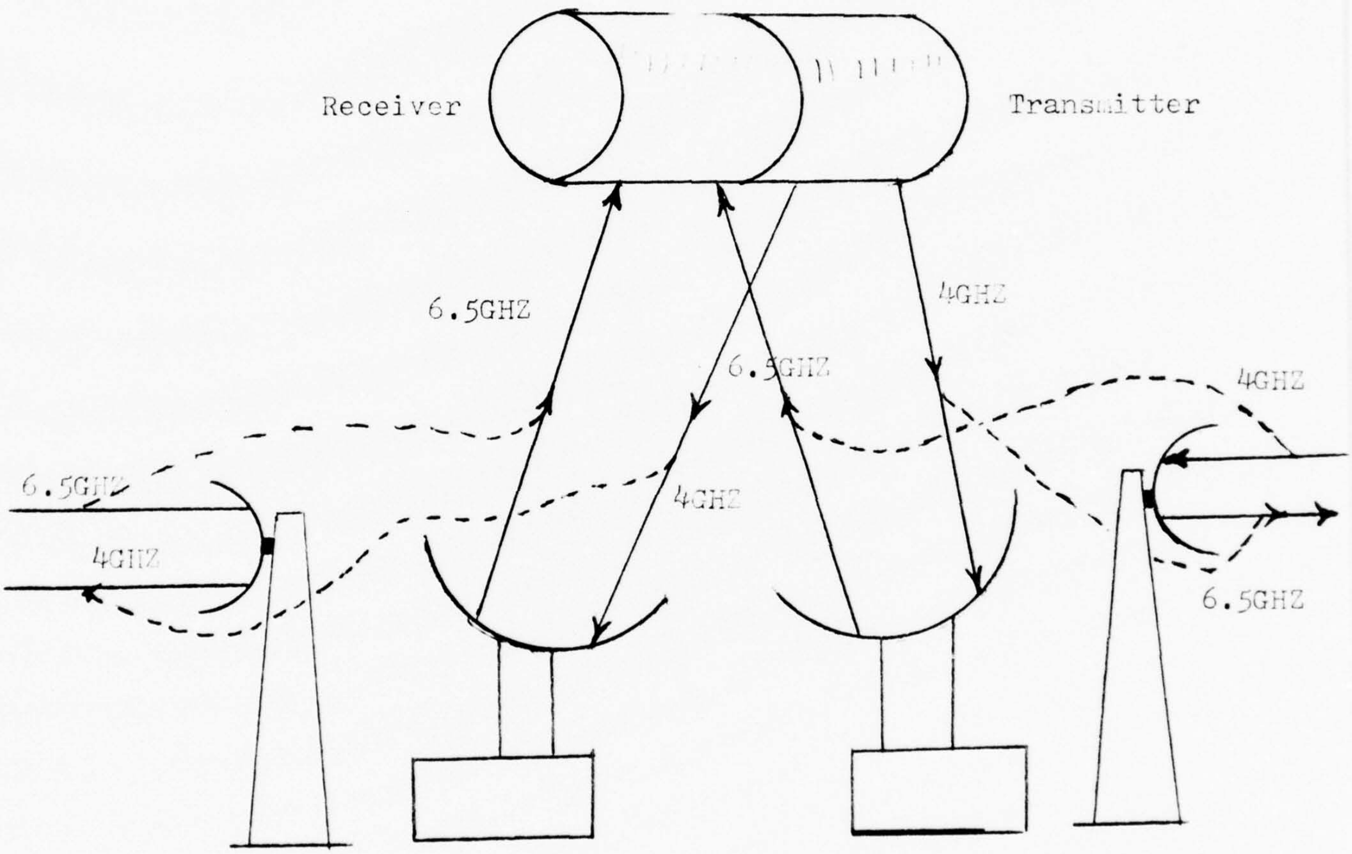
[20] International Telephone and Telegraph. Reference Data for Radio Engineers. (New York: Howard W. Sams & Co., 1968) pp. 2-9. For a discussion of the criteria for noise and interference in hypothetical circuits.

[21] Ibid

[22] Formulae were adapted from the: Technical Appendix to Comments by the Microwave Section of the Electronics Industrial Association; to the House Committee on Science and Astronautics, contained in Communications Satellites Part 2, 1961, page 815.

Figure 19

Possible Interference Between Satellite & Terrestrial Systems



Source: Future Developments in Telecommunications. (Englewood Cliffs, N.J.; Prentice-Hall Inc., 1971)

S/N is:

$$S/N = 80 - 10 \log 25 = 66 \text{ db per system hop}$$ [23]

If the thermal noise and intermodulation contributions are equal, then each contribute half this value. Thermal noise is then:

$$S/N = 66 + 3 = 69 \text{ db per hop}$$ [24]

Where: N_t = thermal noise in a telephone channel.

The television noise recommendations are shown in the CCIR, recommendations in "Reference Data For Radio Engineers".[25] The 20% noise level here is taken as the design level and the allowance of .64% of the time, considering other uncorrelated interference, becomes

55 - 47 = 8 db above the design level. In television, the whole interference power can be considered to fall into the baseband for carrier separations close to the maximum television frequency the ratio of interference power to thermal noise power is essentially the same as the ratio of interference power to Equivalent Noise Input (ENI).[26] This means that using ENI as an interference criteria (.01% of the time) will provide

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[23] Ibid.

[24] Ibid, p. 816.

[25] International Telephone and Telegraph. Reference Data for Radio Engineers. (New York; Howard W. Sams & Co., Inc., 1968), pp. 2-5.

[26] Ibid., pp. 28-29; For a discussion of International Recommendations and Standards for Sound and Television Broadcasting.

an 8 db lower interference level than the CCIR recommended level. The derived technical design parameters for the system are contained in Annex II.

SPACE SEGMENT OF THE TRANSMISSION SYSTEM

The space segment of the transmission system will consist of a geo-stationary satellite orbiting at 23,300 miles. The satellite will contain 24 transponders, each of which can handle up to 600 telephone circuits or one television signal. The satellite receiving system will give a 20 db gain to the received signal. The satellite transponders utilizes a 160 milliwatt transmitter operating at microwave frequencies. The use of multiple transponders in the satellite provides a substantial amount of redundancy, so that if one transponder should fail the entire capacity of the satellite will not be lost.

EARTH TERMINAL STATIONS

There is no hardware development required for the earth terminal station portion of the communications satellite transmission system. For the most part these stations are already emplaced or are commercially available. Associated with the satellite transmission system are two basic types of ground stations. The first type is the larger one and will serve as the traffic relay between points not having direct access to the transmission medium. The smaller station is anticipated to be used to serve the needs of remote regions and areas of the world. The number of channels which any of the earth stations are designed to handle will depend on the traffic density at that particular station. The network provides that each terminal that serves as a primary transmission path will provide at least 600 channels.

SUBMARINE CABLE SEGMENT

The submarine cable segment used as part of the GTN will normally be of the long-haul type and provide at least 300 telephone channels spaced at 3khz intervals.[27] The techniques of Time Assignment Speech Interpolation (TASI) will be employed to increase the availability of channels to the users of the submarine cable systems. "TASI is a high speed switching system whereby the person using the circuit seizes it only when they began to talk. Such an arrangement approximately doubles the circuit capacity of the submarine cable."[28]

COST CONSIDERATIONS IN ESTABLISHING THE GLOBAL TELECOMMUNICATIONS NETWORK

In this section the economic potential of the global telecommunications network is assessed in terms of cost comparisons with the present norms of intercontinental telephone transmission systems. Namely, the presently separate satellite and cable systems. A GTN of the type proposed

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[27] *Ibid.*, pp. 20-35. See for a discussion of TASI and Multiplex Equipment.

[28] *Ibid.*

should greatly increase the number of international telephone channels available at any one time, therefore, the cost per channel should decrease.

The basis of comparison is cost per channel per year. The principal equations used for these comparisons are:

a. Satellite cost per Channel.[29]

$$(1)\quad V_c = \frac{D_c + T_c + O_c K + \frac{N_o}{P}\left(S_c + \frac{L_c}{N_s}\right)\left(1 + \frac{KK}{M}\right)}{CK}$$

Where:

V_c = Cost per voice channel per year

D_c = Development Cost

T_c = Total system investment in terminals

O_c = Annual terminal operating cost

N_o = Number of satellites in orbit

Pr = Probability of successful launch

S_c = Cost of satellite

L_c = Launch cost per launch

N_s = Number of satellites launched with a single vehicle

M = Mean time to failure in orbit

C = Capacity of the system in voice channels

K = Discount factor -- Present value of $1.00 per year for 15 years at 8% interest

The numerator is simply the total cost of the communications satellite system over its life time of 15 years.

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[29] William H. Meckling. Communications Satellite. (Santa Monica, Calif; Rand Corporation, 1961), p. 2.

b. The equation for calculating cost per voice channel for Submarine cable system.[30]

$$(2)\quad V_{cm} = \frac{C_c K + T_c - S_t K'' = A_c - S_a K''}{NCK} + \frac{I - S_i K''}{CK}$$

Where:

V_{cm} = Cost per voice channel per mile per year

O_c = Annual operation cost

T_c = Terminal investment cost

S_t = Salvage value of terminals

A_c = TASI investment cost

S_a = Salvage value of TASI

I = Investment cost per mile of submarine cable

S_i = Salvage value per mile of cable

K'' = Present value of $1.00 fifteen years hence at 8% interest

Capacity of a cable in voice channels

N = Length of the given system in miles

K = Present value of $1.00 per year for 15 years at 8% interest

Cable is expected to have a 20 year life. Therefore to equate cost with satellite systems the cable had to be assigned a salvage value. The salvage value of the cable at the end of 15 years was estimated to be one fourth of the initial investment cost.

c. The results of equations one and two are used directly in the equation to determine the cost per voice

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[30] *Ibid.*, p. 16.

implementation of the GTN. This equation is based on the previous equations with the exception that in order to show the effect of the computerized switches on channel availability, a new factor has been put in the denominator.

$$(3) \quad V_{cgn} = \frac{N_{dc} + N_{oc} K + N_{ec} + V_{cm} + V_c \quad 1 + \frac{K}{M}}{S_f \; S_{ca} + C_{ca} \; K''}$$

Where:

V_{cgn} = Cost per voice channel per year through the GTN

N_{dc} = Network development cost

N_{oc} = Network operating cost

N_{ec} = Network equipment cost

V_{cm} = Cost per voice channel for a submarine cable system

V_c = Cost per voice channel via satellites.

S_f = The factor by which the computerized switch will increase the availability of the voice channels in the systems connected to the network.
= 1.6

S_{ca} = availability of channels on the satellite system

C_{ca} = Voice channels capacity of the submarine cable systems connected to the Switch.

K'' = A constant used to compute costs for systems initially having unused capacity, utilization rate rises for the life of the system.

M = Discount factor--present value of $1.00 per year for 15 years at 8% interest.

Variables to be used in this equation shown in Table IV-2. The cost of a 2,500 mile voice telephone circuit is presently about $24,000 per year. This is compared with the cost of a voice circuit over a satellite at about $20,000

TABLE IV-2

VALUES FOR VARIABLES IN EQUATION #(3)

(Dollars in Millions)

VARIABLES	VALUES
N_{dc}	\$75.0
N_{oc}	\$19.0
N_{ec}	\$52.0
V_{cm}	\$ .024
V_c	\$ .020
K	83
M	5
S_f	1.6
S_{ca}	4,800
C_{ca}	176
K"	3.76

Source: Adapted from Rand Report, RM-2778-NASA, William H. Meckling.

per year.[31] Using the variables provided it is easy to see that the Global Telecommunications Network will offer a substantial reduction in the cost of international telecommunications.

[31] Burton H. Klein, et al. Communications Satellites and Public Policy: An Introductory Report. (Santa Monica, Calif; Rand Corporation, 1961), p. 38.

CHAPTER V

EVALUATION, CONCLUSIONS AND RECOMMENDATIONS

INTRODUCTION

This chapter will briefly summarize and evaluate the material discussed and analyzed in Chapters II, III, and IV. While no new material will be introduced, significant aspects of the material already covered will be explored to isolate data and information on which to base conclusions. Those recommendations warranted by the evaluation, relative to the hypothesis put forth in Chapter I, will be proposed for implementation.

EVALUATION

We have discussed and shown that by its very nature global telecommunications networks require increased communications contact and interdependence among the nations of the world. We have seen the uneven growth in telecommunications (e.g., Africa, Asia, and South America), among the various areas of the world. The amazing growth of global telecommunications and advances in technology promises the world the benefits of continued reductions in telecommunications cost, while at the same time increasing the quality and reliability of service. The increasing availability and decreasing cost of intercontinental telecommunications circuits make the establishment of the GTN a relatively simple engineering task, but one that will require major investments of money in earth stations, computerized switches and in terrestrial telecommunications systems in the less developed areas of the world. Satellite communications systems are preferred over submarine cable systems as a primary transmission means for the GTN because of the cost differential (which was discussed in Chapter IV) favors satellites. Submarine cable systems, however, will still be an integral part of the global telecommunications system, and will serve GLOWATS as a back up system, and to allow those nations of the world not having satellite terminals access to the GTN, via the computerized switches.

In 1963 as a result of the "Cuban Missile Crisis" and the very real prospect of an armed confrontation, Moscow and Washington agreed to establish the DCL as a War Avoidance Telecommunications System. As global telecommunications technology has evolved so has the DCL. The system currently use communications satellites as primary paths, relying on submarine cable as a back up transmission system. In transferring to the satellite systems the security and redundancy of the DCL was substantially improved.

Since the time of its installation the system has been used on 15 different occasions. Prior to the installation of the DCL a state of "Cold War" existed between the United States and the Soviet Union. That relationship has now evolved through stages of increasing amity and cooperation to the point where increased intercultural communications among the people of these two countries are taking place.

Although this is a model system for war avoidance this study must conclude that it could be more economical, if it was a subsystem of a larger communications network world wide. The technological advancements in telecommunications have yet to be used in a general system for war avoidance, that all nations of the world may have access to. As a subsystem of the GTN, the GLOWATS will get a free ride, in terms of cost.

CONCLUSIONS

The rising demand for international and intercontinental communications, will support the establishment of a Global Telecommunications Network. Once established the circuit capacities offered by the network makes it economically attractive to use that system for a general war avoidance system that is available to all nations of the world. The present systems of international and intercontinental telecommunications offer an excellent base from which to transition to the Global Telecommunications Network.

RECOMMENDATIONS

It is recommended that the Global Telecommunications Network (GTN), be established, utilizing the present facilities of the worldwide telecommunications system, augmented where necessary by computerized switches and earth terminal stations in the satellite communications system.

It is recommended that GLOWATS be established as a subsystem of the GTN.

It is recommended that the International Telecommunications Union (ITU), be charged with the responsibility for the engineering, control and management of the GLN as an executive of the United Nations.

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ANNEX I

Countries of the World with Global Telecommunications Facilities

Appendix 1 Map of Europe

2 Map of Africa

3 Map of Middle East

4 Map of South Asia

5 Map of Far East

6 Map of U.S.A.

7 Map of Central and South America

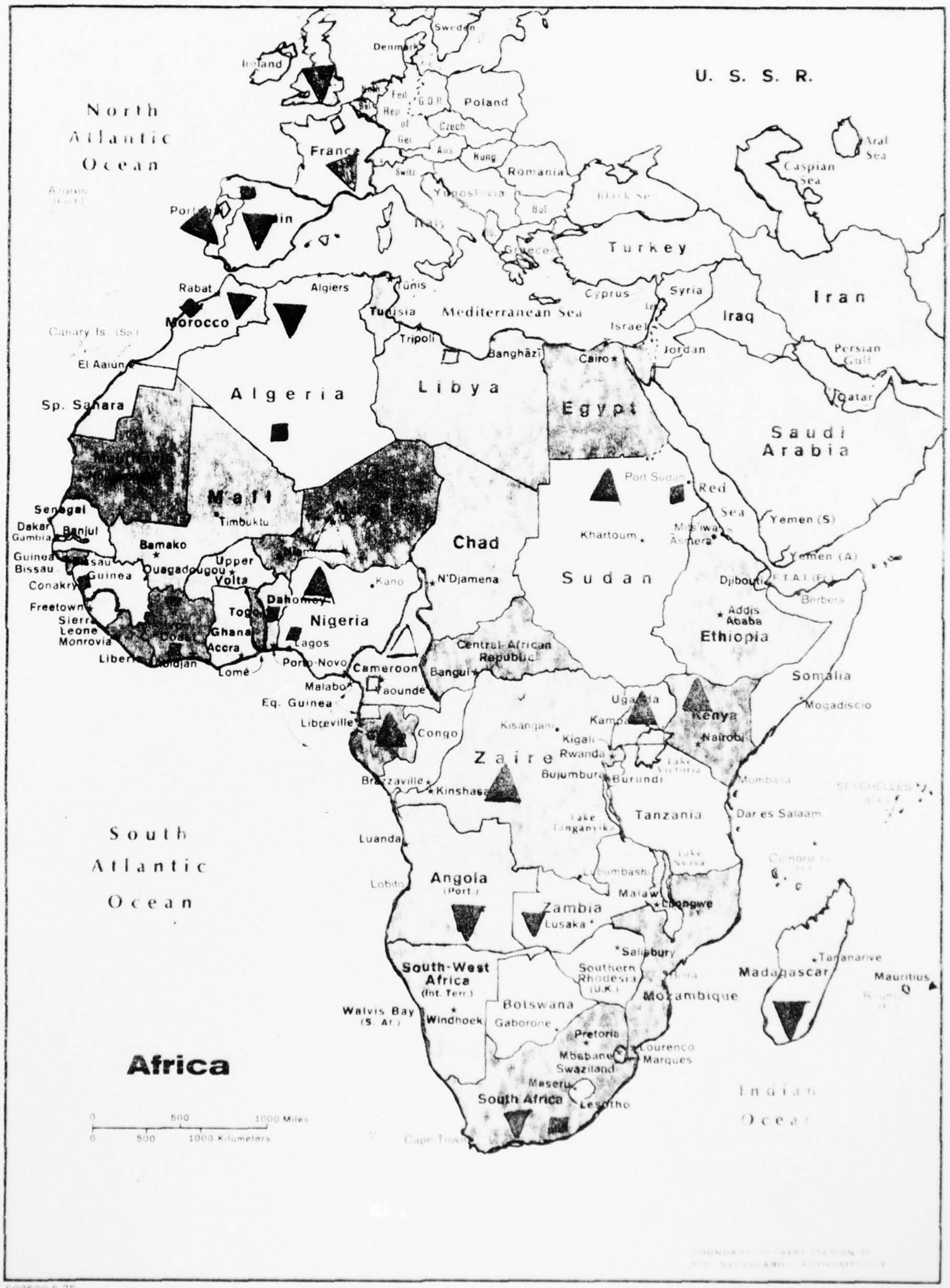
Legend:
On each map the symbols

▲ = Satellite Earth Terminal Station Facilities or Facility

■ = Submarine Cable Communications Facility

Source: Adapted from Strategic Studies Handbook Regional and Area Maps, Command and General Staff College, Fort Leavenworth, Kansas, August 1975.

APPENDIX 1 to ANNEX I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South Atlantic Ocean
Indian Ocean
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Ireland
Denmark
Sweden
Poland
France
Portugal
Spain
Romania
Yugoslavia
Bul
Turkey
Caspian Sea
Aral Sea
Iran
Iraq
Syria
Cyprus
Mediterranean Sea
Israel
Jordan
Persian Gulf
Qatar
Saudi Arabia
Rabat
Algiers
Tunis
Tunisia
Morocco
Canary Is. (Sp.)
El Aaiun
Tripoli
Banghazi
Cairo
Libya
Egypt
Algeria
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Mali
Timbuktu
Senegal
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Banjul
Gambia
Guinea Bissau
Bissau
Guinea
Conakry
Freetown
Sierra Leone
Monrovia
Liberia
Abidjan
Bamako
Ouagadougou
Upper Volta
Togo
Ghana
Accra
Lomé
Dahomey
Porto-Novo
Lagos
Nigeria
Kano
N'Djamena
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Sudan
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Port Sudan
Red Sea
Asmera
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Yemen (A)
Djibouti
Addis Ababa
Ethiopia
Somalia
Mogadiscio
Cameroon
Yaounde
Malabo
Eq. Guinea
Libreville
Congo
Brazzaville
Kinshasa
Central African Republic
Bangui
Zaire
Kisangani
Kigali
Rwanda
Bujumbura
Burundi
Uganda
Kenya
Nairobi
Tanzania
Dar es Salaam
Luanda
Lobito
Angola (Port.)
Zambia
Lusaka
Lubumbashi
Malawi
Lilongwe
Salisbury
Southern Rhodesia (U.K.)
Mozambique
Madagascar
Tananarive
Mauritius
South-West Africa (Int. Terr.)
Windhoek
Walvis Bay (S. Af.)
Botswana
Gaborone
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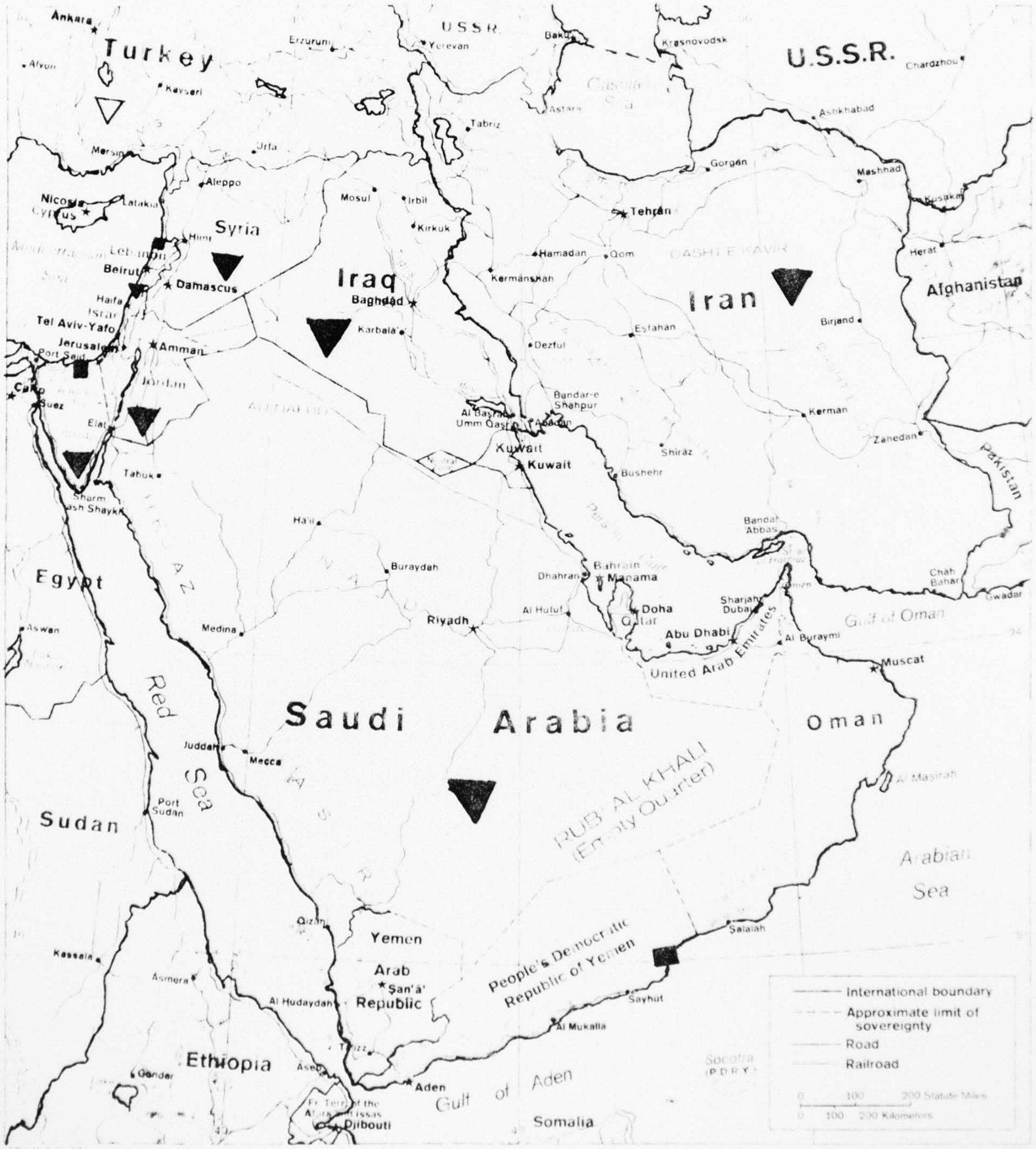
APPENDIX 3 to ANNEX T



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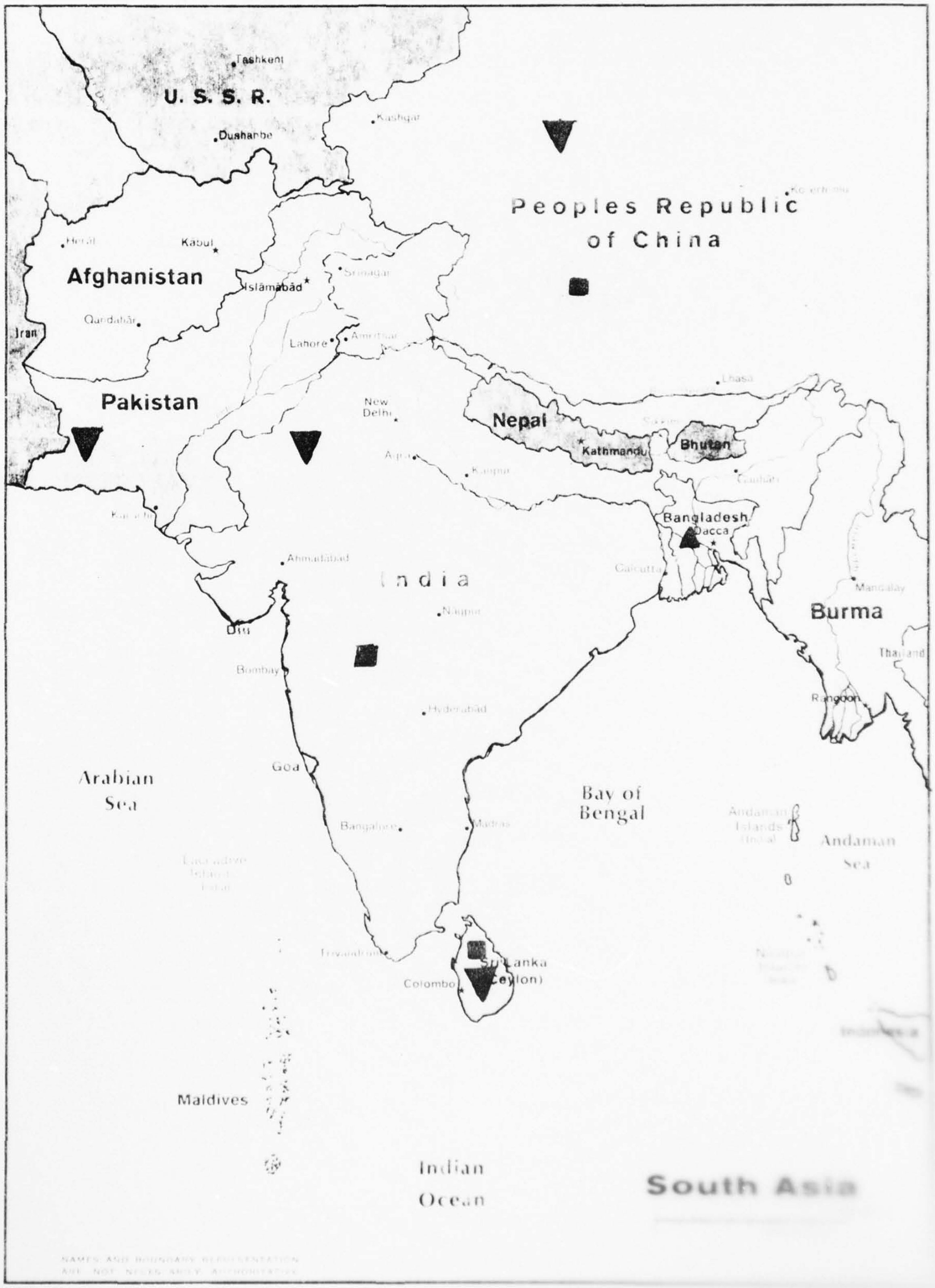

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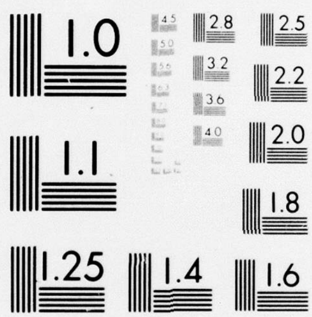
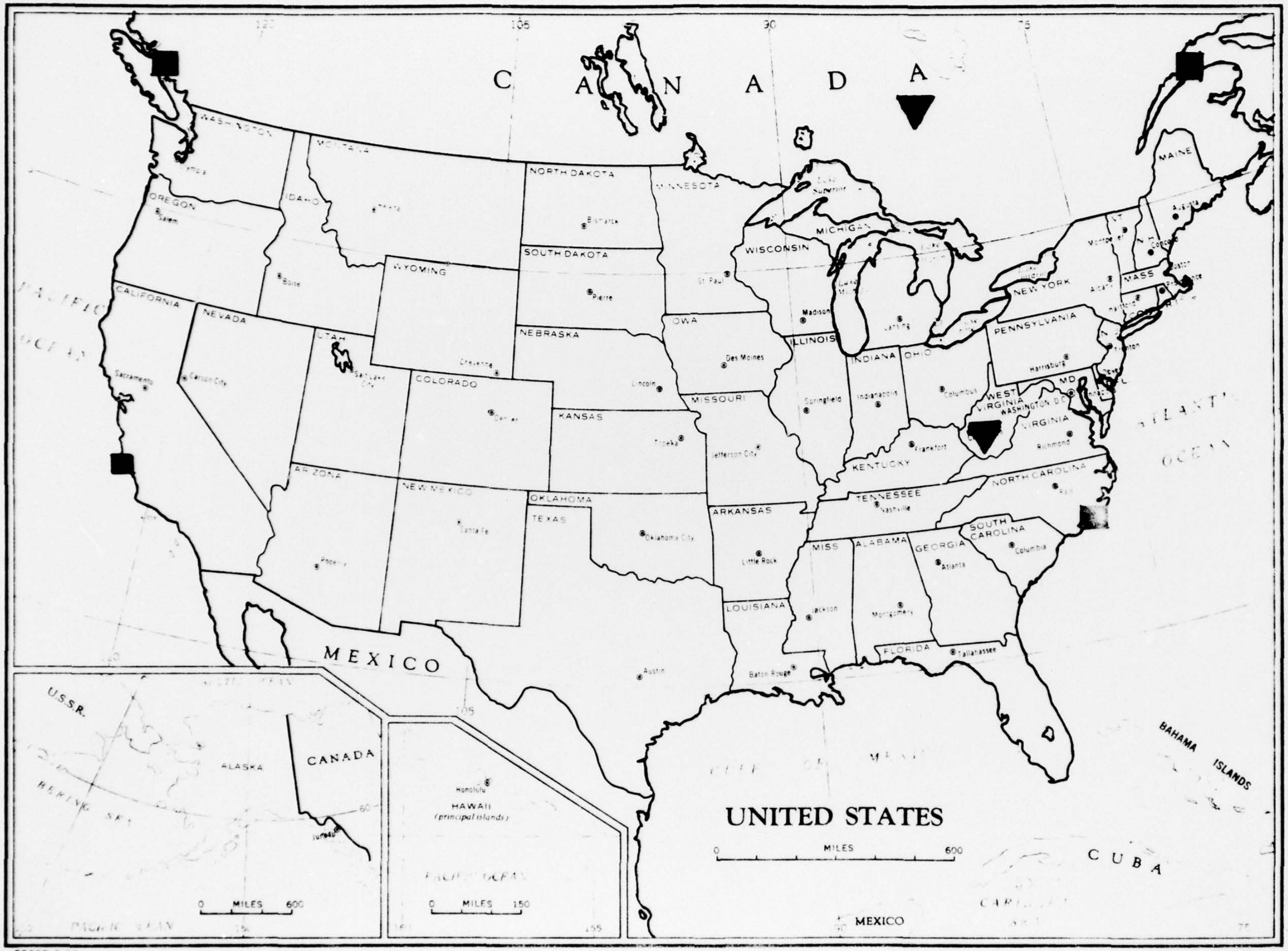


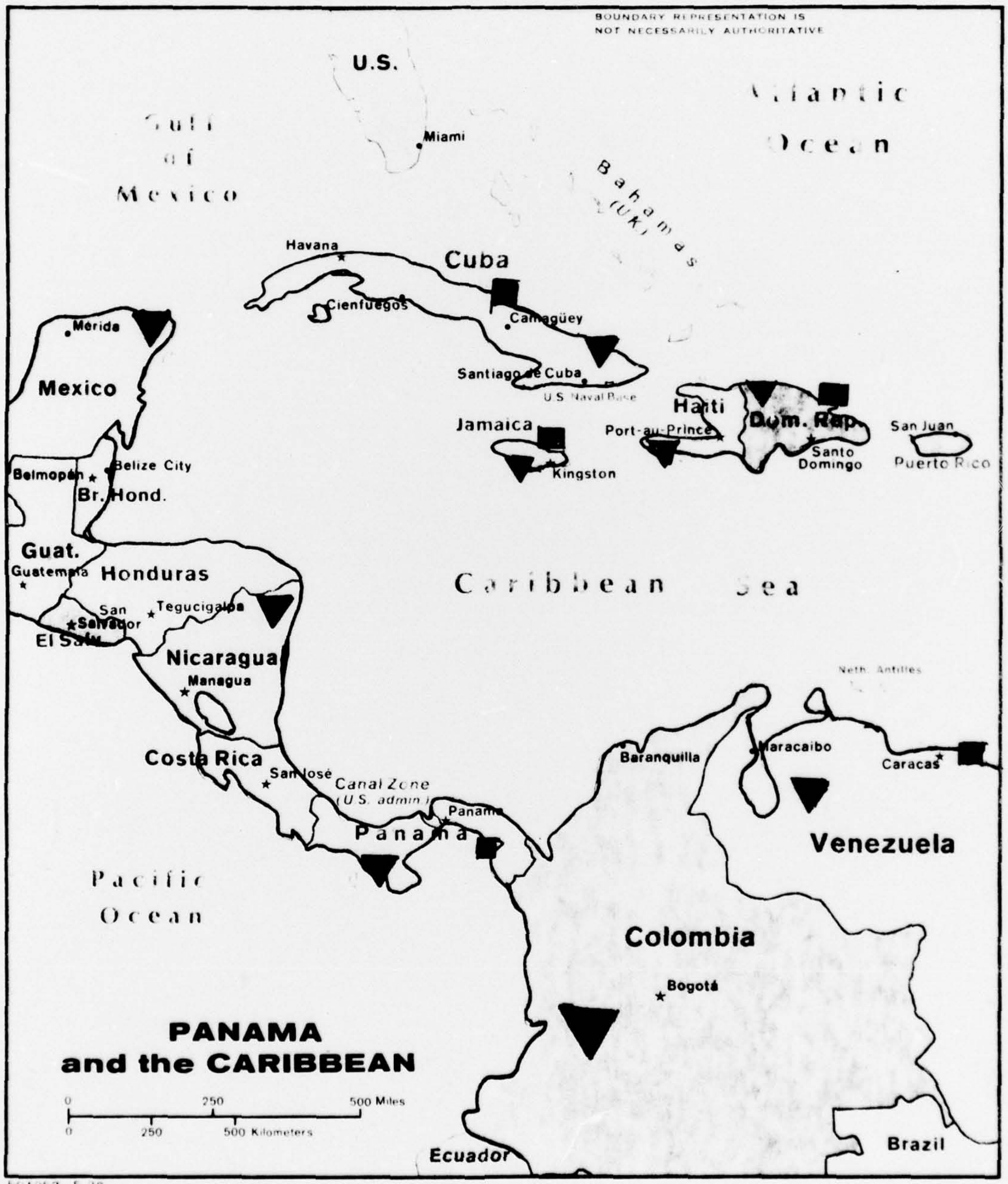
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

APPENDIX 5 TO ANNEX I


CANADA
WASHINGTON
MONTANA
NORTH DAKOTA
MINNESOTA
OREGON
IDAHO
WISCONSIN
MICHIGAN
MAINE
SOUTH DAKOTA
WYOMING
NEW YORK
MASS
CALIFORNIA
NEVADA
IOWA
PENNSYLVANIA
NEBRASKA
UTAH
ILLINOIS
INDIANA
OHIO
COLORADO
MISSOURI
WEST VIRGINIA
MD
WASHINGTON D.C.
VIRGINIA
KANSAS
KENTUCKY
ARIZONA
NEW MEXICO
OKLAHOMA
TENNESSEE
NORTH CAROLINA
TEXAS
ARKANSAS
SOUTH CAROLINA
MISS
ALABAMA
GEORGIA
LOUISIANA
FLORIDA
MEXICO
BAHAMA ISLANDS
UNITED STATES
MILES
0
600
CUBA
U.S.S.R.
ALASKA
CANADA
HAWAII
(principal islands)
MILES
150
MEXICO

55308 3-67

APPENDIX 7 to ANNEX I



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