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INTERIM REPORT

MODERN SOVIET CIVIL TELECOMMUNICATIONS

CONTRACT NO. 9-L65-Z5910-1

18 FEBRUARY 1986

PREPARED FOR:
TECHNOLOGY TRANSFER INTELLIGENCE COMMITTEE

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LIST OF ABBREVIATIONS

ARQ	Automatic Repeat Request
ASVT	Modular System of Computers
AT	Subscriber Telegraph Network
BEF	band elimination filter
CASTAR	Center for the Assessment of Soviet Technology Acquisition Requirements
CCITT	Consultive Committee of International Telephone and Telegraph
CEMA	Council for Economic Mutual Assistance
CMOS	Complementary Metal Oxide Semiconductor
COMSAT	communications satellite
CPU	central processing unit
C^3	command, control, and communications
ECMA	European Organization of Machinery Producers
EhS	ehlektronika-svyaz system
FDM	frequency division multiplexing
FDMA	frequency division multiple access
GDR	German Democratic Republic
IC	integrated circuit
I/O	input/output
IOC	initial operating capability
IREE	Institute of Radio and Electronic Engineering
ISDN	Integrated Services Digital Network
LOS	line-of-sight
MEP	Ministry of the Electronics Industry
MINPRIBOR	Ministry of Instrument Construction, Means of Automation, and Control Systems
MOC	Ministry of Communications
MRP	Ministry of the Radio Industry
OAKTS	Nationwide Automatically Switched Telephone Network
OGAS	Nationwide Computerized System for Gathering and Processing Information
OP	Public Network
PCM	pulse code modulation
PIN	positive intrinsic negative
PWBC	primary wideband channel
R&D	research and development
SATCOM	satellite communications
SCPC	single channel per carrier
SMA	network microprocessor adapter
SMV	network access method
S/N	signal-to-noise
TDM	time division multiplexing
TDMA	time division multiple access

LIST OF ABBREVIATIONS (Concluded)

TDRSS	Tracking and Data Relay Satellite System
TsNIIS	Central Scientific Research Institute for Communications
URS	unattended repeater station
WARC	World Atmospheric Radio Conference
YeASS	Primary Network of the Unified Automated Communications Network

Units of Measure

Hz	hertz
MHz	megahertz
kHz	kilohertz
Mbps	megabits per second
MOPS	million operations per second
m	meters
kbps	kilobits per second
km	kilometers
mm	millimeters
dB/km	decibels per kilometer
μm	micrometers
GHz	gigahertz
kg	kilograms
kV/m	kilovolts per meter
dB	decibels
kW	kilowatts
min	minutes
°/deg	degrees
W	watts
Gbps	gigabits per second
bps	bits per second
hr	hours
%	percent
kbd	kilobaud
er/ln	erlangs per line

1. KEY JUDGEMENTS

This survey of modern civil telecommunications within the USSR was performed as one input to the Center for the Assessment of Soviet Technology Acquisition Requirements (CASTAR) project. "Telecommunications" was defined in its broadest sense as including telephony, telegraphy, and data transmission. The following conclusions are derived almost entirely from analysis of open Soviet technical literature.

1.1 TRANSMISSION SYSTEMS

Since January 1978, all telecommunications nodes, exchanges, and transmission systems within the Soviet Union have been defined to comprise the Primary Network of the Unified Automated Communications Network (YeASS). Uniform definitions and standards generally parallelling those of the Consultive Committee of International Telephone and Telegraphs (CCITT) have been adopted for this network. This primary network provides the foundation for development of various secondary networks which are usually designated by the type of information they carry (e.g., telephone, telegraph, data transmission networks). The Soviets acknowledge that this distinction they draw between primary and secondary networks of the YeASS has no Western counterpart.

Transmission media employed by the Soviets for civil telecommunications include metallic and fiber-optic cable, line-of-sight (LOS) radio relay, troposcatter radio, and communications satellites. Although most of these same media are also employed in the United States, there are important quantitative and qualitative asymmetries between civil telecommunications transmission systems of the two countries as outlined below.

1. The capacity of the U.S. telecommunications network (rated in channel kilometers) is more than five times greater.

2. A vast majority (almost 95%) of the U.S. network is composed of radio relay systems, with the balance divided between communications satellites and cable (coaxial and fiber optic). In contrast, landline cable, about three-fourths of it symmetrical twisted-pair types which had largely disappeared from U.S. long distance service by 1970, is the most prolific Soviet medium. About 20% of total capacity in the USSR is carried over radio relay systems, with troposcatter radio, communications satellites (COMSATs), and even open-wire lines also making significant contributions.
3. Soviet communication satellites as compared to their Western counterparts have comparatively short lives, fewer transponders, and have been slow to move to higher frequencies.

While the civil telecommunications system of the USSR is not as extensive as in the U.S. and much of it is obsolescent by our standards, its greater media diversity and emphasis on buried cable systems makes it potentially more survivable both in natural disasters and strategic war. There is evidence that civil telecommunications transmission trends within the U.S. and USSR will converge over the next decade* with both emphasizing establishment of fiber-optic cable networks and expanding the use of domestic COMSATs. In addition, both countries are preparing (slowly) for ultimate transition to the worldwide goal of an Integrated Services Digital Network (ISDN) by gradually replacing analog transmission media with digital systems.

1.2 THE TELEPHONE SYSTEM

The Nationwide Automatically Switched Telephone Network (OAKTS) is the largest secondary network of the YeASS. Compared to the public telephone network of the U.S., several significant differences can be noted.

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*To some extent, the U.S. and USSR are following parallel trends for different reasons. The Soviets are attracted to fiber optics because it offers a high degree of transmission security and conserves scarce copper and lead which would otherwise go into coaxial cable manufacture.

1. The subscriber population is much smaller, with Soviet telephones located in state-run establishments (Government bureaus, state industries, collective farms). As a result, the number of exchanges required to service these customers is only about one-fourth as great as in the U.S.

2. A much greater proportion of Soviet exchanges employ manual switchboards. If the 11th 5-year plan goal is achieved, the USSR telephone network will be only 55% automated in 1985, while in the U.S. manual exchanges are extremely rare today, even in remote areas. As recently as 1982, a priority goal of the Soviet Ministry of Communications (MOC) was to increase productivity of telephone operators, a concession that the present situation is likely to continue.

3. Although islands of relatively good service exist, predominently in the European part of the USSR, the quality of much of the existing automated telephone service is far below what would be considered acceptable in most parts of the U.S.

The Soviets recognize deficiencies of their telephone network and have an ambitious program to improve it by 1995. A key portion of this plan is upgrading the switching plant, much of which is comprised of obsolescent and incompatible, step-by-step relay exchanges. Three simultaneous approaches are being followed to obtain the necessary state-of-the-art equipment. These have succeeded in reducing the U.S. lead in the introduction of new forms of switching technology into telephone networks from 20 years with second-generation (crossbar) equipment to only 7 years with fourth-generation electronic exchanges.

1. Outright purchase of third-generation equipment (which the Soviets term "quasi-electronic") from Yugoslavia and other countries.

2. Joint development with their European Council for Economic Mutual Assistance (CEMA) partners, particularly the German Democratic Republic (GDR), of third-generation exchange equipment. The "Kvarts" quasi-electronic switching system resulting from this cooperation was first installed in Leningrad in the late 1970s and will be the basic type of long distance exchange during the 12th 5-year plan (1986 to 1990).

3. A joint Soviet-French "Working Group on Scientific and Technical Cooperation in Communications" which has been in existence since 1975. This high-level body probably facilitated the Soviet purchase of fourth-generation telephone exchanges from Thomsom CSF along with a factory for their manufacture.

1.3 THE TELEGRAPH NETWORK

Within the Soviet Union telegraph service is provided by two domestic networks, a public network which operates between offices run by the MOC and a subscriber network which functions similarly to TELEX in the West. In addition, limited access is afforded to two international telegraph networks: GENTEX, which serves mostly Eastern Europe, and TELEX, an international network with hundreds of thousands of subscribers mostly in Western Europe and the U.S.

The public telegraph system in the USSR is a relatively more important communications medium than its Western counterparts. In part this is due to less widespread availability of telephones, but also because it carries much of the Government and Military traffic often routed over separate networks in other countries.* As a result, modernization of the Soviet telegraph network has not lagged that of other developed countries so much as is the case with the OAKTS. A program to upgrade message switching centers with equipment based on unified system (Ryad) computers began in 1979 and is progressing rapidly. There are also longer range plans to replace electromechanical switching centers of the subscriber network with electronic exchanges.

1.4 DATA TRANSMISSION NETWORKS

In an economy where the necessity for, and efficiency of, centralized management is an article of political faith, the concept of

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*A comparatively few networks, such as the PAGODA network of the national hydrometeorological service, exist outside the national telegraph framework. However, these primarily function as specialized data transmission systems.

a nationwide computer network to improve economic planning and day-to-day management is extremely attractive. The Soviets have a longstanding plan for establishing such a network which they have named the Nationwide Computerized System for Gathering and Processing Information (OGAS). However, until recently both their computer technology and telecommunications resources were grossly inadequate for the task. Consequently, OGAS has not progressed very fast, with only Moscow, Kiev, and Riga netted by 1982, and network completion has been delayed until (at least) the year 2000.

Although the OAKTS and subscriber telegraph networks are widely used to support the teleprocessing applications operational today, their error rates are so high when transmitting digital data it was decided to build a national data transmission network from the ground up. This was originally intended to have two main parts:

1. A circuit-switched network, to be built in three phases. Phase one, known as the PD-200 network, has been under construction since 1979, but major problems in getting it operational will probably delay completion beyond the originally projected date of 1985.
2. A message-switched network, originally projected to be an upgraded version of the national public telegraph network. It appears increasingly probable that, when finally built, this network will instead incorporate packet-switching technology.

In conjunction with their CEMA partners, the Soviets have developed an extensive family of teleprocessing equipment to complement the unified series (Ryad) computers, which are based on IBM S/360 and S/370 technology. In addition, the SM-EhVM series of process control computers based on Hewlett-Packard and PDP-11 designs, has proven easy to adapt to communications handling roles within computer networks. In several cities computer networks, like the Latvian Academy of Science operation in Riga, are quite large and have served as valuable test-beds for packet-switching technology.

It is quite likely that the USSR will possess a nationwide packet-switching network before the year 2000 (about 10 to 15 years behind comparable Western developments) and, thus, bring OGAS closer to realization. Such a network is likely to:

1. Adhere to ISO and CCITT standards (including the X.25 protocol),
2. Use SM EhVM (SM-3, 4, etc.) computers as communication handlers,
3. Incorporate a network architecture similar to the IBM SNA, and
4. Employ adaptive rather than fixed routing methods.

2. INTRODUCTION

2.1 PURPOSE

This summary report on Soviet civil telecommunications was prepared as a partial input to tasks 2 and 3 of the CASTAR project. "Telecommunications" is used here in its broadest sense to include not only telephony, but also telegrapy and data transmission.

Objectives of the CASTAR project include assessment of the current Soviet state of the art in fiber optics and digital switching and projecting it through the year 2000. Equipment currently in use for civil telecommunications defines the lower limit of the USSR state of the art, while the upper limit corresponds to what is being demonstrated in research and development (R&D) laboratories. This report deals with some of both, but with emphasis on the former. Some Red-Blue comparison has been included for perspective and to increase the general utility of the document.

2.2 METHODOLOGY

This report is mainly based on Soviet open literature, with gaps filled in from unclassified U.S. publications where necessary. Available Soviet translations fall generally into three categories: textbooks, patent descriptions, and technical magazine articles.

Textbooks offer the most comprehensive treatment of any particular subject, but usually do not contain truly up-to-date information. Soviet publications must undergo a variety of reviews much more time-consuming than that given to books published in the United States. Once published, additional time (often years) elapses before the books are translated into English. As a rule of thumb, the information in Soviet textbooks appears to be about two years older than its publication date, and at least another year will probably elapse before the translated work is available to U.S. researchers.

Patents (or author's certificates as they are referred to in the USSR) have been disappointing as sources of information about communications technology. They are typically dull reading, concentrating on proving the uniqueness of claims, and are rarely illustrated with more than a single sketchy block diagram. Most important, they furnish no clue as to whether the invention remains a laboratory curiosity or has been selected for series production.

The most valuable single information source has been Soviet technical journals. Prepublication reviews do not appear to be as lengthy as for books, and the authors are usually writing about topics of high current technical interest as opposed to history. The most useful journals are Ehlektrosvyaz' (Telecommunications) and Vestnik svyazi (Herald of Communications), but for computer-related topics including packet switching Avtomatika i vychislitel'naya tekhnika (Automation and Computer Technology) is also of high value. For journals relevant to fiber-optics developments see Subsection 3.3.

Since all Soviet open-source materials have been approved for publication only after passing KGB security review, some discretion is required in evaluating their contents. Deliberate misinformation would be potentially dangerous if planted in textbooks and technical literature, but there are more subtle ways in which a reader can be misled. There is a disturbing lack of distinction by many Soviet authors as to whether they are writing about Soviet or Western technology. Sometimes it is possible to tell by referring to the list of technical references, but not always. Soviet authors have written so extensively about Western developments that instances are encountered where survey articles of Western technology quote only Russian publications.

One rule almost universally followed in Soviet writings is to give no credit to the West for anything currently in use within the Soviet economy. It is apparently acceptable to acknowledge manufacture in other Socialist countries such as Eastern Europe and even Yugoslavia.

But "capitalist" produced equipment, even when it retains its original nomenclature in Soviet use, is never identified by its origin. Examples would be ARM-20 long distance telephone exchanges which are imported from Sweden, Japanese radio relay systems, and foreign made cable.

A further annoyance when using open literature if one is not literate in the Russian language is dependence upon translators. Different Americans translate technical Russian expressions in different ways; for example, "obshchegosudarstvennaya" was translated by three different individuals as Government-wide, nationwide, state, and all-state. Likewise, "Yedinaya" was variously translated as unified or consolidated, and the Soviet series of unified computers was abbreviated as either YeS, ES, or EC. Further complications arise because the Russians themselves sometimes use the same abbreviation to mean very different things. For example, by itself KP expands to "kommutatsiya paketov" (packet switching), but PD-KP is an abbreviation for a collective use data transmission network which will not necessarily use packet switching. To the extent possible, the most common terms and abbreviations have been sorted out and are included in the Glossary.

2.3 ORGANIZATION OF THE REPORT

Since under the Soviet concept of YeASS all transmission systems belong in common to the primary network, it seemed logical to begin the survey with transmission systems. The four media selected are cable, LOS radio relay, troposcatter, and COMSATs. They are not the only ones used for Soviet civil telecommunications, but account for all but a miniscule portion of the traffic volume.

The survey next considers the three largest secondary networks of the YeASS. The OAKTS is by far the largest, accounting for (by some Soviet estimates) 80 to 90% of all transmission capacity. The Soviet National Telegraph Network (or rather networks, there are at least four) is discussed next. Data transmission networks are given rather more space than their limited present use would dictate because they are growing rapidly and may be expected to play an increasingly important role over the next decade and a half. The discussion of each secondary network concentrates on subscriber equipment and especially on switching. Appropriate data conversion gear and channelizing apparatus are also covered.

Since this report is only intended as a limited survey, much in-depth information available in the source materials has not been included. Those interested in such details may consult the sources listed in the references and bibliography. Regretfully, space and time limitations have also made it impossible to include all the tutorial background which would have been desirable for this highly technical subject.

3. SOVIET TRANSMISSION SYSTEMS

Both quantitative and qualitative asymmetries exist between the transmission media employed in the United States and the USSR for civil telecommunications. In 1980, the last year for which definitive figures for both countries are available, the United States had about 770 million channel kilometers of long-distance telephone circuits in service (Reference 1). Although both the Soviet landmass and population are considerably larger than that of the U.S., the USSR could claim only 145 million channel kilometers of comparable facilities despite a major growth spurt in 1979 and 1980 to support communications needs of the Moscow Olympic games.

Media composition also differed significantly. About 95% of the U.S. capacity was in microwave and other radio relay circuits, with the balance divided between domestic satellites and cable (coaxial and fiber optic). Radio relay systems in contrast made up less than 20% of the Soviet capacity. Their most prolific medium was, and continues to be, landline cable (Reference 2). Nearly three-fourths of this is of the symmetrical (balanced) twisted-pair type which had largely disappeared from the U.S. long-distance picture by 1970. A significant amount of open-wire telephone lines were still active in parts of the Soviet network in 1980; this medium was last used for long-distance service in the U.S. in the mid 1960s.

While the United States has by far the more prolific telecommunications, the Soviet network is inherently more survivable both in natural disasters and in nuclear warfare because of its greater reliance on landlines. Interestingly, in the last few years there is evidence that telecommunications of both countries may be moving in similar directions where transmission media are concerned. The greatest growth areas both in the U.S. and USSR are in use of COMSATs and in transmission by fiber optic landlines. In the case of fiber optics, this convergence of interest appears to be for somewhat different reasons. The massive capacity of fiber optics makes that medium highly cost competitive within the deregulated U.S. common-carrier market,* while the Soviets find the enhanced security provided by this medium as well as the opportunity to conserve the scarce copper and lead which now go into coaxial cable production** very attractive.

3.1 THE CONCEPT OF THE YeASS

YeASS is defined by GOST 22348-77 which became effective 1 January 1978. The YeASS is conceived as a "telecommunications system which is a complex of communications devices which interact on the basis of the principles of organizational-technical unity and automation" (Reference 4). There is a single primary network, which consists of "all the network nodes, network exchanges, and transmission lines, forming a network of standard transmission channels and standard group circuits" (Reference 5). This primary network provides the foundation for the development of various types of secondary networks, which are designated based on their function or type of information carried. The major types of secondary networks recognized are telephone, telegraph, facsimile, audio broadcast, TV distribution, and data transmission. This distinction between primary and secondary networks is very interesting because it lacks any direct Western counterpart.

A transmission channel is the term describing all technical means and propagation media that facilitate the transmission of electrical communications signals either within a specified band of frequencies or at a specified rate between two exchanges or nodes. A channel with regulated parameters is called standard. Standard channels of the YeASS are shown in Table 3-1.

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*When the first fiber-optic transatlantic cable (the AT&T TAT-8) becomes operational in 1988 it is projected to carry 10% of the total traffic in that huge telecommunications market (Reference 3).

**Acccording to some estimates, as much as 25% of the total copper and lead used by the USSR goes into cable production. These materials are much in demand for military projects, particularly in (or by) the nuclear industry.

Table. 3-1. Standard Channels of the YeASS

Designation	Frequency Band
Tonal Frequency Channel (Hz)	300 to 3400
Audio Broadcast Channel (Hz)	30 to 15,000 (upper class) 50 to 10,000 (first class) 100 to 6,300 (second class)
TV Audio Transmission Channel (Hz)	30 to 15,000 (upper class) 50 to 10,000 (first class)
TV Image Signal Transmission Channel	50 Hz to 6 MHz
Wideband Channel (kHz)	60.6 to 107.7 (primary group) 312.3 to 551.4 (secondary group) 812.3 to 2043.3 (tertiary group) groups of higher order

There is a distinct correspondence between some of these definitions and the frequency division multiplexing (FDM) hierarchy used in North America, and elsewhere. Tonal frequency corresponds almost exactly to voice grade channel, both in use and bandwidth. Compare the primary group to Bell Network Group (60 to 108 kHz) and the secondary group to Bell supergroup (312 to 552 kHz). The tertiary group does not compare directly to Bell mastergroup, but some of the higher-order groups do have North American counterparts.

A group circuit comprises all the technical means which facilitate the transmission of electrical communications signals either within the band of frequencies (FDM) or at the transmission rate (time division multiplexing—TDM) of a regulated group of channels. If the parameters of a group circuit are regulated, the circuit is called standard. FDM systems currently predominate in mainline primary networks while time division systems were being introduced primarily into local primary networks as recently as 1983. The following standard digital routes will eventually be used in the primary network as shown in Table 3-2.

Table 3-2. YeASS Digital Hierarchy

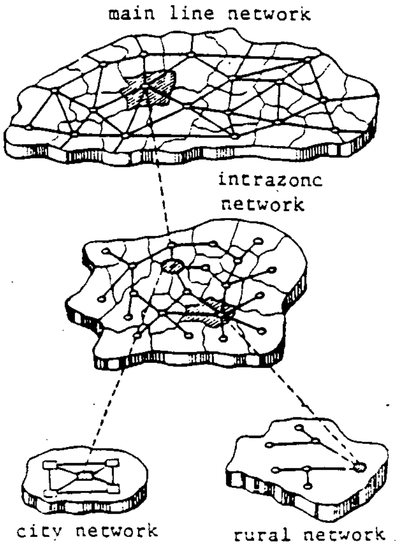
Soviet Nomenclature	Transmission Speed (Mbps)	CCITT Standard
Sub-primary Digital Route (STsT)	0.512	none
Primary Digital Route (PTsT)	2.048	Level 1
Secondary Digital Route (VTsT)	8.448	Level 2
Tertiary Digital Route (TTsT)	34.368	Level 3
Quaternary Digital Route	139.264	Level 4
Pentary Digital Route*	565.148	Level 5

*Mention of this appears mostly in fiber-optic literature.

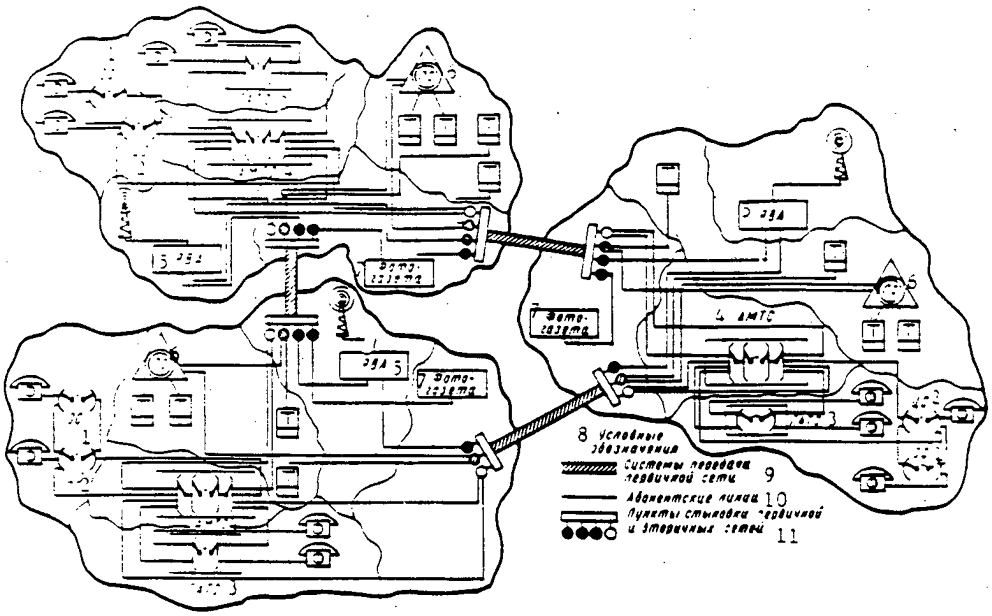
It should be noted that the CCITT (and Soviet) TDM hierarchy differs considerably from that used in North America and Japan.

Primary networks are divided into local, zone, and mainline. The portion of a primary network which lies within a city or rural region is called a local primary network. An intrazone primary network is a part of a primary network which lies within a territory coinciding with a numbering zone of OAKTS. A numbering zone usually coincides with the administrative boundaries of an oblast. The intrazone primary and local primary networks within a territory coinciding with a numbering zone form a primary zone network. That part of the primary network which connects standard-group circuits and standard-transmission channels serving intrazone primary networks throughout the entire country forms a mainline primary network. This concept is illustrated in Figure 3-1 (a).

Network nodes are named in accordance with the primary network to which they belong, and are divided into junctions and stations. Network junctions are transit facilities where routes branch, while network stations are the primary network terminal points at which the bulk of the channels and routes are made available to the secondary networks.



a) NETWORK HIERARCHY



Key: 1 - Terminal exchange (OS); 2 - Central exchange (TsS); 3 - Municipal automatic telephone exchange (GATS); 4 - Automatic long-distance telephone exchange (AMTS); 5 - Radio broadcast equipment (RVA); 6 - [Expansion not given] (PS); 7 - Facsimile newspaper; 8 - Legend; 9 - Primary network transmission system; 10 - Subscriber lines; 11 - Junction points between primary and secondary networks.

PRIMARY AND SECONDARY CONSOLIDATED AUTOMATED COMMUNICATIONS NETWORKS
SOURCE: Reference 6

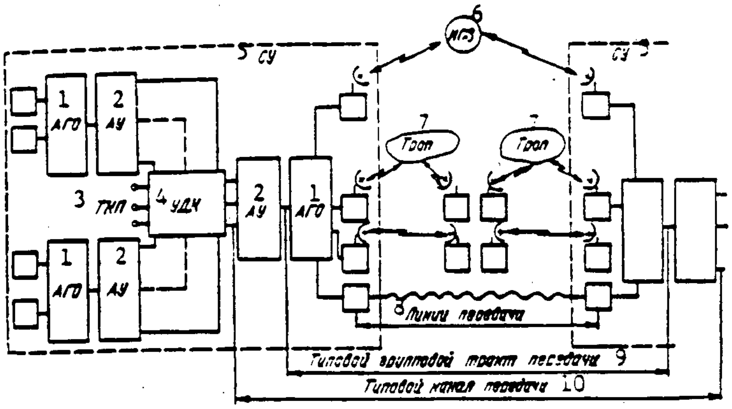
Figure 3-1. The YeASS Concept

All primary networks are said to have four basic characteristics (Reference 5). Structure determines the relative location of the network nodes, exchanges, and transmission lines, regardless of their territorial position (note: roughly Western architecture). Topology is the structure considering actual position on terrain. Capacity is determined by the number of standard channels or combined spectrum width of all the communications channels in a transmission line. Viability determines the resistance of transmission lines and nodes of a primary network to damage. Damage resistance is a function of the technical reliability of the equipment, resistance to natural disasters, and a number of other factors (such as protracted conflict?).

Secondary networks are carried over the primary network and are defined to include subscriber equipment. Most also have the same three-tier structure of the primary network. A channel of the secondary network is any part of the telecommunications channel between nodes. The type of secondary network gives the secondary network channel its name. An illustration of the concept of primary and secondary networks is shown in Figure 3-1 (b). Secondary networks shown are telegraph, telephone, audio broadcast, and newspaper facsimile.

A primary network transmission line is defined as "an aggregate of equipment which ensures the generation of a line route, standard group routes, and transmission channels of the primary network of the YeASS" (Reference 4). This end-to-end definition includes the transmission system stations and the propagation medium of the communications signals. Figure 3-2 shows a fragment of a primary network employing four different transmission media.

Standard Soviet transmission systems are designated by type of multiplexing and voice channel capacity. The two types of multiplexing used are FDM prefixed with the letter K and TDM prefixed IKM. The maximum channel capacity follows the prefix (e.g., K-1920 is an FDM multiplexed transmission system with a capacity of 1920 voice-grade channels). Since the Soviet transmission network is presently largely analog, the FDM systems predominate. Table 3-3 summarizes characteristics of the okonyrchnoy komplyeks oburudovaniye peredachye (OKOP) standard family of FDM systems. Many nonstandard FDM systems are also in common use.



1 - Information equipment (AGO); 2 - Multiplexing equipment (AU); 3 - Standard transmission channel (TKP); 4 - Long-term switching device (UDK); 5 - Network node (SU); 6 - Satellite (ISZ); 7 - Troposcatter (Trop); 8 - Transmission lines; 9 - Standard group transmission circuit; 10 - Standard transmission channel.

SOURCE: Reference 5

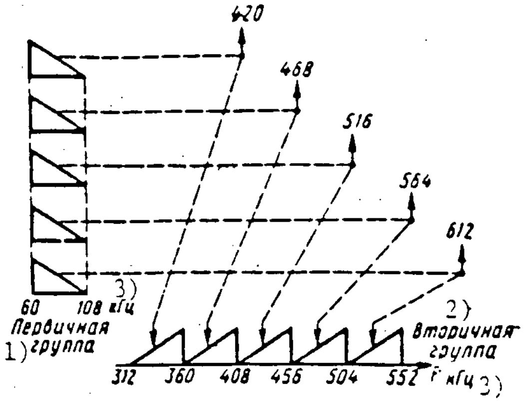
Figure 3-2. A Segment of a Primary Network

All FDM transmission spectra are built up modularly from the standard channels and groups of channels previously described. Figure 3-3(a) and (b) illustrates the process of forming a 60-channel secondary group (supergroup) from five separate primary groups (which in turn are formed from 12 individual voice grade channels), as portrayed in a Soviet and U.S. text, respectively. The signals added at the mixers (Figure 3-3 (b)) are called group carrier frequencies. They are determined by the relationship:

Table 3-3. Soviet FDM Transmission Systems of OKOP Family

System Designator	Number VGCs*	Data Frequency Band (kHz)	Intended Application	Types of Transmission Media				Status
				Sym Cab	Coax	RRL	COMSAT***	
K-60	60	12 to 252	Local Primary Network	X		X	X	Operational
K-120	120	60 to 552 812 to 1304**	Zone Primary Network	X	X	X	X	Operational
K-300	300	60 to 1300	Zone Primary Network	(X)	X	X		Operational
K-1020	1020	312 to 4636	Zone or Mainline Network	X	X	X		Operational
K-1920	1920	312 to 8524	Mainline Transmission Network		X	X		Operational
K-3600	3600	812 to 17,596	Mainline Transmission Network		X			Operational
K-10800	10800	4232 to 59,684	Mainline Transmission Network		X			IOC Planned for 1985

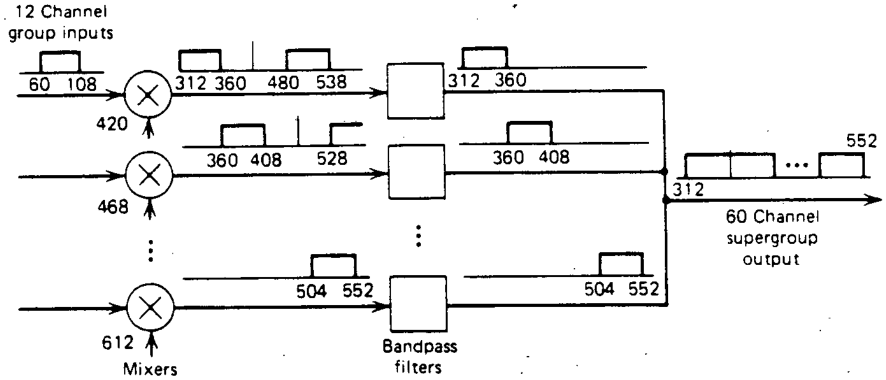
*Bandwidth of one VG channel is nominally 4 kHz
**Double sideband system. All others are single sideband
***All that can be confirmed from the available literature. Use of others is also suspected.



1) Primary group
2) Secondary group
3) kHz

(a) Diagram of Frequency Conversions of a 60-Channel Audio Frequency Transmission System (Secondary Group)

SOURCE: Reference 5



(b) Formation of a Supergroup

SOURCE: Reference 7

Figure 3-3. Formation of Higher-Order FDM Groups

$$f_{sec} = 312 + 48\ m\ (kHz)$$

where m = 1, 2, 3, 4, 5 is the number of a primary group. This results in a spectrum of 312 to 552 kHz, which is downshifted by 300 kHz to form the transmission spectrum of the K-60 FDM system. Generation of the other standard transmission spectra is similar in principle, but more complex in practice (see Reference 5 for details).

The Soviet K-1920, K-3000, and K-10800 systems specifications and capacities closely correlate (respectively) to the L-3, L-4, and L-5 transmission systems operated within the U.S. by AT&T. It is believed, however, that the Soviet systems' performance is probably of lower quality in terms of signal-to-noise (S/N) ratio and other channel linearity factors. It has been reported that the military must usually test and choose the best channels in order to assure reliable communications for their command, control, and communications (C^3) systems.

Although very much in the minority at present, Soviet digital transmission systems will become progressively more important over the next decade as the USSR joins the rest of the world in moving toward the distant goal of an Integrated Services Digital Network (ISDN). Soviet authors (Reference 7) recognize that transition to an all-digital system "in large countries like ours ... is an extremely difficult problem which takes a great deal of time to solve. The U.S. proposes only to switch 25 to 30% of all mainline network channels to digital facilities by 1990." It is not mentioned that this exceeds the total Soviet telecommunication capacity now in service!

As of mid-1983, development of the basic digital communications facilities for the YeASS was reportedly in the process of being completed. However, it was acknowledged that industry will need time to master production of digital transmission systems. During the transistion period, digital transmission systems will have to be used as ordinary analog systems in many cases.

A digital channel with a throughput capacity of 64 kbps corresponds to a voice grade analog channel (using 8-bit coding and A-87.6 companding) and has been selected as the primary digital channel. A digital transmission system hierarchy has been developed as shown in Table 3-4. The maximum length of a homogenous digital transmission system line circuit in mainline, intrazone, and local primary networks is 2,500, 600, and 100 km, respectively.

Although digital transmission systems have found application in both Soviet urban and zone primary networks, in 1982 a plan was formulated for development of rural primary networks, primarily on a base of digital systems. It is acknowledged that return on this investment will be slow, however many rural networks are underdeveloped and in need of extensive modernization anyway. This "bottom up" approach to (ultimate) introduction of digital equipment throughout the YeASS is almost the opposite of that being pursued in most Western countries. If sustained, it could provide an excellent base for ultimate transition to a nationwide integrated services digital network (ISDN).

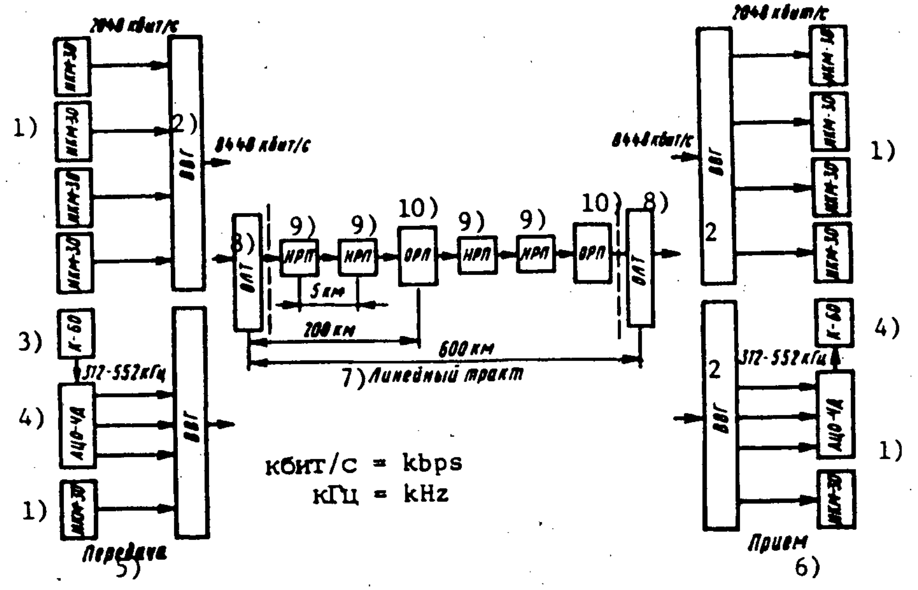
Existing digital transmission systems incorporate hardware to ensure compatibility with analog transmission systems. Equipment designated ATsO-ChD-60 and ATsO-ChD-300 has been developed for setting up analog transmission system supergroup and mastergroup circuits (respectively) within a digital transmission system. An example of how this is implemented is shown in Figure 3-4.

Figure 3-4 also illustrates the three basic functional parts of digital transmission equipment: 1) channel formation equipment (one in figure); 2) time group formation equipment (two in figure), secondary is illustrated but ternary and quaternary are the same in principle; and 3) line circuit equipment (eight in figure). This is special-purpose equipment dedicated to a specific transmission medium. The diagram shows a cable, but digital line circuits have also been developed for optical cables, radio relay, and satellite links.

Table 3-4. Soviet Digital Transmission Systems

System Hierarchy	System Designator	Number VGCs*	Transmission Rate (Mbps)	Intended Application	Types of Transmission Media					Status
					Cable			RRL	COMSAT	
					Sym	Coax	FO			
Subprimary	IKM-15	15	1.024	Local Primary Network	X				X	Operational
Primary	IKM-30	30	2.048	Local Primary Network	X	X	X	X	X	Operational
Secondary	IKM-120	120	8.448	Zone Primary Network	X	X	X	X	X	Operational
Tertiary (Ternary)	IKM-480	480	34.368	Zone Primary Network		X	X			Operational
Quaternary	IKM-1920	1920	139.264	Mainline Transmission Network		X	X			IOC Planned late 1980s
Pentary (Quinary)	IKM-7680	7680	565.148	Mainline Transmission Network			X			Planning

*One VGC is defined as 64 Kbps equivalent.



кбит/с = kbps
кГц = kHz

1 - IKM-30; 2 - secondary time group formation equipment (VVG); 3 - K-60; 4 - FDM supergroup analog-digital conversion equipment (ATsO-ChD); 5 - transmit; 6 - receive; 7 - line circuit; 8 - line circuit equipment (OLT); 9 - unattended repeater (NRP); 10 - attended repeater (ORP).

SOURCE: Reference 8

Figure 3-4. Diagram of IKM-120 Secondary Digital Transmission System

3.2 OTHER NETWORKS

Despite the Soviet emphasis on YeASS, special needs of the more important ministries are recognized to sometimes require communications systems which do not completely conform to the definition of YeASS secondary networks. These departmental (or ministirial) networks may lease channels from the YeASS or, where these will not suffice, sometimes develop their own cable, open wire, or radio relay transmission lines. The largest civil users of departmental networks are the petroleum and gas industry, the Power Engineering and Electrification Administration, and the Ministry of Railroads. It is safe to assume that the military and KGB also operate similar networks.

3.3 METALLIC CABLE

Cable is the dominant transmission medium within Soviet civil telecommunications networks. By the end of 1980, the Soviets had more than 70 million channel-kilometers of cable in service, about three times the capacity of their common-carrier radio-relay facilities. Cable is used for telephone, telegraph, TV (video and audio), broadcast audio, facsimile, and data transmission.

Much of the expansion of cable (and other) transmission facilities occurred toward the end of the 10th 5-year plan (1980) to support the Olympic games in Moscow that year. While much new cable was laid, the majority of the capacity increase (which exceeded the goals of the 5-year plan by 17%) was achieved by the installation of higher capacity multiplexers on existing cable routes. The Warsaw Pact is not fully self-sufficient in cable production. While much of the new cable installed 1975 to 1980 came from domestic production, or from East Germany and Hungary, some equipment was purchased from Yugoslavia, Finland, and Japan.

Although the Soviets have published equally ambitious goals for telecommunications expansion under the 11th 5-year plan (1981 to 1985), there are several reasons to believe that their record-setting progress of the recent past is unlikely to be repeated.

1. A large portion of the channel-kilometer increases during the 1975 to 1980 period were achieved by installing higher-capacity multiplexing equipment on existing routes (chiefly replacing K-1920 with K-3600 on mainline coax as described in Reference 9). This approach has reached the limits existing communications lines can support. Although higher capacity FDM multiplexers than those already installed are under development, their 60-MHz bandwidth requirements will stress capabilities of the present transmission plant. The Soviets admit existing mainline cables are designed for operation only up to 25 MHz; when operated at 60 MHz they do not meet CCITT attenuation standards.

2. Some gains will continue to be achieved as television, audio broadcast, and newspaper facsimile distribution is increasingly shifted from cable and radio relay lines to COMSATs, freeing up those trunks for communications. However, this will soon reach the point of diminishing returns, and represents only a one-time saving.

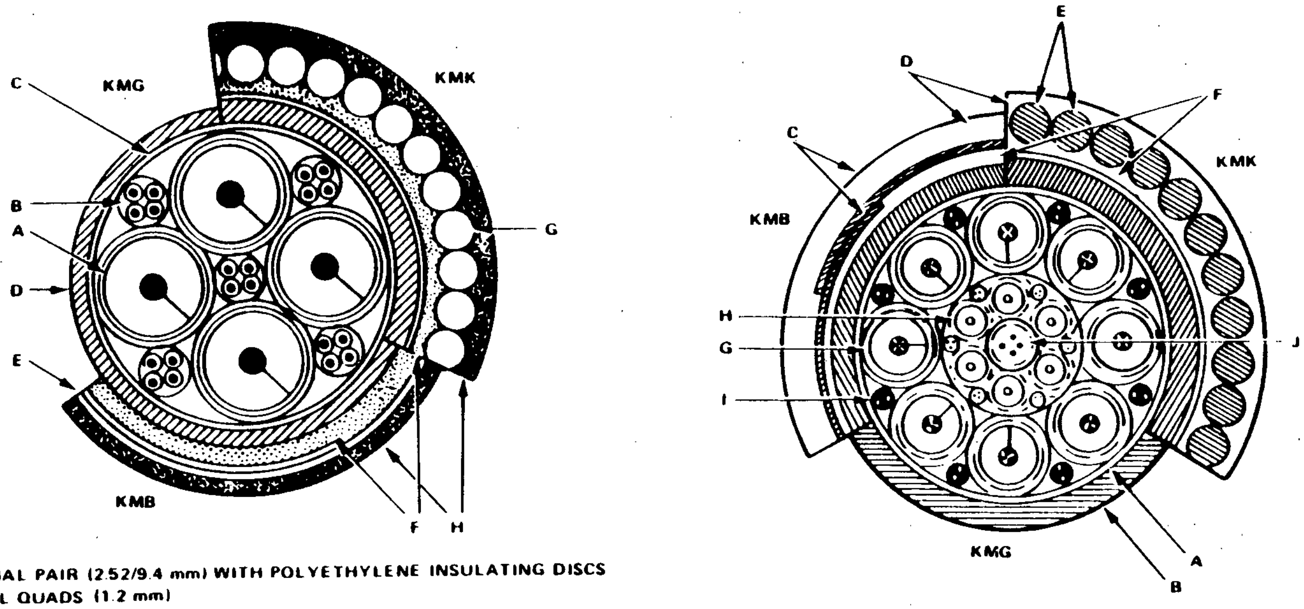
3. Many existing Soviet cable links are outmoded and incapable of operating at the full potential of new transmission systems. In addition, some Warsaw Pact-manufactured cable has proven to be incapable of demonstrating the expected 50-year service life given the extremely harsh operating environment in much of the USSR. As a result, it becomes increasingly uneconomical to keep much of the older cable plant in service. Significant resources which might have gone toward expanding the network may instead have to be diverted to replacing older cables. Since the replacement cables will be of higher capacity, this will result in some gain, but less than if the improved cables were laid on new routes.

Within the USSR telecommunications cables are classified as national (long distance), provincial (urban), and district (rural). They are further categorized by intended installation (suspended, buried, submarine); by the type of insulation and/or armor employed; and as symmetrical, coaxial, or optical fiber. Symmetrical cable consists of at least two insulated conductors that are structurally identical and electrically balanced. These conductors are then twisted into groups of pairs or quads. A coaxial cable in contrast consists of an inner and an outer conductor separated by insulating material.

Symmetrical (balanced) multiconductor cable is about three times as common within the Soviet civil telecommunications networks as coaxial. The most widely used symmetrical cables are those containing one, four, and seven quads. Each quad can handle up to 60 multiplexed voice-grade channels, and more than one cable can be laid in the same trench. While capacities of symmetrical and coaxial cables overlap somewhat, the balanced multiconductor cables cannot rival the capabilities of the larger coaxial types.

Coaxial-type cables employed in the USSR are categorized as composite, mainline, small, or lightweight. The Soviets have a few standardized coaxial tube sizes, which are specified by outside diameter of inner conductor/outside diameter of the outer conductor. Cable with an inner conductor of 2.6 mm and an outer conductor of 9.4 mm (2.6/9.4) is referred to as standard, while 1.2/4.6 tubes are considered small. Most of the major types of coaxial cables are made up of combinations of these tubes. For example, the KMB-8/6 composite cable has eight standard and six small tubes, while the KMB-4 mainline coaxial cable has four standard tubes. Cutaway diagrams of these are shown in Figure 3-5. The KMB-4 cable is used on the Druzhba (friendship) cable route which connects Moscow with Berlin, Prague, and Warsaw.

As can be seen from the figure, these cables contain more than just the coaxial tubes. The KMB-8/6 also contains one symmetrical quad, eight symmetrical pairs, and six single conductors, while the KMB-4 has five additional symmetrical quads. These extra wires can be used for additional communication capacity or some may form service communications for keeping the main trunks operating, providing remote control or feedback signals for managing unattended repeaters, or



A. COAXIAL PAIR (2.52/9.4 mm) WITH POLYETHYLENE INSULATING DISCS
B. SIGNAL QUADS (1.2 mm)
C. STRIP INSULATION (PAPER)
D. LEAD JACKET
E. STEEL TAPE ARMOR
F. CUSHION
G. CIRCULAR ARMOR WIRES
H. OUTER COVER (JUTE)

(a) Structural Design of KMB-4, KMG-4, and KMK-4 Standard Coaxial Cable

A. INSULATING JACKET
B. LEAD JACKET
C. DOUBLE ARMOR CLADDING (STEEL)
D. PROTECTIVE OUTER JACKET (JUTE)
E. CIRCULAR ARMOR WIRES
F. CUSHION
G. COAXIAL PAIR (2.52/9.4 mm) WITH POLYETHYENE INSULATING DISC
H. SMALL COAXIAL LINES WITH POLYETHYLENE INSULATION
I. SIGNAL WIRES
J. SIGNAL QUAD

(b) Structural Design of KMB-8/6, KMG-8/6, and KMK-8/6 Combined (Standard/Small Diameter) Coaxial Cable

SOURCE: Reference 2

Figure 3-5. Construction Details of Typical Soviet Coaxial Cables supplying power to unattended repeaters. Most coaxial cables are installed underground on long-distance mainline trunks with heavy traffic loads.

In addition to landlines, the Soviets manufacture submarine cable capable of carrying up to 120 telephone channels. Submarine cables link the Kamchatka peninsula with the USSR mainland, and the USSR with Bulgaria, Denmark, Finland, North Korea, Japan, Poland, and Romania.

The majority of Soviet cables now in use carry FDM transmission systems, the characteristics of which are summarized in Table 3-5. In the table, emphasis is placed on the type of cables with which each system is primarily used, and on some of the peculiarities of the systems as implemented on cable (repeater spacing, branching, auxiliary functions). In addition to the OKOP family of FDM systems as outlined in Table 3-3, Table 3-5 contains many of the nonstandard FDM systems still in common use.

The Soviets have traditionally had problems in producing highly reliable coaxial cable of consistent parameters, according to Reference 2. Because of this, their equalization circuits are probably more extensive than those required on comparable Western-manufactured cable systems. Other components of cable transmission standards may also be of substandard quality. Reports indicate that poor quality amplifiers and repeaters along the route of the Druzhba cable are major contributors to problems that prohibit full utilization of system capacity.

3.4 FIBER-OPTIC CABLES

Since 1965, a worldwide effort to develop optical communication systems has taken place, with Soviet R&D following in direct response to advances taking place in the West and Japan. This is evidenced by the constant references in Soviet literature to the capabilities of non-Warsaw Pact systems.

Table 3-5. FDM Cable Transmission Systems Used on CEMA Cables

Designator[1]	Type Cable(s)[2]	Max Range (km)	No. Voice Grade Chs	TV?	Data Freq Band (kHz)	Branching[3] Possible?	Repeater Space (km)		Auxiliary Functions	
							Attend	Unattend	Svc and RC Comms	AGCs
KV-12	MKS,MK,TDSB	2400	12	No	36 to 143	Probably	type cable depend		Power Only	Flat Sloping
K-12 + 12	MKS,MKAP,ZKP,KSPP	1500	12	No	12 to 120	Yes A/U	type cable depend		2eaSC mplx + signal	Pilots+Temp
VLT-24P[4] K-24R	Balance Pairs in KM-4 or KM-8/6	372	24	No	12 to 108	Yes A/U	186	6	Yes	2 Pilot+Temp
K-60P[5] V-60E	MKS Multiquad ZK Single Quad	12,500 5,000	60	No	12 to 252	?	300 230	19 10	RC Mplx, SC on Special Channels	3 Pilot+Temp
VLT 120	MKS Multiquad	2,500?	120	No	12 to 552	?	75	9	RC,SC Mplx	Pilot AR Only
K1020S K1020R	MKS Multiquad Small Coax KM8/6	800 1,500	1020 1020	No No	312 to 4636 312 to 4636	Some Yes A lim	280 186	3 3	Yes Yes	2 Pilots 2 Pilots
K-120	VKPAP Coax MKSB Balanced	600	120	No	60 to 552 812 to 13046	Yes A lim	150 to 200 240	10 15	Yes	2 Pilots
K or V 300 K-300R	MKTS Small Coax Small Coax KM8/6	12,500	300	No	60 to 1300	Yes A lim	246	6	In Voice Grade CH or Balanced Pairs	2 Pilots
VK-960-2 or V-960	Small Coax KM8/6 Large Coax KM8/6	432	960	No	60 to 4028	Yes	POUP[7]	4 9	RC - 3 Cable Pairs SC - Cable Quad	Pilot
K-1920U,P VLT1800/ 1920	Standard Coax KM 8/6, KM-4	12,500	1920 or 300	0 1	312 to 8524	TV and VGC Max 3 A	246 or 186	6	Yes	Pilot+Temp
V-2700	Standard or Small Coax	?	2700	No?	300 to 12,400	?		4.5	?	?

Table 3-5. FDM Cable Transmission Systems Used on CEMA Cables (Concluded)

Designator[1]	Type Cable(s)[2]	Max Range (km)	No. Voice Grade Chs	TV?	Data Freq Band (kHz)	Branching[3] Possible?	Repeater Space (km)		Auxiliary Functions	
							Attend	Unattend	Svc and RC Comms	AGCs
K-3600	Standard KM 8/6, KM-4 Coax Large Conductor	12,500 25,000	D 3600 or I 1800	0 1	812 to 17,596	TV only A spec eqpt	186	3	Same as K1920P	3 Pilot+Temp
K-10800[8] V-10800	Standard KM-4-60 Large Coax Conductor	12,500	10,800	Yes	4232 to 59,684	?	120	1.5	Yes	Yes

Notes:

K-60, K-120, K-300, K-1020, K-1920, K-3600 and K-10800 make up the OKOP family which is built to CCITT standards.

[1] Prefixes in designators: K = USSR manufactured, V = GDR, VK = Hungarian Suffixes: P = semiconductor, U = tube

[2] Unless stated to be coax, all cable types are symmetrical (balanced) twisted pair.

[3] Under Branching Column: A = attended repeater; U = unattended repeater; lim means some groups but not all can be extracted; VGC = voice grade channel

[4] AK24T system was developed for Railroad Departmental Communications Nets, and entered production in 1983.

[5] AKS 60 + 60 system was developed for use on rural KSPP cables. It has a capacity of 60 channels in each direction transmitted on a different twisted pair and different subcarrier frequency. 312-552 kHz (304 kHz pilot) is used in one direction and 48-288 kHz (296 kHz pilot) in the other.

[6] This is a double sideband system. All others are single sideband.

[7] Semiattended repeaters are used.

[8] 4 IOC date 1985.

Soviet R&D efforts in fiber-optic communications have been centered at the Institute of Radio Engineering and Electronics (IREE), the P. N. Lebeder Physics Institute (FIAN), and the Institute of Chemistry, of the Academy of Sciences. The primary sources of information on fiber-optic technology are the two journals: Soviet Journal of Quantum Electronics, which emphasizes research and computer applications, and Telecommunications and Radio Engineering, which stresses the implementation of fiber-optic communication systems. Some prominent Soviet personalities in this field are E. M. Dianov, V. V. Grigor'yants, A. N. Gur'yanov, A. M. Prokhorov, M. I. Belokolov, and I. N. Sisakyan.

From the Soviet standpoint, the advantages inherent in fiber optics as opposed to coaxial cable transmission include:

1. The comparative abundance of the natural resources utilized to manufacture optical fibers, allowing the conservation of the scarce, nonferrous metals (copper and lead) which is a continuing, critical Soviet concern;
2. The large data transmission capacity, expressed in Gbit-km/s, permitting a large number of channels over great distances;
3. The small size and mass of optical cables;
4. Immunity to electromagnetic effects;
5. Low attenuation; and
6. The wide, usable bandwidth potentially permitting efficient spectral multiplexing.

3.4.1 Soviet Optical Fibers

One of the critical barriers the Soviets face is development of the highly integrated manufacturing technology necessary for efficient, reliable, and controllable fiber fabrication. Parameters of Soviet-produced fibers often vary from batch to batch, and major problems have limited the length of continuous fibers to less than a few kilometers.

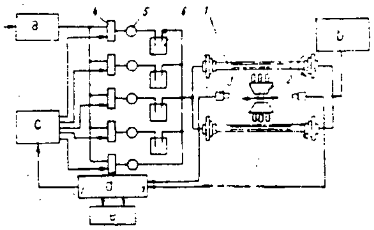
Also, no mention was found in available Soviet literature describing a domestic manufacturing system similar to the axial deposition method used in the West for continuous fiber manufacturing.

In 1979, Soviet automated production of fibers began using the "Model UIZS-1" chemical vapor deposition system (Reference 10). This equipment is located at the IREE and is shown schematically in Figure 3-6. The authors of this 1982 article claim production of multimode and single-mode fibers with losses of 0.4 dB/km at 1.3 µm with a passband of 1.5 GHz-km. The manufacturing technique has dopant profile flexibility through four teflon diffusers containing $SiCl_4$, BBr_3, $POCl_3$, and $GeCl_4$ and a programmable device employing a 15VSM-5 computer. Figure 3-7 shows the characteristics of the fibers obtained using the UIZS-1 system. The degree of similarity between this system and past/present Western manufacturing techniques has not been assessed.

Quality of the fibers produced by the UIZS-1 system depends on the quartz support tube as shown in Reference 11. Tubes from the USSR, Bulgaria, and West Germany were used, and the resultant fibers are compared in Figure 3-8. From this curve, we see that Soviet quartz support tubes yield fibers with the highest attenuation and the widest sample-to-sample variation. It is apparent from this study that the Bulgarian quartz support tubes were probably used to obtain the 0.4 dB/km fibers reported in Reference 10.

3.4.2 Optical Cable Construction

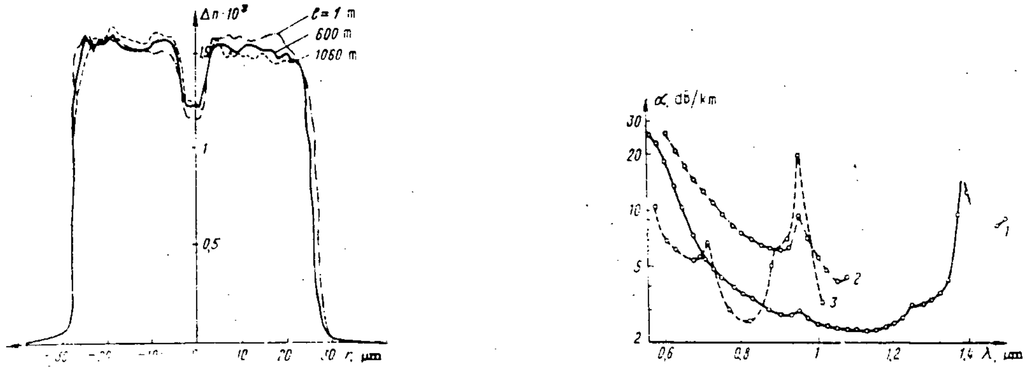
There have been several good summary articles published by the Soviets on optical cable construction, but is is not clear which of the structures discussed is currently being manufactured in the USSR (References 12 and 13). Appreciation for the desirable properties of the AT&T 12 x 12 ribbon cable which requires advanced manufacturing and connector technology is frequently expressed. It is apparent from the Soviet literature that connectors remain a very weak spot in the development of high-capacity cables for communications applications.



a - DRYING STATION
b - NEUTRALIZATION SYSTEM
c - CONTROL UNIT
d - PROGRAMMING UNIT
e - 15VSM-5
1 - QUARTZ SUPPORT TUBE
2 - GAS-OXYGEN BURNER
3 - LIMIT SWITCHES
4 - GAS-FLOW REGULATOR
5 - FILTER
6 - BUBBLER-TYPE METERING APPARATUS

SOURCE: Reference 10

Figure 3-6. The UIZS-1 Manufacturing System

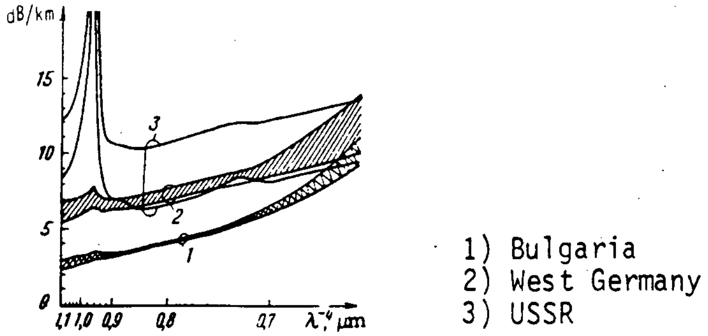


(a) Doping Profile

(b) Attenuation Curves

SOURCE: Reference 10

Figure 3-7. Fibers Obtained Using the UIZS-1 System



SOURCE: Reference 11

Figure 3-8. Dependence of Fiber Attenuation on Quartz Support Tubes

There has been an attempt to standardize the Soviet notation for labeling optical fiber communication cables (Reference 14). The hierarchy is divided into OKZ intrazonal cables and OKM trunkline long-distance cables, as shown in Table 3-6. OKZ cables list the number of fiber pairs, followed by the channel capacity for each fiber. Thus, an OKZ 2 x 120 cable is a two-pair fiber cable, each pair of which carries IKM-120 transmission system for use in a zonal network. OKM cables list the number of fiber pairs and channel capacity defining the long-distance capacity, followed by the capacity of those additional fibers intended for distributive systems (i.e., those channels which can be branched off at junctions and some repeaters). Thus, an OKM 4 x 1920/2 x 480 is a four-pair fiber trunkline cable, each pair of which can support an IKM-1920 transmission system, with two additional pairs, each pair of which can handle a distributive IKM-480 system. It should not be assumed that because a cable appears in this table, such a system is actually operational.

Table 3-6. Fiber-Optic Cable Hierarchy for OKZ Zonal and OKM Trunkline Cables

Type Network	Cable Nomenclature	Number Fibers	Total Number Channels
Intrazonal	OKZ 1 x 120	1	120
	OKZ 1 x 480	1	480
	OKZ 2 x 120	2	240
	OKZ 2 x 480	2	960
	OKZ 3 x 120	3	360
	OKZ 3 x 480	3	1440
Trunk	OKM 1 x 1920/1 x 480	2	1920/480
	OKM 1 x 7680/1 x 1920	2	7680/1920
	OKM 2 x 1920/1 x 480	3	3840/480
	OKM 2 x 7680/1 x 1920	3	15,360/1920
	OKM 4 x 1920/2 x 480	6*	7680/960
	OKM 4 x 7680/2 x 1920	6*	30,720/3840

*Reference gives this number as 4, which is believed to be in error

SOURCE: Reference 14

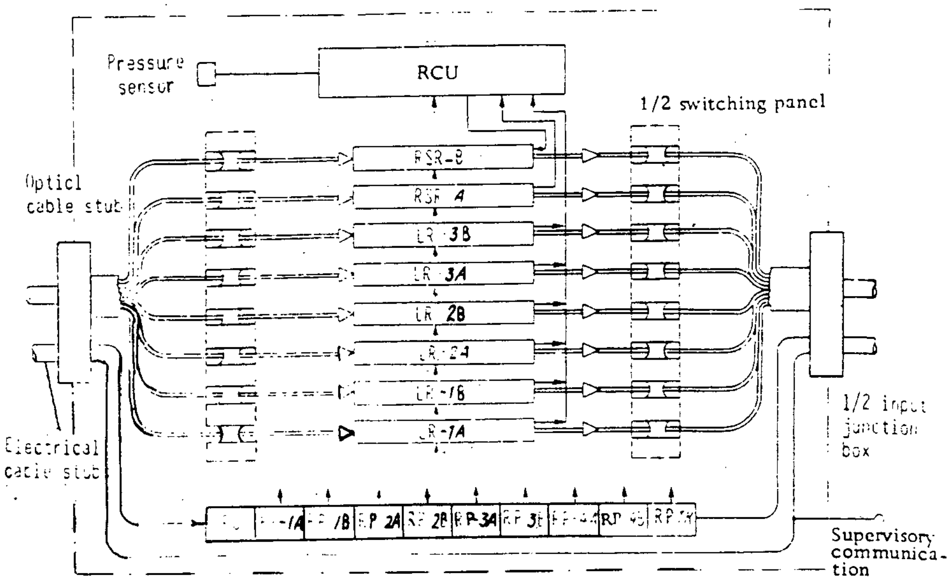
3.4.3 Prototype Telecommunication Links

A review article of May 1982 (Reference 15) describes four prototype installations in operation in the USSR at that time. The first link began operation in 1977 carrying an IKM-12 system. A second setup became operational in January 1980 to connect two private-branch exchanges in an IKM-30 system. In November 1980, a third system became operational functioning between a long-distance exchange and an automatic city exchange carrying IKM-30 data rates. The fourth system became active in November 1981 carrying IKM-120 traffic between automatic city exchanges. All of these systems operated in the 0.85-μm regime.

An IKM-30 optical cable link for use in a city telephone system is described in detail in Reference 16. The cable supports interexchange and intertoll city telephone exchange trunks at a data rate of 2.048 Mbps, and uses a laser-diode source and silicon PIN photodiode detectors. Tests on the system showed that the error probability was no worse than 10^{-9} with a total optical power loss on the order of 45 dB.

The IKM-120 system mentioned above is described in great detail in Reference 17. This fiber-optic system was demonstrated by the Soviets at the International Exposition "Telecom-79" in Switzerland. It is designed to provide a communication link between either automatic telephone stations or within urban telephone networks at a data rate of 8.488 Mbps. This system also used a laser diode operating at 0.85 μm and a PIN photodiode detector and had the same error specification as the IKM-30 link described previously. In addition to the primary transmitter and receiver modules, there is a remote control system that checks the status of the data channel equipment at the unattended repeater stations (URS). A schematic of the URS is shown in Figure 3-9. The volume of this repeater is 1200 x 560 x 350 mm and it weighs 150 kg, which is very bulky relative to comparable Western repeaters. The URS was designed for installation through large and medium manholes. This fiber-optic system is relatively capable and quite representative of the best operational Soviet systems available for installation in the early 1980s.

Reference 18 reports on a fiber optic system based on Soviet elements which has a 400-Mbps capacity. Because 400 Mbps is not a standard increment in the Soviet digital transmission heirarchy, the



LR - LINE SIGNAL REGENERATOR
RSR - REMOTE CONTROL AND SUPERVISORY COMMUNICATION REGENERATOR
PU - PROTECTION UNIT
RCU - REMOTE CONTROL UNIT
RP - REMOTE POWER SUPPLY

SOURCE: Reference 17

Figure 3-9. The IKS-120 Unattended Repeater Station (URS) device was obviously experimental. A 2-km long, single-mode fiber and an AlGaAs laser source were used. The device used to mate the cable to the source was a very bulky three-axis coupler which would be obviously unsuitable for operational use. At the time this development was reported (1983), single-mode laboratory demonstrations in the West exceeded 100-km spacings at several hundred megabits per second, and the first commercial U.S. and British single-mode links began to appear (Reference 19).

3.4.4 Prototype Computer Links

In many applications of fiber optic lines to computer networks, the distance between source and receiver is not very large, allowing high-loss (up to 100 dB/km) fibers to be used. In addition to their advantage of high capacity, the small volume and electromagnetic immunity of optical fibers are very attractive features for computer networking applications. The possibility of developing hybrid optical-electronic computers could serve as a further spur to the use of fiber optics in the Soviet cybernetics field.

An excellent 1982 review article on fiber optic computer links (Reference 20) describes many of the new trends in this field. In this article, which also describes many Western systems, two Soviet successes are noted. First, a single fiber replaced a 10-conductor cable for data transmission at 5 Mbps in the KAMAK data collection system. The second development allowed conversion of the YeS computer parallel interface having 34 conductors to a two-fiber, 60-Mbps series interface. The authors also mention that "significant difficulties arise in the development of the necessary framework (rapid code converters, various types of switching and logic elements, etc.)."

The VEB Robotron Center for Research and Technology in Dresden, East Germany has been conducting experiments using fiber optic interfaces in the K1600 and YeS 1055 computer systems (Reference 21). The authors note that CEMA member nations have a standard with respect to logic conditions but stress that agreements must be made to standardize optical cables, transmitters, receivers, and connectors to insure system compatibility.

A 1982 Soviet article discusses the use of fiber optics in the computers using parallel "Interfeys-T" and series YeS-7920 interface algorithms (Reference 22). Two implementations of the interfaces appear in the "Electronika-60" microcomputers and the YeS series computers, both employing the KAMAK-standard equipment.

Other prototype fiber optic computer interfaces which have been installed include:

1. A charged particle accelerator automatic control system making communication between objects at a potential difference of 100 kV/m possible (Reference 23),
2. An interchange network in the Polish E-10 computer (Reference 24),
3. A 3.4-km link in the Fellas-2500 system developed at the Bucharest computer plant (Reference 25), and
4. The first permanent link in the USSR, used to transmit data from the USSR Ministry of Geology to the Leningrad Computer Scientific Research Center of the Academy of Sciences (Reference 26).

3.5 LINE-OF-SIGHT RADIO RELAY

The Soviets recognize three distinct generations of radio relay systems: the first generation which employs vacuum tubes, the second which uses mostly discrete semiconductors, and the third which is built on integrated circuits (Reference 27). Table 3-7 summarizes characteristics of the main Soviet-developed systems in use today in the USSR (Voskhod and Druzhba were developed jointly with Hungary). In addition, equipment manufactured in Hungary, the GDR, and Japan, is currently in service.

Table 3-7. Soviet-Developed Radio Relay Systems

Nomenclature	Generation	When Developed	Frequency Band (GHz)	Max Range (km)	No. Trunk	No. Phone Channels	TV?	Type Antennas	Type Backup	Service Comms	Digital Transmit	Carries+ FDM Systems
R600	1	1957	4	12,500*	6WB	300 to 420	Y	RPA-2P	(2+1) F	2 NB TRK	No	Unknown
R600 2M	1		4	12,500*	6WB	1020**	Y	RPA-2P	(2+1) F	2 NB TRK	No	K300,K60+TV
R600 2MV (Rassvet-1)	1	1967	4	12,500*	8WB	1020**	Y	RPA-2P	(1+1) F +Spatial	MPLX WB	No	K300,K60+TV
Rassvet 2	1	1972	4	12,500*	4WB	1020**	Y	RPA-2P	(3+1) F	MPLX WB	No	K-1920, K60
Voskhod	2		4	12,500	8WB	1920***	Y	ADEh-5 RPA-2P	Spatial	MPLX WB	No	K-1920
Druzhba	2		6	12,500	8WB	1980***	Y	RPA-2P-2	(6+2) F	2NB TRK+ MPLX WB	No	K-1920 + K60
Kurs-2M	2	1976	2	1,400*4	6WB	300	Y	RPA-2P-2 ADEH-5	(2+1) F	MPLX WB	IKM-30 IKM-120	K-1920,K-300 K60 Various Combinations

*2,500 km for TV and telephone under most conditions
**Maximum; if long waveguide 720, if periscope 600
***Reduced to 1020 if long waveguide used
*4 600 for TV

+Some remultiplexing and/or selection of only a part of the transmission spectrum for transmission over a single trunk may be necessary

For definitions of service and type backup, see text.

Table 3-7. Soviet-Developed Radio Relay Systems (Continued)

Nomenclature	Generation	When Developed	Frequency Band (GHz)	Max Range (km)	No. Trunk	No. Phone Channels	TV?	Type Antennas	Type Backup	Service Comms	Digital Transmit	Carries⁺ FDM Systems
Kurs-4	2	1976	4	12,500*	8WB	720	Y	ADEh-3.5 Periscope	(3+1) F	MPLX WB	IKM-120	K300, K60
Kurs-6	2	1976	6	12,500*	8WB	1320	Y	Periscope	(3+1) F	MPLX WB	IKM-120	K1920, K300, K60
Kurs-8	2	1976	8	1,400*4	8WB	300	Y	Periscope	(3+1) F	MPLX WB	IKM-120	K300, K60
Oblast'-1 (Kurs-8-0)	2	1976	8	250	1WB	300	N	AMD-2.5 Periscope	None	MPLX WB	IKM-30?	K-300, K60
Tral 8-60/ 120	2	1975	8		2WB	120	N	Persicope	(1+1) F	MPLX WB	No?	K-120
Kontejner	2	1972	0.4	200 to 300	2NB	12	N	8-EL-Array	Red Chs	1 CH/Trk	No	Special
EhS-2	3	1979	2	250	3WB	720 to 1320	Y	ADEh-5,3.5	(2+1) F	MPLX WB	IKM-30 DAV IKM-120	K-1920,K-300 in Various Combinations

*2,500 km for TV and telephone under most conditions
**Maximum; if long waveguide 720, if periscope 600
***Reduced to 1020 if long waveguide used
*4 600 for TV

⁺Some remultiplexing and/or selection of only a part of the transmission spectrum for transmission over a single trunk may be necessary

For definitions of service and type backup, see text.

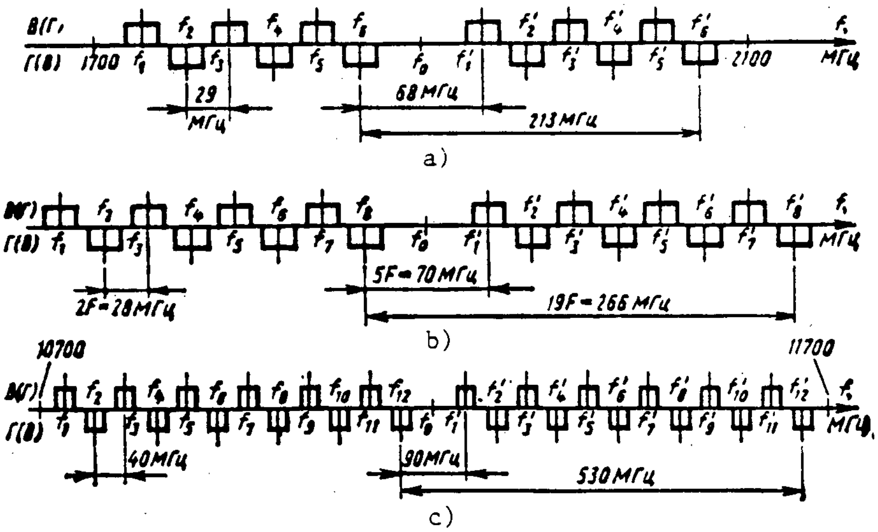
Table 3-7. Soviet-Developed Radio Relay Systems (Concluded)

Nomenclature	Generation	When Developed	Frequency Band (GHz)	Max Range (km)	No. Trunk	No. Phone Channels	TV?	Type Antennas	Type Backup	Service Comms	Digital Transmit	Carries[+] FDM Systems
EhS-4	3	1979	4	2,500	4WB	1020 to 1920	Y	RPA-2P-2 EDEh-5,3.5	(3+1) F	MPLX WB	IKM-120	Same
EhS-6	3	1979	6	2,500	4WB	1020 to 1920	Y	PPI-1	(3+1) F	MPLX WB	IKM-120	Same
EhS-8	3	1979	8	2,500	4WB	300 to 720	Y	ADEh-3.5 AMDU 2.5	(3+1) F	MPLX WB	IKM-120	K300. K60
EhS-11A	3	1979	11	250	4WB	300	Y	ADehM-1 AMDU-1.75	(3+1) F	MPLX WB	IKM-120	K-300
EhS-11T	3	1979	11	250	2 Dig	150	N	AMDU-1.75	TRK PRI.	PRI DIG	IKM-30+ IKM-120	None
Ehlektronika	3	1976	11	5 to 30	2 Dig	12 to 132	N			MPLX	Only	None

[+] Some remultiplexing and/or selection of only a part of the transmission spectrum for transmission over a single trunk may be necessary

For definitions of service and type backup, see text.

Soviet radio relay systems operate in the UHF, and in the 2-, 4-, 6-, 8-, and 11-GHz microwave bands. In comparison, only the UHF, 2-, 4-, 6-, and 11-GHz bands are available for this use in the United States, and 2 GHz is rarely used because the relatively narrow allocated channel bandwidths do not permit implementation of economical numbers of voice circuits. Since the Soviets allocate 400 MHz (1.7 to 2.1 GHz) instead of 20 MHz as in the U.S., they find 2 GHz quite suitable. Frequency plans differ for the various systems and frequencies; some examples are shown in Figure 3-10. Duplex transmission and a two-frequency plan are illustrated in each case. One group of frequencies will be used for transmission in one direction, the other for transmission along the reverse route. Separation of channels is improved by giving even and odd trunk groups different polarizations.



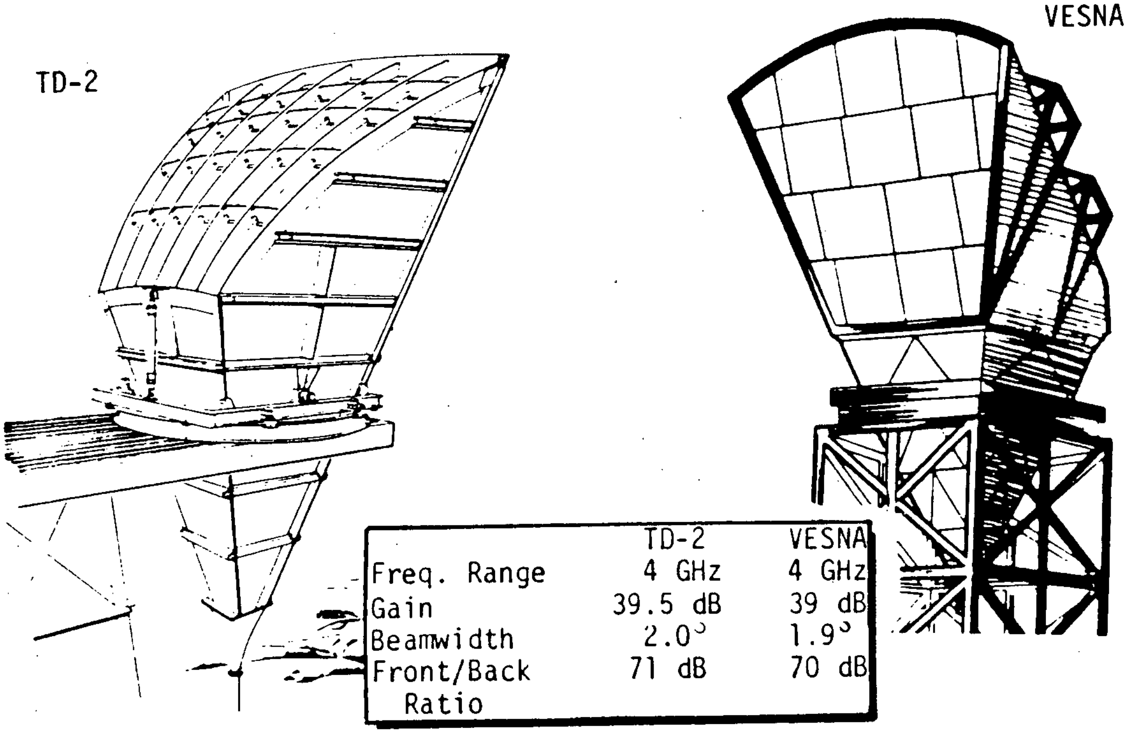
a -- KURS-2M, EhS-2; b -- R-600 2MV, RASSVET-2, KURS-4, VOSKHOD, EhS-4, KURS-6, EhS-6, KURS-8, EhS-8; c -- EhS-11.
[МГц=MHz]
SOURCE: Reference 27

Figure 3-10. Frequency Plan of Radio Relay Systems

Three types of antennas are used in Soviet common carrier microwave links. The first and most common is a parabolic horn antenna designated "Vesna" or RPA-2P (an improved version is known as RPA-2P-2, and other variants exist). As shown in Figure 3-11, Vesna is remarkably similar in both appearance and performance to the TD-2 antennas widely used in AT&T microwave installations. A second type is the appropriately named periscope; Figure 3-12 illustrates the "Strela" installation for the now-defunct R60/120 system, but others presently in service are very similar. The last type is an offset Cassegrainian variant known as a double-reflector antenna with an elliptical cone, illustrated in Figure 3-13. This type is designated ADEh or AMDU followed by its diameters in meters (example: the ADEh-3.5 antenna is 3.5 m in diameter). In contrast, radio-relay systems operating in the UHF band (nominal 400 MHz) usually employ multiple-element antennas similar to the one shown in Figure 3-14 (used with Kontejner).

At microwave frequencies, any radio-relay system experiences variable fading due to multipath. The Soviets normally combat this problem with frequency diversity. Since one group of frequencies is usually affected the most, a spare trunk is kept on hot standby and if fading becomes too bad, the affected trunk is switched automatically to the standby trunk. This type of protection is specified in terms (No. active trunks + No. standby trunks). For example, the Rassvet 2 employs a (3+1) frequency diversity backup; one of the four wideband trunks is available as a spare. Should fading simultaneously affect more than one trunk, a priority assignment scheme is used to determine the trunk to be switched.

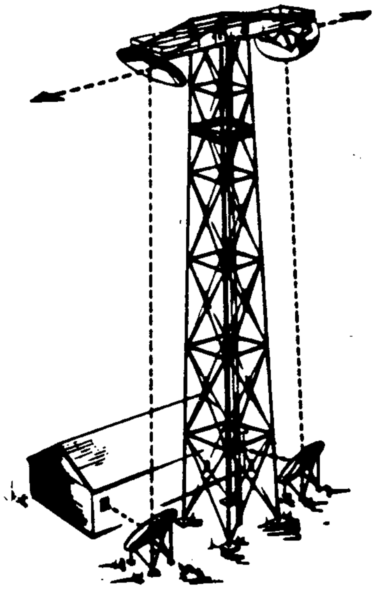
Another technique for dealing with multipath is spatial diversity. Since wavelengths at microwave frequencies are very short, two antennas mounted at different heights on the same tower and illuminated by the same beam will be affected differently by multipath. The two signals are typically compared, and the stronger one selected at the relay point. Spatial diversity is less favored in the U.S. because



	TD-2	VESNA
Freq. Range	4 GHz	4 GHz
Gain	39.5 dB	39 dB
Beamwidth	2.0°	1.9°
Front/Back Ratio	71 dB	70 dB

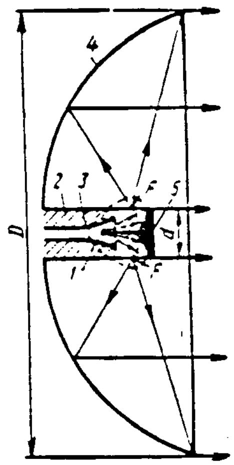
SOURCE: References 27, 28

Figure 3-11. Comparison of Parabolic Horn Antennas



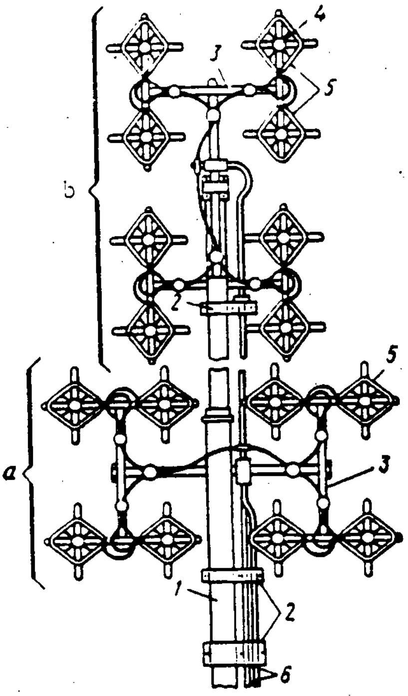
SOURCE: Reference 27

Figure 3-12. Periscope Antenna



SOURCE: Reference 27

Figure 3-13. ADEH Antenna

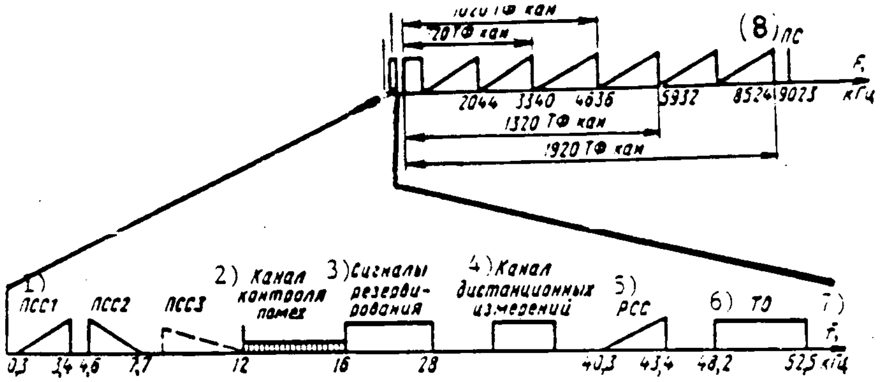


a and b -- for vertical and horizontal polarization: 1 -- standard; 2 -- clamps; 3 -- frame; 4 -- insulator; 5 -- irradiator; 6 -- cable with adapters.

SOURCE: Reference 27

Figure 3-14. An Eight-Element Phased-Array Antenna of the high initial capital cost of installation. The Soviets operate two systems with spatial diversity: Voskhod, where it is the only backup technique, and Rassvet-1, where a (1+1) frequency diversity is also available. Such a combination is extremely rare and may imply a worst case (wartime?) design scenario.

In addition to the common carrier traffic which has been frequency (FDM) or pulse code (PCM) multiplexed into the wideband channels, pilot tones and service communications are always transmitted within radio-relay systems. The service communications may either be carried in a separate narrowband trunk or, more commonly, they are multiplexed onto the wideband carrier, generally in a portion of the wideband channel frequency spectrum below the lowest voice channel. These can include voice order wires, telegraph channels, and remote service signals for controlling unattended repeater stations. The spectrum for the fairly complex service communications of the Ehlektronika-Svyaz (EhS) system is shown in Figure 3-15.



1) Station to station service communications
2) Interference monitor channel
3) Backup signals
4) Remote test channel
5) Rayon service communications
6) Remote service
7) f, kHz
8) pilot tone

SOURCE: Reference 27

Figure 3-15. The Frequency Spectrum of Service Communications Channels of the Ehlektronika-Svyaz Systems

Virtually every radio-relay system developed after 1975 for mainline service has some provision for transmitting digital data. This is accomplished differently depending upon the specific system. The EhS family of systems can place an IKM-30 PCM multiplexed transmission above a 720-channel FDM group on any given trunk. This is so reminiscent of the AT&T concept of transmitting "data under voice" on U.S. 1A radio relay links that it is referred to here as "data above voice," although the Russians do not use this term. Alternatively, if heavier digital traffic materializes, an entire trunk can be devoted to an IKM-120 transmission system.

With the introduction of the EhS-11T and Ehlektronika-M systems, the Soviets have placed in service their first radio-relay systems built from the beginning solely for digital transmission. It is significant, however, that both are intended for short-haul applications (the 11-GHz frequency band is not used for long distances because of rainfall attenuation problems). Large quantities of digital traffic on long-haul common carrier systems are far in the future for the USSR (as it is for the rest of the world).

3.6 TROPOSCATTER RADIO

Several troposcatter radio systems operate as part of the USSR civil telecommunications networks. They are usually employed to serve scattered population centers in isolated parts of the country where the cost of landlines or even microwave relay would be prohibitive. It is more economical to install troposcatter systems in such cases because the distance between relay stations is normally 150 to 300 km versus approximately 25 km for microwave and 10 km or less between cable repeaters.

The largest such troposcatter system which serves mostly the northern tier of the country and Siberia is known as Gorizont (Horizon). This system was constructed during the mid-1960s and employs both space and frequency diversity (quad diversity). The Soviets have reported

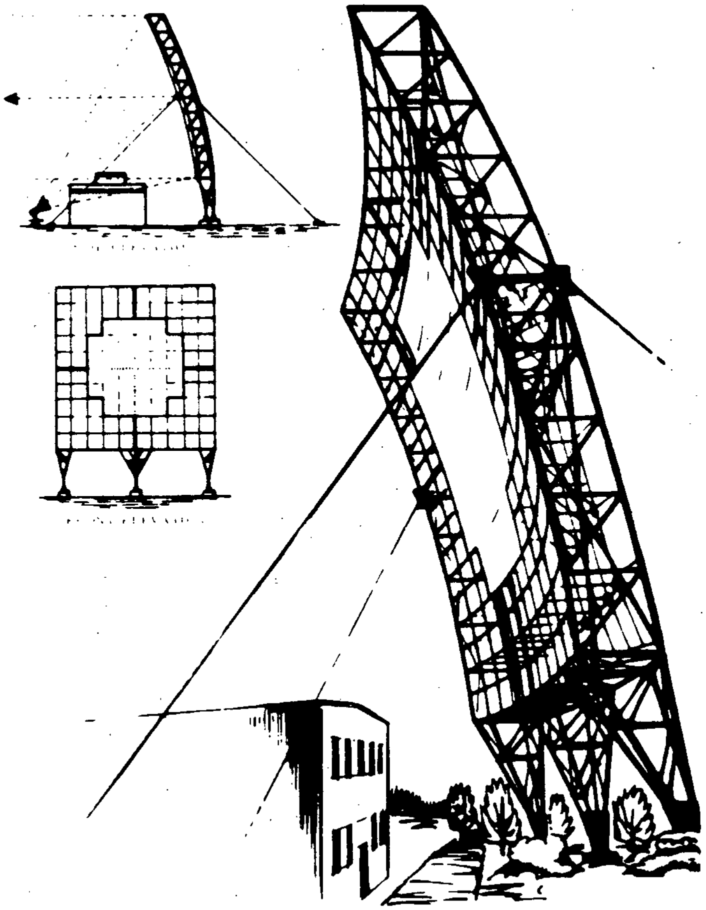
(Reference 29) development of autocorrelation receiver systems named Akkord and Saturn which likely are used to combine the four signals resulting from quad diversity reception at relay and terminal points. Gorizont transmitters probably use power levels of 3 to 10 kW or more to compensate for the high losses inherent in all tropo systems. Gorizont antennas are very large (normally 20 x 20 m, but 30 x 30- and 40 x 40-m antennas are needed in some situations) as shown in Figure 3-16. These are somewhat reminiscent of the antennas associated with the now defunct White Alice tropo system, which once linked Alaska and Northern Canada, and of those used in the Ace High NATO tropo system.

Because it uses a 1-Ghz frequency, Gorizont is normally limited in capacity to only one (or at most two) K-60 transmission systems. A modification to this system was planned (called Gorizont "S") which would have used a 4.5-GHz frequency and accommodated two K-120 trunks (or possibly TV transmission). It was apparently not built because COMSATs proved a more cost-effective approach to serving isolated areas. For that same reason, further major expansion of the civil tropo network appears unlikely.

3.7 COMSATs

The USSR employs a three-tier network to ensure reliable domestic and international communications for both military and civil needs (Reference 30) as shown in Table 3-8. The lowest tier consists of two constellations of low orbiters intended for store-dump communications between official government entities worldwide and Moscow. Since they are therefore not part of civil telecommunications, they will not be discussed further.

The second tier of COMSATs employs highly elliptical orbits. Because these were the first payloads of any nation to regularly use such orbits, the orbits, like the satellites, are often referred to as Molniya (lightning). Two Molniya constellations exist; the older system (Molniya 1) which employs frequencies below 1 GHz, is thought to be used



SOURCE: DST-1720H-512-81 VOL 3

Figure 3-16. Gorizont Tropo Antenna

Table 3-8. Soviet COMSAT Contellations

Program	Altitude (km)	Inclination (deg)	Period (min)	Normal Phasing	Communications Subsystem Transponder/Trunk*	Power	Frequency
Low-Altitide Communications	790 to 810	74	101	3 Planes Spaced 120° 1 Satellite/ Plane	Store dump "Official" communications		
	1350 to 1550	74	115	24 Satellites in One Plane	Store-dump "Official" communications		
Molniya 1	400 to 40,000	63	718	8 Planes Spaced 45° 1 Satellite/ Plane	3/1 (20-W telephony; 40-W B&WTV)	40/20-W	1/0.8 GHz
Molniya 3	400 to 40,000	63	718	4 Planes Spaced 90° 1 Satellite/ Plane	3/2 (telephony and color TV)	40 W	6/4 GHz
Raduga	35,785	0	1436	4 Satellites 35°, 45°, 85°, 128°E	6/3 (telephony and color TV)	15 W	6/4 GHz
Gorizont	35,785	0	1436	6 Satellites 40°, 53°, 80°, 90°, 140°, 346°E	1/1 5/5 (40-W "Moscva" TV Distribution)	40 W 15 WW	6/4 GHz 6/4 GHz
Luch	35,785	0	1436	Secondary Payload on Gorizont 5	Experimental 14/11-GHz Communications		
Volna	35,785	0	1436	Secondary Payload on Gorizont 5	Maritime and Aero Mobile Restricted to USSR (1.5 GHz)		
Ekran	35,785	0	1436	Multiple Satellites at 99°E	TV Relay to Soviet Far East on 714-MHz Downlink Estimate 200-W Transmitter		

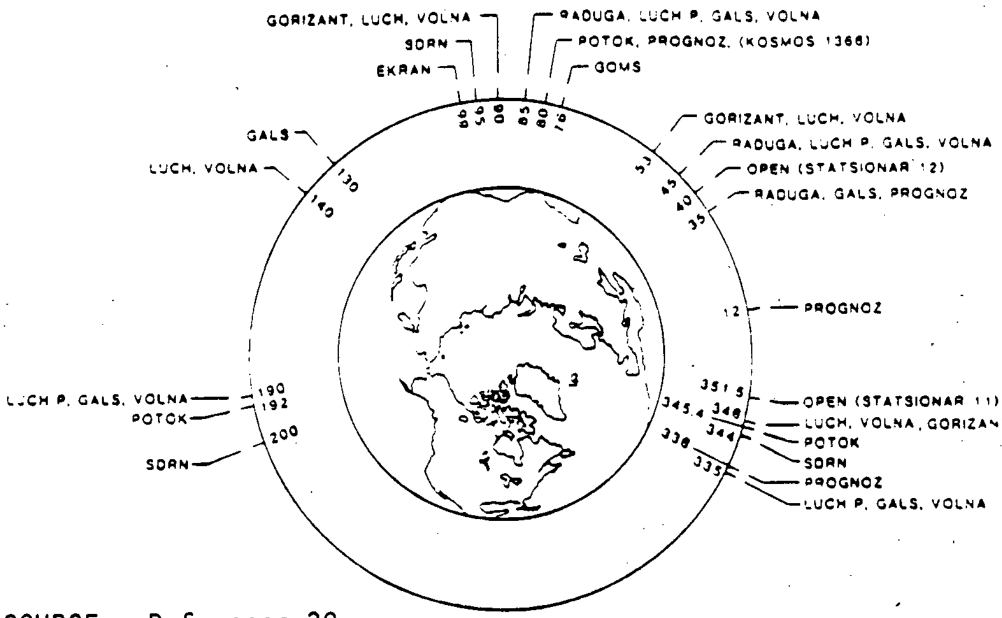
*Transponders = Total number at start of mission
Trunk = Number transponders active at any one time (others are held in reserve)

mostly by the military. Molniya 3 carries civil telecommunications and relays television through the Orbita network.

As can be seen from Figure 3-17, the Soviets have announced extensive plans for utilizing geosynchronous COMSATs through their registrations with the World Atmospheric Radio Conference (WARC) and other international bodies. Of the announced programs, two have yet to appear: GALS (Tack), which will operate in the military 8/7-GHz band, and SDRS, a Soviet counterpart of the NASA Tracking and Data Relay Satellite System (TDRSS). The COS 1366 type satellites may represent initial steps to implement the POTOK digital-data relay system, which was announced about the same time as GALS and SDRS. None of these will serve civil telecommunications functions. Existing Soviet geosynchronous satellites at the end of 1984 are illustrated in Figure 3-18.

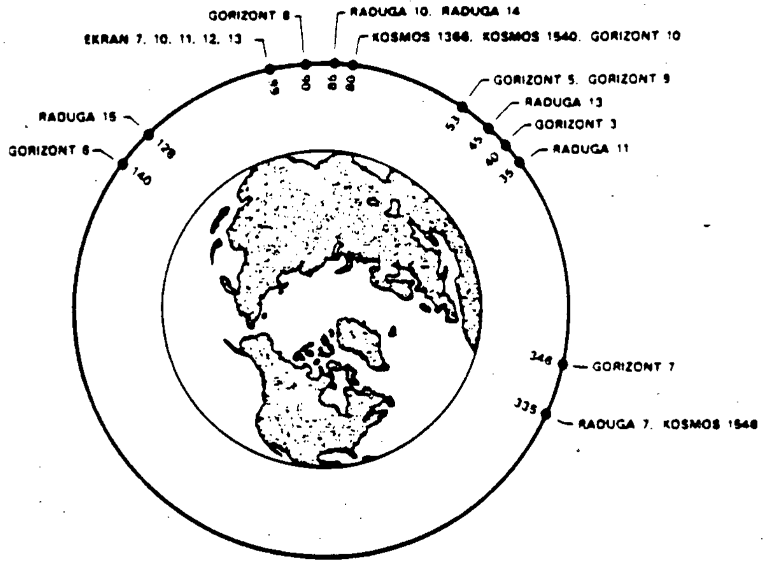
The three predominently civil satellite programs using the geosynchronous regime are illustrated in Figures 3-19 through 3-21. Ekran (Screen) is a television relay directly rebroadcasting national television programs to low-population density areas of the USSR. Because it uses the regular TV frequency band (714 MHz) for its broadcast downlink, Ekran service areas are restricted to those where interference with other nations will not occur. Raduga (Rainbow) and Gorizont (Horizon) satellites also handle television as part of the Orbita distribution network. Gorizont can broadcast television signals directly to 2.5-m antennas as part of the "Moskva" distribution system.

The nature of the Soviet system causes considerable resources to be devoted to the distribution of official information (propaganda) from Moscow (where almost all programming is prepared for the rest of the country) via television, radio broadcast, and newspapers, which are transmitted to local printing plants by facsimile. One-half the capacity of each Molniya 3 is usually devoted to TV transmission, as is one of three available channels on each Raduga and two of six on each Gorizont. Significant portions of the remaining capacity are used for



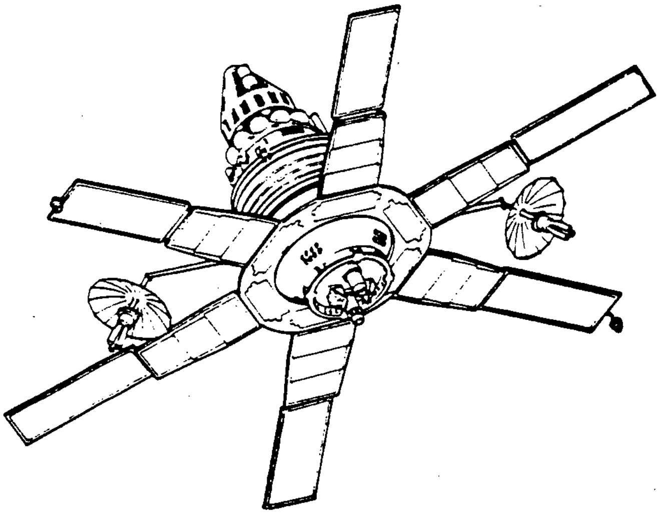
SOURCE: Reference 30

Figure 3-17. Soviet Plans for Utilization of Geostationary Orbital Regime



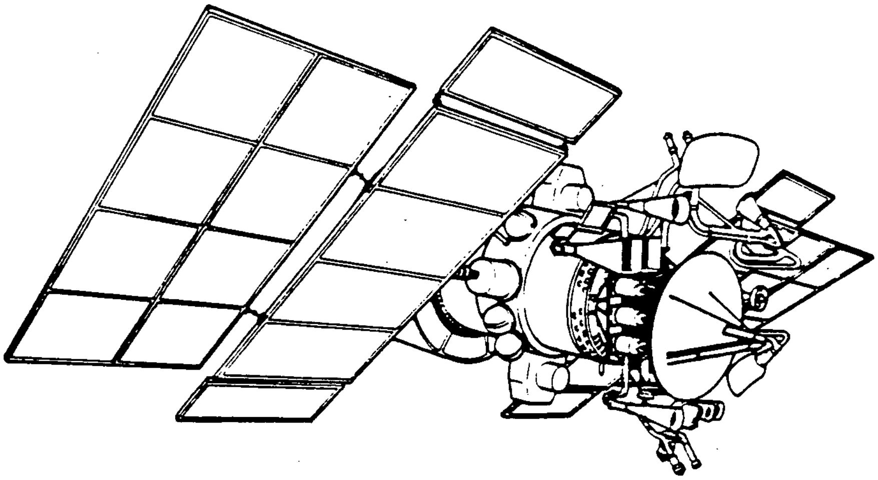
SOURCE: Reference 30

Figure 3-18. Soviet Satellites in Geostationary Orbits as of 1984



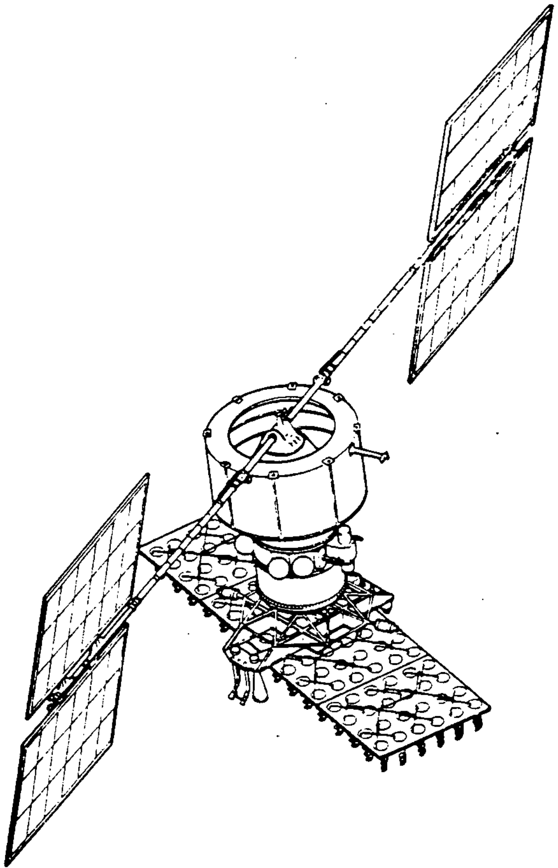
SOURCE: Reference 31

Figure 3-19. Molniya 1 Satellite



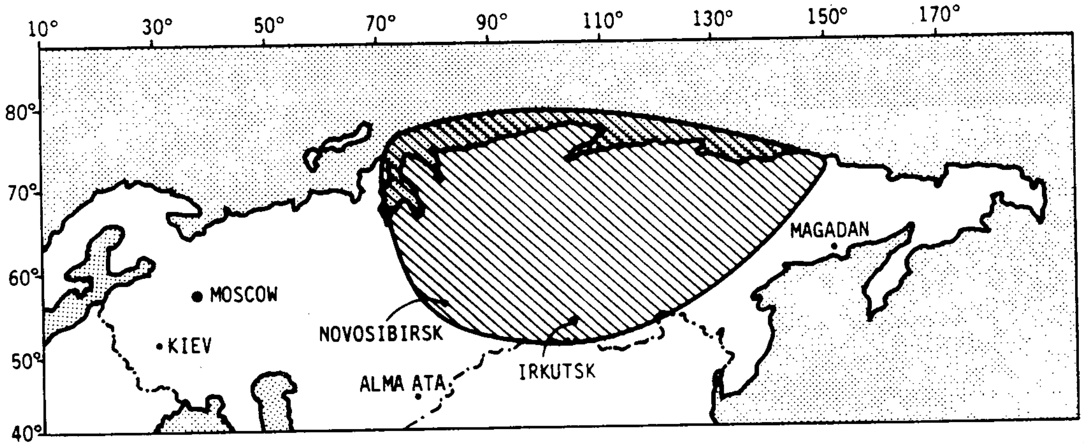
SOURCE: Reference 31

Figure 3-20. Gorizont Satellite



(a) Ehkran Satellite

SOURCE: Reference 31



(b) Ehkran Service Area

Figure 3-21. Ehkran Direct Broadcast Satellite System audio broadcast and facsimile distribution. Sometimes these are transmitted by FM multiplexing onto a TV broadcast channel, but the "Orbita-RV" equipment permits some combination of audio and facsimile channels (up to 25) to be time division multiplexed into one-half the capacity of a Raduga or Gorizont transponder. Special coding (3:4 redundancy ratio) is used to reduce undetected errors on audio broadcast channels to less than 1×10^{-9}. The corresponding error probability for "Gazeta-2" newspaper facsimile is 1×10^{-4}; this lower standard is considered acceptable. Table 3-9 lists specifications for this and other commonly used Soviet facsimile equipment.

Table 3-9. Characteristics of Selected Soviet Facsimile Equipment

Nomenclature	Primary Use	Size Image (mm)	Transmission Time (min)
"Aragvi"	Transmit/Receive Shaded Images	220 x 150	6.0
"Shtrikh"	Transmit/Receive Shaded Images	220 x 150	2.1
FTA-PM	Transmit/Receive Shaded Images	220 x 300	12.5
"Ladoga"	Weather Maps	480 x 690*	22.0
"Neva"	Half Tones and Shaded Images	220 x 300	6.0
"Gazeta-1"	Newspapers	520 x 610	50.0**
"Gazeta-2"	Newspapers	520 x 610	2 to 3

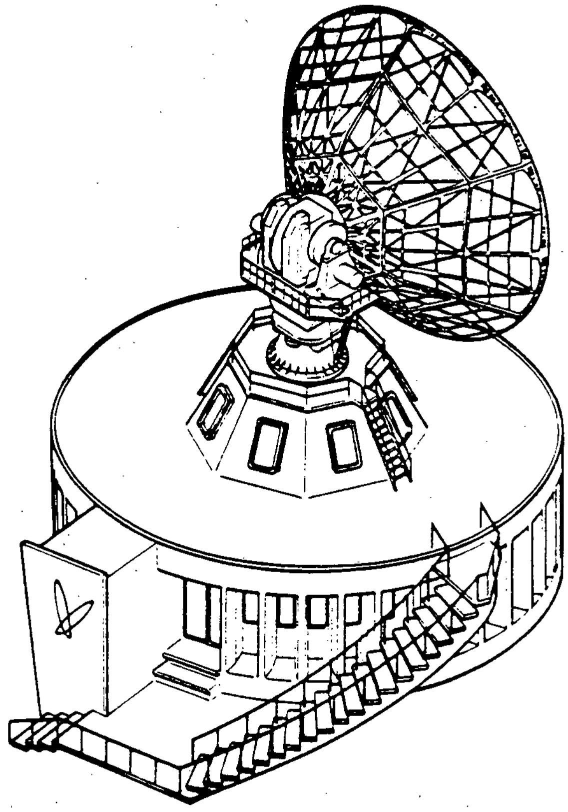
*Maximum limit for width; length is unlimited
**Strict requirements for image skew (NTE 1/100 mm page length)

Two main civil telecommunications networks are in operation with Soviet COMSATs: the Orbita 2 network for domestic service and the

Intersputnik international network. The space segment of the Orbita network consists of Molniya 3, Raduga, and Gorizont satellites. The ground segment is made up of "about 100" large Earth stations most of which employ 12-m (TNA 57) parabolic antennas, one of which is illustrated in Figure 3-22. The Orbita network is used for television distribution, newspaper facsimile distribution, telephony, and telegraphy. A portable ground station known as "Mars" with a 7-m dish can also work with the Orbita system. It has the capacity of one TV channel or an equivalent communication trunk, and is air transportable and truck mounted. It has been in use since 1973 (usually for TV relay). Both FDM and TDM circuits are available for domestic service. TDM streams typically have the higher capacity.

Intersputnik was established in 1971 as a socialist alternative to Intelsat. Although originally subscribed to by only European Communist countries, Mongolia, and Cuba, it is open to any state. Many Soviet-aligned "neutrals" have joined in recent years including Vietnam, South Yeman, Afghanistan, Syria, and Laos. Algeria and Iraq also lease channels from Intersputnik because it is cheaper than Intelsat. Each subscriber must establish a station built to Orbita (12-m dish) standards, but the equipment need not come from the USSR (Nippon Electric supplied most components for the stations built in Algeria and Iraq). The space segment consists of four transponders on Gorizont-Statsionar 4 and two on Gorizont-Statsionar 5. Typically, nearly half this capacity is devoted to television and radio broadcast interchange, with the balance devoted to single channel per carrier (SCPC) telephony and telegraphy generated through the use of "Gradient-N" channeling equipment.

An important feature of Soviet COMSAT systems is the high degree of equipment standardization. Only three transmitters are used within the entire range of civil telecommunications systems, with characteristics shown in Table 3-10. Likewise, Orbita receiving equipment is standardized, the installations differing mostly between



SOURCE: Reference 31

Figure 3-22. Orbita Ground Station

those intended for broadcast distribution only and those which also can receive telecommunications streams.

Table 3-10. Transmitters Used With Soviet COMSATs

Nomenclature	Power Output (kW)	Frequency Band (GHz)	Cooling	Use
"Gradient"	10	5.975-6.225	Water	Ehkran Earth Stations
	3	5.975-6.225	Water	Mars-2 Earth Stations
"Gelikon"	3	6.000-6.250	Air	Other Earth Stations
"Grunt"	0.2	5.975-6.275 (1 of 6 WB Trunks)	Air	"Gradient-N" Trunks "Gruppa" FDMA Telephony

At least three standard forms of multiple access equipment are used*; two incorporate frequency division multiple access (FDMA) techniques and the third uses time division multiple access (TDMA). The "Gradient-N" FDMA equipment is mostly used in Intersputnik service; there are 200 carriers in the SCPC trunk, and two must be combined to form a duplex channel so the capacity of a trunk organized with this equipment is only 100 duplex channels. "Gruppa" equipment can place either a 12-channel FM multiplexed group or a 512-kbps digital system stream on each of up to 24 carriers. Total trunk capacity is 288 FM channels or in excess of 12-Mbps digital data.

"The MDVU-40 equipment is based on the TDMA principle with a 40-Mbps line digital stream transmission rate in a satellite trunk. The equipment is intended for joint operation with terminal equipment that performs analog-digital conversion either of a standard 60-channel frequency division multiplex group (the binary stream rate is 5.12 Mbps)

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*This list is probably <u>not</u> exhaustive or of eight standard audio frequency channels (binary stream rate is 512 kbps). In either case, pulse code modulation is used for analog-digital conversion" (Reference 32). The MDVU-40 equipment may be used either alone (carrying only telecommunications channels) or in conjunction with "Orbita RV" equipment for distributing audio/facsimile transmissions, in which case its normal telephony capacity is halved. Up to 36 stations can be accommodated in TDMA networks formed using this equipment. Each of these multiple-access systems provides pilot tones and service channels to accomplish the "orderwire" function. In the case of MDVU-40, the service channel uses voice "delta-modulated" at a 16-kHz rate.

Although they use the same frequency bands as Western COMSATs for the most part, Soviet systems such as Molniya, Raduga, and Gorizont differ in significant ways from Western counterparts. Their service life is typically much shorter, and they carry less than half as many transponders (of roughly equivalent bandwidth) per satellite. The satellite modulation and access schemes do not incorporate the flexibility of techniques common in the West. On the average, the Soviets appear to be between 5 and 10 years behind Western countries in several areas of COMSAT technology.

3.8 TRANSMISSION SYSTEM R&D

Soviet R&D intended to lead to improved civil telecommunications transmission systems is primarily involved with satellite communications and landlines. In addition to the items discussed below, it should be remembered that several of the higher-capacity transmission systems of their "standard" hierarchies—the K-10800 FDM and the IKM-1920—are still considered experimental, and that the IKM-7680 is best described as conceptual.

3.8.1 COMSATs

Since the experimental 14/11 GHz Luch* (Ray) transponder was orbited on Gorizont 5 on 15 March 1982, the USSR in conjunction with all its European CEMA partners except Romania, has been using the transponder as part of a research project known as the "Dubna Test Bed" (Reference 33). Dubna is a city some 128 km north of Moscow, and in addition to being the primary ground station for the Luch experiment, the test-bed also includes ground test facilities for 11-, 20-, and 30-GHz communications. The other end of the experimental COMSAT link is at Nev Holm in the GDR, and receive-only terminals are located in other CEMA countries. The first-class ground terminals, which can transmit and receive, employ 12-m dish antennas; the second-class receive-only terminals require only 3-m dishes. Objectives include an "integrated study of RF propagation above 10 GHz" and "assessment of atmospheric/weather influences on data transmission at frequencies greater than 10 GHz" (Reference 32). The experiment was scheduled to be completed in 1985.

Opening up the Ka and Ku bands for satellite communication will greatly expand the bandwidth potentially available to the USSR for telecommunications, as well as enhancing transmission security because of the smaller broadcast footprints at the higher frequencies. It should be noted, however, that the Soviet efforts considerably lag Western state of the art in this area. The first commercial satellite carrying Ku (14/11 GHz) band transponders was launched by Canada in 1978, and many have since followed. The first U.S. space tests of Ka-band (44/20 GHz) communications will begin after the launch of FLTSATCOM 7 in 1987.

3.8.2 Superconducting Cables

The Soviets have reported successful experiments involving cryogenically-cooled, miniature, coaxial cables (Reference 34) over a 3-km distance. These experiments resulted in an extremely wide, usable

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*Luch is sometimes also spelled Loutch or Lutch.

bandwidth and high data throughput without frequent repeaters. Many aspects of this "BSPK-50" test, however, indicate a program still in the early research stages. While the author of Reference 33 attempts to create the impression that the Soviets are as near to making superconductive cable a viable transmission medium as are the Japanese, the facts suggest otherwise.

3.8.3 Waveguide Communication Lines

During the 1970s, the Soviets reported significant research on communications by means of millimeter waves (30 to 120 GHz) propagating within closed waveguides. These were represented as being suitable for high-capacity digital data transmission within the primary YeASS network. Both line and spiral waveguides and combinations of the two were investigated. Although Reference 29 reported that by 1980 "the major technical problems have been practically solved," recent literature takes little note of this transmission medium. It seems likely that this technology has been obsoleted by rapid developments in the field of fiber optics over the last decade.

3.8.4 Fiber Optics

The wide scope and large magnitude of Soviet fiber optics R&D suggest a well-funded, serious program. Work is being performed on all crucial phases of this technology needed for near-term and realizable future developments. Generally Soviet laboratory prototypes closely follow, both in time and reported results, comparable Western developments. But Soviet prototypes have tended to remain in the laboratory environment because of difficulties associated with manufacturing and control. One field in which the Soviets have the potential to overtake Western R&D efforts is integrated optics. Their advanced understanding of solid-state theory and materials science may help in the design of novel, integrated, optical systems for application in computer architecture and fiber-optic communication system components.

Soviet fiber-optic R&D efforts can be subdivided into the following areas:

1. 2 to 11-μm fibers and new approaches to 0.8 to 2.0-μm fibers;
2. Advances in manufacturing technology, primarily in response to the demonstrated superiority of existing Western capabilities;
3. New sources and detectors for use at 1.3 μm and above;
4. Connector technology;
5. High-speed repeaters;
6. Spectral multiplexing to utilize the large bandwidth of fibers;
7. Understanding fundamentals of optical transport within fiber waveguides, and the effects of environmental disturbances on it; and
8. Integrated optics and hybrid electronic-optical structures.

A sampling of the published Soviet R&D work is presented below to highlight the scope of these efforts.

Optical fibers which support transmission in the 2 to 11-μm region offer the potential to decrease fiber losses to 10^{-1} to 10^{-3} dB/km. The authors of Reference 16 state that, as of 1982, "the literature does not contain any reports on the fabrication of low-loss infrared (greater than 2 μm) optical waveguides, but there is intensive research on the subject." The use of arsenic-sulfur and arsenic-selenium glasses for transmission in the 3.4- to 4.7-μm band is investigated in Reference 35, and the interaction of 10.6-μm radiation with KRS5 waveguides is discussed in Reference 36. New approaches to fibers in the 0.8- to 2.0-μm regime include using chalcogenide vitreus glasses such as As_2S_3, As_2Se_3, As_2Te_3, and Sb_2Se_3 to fabricate fibers (Reference 37); and using organic salts of suitable metals as dopants in fibers (Reference 38). Reference 39 claims the capability to fabricate graded index fibers by the chemical vapor deposition method with losses as low as 0.25 dB/km at 1.55 μm and a bandwidth of 900 MHz.

In order to utilize these advances in fiber technology, associated system components must be improved as well. For operation in the 1.0- to 1.6-μm regime, the most promising source is the GaInAsP heterostructure laser (Reference 40). The most popular detectors of radiation being investigated by the Soviets for use in this frequency range are the geranium avalanche photodiode and the GaInAsP photodiode (Reference 41). Although somewhat dated, Reference 42 presents a good insight into Soviet perceptions of the prospects for using the 1.0- to 1.6-μm band and suggests some of their current research directions. Source and detector developments for fiber optics are also aided by the complementary developments in infrared atmospheric communication and infrared imaging in the USSR.

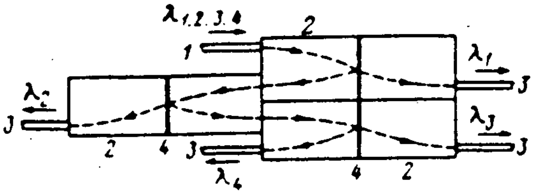
To date, connector technology has been the greatest barrier to successful implementation of practical, system-level fiber optics in the Soviet Union. Although there has been an effort to analyze the losses in present connectors and couplers, and a stated emphasis of the need for better components, little R&D work can be identified in this area. What effort has taken place has tended to be directed toward developing laboratory elements sufficient to demonstrate the properties of fibers, sources, detectors, and the like. Not surprisingly, the resulting connectors tend to be bulky and impractical for implementation in telecommunication and computer systems.

Repeater development assumes increased importance to the Soviets due to their apparent inability to fabricate long, continuous fibers. Reference 43 contains an analysis of a high-speed repeater that operates at transmission capacities in excess of 1 Gbps. The design is based on the controlled Gunn diode which aids in restoring the pulse amplitude and duration. The authors note that it may be possible to combine the detector, source, and Gunn diode elements into one substrate in an integrated form.

As a method of utilizing the large bandwidth in the optical frequency domain, spectral multiplexing is very attractive and has been the subject of a number of papers. An excellent review article (see Reference 44) contains an assessment of the Soviet and Western methods of achieving spectral multiplexing as of 1983. The methods described for multiplexing and demultiplexing in frequency include interference filtering, Figure 3-23 (a), diffraction at gratings, Figure 3-23 (b), focusing rods combined with gratings, Figure 3-23 (c), concave gratings, Figure 3-23 (d), holographic elements, Figure 3-23 (e), and integrated waveguide structures, Figure 3-23 (f). The author concludes that spectral multiplexing of optical fibers can be used to handle tens of channels in one fiber tens of kilometers long. Two prototype spectral multiplexed fiber optic communication lines were also operated experimentally. The first (Reference 45) used a laser source and the grating multiplexer/demultiplexer shown in Figure 3-23 (b). The second (Reference 46) utilizes a light emitting diode, combined with a set of optical filters, to multiplex and demultiplex using a diffraction grating structure also similar to Figure 3-23 (b).

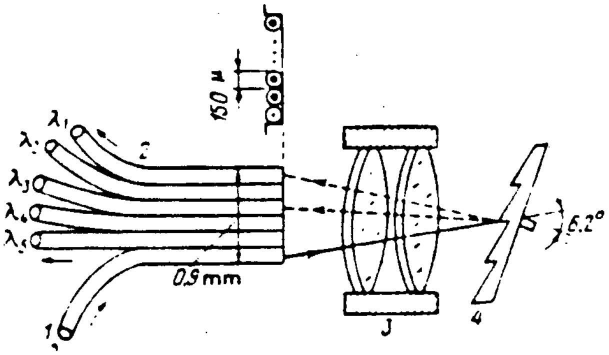
There have also been intensive investigations into the effects that different environmental factors have on fiber systems. For example, factors that are affected by thermal variations are considered in Reference 47, and Reference 48 discusses the use of different polymeric coatings to extend the temperature immunity of a fiber. The effects of mechanical stresses on the fiber are considered in References 49 and 50. Losses due to the relaxing of a polymer protective coating, which causes microbends in the fiber, are analyzed in Reference 51, and the effect of water on fiber strength is evaluated in Reference 52.

The area of integrated optics is receiving a lot of well-deserved attention by the Soviets. This technology is the key to creating efficient optical computers and processors. Reference 53



1. INPUT FIBER
2. FOCUSING RODS
3. OUTPUT FIBERS
4. INTERFERENCE FILTERS

(a) Consecutive Demultiplexing of Four Components Using Filters

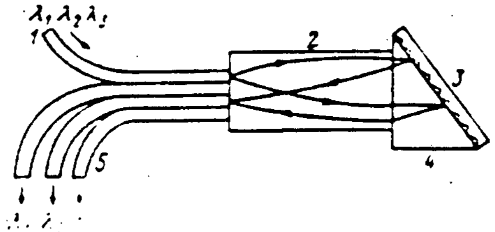


1. INPUT FIBER
2. OUTPUT FIBERS
3. OBJECTIVE
4. GRATING

(b) Parallel Demultiplexing by a Diffraction Grating and Autocollimator

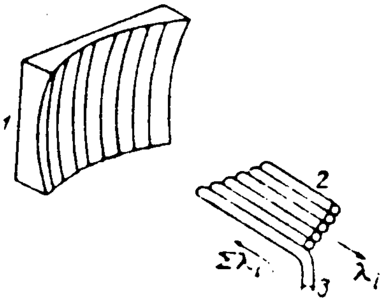
SOURCE: Reference 44

Figure 3-23. Fiber-Optic Demultiplexing Techniques



1. INPUT FIBER
2. FOCUSING ROD
3. GRATING
4. PRISM
5. OUTPUT FIBERS

(c) Focusing-Rod Demultiplexer

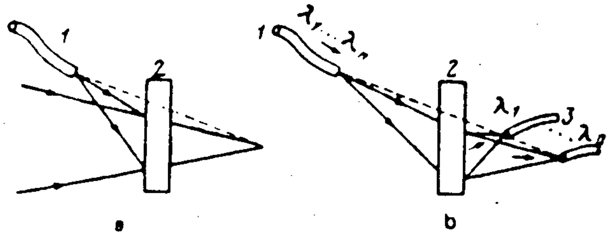


1. GRATING
2. OUTPUT FIBERS
3. INPUT FIBER

(d) Concave-Grating Demultiplexer

SOURCE: Reference 44

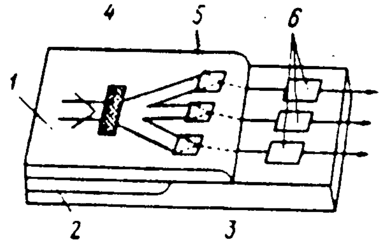
Figure 3-23. Fiber-Optic Demultiplexing Techniques (Continued)



a. METHOD TO RECORD HOLOGRAM
b. DEMULTIPLEXING SCHEME
1. INPUT FIBER 2. GELATIN FILM 3. OUTPUT FIBERS

(e) Holographic Demultiplexing

1. THIN-FILM (3 to 5 μm) As_2S_3 WAVEGUIDE
2. INSULATING S:0_2 FILM (0.5 μm)
3. SILICON PLATE
4. SUPERIMPOSED BRAGG GRATINGS
5. BIPOLAR PHOTO-TRANSISTORS
6. TRANSISTOR SWITCHES



(f) Integrated Optical Waveguide Demultiplexer

SOURCE: Reference 44

Figure 3-23. Fiber-Optic Demultiplexing Techniques (Concluded) discusses research involving integrated structures of $LiNbO_3$, CdS, and ZnSe for modulating the light in a communication system. Although this source is dated 1979, it contains good review material. The capability of the Soviets to manufacture thin film waveguides in integrated structures is discussed in Reference 54, and the potential of the present state of hybrid optical devices is shown in Reference 55. It can be assessed that the Soviets may keep pace with the West in this very important field.

4. THE OAKTS

4.1 NETWORK ARCHITECTURE

The OAKTS is the largest single secondary network of the YeASS. At present, the nationwide telephone network does not completely conform to the outline of the OAKTS because of the way it evolved. For many years, the Soviet long-distance telephone network was built and expanded on the "radial center" principle (star topology). In order to accommodate increased traffic flow, tandem connections were made at all levels. The organization of tandem centers and tandem exchanges was a first step toward network rationalization. Tandem centers are connected to each other by the "each-to-each" principle (grid topology) and the tandem exchanges by direct channels to the tandem center serving their territory.

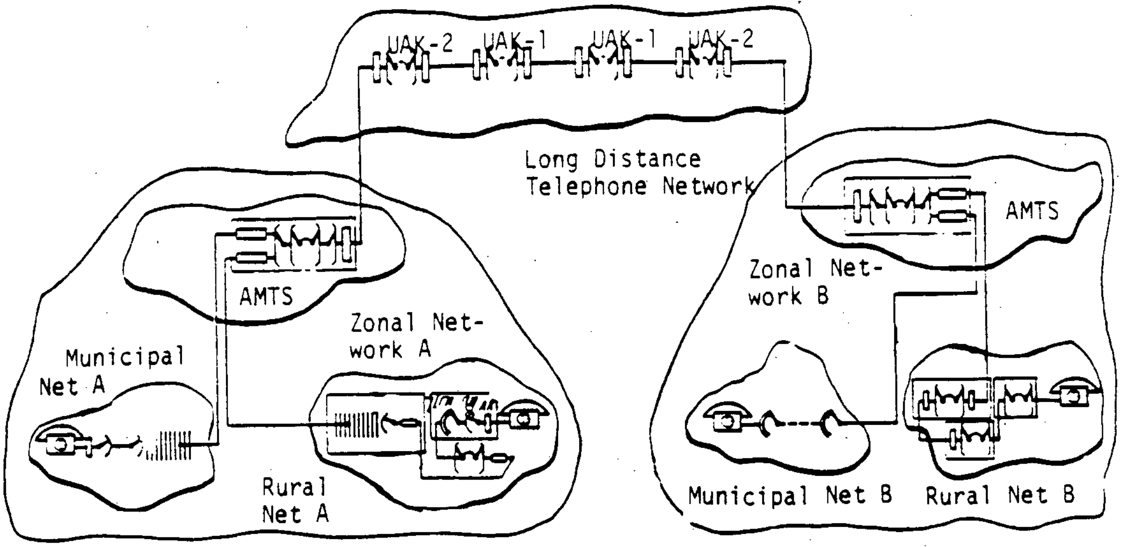
The term "automatically switched" in the OAKTS title is also presently somewhat of a misnomer. As of 1983, "almost 50% of all long-distance channels employed automatic methods for making connections. By the end of the 11th 5-year plan (1985) the level of automation of long-distance telephone communications is to reach 55%" (Reference 56). Even where automation has been achieved, the quality of service is not satisfactory. "The average number of attempted connections per conversation is 3.1 to 3.5, while the optimum number is 1.6 to 1.8" (Reference 56). Widespread use of "step-by-step" switches in the automatic exchanges severely limits utility of the OAKTS for digital data transmission. However, there are plans to reduce or eliminate these deficiencies. The OAKTS is being developed in stages; the 11th 5-year plan (1981 to 1985) is phase one. Physical construction will be completed by the end of stage two, which is to be the completion of the 12th 5-year plan (1990).

The OAKTS consists of long-distance and zone networks. The latter include local (municipal and rural) and intrazone telephone networks. The long-distance network incorporates automatic long-distance telephone exchanges (AMTS), first- and second-class automatic switching centers (UAK-I and UAK-II), and bundles of voice-grade channels obtained from the primary network. All automatic long-distance exchanges are terminal exchanges in the long-distance network, and are connected to automatic switching centers by bundles of high performance channels. In the future, it is planned that all automatic long-distance exchanges will have direct access to two automatic switching centers. Automatic switching centers (tandem exchanges) are intended to handle tandem traffic and to distribute telephone traffic between automatic long-distance exchanges. Automatic long-distance exchanges, however, can be directly connected to one another if traffic density dictates.

All class-I automatic switching centers (UAK-I) are connected to one another by direct bundles of channels designed for high-performance transmission which form a "last choice path" for long-distance traffic. These channels carry telephone traffic between automatic long-distance exchanges, which was not able to be accommodated over a more direct path. Figure 4-1 shows operation of the long-distance phone network in this limiting case (i.e., the "last choice path").

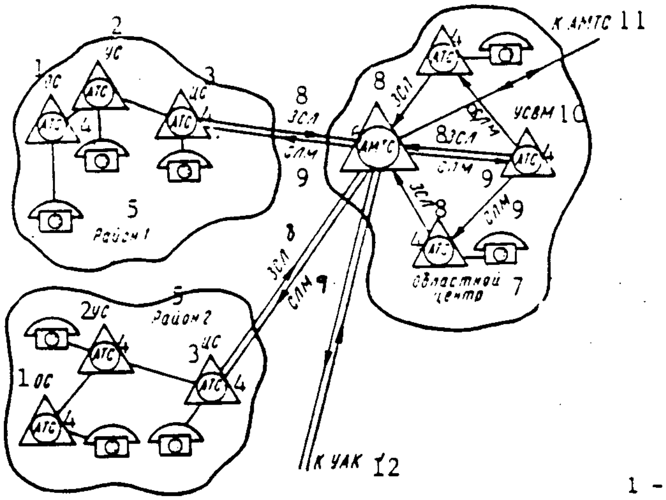
All zone telephone networks are also part of the OAKTS. These networks provide telephone communications between subscribers within a zone and, via the long distance network, subscribers in other zones. These networks also provide access to the international telephone network (Automatic telephone communication has been in effect between Moscow, East Berlin, Prague, Warsaw, and Budapest since 1970, and with Sophia since 1974). A zone usually, but not necessarily, corresponds to a political division. As a rule, a zone will contain only a single, automatic long-distance exchange, although exceptions are made where technically or economically advisable. A diagram of a conceptual automatic zone communications network is shown in Figure 4-2.

With automatic and semiautomatic long-distance telephone communications, the called party is dialed by the calling party or



SOURCE: Reference 6

Figure 4-1. Long-Distance Calling Between Zones



1 - Terminal exchange (OS); 2 - Node exchange (US); 3 - Central exchange (TsS); 4 - Automatic telephone exchange (ATS); 5 - Region; 6 - Automatic long-distance exchange (AMTS) (LDX); 7 - Oblast' center; 8 - Recording-completion trunk (ASL); 9 - Toll trunk (SLM); 10 - USVM [expansion not given]; 11 - To automatic long-distance exchange (LDX); 12 - To automatic switching center (UAK).

SOURCE: Reference 6

Figure 4-2. Construction of Automatic Zone Communications Network operator in the following manner: 8-ABC ab xxxxx, where "8" is the access code for the automatic long-distance exchange; ABC = three-digit, long-distance zone code; ab = two-digit code for 100-thousands group of exchanges or regions within zone; and xxxxx = five-digit local subscriber number. In order to make an automatic connection with a subscriber within his own zone, a caller must dial the guide digit "2" instead of the three-digit, long-distance code. The number dialed in this case is 8-2 ab xxxxx.

While there are similarities between this description of the Soviet national telephone system (drawn entirely from Russian sources, principally References 6 and 55) and that which operated in the United States prior to AT&T divestiture, certain marked asymmetries are also evident. The most obvious is the number of subscribers serviced by the two systems. The United States, with approximately 71 telephones per 100 population (1983), ranks number three in this statistic among the countries of the world (after Sweden and Switzerland). Comparable figures for the entire Soviet Union are not available,* but judging from some statistics for Eastern European countries (East Germany 20 telephones/100 population, Hungary 12.5/100, and Poland 10/100), the number of subscriber instruments serviced is probably less than one-fifth that in the U.S. (Reference 57). The majority of phones in the USSR are located in state-run establishments (Government bureaus, state industries, businesses, and collective farms) with location in residences less common.** This smaller subscriber popoulation translates into a smaller number of required exchanges—perhaps about one-fourth the 21,000 operating in the U.S. in 1983. In turn, this requires a less hierarchical system; the OAKTS appears to have a four-level hierarchy—UAK-1, UAK-2, AMTS, and central office. The

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*Available information suggests, however, wide variation between various regions of the USSR with 14.57/100 population in rural Latvia and only 1.06/100 in rural Tatzhikistan (national rural average 4.04/100).

**However the Soviets claim that 3.5 million of 6 million subscribers added in 1975-1980 were "residence telephones."

predivestiture Bell System hierarchy in the U.S. had five levels—Regional, Sectional, Primary, Toll, and Local Central. Another asymmetry concerns the level of system automation, which exceeded 90% in the U.S. in 1970 and is close to 100% today, while in 1985 (if all 5-year plan goals are accomplished) it is scheduled to reach 55% in the USSR. Finally, it should be noted that despite a much smaller system which is also much more labor intensive, Soviet subscribers enjoy service which, by official admission, does not meet norms and is certainly much poorer than would be accepted in the U.S.

It should be not be assumed, however, that poor telephone service is experienced everywhere in the USSR. As a result of enjoying the highest priority for installation of imported equipment over the last decade and a half, telecommunications within and between Moscow and Leningrad are probably significantly better than in the country as a whole. Many of the European Republics (Latvian, Lithuanian, Moldavian, and Belorossian) enjoy automated service on a far higher percentage of lines than the national average while in the Turkman, Tadzhik, Azerbaydzhan, and Georgian SSRs only 18 to 25% of connections are automated. Reports of new equipment installations and modernization plans (Reference 56) suggest continued priority on improving service in and between major cities of the European USSR (Vilnius, Minsk, Kiev, Khar'kov, and Rostov on Don). Near-term upgrades are also planned for Tashkent, Alma-Ata and Novosibirsk.

4.2 SUBSCRIBER EQUIPMENT

Several types of telephone sets, including the TA-60, TA-65, and TA-72, are manufactured in the USSR. Additionally, the Soviet Union imports significant numbers of telephones from its CEMA partners Poland, Czechoslovakia, and the GDR. Most of these phones are probably of the dial type, although newer types of exchange equipment are compatible with pushbutton sets. There are also coin-operated telephones for long-distance service, of which the latest model is designated MTA-15-3 and includes a rate-computing attachment. It should not be assumed these are widely distributed; in 1982 there were only 1200 coin-operated phones in all of Belorussia (population more than 10 million)! All of these telephones are conventional analog models intended for operation on normal, analog, voice-grade channels.

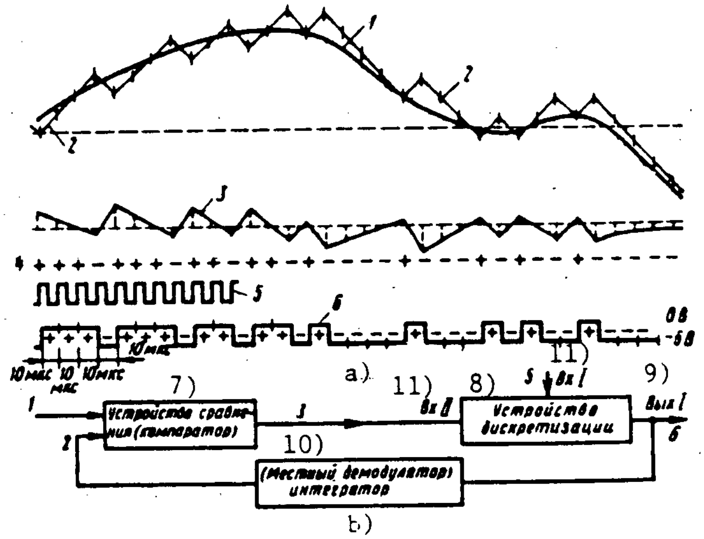
Although the need for substantial quantities of such instruments seems far off, the Soviets have published a number of articles describing digital telephones. In most cases, these have used a special form of differential PCM called delta modulation. In delta modulation what is transmitted is not a function of the total message but only the sign of an increment referenced to previous samples in calibrated time slots. The process of implementing delta modulation in a CODEC is illustrated in Figure 4-3. This type of modulation seems similar to the continuously variable slope delta modulation used to digitize voice at 16 kbps in Tri-Tac digital subscriber voice terminals, but differs significantly from the more straightforward 8-bit PCM approach used in T-carrier systems in the U.S.

A drawback of delta modulation is that distortions occur during transmission of fast changes of a signal. In order to reduce this problem, a modified coding referred to as "adaptive delta modulation" can be used. Adaptive delta modulation is said to reduce the required digital channel capacity to only 10-16 kbps instead of the 64 kbps that would be needed for normal 8-bit PCM coding of a voice grade channel. Several Soviet engineers have been issued patents for various voice coding (vocoding) schemes that would reduce the transmission requirment further to the 1200- to 2400-bps range.

Equipment used for data transmission over the telephone network will be described in Subsection 6.2.

4.3 TELEPHONE SWITCHING SYSTEMS

The Soviet Union has historically been quite backward in its introduction of automatic switching into the national telephone network. Widespread automation of long-distance traffic did not begin until about



a -- diagrams of voltages;
b -- structural diagram: 1 -- input LF signal; 2 -- local demodulated signal; 3 -- difference of the two signals; 4 -- polarity of the difference signal after digitization; 5 -- digitized signal; 6 -- encoded signal.

7) Comparator
8) Digitizer
9) Output
10) (Local demodulator) integrator
11) Input
[мкс=μs; B=V]

SOURCE: Reference 27

Figure 4-3. A Delta Modulator

1971. Even in 1982 a Soviet author (Reference 56) noted that: "in spite of all the work being done to automate long-distance telephone communications, manual and semi-automatic traffic comprise a major share...there will be practically no reduction in its absolute amount...(for) about the next five years." Consequently, as late as the early 1980s, considerable effort was being devoted by the MOC to develop and field equipment designed to improve operator efficiency. This included cordless switchboard equipment and "light weight headsets without headbands."

The same four generations of automatic telephone switching equipment can be distinguished in the U.S., the USSR, and the rest of the world.

1. Step-by-step or 10-step exchanges are comprised entirely of bulky electromagnetic relays, many of the pulsed-rotary type from which the term "step-by-step" is derived. These use progressive control where each dialed digit successively sets up a communication path through the exchange. This is the simplest type of control to implement with electromagnetic components, but has the drawback that all equipment is tied up for the duration of the call and that even if a clear path is available it may not be properly selected because of an unfortuitous early step in the selection process. Exchanges built on this principle require a great deal of space and are very noisy in operation.

2. Crossbar exchanges are also composed of electromechanical relays but the "common control" principle permits some real improvements over step-by-step systems. All dialed digits are accumulated in a register, and then the equipment selects the optimal route. This arrangement uses less equipment to "hold" a call than to "establish" one, with a corresponding increase in operating efficiency. Crossbar equipment is considerably smaller than step-by-step, quieter in operation, easier to maintain, and uses less power.

3. The Soviet writings all refer to the third-generation equipment as "quasi-electronic" to distinguish it from the forth-generation; this nomenclature is not generally used in the United States. Quasi-electronic exchanges implement stored program control over the switching process with special-purpose digital computers, but the switching

elements themselves are still basically electromechanical. Switching element contacts are usually enclosed in glass tubes, which greatly improves reliability. Because the control element is a computer, it is possible to introduce a variety of specialized services such as conference calling and call forwarding.

4. Fourth-generation exchanges are entirely digital with both the control computer and switching elements composed largely of integrated circuits. In contrast to the first three generations which were strictly space-division switches, time-division switching is often implemented in fourth-generation equipment, which truly deserves its name "electronic switching." This generation of exchanges is fully compatible with the needs of an all-digital network like the ISDN.

Figure 4-4 compares the dates when the various switching generations first entered service in the U.S. and the USSR. The U.S. lead in the introduction of new switching technologies has been reduced from approximately 20 years for crossbar equipment to 14 for quasi-electronic switching and only 7 for fourth-generation gear. As in many other areas of the Soviet economy, this performance has been achieved primarily by importing, and in many cases copying, foreign-made equipment. A rather surprisingly small portion of switching equipment presently in service represents original Soviet designs, and this trend shows little sign of changing.

Soviet telephone switching plants are usually divided into local and long-distance equipment by intended use, and the distinction is important. Local switching, particularly in the major cities, was the first to be implemented; consequently, more obsolete step-by-step equipment is in service at this level. Despite considerable effort to modernize local telephone service, at least 50% of the switching plant employs "10-step" switching. Local switches are often distinguished as being intended for municipal or rural exchanges, which implies differences in the number and lengths of subscriber loops they are designed to accommodate; although, in practice, some cross-application occurs. Table 4-1 (drawn mostly from References 58 and 59) summarizes the most important types of exchanges in local service. Many types of

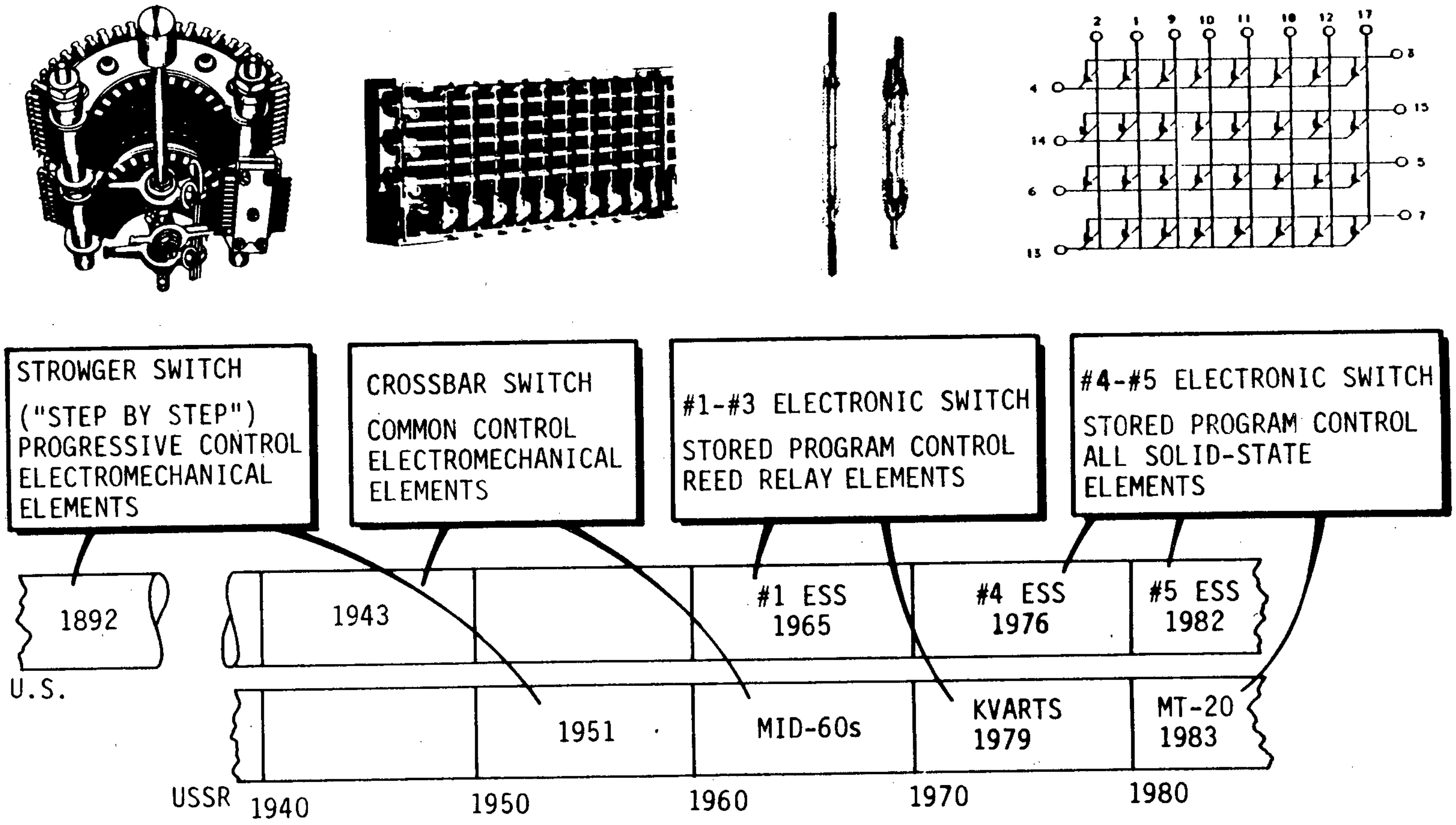


Figure 4-4. Comparative Timelines for Telephone Switching Evolution

Table 4-1. Soviet Local Telephone Switches

Designation	Type Switch	Category	Capacity	Year Fielded	New Installation?	Remarks
ATS-47	10-Step	Municipal	10,000 ln	1951	Obsolete	Unreliable, expensive, and a fire hazard
ATS-54	10-Step	Municipal	2,000 ln	1960	Obsolete	Derived from ATS-47, corrected many problems
ATS-54A	10-Step	Municipal	2,000 ln	1970	Obsolescent	Further evolution
ATS-VRS-20M	10-Step	Rural			Obsolete	Cannot be used for long-distance access
VRS-50/100	10-Step	Rural	50/100*	1964	Obsolete	
ATS-10/40	10-Step	Rural	10/40	1967	Obsolete	Cannot be used for long-distance access
ATS-50/100	10-Step	Rural	50/100	1964	Obsolete	Cannot be used for long-distance access
ATS-100/500M	10-Step	Municipal	100/500	1970	Obsolescent	
ATS-50/100M	10-Step	Rural	50/100	1970	Obsolescent	
ATS K-40/80	Crossbar	Rural	40/80		Obsolete	Cannot be used for long-distance access

*To be interpreted as having a basic capacity of 50 lines, expandible to 100 in blocks of 50. Other figures below are designed similarly.

Table 4-1. Soviet Local Telephone Switches (Concluded)

Designation	Type Switch	Category	Capacity	Year Fielded	New Installation?	Remarks
ATS K-50/200	Crossbar	Rural	50/200		Obsolescent	3-digit open numbering only
ATS K-50/200M	Crossbar	Rural	50/200		Recommended	5-digit open/closed numbering
ATS K-100/2000	Crossbar	Rural	100/2000	1983	Recommended	3- and 5-digit open/closed numbering
RS-1000S	Crossbar	Municipal	1000/Block	1979	Recommended	Imported from Poland and Romania
"Istok"	Quasi-Electronic	Rural	4,096 ln**	1980?	Recommended	Fully analog/digital compatible, made in USSR and GDR
"Kvant"	Quasi-Electronic	Large PBX and Rural	4,096 ln	1979	Recommended	Technology similar to AT&T #3 ESS
Metaconta 10C	Quasi-Electronic	Municipal	63,000 ln**		Recommended	Manufactured in Yugoslavia under ITT license
MT-25	Electronic	Municipal	65,000 ln**	1983	Recommended	Manufactured the in USSR under French license

**Maximum capacity.

local exchanges were not designed for incorporation into a nationwide network because they use a numbering system inconsistent with the OAKTS and do not incorporate automatic (caller) number identification. In many cases, it will probably prove more economical to replace these obsolete exchanges rather than modernize them.

Widespread automation of long-distance telecommunications was not initiated until the early 1970s, so long-distance switching is not plagued by the same high proportion of obsolete equipment. It is estimated that approximately 60% of mainline switching is by crossbar exchanges. Characteristics of the most important types of toll exchanges are shown in Table 4-2.

At least three different approaches are simultaneously being taken by the Soviets in an effort to modernize their telephone switching plant with third- and fourth-generation equipment. As an interim measure, they are importing a number of exchanges. One supplier the Soviets publicly acknowledge is the Iskra firm in Yugoslavia which produces "Metakonta-10S quasi-electronic exchanges..in accordance with the USSR Ministry of Communications specifications" (Reference 55). These are believed to be minimally modified versions of the Metaconta 10C exchange which Iskra manufactures under license to ITT*. Overtures to other Western or Western-licensed suppliers of third-generation equipment are also likely. The expertise is so widespread and the industry so competitive that the USSR can probably obtain multiple bids on third-generation exchanges.

As a more long-term solution, the USSR and some of its European CEMA partners are cooperating in development of third-generation exchange equipment in a program called ENSAD. While Hungary and some other CEMA members have developed advanced small exchanges of PBX size, the most significant results have come from USSR/GDR bilateral cooperation. In 1979 a quasi-electronic prototype long-distance

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*Among the known installations of this equipment is the Moscow international telephone exchange.

Table 4-2. Major Soviet Long-Distance Telephone Exchanges

Name	Equipment (*4)	Capacity (Chs)	Max Load (ErL/Stg)	Max Calls (PLH)	Prior?	Special Features		
						AON*	KIA**	OKC***
AMTS-1M	DShl	180	100	13,000	no	no	no	no
AMTS-2	MKS	1500/3000	2100	60,000	no	yes	some	no
AMTS-3	MKS	700	500	13,000	no	yes	some	no
ARM-20	MKS	8000	2600	70,000	yes	yes	better	no
ARE-13	MKS	8000	(produced by "Nikoli Testla" Yugoslavia)					
Kvarts	MFS	8000	6400	175,000	yes	yes	yes	yes
MT-20	ELEC	650-40,000	10000	400,000	yes	yes	yes	yes?

NOTES: ARM-20 is built by Ericsson and imported from Sweden. Soviet copy is known as the AMTS-4. MT-20 are manufactured in the USSR (from 1983) under French license.

*AON = Automatic Number Identification. If an exchange lacks this feature, the calling party must also dial in his own number to complete a connection.
**KIA = Automatic Test Equipment
***OKC = Common Channel Signaling
*4 DShl = 10-step rotary (step-by-step); MKS = crossbar matrix switch;
MFS = Ferreed matrix switch; ELEC = all-electronic

Kvarts technology appears similar to 1 ESS (AT&T)

exchange called "Kvarts" was installed in Leningrad. In July 1980 it was placed into experimental operation. By 1982 at least one additional exchange had been installed at Vil'nyus. "During the 12th Five-Year Plan (1986 to 1990) the Kvarts quasi-electronic exchange will be the basic type of long-distance exchange equipment. As "Kvarts"...goes into series production, production of the AMTS-3 equipment will gradually be curtailed" (Reference 56). (Note: the AMTS-3 was the only long-distance service crossbar exchange produced in the USSR in the early 1980s.) It appears that "Kvarts" had teething troubles because series production was not planned to start before 1984.

"Kvarts" was reportedly developed jointly by specialists from TsNIIS (Central Scientific Research Institute for Communications), the Institute of Cybernetics of the Ukrainian SSR Academy of Sciences, and the Robotron Association (GDR). "The switching system is a six-section arrangement consisting of an incoming line unit and an outgoing line unit. Both units employ identification two-section switching groups with 64 inputs and 64 outputs (64 x 64) each of which incorporates sixteen 8 x 8 x 4 ferreed matrix connectors"* (Reference 60). Stored program control is provided by a "Neva 1" control complex (SUVK) which "consists of two special-purpose control machines SUM-1 and SUM-2. Both control machines perform the same functions in making connections, and they compare the results of executing particular operations in servicing each call according to a definite schedule. When the results of some operations fail to match, the machine which is working properly initiates a test program to trace the fault in the malfunctioning machine, and continues to handle all calls (References 60 and 61)." This means that Neva-1 provides many of the same fault tolerance features present in most Western-developed third-and fourth-generation systems.

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*Soviet writings seem to use ferreed (MSF) and "gerkon" (MSG) as almost interchangeable terms. Both are distinguished from the more advanced "Gezakon" connector employed in "Istok."

At the 1983 Leipzig spring trade fair, the Soviets made exceptional claims for performance of the Neva-1M control complex reliability. "Total down time does not exceed 2 hours over 20 years of operation" (Reference 62). These figures do not agree with those obtained during initial testing of the Kvarts exchange (Reference 60), and are suspiciously close to the reliability claimed by AT&T for its 3B20D fault-tolerant processor in the No. 5 ESS exchanges (6 min of downtime per year) (Reference 63). Note that the Neva had apparently undergone modifications as a result of its shakedown program as evidenced by the changed designator. More recent reports speak of a "Neva-2" suggesting further modifications. The East Germans were also active at the Leipzig fair promoting their OZ-1000 terminal electronic exchange which is controlled by a K1520 microprocessor manufactured by VEB Robotron (Reference 64).

The rural "Istok" exchange was also developed as a result of GDR/Soviet cooperation. In many respects, it is superior to "Kvarts" since it is based on a much more modern switching element (called "Gezakons" by the Soviets) and is also more versatile in operation. It is the first truly integrated analog/digital exchange manufactured in the USSR, and is designed to complement the move toward all-digital primary rural YeASS networks.

A third approach may have paid unexpected dividends in terms of digital switching technology advancement for the USSR. In 1975 a Soviet-French working group on Scientific and Technical Cooperation in Communications was set up with membership from the Soviet Ministry of the Communications Industry and Ministry of Communications, and the French Ministry of Post, Communications, and Television Broadcasting. Experts from French firms such as Thomson CSF, CIT Alcatel, and Matra reportedly take part in its work, which is primarily devoted to technical exchanges in the areas of telephone switching and "diverse means of transmission" (with special attention to fiber optics) (Reference 65). Since France is one of the most advanced nations of the means of transmission" (with special attention to fiber optics) (Reference 65). Since France is one of the most advanced nations of the world in telecommunications technology and the USSR among the more backward in the area, it is not difficult to determine which side was more likely to benefit from these "technical exchanges," unless they resulted in trade agreements, which would be likely to aid French industry. The first such agreement was reportedly concluded in 1979. Thomson CSF contracted to provide models of its latest electronic switching telephone exchanges (models MT-20 and MT-25) to the USSR and to set up a factory in the USSR for their manufacture. This was a major breakthrough for the Soviets and could potentially help them advance much more rapidly in the digital switching area than would otherwise have been possible. The model MT-20 and MT-25 exchanges are very sophisticated, four-stage, time division, computer-controlled switching matrices that reflect Western state of the art as of 1980. However, the Soviets could experience difficulty in mastering the NMOS integrated circuit production technology involved in the manufacture of this equipment.

5. THE NATIONAL TELEGRAPH NETWORK

5.1 NETWORK ARCHITECTURE

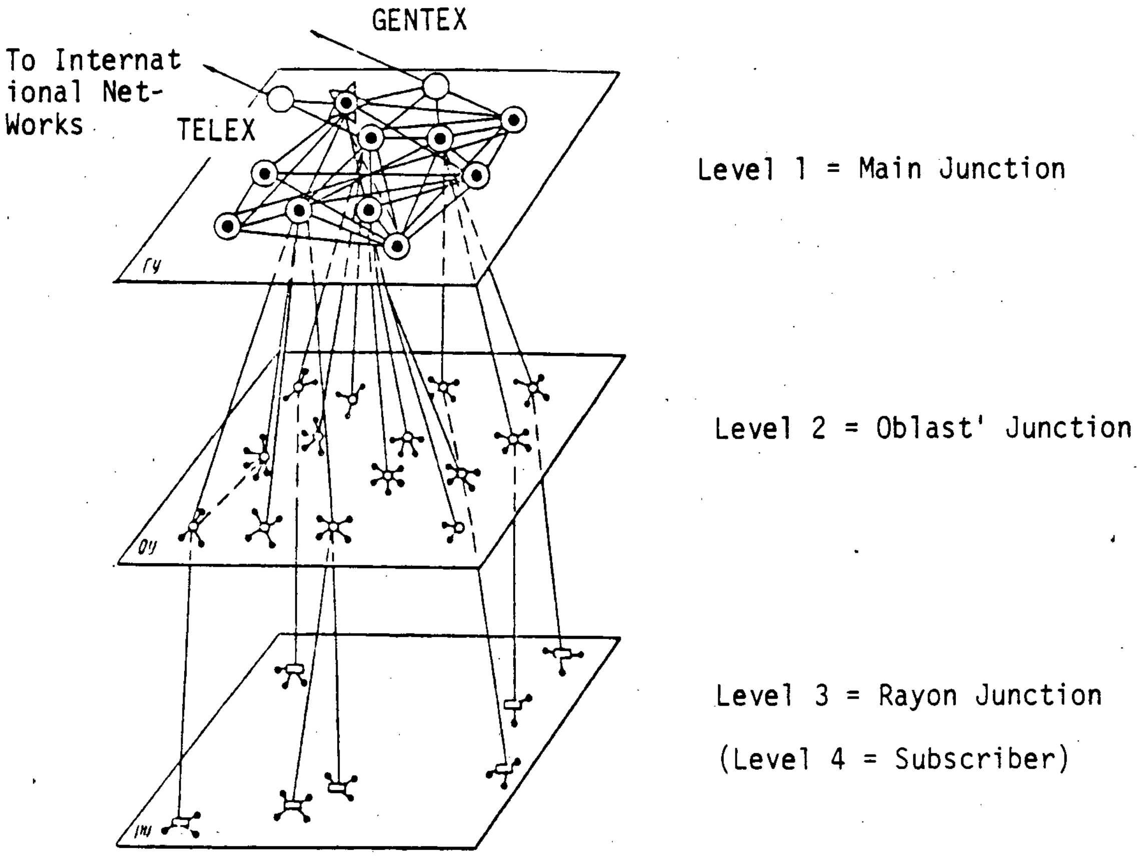
The Soviet National Network (a secondary network under the Unified Automated Communications Network) combines four subsidiary networks (Reference 66):

1. The Public Network (OP), organized between offices of the USSR Ministry of Communications;
2. The Subscriber Telegraph Network (AT), organized between government agencies and institutions;
3. The TELEX international subscriber telegraph network; and
4. The GENTEX international telegraph network of the Socialist countries of Europe.

5.1.1 The Public Network (OP)

The OP is considered the oldest and best-developed low-speed (50 to 75 baud) digital transmission network in the USSR. It has a four-level hierarchy, as shown in Figure 5-1.

The network is said to be built on a "combined" principle, with higher class junctions connected by the "each to all" (mesh or grid) principle and lower class junctions connected radially (star). The entire country is divided into zones, each of which has its own main junction. Main junctions are large oblast and republic centers that handle considerable telegraph traffic, function as transit points for interzonal telegraph streams, and in most cases are located at the intersection of cable and radio relay lines. The Moscow junction is the central junction and functions as the operational supervising junction in the national telegraph network. As shown in the figure, the above-described organization is not rigidly followed at the oblast junction level. Some junctions are connected to the main junctions of other zones as well as their own, and some directly to each other where traffic loads dictate.



SOURCE: Reference 65

Figure 5-1. The Soviet Public Telegraph Hierarchy

The OP includes both a resending network and a direct-connection network. In the resending network, a telegram must be received and retransmitted in each transit office, a somewhat cumbersome procedure. In practice both semiautomatic and automatic systems are used to speed the process. The primary semiautomatic resending system is called "ATOL." The telegraph receiver perforates a paper tape, which is resent on a separate transmitter. Automatic transport is used between the receiving and transmitting equipment (note, this is comparable to technology employed in Western Union networks of the late 1940s). A later evolution was the "LINMAN" system which achieves reduction in number of telegraphers and resending time but at an increase in equipment cost. In addition, the equipment was all-electromechanical, unreliable, difficult to maintain, and, thus, found limited application. Mechanical resending systems like these are considered a semiautomatic application of the message switching principle. Modern message switching networks are based on electronic computers; Soviet efforts in that area are covered in Subsection 5.3.2.

The direct-connection network is a circuit-switched network that incorporates the capability of retransmission in the event that the connection fails. It is implemented with STA-2M start-stop tape machines and manual, step-by-step, and crossbar switching stations. Labor productivity with the direct-connection equipment is three to four times higher than with ATOL and about one and one-half times higher than with LINMAN. A unified six-digit number system is used by the USSR MOC and will eventually be standardized throughout the network. The first three digits are the number of a station (101 to 599 are estimated to be sufficient for a long time; an urgent call is indicated by adding 5 to the first digit of the station number e.g., 601 - 099). The last three digits are the number of a terminal point, with 001 to 499 assigned to municipal communications departments and 500 to 599 to rayon junctions. The number with the fewest dial pulses is assigned to junctions with the heaviest traffic.

The direct-connection system was first adopted in the Estonian SSR with the first direct connection at Tallin. Gradually, several direct-connection zones were formed, and for some time interzonal communications were mostly carried by the resending system. Only after crossbar exchanges were placed in operation in Moscow, Leningrad, and other cities were the unconnected direct-connection zones consolidated.

The pubic telegraph system in the USSR is a relatively more important communications medium than its counterparts in the U.S. and Western Europe. Partly, this is due to the relative difficulty of gaining access to long-distance telephone communications in the USSR. An even more significant factor is that in the Soviet Union much traffic is routed over the "public" network that would be carried over separate military or governmental nets in most Western countries. As a result, modernization of the Soviet national public telegraph network has not lagged the rest of the world by nearly as much as has been the case with their telephone network.

5.1.2 Subscriber Telegraph Network (AT)

The AT is intended for supplying government agencies, enterprises, and organizations of the USSR with direct documental communications. Connection to any other subscriber of the network for half-duplex communication is possible, as is retransmission to nonsubscribers and limited low-speed data transmission to and between computers. The subscriber telegraph system is structurally analogous to the direct-connection system except that the channel switching principle is strictly observed (i.e., there is no provision for resending at switching centers). The network has the same four-level heirarchy as the public network, and is interconnected by the same principles. The subscriber telegraph network presently uses a mixed number system, and will continue to do so until all "register-less" (unmodified step-by-step) switches have been replaced. Ultimately it is hoped to use a similar six-digit number system as in the direct-connection public system.

Subscriber telegraphy got its start in the Soviet Union in 1949 and by 1966 there were 9,000 subscribers. Between 1966 and 1967 this more than doubled to nearly 18,500, and by 1975 there were 33,000 subscribers. By 1981, the subscriber population had reached 67,000, and a general plan provides for 300,000 subscribers by 1990.

The Soviet subscriber telegraph network is directly analogous to the TELEX system operated by Western Union in the U.S. and by post and telegraph ministries in most European countries which services hundreds of thousands of mostly business and industrial subscribers around the world. A similar network, TWX, formerly operated by AT&T, was sold to Western Union in 1970 and combined with TELEX. TWX popularized the term "teletypwriter" or "teletype" which were originally trademarks.

5.1.3 International Networks

The TELEX and GENTEX networks are separated in the USSR and have different switching exchanges and channels. TELEX, an international system, is accessed through the Moscow exchange via an automatic or manual system. To reduce distortion on the TELEX traffic to internationally agreed levels, permission to enter the international network through the Moscow TELEX station is granted only to subscribers of Soviet exchanges that have access to Moscow through not more than one subscriber telephone exchange.

GENTEX is considered a public telegraph network which is organized by the direct-connection system and intended for exchange of international telgrams. Communications are presently possible with Poland, Czechoslovakia, East Germany, Hungary, and Romania; in the future this will be expanded to include direct connections with Western European countries through the Prague and Berlin exchanges. GENTEX is a segregated network without provision for joint use of channels. TW-55

10-step exchanges, manufuactured in GDR, are used as switching centers. The GENTEX network employs a five-digit numbering system, the first two are station numbers and the last three the number of a called terminal.

5.2 SUBSCRIBER EQUIPMENT

In contrast to the situation in the OAKTS, most subscriber equipment operating in the Soviet National Telegraph Network appears to be of domestic manufacture. A few T-51 and T-63 instruments manufactured in the GDR are also in service. Details of Soviet-manufactured equipment in service in 1979 (Reference 26) and one introduced in 1982 (RTA-80) are presented in Table 5-1.

Table 5-1. Soviet-Built Teletype Equipment

Nomenclature	Baud Rate(s)	Major Features
ST-35	50	Very basic
ST-2M	50	Very basic
STA-2M	50	Has tape transmitter/duplicator for use in resending networks
STA-M67	50	Modification of STA-2M
RTA-6	50, 75	Start/stop page printer attached (215-mm wide)
RTA-7	75, 100	Largely electronic; start/stop page print
RTA-80	50, 100	Fully electronic page print

Relatively recently there has been concern over increasing telegrapher productivity. In 1982 a symposium paper (Reference 67) described an experimental telegraph terminal using microprocessor control and a CRT display called "Elit-T." The terminal was intended for use where telegrams are received by telephone, where perforated tape is prepared, or at input stations to the message-switched telegraph network. A number of modifications were incorporated to make the "Elit" video terminal more suitable for telegraphy use. Letter and number keys were arranged in the same order as a teletype machine, function keys for commonly used code sequences were provided, and the alphanumeric screen displayed 69 character lines (as in roll teletype machines). Elit-T was designed for use on telegraph lines having speeds up to 200 bauds, and its output was International Telegraph Code 2 (five-digit Baudot code). Productivity improvements of 16 to 40% were claimed for the device, which was developed jointly by the Central Scientific Research Institute of Communications and its Leningrad and Kiev branches.

While it is unclear if Elit-T was ever placed into production, a somewhat less sophisticated device designated OUKS-T is apparently being placed into widespread service as an input terminal to message-switched telegraph networks (Reference 68). Routing index is dialed by a "push-button dial," and basic codograms are selected by buttons. It is hoped these will greatly reduce operator input errors which cause considerable slowdown when propagated into the message switching computers and usually necessitate retransmissions.

Another attempt to enhance telegraph system productivity is represented by introduction of TAKT apparatus which became available in 1982. This equipment is located in a telegraph switching station and automatically monitors subscriber sections for malfunctions. Those sections which fall below permissible distortion norms are identified and blocked from access to the switch until repaired. This equipment can work on any form of telegraph or data-transmission network so long as the data rate does not exceed 100 baud. It is built largely of integrated microcircuits.

Because of their low data rates, multiple telegraph signals are normally sent over a single voice-grade channel. The multiplexers which combine the telegraphy data streams are referred to as "channeling equipment." Characteristics of Soviet systems in service in the early 1980s are shown in Table 5-2.

Table 5-2. Soviet Telegraph Channeling Equipment

Designator	Year Introduced	Type Multiplexer	Number Channels	Data Rate (bauds)	Meet CCITT and GOST?	Normal Service**			Remarks
						ML	IZ	MUN	
TT-17P	1963	Frequency	17	50	No	X			Group System
TNT-6	1967	Frequency	17	50	No		X		Derived from TT-17P
CHVT-2,11		Frequency/ Time	44 or 28	50 or 75	No	X	X	X	Unreliable
TT-48	1972	Frequency	24,12,6	50,100,200	Yes	X			Individual Principle
TT-12	1975	Frequency	24,12,6	50,100,200	Yes		X		2 Groups
TT-78	post 1980	Frequency			Yes	X			80% IC
DUMKA		Time		50,100,200	Yes	X			UZO 9600,UPS 9600
TVU-12*	1969	Time	12,2,1	200,600,1200	Yes			X	PAM Multiplexer
DATA 3	1973	Time	3	100	Yes			X	
DATA 6	1973	Time	5/1	100/200	Yes			X	
KIT/MOST	1981-3	Time	15	50	Yes		X	X	PCM Multiplexer

*URAL subscriber line separation system can be used in conjunction with TVU-12 to simultaneously transmit digital information (up to 200 baud) and conduct telephone conversations on the same line.

**MUN = Municipal, IZ = Intrazone, ML = Mainline

5.3 SWITCHING SYSTEMS

Two types of switching are used in telegraph networks: channel switching and message switching. Channel or circuit switching, which is almost identical to the process of the same name in telephone systems, will be described first.

5.3.1 Telegraph Circuit Switching

Five generations of telegraph circuit switching centers have existed in the USSR:

1. 10-step exchanges without registers (ATA-Sh, APS-Sh)—now obsolete,
2. The same 10-step exchanges modernized with registers (ATA-Sh-R, APS-Sh-R),
3. Exchanges built on the basis of multiple crossbar connectors (MKS),
4. Quasi-electonic exchanges, which use gercon matrix connectors (MGS) or ferride matrix connectors (MFS), and
5. Entirely electronic, automatic channel switching centers (ESK-A,B).

Ten-step exchanges use step selectors of the DShI-100, ShI-11, and ShI-25 types. The industry is presently manufacturing only crossbar exchanges, but there are still many 10-step exchanges in the subscriber telegraph network. The most important types of exchanges used in the subscriber telegraph network are listed in Table 5-3.

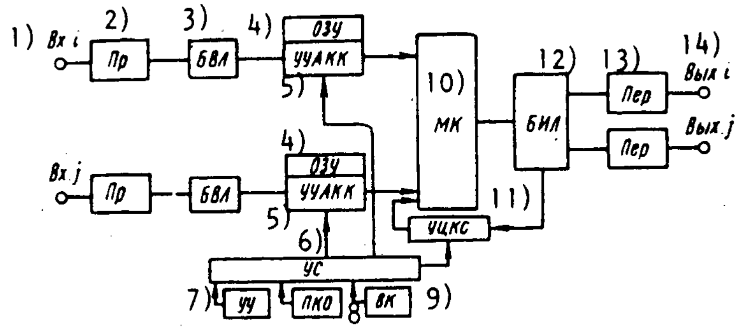
Electronic switching equipment, being designed in 1980, includes the ESK-A electronic switching exchange and the ESK-B electronic switching unattended substation. ESK-A will be able to handle between 512 and 16,394 channels and form up to 400 communications routes. Approximately 2% of total traffic is intended to be 2400 bauds, 4% 1200 bauds, and the balance 200 bauds. It will be common to PD, AT, and PS networks.

Table 5-3. Circuit-Switched Exchanges of Soviet Telegraph Networks

Type of Exchange	Type of Switching Instruments	Number of Subscriber Sets	Number of Main Line Channels	Location
ATA-57-1 (AT Net) APS-57-1 (OP Net)	DShI*	Up to 1000	Up to 800	Main and major communications junctions
ATA-57-2 (AT) APS-57-2 (OP)	DShI	Up to 300	Up to 300	Medium oblast communications junctions
ATA-K (AT) APS-K (OP)	MKS**	From 100 to 600	Up to 800	Large and medium communications junctions
ATA-MK-2 (AT) APS-MK-2 (OP)	MKS	10 or 20	4 or 8	Rayon communications junctions
ATK-20 (AT) APS-20 (OP)	MKS	20	6	Same

*DShI = 10-step selector
*MKS = Multiple crossbar connector

The ESK-A, shown in schematic block diagram as Figure 5-2, will have impressive specifications. Error probability for information passing through exchange equipment is not more than 10^{-7} per binary symbol, and the mean accrued operating time to failure is five years with an average repair time of one-half hour. The computer complex is identified only as "svyaz" and is said to be a special-purpose machine. All systems are duplicated for reliability. The design timeframe of ESK-A seems more consistent with a quasi-electronic than full electronic switch, and the specifications are almost identical to those associated with the Neva-1 control computer of the Kvarts quasi-electronic telephone exchange in 1983. Perhaps "svyaz" was a generic name for this computer while it was under development.



1. Input
2. Receiver Pr
3. Incoming line unit BVL
4. Internal storage system OZU
5. Code address switchboard control system UUAKK
6. Communications system US
7. Control system UU
8. Monitor and display console PKO
9. Computer complex VK
10. Multiplex channel MK
11. Circular and conference communications system UTsKS
12. Outgoing line unit BIL
13. Transmitter Per
14. Output

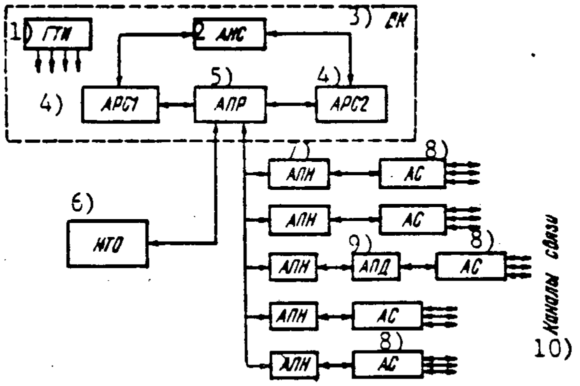
SOURCE: Reference 66

Figure 5-2. Schematic Diagram of ESK-A

5.3.2 Electronic Message Switching

It is uncertain whether Pagoda, the automated network of the Soviet National Hydrometeorological service, should be classed as a very early data transmission network or as a message-switched telegraph network dedicated to a single user. Perhaps it is properly both. The Pagoda network was operational in 1974, reflecting design in the late 1960s, before computers of the unified series (Ryad) became available. However, the high priority traditionally accorded by the Soviets to anything dealing with weather forcasting is reflected in choice of the Minsk-32 computer as the basis for Pagoda message-switching centers. By all reports, the Minsk-32 was the best of the second-generation Soviet computers (utilizing discrete semiconductor components), which were generally a poor lot. Minsk-32 characteristics are summarized in Appendix A, Table A-1. Pagoda reportedly is a highly reliable network with an error probability of about 1 x 10^{-6}.

The configuration of a typical Pagoda switching center is shown in block diagram form in Figure 5-3. Not shown in the block diagram, is the full duplication of much of the computer complex required for reliability. It appears likely that Pagoda message switches employ the Minsk 1560 or Minsk 1500 interfaces. When YeS computers were introduced at hydrometeorological service headquarters in Moscow about 1977, a special input device (which was designated YeS 6022) was developed to ensure compatibility with Pagoda. Eventually the Pagoda network will probably be entirely rebuilt to YeS standards.



1) Clock pulse generator
2) Message storage equipment
3) Computer complex
4) Message distribution equipment
5) Standby switching equipment
6) Technological equipment complex
7) Prestorage equipment
8) Matching equipment
9) Data transmission equipment
10) Communications channels

SOURCE: Reference 69

Figure 5-3. Structural Diagram of Pagoda Message Switching Center

Characteristics of a number of types of message-switching centers described in Reference 66 are summarized in Table 5-4. Although the equipment of obvious Western manufacture has been deleted, there is some uncertainty about origin of the DS-714 and TRC systems. They seem too advanced when compared to those known to be built in the USSR.

It is believed that the Soviet public telegraph network was first upgraded to electronic message switching using centers of the DS-4 series. A typical center of this type is shown in block diagram form in Figure 5-4. It is based on the ST-21 special-purpose control computer and, as shown in the figure, nearly all equipment is duplicated for increased reliability. The basis for the modernization/extension of the public message-switched network which is now in progress, however, is the TsKS-T equipment. This is the first Soviet message-switching center to be built around a Ryad computer. Originally it was planned to use two YeS 1030 computers (known as VK1030 in this application) but production models apparently incorporate twin YeS 1033 machines (VK-1033), an improved successor. AS-160 (160 channels) or AS-250 (250 channels) interfaces connect the computer complex to communications lines. The interfaces are also duplicated for reliability, except for the channeling equipment. Operation of the complex is very similar to that of the DS-4 illustrated in Figure 5-4. A recent article in Ehlektrosvyaz (Reference 70) was unusually candid about the locations of the new message-switching centers, shown in Figure 5-5. It is interesting that the European portion of the USSR has been largely neglected by this program. Perhaps it already has a satisfactory network as a result of earlier construction, or possibly the Soviets are concentrating on modernizing telegraph facilities in areas of the country where telephone service is the worst.

Table 5-4. Characteristics of Various Message-Switching Centers

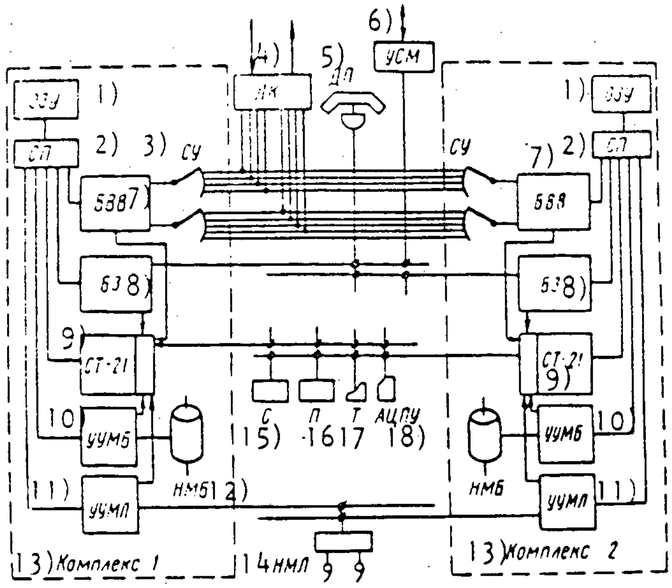
Name	Structure	Mode	Telegraph Channels		Medium-Speed Channels		Capacity (Telegrams/s)	Memory (kbytes)	Number			Processor
			Number	Speed (baud)	Number	Speed (baud)			Disk	Drum	Tape	
DS-4-12	Unduplicated	--	36	50-75	--	------	0.5	32	-	1	-	ST-21
DS-4-21	Duplicate	Parallel	256	50-200	32	600-2400	1.5	64	-	2	8	ST-21
DS-4-32	Duplicate	Parallel	256	50-200	32	600-2400	3.0	64	2	2	8	ITT-3200
DS-6-200	*	**	128	50-200	32	600-9600	1-2.0	128	4	-	4	ITT-1640
DS-6-400	*	**	256	50-200	64	600-9600	3-6.0	256	4	-	4	ITT-1685
DS-714	Duplicate	**	1024	50-200	64	600-9600	3.5	1000	12	-	8	?
TRC	***	**	1250	50-200	32	600-9600[1]	3.0[1]	512	22	-	18	?
KLB-5	Duplicate	**	256	50-200	32	600-9600	8.0	256	-	2	4	Mitr
KLB-5M	Duplicate	**	512	50-200	64	600-9600	15.0	512	-	4	8	Mitr
TsKS-T	Duplicate	Parallel	512	50-200	--	------	3.0	512	8	-	8	YeS1030 or 1033

*Unduplicated or Duplicated

**Parallel reception

***Duplicated and sliding backup. Essentially the TRC has three processors; in the normal mode one is the working processor, one is "hot standby" (which processes all traffic without forwarding it), and the third is a "cold standby" which normally processes statistics, performs debugging operations on software, and monitors system performance. Each of the standby processors can assume the functions of the working processors.

[1] TRC can also handle one 48,000 kbd channel with a peak capacity of 5.4 telegrams/s.



1. Internal storage system OZU
2. Priority system SP
3. Scanning system SU
4. Line set LK
5. Dispatcher console DP
6. Modem interface system USM
7. Input-output unit BVV
8. Character unit BZ
9. ST-21 [computer]
10. Magnetic drum control system UUMB
11. Magnetic tape control system UUML
12. Magnetic drum storage NMB
13. Complex
14. Magnetic tape storage NML
15. Reader S
16. Perforator P
17. Teletype T
18. Alphanumeric printer ATsPU

SOURCE: Reference 66

Figure 5-4. Structural Diagram of DS-4 Center

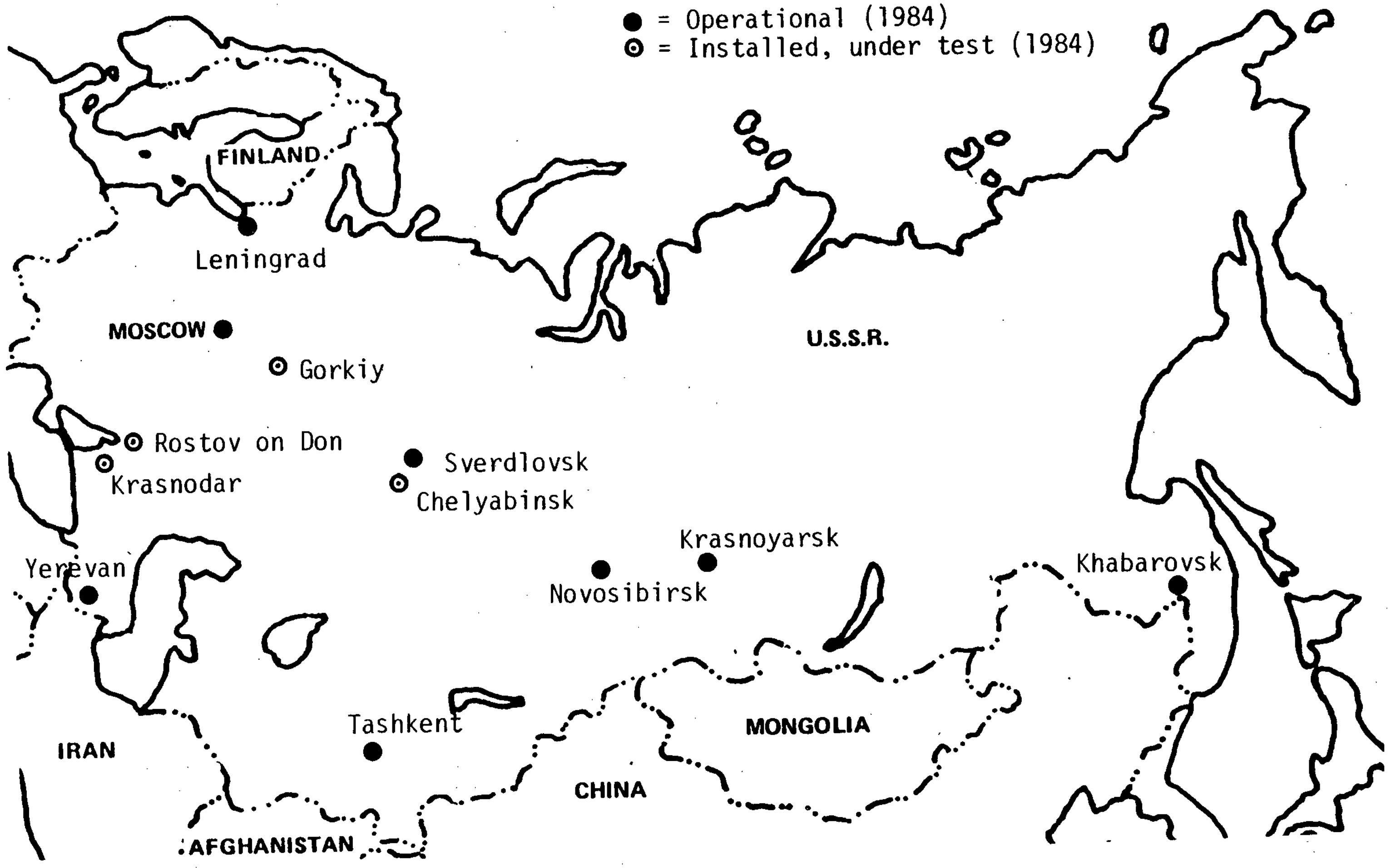


Figure 5-5. Location of Latest-Generation Public Telegraph Switching Centers

6. DATA TRANSMISSION NETWORKS

The purpose of data transmission networks is to link computers to users and to each other. The Soviets have well-developed long-range plans for a nationwide network for management of the economy and shorter-range plans for smaller networks to serve specific groups of users. Actual accomplishments to date have been modest in comparison to those in other developed countries. One reason for this is the abysmal inadequacy of existing Soviet switched networks (OAKTS, subscriber telegraph network) for data transmission, a role never considered in their original design.

6.1 LONG-RANGE PLANS

In an economy where the necessity for and efficiency of centralized management is an article of political faith, the concept of a nationwide computer network to improve economic planning and day-to-day management is extremely attractive. The Soviets have a plan for establishing such a network which they have named the Nationwide Computerized System for Gathering and Processing Information (OGAS). This system was originally intended to serve 600,000 enterprises and organizations by 1990, but this has since been delayed until 2000. OGAS has not progressed very fast, and only three cities (Moscow, Kiev, and Riga) were netted by 1982.

A 1982 article (Reference 71) provided a historical summary and conceptual outline of OGAS, the technical base of which is to be the National Computer Center Network and the National Data Transmission System. The National Computer Center Network consists of all the computer centers in the country, combined via the National Data Transmission System into a consolidated system to satisfy user requirements for data processing and computation at minimum cost. Calculations have shown that, through more efficient utilization of data processing resources and organization and by expansion of a centralized pool of standard algorithms and programs, the National Computer Center

Network can reduce the unit costs for automated data processing by at least a factor of two and one-half. The concept of a state computer center network was shown to be theoretically feasible as early as 1966, but the appropriate hardware to implement the idea did not exist at that time.

Five categories of state computer center network-shared resource computer centers have been proposed, distinguished by required operating speeds of their equipment as follows.

Category 1 = 20 to 50 MOPS/s
Category 2 = 10 to 20 MOPS/s
Category 3 = 5 to 10 MOPS/s
Category 4 = 1 to 5 MOPS/s
Category 5 = 0.5 to 1 MOPS/s

Categories 1 through 4 correspond to capacities of various levels of territorial shared resource computer centers (TVTsKP). Category 1 would exist at the all-union level, Category 2 at republic level, and so forth. There will be a requirement for approximately 200-300 TVTsKP, based on computer modeling. Category 4 computational requirements can be met with YeS 1060 or 1065 machines; Categories 1 through 3 will require supercomputers now under development. Category 5 corresponds to the capacity required for cluster computer centers of which some 2,500 will be required.

Although these collective use computer centers (VTSKP) are described in Soviet literature as the "base cells" of OGAS, their establishment has not been rapid. By 1980 only seven experimental centers had been created. The 11th 5-year plan (1980-1985) only calls for construction of several dozen. Such slow growth will make the scheduled completion of OGAS by the year 2000 difficult to achieve.

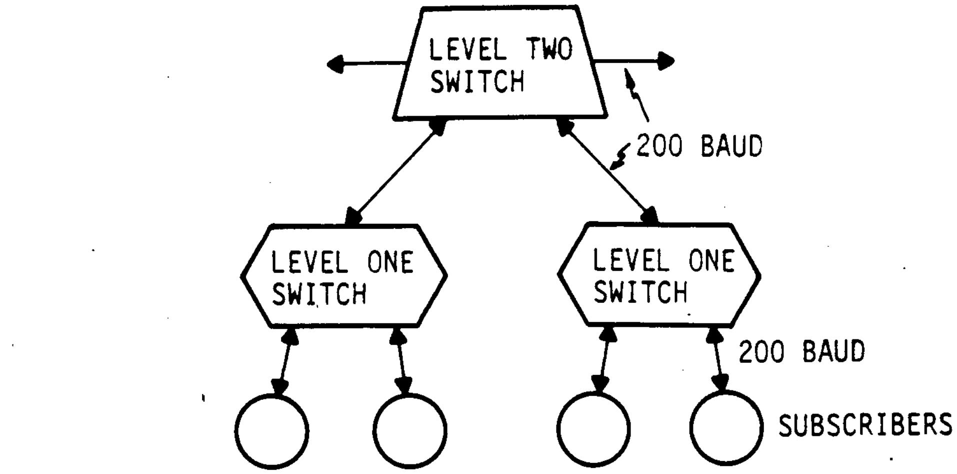
This structure will impose high demands on the National Data Transmission System for reliable, high-performance, data transfers between subscribers and shared-resource computer centers, between subscribers and cluster computer centers, and between different categories of shared resource computer centers. Approximately 200,000 network subscribers operating at rates from 50 to 48,000 bps and higher must be supported. The optimal structure of this data communication network would be one employing packet switching.

6.2 PRESENT REALITIES

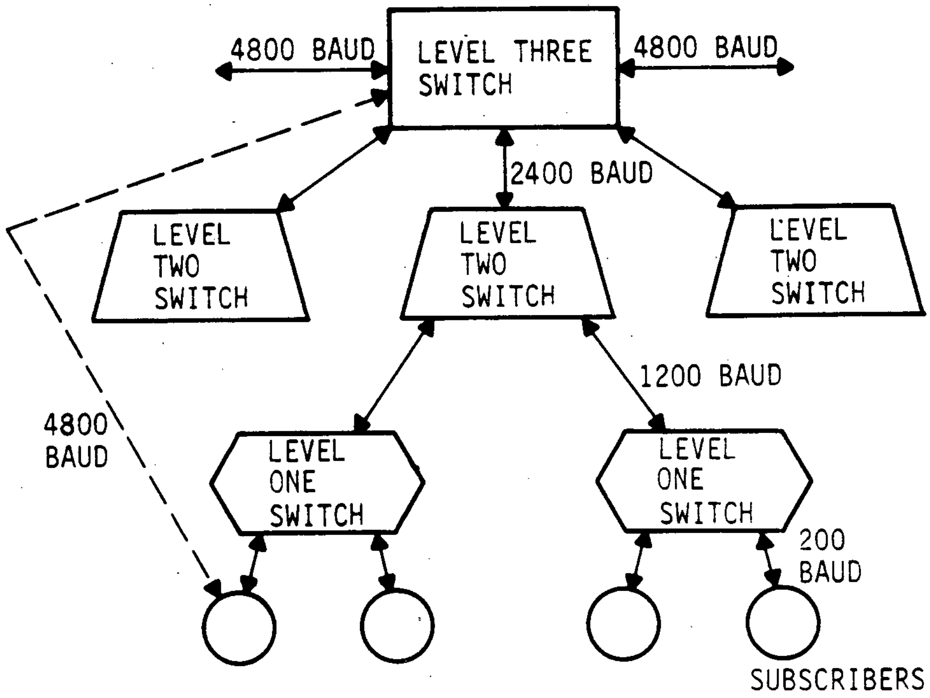
The present status of the National Data Transmission Network (PD-KP) is far removed from that which will ultimately be needed to support OGAS on a national scale. The construction of two networks dedicated to data transmission is planned: one to support medium-speed data transmission using circuit switching (PD-KK), and the other for medium-speed data transmission using message switching. Although the original concept of this second network was a conventional message-switching system along the lines of that employed in the public telegraph system (Reference 66), the likelihood is increasing yearly that, when eventually built, it will employ packet-switching techniques.

The PD-KK network will be built in three phases. Phase one, which will provide 200-bps service to users, is known as PD-200 and has been under construction since 1979. As shown in Figure 6-1 (a), this network will have a three-level hierarchy and is built on the "radial junction principle" (star topology). As the network expands, it will be converted to a four-level hierarchy as shown in Figure 6-1 (b), three classes of priority will be established for servicing calls, and additional services will be added. The PD-4800 network will offer service at rates up to 4800 bps to selected users.

Initial expansion of PD-200 was rapid; as of 5 January 1981, 129 stations and substations were included in the network. However, major problems soon became evident. In January 1982 only 25% of the installed capacity of the PD-200 network was operational. Among the difficulties were problems with installation and repair of the TAP-2 Hungarian-manufactured subscriber equipment and training of subscriber personnel. In addition, there is apparently a lack of enthusiasm for



(a) PD-200 Network



(b) Planned PD-4800 Network

Figure 6-1. Soviet Circuit-Switched Data Transmission Networks this new network on the part of some MOC personnel assigned to run it as evidenced by this excerpt from Reference 72.

> "PD-200 Network subscribers sometimes wait hours for a connection, and answers about the cause of connection delays are untruthful. There are cases when service sets of around-the-clock data transmission exchanges are turned off or nobody bothers to answer an incoming call. As a result, communications are idle for a long time, and the subscribers have no faith in the performance reliability of the PD-200 network. Serious deficiencies continue to exist in the organization of technical servicing by communications offices of the PD-200 network."

Specifically, MOC technical personnel often do not bother to check out subscriber complaints of communications failure.

Assuming that these problems were corrected by 1985, the USSR MOC plans to expand the PD-200 network to where all kray and oblast centers of the country are connected. Priority will be given to satisfying the needs of republic data transmission networks in Belorussia, the Ukraine, Georgia, Armenia, Latvia, Estonia, and Turkmenskaya SSR.

In addition to the National Data Transmission System, a number of other teleprocessing-based networks are in operation throughout the USSR. One of the oldest of these is the Ekspress system for railroad ticketing and reservations (Reference 73). This system became operational in the early 1970s with three "Marshrut" computers; by 1978 there was already a plan to upgrade to Ekspress-2, which will use unified series computers (YeS/Ryad) (Reference 74).

Local area networks have been developed in a number of cities, including Moscow, Leningrad, Kiev, Novosibirsk, Perm, and Riga, containing substantial concentrations of computers (Reference 75).

These are providing valuable test-beds for experience in developing and operating packet-switching systems. The favored computer to handle communications within such networks seems to be the SM-3 or SM-4, although a number of other machines, including M-6000, SM-2, Elektronika 100, and Elektronika 60, are also in use. Choice of the SM-3/SM-4 is not surprising for this application since these machines are basically copies of the PDP-11 series computers widely used as communications handlers in U.S. computer networks.

Perhaps the most extensive (and certainly the one best publicized in the United States) is the experimental computer network of the Latvian SSR Academy of Sciences. That network currently serves some dozen institutes located in Riga; its growth from 1977 to 1981, traced in Figure 6-2, is illuminating. High-level satisfaction with this effort is evidenced by the large amount of new equipment (2 to 3 systems) received each year and, even more significantly, by receipt of new computers less than two years after they entered series production (compare Table A-1). It is thus not surprising that a "computerized information network developed at the Institute of Electronics and Computer Technology at Latvia Academy of Sciences" is to be used to link "all institutes of the USSR Academy of Sciences and of the Academies of the Union Republics" (Reference 76). An experimental section was already in operation in 1984 linking Riga, Leningrad, and Moscow; this is shown in Figure 6-3, along with other pioneering data transmission network efforts. In 1984 the experimental intercity network would support only a 300-baud data rate, but "this will soon be increased to 1200." There are eventual plans for joint projects to develp such networks linking all CEMA members.

An examination of the communications media that these experimental networks are forced to use illustrates why the Soviets decided to build a new data transmission network from the ground up rather than adapting existing telecommunications plants. Medium-speed data transmission (up to 1200 bauds) is possible on the public telephone network (OAKTS). The expected error rate on this network at 1200 bps

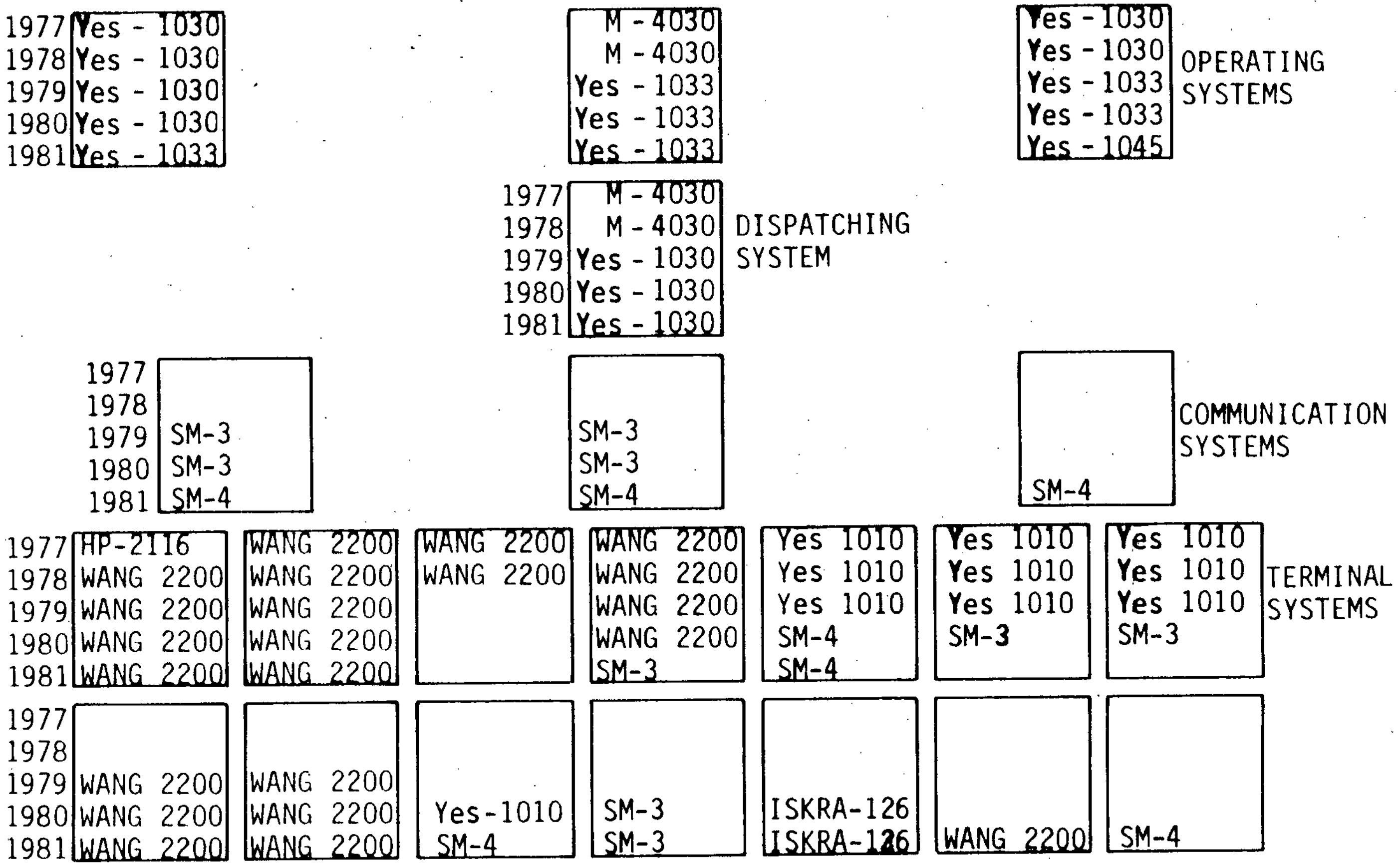


Figure 6-2. Experimental Computer Network of the Latvian SSR Academy of Sciences

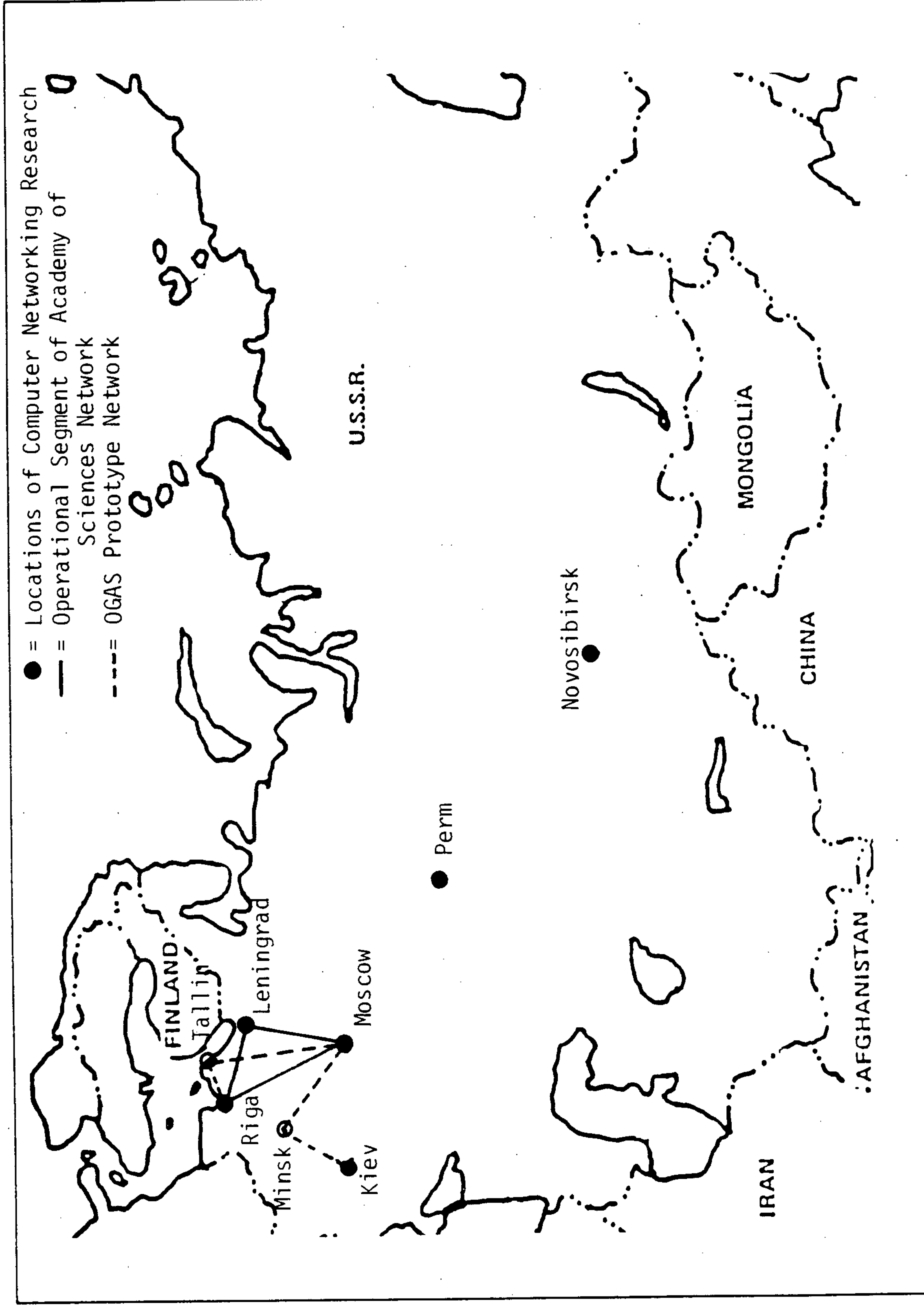


Figure 6-3. Selected Data Transmission Experiments - USSR

without error correction systems is not supposed to exceed 2.5×10^{-3} but because 10-step exchanges are still widely used which cause a great deal of pulse interference, the error factor on some connections can reach 5×10^{-2}. Low-speed data transmission can also use the subscriber telegraph network, but for similar reasons the expected error rate there is also substantial—approximately 1×10^{-3} per letter, excluding terminal equipment errors. Many of these problems can be overcome by utilizing unswitched communications (leased lines). These are categorized as low-speed (50 to 200 bps, typically telegraph channels), medium speed (600 to 9600 bps, mostly voice-grade channels), and high speed (12 to 480 kbps). High-speed traffic requires wideband channels which can be either pregroup (12 to 24 kbps), primary (48 to 96 kbps), or secondary (240 to 480 kbps). These channels are supposed to offer the highest quality indices in terms of fidelity and reliability, but tests of the Modem-48000/UZO-48000 on the Leningrad-Moscow PWB line (K-60 and K-1920 systems) in 1976 encountered errors which "varied within the broad limits from 10^{-2} to 10^{-6}" (Reference 77).

6.3 SUBSCRIBER EQUIPMENT

Data teleprocessing systems are becoming increasingly important in the USSR since introduction of the unified series (Ryad) of computers. Prior to that time only a small variety of equipment was in use, which is summarized in Table 6-1. This equipment is largely obsolescent and not recommended for new installations.

A unified computer system data teleprocessing family of equipment has been developed and extensively reported upon in the 1979 to 1981 timeframe (References 66, 78, and 79). The equipment consists of:

1. At least 11 data conversion devices (Modems) with technical characteristics as shown in Table 6-2,
2. Four error protection devices (UZO) with technical parameters as shown in Table 6-3,

Table 6-1. Data Transmission Equipment not Conforming to YeS Standards

Nomenclature	Type Channel	Duplex	Baud Rate	Accuracy	Peripherals
"Akkord-50"	Telegraph	Half	50, 100	3×10^{-7}	FS-1500*** PL-150 *4
"Akkord-1200" (*5)	Switch Phone Lease Phone	Half or Full	600, 1200	1×10^{-6}	FS-1500*** PL-150 *4
"Minsk-1500"	Same	Same	Same	1×10^{-6}	
"DFE-550" (GDR)	Same	Same	Same	Same	

***Optical reader
*4 Paper tape punch
*5 1200PP = transmit/receive
1200PD = transmit only
1200PM = receive only

Table 6-2. Technical Specifications of Signal Conversion Devices

Model/ YeS Code	Manufacturing Country	Transmission Type*				Data Rate (bauds)	Type Communications Channel	Modulation
		DU	HD	AS	SY			
Modem-200 YeS-8001	USSR,Bulgaria, Romania, GDR, Hungary, Czechoslavakia	X		X	X	200	Switch/Leased Phone	FM
YeS-8002	GDR,HU,CZ	X	X	X		200	Switch/Leased Phone	FM
Modem-1200 YeS-8005	Bulgaria		X	X	X	600,1200	Switch/Leased Phone	FM
Modem-2400 YeS-8010	USSR	X			X	600,1200,2400	Leased Phone	DOFM**
YeS-8011	Hungary	X	X		X	1200,2400	Leased Phone	DOFM**
Modem 4800 YeS-8015	USSR	X			X	2400,4800	Leased Phone	TDFM***
Modem 48,000 YeS-8019	USSR	X			X	24,000;48,000	Unswitched Wideband	****
UPS-NU(*5) YeS-8027	Bulgaria	X	X	X	X	50;1,2,6,12,24,4800	Short Wire	DC Pulse
YeS-8029	USSR	X	X	X	X	up to 9600	Short Wire	DC Pulse
UPS-TG(*6) YeS-8030	Bulgaria	X	X	X	X	50,100,200	Unswitched Telegraph	DC Pulse
YeS-8032	Czechoslovakia	X	X	X	X	50,100,200	Switched/Unswitched Telegraph	DC Pulse

*DU = Duplex; HD = Half Duplex; AS = Asynchronous; SY = Synchronous
**Dual Relative Phase Shift Keying
***Triple Relative Phase Shift Keying
****Two-pole amplitude modulation with one sideband partially suppressed and carrier suppressed
*5 Low-Level UPS
*6 UPS of the telegraph type

Table 6-3. Technical Specifications of Error Protection Devices

Model/ YeS Code	Manufacturing Country	Data Rate (bauds)	Code*	Error Protection Work Algorithm	Transmit Mode	Type Channel and Connection Method
UZO-1200 YeS-8121	USSR	600,1200	MTK-5	ROS with OZh**	Half Duplex	Telephone through "Modem 1200"
UZO-2400 YeS-8122	Hungary	200,600 1200,2400	KOI-7	ROS with OZh**	Duplex	Telegraph through MPD-1
UZO-4800 YeS-8135	USSR	50,100,200 2400,4800	KOI-8	ROS with PP*** or ROS with OZh**	Duplex	Unswitched telephone through Modem 4800
UZO-48,000 YeS-8140	USSR	24,000 - 48,000	KOI-8	ROS with PP***	Duplex	Wideband through "Modem 48,000"

*MTK-5 is a seven element code conforming to GOST 13052-67, KOI-7 is similar; KOI-8 is an eight-element computer code

**ROS with OZh = "Resolving Feedback with Acknowledgement" = Stop and Wait ARK

***ROS with PP = "Resolving Feedback with sequential transmission of information and transmitter locked during time of repetition" = Continuous ARK with pullback.

3. Six data transmission multiplexers with characteristics shown in Table 6-4, and

4. At least 21 subscriber points with different configurations of equipment and technical characteristics, as shown in Table 6-5.

The way in which this equipment is utilized is very similar to the arrangements used to transmit digital information over analog lines in Western countries. A typical arrangement involving the MPD-3 multiplexer; Modems 200, 1200, and 2400; UZO 1200; and AP-1, -3, -11, and -70 subscriber terminals is illustrated in Figure 6-4.

Modem 48000 (YeS-8019) is the highest-speed data conversion device in common use within the unified system. It is designed for duplex synchronous digital transmission with operating speeds of 24 and 48 kbps on primary wideband channels of the public communications network, which have a nominal frequency band of 60 to 108 kHz. Two-pole amplitude modulation with one sideband partially suppressed and with suppressed carrier is used. The equipment is constructed primarily of integrated microcircuits (Reference 77).

Figure 6-5 (a) shows how this modem uses the available frequency bandwidth of the primary wideband channel (PWBC). Soviet PWBCs differ from the CCITT recommended standard in that a group pilot frequency is located in the center of the channel band at 84.14 kHz instead of 104.08 kHz. This necessitates band elimination filters (BEF) in the Soviet design. The data transmission occurs within the frequency band of 65 to 103 kHz while the 104- to 108-kHz band is reserved for voice signals of the service telephone channel.

A high-speed error protection unit UZO-48000 (YeS-8140) is used in conjunction with Modem 48000, with interfaces as shown in Figure 6-5 (b). In addition to this primary purpose, UZO-48000 can also be used at less than its full capacity in 2400 and 4800 bps telegraph channels. This extends its usable range from 5000 to 7000 km (high data rate mode) to 13,700 km at the lower data rates. At the lower rates, operation with satellite communications (SATCOM) is feasible. Error

Table 6-4. Technical Specifications of Data Transmission Multiplexers

Model	Code	Manufacturing Country	Number of Subscriber Points Connectable	Subscriber Point	Data Rate (Baud)	Error Protection Method
MPD-1A	YeS-8400	USSR	15	AP-1, AP-61, AP-62, AP-63, AP-64, AP-70, and others; MPD-1A, telegraph set	75, 4800	Matrix and cyclic codes
MPD-2	YeS-8402	USSR	8 to 176	AP-1, AP-2, AP-4, AP-14, AP-31, AP-50, AP-61, AP-63, etc.; MPD-2 telegraph set	50, 4800	Longitudinal, transverse "check" and cyclic code
MPD-3	YeS-8403	USSR	4	AP-1, AP-2, AP-3 AP-4, AP-70, MPD-3, etc., telegraph sets	50, 4800	Longitudinal, transverse "check" and cyclic code
MPD-1	YeS-8401	Bulgaria	32 to 64	AP-1, AP-31, AP-61, AP-62, AP-70, MPD-1 etc., telegraph set	50, 2400	
MPD-4	YeS-8404	GDR	12	AP-1, AP-5, AP-6, AP-62 AP-70	200 to 1200	Matrix code
UMPD	YeS-8421	Hungary	20	AP-1, AP-62, AP-64, etc., MPD, telegraph set	50 to 200	

Table 6-5. Technical Specifications of Subscriber Points

Model	Nomenclature	Country of Manufacture	Punch Tape and Edge-Punched Card Input	Punch Tape Input	Punch Card Input	Punch Tape and Edge-Punched Card Output	Punch Tape Output	Punch Card Output	Display	Alphanumeric Printer	Typewriter	Tape Drive	Punched, Counters, Punched Certificate	Type of Communications Channel	Data Rate, Baud	Type of Data Transmission Multiplexer	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Notes
AP-1	YeS-8501	Bulgaria	+			+					+			Leased and switched telephone, leased telegraph	50, 75 100, 200	All	
AP-2	YeS-8502	Hungary	+			+					+			Leased and switched telephone, leased telegraph	200	MPD-3	
		USSR	+			+					+				200	MPD-2, MPD-1A	
AP-3	YeS-8503	Bulgaria		+			+				+			Switched and leased telephone	600, 1200	MPD-3	
AP-4	YeS-8504	USSR		+	+		+			+	+	+		Leased telephone	600,1200, 2400	MPD-1A, MPD-2, MPD-3	Intelligent Terminal

Table 6-5. Technical Specifications of Subscriber Points (Continued)

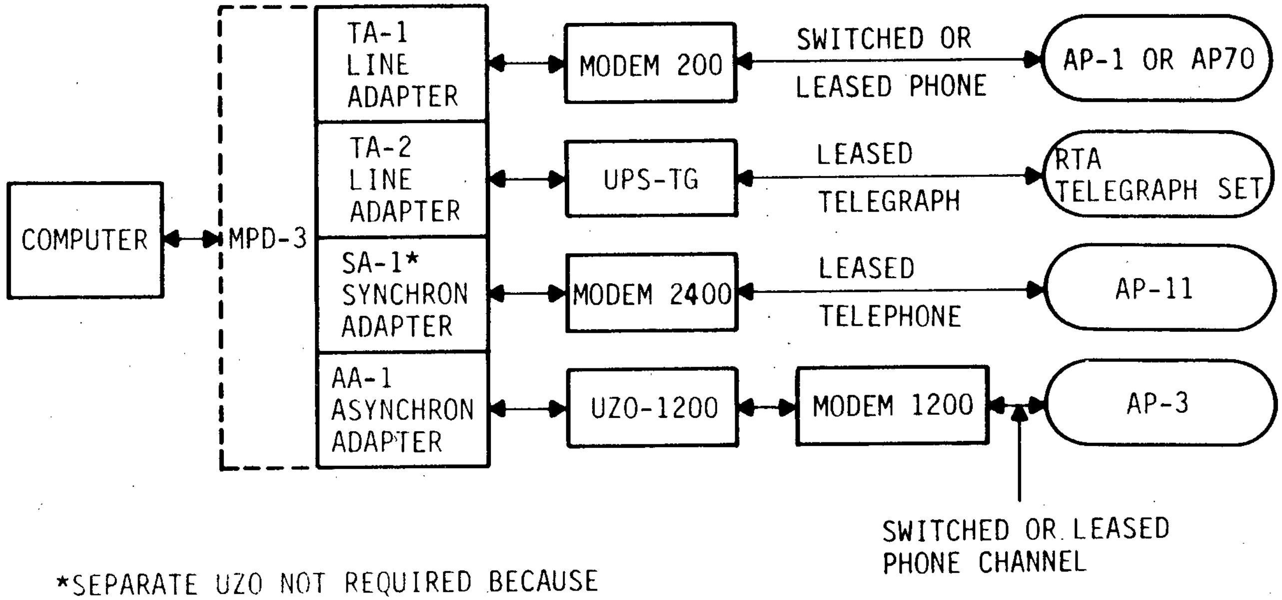
Model	Nomenclature	Country of Manufacture	Punch Tape and Edge-Punched Card Input	Punch Tape Input	Punch Card Input	Punch Tape and Edge-Punched Card Output	Punch Tape Output	Punch Card Output	Display	Alphanumeric Printer	Typewriter	Tape Drive	Punched, Counters, Punched Certificate	Type of Communications Channel	Data Rate, Baud	Type of Data Transmission Multiplexer	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Notes
AP-5	YeS-8505	GDR		+	+		+			+	+		+	Leased telephone	200,600 1200	MPD-4	
AP-6	YeS-8506	GDR		+	+		+				+		+	Leased telephone	600,1200	MPD-4	
AP-11	YeS-8511	USSR		+	+		+	+		+	+			Leased telephone	600,1200, 2400	MPD-2, MPD-1A	
AP-14	YeS-8514	Poland		+	+		+		+	+	+	+		Leased and switched telephone	600,1200, 2400	MPD-1A, MPD-2, MPD-3	Batch Terminal
AP-15																	Batch Terminal
AP-31	YeS-8531	Bulgaria	+	+	+	+	+				+			Leased and switched telephone	200,600, 1200	MPD-1, MPD-1A, MPD-2,MPD-3	

Table 6-5. Technical Specifications of Subscriber Points (Continued)

Model	Nomenclature	Country of Manufacture	Punch Tape and Edge-Punched Card Input	Punch Tape Input	Punch Card Input	Punch Tape and Edge-Punched Card Output	Punch Tape Output	Punch Card Output	Display	Alphanumeric Printer	Typewriter	Tape Drive	Punched, Counters, Punched Certificate	Type of Communications Channel	Data Rate, Baud	Type of Data Transmission Multiplexer	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Notes
AP-32	YeS-8532	GDR		+	+		+				+	+		Leased and switched telephone	200,600 1200	MPD-1A,MPD-2 MPD-3, MPD-4	
	8534	Hungary*							+	+		+			200,1200		Intelligent-SPC
AP-50	YeS-8550	Hungary		+	+		+		+	+	+	+		Leased and switched telephone	600,1200, 2400,4800, 9600	MPD-1A, MPD-2, MPD-3	Intelligent Batch Terminal (based on YeS 1010)
AP-61	YeS-8561	USSR							+		+			Leased telephone	600,1200, 2400	MPD-1, MPD-1A MPD-2, MPD-4	Display Terminal
AP-62	YeS-8562	Hungary							+		+			Leased telephone and telegraph	200,600, 1200,2400	MPD-1, MPD-1A MPD-2, MPD-4	Display Terminal
AP-63	YeS-8563	USSR							+		+			Leased telephone	600,1200, 2400	MPD-1, MPD-1A, MPD-2, MPD-4	

Table 6-5. Technical Specifications of Subscriber Points (Concluded)

Model 1	Nomenclature 2	Country of Manufacture 3	Punch Tape and Edge-Punched Card Input 4	Punch Tape Input 5	Punch Card Input 6	Punch Tape and Edge-Punched Card Output 7	Punch Tape Output 8	Punch Card Output 9	Display 10	Alphanumeric Printer 11	Typewriter 12	Tape Drive 13	Punched, Counters, Punched Certificate 14	Type of Communications Channel 15	Data Rate, Baud 16	Type of Data Transmission Multiplexer 17	Notes
AP-64	YeS-8564	Hungary							+		+			Leased telephone	600,1200 2400,4800	MPD-1, MPD-1A MPD-2, MPD-4	Group Terminal
AP-70	YeS-8570	USSR, Bulgaria									+			Switched and leased telephone, leased telegraph	100	All data transmission multiplexers	
Telegraph set (5-element code)	YeS-8591,	Czechoslovakia												Switched and leased telegraph	50,75,100	MPD-1, MPD-1A, MPD-2, MPD-3	
	YeS-8592	GDR															
Telegraph set (7-element code)	YeS-8593	Czechoslovakia												Switched and leased telegraph *Also has disc drives	100,200	MPD-1, MPD-1A, MPD-2, MPD-3	



*SEPARATE UZO NOT REQUIRED BECAUSE SA-1 PERFORMS THE FUNCTION

Figure 6-4. Typical Application of YeS Teleprocessing Equipment protection is accomplished via the "auto-interrogation method" (basically ARQ with pullback). the cyclic code used is designed to ensure a probability of less than 10^{-7} that a byte will be sent to DPE with an undetected error. Redundancy of the code (including service bits) is approximately 3%.

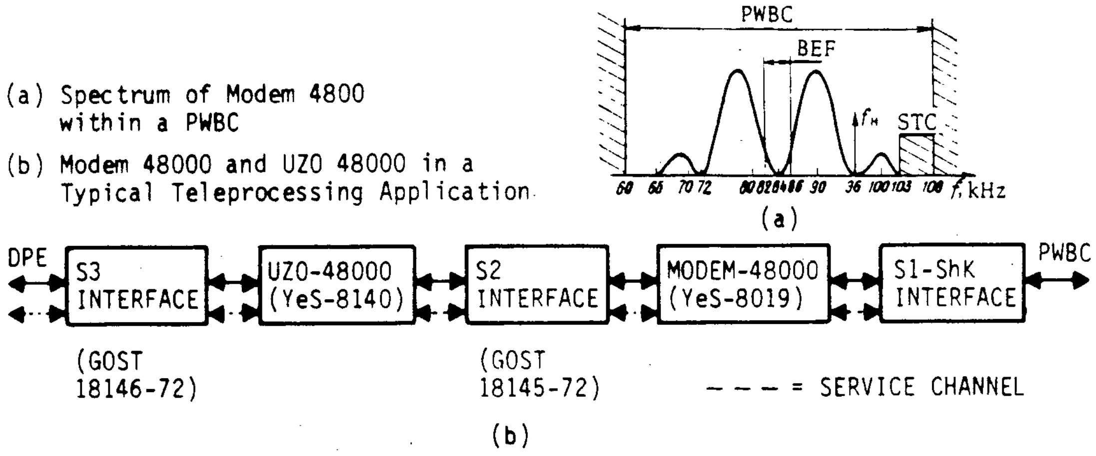


Figure 6-5. Operation of a Soviet High-Speed Modem

The primary subscriber equipment used in the PD-200 network is the TAP-2 (YeS-8502) manufactured by the "Budavoks" company in Hungary. One contributing factor in delays to getting the PD-200 network operational has been difficulties in installing, repairing, and training operators for this equipment. Specifically (from Reference 72):

1. "Some subscribers have been storing expensive equipment in warehouses for a long time—as a result many TAP-2s are connected to a data transmission station for the first time only after the service warranty has expired." (the warranty lasts 15 months from the day it crosses the USSR border),

2. "In the vast majority of cases organizations that have purchased TAP-2 cannot indpendently perform technical servicing of them,"

3. "Considering that it is rather difficult to repair TAP-2...,"

4. "The training of TAP-2 operators for subscribers has not been undertaken everywhere," and

5. "There are cases when subscribers' information cannot be transmitted—because of the fact that TAP-2s, installed in telegraph offices, have been damaged for a long time, and no active measures have been taken to repair them."

6.4 SWITCHING SYSTEMS

Data transmission networks can be circuit switched, message switched, or packet switched, although the last of these is rapidly becoming the method of choice in Western countries. Soviet efforts or plans in each area will be described in turn.

6.4.1 Circuit Switching

As noted earlier, the PD-KK data transmission network now under construction will use circuit switching. Initial installations of switching equipment have involved Soviet-built AT-PS-PD and Yugoslavian "Nikoli Testla" crossbar exchanges as well as PTS-K and ATK-PD substations. Characteristics of each are summarized in Table 6-6. In Phase 3 (PD-4800) electronic switching using ESK-A and ESK-B equipment will be employed.

6.4.2 Message Switching

The original plans for the PD-KS data transmission network envisioned a four-level hierarchy as shown in Figure 6-6 (Reference 66). Conceptual specifications had been drawn up for the zone message switching center (ZTsKS), as shown in Table 6-7. It was to employ a "Svyaz" computer, but whether this is the same unit intended for ESK-A or merely a generic term is unclear. There is no evidence construction

Table 6-6. Characteristics of Combined Automatic Exchanges

Type Exchange	Country of Manufacture	Number Inputs	Number Outputs	Details
AT-PS-PD	USSR	up to 100	up to 400	50, 100, 200 baud
"Nikoli Tesla"	Yugoslavia			
ACT-K 60/R (ACT) MMC-K 57/D (MMD)		up to 400 up to 4000	up to 200 up to 200	Intended for moderate loads (0.33 Er/ln)
PTS-K	USSR	40 to 160	24 to 60	
ATK-PD	USSR	up to 20	up to 8	Total load peak load hour not to exceed 4 Er/ln

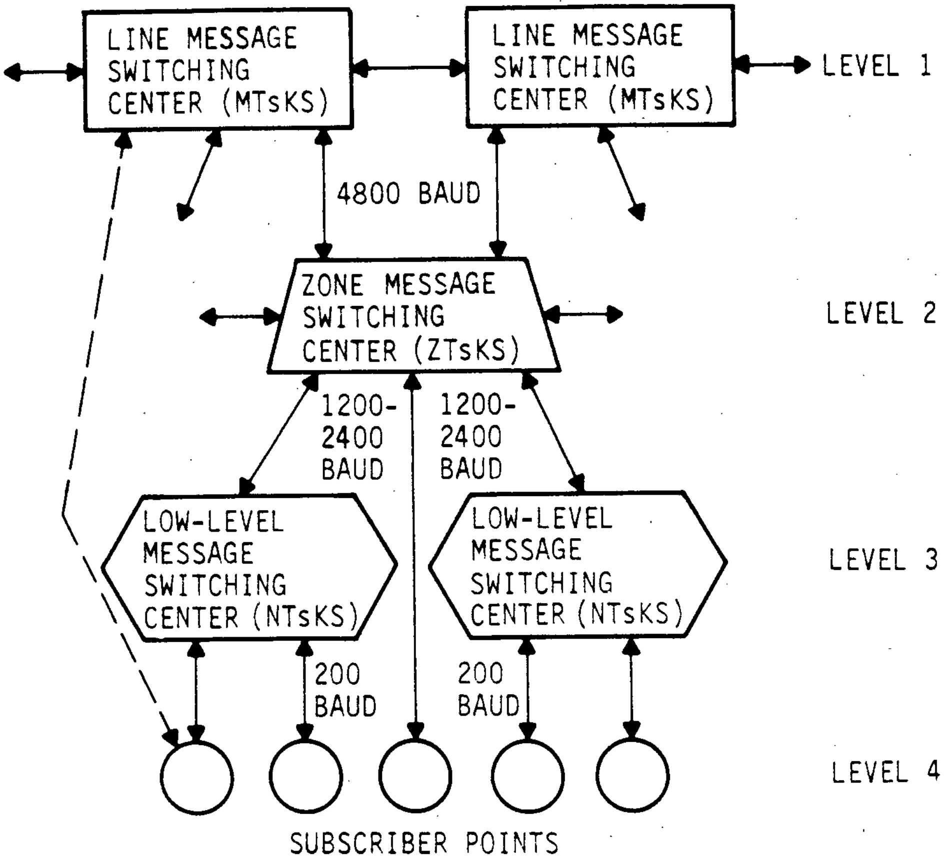


Figure 6-6. PD-KS Network Hierarchy (Plan)

on this network ever began, and with each year bringing the Soviet computer users to a fuller appreciation of the advantages of packet switching, it is increasingly unlikely to be built.

Table 6-7. Specifications for a Zone Message Switching Center for the PD-KS Network

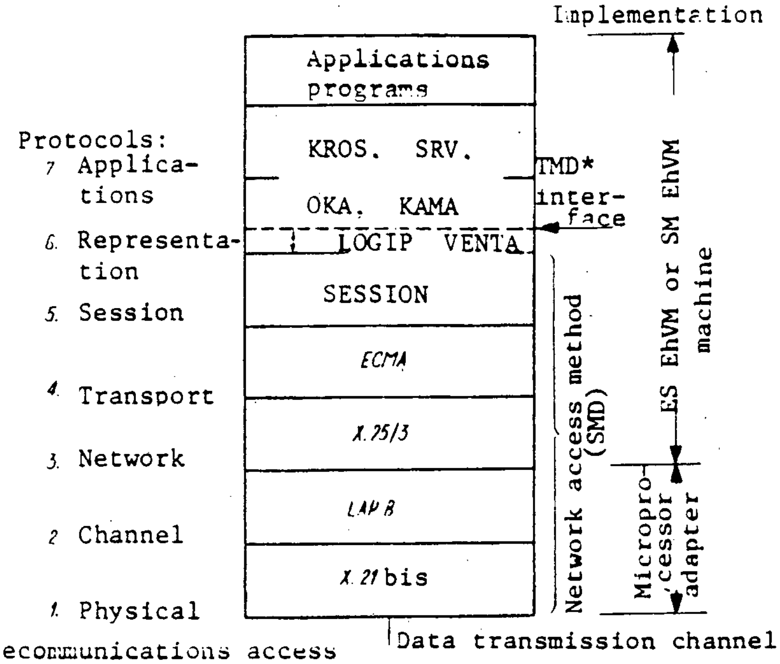
No.Channels	up to 128 telephone, 1024 telegraph
Capacity	5 to 20 messages/s
Transmission Speed	50, 100, 200, 1200, 2400 bps to subscribers 1200, 2400, 4800 bps to other ZTsKS
Message Storage	24 hours
File Capacity	Up to 2.5×10^9 bits
Message Survivability	No less than 10^{-8}
Address Accuracy	Not worse than 10^{-8}
Data Fidelity	NLT 10^{-7}/character
Priority Categories	Four (delivery times 5 min, 30 min, 4 hr, 24 hr)
Reliability	0.99999 with average 30 min time to repair

6.4.3 Packet Switching

In the last five years, Soviet Bloc technical literature has contained a deluge of articles on various facets of packet switching, much of it of a highly theoretical nature. Virtually every facet of the problem has been covered, from protocols and network optimization to packet voice and packet satellite networks. A number of experimental hardware installations have also been described. A 1983 paper described an experimental shared-resource computer network nicknamed SEKOP (which possibly expands to "Set' Kommutatstii Paketov" or packet switching network), which had been in operation since at least 1978 (Reference 80). It consists of BEhSM-6 computers controlled by a Dispak operating system with virtual memory, termed information processors, and M-6000 ASVT-M process control computers, which function as network processors. These network processors support duplex data exchange in the packet-switching mode between any pair of information processors in the network. Each pair of network processors is connected by 10 simplex data transmission channels (5 in each direction) which are independently bidirectional. An APD-MA-TF data transmission set supports a 1200-baud keying rate. Effective data transmission rate between a pair of network processors is about 925 bps.

It is clear that the X.25 protocol is not being used in this network, probably because the high overhead of that format would slow data transfer unacceptably. Instead it apears that a simplified, four-level protocol model (Level 1 - physical control, Level 2 - data link layer, Level 3 - network control, and Level 4 - general functional protocol) has been adopted. Developers are interested in replacing the M-6000 with an SM-2 and the 10 simplex data transmission channels with one 48-kilobaud duplex channel. This will reduce delay in delivering a single packet by about 2.4 s, and may make switchover to an X.25-based protocol feasible.

Another notable paper (Reference 81) presents a conceptual architecture for creating an open computer network using YeS EhVM and SM EhVM series computers. The seven-level ISO conventional architecture is employed (Figure 6-7). The bottom three levels (physical, channel, and network) facilitate implementation of the X.25 international standard. The fourth (transport) level employs a version of the protocol proposed by the European Organization of Machinery Producers (ECMA). The fifth (session) level protocol was developed by the Institute of Electronics and Computer Engineering of the Latvian SSR Academy of Sciences. The top two levels (representation and applications) employ the ES EhVM standards which define the functioning of the software complexes designated KROS, SRV, OKA and KAMA. The complex of programs that implement the five bottom levels in the ES EhVM or SM EhVM is called the network access method (SMV).



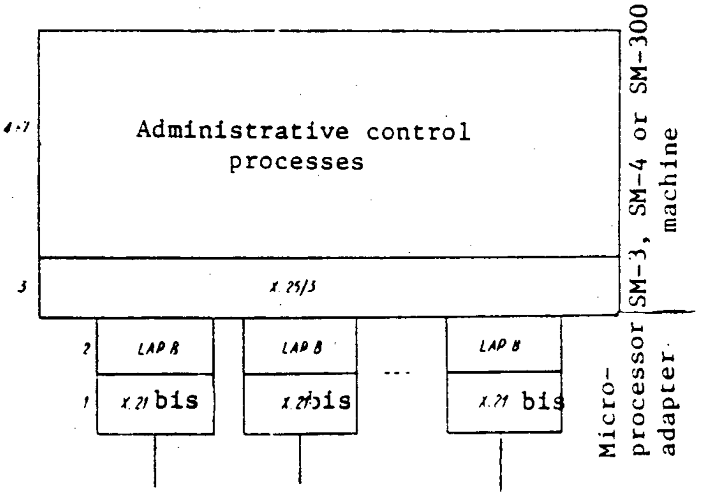
*TMD - telecommunications access method

SOURCE: Reference 81

Figure 6-7. Protocol Layering

Implementation of the two bottom protocol levels shown in Figure 6-7 is provided by a microcomputer-based network microprocessor adapter (SMA). The ES EhVM or SM EhVM machine implements the protocols of levels three through seven and executes applications programs. As a result, the ES EhVM or SM EhVM machine, in conjunction with the SMA, forms the subscriber system of the computer network. Subscriber systems within a network are divided into working, terminal, administrative, and interface.

The structure of the communications system (within the open computer network architecture) is shown in Figure 6-8. The first two protocol levels, like in the subscriber system, are implemented by the SMA. The other levels are executed by SM-3, SM-4, or SM-300 minicomputers. The communications system is thus made up of an SM EhVM minicomputer and "g" adapters, where "g" is the number of data transmission channels leading to the communications systems.



SOURCE: Reference 81

Figure 6-8. Structure of Communications System

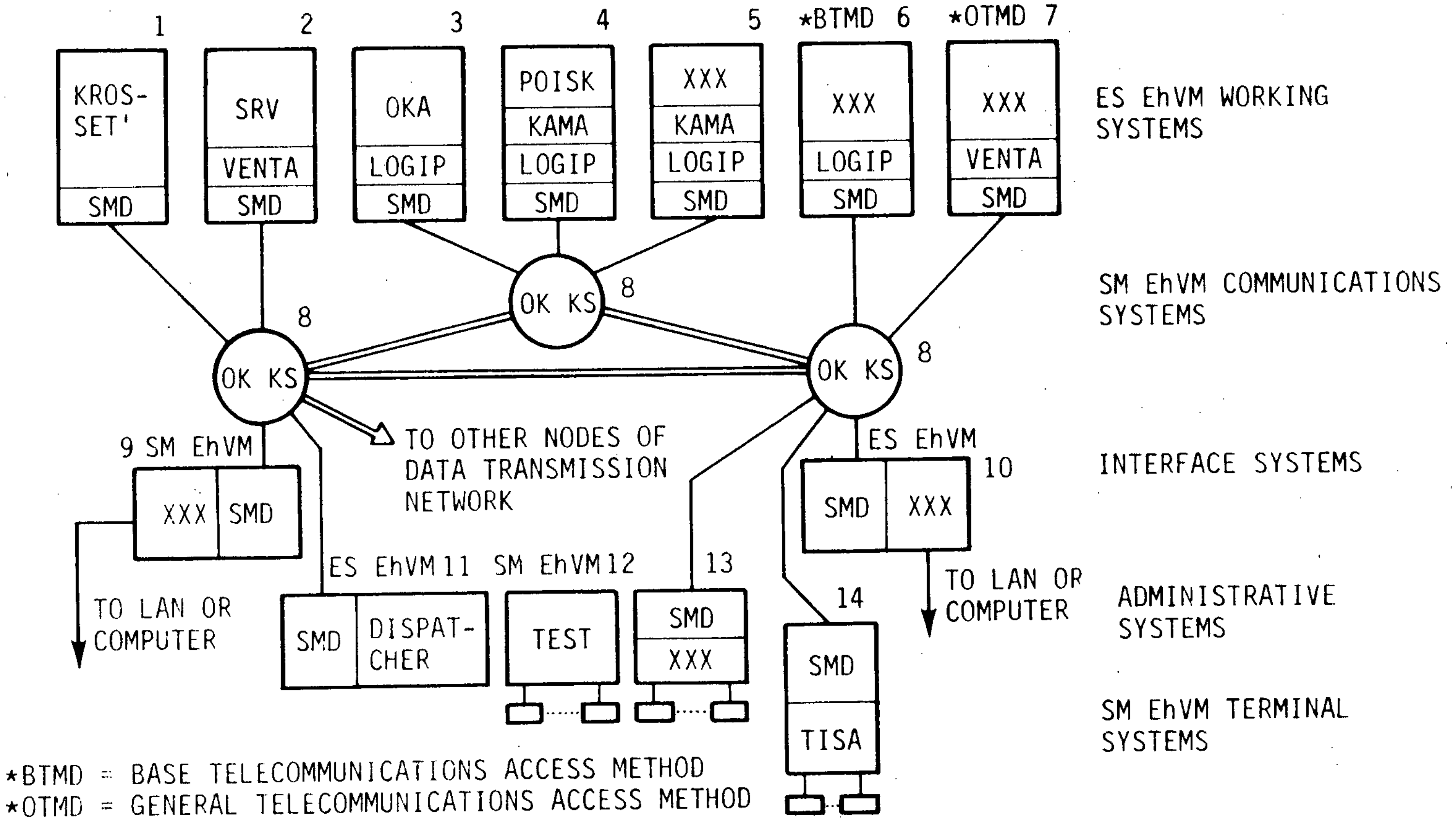
The program complex shown in Figure 6-7 can serve as the basis for different types of computer network systems. Figure 6-9 shows 14 different types of systems that execute different tasks within the network. The notation XXX is used to designate programs written by developers or users.

Program complex eight, called OSKS, makes up the X.25 communications system. The use of one or several communications systems makes it possible to create a data transmission network. In accordance with Recommendation X.25, a computer network is formed by adding subscriber systems to this network.

This article was authored by the Vice President of the Latvian Academy of Sciences, who, as a prolific writer, also serves as its unofficial chief publicist. The "conceptual example" shown in Figure 6-9 is almost an exact description of the configuration used in the experimental computer network operated by that institute (Figure 6-10). From this and numerous other sources, a picture emerges of the likely characteristics of a Soviet nationwide packet switching network:

1. Adherence to ISO and CCITT standards (including the X.25 protocol) wherever possible,
2. Use of process control minicomputers of the SM EhVM family (SM-3, -4) as communications handlers,
3. Incorporation of some form of network architecture similar to SNA (announced by IBM in 1975) possibly including use of the IBM SDLC algorithm (a modification of HDLC); (Soviet YeS EhVM family machines, being functional copies of IBM 360 and 370 series equipment, are particularly suited to this software), and
4. Use of adaptive rather than fixed-type routing methods.

It also appears likely that packet-switching development in the USSR will benefit from collaboration with Western countries. In 1981 a protocol on scientific exchanges related to networks for packet switching of computers. Architecture of those networks and theory of



*BTMD = BASE TELECOMMUNICATIONS ACCESS METHOD
*OTMD = GENERAL TELECOMMUNICATIONS ACCESS METHOD

SOURCE: Reference 81

Figure 6-9. Computer Network Components

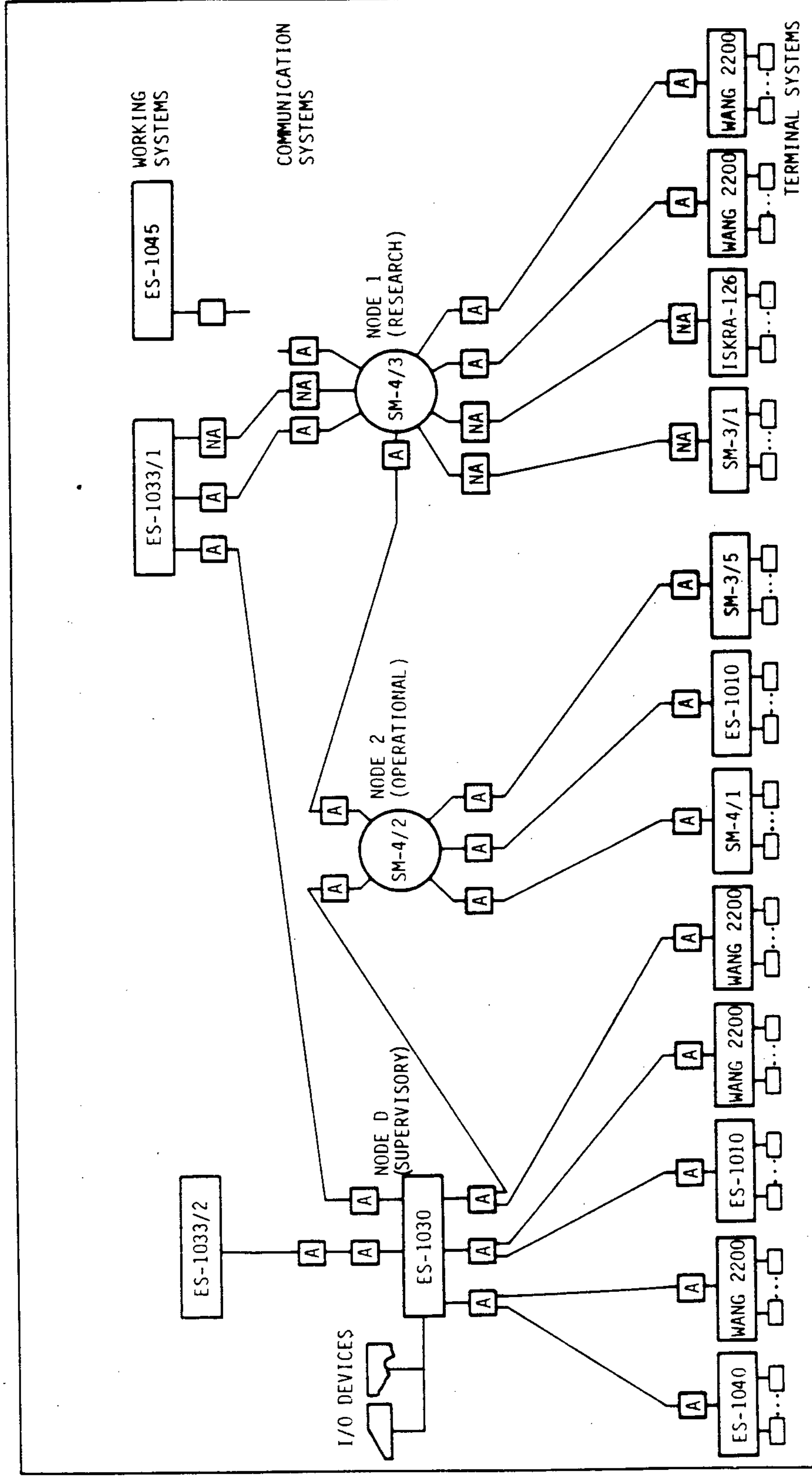


Figure 6-10. Experimental Computer Network of the Academy of Sciences of Latvian SSR (Circa 1981)

their protocols was concluded between the USSR Academy of Sciences and the National Research Council of Italy. Annual technical conferences which alternate between Italy and the Soviet Union have resulted. These exchanges have not been so one sided as those with France; at the 1982 conference Soviet papers outnumbered Italian presentations by 2:1 and the Soviets may be expected to seek bilateral exchanges with other Western countries in similar areas.

APPENDIX A—SOVIET COMPUTERS

This report is not concerned with computers per se, but the influence of those machines on modern telecommunications technology has become so pervasive that at least a brief treatment is required. Much modern telecommunications expansion is primarily driven by the need for computers to exchange information, both with each other and with remote users. Nor is their influence limited to the needs of computer networking; state-of-the-art telecommunications switching is virtually impossible without computers. Special-purpose machines are used to implement stored program control in third- and fourth-generation circuit switches. Message switching has involved computerized equipment since at least the early 1960s, and packet switching involves computers exchanging information through a network composed of multiple nodes each of which is itself a special-purpose computer. Consequently, the numerous serious problems that have afflicted the Soviet computer industry over the last two decades have had a profound effect on the development of Soviet telecommunications as well.

A.1 MAINFRAME COMPUTERS

Historically, computer design and production within the Soviet Union have fallen under the jurisdiction of three primary ministries. General-purpose computers are designed under the auspices of the Ministry of the Radio Industry (MRP). The computers intended for process control of industry and manufacturing are developed at institutes subordinate to the Ministry of Instrument Construction, Means of Automation, and Control Systems (MINPRIBOR). The Ministry of the Electronics Industry (MEP) has primary responsibility for the development of the individual components necessary for the success of computer manufacturing efforts.

By the mid-1960s, it was obvious that the Soviet computer industry was in such disarray that the most basic automation needs of the economy were in danger of not being met. The reasons for the industry problems were numerous. First of all, the industry was almost unbelievably fragmented. During the period 1951 to 1970, 13 research facilities were associated (at one time or other) with computer design, and no less than 22 production plants were identified as manufacturers of computer systems. This led to a proliferation of designs. Of nearly 60 computers known to have been developed during that timeframe, fewer than 20 achieved production levels of 100 or more.

Initially the computer industry suffered from limited financial support and insufficient qualified technical personnel. Many components provided by MEP for use in the computers were of low quality and not readily replaceable through supply channels. For this reason many computer systems were produced containing marginal (or even inoperative) components with corrections intended to be made "later." The component problem was aggravated by the transition from second-generation machines, which were largely built up from discrete semiconductors, to third-generation computers based mostly on integrated circuits (ICs). Although early Soviet ICs were basically copied from Western designs, inadequate manufacturing techniques frequently resulted in low yield, unreliable circuits. As many ICs as possible were imported from Western sources, but there were never enough.

Inadequate or nonexistent maintenance procedures also plagued the computer industry. In many instances the computers selected for production were quickly surpassed by improved models and thus were manufactured in such limited quantities that it was not feasible to develop full-scale maintenance packages.

Perhaps the most troubling single area of Soviet computer R&D was software development. In the early days of the computer industry, most programs were produced in machine language. As the need to use higher-level languages increased, a keen shortage of skilled programmers developed. Since training and development of programmers in advanced languages was a slow process, attempts were made to replicate Western software for implementation on Soviet machines. Delivery of even basic software to computer users usually lagged delivery of equipment, sometimes by years. It was not uncommon for those institutes receiving computers to write their own applications packages in lieu of waiting, nor was it unusual for those without software specialists to allow the machines to sit idle until software support was available.

High-level political attention was soon focused on the problems of the computer industry, and when efforts to cure those problems through edicts went unimplemented, fundamental changes in the way computers were developed were directed. Reform focused upon industry consolidation and the manufacture of standardized systems of computers that were fully hardware and software compatible, including peripherals.

The first successful attempt at a unified series of computers began in 1966 to 1967 when MINPRIBOR announced the designs for an upward compatible family, the Modular System of Computers (ASVT). These machines were to be medium-sized computers to serve industrial process control functions. The development of this series signaled the first attempts by Soviet computer engineers to produce IBM 360 look-alike machines in lieu of designing new machines on their own. The first three models in this class (designated ASVT-D) were second-generation computers and proved only marginally successful, in part because the available peripherals proved inadequate to complement the powerful IBM instruction set.

In December 1967, the first official announcement was made detailing another new series of upward-compatible machines, the general-purpose Ryad ("series") microelectronics-based computers. In 1969 this effort was expanded to include participation by member countries of the CEMA, all of which except Romania made substantial contributions to the project. Similar to the goals of the ASVT project, the RYAD computers were to be closely modeled after and program compatible with the IBM 360 series.

The Ryad project demonstrated that the computer industry problems would not be cured quickly. Peripheral device development for the Ryads fell behind schedule by two to three years. Upper-end models experienced major component problems and eventually had to be redesigned. Only two of the five planned systems were in the production stage by 1972, and only a few of those had been delivered by 1973. Some which did reach users lacked software and maintenance support.

To fill the gap until the Ryads could assume their intended role, considerable effort was devoted to upgrading an existing second-generation machine—the Minsk-32—which had proven unusually versatile and reliable. It was still produced in 400 to 500 units annually as late as 1973. Enhancements were made to its peripherals and core memory size. Additionally, two third-generation machines, the Nairi-3 and K-200, were developed independently of the national effort.

Shortly after introduction of the first IC-based models of the ASVT series (the so-called ASVT-M computers), work was begun on another "unified series" of process control computers known as the SM series. Unlike the ASVTs which were strictly products of Soviet industry, the SM development was to involve other CEMA members. The low-end SM machines were basically copies of Hewlett-Packard computers, while the high-end models (like some of the later ASVT-M computers) resembled PDP-11 series machines both functionally and physically.

Deficiencies with the first-generation Ryad machines included unreliable memory units, poor-quality peripherals, no developed time-sharing capability, and lack of hardware modularity. These were dealt with first by a series of upgrades (the Ryad 1.5 family) and then by a totally redesigned group of machines (the Ryad 2s). Ryad 2 capabilities had been upgraded to the point where these machines were roughly comparable to IBM S/370 equipment. By the end of the 1970s, many of the computer industry troubles had, to an extent, been corrected, but a few problem areas remain. It is uncertain if the third Ryad generation, presently in the design stage, will resolve these.

The most glaring deficiencies which continued into the 1980s involved peripherals. Punched paper tape was rarely used as an input medium for U.S. computers after about 1960, but many modern Soviet machines are oriented toward paper tape as the primary method of data input. Soviet line printers have traditionally been poor by U.S. standards. CRT terminals have been slow to be adopted as part of baseline computer configurations; only one of the first-generation Ryads (model YeS 1050) had such a device, and it had alpha-numeric capability only. As late as 1981 this problem persisted on some special-process machines. When the "Kvarts" quasi-electronic computer was initially installed in Leningrad, the primary communication between the operator and the "Neva-1" control computer was by means of a YeS-7073 electric typewriter. On an experimental basis, an AGAT-2000* display terminal was compared to the typewriter and (not too surprisingly) found to be a far superior tool for operator interaction (Reference 82). Hard-copy devices for Soviet display terminals have also been generally unavailable.

Characteristics of series-produced computers mentioned most prominently in this report are summarized in Table A-1. Generally, the large machines are significant from a telecommunications perspective only as processors to be networked. The Minsk-32, YeS 1030, and YeS 1033 have been used as (or proposed for) processors of message-switching nodes. The smaller machines (M-6000, SMs) are being widely used to handle communications in experimental packet-switching networks. The YeS 1010 is often used as the basis for an intelligent terminal.

Both of the unified computer systems employ a standardized nomenclature system that permits some knowledge about the class of a device to be gained if only its designator is known. This system is described in Table A-2, with emphasis on those devices used for teleprocessing (the 8xxx series).

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*The AGAT appears to be a domestically produced APPLE II-compatible "personal computer" class device. Western observers have faulted it for shoddy construction and slow speed as well as its exorbitant $17,000 price tag (Reference 83).

Table A-1. Soviet Computers of Telecommunications Significance

Model	Family	Generation	Year Introduced	Country of Manufacture	Speed (Kips)	Memory (Bytes)	Comparable U.S. Model
BEhSM-6	BEhSM	2	1965	USSR (Moscow)	800	32K x 48	IBM 7094
Minsk-32	Minsk	2	1969	USSR (Minsk)	65	16 to 64K	Unknown
M-6000	ASVT-M	3	1972	USSR (Severodonetsk)	200	32 to 128K	HP-2100
M-4030	ASVT-M*	3	1973	USSR (Kiev)	300	128K+	IBM S/360
YeS1010	Ryad-1**	3	1973	Hungary (Videotron)	10	8 to 64K	Unknown
YeS1030	Ryad-1	3	1973***	USSR (Yerevan and Kazan)	60	128 to 512K	IBM 360/40
YeS1033	Ryad-1.5	3	1978	USSR (Yerevan and Kazan)	200	256 to 512K	IBM 370/138
YeS1045	Ryad-2	3	1979	USSR (Yerevan) and Poland	4 to 500	256 to 3000K	IBM 370/155
SM-2	SM-EhVM	3	1976	USSR	400	32 to 128K	HP 2XXX
SM-3	SM-EhVM	3	1978	USSR (Kiev) and Poland	200	32K	PDP-11/40
SM-4	SM-EhVM	3	1978	USSR (Moscow)	500	32 to 128K	PDP-11/

*Both ASVT and Ryad compatible.
**Although designated as part of the Ryad family, not in fact upward compatible
***Pilot Model Only.

Table A-2. Uniform Equipment Identification System of the Unified Computers

Item Code*	Nature of the Item
0001-0999	Special Devices and Support Equipment
1001-1999	Computer System Models
2001-2999	Central Processors
3001-3999	Core Storage (Main Memory)
4001-4999	Input/Output (I/O) Channels
5001-5999	Storage Units
6001-6999	Input Devices
7001-7999	Output Devices and I/O Units
8001-8999	Teleprocessing Devices
80xx **	Modems (Signal Conversion Devices)
81xx	Error Protection Units
83xx,84xx	Multiplexers
85xx	Terminals
9001-9999	Off-Line data preparation

*Preface by "YeS" for Ryad computers or by "SM" for SM EhVM machines.
**A few exceptions to this subcategory breakdown have been found.

A.2 MICROCOMPUTERS

Microcomputers* began to appear in the USSR about 1975 with the introduction of the Elektronika S5-01. It was made possible by the K536 family of 8-bit, bit-slice microprocessor* chips which entered

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*As is also the case with process-control computers, the Soviet definition of microcomputers is much broader than that commonly used in the West. The Soviets define a microprocessor as any implementation of a "program controlled device for the processing of digital information on the basis of one or several microcircuits." In the West, the term microprocessor is applied almost exclusively to single-chip implementations of a computer CPU. Since a microcomputer is by definition based on microprocessors, it follows that many Soviet microcomputers would not conform to the usual Western usage of the term.

production a few years earlier and appears to have been of domestic design. This S5 series, which was developed to satisfy requirements for industrial automation and scientific processes, was expanded with more modern models based on later generation chips, but is now regarded as obsolescent. In 1981 Electronika S5-12 and S5-20 microcomputers were reportedly used in an experimental automated centralized system for technical servicing of IKM-30 links within the Leningrad Telephone System (Reference 82).

Further progress came with introduction of the K58X microprocessor series of families about 1979, as part of the 10th 5-year plan. There are 10 of these families (K580 - K589) each built around either a single-chip microprocessor or a set of bit-slice chips sufficient for constructing a central processing unit (CPU). They include supporting chips for I/O, interrupt prioritizing, and similar functions. At least four of these families are functional copies of Western chips, as it is these that appear to have been the most important in development of microcomputer systems.

The K580 is an 8-bit microprocessor based on the Intel 8080 chip and NMOS technology. Although not pin-for-pin compatible with the Intel 8080, it executes the Intel 8080 instruction set. This chip and the technology for its production have been widely exported to European CEMA members and were used to establish the microcomputer industries in several Eastern European countries.

Another important microprocessor family, the 16-bit NMOS K581, consists of functional copies of the CP1600 series chips. The most significant use of the K581 family has been in Elektronika 60 microcomputers, which are copies of the U.S. LSI-11/2 microcomputer, which is fully-compatible with the low end of the Digital Equipment Corporation PDP-11 computer line. Production of this machine, both in the USSR and in Poland (where it is known as the Mera 60), has been in quantities sufficient to make it a workhorse in a variety of Soviet industrial and scientific applications. Open-source literature indicates numerous attempts to use Elektronika 60s in packet-switching networks and as interfaces in teleprocessing applications.

About the same time the K58X families were being introduced in the USSR, the East Germans brought out the first models in what would eventually become a strong microprocessor program. With one exception, East German microprocessors were all copies of Western architectures. Particularly significant is the U880 family which is based on the Zilog Z80, one of the most successful Western 8-bit chips. All microprocessor production in the GDR is controlled by the Microelectronics Combine, and, although not high volume by Western standards (135,000 units in 1983), has been sufficient for both domestic requirements and export to other CEMA countries.

Unlike the USSR, which developed a number of different machines on the basis of each of its microprocessor families, the East Germans have tended to design a single microcomputer architecture for each microprocessor. This is due to the dominance of the Robotron Combine in Dresden within the GDR computer industry. The Robotron microcomputer based on the U880 is designated the K1520. It is the basis for GDR-manufactured quasi-electronic circuit switching systems and could have other telecommunications applications as well.

Both the Soviet Union and the GDR have introduced true 16-bit, general-purpose microprocessors since 1982. The Soviet K1810 series, based on the Intel 8086, is their most important offering. The East Germans continue to prefer to copy the Zilog families with their U8001 and U8002 being based on the Zilog Z8001 and Z8002, respectively.

Today virtually all European CEMA members have fledgling microcomputer industries and are beginning to produce significant quantities of microprocessor chips as well as machines based on them. The Bulgarians are using the K1810 family to construct an IBM PC-compatible, called the Pravets 16 (they also manufacture an Apple II-compatible, designated the Pravets 82, using imported Western chips). Poland, Czechoslovakia, and Hungary also have active programs. It is likely that PDP-11 compatibilty of larger systems will continue to be maintained and that smaller systems will largely conform to the 8080 architecture, followed by the 8086 architecture as production is mastered. Soviet pressure will prevent other CEMA members from pursuing divergent development paths such as the GDR, with its well-developed industry, has followed; conversely, the USSR is unlikely to interfere with microprocessor development within East Germany because of its self-evident successes.

In addition to problems with chip manufacture which have generally kept production quantities low, other difficulties are retarding growth of a viable CEMA microcomputer industry. Most of these sound like "replays" of the mainframe industry problems in the mid-1960s to early 1970s. There is an almost complete lack of any mechanisms for computer service and repair for "normal" users (who do not enjoy the high-priority priviledges of the CPSU Central Committee, the KGB, and much of the military). Domestic software development for the microcomputers has been very weak; however, the compatibility of these machines with Western systems permits partial circumvention of the problem through use of imported application software packages. Computer literacy in the USSR is low compared with the U.S. and some Western countries and, although in the long term more general availability of microcomputers will help correct this, in the shorter term it adversely impacts utilization. The Soviet Politburo, concerned with this situation, has announced plans to introduce computer technology instruction in all USSR secondary schools. Barriers to early implementation of this policy are the massive requirements it imposes for both equipment and qualified teachers (References 83 and 84).

Soviet and other CEMA microcomputers that can be identified to date as having potential for telecommunications developments are summarized in Table A-3. While applications can currently be identified for only a small number, it is likely that the next few years will see the newer microprocessors incorporated into telecommunications equipment to an increased extent.

Table A-3. CEMA Microcomputers of Possible Telecommunications Significance

Designation	Country of Manufacture	Micro-Processor	Western Equivalent	Word Size**	Technology	Date of Introduction	Known Telecommunications Applications
Elektronika S5	USSR	K536	None	8n bit	?	1975	Automated Digital Transmission Servicing System
Various	USSR	K580	Intel 8080	8 bit	NMOS	1979	None
	Czechoslovakia	MHB8080	Intel 8080	8 bit	NMOS	1982	
	Hungary	?	Intel 8080	8 bit	NMOS	1984	
	Poland	?	Intel 8080	8 bit	NMOS	1984	
Elektronika 60*	USSR	K581	CP 1600	16 bit	NMOS	1979	Packet Switching Data Transmission Interface
Mera 60	Poland	K581	CP 1600	16 bit	NMOS	1980?	
Elektronika NT	USSR	K587	None	4n bit	CMOS	1980?	None, but should be suitable for same as Elektronika 60
	USSR	K588	None	16n bit	CMOS	1980?	
Various	USSR	K1810	Intel 8086	16 bit	?	1982	None
Pravats 16	Bulgaria	K1810	Intel 8086	16 bit	?	1984?	
K1520	GDR	U880	Zilog Z80	8 bit	NMOS	1980-81	Quasi-Electronic Exchanges
K1620, 1630	GDR	U830	None	8n bit	NMOS?	1982	None
Uncertain	GDR	U8001	Zilog Z8001	16 bit	NMOS	1983?	None to date
		U8002	Zilog Z8002	16 bit	NMOS		

*Known variants include Elektronika 60M and Elektronika 60T.
**n designates bit-slice chip

SOURCE: Reference 85

GLOSSARY

A

ADEh	ehclipticheskaya dvukhzerkal'naya antenna	elliptical double-reflector antenna
ADG	giperbolicheskaya dyukhzerkal'naya antenna	hyperbolic double-reflector antenna
AMTS	avtomaticheskaya mezhdugorodnaya telefonnaya stantsiya	automatic long-distance telephone exchange
AMTSKEh	AMTS kvaziehlektronnaya	quasi-electronic long-distance exchange
AP	abonentskiy punkty	data (or subscriber) terminal (or point)
APD	apparatura peredachi dannykh	data transmission device
ASP	analogovpta sistema peredachi	analog transmission system
AT		subscriber telegraph
ATSK	koordinatnaya avtomaticheskaya telefonnaya stantsiya	automatic crossbar telephone exchange
ATSDSh	avtomaticheskaya telefonnya stantsiya dekadno-shagovaya	automatic step-by-step exchange
ATsK	al'fatsifrovaya klavatura	alphanumeric keyboard
ATsPU	al'favitno-tsifrovoye pechatayushchee ustroystvo	alphanumeric printer
AVTS	avtomaticheskaya vnutrioblatnaya telefonnaya stantsiya	automatic intra-oblast' telephone exchange
AVU	avtomaticheskoye vyzyvnoye ustroystvo	automatic calling device
AZTS	avtomaticheskaya zonnovaya telefonnaya stantisiya	automatic zone telephone exchange

GLOSSARY (Continued)

B		
BIS	bol'shaya integral'naya skhema	large-scale integrated (LSI) circuit
C		
ChNN	chas naibol'shej nagruzki	peak load hour (PLH)
ChRK	chastotnoe razdelenie (kanalov)	frequency division multiplex (channel)
ChTsT	chetverichnyj tsitrovoj traka	quaternary digital circuit
D		
DM	del'ta-modulyatsiya	delta modulation
DTR	dal'neye troposferonoye rasprostraneyiye	long-range tropospheric scatter
E		
EhIIM	ehffektivnaya izotropnaya izluchaemaya moshchnost'	effective isotropic radiated power (EIRP)
EhPM	elektrricheskaya pishushchaya mashina	electric typewriter
EhVM	elektronnaya vychislitel'naya mashina	electronic computer
ELT	elektronno-luchevaya trubka	cathode ray tube (CRT)
F		
FD	fotodiod	photodiode
FPd	fotoperedatchik	phototransmitter
FPr	fotopriemnik	photodetector

GLOSSARY (Continued)

G		
GTS	gorodskaya telefonnaya set'	municipal telephone network
GO	geostatsionarnaya orbita	geostationary orbit
I		
IKM	impul'sno-kodovaya modulyatsiya	pulse code modulation (PCM)
IMS	integral'naya mikroskhema	integrated microcircuits (IC)
ISZ	iskusstvennyj sputnik Zehli	artificial Earth satellites
ITsSS	integral'naya tsifrovaya set' svyazi	Integrated Digital Communications Network
IZNS		Intrazone Network Station
K		
KIA	kontrol'no-ispytatel'noj apparatura	(automatic) test equipment
KK	kommutatsiya kanalov	channel (circuit) switching
KO	kanaloubrazuyushchee obsurvd-ovaniye	channelizing equipment
KP	kommutatsiya paketov	packet (or parcel) switching
KS	kommutatsiya soobshchenij	message switching
KURS	kompleks unifitsikovannykh radiorelejnykh sistem	Complex of Unified Radio Relay Systems

GLOSSARY (Continued)

L		
LS	liniya svyazi	communication line
LVS	lokal'naya vychislitel'naya set'	local computer network (similar to U.S. local area network- LAN)
M		
MKKTT	Mezhdunnarodnyj Konsul'tativnyj Komitet Telegrafii i Telefonii	International Consultive Committee for Telephony & Telegraphy (CCITT)
MOS	Mezhdunnarodnaya Organizatsiya po Standartam	International Standards Organization (ISO)
MSS	magistral'naya setevaya stantsiya	mainline network exchange
MTS	mezhougorodnaya telefonnaya stantisya	long-distance telephone exchange (LDX)
MTsKS		mainline message switching center
N		
NML	nakopitel'na magnitnoy lente	magnetic tape storage
NTsKS		low-level message switching center
NUP	neobsluzhivaemyj usilitel'nyj punkt	unattended repeater
O		
OAKTS	obshchegosudarstvennaya* avtomaticheski kommutiruemaya telefonnaya set'	Nationwide* Automatic Switched Telephone Network

*this word is variously translated government-wide and state

GLOSSARY (Continued)

O Cont.

OGAS	Obshchegosudarstvennaya* Avtomatizirovannaya Sistema Sbora i Obrabotki Informatsii	Nationwide Automated Data Acquisition and Processing System
OGMTS	ob''edinennaya gorodskaya i mezhdugorodnaya telefonnaya stantsiya	consolidated municipal and long-distance telephone exchange
OGSFS	Obshchegosudarstvennaya* Sistema Faksimil'noj Svyazi	Nationwide Facsimile Communications System
OGSPD	Obshchegosudarstvennaya* Sistema Peredachi Dannykh	Nationwide Data Transmission System
OGSRTP	Obshchegosudarstvennaya* Sistema Raspredeleniya Signalov Televizionnykh Programm	Nationwide TV Program Distribution System
OGSTfS	Obshchegosudarstvennaya* Sistema Telefonnoj Svyazi	Nationwide Telephone Communications System
OGSTgS	Obshchegosudarstvennaya* Sistema Telegrafhoj Svyazi	Nationwide Telegraph Communications System
OGSRZV	Obshchegosudarstvennaya* Sistema Raspredeleniya Signalov Programm Zvukovogo Veshchaniya	Nationwide Audio Broadcast Program Distribution System
OKOP	okonyechnoy komplyeks oburudovaniye peredachye	family of transmission equipment
OKS	obschchekanal'naya sistema signalizatsii	common channel signaling system
OMTS	Oblastnaya MTS	Oblast' long-distance telephone exchange
OOD	Oborudovaniye obrabotki dannykh	data processing equipment
OP	okonchatel'nyj punkt	terminal (point or station)

*Also translated as "government-wide" and "state"

GLOSSARY (Continued)

O Concluded

OS	okonechnaya stantsiya	terminal exchange (end office)
OUP	obsluzhivacmyj usilitel'nyj punkt	attended repeater
OV	opticheskoe volokno	optical fiber

P

PA	parabolicheskaya antenna	parabolic antenna
PAS	periskopicheskaya antennaya sistema	periscopic antenna system
PD	peredacha dannykh	data transmission
PG	pervichnaya gruppa	primary group
PM	pishushahaya mishinka	alphanumeric typewriter
PO	programmnde obespechenie	software
PS	perfoschityvatel'	paper tape reader
PS		direct connection
PShLS	pereklyuchatel' shirokopolpsnykh liniy svyazi	wideband communications link switch
PTsT	pervichnyj tsifrovoj trakt	primary digit circuit

R

RPA	ruporno-parabolicheskaya antenna	parabolic horn antenna
RRL	radiorelajnaya (liniya)	radio relay (link or line)
RRS	radiorelejnaya stantsiya	radio relay station
RUS	rajonnyj uzel svyzai	rayon communications junction

GLOSSARY (Continued)

S

SBIS	sverkhbol'shaya integrai'naya skhema	very large scale integrated circuit (VLSI)
SEV	Soyuz Ekonomicheskoy Vzaimopomoschij	Council for Mutual Economic Assistance (CEMA)
SI	svetoizluchatel'	light emitter
SM-EhVM	sistema malykh EhVM	system of small electronic computers
SPD	sredstvo peredaci dannykh	data transmission system
SS	sluzhebnaya svyaz	service communications
SSM	setevaya stantsiyamestnaya	local network exchange
SSS	sistema sputnikovoj svyaz	satellite communications system
STS	sel'skaya telefonnaya set'	rural telephone network
STsT	subervichnyj tsifrovoj trakt	subprimary digital route
SUK	setevoj uzel kommutatsii	network switching center or node
SUP	setevoj uzel pereklyucheniya	network switching center?
SUV	setevoj uzel vydeleniya	network selection center
SUVK	spetsializirovannyj upraulyayushchij vychislitel'nyj kompleks	special-purpose control computer complex

T

Tch	tonal'naya chastota	voice frequency (grade) channel

GLOSSARY (Continued)

T Concl.

Tf	telefonnaya	telephone
Tg	telegrafno	telegraph
TG	tretichnaya gruppa	ternary (tertiary) group (mastergroup)
TK	telegrafnyy kanal	telegraph channel
TsKS	tsentr kommutatsii soobshcheniy	message switching center
TsKS-T	telegrafnyy TsKS	telegraph message switching center
TsS	tsentral'naya stantsiya	central exchange
TsSP	tsifrovaya sistema peredachi	digital transmission system
TsTA	tsifrovaya telefonnaya apparata	digital telephone set
TTS	telegrafno-telefonnaya stantsiya	telegraph-telephone exchange
TTsT	tretichnyj tsitrovoi trakt	ternary (tertiary) digital circuit
TU	tranzitnyj uzel	tandem center or node
TVTsKP	territorial'nyi VTsKP	territorial shared resource computer center

U

UAK	uzel avtomaticheskoj kommutatsii	automatic switching center or node
UPS	ustroystvo preobrazovaniya signalov	signal conversion device (Modem)
UZO	ustroystvo zashchity otoshibok	error protection unit

GLOSSARY (Concluded)

V

VG	vtorichnaya gruppa	secondary group (supergroup)
VOLS	volokonno-opticheskaya liniya svayzi	fiberoptic communications lines
VRK	vremende razdelenie kanalov	time division (multiplex)
VSS	vnutrizonovaya setevay a stantsiya	intrazonal network exchange
VTs	vychislitel'nyy tsentr	computer center
VTsKP	vychislitel'nyj tsentr kollektivnogo	shared resource computer center
VTsT	vtorichnyj tsifrovoj trakt	secondary digital circuit
VVu	vvodno-vyvodnoye ustroystvo	input-output device

Y

YeASS	Yedinaya Avtomatizirovannaya Systema Svyazi	Unified Automated Communications Network (UACN)
YeS-EhVM	Yedinaya Sistema Elektronnykh Vychislitel'nykh Mashin	Unified Computer System

Z

ZTsKS	Zonovoj TsKS	zone message-switching center
ZTU	zonovoj telefonnoj uzel	zone telephone center or node

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