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Introduction of Modern Telecommunications Equipment in Russia and the New Republics

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The former Soviet Union is still a united country in terms of telecommunications (and telephony in particular). Though different countries have gained their independence, the telephone network is still united and built according to the same technical standards and regulations.

In this article we describe the process of introducing new equipment for the telecommunications networks of the former USSR, taking into account our personal experience. First, it is important that we are dealing mainly with local switching, so the examples discussed are mainly from this particular field.

Today the former Soviet Union is still a united country from the point of view of telecommunications (and telephony in particular). Though different countries have gained their independence, the telephone network is still united and built according to the same technical standards and regulations.

In all the new countries, local calls are not billed as yet and[1] additional services are virtually nonexistent, so it is impossible to generate revenue providing them. Local administrations need to install new equipment in order to upgrade their services, thus making it possible to earn more income from users. The three main sources of income are:

- Installation and subscriber fees.
- Payments on a per-call or per-time-unit basis
- Payments for services and special features.

Currently, the republic's administrations are trying to increase the first item, which can be achieved by upgrading the old electromechanical switches and the analog network. For example, we can mention the development and production of the modernized crossbar equipment with stored program control ATS-AME in Russia.

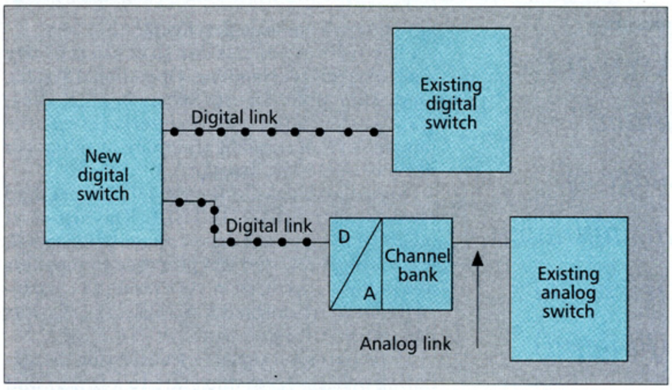
In order to have the second source, you have to install the new electronic equipment on the existing exchanges. The problem, addressed for more than 15 years, is not solved yet.

Of course, the introduction of modern digital switches can boost the three above-mentioned sources. Moreover, network digitalization can provide such a high level of service that per-call (per-time-unit) billing of local calls will not be of interest to the operators (as in Canada).

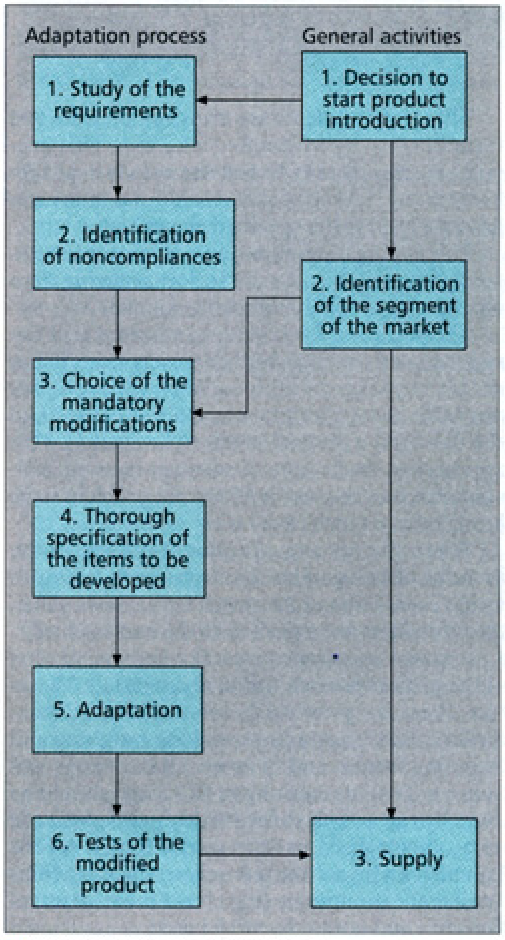
Less than one percent of the users currently have access to fundamental additional services and there is still much demand the plain old telephone service, which has made the commonwealth of Independent States (CIS) market very attractive to digital equipment producers. Most of them are already aware of the difficulties waiting for them in this field.

New equipment is installed into the existing analog environment. Pulse Code Modulation (PCM) transmission equipment has to integrate channel banks which perform signaling conversion according to the standards as defined by the Public Switched Telephone Network (PSTN) Set of Rules and Regulations [1].

In the '80s it was decided that digital switches would be connected to the public network only through digital interfaces. This new switch installation is shown in Fig. 1.



■ **Figure 1.** *New digital switch installation.*



■ **Figure 2.** *Stages of adaptation.*

In Russia this policy is still strictly pursued in the metropolitan areas' public networks, with the exception of the Public Branch Exchanges (PBXs), for which analog interfaces with the PSTN are allowed due to marketing concerns. Apparently, in some of the new republics this approach is not mandatory, although we find it is the most reasonable one from the viewpoint of further development of the network. When the existing analog switching equipment is substituted by the digital one there is no problem regarding interfaces, and the PCM converter can be used somewhere else to upgrade the network.

Unfortunately, this approach is not working very well in rural and long distance networks, because the country is rather large and the cost of installing the new (digital) line equipment is very high.

These problems will be briefly discussed in the first section ("What is Needed for Adaptation") and touched upon in the third ("Different Variants of Adaptation") and the fourth ("Accompanying Problems") sections.

The type of adapted switch has to be approved by the relevant authorities and we believe that some knowledge about the procedure can be useful, which is why we devote the second section ("Type Approval Procedure") to this issue. The fifth section ("Some Examples") illustrates the main ideas.

What is Needed for Adaptation

The title of this section is a bit ambiguous. First of all it means "What requirements are to be met to install the equipment in the former USSR?" The second meaning is "What can be done to meet these requirements?" A general answer to the first question is to do the following: read the document, "The PSTN Set of Rules and Regulations" [1] and implement the features required in the equipment you intend to introduce to the market. This recommendation is easy to make, but difficult to follow. The document comprises more than 700 pages of Russian text (an English version is alsoavailable) and many parts can be understood only by those with some experience in the field.

The main task is to define what requirements are mandatory for your particular piece of equipment and which of them differ from the international requirements. The greatest difference lies within the field of signaling protocols and some call handling procedures [2]. We have worked with these protocols specifications using Specifications and Description Language (SDL). One can find 30 to 35 signaling types on the CIS PSTN and a few more on the private networks (this applies only to country-specific ones).

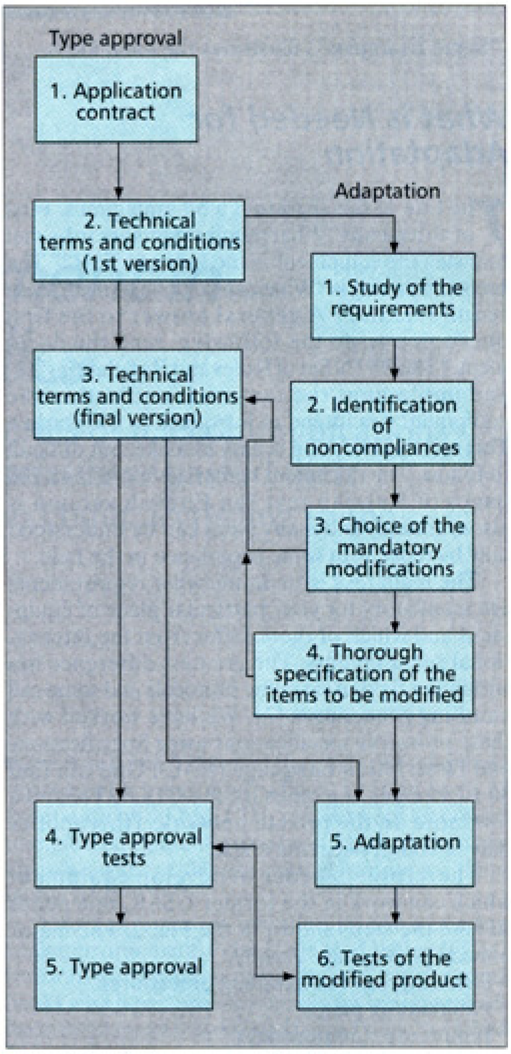
Therefore, in order to develop equipment which can work in the former USSR, one needs to take the steps shown in the Fig. 2. The major noncompliances are usually:

- Signaling and call handling procedures.
- Attenuation plan.
- Input/output impedances. The main effort, of course, lies within the step number four, but to ensure its success one has to be careful in all other items. This process usually corresponds with type approval.

> *Even at the initial stage of digitalization, Telenokia (Finland) proposed the PCM equipment to ensure connectivity with existing analog networks.*

Type Approval Procedure

Type approval is performed by one of the laboratories of the Ministry of Communication. There is a list of such entities and their fields of responsibility. The producer has to submit an application for type approval and file a contract with the designated laboratory. We shall briefly mention the main steps of type approval and their correspondence with the adaptation process (Fig. 3). More information can be found in [3].



■ **Figure 3.** *Type approval procedure.*

After the initial steps (Stage 1) an official document called "Technical Terms and Conditions" (TTC) is prepared. It describes the main parameters and features of the product to be installed in the CIS. During subsequent stages the product will undergo Type Approval Tests (usually in two steps: so-called factory or parametric tests and line or functional tests) prove that all the TTC requirements are implemented. This indicates the serious nature of this document. A problem with its completion is that it is written only in plain text. We believe that a lot of additional information is needed on these stages of the Type Approval/Adaptation process to specify the signaling and call handling procedures [4].

Testing is the most crucial stage, because one must ascertain that the product fits the requirements for both the customers and oneself. Usually this is done by testing the product in the real environment. Also, it provides the only means to test signaling and call handling features.

This approach has a lot of disadvantages, because if one encounters a problem, the test usually gives only a negative result, without any identification of the problem, and there are no means to support its debugging.

That is why the new approach has been adopted. First, it was decided that the switch will be regarded as a "black box" because many producers are reluctant to let any outside engineers have access to information about the design. So the model of the virtual switch has been developed.

The software of this switch consists of five main blocks: Call Handling, Operational System, Operation Maintenance, Subscriber Signaling, and Line Signaling, and has interfaces with the physical level of signaling (firmware of subscriber line units and trunk line units).

Signaling blocks of the model are specified formally using Z.100 ITU-T SDL. This high-level model of the protocol, based on requirements R, was thoroughly tested and proposed to suppliers as a protocol specification. As a result, all compulsory states are defined $S = \{S_0,...S_i,...S_m,\}$ as part of the SDL expression L, or $S \subseteq L_{SDL}$.

Afterwards, all signals c transferring the signaling process from one state to another and tasks to be fulfilled Γ are defined as

$C = \{C_0,...C_i,...C_n\}$ $\qquad C \subseteq L_{SDL}$

$T = \{T_0,...T_i,...T_y\}$ $\qquad T \subseteq L_{SDL}$

Thus, requirements are transformed from text form into an algorithm $R \rightarrow L_{R\ SDL}$. This provides an opportunity to test the switch in a step-by-step way, provided that its external interfaces function follows the specified algorithm.

The testing equipment uses signals transmitted by the switch as signals $\{C\}$ transferring from one state of the formal model to another.

The states of the testing equipment and the switch should match each other at every stage. If they do not correspond with each other, even only once, the test cannot be considered passed and the debugging process needs to be started. This approach is much more convenient than the conventional one because it allows the problem to be localized in a much easier way.

When the testing equipment passes all the branches of the algorithm, the results can be confirmed by the connection of the switch to real lines. After, the procedures are considered to be implemented.

It is also expedient to test the implementation of the protocols when traffic is generated. Therefore, there is a proposal to connect local call simulators to extension lines, to loop outgoing and incoming trunks, and to assess all the delays and failures. Troubleshooting at this stage should be done by the switch software designers, because no protocols discrepancies can be found. All the failures can be attributed only to the particular implementation items (e.g., bus access, reservation etc.) and not to the model used.

For the purposes of testing the switches and signaling converters, the PC-based public Central Office simulator (i.e., protocol tester) was developed. After the tests (if their results indicate successful adaptation), the protocols together with the conclusions of the type approval laboratory are sent to the Ministry of Communication. The materials are then considered by the Type Approval Board of the Ministry and the Type Approval Certificate is issued.

Different Variants of Adaptation

It is evident that there should be different approaches toward adaptation of different types of equipment.

For transmission equipment, the implementation of the international standards is usually sufficient. Of course, when the signaling conversion is needed, the channel banks are to be modified.

For switching equipment, we can distinguish several classes. The first one is small private switches (i.e., key systems) serving less than 100 to 150 lines. They can be connected to the public network via two wire subscriber loops and usually no adaptation is needed. The items to be checked are:

- Transmission parameters.
- Rings and tones. :
- Subscriber loop parameters.

The second class is PABXs. Here, a major adaptation effort is needed. However, one must distinguish between what is needed to get type approval and the demands of the market. In this case, mandatory type approval requirements are only a subset of the items which can be required by the customer. In addition to the issues mentioned for the small switches, one has to keep in mind the following ones:

- Country-specific interfaces (physical and protocol levels).
- Country-specific calling party identification procedures.

For type approval, only one interface implementation – so-called "three wire" or PCM channel associated signaling (CAS) – is sufficient. But users, especially ones with large nationwide private networks, can ask for much more.

The same applies to the rural switches, but here we can also mention:

- Maintenance of the existing exchanges of the lower level of hierarchy.
- Support of the telegraph and cable radio broadcasting signals transmission.

For the urban switches the number of mandatory interfaces is rather limited. As it was already mentioned the PCM CAS with calling party identification and multifrequency address signaling is mandatory. The long-distance offices also have to support some types of the in-band supervision signaling as well as to provide interworking with existing operator positions (manual switch boards) and neutralization of echosuppressors.

Accompanying Problems

"The history of the former USSR telecommunications networks digitalization can be subdivided into three phases.

During the first half of the '80s, the installation of mainly Finnish and Yugoslavian switches (made under the license) took place.

Since the beginning of deregulation more than ten foreign producers have proposed their equipment for our market.

Now we are at the beginning of the next phase: some regulations are introduced. First, only two types of switching equipment are allowed to be used as international gateways in Russia, and only three types for national long distance call switching. Also, it is recommended to use no more that two different types of digital switching equipment in each region of the country. All these regulations are aimed to reduce the cost of the operation, maintenance, and repair. They are applicable only to public networks. Private operators have to resolve these problems individually.

Now we also clearly see the tendency to demand a comprehensive solution of the problems. Customers are mainly interested in the integration of equipment into the existing environment. This means that the switch should be accompanied by the transmission equipment, cables, terminals, etc. The installation should be done and the "key" should be presented to the customer. Also the repair and maintenance problems are to be solved. So we can make a list of the issues to be considered during the implementation of the project:

- Switching and transmission equipment adaptation and type approval.
- Implementation of the specific features needed by the customer.
- Choice of the network and equipment configuration.
- Operation and maintenance center organization.
- Billing center organization.
- Repairs.

Even at the initial stage of digitalization, Telenokia (Finland) proposed the PCM equipment, including their switches, to ensure connectivity with existing analog networks. The weight of this problem can be illustrated by the following figures. In 1993 in the Volga/Ural area, 21 digital switching systems of nine different types were installed. They serve about 120,000, the total number of the PCM primary systems needed is 1954.1222 of them are used for the connection with the central offices of the public network, 548 needed to provide the connections between modules of the newly installed switches, and 184 supporting remote switching units (RSU). There are no special requirements to the PCM equipment supporting RSUs and internal interfaces, but the majority of the systems used for external connections has to support the conversion of the analog super vision signaling into the digital channel associated one.

The producers, who want to provide general solution, have to adapt their transmissions equipment also. This was done by Telenokia Finland in the early '80s for the PCM primary systems or by Nicola Tesla Yugoslavia for the frequency multiplexors with the in-band signaling for the toll switch. This is done by Siemens Germany and NEC Japan right now. Other companies use the equipment produced inside CIS taking advantage of its relatively low cost.

Another problem which becomes more and more important is the operation and maintenance of the equipment. That is why it is strongly advised by the Ministry of Communication not to use more than two different systems in one area. This problem becomes very complicated on the rural networks where the new digital switch, if it is installed as a Central Office, has to support remote maintenance of the terminal switches of different electromechanical systems.

The problems of repair, training etc. also exist, but we do not find them to be specific for our countries.

Some Examples

In this section we illustrate some examples of new equipment installation in the different areas of the former USSR.

The first example is the digitaliztion of the Fergana/Kokhand area in the Republic of Uzbekistan. Several digital switches produced by DAEWOO TELECOM (Korea) have been installed. The network diagrams for Fergana and Kokhand) are shown in Figs. 4 and 5, respectively.

The newly installed exchanges, adapted with the assistance of the authors, are connected to the existing network by means of fiber cables. The number of channels is shown on the links, and the number of subscriber lines served by the switches are shown near the circles representing the exchanges.

Another feature of the project worth mentioningis that one of the specific types of equipment used in CIS is the so-called Special Services Node (SSN), a switch providing access to the emergency services (such as fire brigade, law enforcement and emergency medical care) and information services (more about this aspect is found in [4]). In this project we have a distributed SSN and services are organized over several exchanges.

The existing environment is electromechanical. The main type of switch is ATSK or ATSK-U, which is the branch name of the Soviet crossbar exchanges. The new nodes are connected to then via 30-chan-nel (2 Mb/s) and 120-channel (8 Mb/s) PCM links with analog-to-digital and signaling converters installed on the analog exchange side.

The toll switch in Fergana is a Soviet semielectronic one with a software control (whose brand name is QUARTZ). It is rather flexible and that has eased an integration problem on this particular site.

The Kohhand network uses a Fergana toll switch that connects via frequency division multiplexors, which is why the special signaling converter called AZTS is needed to convert the out-of-band signals into the in-band ones.

Another rather specific problem was that the PABXs used in the area were mainly small crossbar switches used normally on rural networks. Thus, there was a dilemma whether to implement rural interfaces in the digital switch or to modify the signaling via the links to PABXs. Luckily, the local administration has chosen the second, more cost-effective option, although it necessitated much effort on the part of the operator engineers. It is unlikely that such a problem can be encountered in large industrial centers, but it is typical enough for some areas to be mentioned as an example.

There are not many examples of such a modernization of the telephone network of the whole region. More frequently, operators only install single switches.

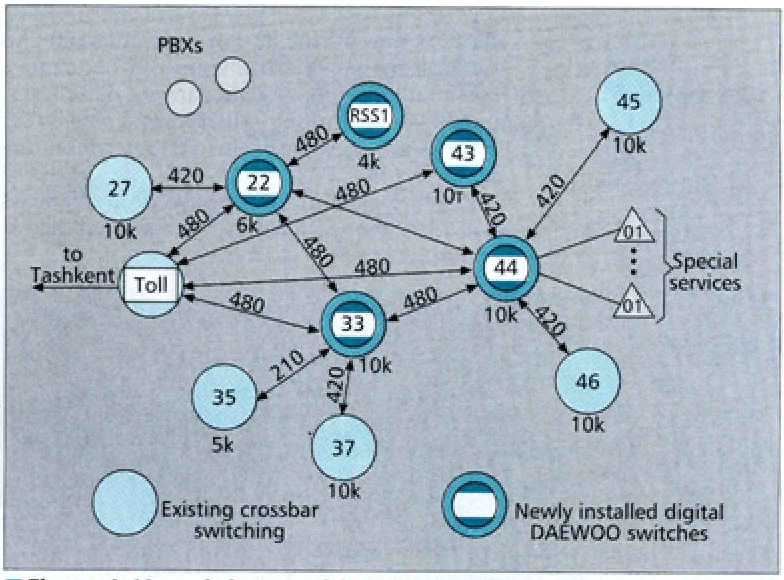
The next example, a typical one, is the introduction of one new digital switch into the existing environment. The switch is the STAREX-TX1, produced by Gold Star Information and Communication (GSIC) (Korea) for Samara, a city on the banks of the Volga River. The environment is mainly electromechanical (Fig. 6). There is only one digital switch (number 41) MT-20/25, produced in the Russian city of Ufa by the BETO company under the license of Tomson CSF (France). Connection with the existing network is achieved by means of PCM transmission equipment with a secondary multiplexion PCM system. In comparison with the case of Fergana/Kokhand, it can be highlighted in this example that SSN is concentrated in one place and is based on the digital equipment (MT-20/25).

The final example under consideration is the introduction of the ALCATEL 1000 EЮ switch in the city of Kharkov (Ukraine) as shown in the network diagram (Fig. 7). This case is very interesting because E10(#14) is connected to the network via MT-20/25 (#10/11) using CCITT R2 signaling, which is supported by both systems.

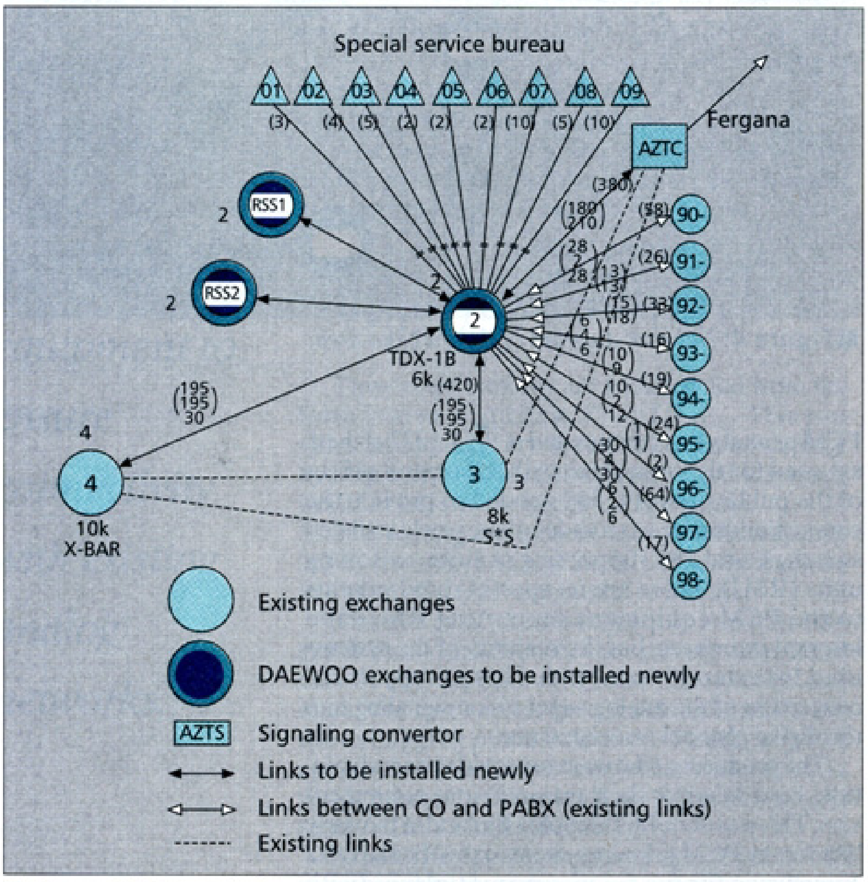
This illustrates the difference in Ukraine's technical policy of. The R2 signaling is not allowed on the interoffice link anywhere else in the CIS, though it is used inside PENTACONTA crossbar switches and as internal interface in some PABX. It is considered not feasible to allow another signaling system now, when the introduction of CCITT CCS7 has started. But it was decided to use R2 in Kharkov, though EЮ is fully adapted, to reduce the complexity of the project.

Conclusion

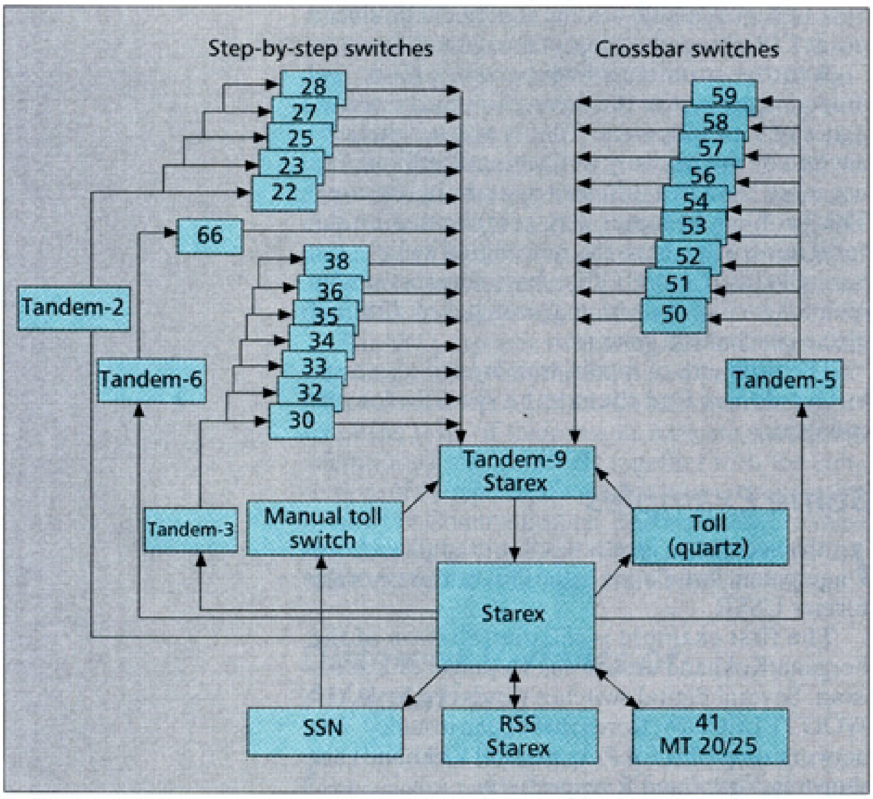
Several technical problems related to the introduction of modern telecommunications equipment in the new republics and Russia were briefly touched upon in this article, and there are many that were not even mentioned. The implementation of any project creates a lot of questions and there are various ways to satisfy customer's demands and solve technical problems, such as the main challenge of interconnection with existing networks. Solving these problems involves gathering all the possible information about the environment and finding ways to reach the final goal.



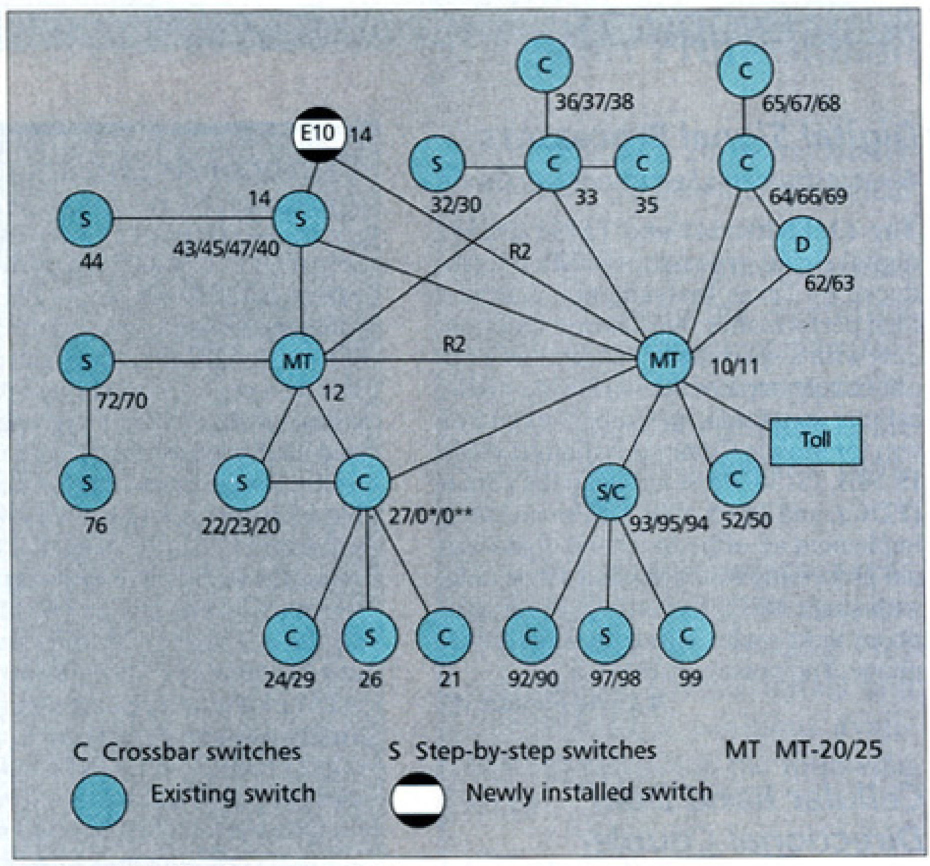
■ **Figure 4.** *Network diagram of the Fergana area.*



■ **Figure 5.** *Network diagram of the Kokhand area.*



■ **Figure 6.** *STAREX installation in the Samara network diagram.*



■ **Figure 7.** *Khrakov network diagram.*

References

[1] PSTN Set of Rules and Standards, Moscow, 1988.

[2] B. Goldstein and L. Sloutsky, "Distinctive Characteristics of Call-Handling Procedures and Signaling Logic in a Russian Public Telephone Network,"/EEEJSAC, vol. 12, no. 7, Sept. 1994, pp. 116V1170.

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Biographies

BORIS GOLDSTEIN received a Dipl.-Ing. in electrical communication and a Ph.D. in technical sciences from Leningrad University for Telecommunications in 1973 and 1982, respectively. He joined LONIIS (R&D Telecommunication Institute), St. Petersburg, in 1973 as an engineer, a member of the scientific staff, and a laboratory manager. Currently, he is director of the LONIIS Software Branch and a professor at the St. Petersburg University for Telecommunications. His research interests include telephone network's signaling protocols, performance analysis of telecommunication software.

LEO SLOUTSKY was graduated from Bonch-Bruevich Telecommunication University of Leningrad (now St. Petersburg) in 1976. The same year he has joined LONIIS (R&D

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