S. F. Golyan and L. A. Lobachevskiĭ, Results of Experimental Studies of the Global Propagation of Short Radio Waves. During 1966–1972, IZMIRAN made experimental studies of propagation conditions for short radio waves on long paths: from Moscow to Antarctica (Molodezhnaya Station) and from Moscow to the diesel-electric motorship "Ob'" during its voyage from Leningrad to Molodezhnaya Station.

The 20-kW transmitter at Moscow was operated in a pulsed mode into a rhombic antenna pointed in the direction of Molodezhnaya. The pulse duration was 500 μsec and the repetition frequency 12.5 pulses per second. It transmitted at three-hour intervals around the clock at 10 fixed frequencies in the band from 4.5 to 23 MHz. The field strength and relative delay time of the received signals were measured at Molodezhnaya and on the "Ob'." A vertical unbalanced dipole was used for reception. Synchronization between the receiving and transmitting stations was obtained by the use of highly stabilized reference oscillators.

Analysis of the voluminous experimental material made it possible to study the propagation characteristics of shortwave radio signals in both the forward direction (along the smaller arc of the great circle) and the back direction (along the longer arc), as well as those of around-the-world signals.

This analysis demonstrated the existence of optimum ionospheric ducts for ultralong-range radio propagation with much less attenuation than would follow from field-strength calculations made by existing methods.

It was found from these data that the optimum ducts are formed in the ionosphere during the periods after sunset and after sunrise, i.e., for propagation in the plane of a great circle turned away from the plane of the terminator (around the earth's axis) through an angle of 15—20° in the direction of the earth's rotation.

Long radio links for which the plane of the great-circle arc coincides at certain times of day and certain times of the year with the plane of the optimum annular duct offer the best conditions for radio communications at these times.

On meridional radio paths, for example (such as Moscow-Molodezhnaya), the most favorable conditions for ultralong-range propagation occur at the equinox 1—1.5 hour after sunset (sunrise). Figure a) shows experimental curves of the diurnal trend of the monthly median field-strength value (E_0) at the optimum working frequencies on the Moscow-Molodezhnaya radio link for the most characteristic periods of the year, an equinox (March 1967) and a solstice (June 1967). The numerals indicate the corresponding values of the OWF in MHz. For comparison, Fig. b) gives calculated values of E_0 for the same periods. The calculation was made by A. N. Kazantsev's method.

The substantial increase in the field intensity after sunrise and especially after sunset at the equinox indicates the presence of optimum ducts in the ionosphere during these periods.

The substantial disagreement between the calculated and experimental values indicates a need for the development of a new method of calculating the shortwave field strength for global transmission paths, one that takes account of the specifics of the ultralong-range propagation mechanism.

It was also shown from the analysis of the experimental materials obtained on the "Ob'" that on transmission paths that never coincide with the terminator, and hence with the optimum annual duct, the best time of day for ultralong-range propagation is the time at which the optimum annular duct intersects the great circle of the path at points on the equator. The best time of year (at the same time of day) is that at which the angle between the planes of the path and the optimum annular duct is smallest.

The results of the work were used to derive analytic expressions and to construct nomograms for determination of the times of the day and year that are most favorable for long-range shortwave radio communications between any two points on the globe in both the forward and back directions, and for determination of the directions and corresponding times most favorable for around-the-world propagation from an arbitrarily specified point.

The simplified picture of the global shortwave radio propagation mechanism presented above calls for the development of more accurate quantitative methods for calculation of the energy characteristics of propagation, and this the IZMIRAN proposes to do on the basis of its current theoretical studies.