THE R-161 RADIO STATIONS

by Joe Bell, G4PMY - Owner & Operator of an R161-A2M

Foreword

In October 1999 I purchased what was advertised as a “Zil Radio Truck”. This ten tonne Russian military communications truck appeared to be well equipped and constructed with reasonable quality, contrary to military doctrine handed down to me whilst in service.

The MoD decided not to release any of the documentation they had received with the truck, as many of the topics dealt with therein were still officially classified secret. Nor would they provide any history relating to where this truck came from.

The original truck was powered by a V8 petrol engine, which developed 150HP at 3000RPM. This specification is the same as all other Zil 131 trucks and probably works just fine in the cargo version, which weighs only two tonnes or so. The power delivery at ten tonnes was totally inadequate for European roads and traffic conditions, and so half way through this years show season I swapped the petrol engine for a B series Cummins diesel with an Eaton six speed box.

Following a number of show events, those members of the MVT and similar organisations who also had an interest in radio frequently contacted me for more information relating to this truck, and some of the radio sets employed. Although I have put info onto my web site http://bellradio.co.uk/amateur.html the requests keep appearing. I decided that the VMARS newsletter may be a good platform to publish the next round of information.

The radio station is actually known as an R161. This number in fact relates to a series of trucks and equipment designed to provide a variety services. The large 161 stations are carried on no less than three trucks and have a staggering 15kW RMS Tx power output. The first section of the following article deals with this larger system. The information has been translated from Russian without too much grammatical correction, and so it may not read as it would if written in English.

The purpose of the larger systems is to provide a communications backbone into which smaller and lower power stations can, if needed, “subscribe”, although the smaller stations are capable of operating independently.

The Subscriber stations are designated R-161-A2M and it is the latter which I obtained, and hence I am able to produce much more detail of these. I do not intend to discuss frequency hopping or encryption, nor do I intend this article to be technical in any way, it is simply a description of a Soviet communication system for which nothing was previously known outside of the USSR and latterly the MoD.

The R161-5 Series Radio System

The R161-5 system is intended for setting up automated, adaptive, noise-immune HF radio-links, providing communication over 3000 to 4000km, with a frequency range of 1.5MHz to 59.999MHz. This frequency agile radio system provides the three goals of a frequency hopping radio - these are:

1) resistance to jamming,

2) resistance to direction finding,

3) resistance to intercept.

The transmission of telephone, telegraph, and data is assured under high random or intentional noise levels. Provision of a communications link is automatic, and will automatically adapt to the noise environment. The remote control of the transmitter vehicle is provided from the receiving vehicle.

The radio station consists of three

Automated Adaptive Mobile H.F. Radio Station

equipment shelters or Kungs, carried on the truck chassis. The receiving shelter and the transmitting shelter are carried on a Ural 43203 chassis. The generator set is carried on a Kamaz 4301 chassis, and is intended to provide power to the transmitter unit only.

The shelters have heating and cooling systems built in to ensure the correct and comfortable environment for the operatives. There are two radio relay sets, these being part of the equipment carried. The radio relay is used to control the transmitting vehicle from the receive shelter (up to 25km). The control link can also be made by data cable (up to 10km). The trucks are also fitted with HF radio for communication whilst travelling in column.

These trucks provide the "Back-Bone" communications network for smaller 161 stations to act as "Subscriber" stations. These smaller units are describer later on.

R161-5 Specifications

General Characteristics of the Radio Station

Time to establish communication at 0.9 probability	50 seconds
Communication probability factor at any time /season	0.8
Number of preset frequencies	10
Adaption type	Frequency two step
Number of sub frequencies in adaption second step	15
Sub frequency adjustment time	2 seconds
Frequency spectrum spacing Hz	100
Weight of each vehicle	13,450 Kg

Operating Modes

Single channel SSB telephony on USB or LSB	A3J
Each telephone band 300Hz to 3.4kHz	A3A, A3J
Two channel SSB telephony with transmission of same information on USB and LSB	
FM telephony	F3
AM telephony	A3
Amplitude telegraphy	A1
FSK telegraphy	F1-200
At a rate of 200 baud	F1-500, F1-1000
Double shift FSK telegraphy	F6-200, F6-500

Radio System Power Supply

Three phase, 2x 30kW, 380V	
Power consumption, kW	
Transmitter vehicle with life support	up to 39kW
Without life support	30kW
Receiving vehicle with life support	11kW
Without life support	4kW

Distance between Rx and Tx truck

When connected by cable	up to 10km
When connected by radio relay	up to 25km

Transmitting Vehicle Specification

Radio Transmitting Power	15kW
Transmitter non linear distortion (2 tone method)	-30dB
Relative frequency instability during 24 hours	$2x10^{-8}$
Time to adjust transmitter to frequency with 20 channel storage ability	2 sec
Time to re-adjust Tx to any frequency	2 sec
Fitted with power and travelling wave meter	Yes

Receiver Specification

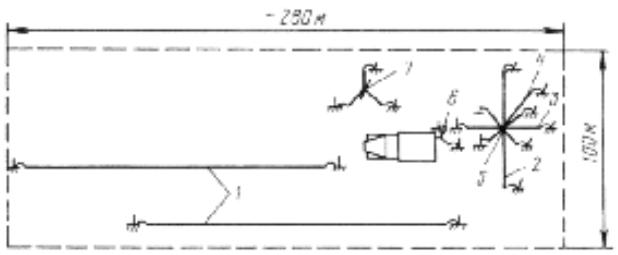
Radio receiver sensitivity in telegraph mode	0.5uV, 12db
Receiver frequency range	1.5 to 60MHz
Double conversion	Yes
Antenna switch	Yes
Automatic mode switching	Yes
Time to re-adjust Rx to any frequency	0.35 sec

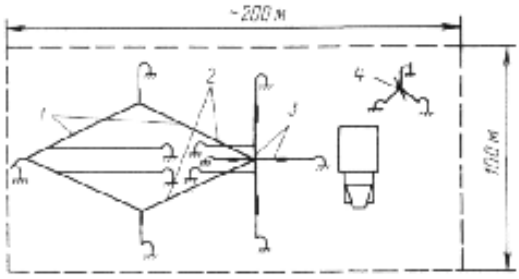
Terminal Equipment

Telegraph Set	STA-8
Morse code sender	R-020
Morse key and telephone sets	1
Modem for digital telephone and telecode at 1200/2400 baud	AT-3004D

Climatic Operating Conditions

Radio Station operating ambient	-40 to +50°C
Tolerable humidity	98%
Maximum altitude ASL	3000m





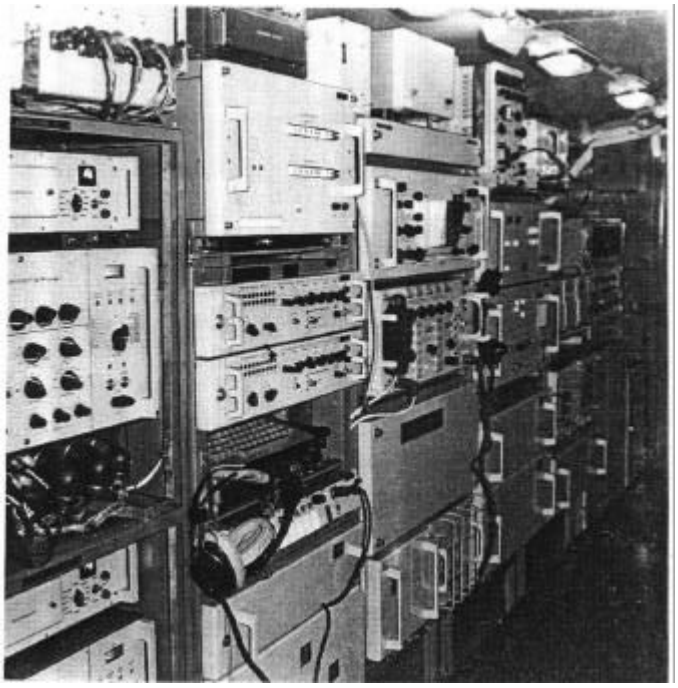
Antenna Configurations

Receiving

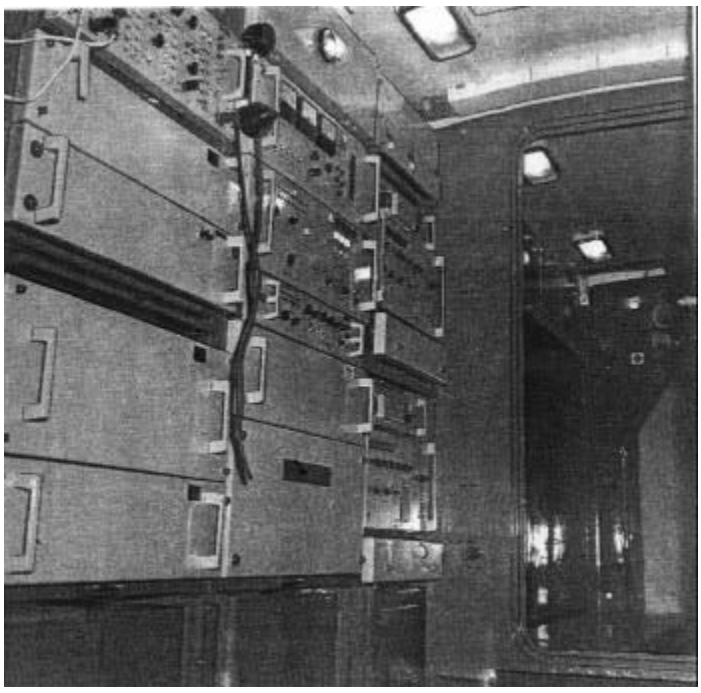
1 Travelling wave antenna
2 Vertical semi-rhombic
3 Slant wire dipole
4 Sloper
5 3m rod;
6 10m rod
7 Radio relay antenna

Transmitting

1 Slant rhombic
2 V-antenna
3 Vertical double rhombic
4 Radio relay antenna



The R161-5 Receiver Cabin



The R161-5 Transmitter Cabin

Radio Station R161-A2M

The R161-A2M is a smaller version of the R161-5 series and is contained in a single shelter or Kung transported on a Zil-131 chassis. The A2M version is also equipped to provide automatic noise immunity HF communications. The method of achieving noise immunity is frequency hopping.

The Kung is divided into three rooms. The rearmost room is equipped with a 16kW, 3-phase, petrol-driven generator. This generator is vented with air intake and hot air exhaust via opening panels in the side of the truck.

This room also contains two large blower motor fan assemblies used to keep the main radio amplifier cool, and a 3kW forced air-cooled dummy load. The room also contains a mains input filter used when the truck is plugged into mains power available at workshop or other buildings, and a 30 amp battery charger used the charge the auxiliary batteries.

To the left can be seen the main generator. The large grey box on the lower right is the blower cabinet, and the smaller grey box above is the dummy load.

Also seen in this picture are two fishing rod style rests above each door. These rests are used to stabilise the tactical whip antennas when they are lowered to slopping position when travelling through trees.

To the extreme right of the picture can be seen one of the sixty foot telescopic masts used to support most of the antenna arrays.

Photo right shows the truck deployed using the VHF broad-band dipole. The cool air intake for the generator can be seen through the open door.

On the roof of the truck can be seen two lockers used to store all of the antenna equipments.

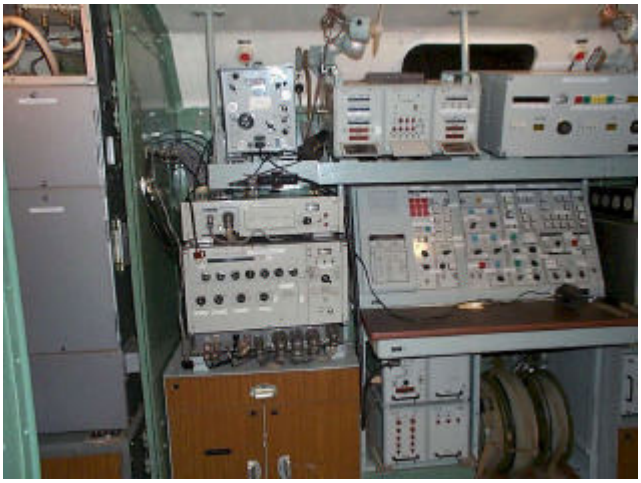
Over the drivers cab can be seen the petrol burning central heating system and mushroom ventilator together with the biological weapons filters.

The centre room of the Kung houses the twin power amplifiers, and the twin antenna coupling units. The frequency split for both units is 30MHz, and selection of the correct amplifiers and coupler combination is achieved automatically from the main operating console.

On the left can be seen the coupling units in the centre room.

On the right are the twin power amplifiers.

The forward room of the Kung contains the main operating console. This is equipped with two radio receivers, one Tx exciter, one frequency hopping control unit, one frequency hopping modem, one antenna tuning control unit, and the main console for selection of signal routing and antenna selection.

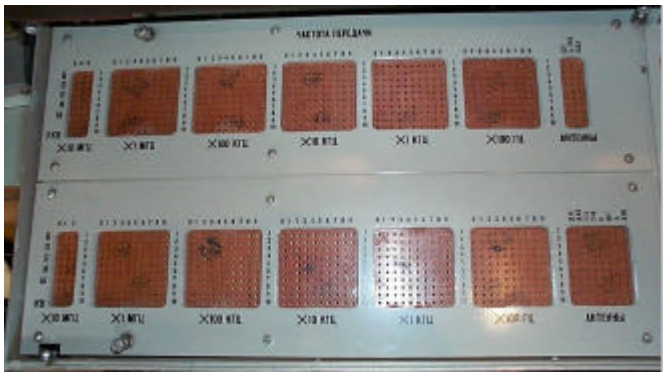


General view of the main console and equipments

To the left can be seen the automatic Morse encoder / decoder and its associated teleprinter. The units are of East German design and manufacture. They are capable of 12 wpm to 50 wpm. The system can also select transmission with or without hard copy.

On the left can be seen the main receiver, designated R160P. This receiver is of modular construction, nuclear hardened and all solid state. There are multiple connectors at the bottom of the receiver. Two connectors are used to enter frequency programming data when the set is switched to remote control. This programming takes the form of a diode matrix located elsewhere in the system. One connector is used to route audio from the receiver to various external equipments, including loudspeaker, keyboard decoder, and modem. The receiver is multi-mode and includes AM, FM, USB, LSB, ISB, FSK, FFSK modes. There is a single aerial input on a coaxial lead, and the other coaxial leads permit the input / output of the 5MHz internal frequency standard. These outputs are used in conjunction with the receiver's frequency hopping capability. One unusual feature of the receiver is that during system antenna tuning the receiver forms a balanced bridge with the exciter and selected antenna. The antenna tuning controls are then adjusted for a maximum dip in the meter reading. By using the exciter output which is only 10mW, antenna tuning can be undertaken without giving your position away during set up, or periods of receive only activity.

At the right can be seen the exciter unit designated "Lazure". This is also nuclear hardened and of modular construction. Fully solid state and equipped to provide "noise adaptive communication" [frequency hopping] these radio sets are among the latest technology seen from the USSR. The connector pattern seen on the receiver is repeated on the exciter and provides the same functionality. Both sets can be seen above with their associated power supply units, which are in fact the same unit providing commonality of spares. The internal modules are also common to both sets. Those inputs and outputs appearing on modules which are used in the exciter but not in the receiver are simply terminated by dummy load. This practise suggests considered design during conception.



On the right is the manual access and control for the antenna tuning. The unit is equipped with ten memory locations where favoured settings may be stored. Also presented are SWR alarms and trip resets, plus control over either "working" or "tuning" states of operation.

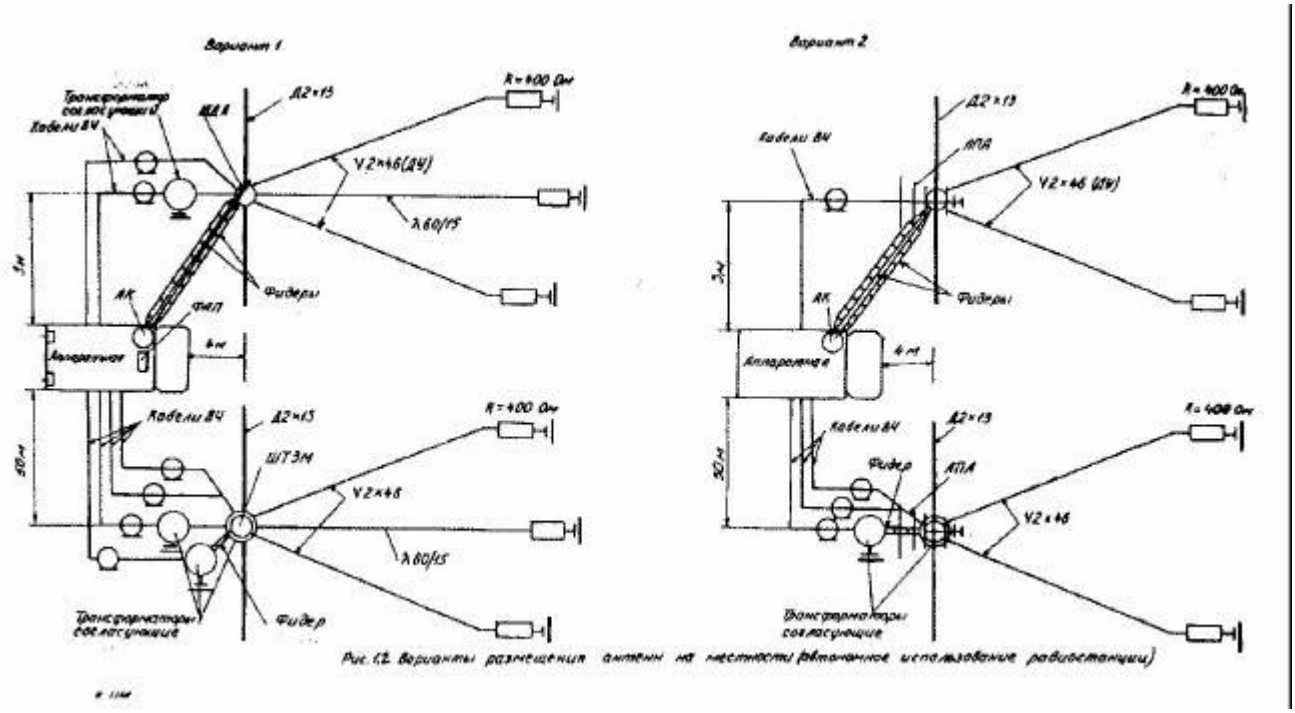
On the left is the noise adaptive controller [frequency hopping control]. Designated the R016, this unit interfaces directly with receiver and exciter taking direct control over their operating frequencies. The controller utilises the main or base frequency set by the operator, and then uses ten sub frequencies to form the selection of frequencies to hop to. During frequency hopping the net synchronisation is achieved by data exchange between all sets suitably equipped and forming part of the net. The writer believes that the hopping rate is about 2 per second.

On the right is the main control panel for the whole system. The red lights on the top left are alarm enunciators for frequency lock, blowers, overloads etc. The centre panel provides operator control over audio routing. Top right provides selection of antenna. Bottom right are the tuning control for the roof mounted active HF antenna. Other control deal with the radio power amplifiers and peg board frequency selection when using remote control.

The system permits single frequency simplex working, split frequency simplex working, and split frequency duplex working. The cover, which is just in view on the far left, covers an audio and system patch field. Suitable interconnection within the patch field will permit re-broadcast operation, and telephone to radio transfer (telepatch).

The truck may be deployed as a long-term communication station providing radio and telephone communications between the rear and forward units. In its long term role the two sixty foot masts would be demounted and set up in the field using the steel guy ropes supplied.

The diagram below gives an indication of how the system would be set up with priority given to either HF or



VHF working. In HF priority working the VHF Tx antenna would be a broad band dipole complete with built in ground plane. The VHF Rx antenna would be a wire connected via a balun then coaxial cable to the receiver antenna switch.

In VHF priority mode, the VHF antennas for both Rx and Tx are replaced with log periodic antennas. In both modes the HF antennas are 400 ohm terminated rhombics with the exception of a single 13m wire dipole. All HF aerials are fed using ladder feeder.

R161-A2M Specification

General Characteristics of the Radio Station

Frequency range	1.5 to 59.999MHz
Transmitting power output	1.5kW RMS
Modes of operation	AM, FM, SSB, ISB, FSK, FFSK
Communication range (on site)	2000km
Communication range whilst moving	350km
Set-up time on site three man crew	1 hour
Set-up time mobile	50 seconds
Main electric Generator	EU-A-16-P/400 16kW Petrol
Second electric generator	EU-131-8-T/400 8kW PTO driven
Truck chassis	Zil-131-H
Gross weight	9.53 Tonnes
Adaption Type	2 frequency step

Antennas

Rhombics	2 off
Dipoles	4 off
Log periodic	2 off
Broad band dipole	1 off
Tactical whips 3m	2 off
4m HF whip	1 off
Active antenna 1 to 14 MHz	1 off

Left can be seen the R326M continuously tuneable receiver. Because the main receiver is tuned to frequency by decimal switches, search tuning is made difficult and time consuming. The R326M is provided for just that purpose. When the desired net is found, the information appearing on the 326's digital readout is transferred to the main sets, and netting begins.

I hope you have enjoyed reading about the R161-5 series. The content represents twelve months of research conducted mainly over the internet.

Joe Bell, G4PMY

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