

# Portable station of radiomonitoring of VHF-UHF frequency band “LOTUS”

## MAIN FEATURES

- Operating frequency band: **25 - 3000 MHz**
- Coverage range within radiovisibility:
  - up to 20-30 km** in the frequency band 25-500 MHz
  - up to 5-10 km** in the frequency band 500-3000 MHz
- Panoramic frequency scanning with a rate of:
  - 2-15 GHz/s** with bearing taking
  - 7-20 GHz/s** without bearing taking
- Real time bandwidth while detection-direction finding **20 MHz**
- Direction finding method: **correlation vector (amplitude-phase) interferometer**
- Error of executive bearing taking of signal:  **$\leq 2^\circ$  (RMS)**
- **Concurrent detection-direction finding within frequency band and executive direction finding on previously detected frequencies**
- Automated detection and direction finding of radio emission sources of up-to-date communication sources, including Frequency Hopping ( **$V = 15 - 2000$  hops/s**)
- Coordinates computation of RES implementing **triangulation method** with display on digital maps
- Analysis and digital recording of IF (**with 5 MHz bandwidth**) and LF signals with visual and audio control over detected signals
- Informational interaction within DF network with operation synchronization by signals of GPS navigation system

# 1. GENERAL INFORMATION

1) VHF-UHF portable station of radiomonitoring “Lotus” is designed for detection, direction finding, audio and visual control and for signal recording of RES operating in the frequency band from 25 MHz to 3000 MHz.

2) VHF-UHF station “Lotus” provides scanning of preset frequency bands or frequency lists, spatial search and position localization of radio emission sources (RES) by surface radiowaves with vertical polarization in the frequency band from 25 MHz to 3000 MHz.

3) Direction finding antenna feeder system (AFS) with radio communication antenna, electronic compass and GPS-receiver are installed onto flat area, equipment of station “Lotus” (highspeed panoramic detector-finder, executive direction finder and operator’s board (computer of Notebook type) with communication equipment are deployed nearby the AFS under cover (in a tent, under canvas, in a trench, dugout).

4) Navigation equipment (electronic compass and GPS receiver are integrated into the mast of AFS) together with equipment of radiocommunication enables synchronous operation of portable stations “Lotus” within direction finding network both in Slave and Master Modes. Master direction finding station “Lotus” has raster maps for display of direction finding results and coordinates computation of RES.

5) Power supply of station “Lotus” is provided from external 12 V accumulators, and from one-phase AC network 220 V, 50 Hz when operating from standard electrostation Honda EU 10i, placed 10 m away from equipment of the station under the canvas.

6) Station “Lotus” is serviced by a single operator. Software is designed implementing cutting-edge technologies and functions under control of OS Windows 7. Due to GUI (virtual panel) operation doesn’t involve high qualification profound knowledge of operator. The built-in diagnostic system allows operator to easily identify a hardware failure up to the replacement node.

7) Detector-finder of station “Lotus” belongs to the class of systems with spatial signal processing and provides signal detection by its spatial features along with direction to RES estimation, implementing **correlation vector interferometer**.

1.8 Station “Lotus” supports a possibility of simultaneous **detection-finding and executive direction finder** that provides successful **direction finding of all RES** on detected frequency. There also exists a possibility to configure detector-finder to the mode of energy detection (for high scanning speed) or spatial detection (detection with bearing measuring) of operating frequencies of a signal.

9) System “Lotus” provides high speed scanning over the band preset by operator and also rapid panoramic spectrum observation and waterfall.

10) Received signals with analogue and digital modulation are demodulated with a possibility to be listened to.

11) Audio listening to the signal is done by operator via audio control section of executive direction finder of station “Lotus” and registration I/Q components of this signal. Digitally modulated signals are listen to from the output of digital demodulator AOR AR-DV1.

12) System “Lotus” provides direction finding of active newly appeared VHF-UHF radiosignals, with determination of direction (bearing) to the source with display of its geographical coordinates on the map calculated implementing triangulation within DF network consisting of two or three stations “Lotus”.

13) Antenna system of VHF-UHF frequency band consists of two ring antenna arrays each containing seven active dipoles, covering 25-1000 MHz and 1-3 GHz subbands respectively and can be quickly assembled into single case.

14) Receiving system of the station is realized on receiver operating in 20-3000 MHz frequency band with two independent sections of analogue and digital signal processing. Tasks of digital signal processing are done by 4-channel section with 16-bit ADC, FPGA Altera Cyclone 4 and DSP produces by Analog Devices under control of software installed in Notebook.

## 2. PURPOSE

Portable VHF-UHF station of radiomonitoring "Lotus" solves the following tasks:

- 1) Control over radio electronic environment within radio i. e. up to 20-30 km in the frequency band 25-500 MHz and up to 5-10 km in the frequency band 500-3000 MHz;
- 2) Search, detection, and direction finding of new sources on preset segments of VHF-UHF (25–3000 MHz) frequency bands (including signals of satellite communication links Turaya, Iridium and frequency hopping);
- 3) Scanning of preset frequency channels on the list;
- 4) Prompt signal analysis and audio control of detected RES;
- 5) Recording of signals in digital form on LF and IF;
- 6) Definition of coordinates with display on the map;
- 7) Informational interaction with stations from DF network via GSM or UHF-telecode communication channels;
- 8) Control of parameters and modes of operation, collecting of information from Slave stations from DF network, including offline triangulation of RES (data on flash-disks from Slave stations);
- 9) Automated processing and documenting REE information.

## 3. COMPOSITION

- 1) Compact VHF-UHF direction finding antenna-feeder system consisting of two ring antenna arrays each containing 7 elements (25-1000 MHz and 1-3 GHz), stored in a cover (total weight not more than 13 kg);
- 2) Compact demountable aluminum mast 10 meters height (SLT-MTL-210) with direction finding AFS holder, guys and a thrust bearing, stacked in a separate cover (total weight not more than 15 kg);
- 3) Omnidirectional antenna of frequency band for telecode communication;
- 4) Receiver operating in 20-3000 MHz frequency band with two independent sections of analogue and digital signal processing, and digital transmissions demodulator AOR AR-DV with audio output in protected portable case 7U produced;
- 5) Operator's board based on a fully rugged computer Getac X500 (at least Intel Core i7, 4 cores of i7-7820HQ Processor type) and personal computer (with flash-disk 2 Tb) for remote viewing of DB and map generating;
- 6) Navigation device with GPS-receiver (with antenna) and Electronic compass;
- 7) Head phones – 2 pcs;
- 8) Transmitting equipment (telecode-modem, radiostation);
- 9) GSM-modem (3G/GPRS, 900/1800 MHz);
- 10) Portable UPS (time period is 20 min) with power line switch;
- 11) Portable accumulator container (with battery 100 A·hours);
- 12) Compact electro station Honda EU 10i in portable case with canister of 10 liters;
- 13) Portable coil of power supply cable AC 220 V with 20 m length;
- 14) Complete set of connecting cables and HF-feeders;
- 15) Complete set of spare parts and accessories (Spear parts kit for one year), and Field heterodynes DG-20M (30-1000 MHz), DG-SVCh (1-3 GHz) with emitter antennas\*;
- 16) Operational documentation (Operating Instructions and User Guides);

\* - is supplied in a set of three station "Lotus".

Note. Radio communication equipment via LAN with secured encryption code is provided by System Integrator on the territory of the Customer.

## 4. TECHNICAL PARAMETERS

### 4.1 Panoramic detector-finder:

- |  |   |
|--|---|
| 1) Operating frequency band  | <b>25-3000 MHz</b>                            |
| 2) Real time bandwidth   | <b>5 / 10 / 20 MHz</b>                        |
| 3) Instrumental frequency scanning rate with processing of detected signals (RTBW=10 MHz):                                 |   |
| Frequency resolution FFT, kHz  | <b>3.125   6.25   12.5   25   50   100</b>    |
| Instrumental detection speed<br><b>with bearing taking</b> , GHz/s   | <b>2.0   3.75   6.5   10.5   14.2   15.0</b>  |
| Instrumental detection speed<br><b>without bearing taking</b> , GHz/s  | <b>7.0   11.5   17.0   18.7   19.6   20.0</b> |
| 4) Instrumental error of signal bearing taking:  |   |
| within frequency band 25-100 MHz   | <b>3.0° (RMS)</b>                             |
| within frequency band 100-1000 MHz   | <b>2.0° (RMS)</b>                             |
| within frequency band 1000-3000 MHz  | <b>2.0° (RMS)</b>                             |
| 5) Sensitivity by EM-field (BW=6.25 kHz):  |   |
| within frequency band 25-100 MHz with 5.0° RMS   | <b>15-30 μV/m</b>                             |
| within frequency band 100-1000 MHz with 3.0° RMS   | <b>15-20 μV/m</b>                             |
| within frequency band 1000-3000 MHz with 3.0° RMS  | <b>15-40 μV/m</b>                             |
| 6) Instrumental probability of detection and bearing taking of single signal<br>with duration 5 ms within 10 MHz bandwidth | <b>&gt; 0.9</b>                               |
| 7) Minimal duration of signal to be detected and its bearing taken   | <b>2 ms</b>                                   |
| 8) Sensitivity of radio receiving sections (SNR=10 dB, BW=12.5 kHz)  | <b>&lt; 0.8 μV</b>                            |
| 9) Dynamic range by 3-d order intermodulations:  |   |
| for 25-1000 MHz  | <b>&gt; 80 dB</b>                             |
| for 1000-3000 MHz  | <b>&gt; 70 dB</b>                             |
| 10) Dynamic range of received signal levels  | <b>&gt; 120 dB</b>                            |
| 11) Suppression of side channels   | <b>&gt; 80 dB</b>                             |
| 12) Relative frequency instability   | <b>±2·10<sup>-7</sup></b>                     |
| 13) Spectral density of heterodyne noise (with 25 kHz detuning)  | <b>- 100 dBc/Hz</b>                           |
| 14) Quality assessment of signal detection-finding   | <b>RMS Θ/U dBμV</b>                           |

### 4.2 Executive direction finder:

- |  |  |
|--|--|
| 1) Operating frequency band  | <b>25-3000 MHz</b>                       |
| 2) Direction finding method  | <b>Correlation-vector interferometer</b> |
| 3) Instrumental error of signal bearing taking:                      |  |
| within frequency band 25-100 MHz                                     | <b>3.0° (RMS)</b>                        |
| within frequency band 100-1000 MHz                                   | <b>1.5° (RMS)</b>                        |
| within frequency band 1000-3000 MHz                                  | <b>2.0° (RMS)</b>                        |
| 4) Sensitivity by EM-field (BW=12.0 kHz):                            |  |
| within frequency band 25-100 MHz with 5.0° RMS                       | <b>15-25 μV/m</b>                        |
| within frequency band 100-1000 MHz with 3.0° RMS                     | <b>10-20 μV/m</b>                        |
| within frequency band 1000-3000 MHz with 3.0° RMS                    | <b>15-30 μV /m</b>                       |
| 5) Signal bearing taking within frequency bandwidths                 | <b>2.5...5000 kHz</b>                    |
| 6) Signal demodulation for listening to within frequency bandwidths: |  |
| SSB  | <b>2.5 kHz;</b>                          |
| CW, AM   | <b>2.5; 6; 10; 12 kHz;</b>               |
| NFM  | <b>6; 10; 12; 18; 25; 50 kHz;</b>        |
| WFM  | <b>100; 150; 280 kHz</b>                 |
| 7) Receiving and recording of signal within frequency bandwidth      | <b>2.5...5000 kHz</b>                    |
| 8) Sensitivity of radio receiving sections (SNR=10 dB, BW=12.5 kHz)  | <b>&lt; 0.8 μV</b>                       |
| 9) Dynamic range by 3-d order intermodulations                       | <b>&gt; 80 dB</b>                        |
| 10) Dynamic range of received signal levels                          | <b>&gt; 120 dB</b>                       |
| 11) Suppression of side channels                                     | <b>&gt; 80 dB</b>                        |

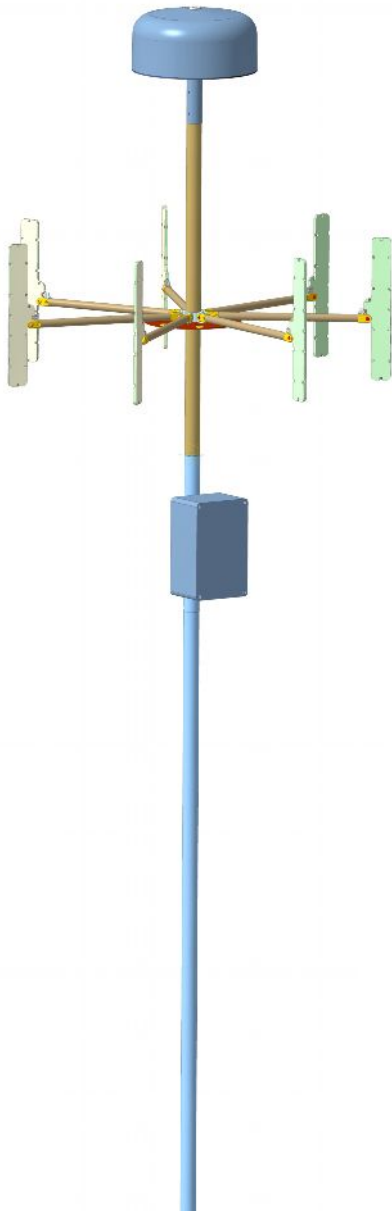
- |   |                            |
|---|----------------------------|
| 12) Relative frequency instability                              | $\pm 2 \cdot 10^{-7}$      |
| 13) Spectral density of heterodyne noise (with 25 kHz detuning) | - 100 dBc/Hz               |
| 14) Minimal duration of signal to be bearing taken              | 0,5...30 ms                |
| 15) Minimal frequency tuning step                               | 1 Hz                       |
| 16) Bearing sample resolution, degree                           | 0.1 or 1.0                 |
| 17) Quality assessment of signal detection-finding              | RMS $\Theta$ /U dB $\mu$ V |

### 4.3 General parameters

- |   |                       |
|---|-----------------------|
| 1) Interface of operation with receiver sections – LAN (Ethernet 1000 Base T)                     |                       |
| 2) Interface of interaction with navigation equipment – USB 2.0                                   |                       |
| 3) Remote control interface – LAN (Ethernet 1000 Base T)  |                       |
| 4) Interaction interface with portable stations “Lotus” – GSM 3G or FM (1200 bps) via UHF channel |                       |
| 5) Total power consumption of the station from DC net   | < 140 W               |
| 6) Time of continuous operation from fully charged battery  | more than 6 hours     |
| 7) Operating temperature range of:  |                       |
| Outdoor equipment   | - 20° C* ... + 50° C; |
| Antenna feeder system   | - 30° C ... + 60° C.  |
- \*- after 20 minutes of self-warming up the equipment of the product “Lotus”

### Arrangement of equipment of station “Lotus”

*Direction finding AFS*



*Two-channel receivers of detector-direction finder and executive direction finder*



*Operator's board*



*Portable accumulator container (with battery 100 A hours) and UPS (20 min)*



## 5. OPERATION MODES

- 1) **Initialization:** serviceability check after switch, setting of initial parameters, subbands for search, fixed frequencies, azimuth sectors, lists of prohibited sections and fixed frequencies, lists of priority and extra frequencies, frequency resolution, averaging parameters (duration of observation frame), adaptive threshold by detection level, selection of preset frequency fragments using F-cursors for the following operation, scanning speed, minimal duration of signal, configuration of position location system.
- 2) **Stand-alone operation:** automatic search, detection, direction finding, servicing of frequency flow of detector-finder by operator, audio control, direction finding and recording of detected signals, collecting and processing of information from other stations (from Slave stations when operating within DF network).
- 3) **Remote control:** automated direction finding by commands coming from Master station, providing of bearing information to Master station on request.
- 4) **Testing:** station operation testing and automated search of faulty unit implementing built-in technological software.

## 6. SYSTEM OF STATION CONTROL

- 1) Generating and operational updating of task by operator.
- 2) Panoramic FFT-scanning of detector –finder and automated frequency tuning of executive direction finder to detected frequency of RES gone on the air.
- 3) Reception and recording of panoramic analysis and direction finding results.
- 4) Automated signals queue processing of detector accounting for frequency priority and azimuth scan sector.
- 5) Automated control of tracking section according to frequency processing, selection of analysis bandwidth and signal record duration.
- 6) Display of detection and direction finding results on the map with overlay of pictograms and events by list provided by Customer (automatically or manually).
- 7) Spectrum display of the recorded signal in the coordinates: amplitude-frequency, time-amplitude-frequency (polychromic spectrum) in real time mode.
- 8) Time fixing of signal detection and record within common timing net of GPS navigation system.
- 9) Generating of DB of radio electronic environment by detected and recorded signals of sources.
- 10) It is possible to control station “Lotus” from standard Notebook via additional LAN cable;
- 11) Built-in automatic classification and decoding of digital radio transmissions:
  - D-STAR** (for NB only, data mode is not supported),
  - ALINCO** (when digital unit EJ-47U is available only (speech mode F1E)),
  - YAESU** (mode V/D only),
  - DIGITAL CR** (for digital encryption system AMBE+2 only),
  - NXDN** (mode 6.25 kHz only),
  - dPMR** (dPMR446 and mode Tier only),
  - P25** (uncoded signal in common mode only),
  - DMR** (modes Tier1 and Tier2, uncoded signals).

## 7. MAIN INDICATION MODES

- 1) Indication of panorama load of under controlled frequency band in coordinates: “azimuth-frequency” (Polar/Cartesian coordinates), “amplitude-frequency” and “time-amplitude-frequency” as polychromatic spectrum.
- 2) Indication of spectrum waveform and autocorrelation function of analyzed signal.
- 3) Digital indication of requests flow and parameters of detected RES and radionets.
- 4) Display of results of measurements of signal technical parameters.
- 5) Automatic display of bearings on the geographic map.
- 6) Display of raster map of under controlled area with detected RES coordinates and azimuth bearing lines of DF network stations with map update in real time mode for fixing several targets concurrently (on Customer’s recommendation).
- 7) Spectrum indication of executive direction finder in the mode: **Average, RMS, Max, Peak, Sample.**

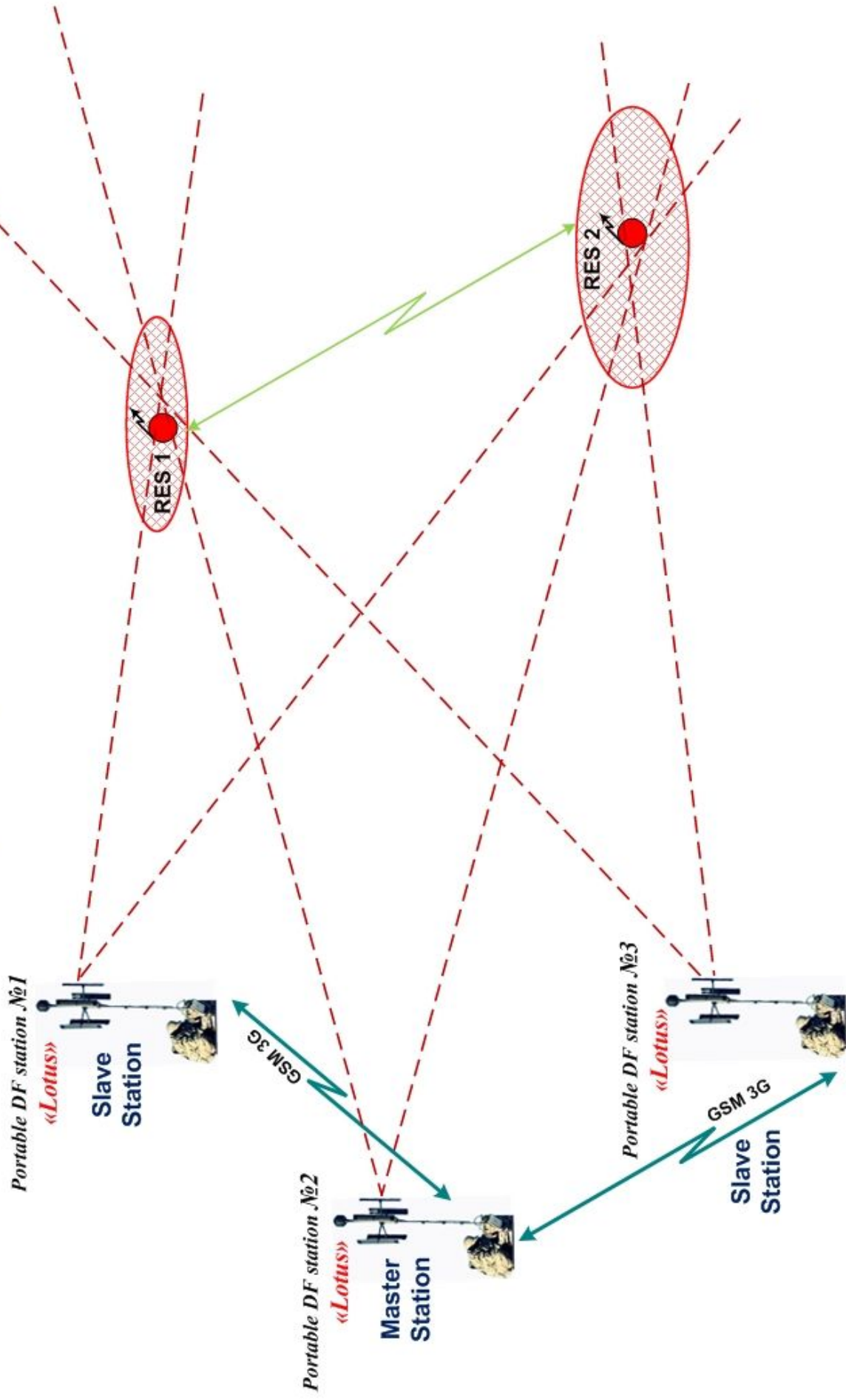
## 8. SOFTWARE

- 1) Equipment of station "Lotus" is supplied to the Customer with all necessary functional Software for transfer of saved data (DB, I/Q-files, Log-files) from computer of operator control board (or Notebook) and back.
- 2) Software of station "Lotus" provides generating of reports in convenient readable form in English.
- 3) Operator has a possibility to control all adjustable settings on single monitor.
- 4) Operator is able to lock the touch screen display so that settings are not changed by inadvertent touch.
- 5) Software displays 2D-spectrograms in the form of frequency tone raster for analysis of RES activity number by tracing its signal in time.
- 6) Any direction finding station "Lotus" has a possibility to initiate triangulation (or biangulation) and result is available in coordinates: "Longitude: Latitude" and in the Military Grid Reference System.
- 7) Software of system "Lotus" provides the following mapping features:
  - display of raster maps in standard format for analysis of coordinates of detected RES;
  - GUI for display of geographic coordinates "Longitude: Latitude" and coordinates in the form of 10 numbers of rectangular coordinates in the Military Grid System;
  - pan and zoom the map;
  - operation with Military Grid System;
  - display of positions of all direction finding stations "Lotus" operating within the DF network;
  - possibility to measure distance between two points on the map;
  - possibility to display latitude and longitude of a point on the map;
  - possibility to display main and azimuth lines or azimuth sector;
  - positions of DF stations and their bearings are updated on the map automatically;
  - operator has a possibility to indicate multi station scenario when the number of stations is more than 3 and up to 6 to increase accuracy of position fix of RES;
  - updates of stations positions are available to other stations in real time mode;
  - licensed solution of developer for control and map display;
- 8) DB viewing and technical analysis software provides playback of I/Q components, recorded by station "Lotus".
- 9) Format of I/Q components record of radio signal makes it possible to use decoding and classification software from 3-d parties.
- 10) System has time synchronization by 1-s signal marks from GPS receiver. In the case of blocking GPS signals operator has a possibility to enter manually coordinates of his radio direction finding station to continue operation.
- 11) Software of station "Lotus" has a possibility to locate position of RES OFFLINE MODE where frequency-time marks and initial data for position location (bearings) are saved on flash-disks and can be further transferred to operators of other stations "Lotus".
- 12) Software support and updates are provided for free during warranty period (or under AMC)

# Structure diagram of integration of DF stations «Lotus»

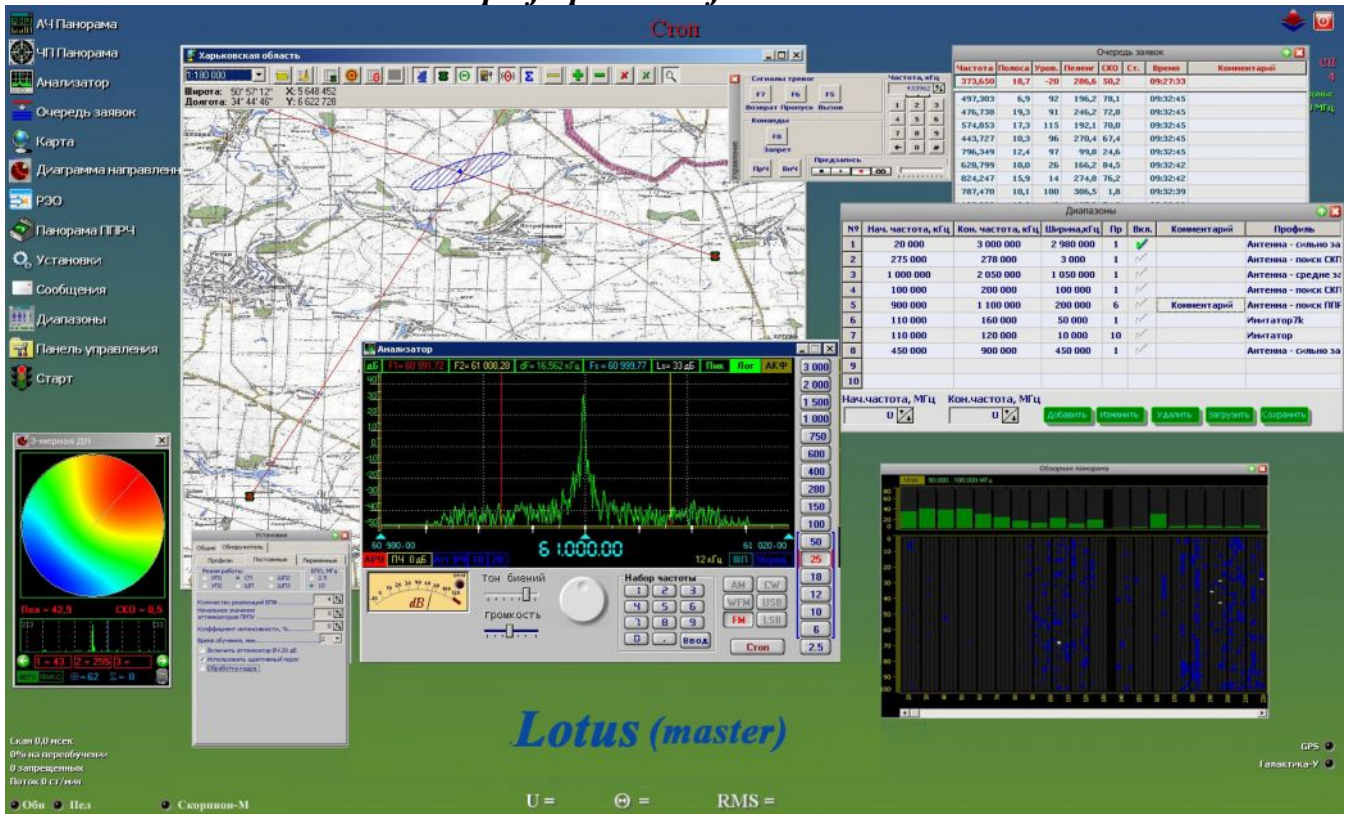
## Triangulation method

(error of position finding 3-5 % from distance to RES)

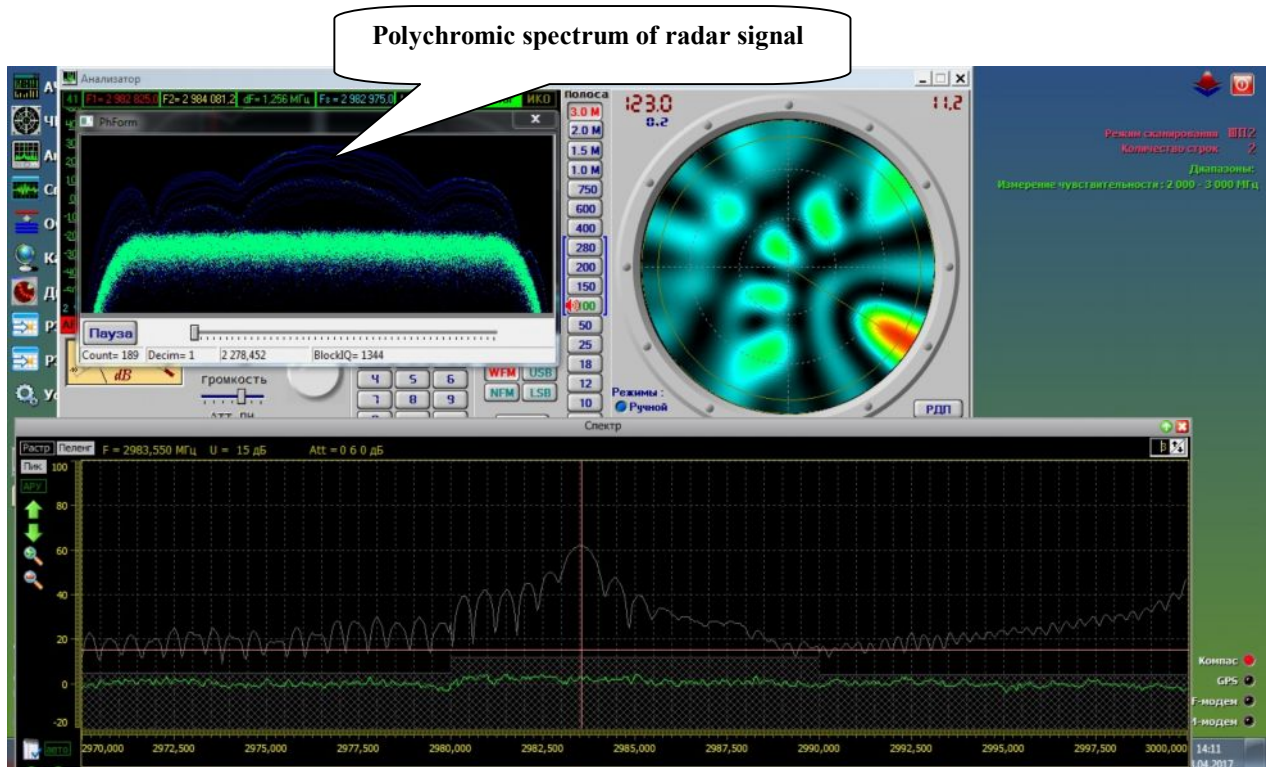




## Desktop of operator of station "Lotus"



Operator's control board desktop of station "Lotus" when detecting radar on the frequency 2.98355 GHz with polychromatic spectrum indication



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