

VNIIRA.

AIR TRAFFIC MANAGEMENT
SYSTEMS AND AIDS



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Complexes of Air Traffic
Control Automation Aids

Air Surveillance Aids

Navigation and
Landing Radio Systems

Weather Radar Systems

Airborne Navigation and
Landing Equipment

Antenna and Feeder
Systems and Devices

Automated Flight
Test System (ASLK)

ATC Training Systems



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Air Surveillance Aids

AURORA-2 MODE S MSSR WITH THE FUNCTION OF ENHANCED SURVEILLANCE IN ADS-B 1090 ES MODE





Gerard de Lairese (1640-1711)
Apollo and Aurora
Oil on canvas, 1671
Metropolitan Museum of Art



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Information about the Company:

All-Russian Scientific Research Institute of Radio Equipment (JSC VNIIRA) has specialized in the development, production, commissioning and maintenance of navigation and landing systems and aids, air traffic control automation, airborne equipment and weather radars.

Areas of activities:

- | automated ATC and ATM systems and facilities for various control areas and for large regions and separate countries;
- | simulator systems for AT controllers;
- | surveillance, approach control, secondary, and weather radars;
- | ground and airborne equipment of short-range radio navigation systems and instrument landing systems;
- | airborne equipment of range measuring, aircraft (A/C) collision avoidance, and early ground proximity warning systems, and transponders;
- | onboard integrated navigation and landing systems;
- | ground and airborne aids of the Automatic Dependent Surveillance-Broadcast (ADS-B).


In 1999 JSC VNIIRA has got a status of the Federal Scientific Production Center.

In 2004 JSC VNIIRA has joined JSC «Concern PVO «Almaz-Antey».

When working out a solution, VNIIRA specialists prove again and again that they are capable of achieving more, inasmuch as each follow-on development surpasses the previous one. The long experience and our Customers' acknowledgements confirm it.

VNIIRA is far more than:

- | 65 years of the successful performance for the benefit of air safety;
- | 150 prototypes of radio-technical systems and the complex of ground and airborne radio instruments;
- | 1 300 Inventor's Certificates;
- | 60 complexes of ATC automation systems and facilities for airports and regional centers of Russia and other countries;
- | 100 types of home-produced aircrafts and helicopters employ the airborne equipment, navigation and landing facilities developed by VNIIRA;
- | 1 600 employees including 11 Doctors of Engineering Science and 68 Candidates of Engineering Science.



«AURORA-2» MSSR is a ready-made solution for pending transfer to the technology of Automatic Dependent Surveillance – Broadcast (ADS-B) systems.

«AURORA-2» MSSR is new generation of surveillance facilities developed by All-Russian Scientific Research Institute of Radio Equipment (VNIIRA).

«AURORA-2» MSSR is a means of MSSR upgrade to the ADS-B mode and mode S at once.

Eurocontrol and FAA (USA) plan to have civil aviation airports retrofitted by 2015-2020 to accommodate ADS-B 1090 ES systems for use as the main data sources in the air traffic surveillance systems.

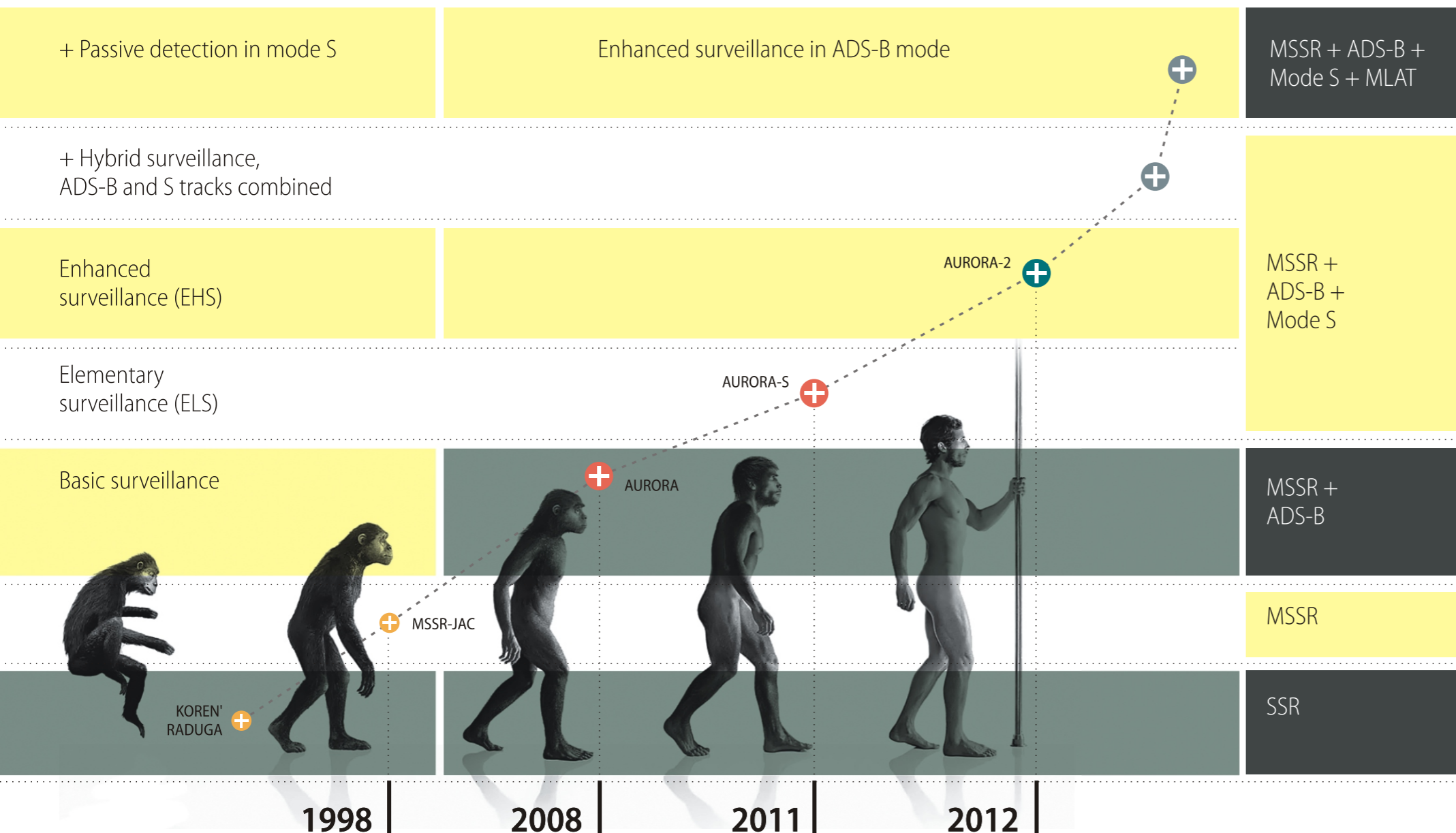
JSC «VNIIRA» has been successful in its efforts to create and implement a new generation of radars.

«Aurora-2» mode S MSSR with the function of enhanced surveillance in ADS-B 1090 ES mode is new generation of surveillance facilities developed by All-Russian Scientific Research Institute of Radio Equipment (VNIIRA).

In working out of the «Aurora-2» mode S MSSR, the development and operation experience of the previous products has been taken into account, namely, the combined «Aurora» MSSR with the function of enhanced surveillance in the ADS-B 1090 ES mode (2008) and a proven solution for the S-mode implemented in «Aurora-S» MSSR (2011).

According to the Global Air Navigation Plan for CNS/ATM Systems (ICAO Doc. 9750), a key element of an advanced surveillance facility will be the Automatic Dependant Surveillance – Broadcast (ADS-B) system. By 2015-2020, it is planned to have civil aviation airports retrofitted for use of the ADS-B 1090 ES systems.

«AURORA-2» MSSR



EVOLUTION OF SECONDARY RADAR SURVEILLANCE FACILITIES IN VNIIRA PRODUCTS

State-of-the-Art Surveillance Technologies Employing Secondary Radar Signals Applied in VNIIRA Products

- Non-selective secondary radar systems – SSR, MSSR: MSSR-JAC, Aurora
- Selective secondary radar systems – Mode S MSSR: Aurora-S
- Broadcast dependent surveillance 1090 ES – ADS-B 1090ES receive stations - NS-1, NS-1A, MSSR with function ADS-B 1090 ES: Aurora, Aurora-S, Aurora-2
- Multilateration on the basis of multi-position reception of signals emitted by airborne transponders – MSS «Mera»

Capabilities of Various Surveillance Technologies Based on the Use of Secondary Radar Signals

Surveillance technologies	Mode A/C transponders	Mode A/C/S transponders	Mode A/C/S/ES transponders
SSR	B	B	B
MSSR	B	B	B
MSSR + AURORA 1090ES	B	B	EL
AURORA-2 MODE S MSSR	B	EL E _H (S)	EL E _H (ES)
ADS-B	B		E _H (ES)
MSS	B	EL E _H (S)	E _H (ES)

Development Trends in State-of-the-Art Surveillance Technology

- Persistent need of the air navigation market in the up-to-date products, including those pertaining to surveillance facilities
- Late 2000's: Mode S becomes a de-facto standard for SSR
- Development of the ADS-B technology and the accompanying multilateration system

Sources and Incentives for New Products Development

- Russian Federal legislation
- International standards (ICAO, EUROCAE, RTCA)
- Operating experience
- New technologies and technological expansion
- Regional plans of the Eurocontrol, FAA, APR countries, and other
- Efficiency and cost

Observation Types

B Basic Surveillance

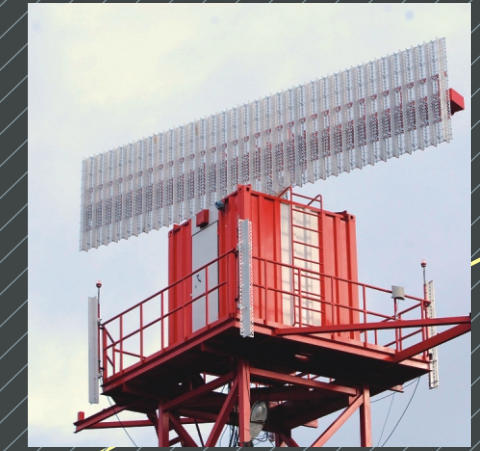
- Aircraft attitude (3D): slant-range distance, azimuth, pressure altitude
- Mode A code

EL (Elementary Surveillance - ELS) Basic+

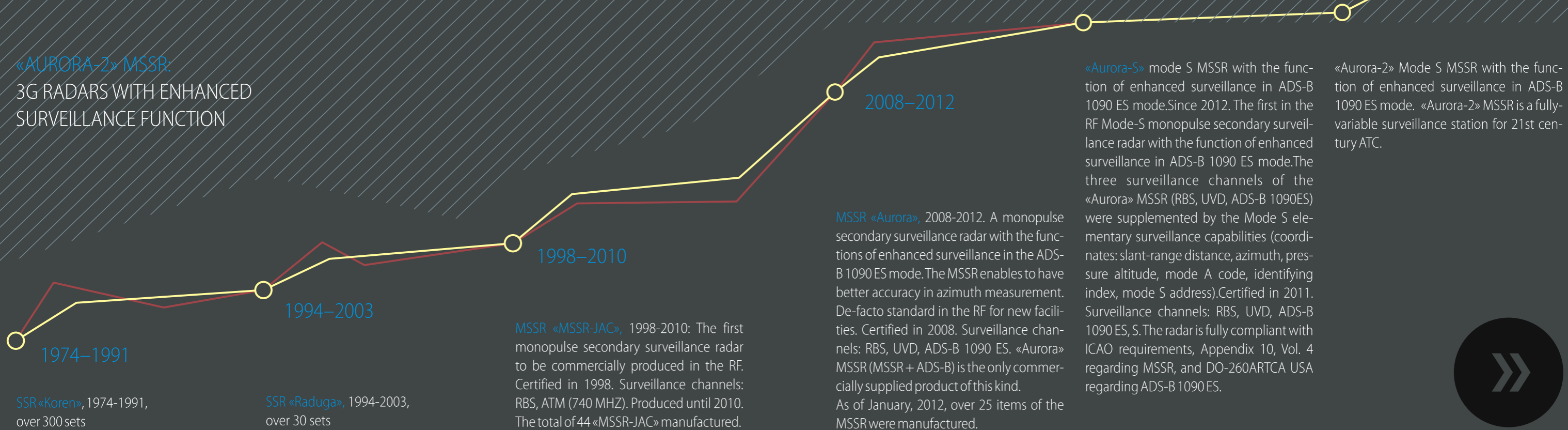
- Aircraft identification – identifying index (Flight ID or registration number)
- Mode S 24-bit address

E_H Enhanced (Enhanced Surveillance - EHS) Elementary+

- Horizontal speeds (airspeed and ground speed)
- Vertical speed
- Magnetic heading and roll angle
- Track true angle and its change rate
- Intention data



«AURORA-2» MSSR:
3G RADARS WITH ENHANCED
SURVEILLANCE FUNCTION



SSR «Koren», 1974-1991,
over 300 sets

SSR «Raduga», 1994-2003,
over 30 sets

MSSR «MSSR-JAC», 1998-2010: The first monopulse secondary surveillance radar to be commercially produced in the RF. Certified in 1998. Surveillance channels: RBS, ATM (740 MHz). Produced until 2010. The total of 44 «MSSR-JAC» manufactured.

MSSR «Aurora», 2008-2012. A monopulse secondary surveillance radar with the functions of enhanced surveillance in the ADS-B 1090 ES mode. The MSSR enables to have better accuracy in azimuth measurement. De-facto standard in the RF for new facilities. Certified in 2008. Surveillance channels: RBS, UVD, ADS-B 1090 ES. «Aurora» MSSR (MSSR + ADS-B) is the only commercially supplied product of this kind. As of January, 2012, over 25 items of the MSSR were manufactured.

«Aurora-S» mode S MSSR with the function of enhanced surveillance in ADS-B 1090 ES mode. Since 2012. The first in the RF Mode-S monopulse secondary surveillance radar with the function of enhanced surveillance in ADS-B 1090 ES mode. The three surveillance channels of the «Aurora» MSSR (RBS, UVD, ADS-B 1090ES) were supplemented by the Mode S elementary surveillance capabilities (coordinates: slant-range distance, azimuth, pressure altitude, mode A code, identifying index, mode S address). Certified in 2011. Surveillance channels: RBS, UVD, ADS-B 1090 ES, S. The radar is fully compliant with ICAO requirements, Appendix 10, Vol. 4 regarding MSSR, and DO-260ARTCA USA regarding ADS-B 1090 ES.

«Aurora-2» Mode S MSSR with the function of enhanced surveillance in ADS-B 1090 ES mode. «Aurora-2» MSSR is a fully-variable surveillance station for 21st century ATC.



FOUR DIRECTIONS OF ADS-B TECHNOLOGY DEVELOPMENT

IN JSC «VNIIRA» SOLUTIONS:

Within MSSR («Aurora», «Aurora-2»)

1 : 2

4-sector antenna, multi-channel decoder

- Upgrade of the existing radar stations. Products: NS-1A, NS-1.
- Autonomous ground station (HC) for heavy-traffic areas.

3 : 4

Single-channel autonomous ADS-B 1090 ES ground station – «NS-1A»

- All-weather, small-sized.
- Low power consumption (<20W), various power options (220 V AC, 12/24/48 V DC), battery pack for 8.5 Ah.
- Can be arranged in any place with the minimal investment for installation.

«NS-1A» within MSS or a GS network, with independent coordinate verification

- Generation of a precise time stamp (to a precision of several nanoseconds), as opposed to the ADS-B time marker requirements (several milliseconds).
- Also, decoding of DF11 squitters, responses to TCAS interrogations (DF0,16) and mode S interrogation

(DF4,5,20,21), RBS replies. Additional information, which is available in the messages of the 1090 MHz channel, is converted into ASTERIX Cat 21 messages.

«Aurora-S» Two-Standard Mode S MSSR with the Function of Enhanced Surveillance in ADS-B 1090 ES Mode

Main Purpose

«Aurora-S» two-standard Mode-S MSSR with the function of enhanced surveillance in ADS-B 1090 ES mode is the first Mode-S monopulse secondary surveillance radar in Russia.

The three surveillance channels of «Aurora-S» MSSR (RBS, UVD (740 MHz), ADS-B 1090 ES) are supplemented by the Mode S elementary surveillance capabilities (coordinates: slant-range distance, azimuth, pressure altitude; mode A code, identifying index, mode S address).

«Aurora-S» Mode-S MSSR with the function of enhanced surveillance in ADS-B 1090 ES mode successfully passed certification tests in December, 2011, with Supplement No. 3 to Type Certificate No. 532 issued.



The radar is fully compliant with ICAO requirements, Appendix 10, Vol. 4 regarding MSSR, and DO-260A RTCA USA regarding ADS-B 1090 ES.

Article Components

The radar includes both a conventional-type surveillance channel (interrogation modes 1, 2, 3/A, C, S) and a dedicated surveillance channel ADS-B 1090 ES, and thus combines the functions of a conventional MSSR and a 4-channel ground station ADS-B 1090 ES.

ADS-B 1090 ES Channel

The ADS-B channel has a dedicated 4-sector antenna system and separate receivers which ensure surveillance of aircrafts via the ADS-B channel with the antenna stopped or MSSR transmitter switched off during scheduled operations.

Control and Monitoring System

The control and monitoring system enables to control over 98% of MSSR components, interfaces, characteristics, and parameters.

The terminals can be connected both over a telephone line by means of DSL connections with distancing up to 15 km and via an IP router.

The MSSR can be operated without permanent presence of the attending personnel, with control effected remotely.



Receiver

Increased sensitivity of the MSSR receiver, as compared with previous-generation radars, ensures high target detection probability characteristics. The digital receiver guarantees long term stability of parameters of the receiving channels, which ensures reliable operation of the radar during the entire service life without extra maintenance. Item-to-item 100% repeatability of receiver characteristics ensures their prompt exchangeability.

Transmitter

Represents a single-module solid-state transmitter with high reliability indices.

To adapt radar characteristics to operation in a particular position, the radar enables the following:

- Independent power adjustment in interrogation and suppression channels
- «Power map» option – up to 32 azimuth sectors with individual power levels for interrogation and suppression channels.

Measurement of the actual power emission levels in interrogation and suppression channels is done in real time. The status of high-frequency transmission paths of interrogation and suppression channels is continuously monitored during radar operation through power and SWR measurement.

Plan Position Indicator (PPI)

Provides MSSR and ADS-B captured targets displaying.



To enable additional monitoring of radar operation, displaying of digital target data is supplemented by simultaneous displaying of analog data received via standard Ethernet card.

The displaying system is provided with a possibility to connect up to 4 test indicators, three of which can be distanced with no limitation. The test indicators can be connected both over a telephone line by means of DSL connections and via router.

Interaction with Consumers and Other Data Sources

Implemented in the radar are all known data transfer protocols, including those meeting standard ASTERIX Cat 34,48,21,23 by EUROCONTROL.

A protocol is selected from the control terminal.

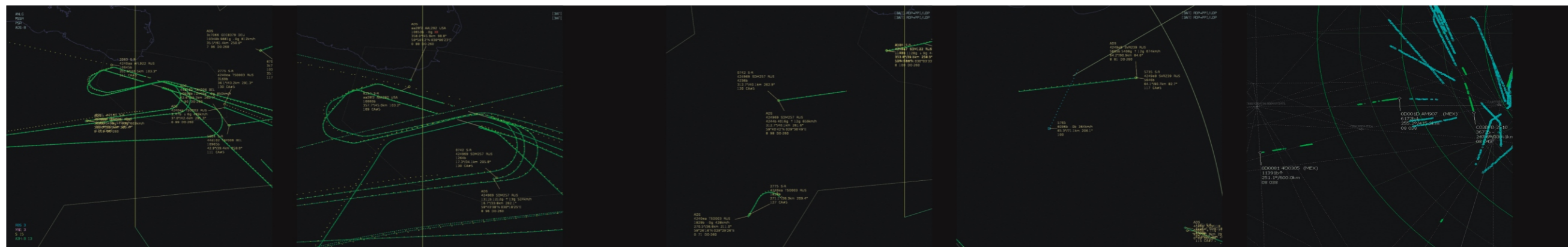
Provision is made for MSSR and ADS-B data transfer over digital channels configurable from the terminal. For standard ASTERIX categories, a Protocol Builder is provided which enables selection of only desired data elements for transmission.

MSSR Channel (by the test results)

- ▮ MSSR surveillance rate – 6 s,
- ▮ Interrogation period – 2.8 ms,
- ▮ RBS mode A/C detection probability – 0,99
- ▮ Range measurement RMS error – 2.5 m
- ▮ Azimuth measurement RMS error – 2.4 min
- ▮ ADS-B mode A/C detection probability with 4 s update rate – 0.9914
- ▮ ADS-B mode A/C detection probability with 10 s update rate – 0.9961
- ▮ The results are calculated based on the data from 150,000 surveillances.

ADS-B 1090 ES Channel

- ▮ Channel for reception of extended A/C data, independent from MSSR channel:
- ▮ Dedicated 4-sector antenna and separate receivers
- ▮ In 2012, ca. 80% of aircraft over St. Petersburg were equipped with ADS-B transponders, of them over 50% having navigation integrity code 8 or higher
- ▮ Data update rate up to 1 s
- ▮ Absolute resolution power
- ▮ The accuracy of position finding does not depend on range but is rather determined by airborne equipment accuracy.
- ▮ Enables to receive information on A/C with antenna stopped or transmitter switched off
- ▮ Enables to improve probability and accuracy characteristics of surveillance, because due to the difference in MSSR and ADS-B antennas fixing heights, antenna pattern nulls in the vertical plane fall under different elevation angles
- ▮ Enables to have additional control over MSSR antenna position based on the information about flyover targets.



Mode S

Improving Air Traffic Safety due to:

- ▮ Absolute resolution power
- ▮ Relieving load on the 1090 MHz radio channel, which is especially important with the ADS-B development
- ▮ Significant increase in information credibility due to redundant encoding of responses and queries
- ▮ Additional information from an A/C (selected altitude, maneuver indication, speed)

Interaction with Consumers and Other Data Sources

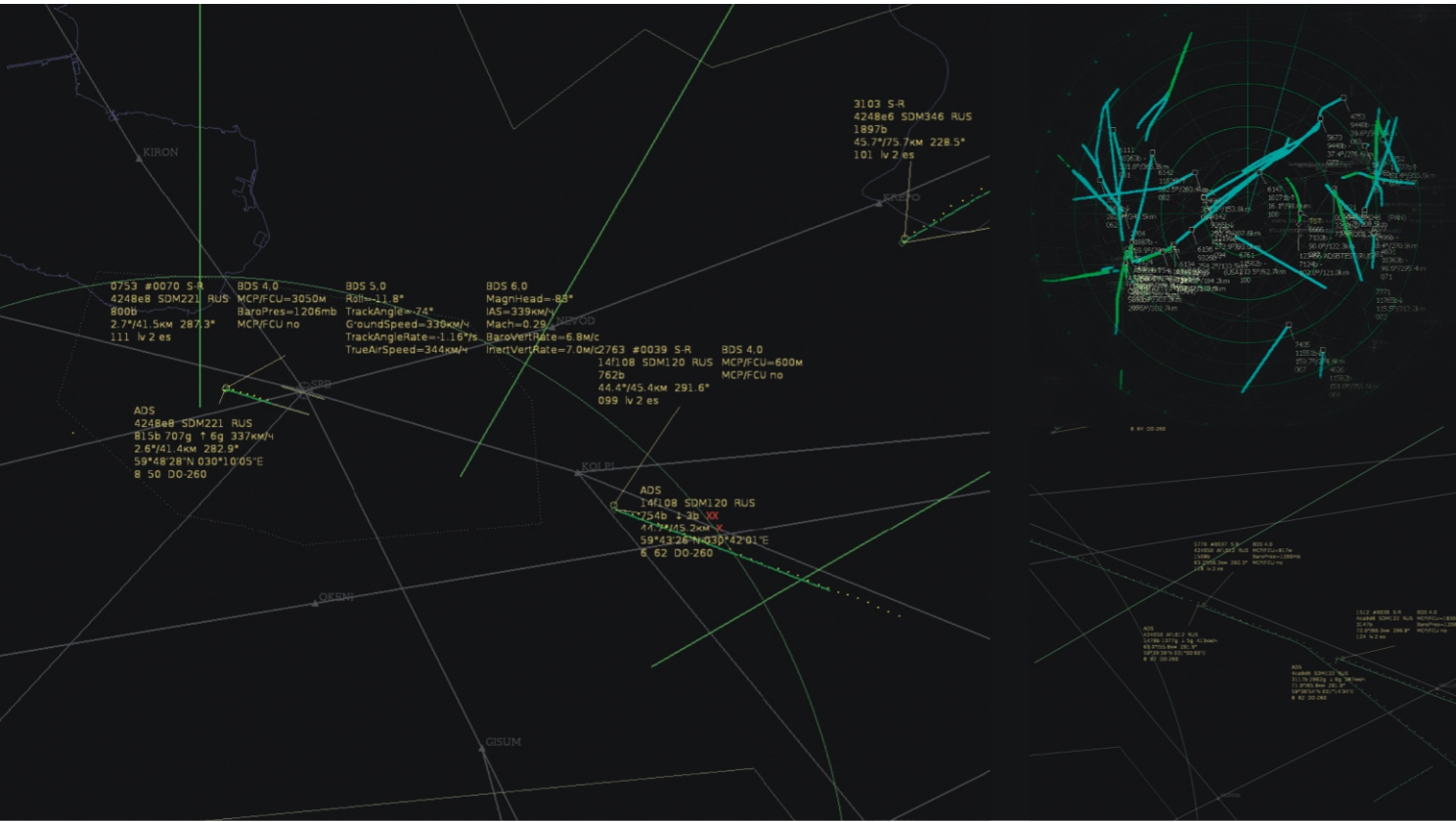
- ▮ Implemented are all known data transfer protocols, including new ASTERIX categories (34, 48, 21, 23) recommended by ICAO
- ▮ A protocol is selected from the MSSR Terminal
- ▮ Possibility of data transmission/reception over digital channels configurable from the MSSR Terminal.
- ▮ Unlimited possibility to implement new protocols
- ▮ For standard ASTERIX categories, a Protocol Builder is provided, which enables selection of only desired data elements for transmission.

Basic Performance Characteristics



Characteristic	MSSR	ADS-B 1090 ES
Coverage area		
Maximum range, km	465	600 (within line-of-sight distance)
Minimum range, km	1	0,25
Altitude, km	20	20
Elevation angle, deg	0,3/45	0,3/45
Number of targets	≤ 1000	≤ 1000
Modes	1, 2, 3/A, C,S, UVD (740 MHz)	
Accuracy (RMS error)		
Azimuth, min	<3	
Range, m	15	
Detection probability	>0,98	>0.98 (per 2 s)
Update rate, s	4...20	1...12
Analog data transfer lines		3 backup lines
Digital data transfer lines with individual profile	8	8

«Aurora-2» MSSR: Fully-Variable Surveillance Station for 21st Century ATC



AURORA-2 Mode-S MSSR with the ADS-B 1090 ES function is the next (after ADS-B

MSSR) generation of VNIIRA-developed surveillance sources—more compact,

switchable, and inexpensive.

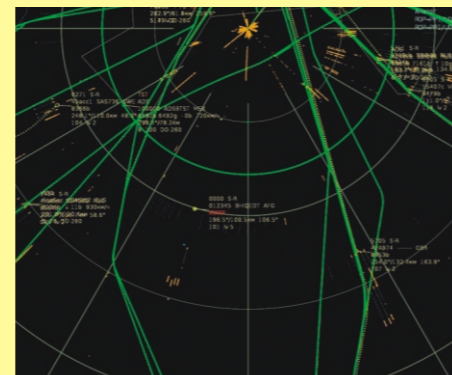


Far Field Monitor

- Intended for functional testing of secondary surveillance radar serviceability.
- It is a simulator of airborne responders operating in the UVD (740 MHz), RBS, S, ADS-B and performing reception and decoding of interrogation signals, generation and transmission of ADS-B response signals and squitters, delay of response signals to range simulation.
- Fully compliant with the requirements of ICAO, Appendix 10, Vol. IV,
- Generates responses to queries:

- In UVD (740 MHz) mode: Number, Altitude
- In RBS mode: 1, 2, A, C
- In S mode: UF4, UF5, UF11
- In ADS-B mode, generates squitters: Location (DF17, 18, 19) CPRF = 0
- Location (DF17, 18, 19) CPRF = 1
- Airspeed (DF17, 18, 19)
- ID and type (DF17, 18, 19)
- Enables radar expanded diagnostics (assessment of interrogation power).
- Does not require unit attendance during operation.
- Controlled remotely with the help of control program via Ethernet interface by UDP/IP protocol.
- Saves operational settings in the non-volatile memory in case of power supply breaks.

- Supports remote software updating (firmware).
- Enables implementation of wireless control via external access points WiFi.
- Protection against environmental impacts according to IP66 class.
- Can be supplied in a set with two-band directional antenna.



Distinctive Features:

- Ground surveillance station supporting all existing surveillance modes and data transfer lines «aircraft – ground»:
 - RBS: modes A/C/1/2
 - UVD (740 MHz)
 - S: ELS, EHS
 - ADS-B 1090 ES (DO-260B/ED-102A)
 - Configurable Hybrid Surveillance (S+ES)
- Terminal, track, or terminal/track mode – configurable period of rotation, interrogation rate, and interrogation sequence
- Configurable special surveillance zones: adjustment of sensitivity, interrogation power, reflectors, etc.
- Digital receiver ensures stability of monopulse channel phase characteristics, path digital phasing for Sum and Delta channels
- Independent 4-channel antenna system and receiver for ADS-B 1090 ES channel
- One or two test responders ensuring through-check of the transceiver path in all operation modes: RBS, UVD (740 MHz), S, ADS-B

- Configurable modes of combining plots/tracks from the aircraft responding in several surveillance modes, so as to reduce RF emission.
- Data output: analog data transfer lines or IP networks
- Individual configuration of protocol and protocol profile for each flight data consumer.
- Separate configuration of output for SSR and ADS-B data

«Aurora-2» Advantages

- Lower cost.** Use of a cutting-edge component base and state-of-the-art technologies. Reduction of equipment volumes and improvement of manufacturability.
- Increased reliability** due to higher integration degree, reduction of the number of units and inter-connections.
- Simple maintenance and commissioning of facilities.** All equipment (main and standby set) accounting for surveillance is arranged in one cabinet. Station's communication part is separated from the processing equipment, so it can be located as close as possible to the attending person-

- nel, or even integrated in the Customer's communication equipment.
- Additional surveillance functions.** EHS (DAPs), hybrid surveillance (S+ES), configuration of surveillance types by spatial zones.
- Monitoring and control.** Customarily, all VNIIRA surveillance facilities are designed for vast control possibilities. The instrument for visualization of various equipment parameters are provided, including remote options.
- Possibility of connection to centralized means of monitoring, documenting, and control (Super Terminal).** Reduction of equipment overall dimensions and increase in reliability result in radars rendered non-supervised. The role of remote condition-monitoring and control means becomes ever increasing. Under availability of different ground surveillance facilities at one operator's disposal (ADS-B stations, MSSR, etc.), it is convenient to control those facilities from a single regional centre. The ground surveillance stations of «Aurora» series are prepared for connection to the RCMRC.

Basic Specifications

MAIN BLOCK:

- Power supply 220 V 50 Hz network;
- consumed power over 220 V 50 Hz network 30 WA max.;
- time of continuous operation non-stop;
- transmitter frequency 740±1 MHz; 1090±1 MHz;
- transmitter power 1.5±0.5 W
- receiver sensitivity minus (60±4) dB*W
- receiver dynamic range 60 dB
- range simulation 50-400 km (with 10 km spacing)
- ambient air temperature from -10 to +50° C;
- relative humidity at a temperature not exceeding 25 °C 95% max.
- atmospheric pressure not below 60 kPa (450 mm Hg)
- Dimensions 440×300×169 mm.
- Weight: 9.6 kg

ANTENNA:

- antenna pattern width at 3 dB level:
 - on 1030/1090 MHz frequencies 15.0±1.0 deg
 - at 740 MHz frequency 22.0±1.0 deg
- VSWR 1.5 max.
- time of continuous operation non-stop
- temperature from minus 50 to 50° C;
- relative humidity at a temperature not exceeding 25 °C 98% max.
- atmospheric pressure (450 mm Hg) not below 60 kPa
- rain 60 mm/h max.
- operating/limiting
 - wind speed, m/s 30/50 max.
- Dimensions 1770×1660×950 mm.
- Weight: 85 kg.