Advanced development by Tikhomirov-NIIP JSC: special and commercial radar systems

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Combat gear development is a complex multifaceted process combining both revolutionary breakthroughs and subsequent evolution that maximises the use of the progress made. A reasonable combination of 'revolution' and 'evolution' has been recognised as the optimal way of combat and special gear development by major powers. Our institute – Joint Stock Company "V.Tikhomirov scientific research institute of instrument design" – a national leader in aircraft weapons control systems and medium-range surface-to-air missile (SAM) systems for the Army – is a stickler to the approach. For over half a century since its inception, the two lines of work in the institute has run in parallel, complementing and refining each other.

To date, the institute has established a unique scientific and practical school of thought dedicated to the development of electronically scanned array radars.

The development was such systems kicked off in the late 1960s, when the institute took an extremely daring, revolutionary decision to develop the Zaslon fire control system based on the passive radar array. The task was extremely difficult and was taken on with regard to an air defence fighter for the very first time in the world. The MiG-31 equipped with the Zaslon fire control system capable of simultaneous acquisition of 10 targets and simultaneous engagement of four of them entered service in 1981. At the time, there was no US or European fighter to rival it. The aircraft remains the most effective warplane in its class. Despite its rather advanced age, the fighter has retained plenty of upgradeability of the fire control system (Fig. 1) in the first place. For instance, in 2013, there were final flights as part of the remedial action resultant from the official joint trials of the modernised MiG-31BM interceptor fitted with the Zaslon-AM fire control system and advanced long- and medium-range air-to-air missiles. About 50 MiG-31Bs have been upgraded to MiG-31BM standard and have been used by the Russian Air Force.

Fig. 1. Zaslon fire control radar

The electronically scanned array radar and technology development by the institute has allowed the emergence of the Bars airborne fire control radar to fit the Su-30MKI multirole fighter (Fig. 2).

The Bars is a multifunction multimode coherent X-band radar system with the passive phased array. It is mounted on the electro-hydraulic tracking actuator. This allowed a considerable increase in the scan area. Its open architecture allows its further modernisation through enhancing the tactical and operating characteristics.

The Bars from Tikhomirov-NIIP fits about 250 Su-30MKI, Su-30MKM and Su-30MKI(A) fighters successfully operated by the Indian, Malaysian and Algerian air forces. The radar has passed all relevant phases of the trials, has been tested through and through and can handle all of tasks assigned to it.

Now, the Irkut corporation is fulfilling two contracts for 60 Su-30SM aircraft for the Russian Air Force, and the first order for the aircraft of the type has been recently awarded to the company by the Russian naval aviation. The plane designed for the Russian Navy is a Su-30MKI derivative, with its radar system having been derived from the Bars.

The 'Russianised' version, designated as Bars-R, embodies a number of improvements in line with the Defence Ministry requirements is more capable than its export-oriented predecessor. Last year, we successfully completed out portion of the special joint flight tests of the Su-30SM, and fighters carrying our Bars-R radar are in service now.

Another new design from Tikhomirov-NIIP is the Osa small-size multifunction multirole phased-array fire control radar (Fig. 3).

The Osa is designed to equip light multirole fighters and future combat trainers. In the air-to-air mode, the Osa has the all-aspect, look-up/look-down head-on/pursuit target acquisition and tracking capability. In the air-to-ground mode, it performs real-beam Doppler beam-sharpening focused-aperture mapping and simultaneous tracking of two surface targets and selection of ground moving targets.

The Osa is an X-band radar with a power consumption of 4.3 kWA, a weight of 120 kg and a volume of 256 dm^3.

The 40-plus-year development of phased-array radars has resulted in a latest of Tikhomirov-NIIP's designs – the Irbis fire control radar intended for the Generation 4++ Su-35 fighters (Fig. 4).

The Irbis embodies the best solutions worked out in the course of the development of the Zaslon, Bars and Osa.

The Irbis, which is part of the integrated avionics suite of the Su-35, performs an extremely wide range of tactical and auxiliary tasks, including the following:

- acquisition and tracking of radiocontrast and radio-emitting aerial and surface targets;
- identification friend or foe (IFF);
- target recognition and classification based on their radar signatures;
- resolution of aerial targets in tight packages;
- low, medium and high-resolution mapping;
- image freezing and the carrier's own position display;
- low-level flight information support in the nap-of-the-earth mode;
- moisture target acquisition and assessment;
- issuing relevant data to the avionics suite and receiving data from it in line with the data communication protocols available;

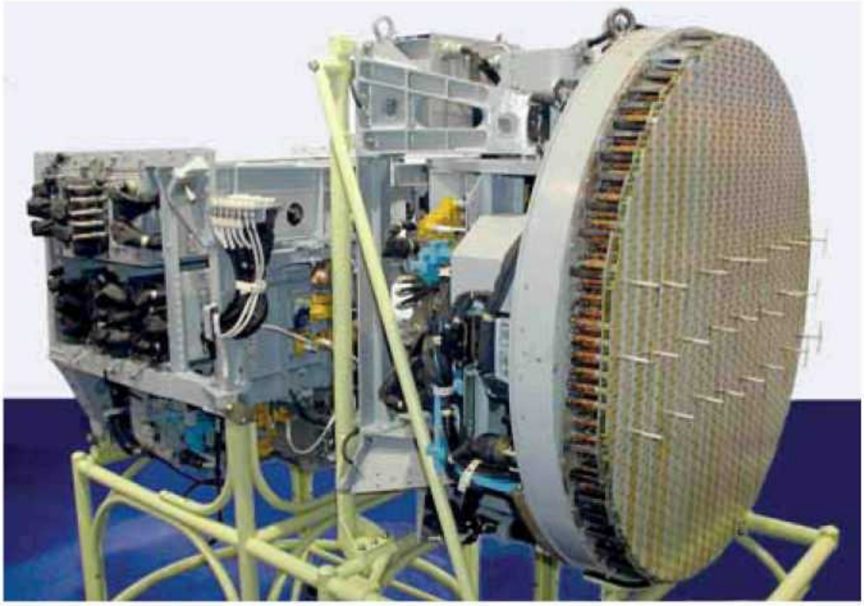

Fig. 2. Bars fire control radar

Fig. 3. Osa fire control radar

Fig. 4. Irbis fire control radar

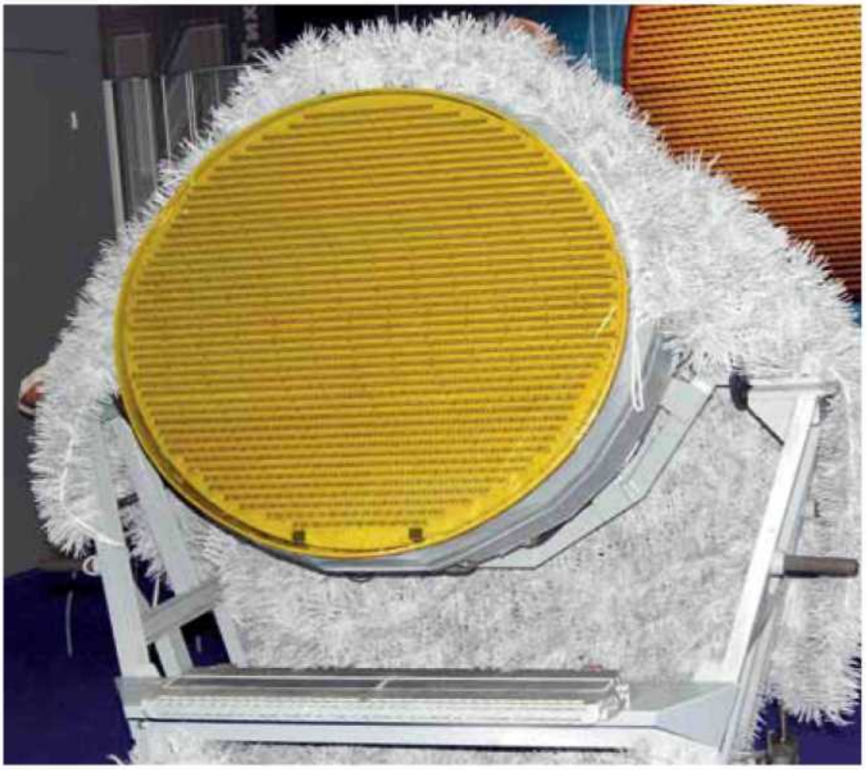

Fig. 5. AESA multifunction radar

- interaction with air-to-air and air-to-surface active and semi-active radar-homing guided missiles;
- operation as a simulator.

In addition to manned fixed-wing and rotary-wing aircraft, potential carriers for the Irbis radar are unmanned aerial vehicles (UAV) of various applications, including strategic cruise missiles, air-to-air and air-to-surface guided missiles, and battlefield and short-range ballistic missiles.

The flight tests of the Su-35 carrying the Irbis radar proved the target acquisition range unmatched by any other Russian and foreign production or prototype fighter.

The Irbis has been in full-rate production by the State Ryazan Instrument-making Plant (Russian acronym GRPZ). At present, the radar equips more than two dozen production-standard Su-35S warplanes delivered to the Russian Defence Ministry under a contract for 48 fighters of the type.

Today, the key order being fulfilled by the institute is the development of an active-phased-array-based multifunction radar system (Fig. 5) to fit the future fifth-generation fighter.

The effort involved a radically advanced technology level, which will beef up the radar's capabilities by far. On the other hand, to attain the level, the developer has to overcome colossal problems, given the stagnation of the Russian electronics industry of the past 20 years. While in the '70s-'80s, the institute was the uncontested world leader in phased-array radar development, it has to take great pains now to catch up with its foreign rivals from an unequal starting position. Nevertheless, progress has been made, and the scale of the work is increasing owing to a contract signed with India interested in the co-development of a future multirole fighter.

To date, we have made as many as six front-mounted AESA radar sets earmarked for the fifth-generation PAK FA fighter. Two are used for bench tests conducted by us and by the Sukhoi company to test advanced operating modes. The other three have been delivered to the customer to equip the third, fourth and fifth flying prototypes of the PAKFA. The flight tests on the third prototype, T-50-3, including the activation of the AESA, commenced in summer 2012. The aircraft has completed the bulk of the AESA flight tests. In addition, the fourth PAKFA prototype (T-50-4) has been flying in Zhukovsky since last spring, having completed a number of tests of our radar. Very recently, the T-50-5 – the third prototype fitted with our AESA – has launched test flights in Zhukovsky. Thus, there are as many as three PAKFAs equipped with our radars in the fight trials, with the total number of flights, on which the AESA was switched on, being about a hundred.

Most of the flights have been successful. The main result produced is the stable operation of the AESA radar in all air-to-air and air-to-surface modes from the outset.

Now, we are conducting bench tests of the early prototypes of side-looking AESA radars. Soon, one of them will be mounted on a prototype PAK FA. In addition, there also will be L-band AESAs set in the slats of the fighter. Thus, the next four PAK FA flying prototypes will have the complete multifunction integrated radar system, including forward-looking and side-looking AESAs and L-band AESAs.

The expertise gained from phased-array airborne radar development has been used successfully in the development of the Buk mobile multirole medium-range SAM system.

The key radar of the SAM system is a multifunction phased-array radar capable of acquiring and tracking 10–12 targets and engaging four of them simultaneously. The radar and the missile launcher can be mounted either on a self-propelled tracked chassis (Fig. 6) or on a self-propelled wheeled one (Fig. 7).

Overall, the Buk SAM system is capable of repealing a massed air raid by simultaneously engaging up to 24 targets attacking from different aspects and from different altitudes. The targets for it to kill include battlefield ballistic missiles, strategic and tactical warplanes, cruise missiles, helicopters, including hovering ones, and small-size aircraft, including unmanned ones.

A further derivative of the Buk is the Army SAM system designated as 9K317M. It completed its official tests last year, and the manufacturer has been awarded the first order by the Russian Defence Ministry.

As far as commercial products are concerned, Tikhomirov-NIIP JSC develops and produces automatic control systems for subway and commuter trains. The Moscow and Sofia (Bulgaria) Metro trains have been using the Vityaz-1 and Vityaz-1M automated control, diagnostics and traffic safety systems since 1998 and 2005 respectively. Russian Railways JSC orders touchscreen displays and software for its automated train control systems from the institute.

Fig. 6. Multifunction radar on the self-propelled tracked chassis

In 2000, the institute teamed up with several organisations of the Russian Academy of Sciences to develop hydro-acoustic systems, paying for the development out of pocket. To date, Tikhomirov-NIIP side-looking sonars, interferometric sonars and parametric surface analyzers are operated in many seas by such customers as Lukoil JSC, Gazprom JSC, RusGidro JSC, Federal Maritime and Riverine Transport agency, Emergencies Ministry, etc., and South Korean customers as well.

Mention should be made that the institute has completed research into the feasibility of using electronic beam steering in sonars.

The participation in the 9th Bow to Great Victory Ships Expedition in May 2013 was a milestone event to Tikhomirov-NIIP. The expedition was aimed at searching for sunken Soviet submarines. The search resulted in the finding of the S-9 submarine that hit a mine in 1943 and the 84-cannon Lefort ship that sank in 1857.

Fig. 7. Multifunction radar on the self-propelled wheeled chassis