ABM AND SPACE DEFENSE
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The work on designing of the antiballistic missiles (ABM) began in 1946. Within the framework of the MX-C94 Wizard project the American Michigan University researched and prepared specifications for the ABM missiles intended for interception of long-range missiles of the V-2 type.

The Soviet Union also started working on the ABM defense problems after World War II. Between 1948 and 1951, the NII-4 research institute of the Defense Ministry (the group of G. Mozharovsky) and the NII-885 research institute (the group of Khlebtsevich), which worked on development and application of ballistic missiles, performed the first, mainly theoretical, research of possibilities of the ABM defense organization. This research offered the schemes for ABMs equipment with two types of homing systems. For the television-guided ABMs a fragmentation warhead was offered with low-speed fragments and a circular-disc effective zone. The warhead was to be exploded with a deflection allowing for formation of the fragments' field. For the self-homing ABMs the directed effect warhead was offered, which had to turn towards the target together with the missile, and had to be exploded in response to the information of the self-homing warhead, creating the biggest density of the fragments' field directed to the target.

In 1950, the Third Main Department (TGU) was organized within the Special Committee under the supervision of Lavrenty Beriya. The KB-1 design bureau, which concentrated the leading specialists developing guided missiles and homing systems, was the favorite of the TGU. Sergei Beriya has been appointed the Chief Engineer of the KB-1. N. Lifshits, G. Kisunko, A. Kolosov, and other prominent radio and electronics specialists have been invited to the KB-1. A. Yelyan, the former Director of Gorky artillery plant No. 92 has been appointed the Director of the KB-1. The Kometa airborne antiship missile was one of the first projects of the KB-1. However, the main project ordered to the design bureau was development of the Moscow air defense system. The pooled efforts of many design bureaus, research institutes, and plants resulted in designing of the S-25 Berkut system. In 1953, the system passed the field trial, and was adopted.

Whereas in 1953 the US began working on intercontinental ballistic missiles development, in August 1953, the General Staff of the Armed Forces requested the Central Committee of the Communist party to consider a possibility of the ABM defense system organization in the Soviet Union. By 1955, G. Kisunko, one of the leaders of the KB-1 who designed guided missiles, prepared the offers regarding creation of the A system, a field experimental ABM defense system. Construction of the special A testing ground was launched for this purpose near the Balkhash Lake, not far from the Sary-Shagan railway station in the stone-covered Betpak-Dala Desert. Mayor General S. Dorokhov has been appointed the director of the testing ground. Over 40 years of the A testing ground operation tens of defense systems and their components have been tested, including the S-75M, S-200, S-300PM, Favorit air defense systems; A-35 and A-13 ABM systems; Kontrakt anti-satellite system; early warning systems, and many others.

In the mid 1950s, a series of experiments was conducted under the supervision of G. Kisunko to define the criteria and forma the fundamental physical basis for the ABM defense system development. The following experimental radar stations have been built for checking of real possibilities of ballistic missiles detection and warheads selection: the RE-1 and RE-4 in Kazakhstan, and RE-2 and RE-3 in Kamchatka on the testing grounds and in the areas of falling of warheads of the R-5, R-12, and R-7 ballistic missiles.

In 1961, preparation for field tests of the A system was accomplished, and the system was successfully tested. This circumstance allowed beginning of designing of the A-35 combat system for the ABM defense of Moscow area.

The direction of the General Staff of the Armed Forces of March 30, 1967, organized the special ABM and Space Defense Forces within the Air Defense Forces.

By 1967, the scientific and technical progress enabled the USSR to prepare draft projects of early warning systems, ABM system, and to begin working on the projects of space defense and system for outer space control. Later all this elements became the main components of the ABM and space defense of the Soviet Union.

By that time, experimental models of the ABMs were undergoing trial at the State Central Research and Development Testing Ground (near the Balkhash Lake), and construction of the first components of the early warning and ABM defense components was underway in the Moscow Region, Baltic republics, and in Trans-Polar regions.

On May 26, 1972, the USSR and the US signed the ABM defense limitation treaty which made limited the ABM systems to two areas in each country: an area having a radius of 150 kilometers with the center in the capital, and an area where ABM silo launchers were deployed. In the area of the capital it was allowed to have not more than 100 ABM launchers and not more than 100 ABMs on launch positions, not more than six ABM radar stations, and the area of each station had to have a shape of a circle with diameter of not more than 3 kilometers. According to the treaty, in the area of silo launchers it was possible to have not more than 100 ABM launchers, and not more than 100 ABMs on launch positions, two phased-array radar stations comparable to similar ABM radars according to the potential (The potential meant the average emitted power in watts multiplied by the antenna area in square meters. The coordinated statement of the USSR and the US set it up at 3 million watts x square meter) being in service or under construction on the date of the treaty signing, and not more than 18 ABM radars with a potential lower than that of the aforementioned phased-array radar stations. ABM systems on testing grounds were not subject to the treaty, and each of them had to have not more than 12 ABM launchers. According to the treaty, each party undertook not to test and deploy systems and components of the maritime, air, space, or mobile ground ABM defense, and multiple and quickly reloaded ABM launchers. The treaty prohibited adding of ABM capabilities to the missiles, launchers, and radars being not the ABM weapons, and their testing for the ABM purposes. Since the date of the treaty's signing, the parties could not deploy early warning radars except for the radars on positions in the periphery of the national territory and directed outwards. The coordinated statement of the USSR and the US signed on May 26, 1972, prohibited deployment of ABMs with more than one individually targetable warhead, and limited the distance between the ABM defense of the capital and the area of ABM launchers at least to 1,300 kilometers. The protocol to the ABM treaty signed on July 3, 1974, limited the ABM defense to a single area for each country. The Soviet Union has chosen Moscow, and the United States the Grand-Forks intercontinental ballistic missile base.

The early warning system of the Soviet Union

The early warning system (EWS) is intended for early and reliable detection of a nuclear missile fired from behind enemy lines, from any continent or from any point in any ocean in the world, and transmission of this information to the warning command posts. The system was designed as a whole unit based on the various principles of the detection of ballistic missiles (BM) from the moment of launch and during the entire flight trajectory. Until recently, the EWS consisted of two echelons: the first echelon for detection of a BM launch, and the second echelon for detection of a BM in the flight trajectory. The first echelon is comprised of an orbital cluster of special satellites placed in various orbits and radio-electronic over-the-horizon detection nodes. The second echelon was built together with the above-the-horizon early warning radar nodes for to create an uninterrupted circular radar field in the border regions of the USSR. The creation of this system stops the possibility of a surprise nuclear missile being fired without any response towards the aggressor.

The above-the-horizon radars for an early warning system to guard missile attacks and outer space control were developed by the Radio-Electronic Research Institute (NIRI) of the Soviet Academy of Sciences under the supervision of A. Mints (Chief Designer Yu. Polyak). According to estimates, the maximum detection range of the above-the-horizon ground radars for a BM launched at 1,600 kilometers was 1,440 kilometers, for a BM launched at 3,200 kilometers was 2,400 kilometers, and for a BM launched at intercontinental distance of 8,000 kilometers was 3,520 kilometers. The first Dnestr radars were deployed in Kazakhstan and Siberia. Together, they formed an uninterrupted radar barrier 5,000 kilometers long. In 1961, the NIRI began designing the upgraded Dnestr-M radar, which was to be stationed in the trans-polar area (RO-1 in Murmansk) and Latvia (RO-2 in Riga). Construction began in 1963-1964. The state tests of the Dnestr-M radar were conducted between 1968 and 1976 in the trans-polar area. Between 1968 and 1972, the Ekvator project was developed which was aimed at creation of an uninterrupted radar field in the western, southwestern, and southern missile danger zones. The new radar nodes of the early warning system were arranged in western Ukraine, the Crimea, Kazakhstan, Siberia, and on the Kola Peninsula based on the Dnepr radar.

In early 1970s, building of the new Dnepr above-the-horizon radars began near Riga, Mukachevo, Sevastopol, Irkutsk, and Balkhash Lake. The additional receiving position Daugava was designed for improvement of information assessment reliability and the reduction of the influence of interference caused by the northern lights in the ionosphere. For the first time the Daugava used a large-aperture phased array and a hybrid super-high frequency technology. Later the Daryal radars of the new generation were developed on the basis of the Dnepr and Daugava.

The trials of the pilot early warning system were completed in 1976. The pilot system included the radio-electronic nodes in Transcaucasia, Latvia, and a command post near Moscow. Later the Dunai-3 and Dunai-3U radars of the A-35 ABM system were switched to the command post of the early warning system.

From the early 1970s, the new Daryal phased array above-the-horizon detection radar was designed under the supervision of A. Mints and V. Ivantsov. The reduced version of the receiving station was successfully tested in the trans-polar area near Pechora. In 1984-1985, the nodes with the Daryal radars were placed on combat duty in the north (Olenegorsk) and in Azerbaijan (Mingechaur).

In the mid-1980s, building of new Daryal-U and Volga radars began at the Dnepr radar positions in Latvia (Skrunde), Belarus (Baranovichi), Ukraine (Nikolaev), Kazakhstan (Balkhash), and Siberia (Irkutsk).

Construction of the new Yeniseysk-15 above-the-horizon radar node started near Yeniseysk for the creation of an uninterrupted radar field on the external border of the USSR in the northeastern missile danger zones.

The building of a new radar near Yeniseysk infringed on the ABM treaty signed by the USSR and the US in 1972. The treaty permitted deployment of EWS radars only along the perimeter of a state border. As a result, when construction of the new radar was nearing completion, the

American party accused the Soviet Union of the violation of ABM treaty, and the construction of the radar was suspended. By January 1, 1987, 203.6 million rubles had been spent on the installation, and 131.3 million rubles on equipping it. The transmitter antenna of the radar had dimensions of 30 x 40 meters. The antenna included many centrally controlled transmitters within it. The receiving antenna had dimensions of 80 x 80 meters. The radar worked in the meter bandwidth. The proposal of the Soviet party to use the radar as an international satellite location system (OS-3) was not approved.

In accordance with the intergovernmental agreement, the obsolete Dnestr-M radar in Skrunde worked until 1998, and then it had to be dismantled within 18 months. The new Daryal radar built nearby was blown up on May 4, 1995. The fate of the EWS radar located near Gabala was on the agenda of negotiations between Russia and Azerbaijan held in Moscow in 1997. The Stopor installation with its' 16-story radar building is located in Gabala. The radar was intended for detection of BM launches from the Indian Ocean. However, the radar is unable to process the information independently, and transmits it to the Kvadrat and Shvertbot installations near Moscow. Russia will probably have to pay rent for the land where the radar is stationed.

To increase the range of BMs detection the USSR also worked on development of the over-the-horizon radars. A scale model of the over-the-horizon radar was built, which tracked rocket launches from Baikonur at a distance of 2,500 kilometers.

The Long-Range Communication Research Institute designed the over-the-horizon radars for the detection of launches of BM of potential enemies and the preparation of complete information about the threat within two or three minutes. The Duga-2 experimental model of such a radar designed in 1970 (Chief Designer F. Kuzmin) was successfully tested using launches of domestic BMs from the Far East and Pacific Ocean to the testing ground on Novaya Zemlya. The radar built near Nikolaev included 26 huge transmitters (each one the size of a two-story building), these were assembled by the Dnepropetrovsk machine building plant. The transmitting antenna was 210 meters wide and 85 meters high. The receiving antenna was 300 meters wide and 135 meters high. The antenna field housed 330 vibrators of about 15 meters each. For the first time the over-the-horizon radar became operational on November 7, 1971. The positive results of the tests were received for a middle-latitude route and in a relatively quiet ionosphere. Later two over-the-horizon radars of this type were built near Chernigov and Komsomolsk-na-Amure. These radars had to reliably detect group and mass launches of intercontinental ballistic missiles from the territory of the US.

Special satellites were another device intended for over-the-horizon detection of intercontinental ballistic missile launches. The EWS satellites were developed by the Central Research Institute Kometa, which split from the KB-1 design bureau in the early 1960s, under the supervision of Chief Designer A. Savin. The first satellites were designed by the Chief Designer V. Kovtunenko of the Research and Production Association of S. Lavochkin. The first Cosmos-520 experimental satellite without location equipment was delivered to orbit in September 1972. The satellite was equipped with an infrared telescope working below the level of thermal noise. The cooling system of the telescope equipment consisting of diode thermal pipes was designed by the Krasnaya Zvezda Research and Production Association. After the US deployed a satellite EWS in 1972, in 1973, the Central Committee of the Communist Party and the Council of Ministers of the Soviet Union issued a resolution on development of a similar full-scale domestic system. Satellites of the first generation were delivered to high elliptical orbits with an apogee of about 40,000 kilometers, and rotation period of about 12 hours. Between 1972 and 1976, four experimental satellites were launched. In 1977, three satellites were delivered to orbit, which Western experts took as organization of a limited operating system. In 1978, the space echelon of the EWS was placed on combat duty in a reduced composition, and in 1982 in full composition. The altitude of orbits of EWS satellites is 35,000-40,000 kilometers.

For EWS Russia is currently using 81G6 satellites of the Prognoz series (Oko) of the second generation, delivery of which to orbit began in 1988. These satellites are manufactured by the Research and Production Association of S. Lavochkin. The orbital EWS cluster includes 9 satellites moving along the common ground route with an interval of 2 hours and 40 minutes, and spaced from one another by 40 degrees. A satellite of this cluster weighs 3,000 kilograms. Sometimes the EWS fails like, for example, in July 1983, when the command post formed false information about a mass BM launch from the territory of the US according to the information received from the satellite. Analysis showed that the information was false, and the information was not transmitted to the EWS command post. When the emergency situation was analyzed, it was found out that the combat program had drawbacks, which resulted in a failure of the on-board central computer when the satellite quickly moved from a space lit by the Sun to the shadow.

By the mid-1980s, the Kometa Research Institute and the Research and Production Association of Lavochkin improved the space system to the required characteristics, and made it the basic, most reliable and effective element in the complex EWS.

ABM defense system of the Soviet Union and Russian Federation

The first practical proposals regarding the ABM defense were prepared in the Soviet Union in 1953. In 1955, Chief Designer G. Kisunko of the SKB-30, a structural sub-unit of the SB-1, a large missile design bureau, prepared proposals about the experimental field ABM system A. By that time the SB-1 designed the first domestic air defense missile system S-25 Berkut, which became a school for the engineers who later took part in development of ABM systems. Estimates of the ABMs effectiveness done by the KB-1 (formerly SB-1) showed that the homing accuracy of the system allowed killing of one warhead of BM by 9-10 ABMs, which made the system not feasible. That is why Kisunko offered another method of coordinates finding for a high-speed ballistic target and ABM, that is, the finding of coordinates of the object according to finding of distance between the object and the radars placed far from one another in the angles of an equilateral triangle (the triangulation). In March 1956, the SKB-30 which split from the KB-1 to an independent organization prepared a draft project of the ABM system A. In 1959, the draft project of the A system was completed under the supervision of Chief Designer of the system G. Kisunko, and building of an experimental field model began. The system included the following elements:

-Dunai-2 long-range radars for BM detection with a range of 1,200 kilometers, designed by the NII-37 under the supervision of Chief Designer V. Sosulnikov;

-three radars for precision homing of ABM at a target, each of them consisting of a radar for finding of target coordinates, and a radar for finding of an ABM coordinates;

-a radar for ABM delivery, designed under the supervision of Chief Designer S. Rabinovich, and an interfaced station for transmission of signals for control over an ABM and actuation of its warhead;

-a launch position with V-1000 ABM launchers, the launchers were designed by the SKB of V. Barmin;

-a main command and computing post of the system;

-radio-relay lines for communication among all components of the system.

Precise homing radars and a station for transmission of commands were developed by the SKB-30 under the supervision of Chief Designer Kisunko. In designing of the precise homing radar also took part the Radio-Electronic Research Institute of the Academy of Sciences headed by Academician A. Mints.

The early warning radar of the experimental field system A was placed on the coast of the Balkhash Lake. During the trial, when a BM or its warhead were detected, the target designation from the radar was transmitted to the station for transmission of commands. Three such stations, located in the Betpak-Dala desert at a distance of 100-250 kilometers from the coastline of the Balkhash Lake in the angles of the equilateral triangle with a leg of about 150 kilometers, used the "three ranges" method offered by Kisunko for accurate finding of target coordinates by the ABM. Rotating parabolic-reflector antennas of the station for transmission of commands could lock on and automatically track warheads of BMs at a distance of about 700 kilometers. The station locked on an ABM according to the signal from the on-board radio responder by the moment when its precise homing at a target began. Ranges were found with mean-square errors of not more than 5 meters. The launch position of the ABMs was located approximately 100 kilometers to the west of the Balkhash Lake, the ABM delivery radar was also stationed there. The launchers could be laid in azimuth and angular elevation to launch an ABM to the area of encounter with the intercepted ABM. The ABM delivery radar had a rotating parabolic-reflector antenna with a scanning beam, and could lock on the ABM for automatic tracking practically immediately after its launch. According to the measured angular coordinates and range of an ABM, its deviation from the optimal delivery trajectory set up by the computer system was defined. At the precise homing stage of the ABM the delivery radar formed target designation for the precise homing radar for tracking of an ABM according to its angular coordinates. Initially the ABMs were equipped with fragmentation warheads of the Zavesa type which had disk-shaped slow spray fragment field. For homing of an ABM the method of parallel approach of an ABM to its target on the counter courses was chosen.

Research of certain problems of dynamics of the homing system with the real control equipment was done at the dynamic test beds of the NII-2 of the Ministry of Aircraft Industry (at present GosNIIAS, the State Research Institute of Aviation Systems). Trial of the field model of the ABM system was started at the A testing ground near the Balkhash Lake in 1960. In early 1966, the OKB-30, a new independent organization, was founded on the basis of the SKB-30. The OKB-30 was later renamed OKB Vympel, and later the Radio Instruments Building Research Institute.

The successful first interception of a BM by the A system was conducted on November 24, 1960. The ABM was not equipped with a warhead.

On March 4, 1961, in the area of the A testing ground the V-1000 ABM with a fragmentation-high-explosive warhead successfully intercepted and destroyed at an altitude of 25 kilometers the R-12 BM launched from the State Central Testing Ground with a dummy warhead weighing 500 kilograms. The Dunai-2 radar of the A system detected the BM at a distance of 1,500 kilometers when it appeared over the radio horizon, then the M-40 central computer found parameters of the R-12 trajectory, and prepared target designation for precision homing radars and the launchers. The ABM was launched and its warhead was actuated by the signal from the command post. The warhead of the ABM consisted of 16,000 balls with a carbide-tungsten core, TNT filling, and a steel hull. The warhead had a fragments field shaped as a disk perpendicular to the longitudinal axis of the ABM. The warhead was actuated by the signal from the ground with a deflection necessary for formation of the fragments field. The warheads of this type were designed under the supervision of Chief Designer A. Voronov. The M-40 central computer was designed by the Precise Mechanics and Computer Research Institute of the Academy of Sciences under the supervision of Academician S. Lebedev. The computer could make 40,000 operations per second.

The V-1000 ABM, which had the maximum flight speed of 1,000 meters per second, was designed by the OKB-2 of the Ministry of Aircraft Industry (MKB Fakel) under the supervision of Chief Designer P. Grushin.

The V-1000 had two stages. The first stage was a solid-propellant booster, and the second stage was a sustainer stage with a warhead which was equipped with a liquid-propellant engine developed by the Design Bureau of Chief Designer A. Isaev. In addition to the fragmentation warhead a nuclear warhead was also designed for the missile. The flight tests of the missile, which could intercept targets at altitudes of up to 25 kilometers, started in 1958. The parallel approach to the target at a strictly counter course was chosen as the method of the ABM's homing. The V-1000 was delivered to the trajectory calculated according to the homing method along the regular curve, parameters of which were defined by the predicted target trajectory. P. Kirillov was the Chief Designer of the missile's automatic pilot. On March 26, 1961, the ABM destroyed the warhead of the R-5 BM with 500 kilograms of TNT. Overall, during the trial of the A system 11 launches of ABMs were performed which destroyed warheads of BMs, and experimental ABMs with heat seeking self-homing warhead, radio-controlled fuses, and optical fuses were also launched. The S2TA version of the V-1000 ABM with a heat seeking self-homing warhead was tested at the A testing ground between 1961 and 1963. The flight tests of the V-1000 with the nuclear warhead (without the fissible material) designed in Chelyabinsk-70 were conducted in 1961. For this warhead two types of proximity fuses were designed and tested: the optical fuse (designed by the GOI under the supervision of Chief Designer Emdin) a and radio-electronic fuse (Chief Designer Bondarenko) for the R2TA and G2TA versions of the missile.

Systems for surmounting of air defenses intended for domestic BM were also tested during the trial of the A system. The launched target ballistic missiles were equipped with inflatable false targets Verba, unfolding false targets Kaktus, and Krot active jammers. Overall, the field tests of the A system showed a principle possibility of BM warheads interception. Experiments under the coded name Operation K were conducted (K1, K2, K3, K4, and K5) to check a possibility of the A system functioning under the influence of nuclear explosions at altitudes of 80 to 300 kilometers between 1961 and 1962 at the Sary-Shagan testing ground. The A system showed its capability to function even when a conventional enemy used nuclear weapons.

By June 1961, successful results of trial of the A system allowed accomplishment of designing of a draft project of the A-35 combat ABM system intended for defense of Moscow from the American intercontinental ballistic missiles of the Titan-2 and Minuteman-2 types. It was planned to include into the combat system a command post, eight Buniy-3 sector early warning radars (Chief Designer V. Sosulnikov) and Dunai-3U (Chief Designer A. Musatov) with a circular radar field around the guarded object, and 32 launchers.

In 1960, the Central Committee of the Communist Party and the Council of Ministers issued a resolution on development of A-35 ABM system for Moscow, and its experimental field model. The new draft project of 1964 made provisions for equipment of the ABM with a nuclear warhead instead of the fragmentation-high-explosive one, and for reduction of the quantity of launchers to 16. Initially the A-350ZH ABM was equipped with the nuclear warhead having a relatively low effect, which was later replaced with the nuclear warhead of enhanced effect. The weight and dimensions of the warhead remained practically unchanged, and hence the outward appearance and parameters of the designed ABM were left intact. These and some other solutions allowed transition to a simper method of target and ABM coordinates finding at the second stage of designing substantially increasing the number of the system's channels. Construction of the S-25 air defense system of Moscow was started in 1962. Simultaneously the Aldan, the experimental model of the A-35 system, was built by 1967 at the A testing ground. The field tests of all elements of the A-35 system were conducted at the Aldan field version of the system. The system was tested in two stages: the first stage with the A-350ZH ABM went on until 1971, and the second stage with the A-350ZH and A-350R ABMs went on after 1971. At the final stage of the trial, between 1976 and 1977, seven launches of ABMs were performed (two A-350R and five A-350ZH) at conventional targets of the 8K63 and 8K65 BM types, and three launches of A-350ZH at 8K63 BM.

The A-35 consisted of the following elements:

-a main command and computing center including the main command post and the central computer of the 5E92 type;

-a node of the Dunai-3 early warning radar;

-eight launch systems each including a command post, a target radar, two ABM radars, and two launching positions with ground launchers;

-A-350ZH ABMs;

-a data transmission system.

The A-35 system included the ground launchers of the open type where the A-350ZH ABMs filled with aggressive fuel components and equipped with nuclear warheads were held in containers. For the first time in the USSR a jet engine with a rotating nozzle was designed for the A-350 ABMs. Such capability of the engine made the jet vanes unnecessary. A few launches were conducted (test bench firing tests), but later, according to the demand of V. Chelomey, the test bench for firing tests of the engine was refurbished for trial of the engine of the UR-100 BM. As a result of successful tests of the new liquid-propellant engine, the A-350 was converted for the liquid-propellant engine of the UR-1`000 with rotating chambers of the jet vanes and fixed chambers of the main engine. The offer to use the modified UR-100 missiles as the ABMs in the A-35 system was also considered, but, according to the recommendation of Kisunko, an alternative option of joint use of the A-35 system with the A-350 ABMs and Taran system with the UR-100 missiles was offered. This option implied the homing of missiles by the equipment of the A-35 system. Due to some reasons not a single option was taken.

The MKB Fakel under supervision of Academician P. Grushin designed the ABM of the A-350 type (NATO code name Galoch) for the A-35 system. The missile was equipped with a thermonuclear warhead developed in Chelyabinsk-70. By 1971, construction of only four of eight radars of the project of sector radars of the Dunai type, and eight launchers of sixteen was accomplished. The state tests of the A-35 system were conducted at the pilot model of the system which included: a reduced version of the main command and computing center, one Dunai-3 radar, and three launchers. The main command and computing center was built 70 kilometers from Moscow, and its building was adjacent to the antenna of the long-range detection system, which domestic specialists called the Shalash, and NATO dubbed the Dog House.

The tests confirmed a possibility of completely automated functioning of the ABM system with regard to killing of monoblock BMs, but the system could not intercept the MIRV missiles. Due to this it was decided to accomplish development of the facilities construction of which already started: the second Dunai-3 radar and five launchers. Work on further deployment of complete system was stopped. As a result the A-35 was put into experimental operation only in 1972, and its upgrading was conducted later.

In 1973, Chief Designer G. Kisunko substantiated the basic technical solutions for the upgraded system capable of destruction of complex ballistic targets. In 1975, the A-35 received a combat task of interception of a single complex multi-element target containing light (inflatable) and heavy false targets along with the combat blocks, which required a substantial improvement of the system's computing center. This was the final improvement and upgrading of the A-35 system, which was accomplished in 1977. The new task was fulfilled mainly through the algorithmic unification of the radar channels for target coordinates finding into the integrated information system, and creation of a new algorithm for centralized management of combat operations. Simultaneously the EWS field was broadened through inclusion of new radars into the A-35 system.

We need to add that, in 1960s and 1970s, development of the ABM systems in the Soviet Union was not confined to the A-35 system and its versions. Chief Designer A. Raspletin of the TSKB Almaz offered development of the S-225 mobile (automotive type) versatile anti-missile and anti-aircraft system. It was developed between 1965 and 1978. This was a two-echelon ABM system intended for interception of one or two combat blocks. The S-225 included: a phased array radar for target tracking and ABM homing, a station for transmission of commands, the ABMs with nuclear warheads and the command homing posts 5YA26 (designed by the OKB Novator), and 5YA27 (designed by the Fakel).

It was planned to receive target designation for the system from the EWS radars of the RO-1 and RO-2 nodes, and later from the Donets radars. Proceeding from the publication of Kisunko, the NII-244 offered the project of its own ABM system Zaslon with the Programma (Programma-2) radar.

In 1963, Chief Designer Chelomey of the OKB-52 proposed the use of the UR-100 intercontinental ballistic missile or development of the Taran ABM system. The OKB-30 had to take part in development of the new ABM system to enable the UR-100 to actively maneuver according to commands of the ground command post for interception of maneuvering targets. In the ABM system it was planned to launch the UR-100 according to the data of the EWS to the points of encounter with hostile BMs far from the defended territory, and to kill them with a nuclear explosion of the missile's warhead.

The TSSO-S multi-channel radar located 500 kilometers from Moscow in the missile hazardous direction (closer to Leningrad) was to be the only new object within the Taran system. According to the data of this radar functioning in the bandwidth of 30-40 centimeters, BMs had to be detected, and coordinates of points of interception and moment of targets' arrival to these points had to be prolonged. The TSSO-S radar had to be switched on according to the signals of the RO-1 (Murmansk) and RO-2 (Riga) EWS nodes. The ABM version of the UR-100 missile was to be equipped with a super-powerful nuclear charge of at least 10 megatons. According to primary estimates of the Research Institute of Academician Keldysh, for killing of 100 Minuteman intercontinental ballistic missiles it was necessary to launch up to 200 ABMs of the Taran system. Along with this, development of the A-35 system was suspended. In 1964, the work on the Taran system was stopped. Dismissal of Senior Secretary of the Central Committee of the Communist Party N. Khrushchev plaid a crucial role in the history of the system's development. Khrushchev was the patron of Chelomey. Later Chelomey himself admitted that he gave up development of the Taran system because he did not pay enough attention to the EWS, which turned out to be very vulnerable to attack weapons of a probable enemy, although it was the key element of his ABM system.

For detection and killing of carriers of maritime strategic ballistic missiles the USSR was designing an anti-submarine defense system. In the process of its development proposals appeared regarding the systems capable of fulfillment of the main task on par with other ABM systems. The Polus system was one of examples of such systems. Between 1963 and 1964, the OKB-156 worked under the Polus code on the topic "Research of a possibility of designing of an airplane system intended for detection of submarines by launches of missiles of Polaris type and their killing with airborne anti-submarine missiles." The Polus anti-submarine system also had to fulfill the following tasks: killing of ground launch positions of BMs, long-range detection of BMs of Polaris type and transmission of data about their trajectory to the ABM system and cooperating forces. For detection of BM launches the system used the infrared equipment with a range of 600-1,100 kilometers and the radar with a range of 100-400 kilometers. For killing of BM carriers it was planned to use a cruise missile with a range of 250 kilometers.

Under the supervision of Kisunko a draft project of the Avrora territorial ABM system was accomplished, which was rejected because it did not meet the reliability and effectiveness requirements. This system was intended for parrying of a mass nuclear missile blow delivered by the enemy at the most important administrative and industrial areas of the European part of the Soviet Union. For the first time during the entire history of domestic ABM systems it was planned to use phased array radars in the system. It was planned to use ABMs of two types: the A-351 with a broad range of altitudes, and the A-900 long-range ABM for delivery of a "clearing blow" and long-range interception of BMs. Provisions were made for mounting of nuclear warheads of variable power on the missiles for various altitudes.

For selection of combat blocks of hostile BMs the Avrora system was to deliver a dynamic blow with assistance of an explosion of a powerful nuclear warhead of a so-called "clearing" ABM, on the elements of a complex target with the following radar surveillance of their movement. Proceeding from comparison of parameters of movement of the elements of a complex target before and after the "clearing" explosion combat blocks had to be identified as the heaviest elements, and, hence, less vulnerable to the explosion effect. In summer 1967, the draft project of the Avrora system was submitted to the state commission. The commission decided not to begin the experimental-designing phase of the project. However, the Argun rotating phased array from this system is still effectively used at the A testing ground as the main measuring device.

In 1975, the Vympel Central Research and Production Association of the Ministry of Radio Industry, founded in 1970, became the lead organization for development of the domestic ABM system. The state trial of the A-35M ABM system began in May 1977. After the trial the A-35M was adopted and placed on combat duty within the separate corps in 1978. The A-350R ABMs were filled with fuel components and equipped with warheads only at the technical base. Dummy missiles were arranged on the launch position. The A-350R differed from the A-350ZH by elements of the on-board equipment with the improved radiation immunity. The main command and computing center of the A-35M system together with the receiving station of the Dunai-3M EWS radar (NATO code Dog House) was located a few tens of kilometers to the west from Moscow, and the launchers of the Tobol and Yenisei types with the A-350 ABMs with nuclear warheads were arranged along the radius of 100 kilometers around Moscow. Due to the planned deployment of American BMs in Western Europe the Dunai-3U radars were upgraded for broadening of their surveillance sector aimed at covering of the West German territory.

In late 1968, a group of engineers under the supervision of A. Basistov was ordered to prepare a concept of building of the new ABM system for the Soviet capital. According to the prepared concept, it was planned to develop an ABM system for defense of Moscow from single, accidental, provocative blows of BMs, or from a limited group of BMs launched by the third countries, or from a single strike submarine which goes out of control. In late 1969, Command of the Air Defense Forces agreed with the initial specifications for designing of a multi-channel launch system including two echelons: the long-range over-the-atmospheric, and the close-range atmospheric one. In spring 1970, the NIIRP announced a tender for the launcher's radar. In the tender participated the following projects:

-the radar with a rotating phased array from the project of the Avrora ABM system (designed by the NIIRP, Chief Designer Kisunko);

-a radar with the lens of Luneberg from the project of the Avrora ABM system (Chief designer Yu. Burlakov);

-a tetrahedral radar with a fixed phased array (designed by the Radio-Electronic Institute, RTI).

In 1971, development of the project of the new ABM system of the second generation was accomplished. Construction of the system on the testing ground and manufacture of its elements by the plants started in 1974. A. Basistov was appointed the Chief Designer of the system, and V. Sloka was appointed the Chief Designer of the Don multifunctional radar.

The multifunctional Don radar, located not far from Pushkino (Moscow region), had a shape of a truncated pyramid with equal length and width (100 meters), and height of 45 meters. Phased arrays with diameter of 16 meters each were mounted on four sides of the pyramid. The radar was designed by the RTI of A. Mints of the Academy of Sciences. Building of the launcher's radar began in 1978.

By 1978, construction of the field model of the launch system was primarily accomplished on the A testing ground, and preparation for the firing tests was in progress. The plans of the US to deploy Pershing-2 medium-range BMs in Western Europe made the upgraded ABM system of Moscow more important. The work on the testing ground was aimed at interception of BMs with a short flight time.

The ABM system of Moscow of the second generation had to include:

-a launcher's radar providing for detection, tracking of targets and homing of ABMs on them;

-a command and computing post with the Elbrus-2 computers with a speed of up to a billion operations per second, system control devices, and maintenance systems;

-silo launchers of ABMs designed under the supervision of Chief Designer V. Barmin;

-long-range ABMs for target interception in the upper strata of atmosphere and in outer space designed by the MKB Fakel under the supervision of Chief Designer P. Grushin;

-high-speed medium-range ABMs capable of target interception within a broad range of altitudes designed by the Yekaterinburg-based OKB Novator under the supervision of Chief Designers L. Lulyev and P. Kamenev;

-systems for data transmission connecting all components of the system into the common combat cycle.

The field model of the new 5ZH60P system was placed on three pads of the A testing ground and included: a radar with a fixed array providing for target detection and tracking and homing of interceptor missiles at them, silo launchers; a data transmission system connecting all components of the system into the common combat cycle. A command and computing post with the computer center and command devices. The second pad of the A testing ground housed the launch positions of the 51T6 missiles for interception of space targets, and the 35th pad housed the launch positions of the 53T6 medium-range interceptor missiles. The eighth pad housed the Don-2NP radar and the 558OP command and computing post of the launch system.

By 1989, the new ABM system was accomplished. The system included missiles of two types: for long-range and for close-range interception. All missiles were placed in silo launchers covered with sliding lids. According to the presidential decree, the A-135 ABM system of the new generation was placed on combat duty in 1995. The A-135 system could intercept hostile missiles at altitudes of 5 to 30 kilometers. The ABMs were equipped with nuclear warheads. Chief Designer of the A-135 system Basistov said, "The system has showed substantial reserves with respect to all parameters. The 53T6 high-speed ABMs of Lulyev can kill ballistic targets at distances of 150% bigger than those we tested them at. The system is ready to kill low-altitude satellites and to fulfill other combat missions."

The Radio Instrument Building Research Institute under the supervision of Academician A. Avramenko developed a plasma weapon capable of killing any target at altitudes of up to 50 kilometers. Engineers and scientists of the institute in cooperation with the National Research Institute of Experimental Physics (Arzamas-16), Central Aerohydrodynamic Institute, and Central Machine Building Research Institute prepared a concept of the international experiment Doverie (Trust) for testing of the Russian plasma weapon at the American ABM testing ground in the Pacific Ocean together with the US. The cost of the experiment was estimated at $300 million. According to Academician Avramenko, the plasma antimissile weapon would not only cost tens times less than the American SDI, but would also be much simpler in development and operation. The offered joint project could save expenditures on development of its own plasma weapon for the US. The plasmoid based on the energy of ground super-high frequency generators or laser (optical) generators creates an ionized territory in the trajectory of a warhead and in front of it, and completely disrupts the aerodynamics of the object's flight, after which a target leaves its trajectory and is ruined by monstrous overloads. The killing effect is delivered to the target at the speed of light.

Development of laser weapons in the Soviet Union began in 1964-1965. Very soon the OKB Vympel and SKB Strela (Almaz Research and Production Association) joined this work. The Vympel designed a laser weapon in the interests of the antimissile defense. A special position was built at the Sary-Shagan testing ground. This work resulted in designing of the Terra-3 research and experimental system. In this work also took part the Physical Institute of the Academy of Sciences and the National Research Institute of Experimental Physics (Arzamas-16). In late 1960, a section of Vympel which worked on laser weapons was transformed into the separate TSKB Luch (now Astrofizika Research and Production Association).

The experimental field system consisted of the laser proper, the system for aiming and holding of the beam, and the information system intended for maintenance of the ground aiming system's functioning. The system was not accomplished, and it had never been used for its intended purpose.

At present not only industrially developed but also developing countries have access to technologies of tactical and tactical theater ballistic missiles designing. The number of countries possessing this weapon keeps growing. Due to this defense of military and civil installations, troops, and civilians from such weapons is becoming increasingly vital. For this purpose development of the S-300V versatile multi-channel mobile air defense missile system began under the supervision of Chief Designer V. Yefremov of Research and Production Association Antei in late 1960s. This system was intended for killing of tactical and tactical theater ballistic missiles. The Ground Forces adopted the S-300V in 1985. The system included: the 9S4567-1 command post, the 9S45MT all-round looking radar, the 9S19M2 sector surveillance radar, and up to four missile launch systems. Each launch system included: the 9S32 multi-channel homing system, six 9A82 and A83-4 launchers, and 9M82 and 9M83 missiles. The system's components were mounted on standardized self-propelled tracked chassis with a high cross country capability (object 830-835), and were quipped with completely autonomous power supply, life support, and radio communication devices. The standardized tracked chassis weighing up to 48 tons was designed by the KB-3 of the Kirovsky plant under the supervision of Chief Designer N. Potapov. In the process of serial production the special equipment and missiles of the system were constantly upgraded. The S-300V system used missiles of two types (designed by the OKB Novator): the 9M82 with a launch weight of 4.6 tons and a maximum speed of up to 2,400 meters per second, and the 9M83 with a launch weight of 2.5 tons and a flight speed of up to 1,700 meters per second. Both missiles had two stages, were solid propellant, and had a combined control system: inertial with semi-active radar self-homing at the final stage of the flight. The system could simultaneously attack up to 24 targets. The defenses area of the S-300V amounted to: 500 square kilometers from a simultaneous attack of four BMs of the Lance type, 240 square kilometers from a simultaneous attack of two BMs of the Pershing-1A tope, and 310 square kilometers from a single attack of the Pershing-1B. In the process of testing and training over 60 ballistic and aeroballistic missiles with a launch range of 65 to 900 kilometers were killed. The warheads of ballistic targets were hit, and the ballistic missiles were moved from the homing point by 15 kilometers. After the upgrading, done in compliance with requirements of the Ground Forces for the next century, the S-300V will be able to intercept BMs with a flight range of up to 3,000 kilometers, will kill targets at distances of 100-200 kilometers, and will be able to simultaneously home a few tens of missiles at 50 targets.

Between 1985 and 1989, the Almaz Research and Production Association under the supervision of Chief Designer B. Bunkin developed the S-300PMU versatile air defense missile system which could also kill tactical BMs. The S-300PMU-1 was developed on the basis of the S-300P. The new version of the S-300PMU-1, the S-300PMU-2 Favorit, was presented for the first time at the MAKS aerospace show in Moscow in August 1997. Favorit can kill air targets at distances of up to 200 kilometers. The Favorit uses the new 48P6E2 missile, which blows up the target's warhead. The S-300PMU-2 can kill tactical and tactical theater missiles. For this purpose the 83M6E2 control system has expanded search capabilities regarding location and tracking of ballistic targets.

The Buk-M1 army air defense system of the Ground Forces was designed by the Instrument Building Research Institute of V. Tikhomirov (Chief Designer A. Rastov) on the basis of experience of development of the Kub and Buk systems. These systems performed well in the troops. The Buk-M1 was adopted in 1983. Initially it was not intended for combating of tactical BMs, but its potential capabilities allow fulfillment of this mission. In addition to its main mission, combating of aerodynamic air targets, the Buk-M1-2 version can also kill tactical BMs and surface ships. The need to fulfill such tasks conditioned a substantial upgrading of the software for the Buk-M1, including its missile. The 9S18M1 target location radar received a sector scanning mode with an angular elevation of up to 55 degrees which improved its jamming immunity, and enabled the radar to detect tactical BMs. The angular elevation of the scan zone

provides the necessary range of BMs lock on by the 9A31M1 self-propelled mount, and a launch range and killing of BMs with a small effective reflecting area. The software of the 9S470M1 command post underwent the biggest improvement for the sake of normal target designation with regard to BMs. During the military exercises Oborona-92 and Osen-93, the Buk-M1 killed not only aerodynamic, but also ballistic targets, the counterparts of Lance (Lance-2) and Pershing-1 missiles. The system can simultaneously kill up to six targets flying at a speed of up to 830 meters per second and overloads of up to 7-8 g, and home 12 missiles. The effective altitude of the Buk-M1 is 15 meters to 22 kilometers, and the effective range is 3 to 35 kilometers. The system includes: the command post, the 8S18M1 target location radar, six 9A310M1 self-propelled mounts with four missiles on each, 3-6 9S39M1 launch and loading vehicles with eight missiles on each, and the 9M39M1 missiles. All system's components are mounted on self-propelled tracked chassis with a high cross country capability. Instruments of the system and its crew are placed in armored hulls. The system's components weigh not more than 36 tons. The maximum speed of the system is 65 kilometers an hour. The 9350M1 missile with a semi-active radar self-homing warhead designed by the Agat Research Institute is 5.55 meters long, and has a launch weight of 690 kilograms. The missile is equipped with a solid propellant engine with the work period of up to 11 seconds. During this time the missile is accelerated to a speed of 1,100 meters per second. The system's deployment time is 5 minutes. The launcher and the transport-loading missile were designed by the Start Research and Production Institute. The system's components are manufactured by the machine building plant of M. Kalinin. Since 1985, the Instrument Building Research Institute under the supervision of Chief Designer Ye. Pigin has been developing the air defense missile system of the third generation. Since 1993, the institute has been developing the promising Ural air defense missile system on the basis of the Buk-M1 in the interests of a potential foreign customer. It is planned to multiply the quantity of channels of the new system through inclusion of a phased array radar.
Space Defense Projects

The USSR has been working on separate space defense projects since 1950s. One of these projects, the Kosmoplan aerospace airplane for interception and killing of hostile satellites, was developed by the OKB-52 under the supervision of V. Chelomey. According to the initiative of S. Korolev, the anti-satellite system was offered, which was based on the R-7 intercontinental ballistic missile with a satellite killer as its last stage. For homing its was planned to use radar facilities of the ABM system A. The satellite killer was developed by the OKB-155 of A. Mikoyan. Designing of the new space defense system (SDS) for killing of military satellites of a probable enemy began in 1962 within the "Satellite killer" program in the Kometa Central Research Institute under the supervision of A. Savin. By late 1960s, a special automated SDS was designed in cooperation with the Central Machine Building Design Bureau of Chief Designer Chelomey. The SDS included: a ground command and computing measuring post located in the Moscow Region, a special launch system on the Baikonur testing ground, a delivery vehicle, and an interceptor satellite. The interceptor satellite was equipped with a self-homing warhead and a fragmentation warhead for killing of hostile satellites. On November 1, the first prototype of the first space interceptor was launched from the Tura-Tam (Baikonur) testing ground. This was the Polyet-1 maneuvering satellite. The Polyet-2, the second such satellite, was launched on April 12, 1964. The satellites were designed by the OKB-52 under the supervision of Chelomey. Satellites of the Polyet type weighed 1,959 kilograms, and consisted of a cylindrical instrument compartment and a propulsion system, in which four spherical fuel tanks surrounded the sustainer engine. The instrument compartment housed a warhead with shrapnel, and the fuse on a rod was moved far behind the instrument compartment. The Polyet satellites obviously had to be delivered to orbit by the UR-200 missile, which was developed by the same design bureau. At any rate, by the moment of launch of the first Polyet satellites the UR-200 was not ready yet, and the satellites were delivered by the two-stage version of the R-7A (8A92), designed by the OKB-1 of Chief Designer Korolev. This rocket could deliver a payload of 1,950 kilograms. Later, the work on the UR-200 intercontinental ballistic missile was stopped, and the R-36 intercontinental ballistic missile designed by the Southern Design Bureau was used as the delivery vehicle. The Polyet-1 and Polyet-2 maneuvering satellites were prototypes of the IS (satellite killer) automatic interceptor satellite.

The Soviet Council of Ministers ordered development of delivery vehicles for the IS and US satellites by its resolution of August 24, 1965. In accordance with the resolution, a draft project of the 11K67 Tsiklon-2A rocket was designed in March 1966. The flight tests of the 11K67 rocket with the IS satellite began in August 1967 at the Baikonur (Tura-Tam). The first launch of the R-36 rocket with the third stage with a multiple switch engine was performed on October 27, 1967. The Cosmos-185 was delivered to orbit. Western experts dubbed the new delivery vehicle the F-1m (maneuvering). The Cosmos-217, Cosmos-248, and Cosmos-374 maneuvering satellites were launched between 1968 and 1970. The first interception in outer space was done by the IS (Cosmos-252) on November 1, 1968. The flight and designer tests of the new 11K69 Tsiklon-2 delivery vehicle with the IS satellite of the ABM system started in August 1969.

For the first time in the world, the IS (satellite killer) experimental interceptor satellite killed a target satellite with a fragmentation warhead in August 1970. The interceptor satellites were about 6 meters long, their hull had a diameter of 1.5 meters, and they weighed about 2,500 kilograms. Domestic SDS could kill satellites with probability of 0.6, whereas its American counterpart had a target kill probability of only 0.18.

This circumstance allowed placement of the SDS on combat duty on July 1, 1979. A. Savin and V. Kovtunenko were the chief designers of the system and its followed versions. The last trial of the IS satellite was performed on June 18, 1982, within the framework of big exercises of the Soviet strategic nuclear forces, when the Cosmos-1379 intercepted a target satellite which imitated an American navigation satellite Transit. Overall, during the trial of the IS interceptor satellites a few tens of launches were conducted. In April 1991, the IS-MU SDS including the Tsiklon-2 delivery vehicle and 14F10 satellite was put into operation.

Since 1978, the Vympel Design Bureau was designing an anti-satellite missile capable of being launched from a MiG-31D airplane. A prototype of the MiG-31D was tested in 1986. In 1976, the Energiya Research and Production Association headed by V. Glushko joined the work on the space anti-missile defense. For killing of military satellites two types of combat satellites were developed from the common basic design. These satellites were to be armed with various types of on-board armament (laser and missiles). The first type of satellites had to be used against low-orbit satellites, and the second type against satellites in medium and geo-stationary orbits. Due to the business of the Energiya with development of the Energiya super-heavy delivery vehicle and Buran shuttle orbiter, the Salut Design Bureau (General Director D. Polukhin) was instructed to continue the Skif theme (development of a laser combat station). The Skif satellites were to be manufactured at the Moscow-based machine building plant of M. Khrunichev. This satellite with a laser on-board system was designed by the Astrofizika Research and Production Association. It was about 40 meters long, and weighed 95 tons. For launches of the Skif satellites it was offered to use the Energiya rocket. Between 1983 and 1987, flight tests were conducted, and distribution of beams of a laser system weighing about 60 tons in the atmosphere was tested at the IL-76MD (A-60) flying laboratory. To power the laser system the satellite received two turbine generators, and the laser gun itself was placed in the fairing moved to the fuselage. This fairing was located between the trailing edge of the wing and the fin.

On August 16, 1983, Yu. Andropov, the General Secretary of the Central Committee of the Communist Party of the Soviet Union, announced that the USSR unilaterally stopped trial of the SDS, and the testing was stopped. However, due to ascension of M. Gorbachev to power, and launching of the "Star Wars" (Strategic Defense Initiative, SDI) program in the US development of the space defense continued. The Skif-D dynamic model was designed for testing of a laser combat station. A scale model of the Skif-DM station (Polus) was made later for test launch of the Energiya delivery vehicle. The model had a length of 37 meters, diameter of 4.1 meters, and weight of 80 tons. The Skif-DM had four sustainer engines, 20 orientation engines, and 16 stabilization engines. At the station it was planned to conduct 15 applied military and a few geophysical experiments, including launching of targets. Before the launch Mikhail Gorbachev, the General Secretary of the Central Committee of the Communist Party of the Soviet Union, declared an impossibility of moving of the armament race to the outer space, after which it was decided not to perform military experiments at the Skif-DM satellite. A test launch of the Energiya delivery vehicle with the Skif-DM satellite was conducted on May 15, 1987. The satellite separated from the rocket 460 seconds after the launch, and fell in the Pacific Ocean some time later because of the control system's failure. There was no laser system on board. Instead the satellite carried its scale model. Some elements of the "Soviet SDI" were to be mounted on the Spektr space module, but it was delivered to orbit only five years later than it had been planned, and was included into the Mir orbital station.

Since late 1960s, the Soviet Union was working on development of ground laser systems for anti-satellite defense and pumping from nuclear explosions. Unlike the Roentgen laser of Teller, such lasers were reusable. One of such lasers was probably built near Dushanbe. In different periods Yu. Babaev and Yu. Ablekov supervised the work on such laser, but due to the unilateral moratorium announced by the USSR, and the followed mysterious deaths of both engineers the work on such lasers was suspended in the mid-1980s.

In 1994-1995, The High Temperatures Institute of the Russian Academy of Sciences sold the Pamir-3U mobile electric generator to the United States. The Pamir-3U had an output of 15 megawatt, dimensions of 2.5 x 2.65 x 10 meters, and weighed about 20 tons. The generator could be used in Russia (USSR) on the ground or in outer space for power supply to long-range laser and super high frequency weapon systems.

The Soviet Union also worked on designing of an "orbital fortress" based on a space station of the Mir type. Modules of the aiming system served as the side blocks of the station. The side blocks were attached to the basic module. The blocks were to be delivered to the station in cargo compartments of the Buran shuttle orbiter. The station was intended for killing of warheads of ballistic missiles from outer space when the crew was on board.

It was also planned to use a group of three missiles to stretch a kevlar net to cut warheads of intercontinental ballistic missiles.

SYSTEM FOR CONTROL OVER OUTER SPACE OF THE USSR AND RUSSIAN FEDERATION

The problem of control over the outer space arose during the exploration of space for military purposes and for provision of security of manned space flights. Russia built the only outer space control center (OSCS) equipped with the quick-acting 5E51 computers of Elbrus type. The OSCS functions in the automatic mode processing the information about space objects at altitudes of up to 40,000 kilometers. The information comes from the early warning system, anti-missile defense system, optronic and laser systems for remote probing of earth. In 1970, the first part of the OSCS was placed on combat duty, and in 1972 the OSCS was adopted. The OSCS keeps and updates the main catalog which lists up to 10,000 space objects and their fragments. V. Repin, A. Kuriksha, Yu. Ochkasov, V. Sidelnikov, and N. Ustinov were the chief designers of the OSCS. Initially the optical surveillance posts and optronic stations of the Astronomic Council of the Academy of Sciences were used for detection and tracking of satellites.

A draft project of the OSCS was prepared and approved in 1965, and composition of the main catalog of space objects began. The early warning Dnestr radar in Kazakhstan became the first specialized radar for outer space control. The radar was tested in 1967.

The radar system for outer space control, including eight radars of the Dnestr type located in Kazakhstan and Siberia, was successfully tested in 1968. The system, which was designed under the supervision of Chief Designer Yu. Polyak, provided a radar barrier of 5,000 kilometers long and a possibility to detect satellites at altitudes of up to 3,000 kilometers. The Cosmos-6 satellite was launched on June 30, 1962, from the Kapustin Yar testing ground. In May 1976, the new Raduga system on the Plesetsk testing ground was adopted. The Raduga included the 11K63 Cosmos delivery vehicle and the DS-P1YU satellite.

Whereas the US started launches of new satellites to orbits with altitude of 20,000-40,000 kilometers, the Soviet Union worked on development of an upgraded outer space control system capable of detection and tracking of satellites at such altitudes. This system still remains on combat duty.

In the North Caucasus and in the Far East the Krona systems were deployed. They were designed under the supervision of chief designers V. Sosulnikov and N. Ustinov. The Okno system designed by the design bureau of the Krasnogorsk plant (Chief Designer N. Chernov) was built in Tajikistan approximately 16 kilometers from the Nurekskaya hydro power station. Western experts believed that this was a military laser system. According to the statement of Soviet officials, this was an optronic system for observation of space objects, similar to the American GEODSS. Besides the systems with radar location, systems with laser location were also developed for observation of space objects. At the Sary-Shagan testing ground the L-1 experimental laser locator was built, with assistance of which information about movement of space objects was received.

For observation of space objects the infrastructure of the Military Space Forces of the Defense Ministry can be used. Equipment of the Military Space Forces is mainly used for observation and control over domestic satellites. The forces have the main center for testing and control, to which the ground command and measuring posts and maritime command and measuring posts are subordinated. The center includes the basic system of stationary and mobile command, programming, telemetric, and trajectory systems, communication equipment, devices for automated collection and processing of information intended for control over all satellites functioning in outer space. This system is universal for all types of satellites. The center can control up to 200 satellites for various purposes constantly staying in orbit. All ground command and measuring systems are united into 13 command and measuring posts located in Krasnoe Selo, Shchelkovo, Maloyaroslavets, Vorkuta, Kolpatovo, Barnaul, Yeniseysk, Ulan-Ude, Yakutsk, Galenki, Korol, Solnechnoe, Yeliseevo. The first ships of the maritime command and measuring system were made from civil ships because of the shortage of time.

"Kosmonavt Vladimir Komarov" (project 1917) was the first ship of the new generation. It had a displacement of about 18,000 tons. It was converted from a cargo ship at the Baltic shipyard in 1967. "Akademik Sergei Korolev" (project 1908) and "Kosmonavt Yury Gagarin" (project 1909) were built between 1970 and 1971. Later a few series of ships were built according to project 1918 (4 ships), project 1929 (4 ships), project 1914 (2 ships), and civil ships "Bezhitsa" and "Ristna" were refurbished. The nuclear ship of project 1941, which was handed over to the customer in 1988, was the last project of the command and measuring ships.

AFTERWORD

Until recently the Anti-Missile and Space Defense Forces in Russia were called the Missile Space Defense Forces. Colonel General V. Smirnov was their commander. The forces included:

the early warning system, the ABM system, the outer space control system, and the space defense system. The outer space control system observes low and high orbits with altitudes of 120 to 40,000 kilometers and higher. The information components of the system can observe, analyze, and list in the catalog objects with diameter of about 10 centimeters staying in low orbits and with diameter of 0.5 meters staying in quasi-stationary orbits. In July 1997, the President issued a decree on re-subordination of the Missile Space Defense Forces to the Strategic Missile Forces. In November 1997, new commander of the united forces Colonel General V. Yakovlev announced that organization of a new branch of Armed Forces increased their combat readiness. At any rate, the service life of 68% of satellites in the early warning cluster and 48% of ground facilities has expired. Nonetheless, the system should fulfill its tasks until 2003, and later it will be renovated.

In September 1997, a package of disarmament documents was signed in Waldorf-Astoria hotel in New York. These documents confirmed the main provisions of the ABM treaty of 1972. It is prohibited to create strategic ABM systems, to test and deploy space ABM systems, but some flexibility is introduced with regard to the tactical ABM defense. The agreement laid some restrictions on the maximum flight speed and quantity of tests for the missiles of a tactical ABM defense system.

At any rate, we cannot rule out a new round of "Star Wars" but this time for peaceful purposes and in the interests of the entire planet's population. Many top ranking militaries and prominent scientists, including Teller, the "father" of the American H-bomb, offer development of systems for warning about asteroid hazard. It is offered to use the available nuclear missiles and such missiles subject to liquidation for destruction of asteroids which are hazardous for planet Earth. However, appearance of majority of hazardous heavenly bodies cannot be predicted, and modern facilities detect them only an hour before their encounter with the Earth. Development of new systems for detection of asteroids capable of finding their trajectory a few days prior to their encounter with the Earth may cost three to ten times more than the cost of all existing and available elements of the SDI.

http://www.fas.org/spp/starwars/program/soviet/990600-bmd-rus.htm