DEPARTMENT OF THE AIR FORCE
NATIONAL AIR & SPACE INTELLIGENCE CENTER
WRIGHT-PATTERSON AFB OHIO

APR 27 2015

CHARLES HOGAN, Colonel, USAF
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John Greenewald
[redacted]

Dear Mr. Greenewald,

This letter is in reference to your Freedom of Information Act (FOIA) request dated 13 August 2014 for a copy of a document entitled *"Missiles Against Missiles."* We received your request and assigned case number 2014-05789-F to it.

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Sincerely,

CHARLES HOGAN, Colonel, USAF
Vice Commander

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NATIONAL AIR INTELLIGENCE CENTER

MISSILES AGAINST MISSILES

by
Tomasz Hypki

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REPORT

MISSILES AGAINST MISSILES
The Americans Launch a Challenge

Tomasz Hypki

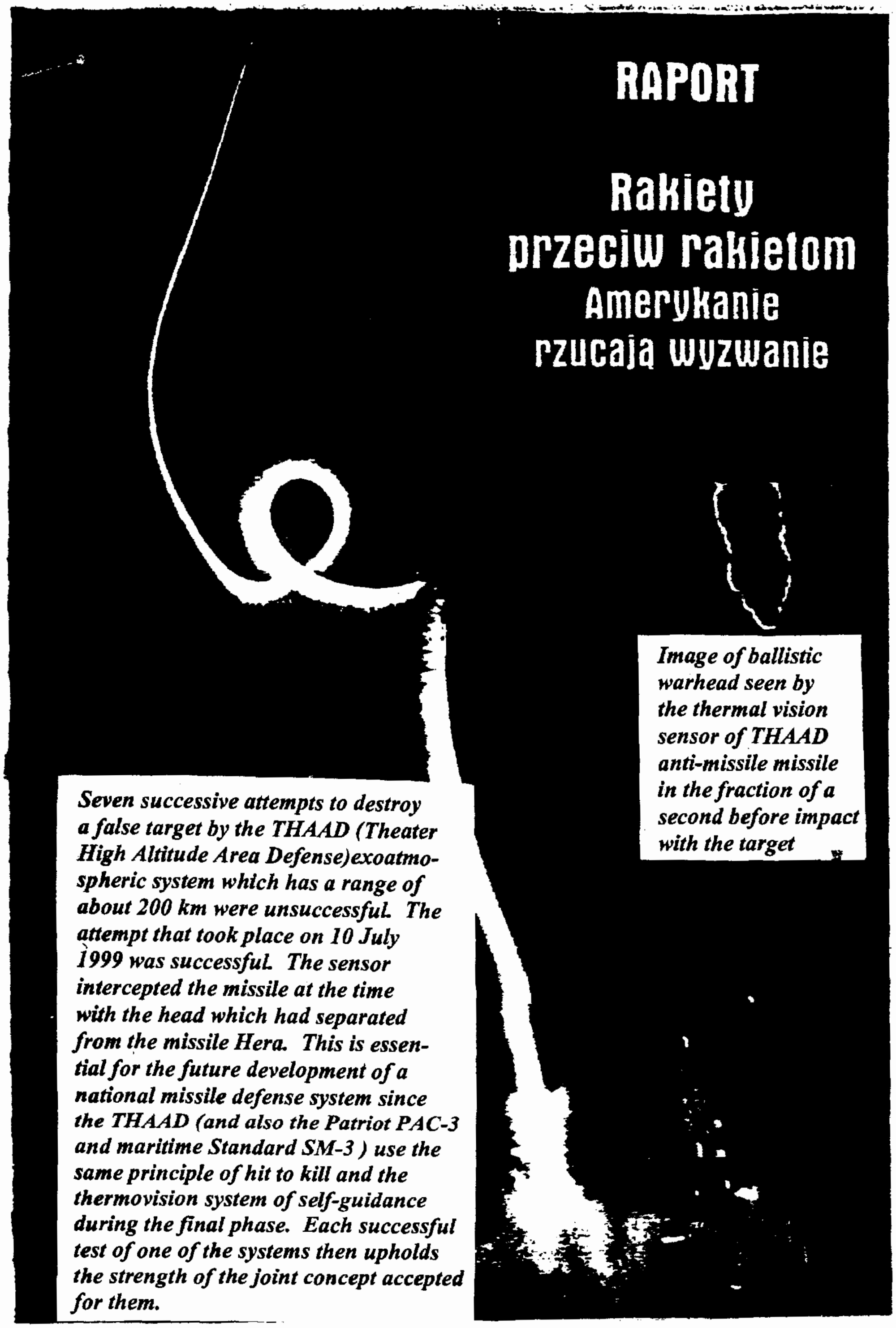


Image of ballistic warhead seen by the thermal vision sensor of THAAD anti-missile missile in the fraction of a second before impact with the target

Seven successive attempts to destroy a false target by the THAAD (Theater High Altitude Area Defense)exoatmospheric system which has a range of about 200 km were unsuccessful. The attempt that took place on 10 July 1999 was successful. The sensor intercepted the missile at the time with the head which had separated from the missile Hera. This is essential for the future development of a national missile defense system since the THAAD (and also the Patriot PAC-3 and maritime Standard SM-3) use the same principle of hit to kill and the thermovision system of self-guidance during the final phase. Each successful test of one of the systems then upholds the strength of the joint concept accepted for them.

As a result of the simulated nuclear missile attack conducted during the command staff exercises entitled ***Decisive Strike*** carried out in the early 1970's in the USSR, there was destruction of 90% of the American armed forces, 70% of its industrial potential and loss of 80 - 90 million residents of the United States. This result exceeded the anticipation of Soviet leaders who had structured entire maps on the development of nuclear weapons. The rivalry with the United States which had started in this manner had reached the point where, by the early 1980's, each side had at its disposal 10 thousand nuclear warheads mounted on delivery vehicles with strategic ranges capable of reaching enemy territory.

START I (***Strategic Arms Reduction Treaty),*** the first agreement for fundamentally reducing numbers of strategic weapons was signed in May 1991, right after the end of the ***Cold War.*** In accordance with this treaty, both the United States and Russia obligated themselves to reduce the number of nuclear war heads to 6 thousand by the end of 2001. In January 1993, the next agreement – START II – was signed which provided for a reduction in the total number of nuclear warheads on various delivery vehicles to 3,000 - 3,500 by the end of 2007. This left 1,700 - 1,750 war heads aboard submarines, 750-1,250 bombs and nuclear missiles in place among bomber weaponry. All inter-continental ballistic missiles with multiple warheads capable of guiding themselves to the target had to be eliminated. The Russian Duma did not ratify the START II treaty until some seven years later in April 2000.

Ratification of the treaty after such a long wait was a surprise but was a consequence of the on-going and natural weakening of the nuclear potential of Russia. Old missiles had to be pulled from the weaponry and the state of Russian finances had made it impossible to purchase a corresponding number of new ones to take their places. Annual deliveries are limited to barely 10 Topol-M missiles. For this reason, it would be better to ratify an agreement that would also force the United States to reduce its nuclear arsenal. Immediately after ratification of the START II treaty, Russian Federation President Vladimir Putin proposed a further reduction in nuclear warheads to 1,500 for each side. This has not been acceptable for the Americans, however, because it would undermine the foundations of the security doctrine of the United States which is based on the principle of potent nuclear deterrence which requires keeping at least 2,500 warheads in a state of readiness.

On the night of ratification, a single allocation chart was still kept in hiding. Russia promised its withdrawal from the START II treaty if the United States broke another resolution of the agreement important to them. This was the Treaty on Limiting Strategic Anti-Missile Defense systems (ABM or ***Anti-Ballistic Missile Systems)*** which was signed on May 26, 1972 together with the SALT 1 strategic arms limitation treaty. This treaty, like the next one - SALT 2 of June 1979 – was of mainly psychological significance in that it limited only the spread of nuclear warhead delivery vehicles while the ABM treaty actually suppressed development of anti-missile systems during these years. It might also be that both sides considered construction of such a system less than feasible for technical reasons. What it does not mean is that they have not tried to do this.

In accordance with Article I, the ABM treaty concerns defense against missiles with ranges in excess of 5,500 km. Article 3 of the Treaty established primarily that each side may build two anti-missile centers for defense of its capital city and a selected baseline number for inter-continental ballistic missiles. More than 100 anti-missile launchers can be found in each of them. On May 3, 1974, an additional protocol was signed limiting the number of regions for placement of anti-missiles to one for each side. At the time, the USSR selected defense of its capital of Moscow while the United States chose the Grand Forks base in North Dakota.

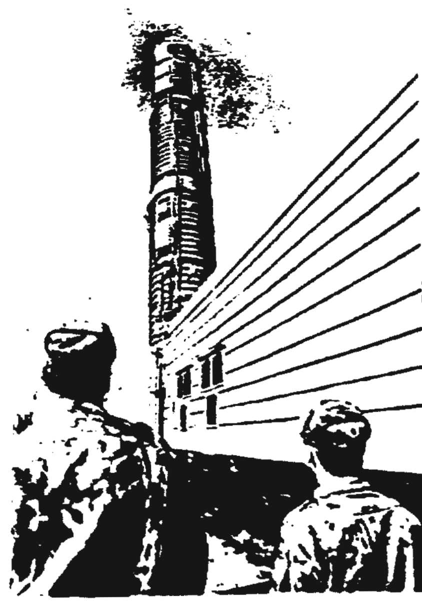
The ABM treaty , then, limited the number of radar stations used for guiding anti-missile missiles and outlined their allowable placement. In Article 5, the USSR and United States obligated themselves not to develop anti-missile systems at sea, in the air, in space, or on mobile missile launchers. Only experimental centers were not subject to limitation under the condition that no more than 15 anti-missile missiles were stationed within them.

During the 1990's, more talks were held during which the definition of strategic anti-missile defense assets was more precisely defined. The permanent consultative commission of the United States and Russia found that these are land-based systems capable of striking ballistic targets developing speeds in excess of 5 km/sec. In the case of sea systems, a limit of 4.5 km/sec was adopted. A system is considered not strategic if no test was carried out with it against a target exceeding these speeds, even if it were capable of striking (with a change in software, for example). The corresponding agreement was signed in September 1997.

A tough choice

The short range tactical ballistic missile of the R-300 type (the popular *Scud*) gains momentum over several dozen seconds with flight to a target 300 km away in about four minutes. Its maximum speed is 2 km/sec. A standard intermediate range missile (1,000 km) accelerates for about a minute and a half after launch and achieves an altitude of 70-80 km during powered flight with speeds in excess of 3 km/sec. The latter continues ballistically to an altitude of 200 km while reducing its speed to about 2 km/sec and then falling and again reaching 3 km per second prior to entering the upper layer of the atmosphere at an altitude of more than 100 km. If nothing stands in its way, the missile's warhead will reach its target 8 - 9 minutes after launch while striking it with a speed reduced to about 1.3 km/sec as a result of the air resistance.

A key element of the Russian strategic nuclear complex is the Kazbek high-level black-box guidance system to which only the Federation president has access



Only the USSR has built a system of mobile, rail-mounted strategic missile launchers which make potential retaliatory strikes more difficult. The RS-22 missile launchers have been eliminated in accordance with the START II treaty.

Flight speed is what distinguishes the ballistic missile from other targets that air defense must strike. Depending on the segment of the flight trajectory, ballistic missiles will reach Mach 5 - 10 while the fastest combat aircraft generally cannot exceed speeds of Mach 2. With a certain amount of simplification, it may be relatively easy to envision the trajectory of the missile's flight even though it can tumble after the head separates from the powered portion thereby making a direct hit more difficult (accuracy also declines here). Modern day ballistic missiles can also maneuver by changing the trajectory of powered flight although numerous false targets and active jamming devices may accompany the target. In order to make identification more difficult, the heads may be placed in a mylar casing coated with aluminum while simultaneously using several identical but empty *balloons*. Outside the atmosphere, they are all but indistinguishable from an actual target.

A range of 1,000 kilometers is typical for missiles launched from submarines. Meanwhile, intercontinental ballistic missiles can cover at least 10 thousand kilometers. Their engines operate for 5 minutes. It is only during this phase that the missile may be relatively easy to conceal. Today's observation satellite systems are capable of doing this after about half a minute after launch at altitudes of about 15 km. When hoping to attack a ballistic missile during powered flight, it is necessary to make a decision in the course of a few seconds which for all practical purposes eliminates human involvement in the decision-making process. This means that it must be fully automated and the risk of making an error is quite high.

In practice, it is possible to assume the risk of attack on an object moving over foreign territory only at the time of military operations. In peaceful conditions, an attack on a misidentified target might have results that are difficult to anticipate... In other words, in war time, it is easiest to simply destroy missile launchers (preventive attacks on various objects that present a threat to security also occur during peace time but this generally occurs in specific conditions such as in the Near East).

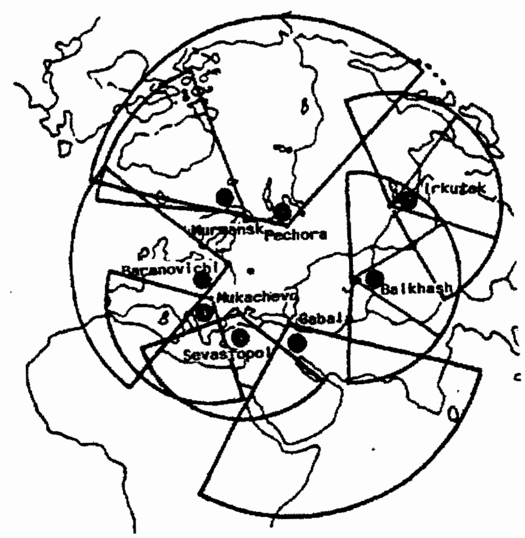
And how do you defend against ballistic missiles without the risk of committing an error? How many minutes can be gained while planning a counter-attack in space with the use of satellite defense? This would mean militarization of space on a large scale. The costs of building a satellite system and utilizing it would not be comparable with those of other systems whether land- or sea-based. In addition, satellites themselves are a relatively easy target...

An attack during the phase of missile flight in the direction of the ground gives more time. During half the ballistic flight, after about 10 minutes of flight, the war head separates from the missile and is completely visible. At the same time there are several minutes to identify the target and anticipate the route of its flight which is the basis for determining the optimum trajectory of flight for an anti-missile missile. It must attack the target outside the atmosphere since it is only then that the results of destroying a nuclear warhead can be minimized. At least 10 minutes are needed here. When we bear in mind that between the time of launch and the time when the head makes contact with the target selected, the time for making a decision is extended to 15 - 20 minutes if the inter-continental missile operates for a total of 25-30 minutes . Doubt as to the nature of the missile's flight decreases with each minute.

For these reasons, current work on building anti-missile systems is being concentrated on the second phase of flight for ballistic missiles. Specifically, when it comes to defense against individual and random attacks. Only, how do you conceal an object with a diameter of 1.5 meters moving at a speed of 6 - 7 km/sec at a distance of several hundred kilometers from the ground in the boundless space of the cosmos and how do you hit it?

Concealment is the first order of business

In the USSR, work on a missile attack warning system during the late 1950's with the appearance of inter-continental ballistic missiles with nuclear war heads. In 1962, after the initial

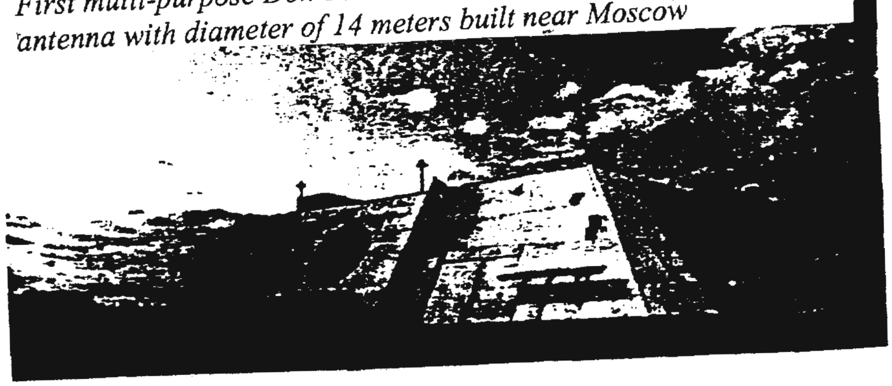


Surveillance zones of Russian SPRN [missile attack warning system] : 1 - Darial, 2 - Dnepr + Dariel-U, 3 - Volga, 4 - Dnepr

range tests of the prototype for the Dnestr early-warning radar, a decision was made to build four such radars designed to be deployed in the areas around Murmansk, Riga, Irkutsk and Lake Balkhash. The Kvadrat automated early detection system (Russian *ranyeye obnaruzheniye* or *RO*) near Moscow and two radar units (RO-1 Murmansk in Olenegorsk and RO-2 Riga in Skruda) which scan the air space in the souther and western directions began test operations on August 25, 1972. The next two Dniestr stations which are also capable of detecting satellites (Russian *obnaruzheniye sputnikov* or *OS*) - the OS-1 Irkutsk and OS-2 Balkhash (Kazakhstan) which scan the south and eastern sectors were accepted as part of the weaponry a year later.

The central scientific production enterprise Vympel which has held a monopoly on work on the Soviet early warning system for many years was created in 1970. It began work on new generation radars with superior ranges and creation of a system capable of surveilling the entire area around the USSR. Plans for modernizing the Dniestr station to the new Dnepr standard got underway at this time as did plans for building the completely new Darial station which operates in the metric range with an independent nuclear source for supplying electricity (the pulse strength of radars of this type is counted in megawatts (the cooling of their subassemblies is extremely energy absorptive). Initially, in order to utilize its maximum range, the plan was to place this type of station in the far north, some where on Franz-Jozef Land. Ultimately, however, two other sites were selected that were more amenable to the installation process.

First multi-purpose Don-2NP radar station with phase-scanning antenna with diameter of 14 meters built near Moscow



operations - Pechora (in the Komi Republic) in the north and Gabala (Mingechaur Azerbaijan) in the in the south. It was also decided to build two radars with over-the-horizon ranges.

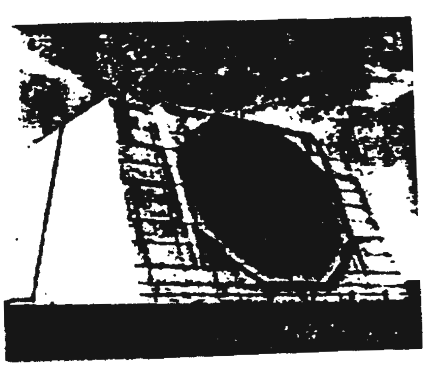
The first phase of modernization included nearly 10 years although the Dnepr prototype station had begun operations in 1974. Two years later, four modernized stations were combined for the first time into uniform, fully automated systems for observation and command and control began military operations in the early warning system. The RO-1 unit supplemented by the Daugawa receiver which had had to increase its resistance to interference went into operation in 1978 followed by two units with Dnepr radars - RO-4 Sevastopol and RO-5 Mukachevo which covered the south eastern sectors with their ranges in 1979. At the same time, work on the Crocus center for analysis and transmission of information obtained was completed.

A year later, two over-the-horizon stations – Duga 1 in Chernigov and Duga-2 in Komsomolsk on Amur were put into use. These were the best radars in the history of the missile warning system. Their transmitter antenna was rectangular with a length of 210 meters and width of 85 meters while the receiver had dimensions of 300 × 135 meters! Each of the 330 resonators had a diameter of 15 meters.

The first Darial-U station, the RO-30 in Pechora was made part of the weaponry in 1984 and a second such unit - the RO-7 Gabala was brought in after a year. At the time, the Russian early warning system was capable of detecting intermediate-range Polaris and Poseidon ballistic missiles based on submarines. With the appearance of the new Trident-2 missiles in the arsenal of the United States and the development of ballistic missiles in the Chinese People's Republic, the requirements imposed on the missile warning system were raised again. At this point, a decision was made to engage in stage-by-stage modernization of individual units and uprgrading the characteristics of the Dnepr station to the standard of the Darial while increasing their resistance to jamming. It was decided to build a new receiver unit that could use signals emitted by the Darial antenna reflected from targets. The first of these stations, the Daugawa-2 which had an active antenna with a scanning phase was placed in the OS-2 while the next were installed in the RO-2 and RO-5.

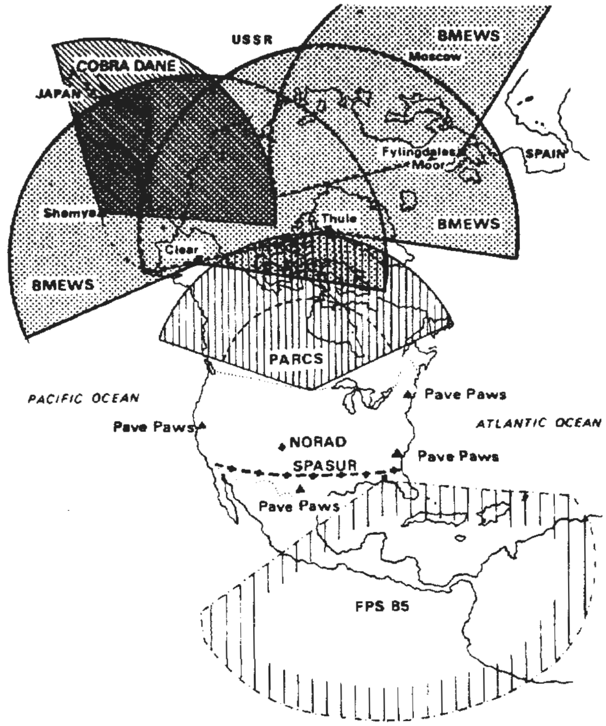
Technologies suited for anti-missile defense were also created outside the United States and Russia. For example, the Ukrainian Institute for Radio Technology offered an over-the-horizon bi-static radar with a range of 600 to 2,500 km. Its receiver antenna had a length in excess of 600 meters and it could be placed 20 - 200 km from the transmitter which used 12 antennas with outputs of 15 kW, each. The radar which operates in the range of 5-28 MHz can detect ballistic missiles in a sector of 60 °at altitudes of 5 - 100 km moving at speeds of 40 -3,600 km/hr. Photo: Ukrspetexport

During the next stage of modernization, the plan was to start building a Darial-U station in the OS-2, OS-1 and in the new OS-3 unit in the areas around the Yeniseysk-15 (Norylsk and Yakutsk were also considered but it was not possible to guarantee sufficient power there) to be followed by the Darial-UM in RO-2 and RO-5. Design of Volga digital radars operating in the decimetric range which were to supplement the already-functioning Darial stations also got underway. The Volga which was designed in a NIIDAR [Scientific Research Institute for Long-Range Radio Communications) competition before the Wympel had to have the ability to vary its frequency within a wide range and to operate simultaneously in two ranges with the ability to use a moveable antenna mounted outside the station to control its transmitter-receiver modules. The first of these sentry posts was to be built in Biysk in the Altay Kray. The complex design proved to be too expensive and difficult to use and ultimately in 1984, the decision was made to build four stations in the somewhat simpler Volga-M version with a range of 4,800 km. Construction was started on the first of them in Ganchevichi 50 km from Baranovichi in Belarus. The appearance of Pershing-2 intermediate-range ballistic missiles in Western Europe determined this location. Prior to their discovery, it had been decided to use Dunaj-ZM radar equipment from the A-35 air defense system even after appropriate modernization of the Imbir radar stations and others. It was decided to build the Volga series in the area of Sevastopol and Komsomolsk-na-Amur.



The PAR station in the area of the Grand Forks region as part of the Safeguard anti-missile system.

During the latter half of the 1980's, development of the Soviet missile warning system was subject to sudden slow-down. More than just economic considerations contributed to this. In 1986, after the Chernobyl nuclear power plant disaster in Ukraine, it was necessary to shut down the Duga-1 over-the-horizon station in Chernigov. This was done without regret in view of its low level of effectiveness. With time, it was also intended to eliminate the Duga-2 station but this problem was resolved by the fact that it was destroyed by fire in 1990. Earlier, in 1987, the Russians were forced tosuspend construction of the Yeniseysk-15 station because its presence was not compatible with the ABM treaty. The amount of money spent on building the transmitting (measuring 30 × 40 meters) and receiving (80 × 80 meters) has been estimated to be in excess of 300 million of today's rubles!



Surveillance zones of American early warning system

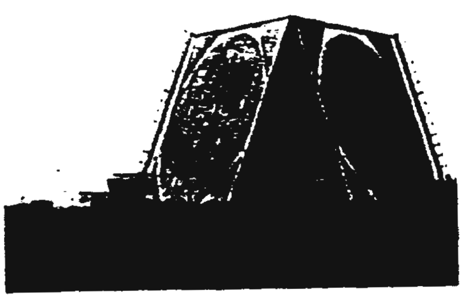
After the break-up of the USSR, a number of stations were outside the territory of the Russian Federation. The Darial-UM in Mukachevo and in Skrunda near Riga are now in Ukraine and Latvia. The Darial station in Gabala is in Azerbaijan while the Darial-U station near Balkhash is in Kazakhstan. Only the RO-2 station had to be terminated and dismantled because of the refusal of Latvia to grant consent for its further functioning, however (stations from the Moscow region are filling in for it temporarily while the in-coming Volga-M station in Baranovichi remain unfinished and in test operation since 1994). The radar in Mukachevo was left under control of Ukraine but bearings data from it are transmitted to Russia (after all, the entire system is operating formally as property of the surveillance post). Only the status of the station in Gabala continues to be unclear.

An important problem in using the missile warning system is the fact that a major supplier of parts for radars – DMZ in Dnepropetrovsk – remains outside the borders of Russia. In order to ensure itself regular and possibly secret supplies, an appropriate agreement has been concluded with

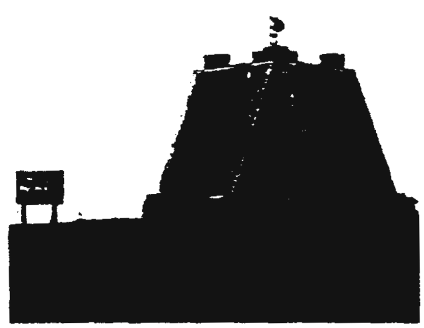
Ukraine (parts in exchange for payment of debts associated with deliveries of gas). The Russians are also attempting to initiate domestic production similar to what took place in the case of sub-assemblies of the Topol-M missiles.

In the missile warning system which remains subordinate to the strategic missile forces there are currently 8 units with 2 Darial stations, 3 Dnepr stations, 2 Dnepr/Darial-U stations and 1 Volga-M. These stations and command systems must be modernized over the course of the next 10 years with the use of new micro-processor assemblies. The building of completely new stations that are smaller and less energy consumptive (and perhaps also mobile) is also planned in the north west and northern Caucasus to protect Russia from directions recognized today as extremely subject to missile attack.

In the United States, the first experimental radar stations in the early warning system were created in the late 1950's. Initially, they had a range slightly greater than 1,500 km (AN/FPS-17) although within a few years, they were able to increase this to 5,000 km. Within the framework of program 474M, by the early sixties, the BMEWS ***(Ballistic Missile Early Warning System)*** had been developed. Three radar stations of this system became part of the arsenal in 1963. These stations were located in Alaska (Clear), Greenland (Thule) and Great Britain (Fylingdales Moor). Each of these stations consisted of four antennas (120 × 50 meters, each) with a range of 5,000 km and sectors of observation measuring 30°each. Once they have detected a missile overhead, they transmit a signal to this effect to three other antennas which then begin tracking the targets.



One of three Pave PAWS - AN/FPS-115 radar stations. Stations in this system will be modernized by Raytheon to meet the needs of nuclear missile defense



A BMEWS station at the Fylingdales Moors British base.

After a number of modernizations, the BMEWS remain in service today. There is a relatively old AN/FPS-92 (modernized AN-FPS-49) surround radar at the Clear base with a range of 5,000 km along with a target tracking AN-FPS-50; there is an AN/FPS-120 (modernized AN/FPS-115) at Thule with a Pave PAWS [Phased Array Warning System] system (the AN/FPS-49 and AN/FPS-50 system was replaced in 1987) with a range of observation of 240° while an AN/FPS-49 radar was recently replaced with an AN/FPS-115 radar at Fylingdales Moor.

A PARCS station was also placed at the Grand Forks base as part of the American early warning ground system. The AN/FPS-108 Cobra Dane system which is capable of the simultaneous tracking of 300 targets with a range of 3,700 km was the next major advance in the northwest and has been in operation since 1977 at Shemya in the Aleutians. At the opposite end of the United States at Mc Dill [Air Force] Base in Florida is an AN-ESS-7 radar.

The modern RC-135S Cobra Ball aircraft play an essential role in the ballistic missile warning system. MIRA sensors developed by Lockheed-Martin can also detect missile launches as well as warheads enteringthe atmosphere

Work on a space system for detecting launches of ballistic missiles from the United States began in the USSR during the early 1960's. The first experimental satellite system not equipped with complete intelligence apparatus, the Kosmos-520, was placed in an orbit with an altitude of 35 -40 thousand kilometers in 1972. Later on, three experimental satellites had been launched by 19767 with 3 more in 1977. In 1978, the system achieved a limited operational capability and has been operated in full force since 1982.

The system was successively developed up until the late 1980's when it was decided to expand the range of its operations to a global scale with consideration for the Chinese People's Republic and even the oceans. The first new satellites (8IG6 Prognoz, Oko) became part of the arsenal in 1996 and two years later, its eastern command post began operational testing. Currently 9 satellites that cover the globe at intervals of 2hours 40 minutes make up the Russian missile warning system.

In the United States as well, as the 1950's became the 1960's, an attempt was made to create space-based early warning system. In 1960, 4 MIDAS satellites were placed in near-polar orbits with altitudes of 3,300 - 3,700 km. These satellites were able to observe launches of Titan ballistic missiles within 90 seconds after lift-off at an altitude of 50 km. It happened, however, that the system was jammed by solar reflections originating on the surfaces of clouds and after two years, its functioning was suspended.

Artist's rendering of IMEWS-2 satellite

In 1966, the new program 949 started and carried over to the early 1970's to the Defense Support Program. The First satellite, the IMEWS-1 which was built within its framework was in a geostationary orbit two years later. The Satellite was equipped with an optical telescope, infra-red sensors, TV cameras and x-ray radiation detectors. By 1970, the system consisted of 4 satellites and in 1972, it was moved to the NORAD North American aerospace command. The system which consists of 3 - 4 main and 2 - 3 reserve IMEWS satellites went into operation in 1974. Altogether, 13 IMEWS satellites have been built with the last placed in orbit in 1987.

During the 1980's the United States undertook modernization of its early warning satellites. The IMEWS-2 satellite was created at this time, the first of which was launched into orbit in mid-1989. Their design included not only improvements in the intelligence systems but also an increase in resistance to the effects of anti-satellite systems. The fact that they picked up the launch of Iraqi Scud during Operation ***Desert Storm*** within 30 seconds after launch at altitudes of less than 15 km attests to the quality of the new satellites.

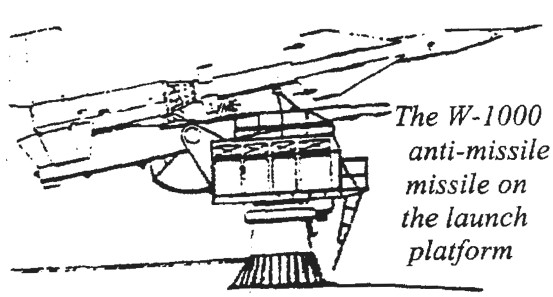
This is how the SBIRS Low intelligence satellite sub-system which will become part of the DSP in the next few years will look.

The geographic position of the United States far away from nations with ballistic missiles at their disposal leads them to concentrate their attention on the threat posed by missiles launched from submarines more than the USSR. As a result, during the 1960's within the framework of program 474N, a system for warning concerning an attack from the oceans touching the United States was developed. Appropriately modernized AN/FPS-26 anti-aircraft radars were used for building the anti-missile radar stations. The new stations which had a range of 1,500 kilometers were given the name AN/FSS-7.

The new system which belonged to the USAF with the code name Pave PAWS (***Phased Array Warning System)*** became active in 1971. Initially, it consisted of 8 radar stations (4 in the east, 3 in the west and 1 in the north) of which six remained in 1976. At present, the Pave PAWS system is made up of AN/FPS 115 scan-phase antenna radars on bases in Beale (California) and Cape Cod in Massachusetts which were placed in operation during the years 1980-81 and two radars on the Robbins (Georgia) and Goodfellow (Texas) bases which were put into operation during 1986-87.

The Americans have also done work on over-the-horizon radars. The AN/GSQ-93 bistatic radar was created within the framework of the 470L program during the sixties. Its transmitter antennas are located in Asia (in the Philippines, Taiwan, on Okinawa and the Japanese island of Hokkaido) with receivers in Europe (in Italy, West Germany, Great Britain and on Cypress). The AN/GSQ-93 was capable of monitoring an area in excess of a million square kilometers but its indications were not terribly precise. With the appearance of more modern satellite systems, work on program 470L was suspended.

During the 1970's, an attempt was made to build the next over-the-horizon radar. The AN/FPS-95 radar which had a scanning phase antenna with a range of several thousand kilometers was built within the framework of the 441L ***Cobra Mist*** program 44L. Its giant antenna consisted of 18 electrically controlled elements with lengths of up to 430 meters. It had been intended to build 6 -



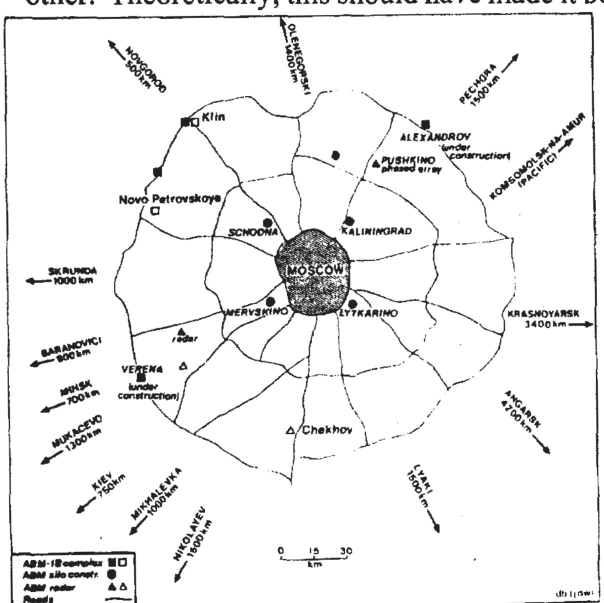
The W-1000 anti-missile missile on the launch platform

7 stations equipped with AN/FPS-95 units but ultimately, only one was built in 1971 in Great Britain. Its test operation lasted for two years.

Modernization of selected Pave PAWS and BMEWS radars is planned within the next few years. A new AN/FPS-120 station will be built at clear with the AN/FPS-115 stations at Beale and Cape Cod to be modernized to the same standard with use of new generation electronic subassemblies. These stations should become part of the new system of anti-missile defense.

Destroy at great cost

In the USSR, work on anti-missile systems (code name A) began in 1953. Two years later, these systems went into field testing with use of the S-25 Berkut air defense system. At the time, it happened that the accuracy of directing anti-missile missiles at a target by means of a single radar guaranteed a hit probability on the order of 10%. In order to increase this level of accuracy, a guidance method was developed using three radars several hundred kilometers away from each other. Theoretically, this should have made it possible to achieve a guidance accuracy of 5 meters.

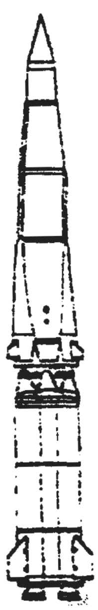


Deployment of elements of anti-missile system around Moscow

In 1959, work was completed on the first Soviet anti-missile system A. It was made up of the Dunaj-2 early-warning radar which had a range of 1,200 km, three precision guidance radars with ranges of 700 km, an anti-missile tracking station with a system for control and remote detonation of the warhead, a launcher for W-1000 missiles and a command station and posts for radio-line communications. The M-40 computer used in the system was capable of carrying out 40 thousand operations per second. The anti-missile missile itself was a two-stage rocket with the first stage powered by solid fuel designed by P. D. Grushin of MKB Fakel which achieved a maximum speed of 1,000 km/hr. A fragmenting warhead was used in it made up of 16 thousand tungsten spheres with a burst field in the shape of a disk.

Tests of the W-1000 were initiated in 1958. The experimental system A was deployed in the desert near Lake Balkhash. Initially, as the 1950's gave way to the 1960's, operation of the guidance system itself was studied aboard an R-5 ballistic missile. The first test using a warhead was carried out in March 1961. At the time, the W-1000 anti-missile missile destroyed a mock-up warhead carried up by an R-12 rocket. Altogether, 11 tests of intercepting the heads of ballistic missiles were carried out with the majority successful. In order to increase the level of difficulty of the tests, the anti-missile missiles were also fired at missiles equipped with jamming systems (Verba and Cactus mock targets and the active system Krot). A variant of the W-1000 head with a guidance system that operates in the infra-red range was tested for the purpose of increasing the accuracy of the guidance process. Within a short time, a head with a nuclear charge had also been created for which two types of remote detonators – optical and radio – were planned.

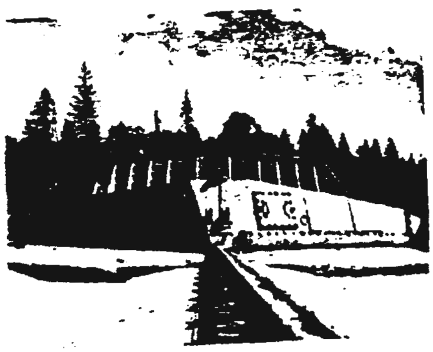
The A-350 anti-missile missile



After the positive conclusion of tests of the experimental system, a design for the A-35 incoming system of anti-missile defense was developed. It consisted of 8 Dunaj-3 (3U) radar stations and 32 anti-missile launchers also designed by P.D. Grushin. A decision was made to use low power nuclear heads in the system which were significantly more certain than the fragmenting heads. In the wake of this, the number of anti-missile missiles in the system was reduced to 16 and later on to 8. Since the nuclear heads required considerably less accuracy in hitting the target, a decision was made to move to guidance using an individual radar.

Firing range studies of the A-35 system were carried out over a period of 10 years using a simplified ***Aldan*** complex built in 1967. A newly designed A-350Zh (A-350R) anti-missile missile was fired in the direction of 8K63 and 8K65 ballistic missiles. For the first time in the USSR, the A-350Zh anti-missile missiles had engines with control nozzles (a power plant designed primarily for V. N. Chelomey on the basis of which another anti-missile system was designed – the Taran – was used in these missiles).

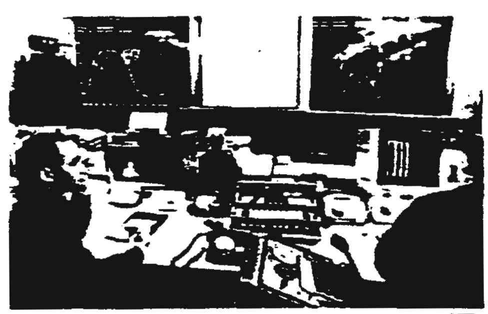
Tests confirmed the ability of the A-35 system to destroy single-head ballistic missiles. At the time, however, multi-head missiles with a built-in system for active and passive jamming of the Minuteman-3 and Poseidon-3 missiles had already become part of the arsenal. For this reason, it was decided to back off from further building of the system and its essential part (three anti-missile systems, one Dunaj-3 station and a ***Shalash*** early warning station located 70 km from Moscow) which had been designed for experimental use. It lasted until 1977 when the Moscow A-35M anti-missile defense system was sent for testing. The system with A-350R missiles armed with nuclear (Tobol and Yenisey systems) and the Dunaj-3M radar head were deployed within a radius of 100 kilometers of the city.



Silo shielded with steel plate containing an anti-missile in a base not far from Moscow

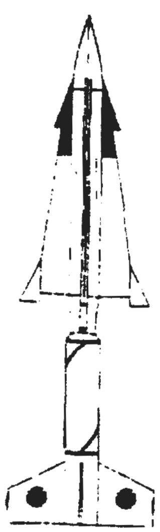
During the 1960's, an attempt was made to build an anti-missile territorial defense system. It had been used to protect major industrial centers in the European part of the USSR. Plans were made to use the A-35 I and A-900 in the ***Aurora*** system. The A-35 I and A-900 which had a longer range had to be able to carry out ***precision*** strikes. An appropriately chosen nuclear explosive (use of a head with reduced force had been planned) had to destroy or vary the trajectory of movement of the targets noted (generally less expensive than war heads) in order to facilitate assignment of the A-351 anti-missile. Design of the Aurora system was interrupted, however, during the experimental phase and only the ***Argun*** radar and phase-scanning antenna which was used later for measuring purposes is left.

Inside the command center of the system used for anti-missile defense of Moscow

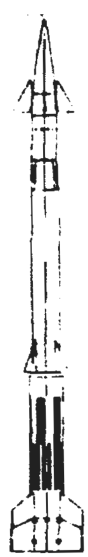


Design of the *Fon* second-generation anti-missile system started during the late 1960's. It did not have the ambition of protecting the capital city of the USSR but rather, was aimed against random limited attacks from different directions. The 5Zh60P simplified experimental system was tested in 1974 with construction of the system itself around Moscow initiated a year later. A Don-2NP multi-purpose radar station with phase-scanning antennas measuring 16 meters in diameters was the first to be developed at the time. A 5K80P command and control center (with an Elbrus-2 computer which could perform a billion operations per second), launch silos, long-range 51T6 anti-missile missiles (P. D. Grushin of the Fakel Design Bureau) for intercept of targets in the upper layers of the atmosphere and in space (including satellites) and 53T6 hypersonic intermediate-range anti-missile missiles capable of target intercept at altitudes of 35 kilometers (L. Luliev from the Nowator Experimental Design Bureau) as well as a data transmission system went into the complete A-135 system whose construction was finished in 1989. Missiles of both types were armed with nuclear warheads. The system went into normal operation in 1995.

1 meter



The Nike-Zeus A anti-missile missile had large aerodynamic controls which were carried over to the Nike-Zeus B which was designed to go up against nuclear warheads outside the atmosphere



In the United States, studies of the possibility for destroying ballistic missiles (V2 class) had been initiated in1946. Supported by work done by scientists from the University of Michigan, the United States Air Force contracted to build the Wizard anti-missile system. Two anti-missile missiles were created within the framework of this program – the Wizard I which had semi-active radar guidance designed for protection of strategic miliary targets and the Wizard II which was designed to defend the entire area of the United States. During the first stage which lasted until 1948, radar with a range of 360 kilometers was created as was a system for automatic tracking of targets and algorithms for

[Words illegible] launch thrust of 25,000 g with maximum speeds reaching Mach 10. The Sprint remains the fastest missile in the world even now.

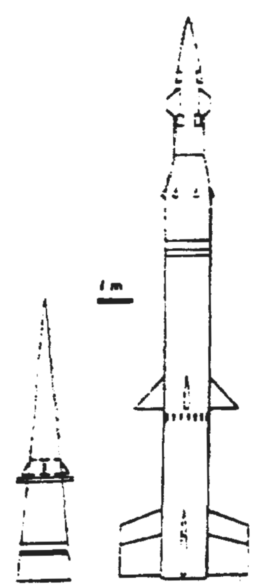
radio command guidance of a long-range missile. The Wizard program did not advance beyond the technical design stage, however, and the second stage of building anti-missile missiles was suspended in 1949.

The United States Army took over construction of the American anti-missile system until 1955. It was planned that the Nike Zeus anti-missile missile developed by Western Electric on the base of the Nike Hercules anti-aircraft missile and similarly armed with a W-31 nuclear warhead rated at 20 kilotons would intercept high-flying ballistic missile warheads outside the atmosphere. At the time, however, the Department of Defense limited the Army's are of operations to the atmosphere and ultimately, only an improved version of the Nike Hercules with a range of 340 km and ceiling of 45 kilometers was built during the first phase. Tests of the Nike Zeus A were carried out as 1959 became 1960 with varying degrees of success but it was not of major significance.

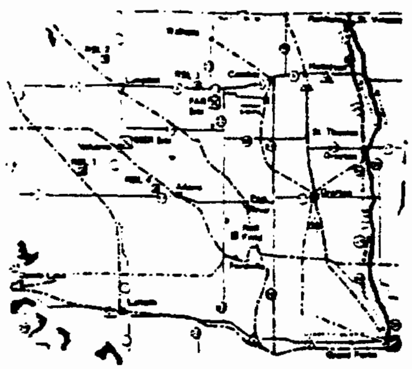
After launch of the first Sputnik by the USSR on November 4, 1957, the barriers were shifted and development of the next version of anti-missile missiles – the Nike Zeus B with a range outside the atmosphere got underway. This was a three-phase missile with gas dynamic control of the final phase (without the built-in control services characteristic for the Nike Zeus A), a range of 640 kilometers and operational altitude of up to 370 kilometers. It was radio-command controlled and a head with radar self-guidance was studied. Four radars for detecting targets with ranges of 1,600 kilometers, for target identification, target tracking with a range of 1,000 kilometers and for guidance of the anti-missile missile were used in the guidance systems. Firing range tests of the Nike Zeus B were initiated at the Point Mugu base in 1960 while the process of firing at ballistic missiles (Atlas D's launched from Vandenberg Air Force Base) took place at the Kwajalein [Marshall Islands] base two years later. The tests were successful but in view of the excessively low level of resolution of the guidance system which was not able to isolate targets noted as well as the lack of ability to attack objects in the atmosphere, the Nike Zeus B did not become part of the arsenal. A later version built on its base was created to knock down satellites and was designated the DM-155. Missiles of this type armed with nuclear warheads were deployed at the Kwajalein base during the period from 1964 - 1966.

In 1963, design was started on the second-generation Nike-X missiles which had an increased range and in which a radar with a parabolic antenna proved to be significantly more accurate than the phase scanning antenna. After four years of operations, the program was modified while giving the systems that had been built the name Sentinel. The Nike-X was renamed the Spartan at the time. The new missile had a range of 650 kilometers and a ceiling of 500 kilometers. Tests initiated in 1970 ended in success. In January 1971, ballistic warheads and satellites were destroyed simultaneously by Spartans in a successful test.

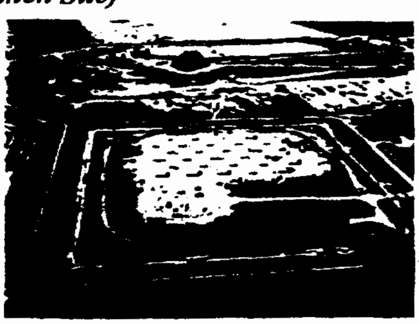
The Sprint anti-missile missile which had a range of 40 kilometers and acceleration of 1 km/sec^2 during the launch phase not seen prior to this was a supplement to the Spartan system. In 1963, it was known that anti-missile devices outside the atmosphere had to be supplemented by booster rockets at the last minute to destroy ballistic warheads that tore through this boundary. Martin Marietta began developing a new missile in 1963. This task was exceptionally difficult since the electronic systems in the missile had to carry increasing large launch loads and the control signals had to get through clouds of ionizing gases



Rockets of Safeguard system: Sprint and Spartan



Deployment of the Safeguard system in the Grand Forks area. Noticeable placement of MSR and PAR stations and 4 remotely controlled regions for launch of Sprint missiles (RSL -Remote Launch Site)



Position of Safeguard system in area of Nekoma. Sprint missile launchers are in foreground with rectangular Spartan silos behind them and MSR in depth.

Missiles of the Safeguard system: Sprint and Spartan

from the launch engine and layer of burning ablation material protecting the warhead againsextremely high temperatures exceeding 3,400° C. By the end of 1965, initial tests of the Sprint had started at the White Sands test range. At the same time, construction of target selection and missile guidance radar (*Missile Site Radar, or MSR)* had gotten underway at Kwajalein. In the fall of 1968, radar intercepted a ballistic missile for the first time and in the summer of 1970, the complete system had been tested. On 23 December, the Sprint destroyed targets with its warhead for the first time. By the end of 1973, 48 tests had been carried out, 41 of which were successful.

Both the anti-missile weapons making up the Sentinel system were armed with nuclear warheads (the Sprint had a neutron warhead) while three radars were used to guide them. In 1969, the program was given the name Safeguard and the number of radars in the system was reduced to two (for detection and early identification of PAR [precision approach radar] targets and the MSR missile site radar). The system was built and tested at the Grand Forks strategic missile base. Its installation was begun in 1974 and within the next year, 28 Sprints and 8 Spartans had achieved full operating capability. The full capability of the Safeguard system which was made up of PAR and MSR's and 30 silos with

Spartan missiles with 70 Sprint launchers obtained by October 1975. The system operated for barely six months after which its elements were mothballed leaving only the PAR radar as part of the arsenal (MSR's were removed earlier) which still functions today within the early warning system.

The Americans recognized that a system using nuclear war heads for defense against a nuclear attack made no since. This was not just about the possibility of causing enormous damages. Tests indicated that explosions of Sprint warheads interfere with the work of ground electronics systems over a wide area. This would mean an additional decline in the effectiveness of the system and thus, it had very little chance.

From SDI to NMD

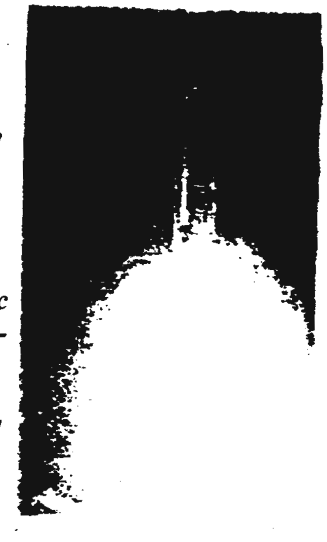
During the period 1983-1984, the United States turned to analyzing the prospects for defense against strategic missiles within the framework of the Strategic Defense Initiative, or SDI. At the time, studies of the ability to destroy ballistic missiles by means of non-nuclear warheads were initiated among other things. An anti-missile missile was built on the base of the Minuteman I rocket equipped with an infra-red self-guiding head. Of four tests carried out within the framework of the HOE (***Homing Overlay Experiment)*** only one was successful when the target was hit at an altitude of 200 kilometers and an encounter speed of 6 km/sec.

By the end of the 1980's, it had broken away from the ***Star Wars*** vision and the concept of building a global system of defense against a limited nuclear attack came about within the United States. It would have to be made up of 100 - 400 new generation anti-missile missiles that would defend the entire territory of the United State. This plan also did not come to realization.

More than 40 billion USD have been spent on studies associated with SDI and its derivatives since 1983. Ultimately, Americans did not want to waste this money. After a few years, they went back to the notion of building a continental anti-missile system. In 1996, the Ballistic Missile Defenșe Organization (BMDO) was established which has coordinated the development of anti-missile technology since that time.

As of1995, American intelligence reports have anticipated that there will be no direct threat to the United States posed by long range ballistic missiles on the part of unfriendly nations developing the appropriate technology before 2010 at the earliest. By 1998, however, a special Congressional committee which had access to intelligence data on a scale not encountered before found that a threat might appear in the next few years. North Korea and Iran which were 3 - 5 years away from building long-range ballistic missiles were seen as the most threatening. Worse still, these countries which are operating under licenses and with assistance of Russian specialists (Iran, for example, purchased a license for the Russian RD-214 missile engine) and Chinese experts engaged in the export of missile technology to Pakistan, Iran and Libya, among others.

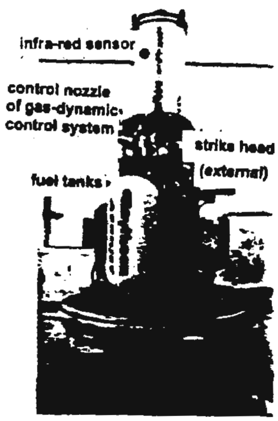
In 1991, the United States carried out tests which needed to demonstrate the ability to destroy the head of a long-range ballistic missile by direct hit. In one of them, the ERIS (Exoatmospheric Re-entry Vehicle Interceptor System) hit a target situated at an altitude of 270 km and at a distance 925 km from the anti-missile missile's launch site.



The commission came to the conclusion that determination of North Korea had not been properly appreciated up to that point. It came to light that the No Dong two-stage missile which has a range of 1,300 kilometers had been present in operational units as early as the 1980's, significantly earlier than official reports of the CIA had indicated (previously, the technology involved in two-stage ballistic missiles was in the hands of only the United States, Russia, the Chinese People's Republic,

The Korean Taepo Dong I ballistic missile which has a range of 1,500 kilometers which includes the whole of Japan among other countries has a length of 25 meters. Its first stage is a four-engine assembly with a No Dong missile while the second is derived from missiles of the Scud class. According to American estimates, the Taepo Dong I can carry a warhead weighing 1,350 kg.

North Korea conducted its first successful test of the new missile on August 31, 1999, firing it from the Hawdaegun base which is located 100 km east of the port of Chongjin. The test provoked great concern in Japan over which the missile passed while falling into the Pacific 850 km north east of the base at Misawa.



The strike head designed by Raytheon has a length of about 1.4 meters. Its infra-red sensor located in a beryllium housing is able to detect and identify 12 objects on a surface of 4-5 km² at a distance of 700 to 800 km. This is all during flight at a speed of 10 km/sec.

France, Japan, Great Britain, Israel and India). By the late 1990's, the Korean Democratic People's Republic had completed work on the Taepo Dong 2 missile which had a range of 4,000 - 6,000 km making it capable of reaching Alaska and Hawaii. The next version which had a range of 10,000 km would threaten the continental United States itself. Within this range lay the west coast f the United States from Phoenix to Madison.

The conclusion from the work of the commission was recognition of the need to intensify work on an anti-missile defense system that could defend the territory of the United states against a ballistic attack. The tactical Patriot PAC-3 and THAAD tactical systems developed at the same time were capable of destroying missiles of the Scud or No Dong classes but were helpless against long-range ballistic warheads. Consequently, work was started on a national missile defense or NMD system. Since 1997, it has been realized by the consortium of the United Missile Defense Company appointed by Raytheon, Lockheed Martin and TRW with Boeing added more recently.

The technologies used in building the EKV strike head are extremely complicated. Its unique gas-dynamic control system was developed over a number of years of research and is used in the heads of various types of anti-ballistic missiles.

According to the general concept, the national missile defense system consists of the following components:

– interceptor missiles (Ground-Based Interceptors, or GBI) with strike heads (*Exoatmospheric Kill Vehicles, or EKV's*) weighing about 55 kg equipped with Mc-Cd-Td sensors with a resolution of 256 × 256 which operate in the infra-red portion of the spectrum in three frequency

Raytheon which was responsible for developing the GBR built an small-scale prototype at Kwajalein. Radar with a phase scan rotary antenna is hidden by the spherical shield.

ranges are capable of target intercept, tracking and identification (two competitive heads are bing designed by Raytheon and Boeing). Liquid fuel (monomethyl hydrazine) engines give the heads the ability to move about in space. Three launch and acceleration phases will have to be built on the base of the existing engines. The first phase is the GEM engine built by Alliant Techsystems with a Delta II carrier vehicle while the second and third are derived from the Orbus 1A missile. During the initial phase of system tests, these stages were built with the use of appropriate assemblies from Minuteman 2 missiles. The range of the ground-based interceptor is estimated at 2,000 km while the required probability of a hit is 0.85,

– high resolution radars operating in the X band (ground-based radar, or GBR) capable of operating in conditions of severed electro-magnetic interference. GBR antennas with diameters of 7 meters are made up of more than 80 thousand computer controlled transmitting and receiving elements. The range of ground-based radar will be more than 3,000 km while a rotary base will ensure all-around control,

– the BMEWS [ballistic missile early-warning radar system] and Pave PAWS [phased array warning system] modernized early warning radars with new control processors and software,

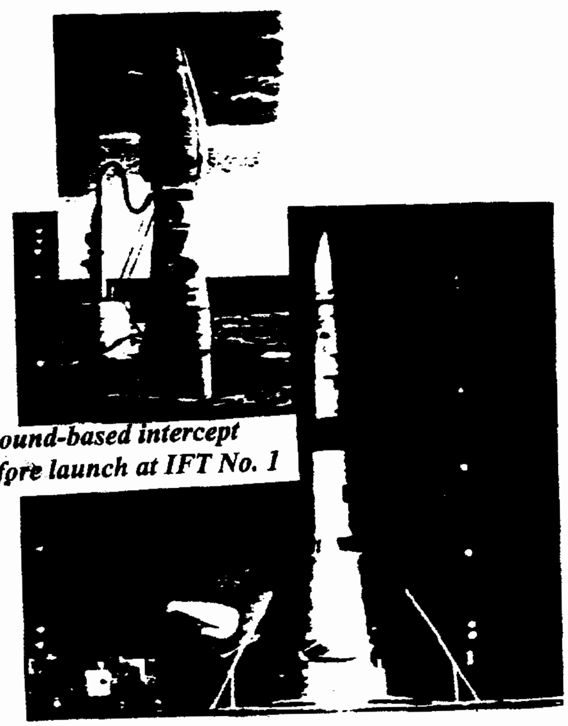
– SBIRS (Space Based Infra-red System) satellite systems for detection of launches and tracking the flight of ballistic missiles. Five (5) SBIRS satellites high in geostationary orbits which will replace the existing network of DSP (***Defense Support Program***) satellites will provide for detection of ballistic missile launches. The next 24 SBIRS satellites would track their flight during its middle phase which requires radar stations that would extend the time to that needed for analysis of the situation and preparation for launch of ground-based interceptors and also reduce the effect of jamming operations,

– centers for communications with interceptor missiles (*ICF*) which are part of the IFICS, or In-flight Interceptor Communications System, which transmits information to the ground-based interceptor during flight,

– a command/control and communications systems (***Battle Management, Command, Control and Communications system, or BM/C3*** which is most probably located in the Cheyenne mountains in Colorado. In view of the shortage of time, it must be fully automated with a minimum amount of human input on its operations (***humans in control***).

The basic national missile defense variant (***Capability I***) envisions deployment of 20 interceptor missiles in 2005 at the Fort Grey base in Alaska, placement of one ground-based radar at Shemya, modernization of BMEWS and Pave PAWS radars along with installation of three ICF's. During this phase, the system would make use of the DSP defense support program network. According to various analyses, only installation of the ground-based interceptor in Alaska will make it possible to place the entire United States under the cover of an anti-missile umbrella.

During tests of targets conducted in the United States, the targets were essentially modified Minuteman II missile launched from Vandenberg Air Force Base. About 20 minutes later, an intercept rocket was launched about 6,900 km away at the Kwajalein base in the Marshall Islands in the Pacific. Its first stage operated for about 65 seconds with the second dropping away after 157 seconds of flight. For the next 490 seconds, the exoatmospheric kill vehicle continued on independently during which , power and cooling of the guidance sensor were turned on after 80 seconds. Strike was supposed to occur after about 12 minutes of flight by the anti-missile missile. It is appropriate to note that each anti-missile test cost approximately 100 million USD.

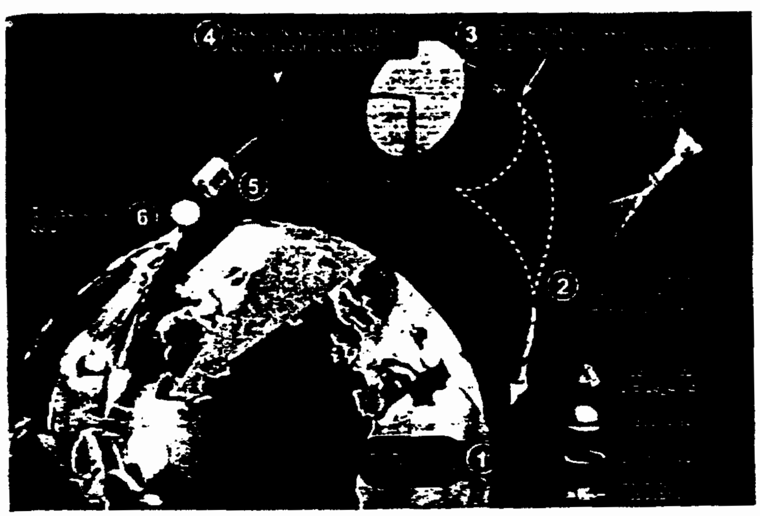


Ground-based intercept before launch at IFT No. 1

The system achieved full operational capability some two years later with an increase in the number of missiles to 100 and the start of use of the first SBIRS satellites. The complete national missile defense system (*Capability 2*) was to have been put into operation in 2010 with acquisition of complete operational capability by the SBIRS-high and SBIRS-low satellites and the placement of the next three ground-base radars into operation.

A variant of the national missile defense system of up to 250 ground based interceptors (*Capability 3*) to be built by 2001 was also developed. Additional missiles might be stationed in areas such as Grand Forks which would facilitate defense against warheads coming from the area of the Near [Middle] East. In this version, the system would be able to strike 10 ballistic missiles simultaneously from 9 ground-based radars and 5 ICF's. When looking at the standard probabilities for ground-based interceptors destroying warheads destroying warheads, it was felt that if a system consisting of 10 anti-missile missiles would be capable of defending against 20-25 warheads, then 250 anti-missile missiles could strike 40-60 warheads.

Diagram of functioning of national missile defense system in accordance with current plans



According to the Budget Office of the Congress of the United States, the cost of building a national missile defense system in the full C1 version would come to approximately 21 billion USD (government simulation gives a sum of about 3 billion USD less). Its development in the C2 version would take an additional 6 billion USD wile building to the C3 version would cost yet another 13 billion USD. Altogether, the entire national missile defense system with 250 intercept missiles on two bases would cost about 49 billion USD when the start-up operational expenses are figured in.

In addition to the significant costs, critics of the national missile defense system (the creators of the NMD system state that they cannot be compared to rebuilding even a single American city) stress primarily the potential ease of jamming it. In a special report, a group of scientists from Massachusetts Institute of Technology have stated that an anti-missile missile can be prepared only for counteraction by known jamming devices (at the very least, this would mean carrying out basic tests). Since predicting all the means that an attacker might use is not possible, it would mislead the defense. Therefore, it will recognize the basic principles of the system's functioning. And a nation that is capable of producing an inter-continental ballistic missile will not regret money spent to ensure its maximum effectiveness....

Before deciding

The initial test of the national missile defense system which began in January 1997 was suspended prior to firing a missile because of problems in the data transmission system. It was repeated with success by July 7, 1997. A Boeing interceptor picked up and tracked a target flying in the company of two false targets. On 15 January 1998, the test was repeated with a Hughes (Raytheon) interceptor. In both cases, the test took place without use of a radar guidance system and the anti-missile missile flew along a pre-programmed route (both candidates in the missile test were equipped with a GPS satellite navigation system which makes it possible to track their flight).

For the first time, an integrated test aimed at destruction of a target by the national missile defense system (*Integrated Flight Test No. 3*) succeed in October 1999. The target was disintegrated. The test did not come off without problems however. The test of the self-guidance sensor which analyzes the alignment of stars observed after activation was not successful at first (if the image did not contain anomalies, it meant that all pixels were active). At the time of the attempt, the first test was successful but the image obtained in the second did not correspond to what was in the memory of the system. Nevertheless, the sensor intercepted an object with proved to be a false target that was flying from the opposite direction. This revealed the algorithm used in the system which also assisted in finding the actual target (the system is capable of determining the density of the object being tracked).

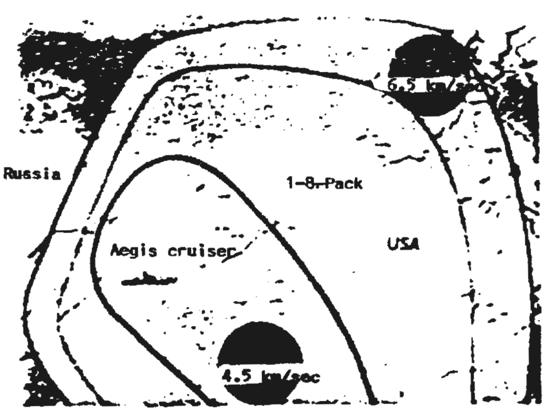
Critics of the national missile defense system later established that detection of a relatively large jamming balloon is easier than a smaller ballistic warhead and for this reason, the results of the test are not credible. It is important to bear in mind, however that in the tests that were carried out in January 1998, a number of false targets of various types accompanied the ballistic warhead. Among them were two light-weight semi-rigid cones the same size as the warhead (MRLR or *Medium Rigid Light Replica*), one compact head mock-up (SCLR or *Small Canisterized Light Replica*) and five balloons of various types. Altogether, a total of 12 objects including Mars and stars appeared in the lens of the exoatmospheric kill vehicle emitting infra-red radiation. It is therefore difficult to talk about making the tasks of the anti-missile system excessively easy.

It was not possible to duplicate the success with use of the Raytheon kill vehicle in which problems with the self-guidance system occurred during the test carried out on 18 January 2000. Cooling of the sensor occurred 6 seconds prior to the planned killed and in effect, the interceptor passed the target at a distance of 73 meters. There was also a third test during which satellite and radar elements of the guidance system (without the ICF sub-system) used for the first time proved to be less than successful. The strike head did not separate according to plan after 157 seconds of flight from the second accelerating stage. It did not receive the signal from the accelerometer concerning the drop in engine thrust which normally indicates exhaustion of the fuel reserve and the end of second stage operation. Another problem was the fact that the ground-based radar did not manage to intercept a target detected earlier by other elements of the system.

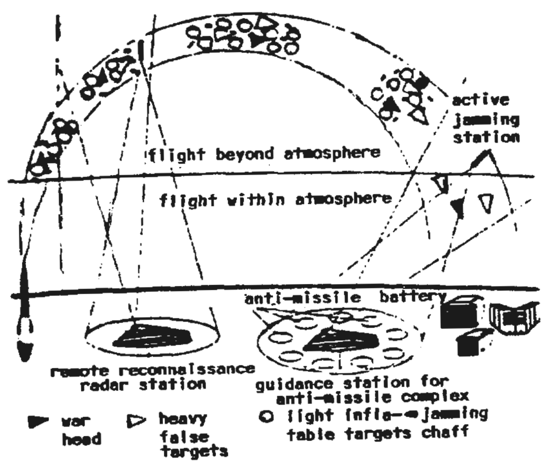
The outcome of the test should not have had any major significance for making a merit-based decision to continue the program. Hitting a target is only one of the elements evaluated during studies. According to General Ronald Kadish, chief of the BMDO (*Ballistic Missile Defense*

The U.S. Navy also wanted to take part in building the national missile defense system. The leadership of the American Navy asserts that it would be easier to modify the vertical missile launchers aboard ships than to sink silos into the tundra of Alaska. The U.S. Navy's concept was aimed at appropriate modification of the NTW (Navy Theater Wide) system built over the last few years. Armed with 8 anti-missile devices developing a speed of 4.5 km/hr with a kinetic head weighing 40 kg built on the base of SM-3 Standard anti-missile missiles, the Enhanced NTW system installed aboard a cruiser sailing the coast of Japan would be able to protect the entire Pacific area against missiles launched from North Korea or the Chinese People's Republic. Increasing the speed of the interceptor to 6.5 km/hr and using an exoatmospheric strike warhead weighing 50 kg (the New 6-pack option) would make it possible to the up defense of the entire area of the United States. The system would utilize the same strike warhead, command and communications systems as currently planned for land-based anti-missile missiles.

The cost of building this sea-going anti-missile system would be 19 billion USD. The system would be supplemented with a land-based system that would be limited to a single region for stationing ground-based intercept. The problem with this is that the 1972 treaty excludes construction of anti-missile components outside of solid ground.



The first test of the SM-3 missile of 50 planned within the threat reduction program over the next 2-3 years and carried out on July 14, 2000 ended in failure. The three-stage missile launched from an Aegis-class cruiser had to be destroyed because the LEAP (light exoatmospheric projectile) failed to separate. The remainder of the system functioned flawlessly.



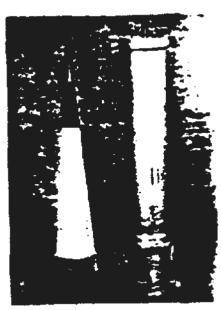
◄Action diagram of a system for radio-electronic strategic missile warfare. Together with returning to the atmosphere, the number of objects is reduced but eliminating a warhead with an effective cross section of reflection of 0.01-0.001 m² from among false targets in conditions of electronic jamming is a very difficult task. Key - from left: solid triangle - war head; white triangle - heavy false target; circle: light inflatable target; – jamming chaff

Organization), tests carried out to date have made it possible to examine more than 90% of the elements of the system planned and 40 - 50% of the aspects of its functioning. About a thousand different criteria have been developed to utilize these results. A final decision has not been made, however, with the last word being left to the politicians.

The politicians will decide

The ground-based radar station built on the island of Shemya is a breach of the ABM agreement although it can be argued whether this will occur with laying of the foundations or after installation of the electronics equipment. If we accept that this is the second half of the game, then the United States has at least until 2003 to negotiate changes in the treaty with Russia. What will it mean if the sides to not come to an understanding? Russia is not capable of building its own system of defense against strategic missiles so that its response to the American plan is necessary asymmetrical. This involves the development of offensive weapons which would not be in keeping with international treaties. This might include, for example, the arming of existing missiles with several warheads that have self-guidance systems or equipping them with better means to break through defenses.

One of the types of heavy false targets placed in Russian inter-continental missiles. Systems of the next generation will have to have the ability to adapt independently of the modernization of anti-missile defense



National missile defense, at least presumptively, is not directed against Russia it has an extremely potent nuclear arsenal at its disposal. Its construction could, however, disrupt the balance of power in Asia where a number of nations that compete with each other have a small number of missiles with nuclear warheads. The power ambitions of the Chinese People's Republic could force it into modernizing its 18 existing but aging Dong-Feng 5 missiles (by increasing the number of warheads and equipping them with jamming devices, for example), purchasing next-generation submarines armed with nuclear missiles (currently, there is only one such boat with 12 missiles that have a range of 2,700 km) or building new generation missiles with solid fuel engines (DF-31) so that there would be a change for possible breaching of the American defense. This, in turn, has caused a certain reaction in India and, as a consequence, in Pakistan as well, two countries that remain in a constant state of conflict. American promises to supply tactical anti-missile systems of the latest generation to Taiwan and South Korea complicates the situation in this region. Japan has also gotten the same systems supplemented with ship-based missiles.

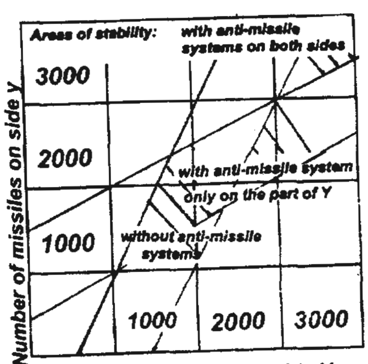
During intensive talks held in recent months and the participation of presidents Clinton and Putin, Russian and the United States have not reached in compromise on the subject of the future of the anti-missile defense treaty. They have agreed only to create a joint center for the exchange of information on their own tests of strategic missiles and satellite system and actions by other nations observed in this regard. The center which is located in Moscow will operate 24 hours a day while making use of the experience gained earlier during monitoring ***Problems of 2000***. The center will begin functioning in June 2001.

In the course of the talks, in order to take the initiative, the Russians proposed a number of outstanding propositions. Among other things, they offered the European nations to build a joint anti-missile system. It would be consistent with the tenets of the ABM treaty which had called, after all, for installation of systems against ballistic missiles with small ranges. In keeping with it, it would therefore create an umbrella over Europe that would protect against potential attacks even by Iran which has Shahab-4 missiles with a range of 2,000 kilometers at its disposal while it is developing the next Shahab 5 models. The offer was so interesting that the European weapons industry is left to build anti-missile systems far behind the United States and Russia.

The Russians also proposed development of a system to strike strategic missiles during the powered phase of flight jointly with the United States. Both the European nations of NATO and the United States rejected the proposed offer while characterizing it as unrealistic. William S. Cohen, the American Secretary of Defense indicated interest only in possible cooperation in building tactical systems of anti-missile defense. He expressed an understanding of the Russian concept of ballistic missile warfare right after their encounter since Russia borders directly on a number of countries that are potential threats to it and consequently, the reaction time of its anti-missile system must be cut to the minimum.

The next surprise for the Americans was North Korea's offer to stop development of ballistic missiles brought from Pyongyang by the Russian President. According to Putin, the Koreans would also back off from exporting missile technology. In exchange, they asked economic assistance from the United States while placing its level at 1% of the anticipated costs of building a national missile defense or about 600 million USD. It would also want assistance in the peaceful exploration of space. If the offer was accepted, one of the greatest threats justifying construction of the American system would disappear...

Is building an anti-ballistic missile system against large scale attacks even theoretically possible? If we assume that one side needs 600 and the 450 missiles with individual warheads so that the party attacked can mount an effective retaliatory strike (the level recognized as minimum to ensure mutual deterrence) while 2 missiles are needed to destroy every starting platform, it is possible to draw two straight lines that meet these conditions in the diagram below. In the absence of anti-missile defense, the area contained between these lines is an area of stability which starts with 1,000 missiles on one side and 1,100 on the other for a total of 2,100 missiles. If one of the sides develops a system capable of destroying 1,000 attacking missiles, the area of stability will increase to 1,767 on one side and 2,333 missiles on the other. In the opposite situation, there would be 2,433 and 1,667 missiles, respectively or a total of 4,100. Installation of anti-missile systems on the part of both sides would require the building of missile arsenals numbering up to 3,000 and 3,100 to maintain equilibrium for a total of 6,100 missiles with nuclear warheads. ▼



How anti-missile defense is seen can accelerate the arms race since to achieve equilibrium, the appearance of 2 offensive missiles must accompany every effective anti-missile device . Of course, considering additional factors (such as the use of multiple warhead missiles, the probability of a hit, the level of military preparedness, the level of damage to systems, the use of jamming, etc.) complicates the model while the number of missiles required continue to grow and the conclusions remain the same.

Bringing down long-range self-guiding missiles may be an even greater challenge than defending against ballistic missiles. Missiles such as those in the hands of the Chinese People's Republic, among others, are significantly more difficult to detect. For this reason, when range is 2,500 km, they are considered to be strategic. ▶

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According to unofficial data, work on laser anti-missile systems was begun in the USSR during the period 1964-65 in the Vympel Special Design Bureau and the Strela Special Design Bureau. They designed the Terra-3 experimental system which consisted of a CO_2 laser with power of 1 MW (from the Kurchatov Institute), a guidance system and control system which had been tested at the Sara-Shagan test range. It never reached full operational capability, however. In 1989, fragments of the system were shown to a delegation from the American Congress. Three years later, on the basis of information obtained in the process of building combat lasers, construction of the MLTK-50 complex designed for extinguishment of fires occurring in oil wells was initiated under an agreement with RAO [Russian Corporation] Gazprom.

The Americans decided to mount their laser system aboard an aircraft. The COIL pulsating laser with a power rating of about 3 MW which emits a radiation beam with a frequency of 1.315 nm (not visible to the human eye) which will be carried aboard an appropriately rebuilt Boeing 747-400F was developed within the framework of the program controlled by the U.S. Air Force. On detection and intercept of the target consisting of missiles during the powered phase of flight, a system of reflectors directs a pulse of several seconds at the fuselage whose purpose is to inflict damage on filled fuel tanks (which is generally fairly thin and made of plate with a thickness of about 1 mm) and cause it to explode.

The range of the laser will be about 300-400 km at its operational altitude of about 12 kilometers where there will be relatively little disturbance associated with non-uniformity of the air. The aircraft transporting it must patrol the area directly adjacent to that where the

FROM SDI TO NMD - the inside political story

Jacek Sawicz

When I found myself in Los Angeles face to face with past President Ronald Regan in 1990, I felt that here was a chance to bow to the fortieth President of the United States and the conqueror of communism rolled into one in a personal reflection on the history of the genesis of his *beloved child* – the Strategic Defense Initiative known under the popular name of *Star Wars*. I was aware that in 1979, Reagan who was then governor of California had visited for the first time in his life the Command Center of the American Strategic Forces which is located in an enormous shelter inside Cheyenne Mountain in Wyoming. There, he had learned with astonishment that the United Stated had no system for defense of its territory against Soviet long-range ballistic missiles (ICBM's). The only response to such an attack would have to be a massed retaliatory attack in accordance with the then mandatory doctrine of Mutual Assured Destruction or MAD. This was the foundation of the American concept of nuclear deterrence.

As a number of analysts of the Reagan presidency of stated (the latest being F. Fitzgerald in the book ***Way Out in the Blue***), he frequently made decisions out of idealistic motivations based on a deep faith in God. It was no different in the case of SDI and the information he garnered in

Continuation of commentary in box

launchers of ballistic missiles are based 24 hours a day which will increase the risk of its use. Aircraft with the ABL Airborne Laser system will enter the arsenal in 2006-07. There will be seven of them.

The Americans are also working on satellites to be equipped with lasers for destruction of ballistic missiles shortly after launch. The SBL, or Space-Based Laser developed by Boeing in co-operation with Lockheed Martin will supplement a ground system while using a version of the Alpha laser developed by TRW during the 1970's with a power rating of 1 MW. Launch into the orbit of a demonstration satellite is planned for 2005 with an attempt to destroy a missile scheduled for 2010. Ultimately, the system will consist of 24 satellites cruising in a low orbit with an altitude of 1,000 km. The Pentagon is not treating this program as having top priority and cites the occurrence of major technical problems.

Continuation of Sawicz article

into specific action when he became the next occupant of the White House in 1981. The President surrounded himself with a galaxy of distinguished political advisers representing conservative brain trusts such as the Heritage Foundation and Hoover Institution, Pentagon analysts, diplomats and nuclear physicists. Among them were D. Rumsfeld, M. Anderson, R. Perle, A. Haig, C. Weinberger, J. Abrahamson, G. Schultz and a number of other personages of influence on the American political scene at the time.

The concept of the *protective umbrella* would not have emerged at all were it not a determination and merely the fanatical belief of one man. This was legendary nuclear physicist Edward Teller. A Jew of Hungarian origin and creator of the formula for thermodynamic protection (together with Professor Stanislav Ulam, a Pole from Jan Kazimierz University in Lvov), he managed to convince the President that building a high-tech anti-missile shield is possible. And, more importantly, placing its components in space is possible.

In its most ambitious version, the SDI system would be made up of three elements:

– satellites capable of detecting and reporting to the command center within a matter of seconds the onset of an enemy missile attack,

– a laser component deployed in orbits suitable for destroying missiles during lift-off and the initial phase of flight,

– submarines equipped with lasers and surface to air missiles designed stop missiles that might have penetrated the space system.

Following the celebrated speech by President Reagan on 23 March 1983 which pronounced the activation of the nuclear shield in the near future as completely useless, work on the system whose cost was estimated at 65 billion dollars got underway at full steam. The Strategic Defense Initiative Organization (SDIO) came in to being with General John Abrahamson named as chief of the program.

Such a costly program about which virtually no one was certain or would state on his own accord was forced out onto the procedural shoals. They appeared when the Democrats took control of congress after the 1984 elections and the flow of money for SDI began to change to a narrow stream. This was a real blow caused by the enormous cost of research on particle accelerators in the famous Los Alamos and Lawrence Livermore laboratories. When it became clear that except for unequivocal presidential support, the concept of building an anti-missile shield could not be realized in the foreseeable future, General Abrahamson resigned from his post. The fact that when George Bush, Reagan's successor, took office in 1989 placed limitations on financing for the program and shifted the emphasis to building the strategic triad also had an effect on his decision.

Continuation of Sawicz article

Abrahamson was replaced by General George Monahan who within a short time had presented a significantly modified version of the missile defense under the name *brilliant pebble*. Under this code name was hidden a plan for deployment of about 10 thousand small missiles on platforms in space that would be directed at enemy missiles with the use of sensors placed aboard satellites and in ground detection stations. Small smart missiles would have a length of 1 meter and weigh about 45 kg. They would be equipped with the latest wide-angle sensors located in the front portion of the missile covered by a layer of silicon.

This project was also without much success. Historical changes in the international situation during the period from 1989 to 1991 meant that President Bush made the decision about the next modification to the system of anti-missile defense and in his State of the Union Address on January 29, 1991, he announced that while looking at the currently available information on SDI, the decision had been made to build the system called Global Protection Against Limited Strikes, or GPALS. The profound changes occurring in the USSR and ultimately, its break-up provoked a basic anxiety in the United States that the enormous nuclear arsenal of the former USSR might slip out of control because of the poor system of safeguards, pressure from irresponsible politicians and troops or finally, the actions of Islam terrorists or countries able to come into possession of Soviet (and then Russian, possibly those in the territory of Kazakhstan) missiles with nuclear warheads.

The GPALS system assumed deployment systems for detection of missiles and their intercept on the ground and in space that would be placed within the territory of the United States as well as the nations of NATO. This project was based on the *TMD* or *theater missile defense* concept. Intercept systems of the *hit-to-kill* class located in space had to be capable of the impact (kinetic) destruction of missiles with ranges of more than 600 km. Missiles within the less than 600 km range of intercept equipment would be taken out by ground systems.

The changing concept of anti-missile systems enjoyed the solid support of Republicans but with Democrats, things were just the opposite. The decision made by the next President of the United States, Bill Clinton, who eliminated the GPALS program in 1993 was proof of this. Officially, SDI and the modification of anti-missile systems created on its based ceased to exist in the American defense strategy at the time. Declared advocates of having the United States covered by a protective umbrella against attack by enemy missiles – and especially the Republicans – did not suggest the weapons, however. Although Les Aspin (Secretary of Defense in the Clinton administration) changed the SDIO into the Ballistic Missiles Defense Organization, or BMDO, in 1993 while giving priority to protecting American allies in the sore-point regions of the world and to protecting American troops located at various points of the globe, the Republicans launched a counter-offensive after winning the Congressional elections in 1994. In their celebrated manifesto known as the Contract with America of 1995, they announced a return to the concept of a national system of anti-missile defense. In spite of the fact that such influential politicians as Newt Gingrich, Speaker of the House of Representatives and Senate Majority Leader Bob Dole and his successor Trent Lott returned to this concept in the years that followed, it shared in the ups and downs of foreign policy as a whole and did not become a prominent problem during the presidential election campaign in 1996.

Senator Thad Cochran from the state of Mississippi who in 1998 lacked only one vote would bring the Senate into discussion on the proposed National Missile Defense Act showed amazing determination in forcing the issue of the National Missile Defense. The turning point occurred as a result of a report by the Rumsfeld commission which showed missile attack on the part of so-called rogue states as the real threat to the territory of the United States within the perspective of 5 - 15 years (currently, the United States has gotten away from this terminology and has moved to the term *states of concern* or *states that cause problems)* among which it numbers the Korean Democratic People's Republic, Iran, Iraq, Libya and Syria among others. With particular anxiety, the Rumsfeld report referred to the missile program of the Korean Democratic People's Republic which it considered to be very advanced (missiles of the *Taepo-Dong* type).

The public opinion backing for plans to cover the territory of the United States with a protective umbrella, the work of Senator Cochran full of passion which Democrats began to join, lobbying on the part of large industrial concerns and the increasingly more rapid development of advanced technology meant that the Senate by forming a bipartisan coalition which took control of the majority of votes (97:3) finally adopted the National Missile Defense Act on March 17, 1999. President Clinton signed this act on April 23 of last year. The Pentagon was then able to sign a contract with Boeing as the main contractor of the strategic anti-missile system whose cost has been estimated at 60 billion dollars.

On this occasion, it is appropriate to mention Senator Thad Stevens, an influential leader of the permanent sub-commission for defense within the Senate Ways and means Committee. A system of silo shelters with American ballistic missiles drove the initially established deployment of missiles in the system in Grand Forks, North Dakota. Since the range of intercept equipment proved to be quite small, in order to cover the territory of the Aleutian island chain (nearly non-resident) which is part of the territory of Alaska, Senator Stevens demanded a change in the Pentagon decision with respect to location of the system which determined its placement in Alaska. And so, a great politician appears...

Jacek Sawicz

The author is a specialist in matters of nuclear weapons in the Ministry of Foreign Affairs