Snooping on Radars: A History of Soviet/Russian Global Signals Intelligence Satellites

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This paper provides an overview of global signals intelligence satellites flown by the Soviet Union and Russia over the past four decades. Recent Russian publications have partially lifted the veil of secrecy that once surrounded these satellites, although their exact capabilities and targets remain largely classified.

Keywords: **Signals intelligence, electronic intelligence, Zenit-2, Kust-12M, DS, Tselina**

1. Introduction

The Soviet Union began flying signals intelligence payloads on its photographic reconnaissance satellites in the early 1960s and introduced a series of dedicated signals intelligence satellites in the late 1960s. The programme reached peak launch rates in the 1970s and 1980s, but as many other Russian military space projects saw a spectacular decline after the end of the Cold War and the collapse of the Soviet Union.

2. Defining SIGINT

Signals intelligence (SIGINT) is one of the basic forms of intelligence besides image intelligence (IMINT) and human intelligence (HUMINT). It can be broken down into two main components:

- communications intelligence (COMINT)
- electronic intelligence (ELINT)

COMINT is defined as intelligence obtained by the interception, processing and analysis of the communications of foreign governments or groups, excluding radio and television broadcasts. Communications may be in the form of voice, Morse code, radio-teletype or facsimile and they may be either encrypted or transmitted in the clear. Targets of COMINT include diplomatic communications (from a nation's capital to its diplomatic establishments around the world), governmental communications (between various branches of a nation's government, including the military), communications of terrorist or guerrilla movements and communications associated with economic activity (both legal and illegal).

ELINT involves the interception of non-communication signals of civilian and military hardware. The primary targets are signals emitted by radars used for early warning of bomber and missile attacks, for guiding anti-ballistic missiles, for space tracking and intelligence. By determining the location and operating characteristics of such radars, it may be possible to circumvent or neutralize them through direct attack or electronic countermeasures. A subcategory of ELINT is telemetry intelligence (TELINT), in other words picking up telemetry from a rocket or missile during launch [1].

3. Soviet/Russian SIGINT: The Broad Picture

Satellites are just one way of gathering signals intelligence. SIGINT is also obtained by ground-based, sea-based and airborne sensors and in the Soviet Union and Russia these seem to have far outweighed the role of satellites.

SIGINT has been the responsibility of both the former KGB and its successors (on the government side) and the Main Intelligence Directorate (GRU) (on the military side). Within the KGB SIGINT operations were run by the 16th Main Directorate, which after the collapse of the Soviet Union was merged with the 8th Main Directorate to form the Federal Agency for Government Communications and Information (FAPSI), a rough analogue to the US National

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Security Agency. FAPSI was disbanded by President Putin in 2003 and its functions were distributed among the Foreign Intelligence Service (SVR – the former 1st Main Directorate of the KGB), the Federal Security Service (FSB – the former 2nd Main Directorate of the KGB, responsible for counterintelligence) and the Federal Guards Service (FSO – part of the former 9th Main Directorate of the KGB).

The GRU is the foreign intelligence organ of the Ministry of Defence and is sometimes compared to the US Defence Intelligence Agency, although it has much broader responsibilities. SIGINT has been the responsibility of the GRU's 6th Directorate, which itself consists of four departments [2].

SIGINT data obtained worldwide by the intelligence services of the Soviet Union and its allies was reportedly collected into a database accessible by approved persons in the Warsaw Pact countries. Called SOUD (Joint Database System on the Enemy), this was the equivalent of the Echelon system (accessible by persons in the US, Britain, New Zealand and Australia) and is believed to have been set up in 1979 prior to the Olympic Games in Moscow. Although it must have been significantly scaled down after the collapse of the Soviet Union, SOUD is still believed to exist in one form or the other [3].

Ground-based SIGINT within the country itself has included things like breaking codes used by foreign embassies in Moscow and intercepting and decoding transmissions to foreign agents on Russian territory. For ground-based SIGINT abroad the Russians have relied on equipment installed in their embassies and consulates, covert mobile collection platforms and also on a series of SIGINT stations on the territory of their allies. These have apparently been operated jointly by KGB/FAPSI and the GRU. For SIGINT of the continental US the Russians heavily relied on a complex in Lourdes, Cuba about 150 km from Key West, Florida. Opened in 1964, this was the largest such facility operated by the Russians abroad. It intercepted communications from microwave towers in the US, downlinks from US geostationary communications satellites and a wide range of shortwave and high-frequency radio transmissions. It also is believed to have served as a ground facility and analytical site for Russian SIGINT satellites. The Lourdes site was closed down in late 2001 as a cost-saving measure, just like a similar Russian SIGINT facility in Cam Ranh Bay, Vietnam. One of the reasons given was that satellites could take over some of the functions performed by these sites, although this is very doubtful. An important factor in shutting down the Cuban site may have been that long distance voice and data communications in the US now primarily take place via fibre routes, which have much higher capacity and better data error characteristics than microwave links and are not susceptible to interception [4]. Most, if not all of Russia's SIGINT facilities abroad are believed to have been closed down.

Aside from ground-based facilities, the Russians have also operated a wide variety of SIGINT-collecting aircraft around the world. For instance, a com-

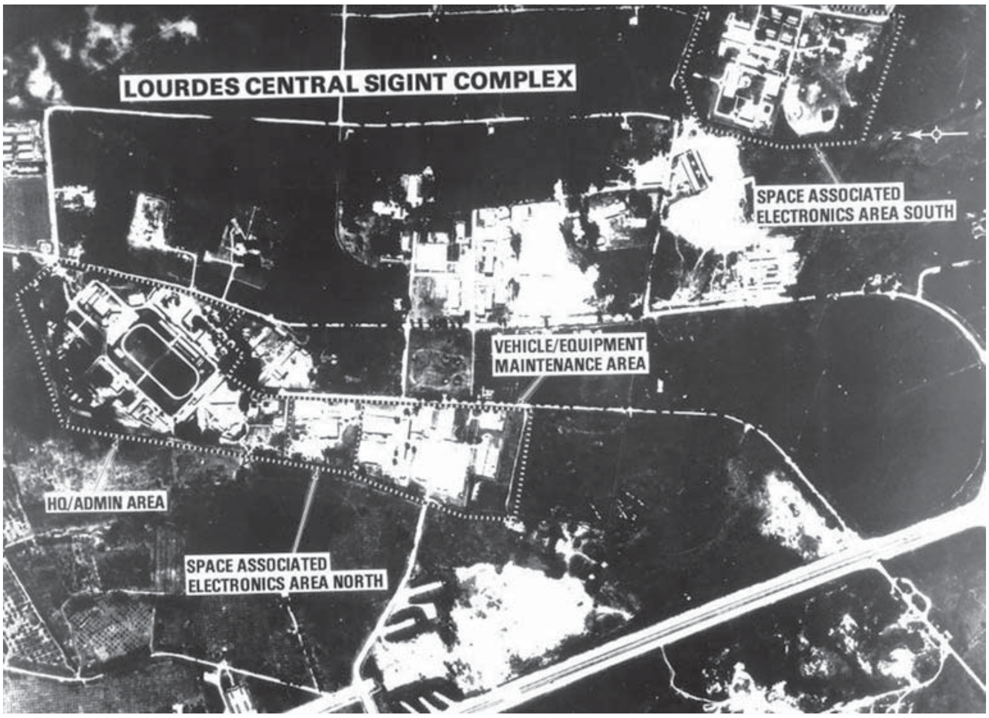

Fig. 1 Satellite image of the Russian SIGINT complex in Lourdes, Cuba.
(source: Federation of American Scientists)

mon way of obtaining ELINT on foreign radar complexes during the Cold War was for reconnaissance aircraft to fly along enemy airspace to force the adversary to turn on its air defence radars, allowing the aircraft to monitor the emitted signals. These missions were colloquially known as "ferret missions", because just like a ferret digs into the ground to reach its prey, these aircraft would snatch radar signals from the sky by faking attempts to penetrate into enemy territory [5].

For ELINT of radar systems on the US mainland, the Russians were handicapped by the lack of permanent bases in the immediate vicinity of the US and they had to be content to periodically deploy Navy TU-95 BEAR reconnaissance aircraft to Cuba for ELINT collection missions. Most Russian ferret aircraft, such as the IL-20, operated exclusively from bases in the USSR against targets around the Soviet periphery such as West Germany, Norway, Finland, China and Japan [6]. The Russians have also used their A-50 "Mainstay" early warning aircraft (the "Russian AWACS") for passive SIGINT. For instance, one such plane was reportedly actively involved in the killing of Chechen rebel leader Dzhokhar Dudayev in 1996, pinpointing his exact location by intercepting a satellite phone call he was making [7].

Finally, the Russians have also relied on a worldwide fleet of ships, often disguised as trawlers, to collect signals intelligence wherever Russian interests were involved. For example, such ships shadowed American naval vessels and were also regularly deployed near Cape Canaveral or Vandenberg to monitor telemetry from American rocket launches.

4. Soviet/Russian Space-Based SIGINT: Organizational Aspects

The Soviet Union flew SIGINT payloads on two types of photographic reconnaissance satellites (Zenit-2 and Zenit 2M) in the 1960s and 1970s, and after an experimental flight with a DS satellite in the early 1960s also began the deployment of a dedicated SIGINT constellation (Tselina) in the late 1960s. In addition to that, the Russians have operated specialized ocean reconnaissance satellites, both a passive ELINT system (US-P) and an active system equipped with radar (the nuclear-powered US-A), but these will not be covered in this article [8]. To distinguish the Tselina satellites from their ocean-monitoring counterparts, they have usually been referred to in Western literature as "global" signals intelligence satellites, although the bulk of their targets are believed to have been land-based.

Apparently, space-based intelligence has been the exclusive domain of the GRU, with the KGB and its successors playing little or no role [9]. One of the early promoters of space-based SIGINT collection is said to have been Pyotr Ivashutin, who headed the GRU from 1963 to 1986 after having served as First Deputy Chairman of the KGB. In the latter capacity he had already been involved in the space programme as a member of the State Commission for Vostok-1. The GRU has a Satellite Intelligence Directorate, which in some respects is the equivalent of the US National Reconnaissance Office. It is believed to be responsible for operating the country's photographic and global signals intelligence satellites. Its nerve centre is the Centre for Space Reconnaissance in Moscow, also known as "Object K-500". It is not entirely clear how or if the Satellite Intelligence Directorate interacts with the GRU's 6th Directorate. The 6th Directorate is said to have a facility in Vatutinki near Moscow to collect information from SIGINT centres in Russia and abroad and also another facility in Klimovsk to process that information [10]. However, it is not known if those facilities are also involved in collecting and processing satellite-based SIGINT data. The Tselina satellites are known to have used at least two "data reception and processing centres", the second one of which was opened in 1981 [11]. One of these is reportedly located in Noginsk near Moscow [12].

While the GRU was the end user of the SIGINT satellite data, specifications for the satellites (as well as most other military and even civilian satellites) had to be approved by a special "space branch" of the armed forces, which was also responsible for launching and tracking operations. For more than 20 years this branch was subordinate to the Missile Forces of Strategic Designation (RVSN), better known in the West as the Strategic Rocket Forces. Originally (1960-1964) it was known as the Third Directorate of the Chief Directorate of Reactive Armaments (GURVO), subsequently reorganized into the Chief Directorate of Space Assets (GUKOS) (1964) and the Central Directorate of Space Assets (TsUKOS) (1970). This was finally removed from RVSN and placed under the direct jurisdiction of the Minister of Defence in 1981. In 1986 TsUKOS became the Directorate of the Chief of Space Assets (UNKS), reorganized in 1992 into the Military Space Forces (VKS). VKS was reabsorbed by RVSN in 1997, only to regain its independent status as the Space Forces (KV) in 2001.

On the industry side, the buses of the dedicated SIGINT satellites were developed by a design bureau set up in the Ukrainian city of Dnepropetrovsk by Mikhail Yangel in 1955. This was originally known as OKB-586 and was renamed KB Yuzhnoe in 1966. Although the bureau was primarily involved in designing nuclear missiles, it also started developing launch vehicles and satellites in 1959-1960. A specialized satellite department (KB-3) was set up within OKB-586 on 30 October 1965 and it was initially headed by Vyacheslav M. Kovtunenko [13]. Still, Yangel never considered satellites a priority, something which led to some internal conflicts between him and Kovtunenko. Attempts by Kovtunenko in the late 1960s to turn KB-3 into an independent design bureau specializing in satellites, nuclear warheads and rocket nose fairings failed and even resulted in over 100 specialists of KB-3 being transferred to ICBM-related work, a move that may have negatively affected early development of the Tselina satellites [14].

A factory aligned with Yuzhnoe (Yuzhnoe Machine Building Plant or Yuzhmash) was responsible for manufacturing the satellites. In 1986 KB Yuzhnoe and Yuzhmash were united as NPO Yuzhnoe (NPO standing for Scientific Production Association), also absorbing an institute known as the Dnepr Scientific Research Institute of Machine Building Technology. This structure was disbanded in the early 1990s [15]. The design bureau is now called GKB Yuzhnoe (GKB Pivdenne in Ukrainian). OKB-586 initially was subordinate to the State Committee of Defence Technology (GKOT) and from 1965 to the Ministry of General Machine Building (MOM), which oversaw most space-related enterprises until the collapse of the Soviet Union.

The SIGINT payloads for all Zenit-2, DS and Tselina satellites and related ground-based facilities were designed and built by a Moscow-based organization currently known as the Central Scientific Radiotechnical Research Institute (TsNIRTI). This also acted as overall systems integrator. The institute was set up in 1943 by Axel Berg and was originally called TsNII-108. Until the mid-1950s the institute's main orientation was radar systems, but later it specialized in systems for electronic warfare. The chief designer of space-based SIGINT systems was Mark Ye. Zaslavskiy (1920-1995), who joined the institute in 1946. Other leading participants were A.G. Rapoport, S.F. Rakitin and E.F. Meshkov. Zaslavskiy was initially also placed in charge of developing the SIGINT payload for the electronic ocean surveillance satellites, but due to the high workload of the design bureau this work was transferred to a branch in the city of Kaluga (KNIRTI). TsNII-108 was subordinate to the State Committee for Radioelectronics (GKRE), which was reorganized as the Ministry of the Radio Industry (MRP) in 1965 [16].

Fig. 2 Vyacheslav Kovtunenko.
(source: Mashinostroyenie publishers)

Fig. 3 Mark Zaslavskiy.
(source: Mashinostroyenie publishers)

5. Targets of Soviet/Russian SIGINT Satellites

Although the Russians have now declassified basic design data on all their global signals intelligence satellites, little remains known about their targets and actual capabilities. Comparing the orbits of US and Russian SIGINT satellites, it would appear that the former have performed a much wider variety of tasks. The US has flown SIGINT satellites in three types of orbits:

- relatively low Earth orbits

Several generations have been launched since the early 1960s either as piggyback or dedicated payloads. Air Force satellites performed ELINT of Soviet air defence, missile defence and ABM radars, while Navy satellites pinpointed the position of naval targets. It is believed that in the early 1990s these tasks were consolidated on a single platform.

- highly elliptical ("Molniya-type") orbits

A series of satellites launched into highly elliptical orbits since 1971 (code-named JUMPSEAT and later TRUMPET). Their primary mission is probably COMINT of Soviet/Russian territory and interception of communications from Soviet Molniya satellites.

- geostationary or quasi-geostationary orbits

Two series of satellites (one alternately called CANYON, CHALET, VORTEX and MERCURY – flown between 1968 and 1996 – and another called RHYOLITE, AQUACADE, MAGNUM and ORION – flown since 1970). The first is believed to have been used primarily for COMINT and the second for TELINT, later also expanding to COMINT.

The Russians, on the other hand, have only flown their signals intelligence satellites in relatively low orbits. This probably means they have rarely been used for COMINT and TELINT. Those two types of SIGINT can only be effectively performed from high altitudes (preferably geostationary orbits), because the chances of picking up interesting voice communications or telemetry from rocket launches during brief passes by low-orbiting satellites are very slim indeed. It is quite surprising that the Soviet Union never deployed a constellation of SIGINT satellites in highly elliptical orbits, given the fact that such orbits were used by Molniya communications satellites and Oko early warning satellites. There *were* plans for a geostationary SIGINT system, but that was abandoned after the country disintegrated in the early 1990s. Therefore, it is safe to conclude that the capabilities of Russian signals intelligence satellites have never matched those of their US counterparts and that satellites have played a relatively minor role in overall Russian SIGINT collection.

The only COMINT-related role that the Russians have mentioned for their Tselina satellites is their ability to determine "the intensity and character" of radio conversations between military commanders. By detecting changes in those it was possible to predict troop movements before those were observed by photoreconnaissance satellites [17]. In a 1980 assessment of Soviet military space capabilities, the CIA concluded that Soviet SIGINT satellites were capable of "contributing to the determination of force disposition and composition" [18]. However, it appears that actual *eavesdropping* on communications from space has been limited, if possible at all [19].

It is very probable that Russian SIGINT satellites have never performed TELINT, not only because their orbits weren't suited for that, but also because there simply was no need to use satellites for this purpose. Since the US launches all its rockets over the oceans and launch dates have always been announced well in advance, the Russians can pick up telemetry from American rocket launches from ships stationed off the East or West Coast for launches from Cape Canaveral and Vandenberg respectively.

With COMINT and TELINT playing only a minor role (if any at all), the primary objective of Russian SIGINT satellites must have been ELINT of foreign radar complexes. Not only are the observed orbits very well suited for that purpose, Russian sources usually describe their SIGINT satellites as being used for "radiotechnical surveillance" (acronym RTR), which is the Russian term for ELINT [20]. Since the Soviet Union was limited in its capability to perform airborne "ferret" missions near US territory, satellites may have played a vital role in covering this gap in electronic intelligence gathering. One official Russian source says that information gathered by SIGINT satellites has made it possible "not only to find radio-emitting sources and pinpoint their location, but also to precisely determine their purpose, characteristics and modes of operation. By detecting radar emissions it has become possible to determine their range, sensitivity, coverage volume, which has made it easier to develop countermeasures" [21].

Vladimir Utkin, who headed KB Yuzhnoe from 1971 to 1990, summarized the capabilities of the first-generation Tselina satellites as follows: "It was possible to detect land-based and sea-based radiotechnical systems, determine their coordinates and modes of operation, to discover newly deployed radiotechnical systems and determine their tactical and technical features with the aim of finding out their capabilities in a combat situation and obtaining data to take electronic countermeasures. The task was solved of uncovering radiotechnical networks used to support anti-missile, anti-aircraft, Air Force and Navy systems. The continuous operation of this system made it possible to [keep an eye on radiotechnical systems] in various parts of the world with the aim of detecting signs of changes in the activities and battle preparedness of the armed forces of foreign nations" [22].

The information obtained by these satellites should have made it possible to draw up an "electronic order of battle" (EOB) which would influence the conduct of an engagement. For instance, ELINT satellites can determine range restrictions and viewing angle constraints as well as other operational limits of ICBM and SLBM tracking radars. That information can then be exploited in an actual combat situation. Continued monitoring of such sites is required to detect upgrades that may enhance a radar's capabilities [23].

Information obtained from people involved in the Tselina programme and US intelligence sources would suggest that the capabilities of the Tselina satellites may not have been so impressive as has been claimed by the sources mentioned above. Accurately pinpointing the location of radars, especially mobile systems such as surface-to-air missile radars, seems to have been a problem due to the absence of advanced direction-finding gear. Another problem was that the datalink connection between the satellites and their ground stations left much to be desired, with a lot of the analogue data getting garbled in transmission or simply refusing to dump when ordered to do so. Perhaps the biggest handicap was that due to a lack of powerful computers much of the data processing had to be done by human beings, a very labour-intensive and time-consuming business [24].

Although the Russians have never revealed what radar sites they observed with their SIGINT satellites, there can be little doubt that during the Cold War the emphasis was on radar systems employed by the United States and its allies. An overview of such radar systems will be given here.

5.1 Air Defence Radars

One target of Soviet space-based ELINT sensors may have been a vast network of air defence radars across the US, Canada and Greenland to detect Soviet long-range bombers approaching the North American continent over the North Pole. Deployed in the 1950s, this network consisted of hundreds of short-range and long-range radar stations (many unmanned) to monitor the progress of intruding bombers and then provide the data to so-called combat and direction centres, which could in turn send orders to engage the enemy bombers to interceptor squadrons and surface-to-air missile batteries scattered across the US. The command and control system was known as the Semi-Automatic Ground Environment (SAGE) system.

By the early 1960s there were over 200 air-defence radar sites on the US mainland. These included primary sites and gapfiller sites. The primary sites (both permanent and mobile) were equipped with long-range search radars and height-finder radars. The gapfiller sites were outfitted with short-range radars and placed in areas where it was thought enemy planes could fly low to avoid detection by the primary sites. A significant portion of the primary sites used radars that could change frequencies so as to complicate jamming by the enemy. As the threat of Soviet bomber attacks decreased in the 1960s, many of these stations were shut down or turned over to the Federal Aviation Administration (FAA). In the early 1980s the national air defence system was reorganized as the Joint Surveillance System, co-owned by the FAA and the Air Force and used for both air traffic control and defence tasks.

More timely warning against incoming Soviet bombers was provided by three radar networks spread over Alaska, Canada and Greenland. These were the Pinetree Early Warning Line, straddling the US/Canadian border along the 50th parallel (operated between 1954 and 1988), the Mid-Canada Line centred along the 55th parallel (1957-1965) and the Distant Early Warning (DEW) Line centred along the 70th parallel (1957-1988). The DEW Line was the first line of defence against a nuclear bomber attack from the Soviet Union, providing several hours of advance warning of aircraft penetrating the northern hemisphere. In the mid-1980s to the early 1990s the DEW Line was upgraded to the North Warning System, consisting of 47 unmanned radar stations (36 long-range radars and 11 short-range "gapfiller" sites) [25].

Overseas NATO established a vast air defence network to protect Europe from Soviet bomber attacks. Known as the NATO Air Defence Ground Environment (NADGE), it was a modernized, semi-automatic defence system, comprising radars, ground-to-air communications systems and computer-based control sites. Upon completion in 1972, it consisted of over 80 radar stations stretching all the way from Northern Norway to Eastern Turkey. Later NADGE was improved to provide interoperability with NATO's Airborne Warning and Control System (AWACS) aircraft, which themselves may have been the focus of Soviet ELINT satellites. NADGE is to be superseded by the Air Command and Control System (ACCS), designed to combine the tactical planning, tasking and execution of all air defence, offensive air and air support operations. Its scope is therefore much broader than just air defence [26].

There is good reason to believe that Soviet/Russian ELINT satellites have also focused on air defence radars in China and in hotspots around the world such as the Middle East, Afghanistan and what have become known as the "rogue states".

5.2 Surface-to-Air Missile Radars

A last line of defence against intruding Soviet bombers were surface-to-air (SAM) missiles stationed across the North American continent to protect cities and military installations. By the early 1960s the Army operated three systems for point defence, two stationary (Nike Ajax and Nike Hercules) and one mobile (Hawk). The Air Force had the BOMARC system for area defence, being capable of destroying incoming bombers before they could reach the US mainland.

The BOMARC missiles were stationed both in the US and Canada and were operational between 1959 and 1972. Having a range of about 400 km, they relied on data from the long-range SAGE air defence radars for initial guidance and subsequently used a built-in radar for final interception. The Nike missiles, on the other hand, needed their own set of ground-based radars for detection and interception. Each Nike battery was equipped with an acquisition radar to detect the target, a target tracking radar to determine the enemy aircraft's range, direction and elevation and a missile tracking radar to guide the missile to its target.

Nike Ajax, having a range of about 50 km, was deployed in the US from 1954 to 1964. The more capable Nike Hercules had a range of about 140 km and could be equipped with a nuclear warhead. First deployed in 1958, it gradually replaced the Nike Ajax system and remained in operation until 1974, except for a few batteries in Alaska and Florida, which operated until the late 1970s. Peak deployment was in 1963 with 77 Nike Ajax and 134 Nike Hercules batteries. The United States also supplied Nike missiles to its allies in Europe and also to Japan, South Korea, Taiwan and Turkey. Overall more than 100 Nike squadrons were deployed outside the US.

The Hawk, which achieved initial operational capability in 1959, relied on a pulse acquisition radar for high and medium-altitude threat detection, a continuous wave acquisition radar for low-level threat detection, a tracking radar and a K-band pulse radar to provide ranging data in case the other radars were jammed by countermeasures. Its range was roughly 25 km. The Hawk and its ground-based radars went through several improvements over the years and were also used by many NATO and other countries. The US Army operated the Hawk until the mid-1990s, but it has now been completely replaced by another mobile system called Patriot, which was introduced in the early 1980s. This was gradually upgraded as PAC-1, PAC-2 and PAC-3 (Patriot Advanced Capability) to destroy not only aircraft, but also cruise missiles and tactical ballistic missiles. Exclusively stationed abroad, Patriot gained worldwide fame through its use against Iraqi Scud missiles during the 1991 Gulf War, although the number of hits was much lower than reported at the time. The Patriot uses a phased-array multipurpose radar for tracking, IFF ("Identification Friend or Foe") and target illumination [27]. Aside from these US-built SAM radars, several European and Chinese-built SAM radars may also have been targets for Soviet/Russian ELINT satellites.

5.3 Missile Defence Radars

As the Soviet ICBM threat increased, warning networks needed to be upgraded to allow strategic forces additional time to launch a retaliatory strike should the Soviets attack. This need became all too apparent after the first successful launch of the Soviet R-7 ICBM in August 1957 and the launch of the two first Sputniks using the same booster in October and November 1957. In January 1958 US Secretary of Defence Neil H. McElroy approved the deployment of a Ballistic Missile Early Warning System (BMEWS), consisting of three sites that would cover all possible flight paths of missiles launched from Soviet territory. Site I at Thule Air Base in Greenland (operational in late 1960) provided coverage for most missile approaches from the Eurasian landmass, Site II at Clear Air Force Base in Alaska (operational in late 1961) was focused on possible ICBM attacks from the Soviet far east and Site III at RAF Fylingdales in the UK (operational in late 1963) was to detect

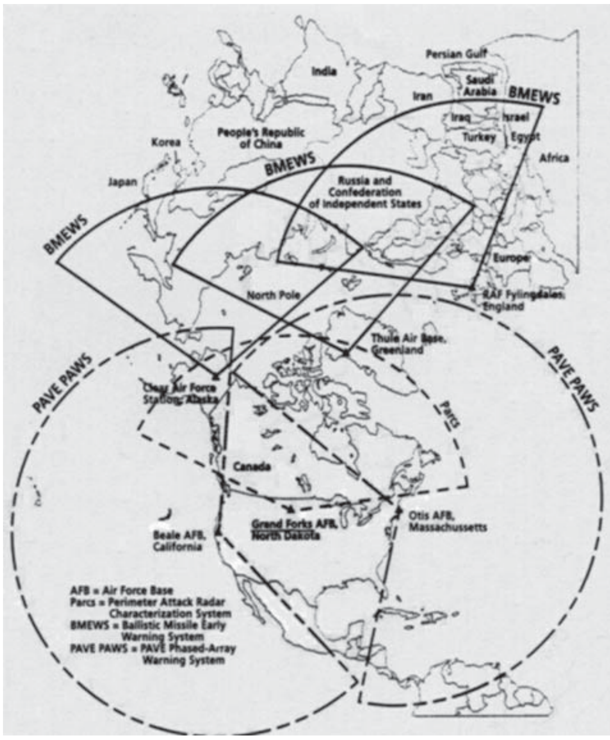

Fig. 4 Location of the BMEWS and PAVE PAWS sites. (source: Yorkshire CND)

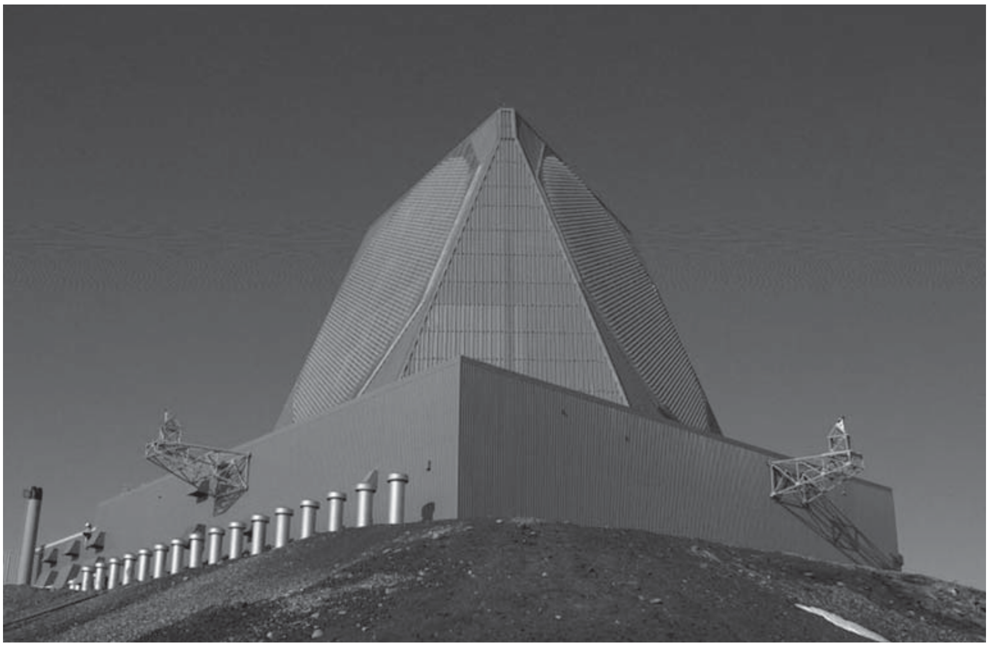

Fig. 5 AN/FPS-120 phased array radar at Thule AB in Greenland. (source: Michael Salling)

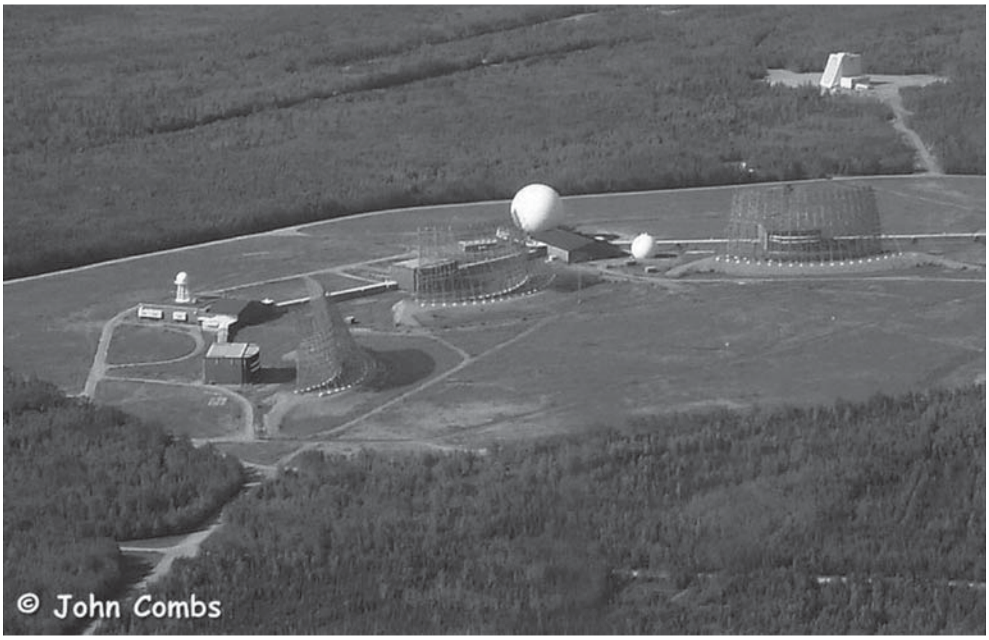

Fig. 6 Aerial view of the BMEWS site at Clear AFB in Alaska. The older mechanical AN/FPS-50 and AN/FPS-92 radars are in the foreground, the new AN/FPS-123 phased-array radar is in the background. (source: John Combs)

either ICBMs launched to the US from the far west of the Soviet Union or intermediate range missiles fired at targets in Western Europe.

The sites were equipped with AN/FPS-50 detection radars and AN/FPS-49 or AN/FPS-92 tracking radars, the latter being housed in what looked like giant golfballs (so-called radomes). The detection radars literally blanketed certain areas of the sky with fans of radar energy, waiting for an object to pass through them. Once this happened, the tracking radar would lock onto the object and provide much more accurate positional data, making it possible to precisely predict its trajectory.

Between the late 1980s and 2001 all BMEWS sites were upgraded with phased-array radars, which combine the functions of detection and tracking radars. Instead of moving the antenna mechanically, the radar energy is steered electronically. Phased-array radars consist of a myriad of small transmit/receiver antennas placed on the side of a large wedge-shaped structure. They can form multiple beams at the same time and –unlike the earlier tracking radars- are capable of tracking several hundred targets simultaneously. Thule and Clear have dual-faced phased array radars (AN/FPS-120 and AN/FPS-123 respectively), while Fylingdales operates a unique three-faced system

(AN/FPS-126) with full 360° coverage of possible missile threats.

A new threat that began to emerge in the early 1960s was the Soviet Union's capability to launch submarine-based missiles from relatively short distances off America's coastlines. Although the ultimate goal was to detect these with Over-the-Horizon Backscatter (OTH-B) radars, an interim detection capacity was needed to counter this threat. This goal was achieved by modifying one type of height-finding radar used in the primary air defence sites. Known as the AN/FSS-7, seven of these were operational by the early 1970s on the Atlantic, Pacific and Gulf coasts at sites in California, Oregon, Maine, North Carolina, Florida and Texas. Shortly afterwards they were joined by the world's first phased-array radar (AN/FPS-85) at Eglin AFB, Florida, originally built in the 1960s for space tracking.

During the 1970s the Russians developed SLBMs that could be launched to the US from much greater distances and that were beyond the detection capability of the AN/FSS-7. This led to the deployment of a new network in the late 1970s that eventually replaced the AN/FSS-7 sites. Known as PAVE PAWS [28], it initially consisted of two sites at Cape Cod AFS (formerly Otis AFB) in Massachusetts (the northeastern segment) and Beale AFB in California (the northwestern segment). Two more sites were opened in the mid-1980s at Robins AFB in Georgia (replacing Eglin) and Eldorado AFS in Texas, but these were shut down in the mid-1990s. Both Cape Cod and Beale use dual-faced phased array radars (initially the AN/FPS-115, now the AN/FPS-123).

An additional missile early warning radar site is PARCS (Perimeter Acquisition Radar Attack Characterization System) at Cavalier AFS in North Dakota, situated just over 20 km south of the Canadian border. Originally built as an acquisition radar for the Army's Safeguard anti-ballistic missile system, it was modified in 1977 to provide SLBM warning over the Hudson Bay and additional ICBM coverage of the central BMEWS area. It uses an AN/FPQ-16 single-face phased array radar [29].

5.4 Anti-Ballistic Missile Defence Radars

An important focus of US ELINT satellites during the Cold War were the radars used as part of the A-35 anti-ballistic missile defence system around Moscow. Such radars were used for detection and tracking of incoming warheads and for precision homing of ABM missiles. In the United States there was much scepticism about the need for an ABM system, not only because of its high cost, but also because it was felt it could not effectively counter the Soviet threat. Several systems that were proposed in the late 1950s and 1960s (Nike Zeus, Nike-X, Sentinel) never saw the light of day, but development work on these systems may still have affected Soviet ELINT planning. In March 1969 President Nixon announced the Safeguard programme, designed to provide limited defence against both Soviet and Chinese missiles and warheads delivered to US territory by the Soviet Fractional Orbit Bombardment System (FOBS). With Safeguard the emphasis shifted from protecting populated centres to guarding ICBM sites. Initial plans called for twelve sites, but the ABM Treaty signed as part of the SALT I agreement in May 1972 limited each party to two ABM sites with 100 missiles each, one to protect an ICBM field and the other the national command authority in each nation's capital. An

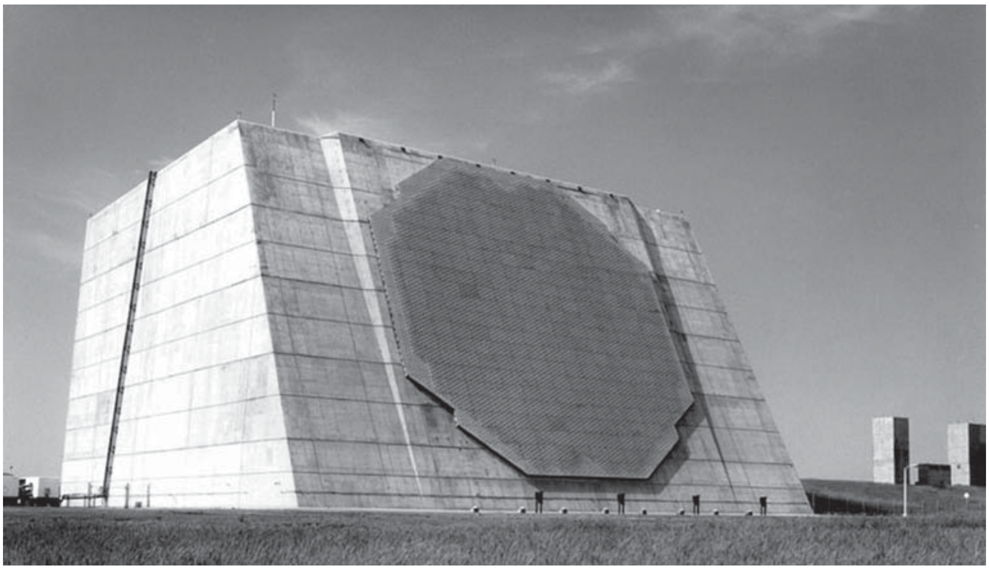

Fig. 7 The AN/FPQ-16 PARCS early warning radar in North Dakota, originally built for the Safeguard ABM programme. (source: Pan Am)

amendment of the SALT agreement in July 1974 restricted this further to a single ABM site to protect either each nation's capital or an ICBM site.

The American ABM site was built not far from Grand Forks, North Dakota and was designed to protect the 150 Minuteman missiles stationed in that area with nuclear-tipped Sprint and Spartan missiles. Two phased-array radars were needed to assist these missiles in intercepting their targets. One was a Perimeter Acquisition Radar (PAR) that would detect the incoming warheads and compute their impact points within seconds. The other was a Missile Site Radar (MSR) that tracked the warheads once they came within range and then guided the Sprint and Spartan missiles to their targets with the help of associated ground-based computers.

Testing of the PAR and MSR began in August 1972 and January 1973 respectively. The Grand Forks ABM site reached initial operational status in April 1975 (with 28 Sprint and 8 Spartan missiles) and became fully operational on 1 October 1975 (with 70 Sprint and 30 Spartan missiles). Ironically, the House of Representatives voted to shut down the system just one day later, followed by the Senate in November (and the Pentagon had actually decided to deactivate it even earlier). It went into caretaker status in February 1976 and was definitively shut down in 1978. This decision was made not only because of the staggering cost of the system, but also because it offered poor protection against Soviet missiles with multiple warheads (under development at the time) and because the radars were vulnerable to attack and could even be blacked out by the detonation of the Sprint and Spartan warheads themselves. Although the Grand Forks ABM site operated for only several months, the PAR and MSR radars may have been observed by Soviet ELINT satellites from the moment their testing began in 1972-1973. One of their tasks would have been to determine if their characteristics did not violate those stipulated by the ABM treaty. As mentioned earlier, the PAR was later included in America's missile early warning radar system [30].

Anti-ballistic missile defence received a new boost in the US with the initiation of the space-based Strategic Defence Initiative under the Reagan Administration in 1983, scaled down in the 1990s to ground-based systems to protect US and allied troops in the field against short-range missile attacks ("theatre missile defence") and US territory against limited strikes by long-range missiles ("national missile defence"). In 2002 the Bush Administration integrated these efforts into the Ballistic Missile Defence System (BMDS), which should ultimately offer protection against all types of missiles (short, medium, long range) in all phases of flight (boost, midcourse, terminal). Since the ABM Treaty forbids deployment of a national missile defence system, the US officially withdrew from the treaty that same year.

The initial focus will be on a system to intercept missiles in the midcourse phase. For long-range missiles this is the Ground-Based Midcourse Defence (GMD) system, in which Ground Based Interceptors (GBI) tipped with Exoatmospheric Kill Vehicles (EKV) will employ data from upgraded BMEWS and PAVE PAWS radars as well as a sea-based X-band (SBX) radar to engage their targets. Planned for deployment in 2005, the SBX will be mounted on a converted oil-drilling platform home-ported in Adak, Alaska and will prove especially helpful in distinguishing real warheads from decoys and assessing the intercepts. It is an offspring of the Ground Based Radar-Prototype (GBR-P), which has served as the fire control radar for flight and intercept tests at the Kwajalein Missile Range since 1999. In addition to this, a forward-deployed transportable X-band phased-array radar is being developed to perform early acquisition and tracking of various types of missiles.

Mid-course interception of short to intermediate range ballistic missiles will be performed by an improved version of the sea-based Aegis Weapon System, which will use SPY-1 radars to detect the missiles and guide missiles to intercept them. Installed on forward-deployed Navy Aegis destroyers and cruisers, these same radars can also be used for initial tracking of long-range missiles in support of the GMD system.

Already deployed for terminal interception of short-range ballistic missiles in South Korea and the Persian Gulf is an advanced version of the Patriot missile (PAC-3) with its associated radar system. Under development for terminal interception of short and medium-range ballistic missiles at higher altitude is a system known as THAAD (Terminal High-Altitude Area Defence), which will rely on an X-band phased array radar to scan the horizon for hostile missiles and send targeting information to the interceptor vehicle [31].

BMDS was expected to achieve initial operational status in the autumn of 2004, more than twenty years after Ronald Reagan's announcement of the much more sophisticated SDI. Although BMDS is officially designed to counter missile threats from "rogue states", Russia has expressed concern that the system could have significant capabilities against its dwindling ICBM force and destabilize the US-Russian strategic balance. Therefore, the numerous radars that have been or will be fielded as part of BMDS will no doubt continue to be closely monitored by Russian SIGINT satellites.

5.5 Intelligence Gathering and Space Tracking Radars

Also on the target list of Soviet/Russian SIGINT satellites have probably been radars used by the US for gathering intelligence on missile and rocket launches and for tracking space objects. Disabling such radars in a conflict would have seriously affected the United States' capability to detect launches of Soviet anti-satellite weapons or nuclear warheads launched from Baikonur on southbound trajectories as part of the Fractional Orbit Bombardment System.

The US operated one detection radar (AN/FPS-17) (since 1955) and one mechanical tracking radar (AN/FPS-79) (since 1962) at Pirinclik, Turkey, close to the southern border of the Soviet Union, mainly for collecting intelligence data on Soviet missile and space events, including reentries of Soviet spacecraft. The site was shut down in late 1997. Another system is the COBRA DANE (AN/FPS-108) single-face phased array radar (AN-FPS 108) at Eareckson AFS (formerly Shemya AFB) on the far end of the Aleutian island chain in Alaska. Opened in 1977, this site has primarily been used to track test flights of Soviet ballistic missiles impacting in Kamchatka or the Pacific Ocean and space launches from Soviet cosmodromes. Plans to install an X-band radar at Eareckson for the National Missile Defence system were cancelled in favour of the sea-based X-band radar. Instead, COBRA DANE itself is being upgraded to provide a support role for the Ballistic Missile Defence System. Complementing COBRA DANE in its intelligence mission has been a ship-based radar system called COBRA JUDY. Consisting of an S-band phased-array system and an X-band dish radar, it is installed on a converted merchant vessel known as the US Naval Ship Observation Island, operating from Pearl Harbour. Its mission has been to collect exoatmospheric and endoatmospheric data on Russian ballistic missile tests over the Pacific Ocean and it may play a role in BMDS as well.

Launches of rockets and missiles from Plesetsk and of Soviet SLBMs over the Northern Sea have been monitored since the early 1960s by a US radar system at Vardo in Norway, just about 60 km from the Russian border. The Norwegians refer to it as Globus I. In 1998 Vardo's capabilities were expanded with a US-built X-band mechanical dish tracking radar called HAVE STARE (AN-FPS 129), originally installed at Vandenberg AFB in 1995 for tests in the framework of the National Missile Defence programme. Called Globus II by the Norwegians, its official goal is to track satellites and space debris, but its location strongly suggests that its primary mission is the same as that of Globus I. If its data is combined with that of the sea-based X-ray radar near Alaska, the US would be capable of collecting precision X-band radar signature data on virtually every phase of Russian long-range ballistic missile launches from Plesetsk or the Northern Sea, including the critical mid-course phase where warheads and decoys separate from the missile. It has been claimed that such precision information could be employed in developing a ballistic missile defence system specifically aimed at Russia, which would make the X-band radar at Vardo a primary target for Russian SIGINT satellites [32].

Finally, there are two dedicated space tracking radar systems on US territory. Since the late 1960s the Air Force has operated the earlier mentioned phased-array radar (AN/FPS-85) at Eglin AFB, Florida (also temporarily used for early warning of SLBM attacks). In the late 1950s the Navy began deployment of NAVSPASUR (Naval Space Surveillance System), an electronic "fence" stretching across the southern US from Georgia to California and consisting of three powerful transmitters and six receivers, all using phased array antennas. It should also be noted that the BMEWS, PAVE PAWS and PARCS radars have space tracking as a secondary mission besides early warning of missile attacks [33].

6. Zenit-2(M)/Kust-12M

Studies of the military applications of satellites began in the Soviet Union on the basis of a government decree issued on 30 January 1956. Although the main focus of the decree was on the launch of a scientific satellite (Object-D, which later became Sputnik-3), a team at the NII-4 research institute of the Defence Ministry was tasked to come up with proposals for a variety of military satellites. This team, headed by Mikhail Tikhonravov, was joined by specialists from Sergei Korolyov's OKB-1 design bureau when that separated from the NII-88 to become an independent entity in August 1956. One of the applications studied in the 1956-1958 timeframe was signals intelligence [34].

Still, as in the United States, signals intelligence initially had to take a backseat to photographic intelligence. Around 1956/1957 OKB-1 started design work on a photoreconnaissance satellite known as OD-1. Using a passive orientation system, the satellite was to consist of an unpressurized instrument and propulsion section and a small recoverable capsule to return exposed film back to Earth. In a move to cut costs and gain military support for financing manned space missions, OKB-1 began working out plans in late 1958 to unify the design of OD-1 and a manned spacecraft called OD-2 into a dual-role vehicle that could be used for both photoreconnaissance and manned missions. Korolyov's plans did not win approval until April 1959 (possibly in the wake of the first launches of American CORONA spy satellites) and were spelled out in a government decree released on 22 May 1959 (nr. 569-264). Korolyov planned four versions of this so-called "Object K", one a common prototype version (1K), two specifically designed for photographic reconnaissance (2K for "area survey" missions and 4K for "close look" missions) and one adapted for piloted missions (3K). In official documentation these were also known as Vostok-1, Vostok-2, Vostok-3 and Vostok-4 (not to be confused with the identically named manned spacecraft), with the spy satellites later being called Zenit-2 and Zenit-4.

Rather than fly specialized SIGINT satellites, a decision was made initially to fly SIGINT sensors as payloads on photoreconnaissance satellites. From the scarce information that is available on the OD-1, there are no indications that SIGINT was part of the mission at this stage. The earliest known reference to space-based SIGINT comes in a document signed on 16 February 1959 by Korolyov and Mstislav Keldysh, the later President of the USSR Academy of Sciences. In the document the two outline plans for space activities in 1959-1960 to Konstantin Rudnev (the Chairman of the State Committee for Defence Technology, essentially the first industrial manager of the Soviet space programme) and Georgiy Pashkov (deputy chairman of the Military Industrial Commission (VPK), a body overseeing the entire defence industry). Summing up the possible applications of reconnaissance satellites, they mention SIGINT as one of the tasks aside from photography and infrared observations of military targets: "...conducting radio intelligence of anti-missile defence means of a possible adversary with the help of special reception and registering equipment on board a satellite" [35].

It is very likely that SIGINT was included as an objective for the Object-K in the 22 May 1959 government decree. A recently declassified report outlining progress made on that decree by February 1960 says the goal for the Vostok-2/Zenit-2 SIGINT system was to carry out "radio reconnaissance of anti-missile defence means in the 0.6 to 1.6 m range during missions lasting up to 15-20 days" (although in practice flight duration would remain limited to about a week) [36].

Very little has been revealed about the Zenit-2 SIGINT payload. It was developed at TsNII-108 under the leadership of Mark Zaslavskiy, whose deputy at the time was Yevgeniy Fridberg [37]. Known as "Kust-12M" (*kust* meaning "bush"), its only externally visible element was a parabolic antenna mounted on the interface between the descent capsule and the instrument module, which is also where the gas tanks for the attitude control system were located. There is even conflicting information on whether the SIGINT equipment itself was located inside the instrument module or the descent module [38]. In the first case, the information would have had to be transmitted to Earth during the mission, in the latter case it would have returned to Earth. The wavelengths mentioned in the February 1960 report correspond to frequencies between about 215 and 570 MHz, which is in the VHF/UHF band. The radars of the Ballistic Missile Early Warning System operated in the lower part of the UHF band (around 425 MHz) and were therefore almost certainly among the targets of Kust-12M. The system may also have observed some of the US air defence radars, although the majority of these emitted at much higher frequencies (primarily in the L and S bands). The Nike surface-to-air missile radars would not have been detectable by Kust-12M if it remained limited to the frequencies given in the February 1960 document.

The preliminary design ("draft plan" in Russian terminology) of the Vostok-2/Zenit-2 spy satellites was finished by April 1960. In May 1960 the Soviet Union began a series of test flights of the basic "Vostok-1" vehicle. Announced as "Korabl Sputnik" ("Satellite Spaceship"), these missions have usually been interpreted as unmanned precursors of the first Vostok piloted spaceships, but new evidence shows that they were primarily designed to pave the way for the first Zenit reconnaissance satellites, which were seen as a higher-priority objective than manned flights [39].

Eventually, the first Zenit-2 was launched on 11 December 1961, but it tumbled back to Earth after a launch vehicle failure. The first Zenit-2 to reach orbit was Kosmos-4, launched on 26 April 1962. All indications are that the Kust-12M payload was flown from the very beginning, although nothing is known about its actual performance. A total of 81 Zenit-2 satellites were launched, seven of which never reached orbit due to rocket problems. The last one (Kosmos-344) went up on 12 May 1970. Launches were per-

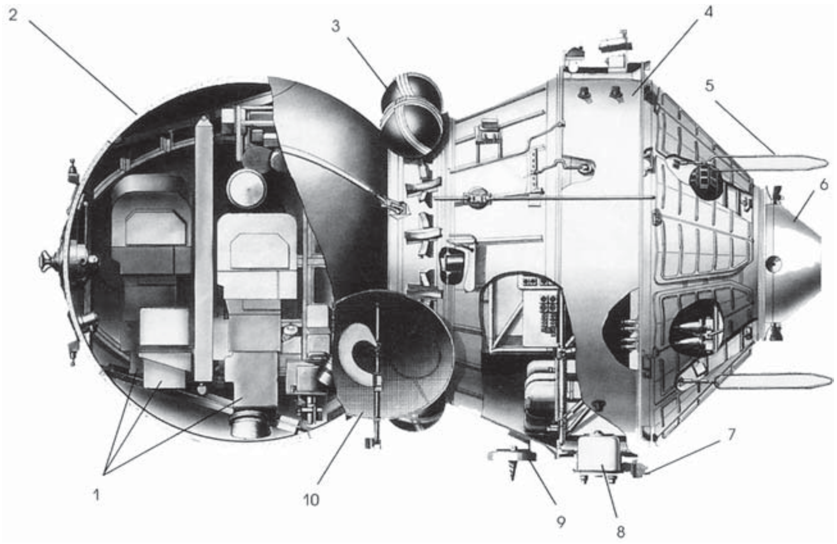

Fig. 8 Zenit-2 photo reconnaissance satellite with SIGINT parabolic antenna (location 10). (source: RKK Energiya)

formed from Baikonur into 51° or 65° inclination orbits and, beginning in 1966, from Plesetsk into 65°, 73° and 81° orbits [40]. Most of these orbits would have allowed observations of the BMEWS sites.

An improved model of Zenit-2 capable of staying in orbit just under two weeks (Zenit-2M) was introduced in March 1968 (Kosmos-208) and flown until March 1979 (Kosmos-1090), and declassified CIA reports indicate that these satellites continued to fly the same ELINT payload. In all, 96 launches are believed to have taken place (including four failures), with the Russians averaging 10 launches per year between 1970 and 1978. Zenit-2M flew both from Baikonur (51°, 65°, 71° inclination orbits) and Plesetsk (63°, 65°, 73°, 81° orbits). One of the CIA reports noted the limited capabilities of the ELINT payload: "The short orbital lifetime limits the usefulness of these vehicles to spot checking or sampling selected radars ... The Soviet first-generation ELINT system is a simple one that collects rudimentary data from emitters. These emitters have included US space surveillance radars and shipborne surveillance radars. We suspect the system can detect other emitters as well. In an uncluttered radar environment, data from one satellite pass can be used to derive the position of rotating emitters with known characteristics" [41].

A SIGINT payload capable of covering a broader range of frequencies was originally also planned for the Vostok-4/Zenit-4 "close look" satellites, which began flying in November 1963 [42]. However, from the little information that has been released about Zenit-4 there are no indications that this improved payload was ever flown. Moreover, the only drawing released of Zenit-4 does not show the SIGINT parabolic antenna flown by Zenit-2 and none of the released CIA reports indicate that the close-look satellites ever flew a SIGINT payload [43].

Undoubtedly, flying SIGINT sensors on photoreconnaissance satellites had many disadvantages, if only because SIGINT and IMINT have conflicting requirements in terms of orbital parameters and satellite orientation. Although the US also launched SIGINT payloads on photoreconnaissance missions, they were always deployed into independent orbits. Still, the fact that the Russians continued to fly these piggyback payloads until the late 1970s indicates that they added important information to that collected by their dedicated SIGINT satellites.

7. SIGINT Payloads on DS Satellites

In the late 1950s, even as it was still preparing to fly the Kust-12M payloads on OKB-1's Zenit-2 satellites, TsNII-108 also became involved in developing a SIGINT payload for Mikhail Yangel's OKB-586 in Dnepropetrovsk [44]. At that time OKB-586 was beginning to work out plans for a series of lightweight satellites called DS ("Dnepropetrovskiy Sputnik") to be launched by the bureau's 11K63 (also known as 63S1) booster (based on its R-12 missile). On 8 August 1960 the Soviet government issued a decree authorizing the development of several types of DS satellites. One of these, DS-K8, was designed to study "methods and means of measuring the parameters of signals from radar stations" and was also equipped to study micrometeorites in near-Earth orbit.

It is unclear what the rationale was behind developing SIGINT systems for two types of satellites at the same time. Possibly, Kust-12M was originally seen only as a stopgap measure until the time was ripe to fly dedicated SIGINT satellites. Meanwhile, the DS satellites would have to prove the technology needed to fly such satellites.

Like most other DS satellites, DS-K8 was made up

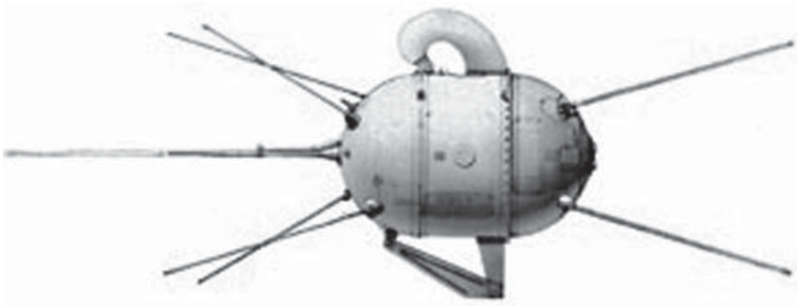

Fig. 9 The DS-K8 experimental SIGINT satellite. (source: GKB Yuzhnoe)

of two semi-spherical compartments connected by a cylindrical section measuring 800 mm in diameter. The systems inside the satellite operated in a pressurized nitrogen gas environment. Most of the housekeeping systems were located in the lower semi-spherical compartment, while the payload was in the cylindrical section and upper semi-spherical compartment. The housekeeping systems included a set of chemical batteries, a radio command link (BKRL-E), a radio telemetry system (Tral-MSD) and a radio system for orbit determination (Rubin-1D). Thermal control was accomplished with the help of two ventilators, a control unit with temperature sensors and the use of a reflective surface. At least 8 antennas were installed on the satellite's exterior. An identical set of antennas can be seen on the DS-A1 satellite (used for detecting high-altitude nuclear explosions), which would indicate that the external part of the SIGINT payload were the two features extending from the cylindrical section.

By December 1961 the preliminary design of the DS-K8 satellite was finished. Only one satellite was built and launched as Kosmos-8 from the Kapustin Yar cosmodrome near Volgograd on 18 August 1962. The 235 kg satellite was placed into a 259x569 km orbit inclined 48.9° to the equator, with the on-board batteries providing enough power to operate it for 10 to 12 days. The satellite re-entered the atmosphere on 17 August 1963. The relatively low inclination, dictated by the location of the launch site, would not have allowed observations of the BMEWS radars. Among the targets may have been air defence radars in the United States or possibly even radars in the Soviet Union itself, just to see if the satellite could detect these. It would seem that US intelligence was not aware of the satellite's purpose. A 1965 CIA report listed Kosmos-8 as a satellite with an unknown mission and mentioned that there apparently had been a "system failure". Possibly, the fact that the satellite had a limited operational lifetime due to the use of batteries was misinterpreted as an indication that its mission had been terminated ahead of schedule [45].

After the DS-K8 mission a final decision was made to press ahead with the development of a specialized SIGINT satellite. In the first stage, two more DS satellites would be flown to prove the technology and these would be followed by the deployment of an operational system known as "Tselina" ("Virgin Lands") using much lighter SIGINT equipment [46].

The two experimental DS SIGINT satellites were designated DS-K40 and were built on the basis of new DS buses called DS-U1 and DS-U2, designed by OKB-586 in 1963. The main difference between the two was that the DS-U1 bus relied on chemical batteries, whereas the DS-2U was equipped with solar panels. The DS-U1 bus had a mass of 265 kg and could carry a payload of up to 50 kg, while the DS-U2 bus weighed between 200 and 230 kg with a payload of up to 60 kg. Neither of the two buses could be oriented in space. The maximum operational lifetimes for DS-U1 and DS-U2 were one and three months respectively.

It is not known on the basis of which bus the DS-K40 satellites were built. In fact, very little has been revealed about them, except that they carried more sensitive SIGINT equipment of different size and mass than that flown by Kosmos-8. Presumably, these were experimental precursors of the SIGINT equipment to be flown by the Tselina-O satellites, which required no accurate pointing of antennas. No drawings of DS-K40 have been released.

Unfortunately, none of the two satellites reached orbit due to first stage failures of the 63S1 rocket. The launch attempts took place at Kapustin Yar on 28 December 1965 and 21 February 1966. Despite these setbacks, the Soviet Union moved ahead with the development of the Tselina satellites, which had in fact already been approved when these launch failures took place [47].

8. A Cancelled Multi-Purpose SIGINT Satellite

As the design of the Tselina satellites got underway, some felt that in order to save costs they should take over the role of the ocean-monitoring SIGINT satellites that had already been under development at that time for a couple of years. It should come as no surprise that the Russians placed much heavier emphasis on ocean-monitoring SIGINT satellites than the US. Rather than deploy extensive naval forces (particularly aircraft carriers), the Soviet Union had

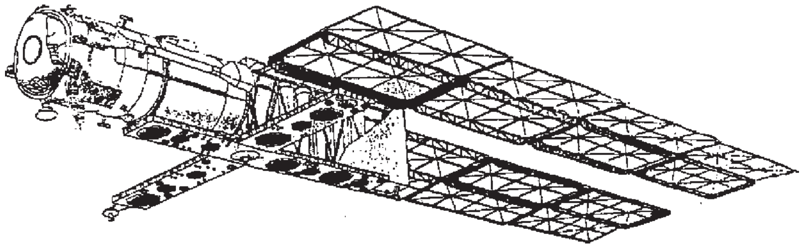

Fig. 10 US-P electronic ocean reconnaissance satellite.
(source : Galeya Print, St.-Petersburg)

elected to invest heavily in anti-ship missiles mounted on various types of surface combatants and submarines. As early as June 1960 a decision had been made to develop a dedicated ocean-monitoring satellite system that would have to precisely determine the location of American naval systems that were the targets of these missiles. Assigned to the OKB-52 design bureau of Vladimir Chelomei and the KB-1 bureau of Aleksandr Raspletin, it was called the "Space-Based Sea Reconnaissance and Detection System" (Russian acronym MKRTs), which was split into two components in early 1961. One was an "active" spacecraft (US-A, also known in the West as RORSAT) with a powerful nuclear-powered radar as the primary means of detecting ships on the ocean's surface. The other was a "passive" satellite (US-P or EORSAT) with ELINT systems to monitor and detect transmissions from ships to supplement that radar information. US-A began test flights in 1965 and US-P in 1974 [48].

There was considerable pressure both from the Ministry of General Machine Building (the "space and rocketry" ministry set up in 1965) and the "space branch" of the Strategic Rocket Forces (TsUKOS) not to build the US-P satellites and incorporate their functions into the Tselina system. Eventually, the general designer of the MKRTs system M.K. Serov and specialists of the Soviet Navy were able to prove that Tselina would not be capable of providing the kind of precision data needed for the accurate firing of anti-ship missiles. They found support from Pyotr Pleshakov, who had become Deputy Minister of the Radio Industry in 1964 after six years at the helm of TsNII-108 and had been behind the decision in early 1961 to build a specialized ocean electronic reconnaissance system. The idea to combine the US-P and Tselina systems was turned down by a special commission set up to investigate the matter and by the Military Industrial Commission [49].

A major obstacle to unifying the two systems must have been the rivalry between different branches of the armed forces to gain responsibility for military space projects. While Tselina was run by TsUKOS, US-P was a Navy project. Attempts in the 1960s to concentrate responsibility for *all* military satellites under a single branch of the armed forces failed. There were probably technical considerations as well that torpedoed the concept of a multi-purpose SIGINT satellite. Whereas the Tselina system was to detect a wide range of frequencies, the US-P system was to home in on a very narrow band of frequencies used only by ships. While that hurdle may have been relatively easy to overcome, a bigger problem was that US-A and US-P were designed to be interdependent systems using synchronized orbits and sharing the same ground facilities. Also, the US Navy was perceived as the biggest threat to the nation, justifying the need for a dedicated ocean monitoring system [50].

Fig. 11 Pyotr Pleshakov, head of TsNIRTI from 1958 to 1964.
(source : Krasnaya Zvezda)

Clearly, the idea to unify Tselina and US-P came too late and would have to wait until the first generation of land and ocean-monitoring SIGINT satellites had outserved their usefulness. Although Tselina did fulfil an ocean monitoring role as well, this was not its primary mission.

9. First-Generation Tselina

Not only was the idea of a multi-purpose SIGINT satellite abandoned, in the end even Tselina itself was split into two subsystems: Tselina-O (11F616) for "area survey" SIGINT (the "O" standing for *obzornyy* - overview) and Tselina-D (11F619) for "detailed" SIGINT (the "D" standing for *detal'nyy* – detailed). The area survey satellites would survey the electronic terrain to compile and update electronic order of battle data and provide a rough estimate of where the sources were located. The detailed SIGINT satellites would then determine the location and exact characteristics of the radar systems with much greater accuracy, allowing engineers to develop jammers or countermeasures [51].

A government decree sanctioning the Tselina programme was issued in 1964. One factor in the decision to press ahead with Tselina were the numerous launches of American "ferret" satellites that had taken place earlier in the 1960s [52]. One source says the preliminary design of Tselina-D was finished in October 1965 and that of Tselina-O "even earlier" [53].

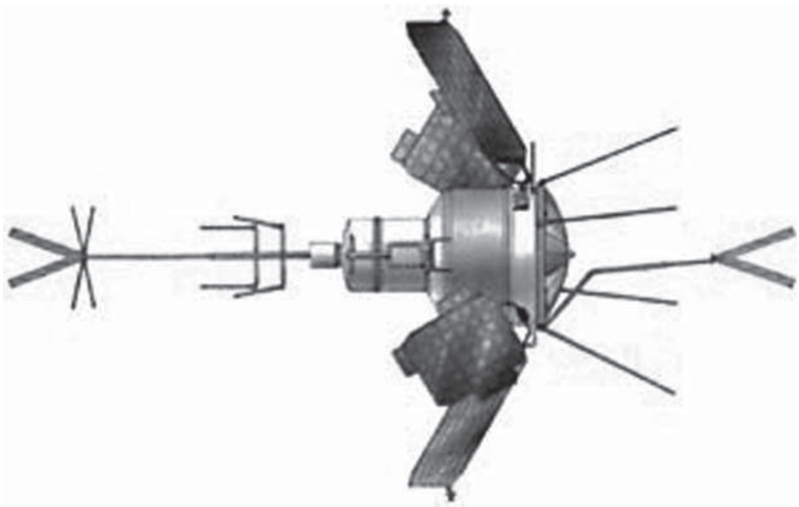

Fig. 12 Tselina-O class satellite. (source: GKB Yuzhnoe)

9.1 Tselina-O

Three subclasses of Tselina-O satellites were flown over a 15 year period: Tselina-O, Tselina-OM and Tselina-OK. The differences between these satellites are unknown. The mass for Tselina-O class satellites has been given as ranging from 339 to 434 kg with a payload mass between 170 and 190 kg (the differences are believed to reflect changes in the various Tselina-O subclasses). The pressurized bus was 2.5 m high and consisted of two sections, one 1.2 m in diameter, the other 0.8 m. The Tselina-O class satellites are said to have been constructed "using some elements of earlier built satellites". They used solar panels and could not be oriented [54]. Extending from the exterior were several intercept antennas and installed inside were ten high-frequency receivers [55]. The satellites were designed to provide a rough estimate of the location of radio-emitting sources by measuring the doppler shift of the carrier frequency and the amplitude of the signals from different points in their orbits. Information would be stored on board and dumped to the ground once or twice a day [56].

Being the simpler of the two systems, Tselina-O was ready for deployment first. Test flights were supervised by a State Commission headed by Lieutenant General Galaktion E. Alpaidze, who headed the Plesetsk launch site from 1963 until 1975. The launch vehicle selected for Tselina-O was the 11K65M (retrospectively called Kosmos-3M), designed by Yuzhnoe on the basis of the R-14 missile and produced at the time by NPO PM in Krasnoyarsk. An earlier version of this rocket (11K65) had already flown 10 missions (8 successful) from Baikonur since August 1964 and the slightly more capable 11K65M made its debut with a launch from Plesetsk on 15 May 1967, carrying a Tsiklon navigation satellite (or possibly a mock-up). The next satellite in line was the first Tselina-O, but the launch ended in failure on 26 June 1967. The first Tselina-O to reach orbit was Kosmos-189 on 30 October 1967. It was placed into a roughly circular orbit just above 500 km with an inclination of 74.0°. Speculation that these two first satellites were mass models cannot be confirmed at this point [57]. Following just one more launch in January 1968 (Kosmos-200), Tselina-OM was introduced with the launch of Kosmos-250 on 30 October 1968. Test flights of Tselina-OM were finished in June1970, but it wasn't until the release of a government decree on 26 March 1972 that the system was officially declared operational ("taken up in the armaments" in Russian terminology) [58].

Between 1970 and 1977 the Russians averaged four Tselina-OM launches per year, operating perhaps as many as four to six satellites simultaneously in orbital planes spaced 45° apart. The high launch rate was not only dictated by the relatively short lifetime of the satellites, but also by the need to pinpoint the location of emitters as accurately as possible. Since these low-orbiting satellites passed over a given site on Earth infrequently, several satellites were needed to reduce the time of detection and triangulation. In addition to that, the movement of mobile emitters could be tracked better if signals were intercepted on the order of every few hours [59].

In 1978 the launch rate suddenly dropped dramatically, while that of Tselina-D began to increase. According to one source Tselina-D was able to satisfy all SIGINT requirements by the early 1980s [60]. In all, 34 Tselina-OM satellites were successfully placed into orbit, the last one being Kosmos-1345 in March 1982. There was one launch failure and another satellite was lost when a Kosmos-3M exploded on the pad during fuelling on 26 June 1973, claiming the lives of nine people. The Tselina-OK series saw just three launches between November 1975 and May 1978 (Kosmos-781, 924 and 1008).

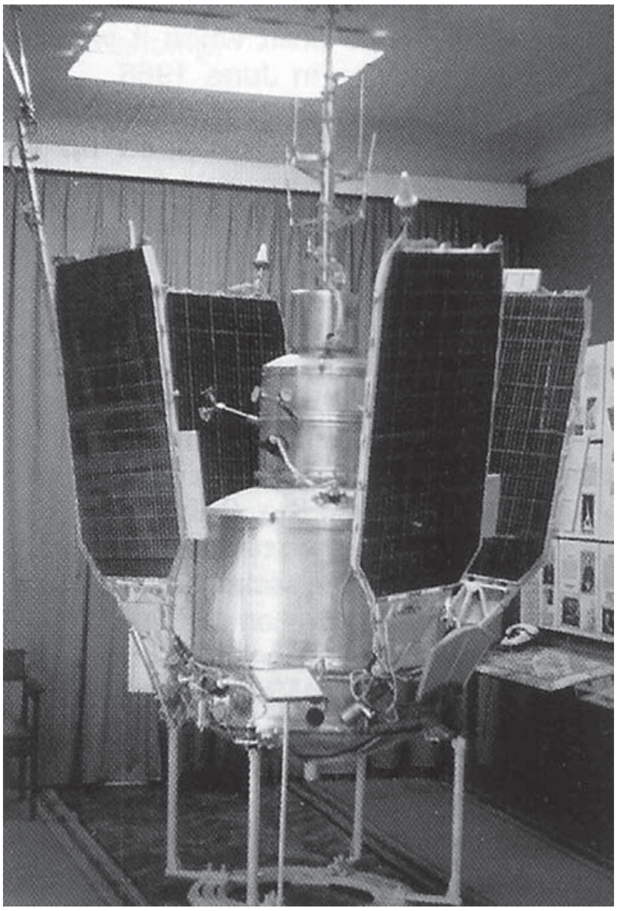

Fig. 13 Tselina-O class satellite on display at the Mozhaiskiy Academy in St.-Petersburg. (source: T. Varfolomeyev)

Fig. 14 Tselina-O class satellite on display. (source: Arsenal magazine/Intervestnik)

Declassified US intelligence information indicates that a major handicap of the satellites was their inability to send real-time data to Earth, something which US ELINT satellites *were* capable of by the mid-1970s. The satellites were programmed once a day by ground stations in the Soviet Union to carry out between 7 and 11 specific pre-programmed ELINT collection missions. At the end of the day they would downlink the data to the ground on ten separate telemetry channels. Each satellite was equipped with two tape record/playback units. The intercept equipment was sufficient for collecting wide-area electronic order of battle data. Location accuracy was approximately 20 nautical miles for stationary targets after several passes and about 100 nautical miles for mobile targets after a single pass, much worse than what US ELINT satellites are believed to have been capable of during the same time period [61].

The Tselina-O satellites also seem to have had a limited capability to track American warship movements. In a 1973 assessment of Soviet military space capabilities, the CIA even concluded that monitoring ocean and coastal areas was the satellites' main mission. A 1975 CIA report noted that "the Soviets appear to use this system to detect and approximate movements of foreign ships, in particular US aircraft carriers in transit. An estimate of a ship's movement can be made after many satellite passes have occurred and the ELINT data has been analysed. By providing the approximate location of ships, this satellite system provides some support to Soviet ocean surveillance capabilities. There is evidence that ship position data from these satellites is correlated with data from other more conventional ocean reconnaissance sources." Presumably, the ocean monitoring role of Tselina-O became less important after the specialized ocean electronic reconnaissance satellites (US-P) began flying in December 1974. By 1980 the CIA believed Tselina-O was capable of monitoring the radar environment of surface-to-air missile systems, early warning systems and surface ships (combatants) and also of identifying specific radar types used on ships and determining the status of ground forces [62].

The design lifetime of the satellites was six months, although the US intelligence sources quoted above estimated at the time that their operational lifetime was about 18 months [63]. At any rate, it would seem that the quality of the satellites left much to be desired. One TsUKOS officer involved in the Tselina-O programme recalls that in order to keep up with the production schedule the manufacturer would often send satellites to the cosmodrome that had not yet been completely

TABLE 1: *List of Tselina-O Launches.*

Official name	Launch date/time (UTC)	Launch site and vehicle	Inclination	Perigee/Apogee	Comments
-	26.06.1967 ?	Plesetsk 11K65M	-	-	Tselina-O Launch failure
Kosmos-189	30.10.1967 17.59	Plesetsk 11K65M	74.0	526x574	Tselina-O Re-entered 08.06.1978
Kosmos-200	19.01.1968 21.59	Plesetsk 11K65M	74.0	516x536	Tselina-O Re-entered 24.02.1973
Kosmos-250	30.10.1968 22.00	Plesetsk 11K65M	74.0	520x539	Tselina-OM Re-entered 15.02.1978
Kosmos-269	05.03.1969 17.25	Plesetsk 11K65M	74.0	520x541	Tselina-OM Re-entered 21.10.1978
Kosmos-315	20.12.1969 03.26	Plesetsk 11K65M	74.0	516x538	Tselina-OM Re-entered 25.03.1979
Kosmos-330	07.04.1970 11.10	Plesetsk 11K65M	74.0	512x530	Tselina-OM Re-entered 12.06.1979
Kosmos-387	16.12.1970 04.29	Plesetsk 11K65M	74.0	524x537	Tselina-OM Re-entered 19.01.1980
Kosmos-395	17.02.1971 21.09	Plesetsk 11K65M	74.0	527x543	Tselina-OM Re-entered 06.04.1980
Kosmos-425	29.05.1971 03.49	Plesetsk 11K65M	74.0	507x548	Tselina-OM Re-entered 15.01.1980
-	22.07.1971 ?	Plesetsk 11K65M	-	-	Tselina-OM Launch failure
Kosmos-436	07.09.1971 01.15	Plesetsk 11K65M	74.0	509x541	Tselina-OM Re-entered 04.01.1980
Kosmos-437	10.09.1971 03.37	Plesetsk 11K65M	74.0	519x542	Tselina-OM Re-entered 29.03.1980
Kosmos-460	30.11.1971 16.39	Plesetsk 11K65M	74.0	516x538	Tselina-OM Re-entered 05.03.1980
Kosmos-479	22.03.1972	Plesetsk 11K65M	74.0	512x538	Tselina-OM Re-entered 13.02.1980
Kosmos-500	10.07.1972 16.15	Plesetsk 11K65M	74.0	506x543	Tselina-OM Re-entered 29.03.1980
Kosmos-536	03.11.1972 01.34	Plesetsk 11K65M	74.0	515x542	Tselina-OM Re-entered 20.07.1980
Kosmos-544	20.01.1973 03.36	Plesetsk 11K65M	74.0	509x544	Tselina-OM Re-entered 15.06.1980
Kosmos-549	28.02.1973 04.37	Plesetsk 11K65M	74.0	510x543	Tselina-OM Re-entered 29.06.1980
-	26.06.1973	Plesetsk 11K65M	-	-	Tselina-OM Rocket explodes during fuelling. 9 people killed.
Kosmos-582	28.08.1973 10.08	Plesetsk 11K65M	74.0	517x541	Tselina-OM Re-entered 05.09.1980
Kosmos-610	27.11.1973 00.08	Plesetsk 11K65M	74.0	513x544	Tselina-OM Re-entered 15.09.1980
Kosmos-631	06.02.1974 00.34	Plesetsk 11K65M	74.0	518x543	Tselina-OM Re-entered 03.10.1980
Kosmos-655	21.05.1974 06.16	Plesetsk 11K65M	74.0	520x541	Tselina-OM Re-entered 19.11.1980
Kosmos-661	21.06.1974 09.03	Plesetsk 11K65M	74.0	510x545	Tselina-OM Re-entered 27.08.1980

TABLE 1: *List of Tselina-O Launches (Contd).*

Official name	Launch date/time (UTC)	Launch site and vehicle	Inclination	Perigee/Apogee	Comments
Kosmos-698	18.12.1974 14.12	Plesetsk 11K65M	74.0	512x551	Tselina-OM Re-entered 09.02.1980
Kosmos-707	05.02.1975 13.15	Plesetsk 11K65M	74.0	500x546	Tselina-OM Re-entered 07.09.1980
Kosmos-749	04.07.1975 00.56	Plesetsk 11K65M	74.0	508x548	Tselina-OM Re-entered 26.09.1980
Kosmos-781	21.05.1975 17.11	Plesetsk 11K65M	74.0	505x548	Tselina-OK Re-entered 26.11.1980
Kosmos-787	06.01.1976 04.52	Plesetsk 11K65M	74.0	516x546	Tselina-OM Re-entered 12.12.1980
Kosmos-790	22.01.1976 22.26	Plesetsk 11K65M	74.0	510x546	Tselina-OM Re-entered 12.11.1980
Kosmos-812	06.04.1976 04.14	Plesetsk 11K65M	74.0	507x546	Tselina-OM Re-entered 30.10.1980
Kosmos-845	27.07.1976 05.21	Plesetsk 11K65M	74.0	511x545	Tselina-OM Re-entered 15.11.1980
Kosmos-870	02.12.1976 00.17	Plesetsk 11K65M	74.0	511x547	Tselina-OM Re-entered 20.12.1980
Kosmos-899	24.03.1977 22.11	Plesetsk 11K65M	74.0	501x546	Tselina-OM Re-entered 19.10.1980
Kosmos-924	04.07.1977 22.20	Plesetsk 11K65M	74.0	512x547	Tselina-OK Re-entered 10.02.1981.
Kosmos-960	25.10.1977 05.25	Plesetsk 11K65M	74.0	499x544	Tselina-OM Re-entered 22.10.1980
Kosmos-1008	17.05.1978 14.39	Plesetsk 11K65M	74.0	495x546	Tselina-OK Re-entered 08.01.1981
Kosmos-1062	15.12.1978 13.19	Plesetsk 11K65M	74.0	501x545	Tselina-OM Re-entered 20.04.1981
Kosmos-1114	11.07.1979 15.41	Plesetsk 11K65M	74.0	503x549	Tselina-OM Re-entered 26.12.1981
Kosmos-1215	14.10.1980 20.41	Plesetsk 11K65M	74.0	492x545	Tselina-OM Re-entered 12.05.1983
Kosmos-1345	31.03.1982 09.00	Plesetsk 11K65M	74.0	501x543	Tselina-OM Re-entered 27.09.1989

Launch times (some estimated) and orbital elements are from Jonathan McDowell's Launch Log and Satellite Catalog. See http://planet4589.org/space/jsr/jsr.html

tested or didn't even have all their systems installed. This left a lot of work to be done by cosmodrome personnel and also by design bureau engineers who often had to be dispatched to the launch site for months on end. The net result was that launches were regularly delayed or that low-quality satellites were sent into space. TsUKOS, which placed orders for the satellites, was forced by law to impose financial sanctions on the manufacturer if satellites malfunctioned earlier than expected, but at the same time was not allowed to reward the manufacturer if the satellites *exceeded* their design lifetime. In order to stimulate the manufacturer to produce better satellites, a system of financial rewards *was* eventually worked out, but according to the officer in question "these matters remained unresolved for many years due to the absence in those days of well-developed economic relations and the conservatism of financial and legal structures". Another problem recalled by the officer was that during the early flights there was often disagreement on when to declare the satellites defunct, which would depend on how many of the 10 on-board receivers were still operational. Eventually, a set of criteria was worked out between a branch of the NII-4 military research institute and the manufacturer that helped determine when satellites should be written off [64].

9.2 Tselina-D

As the Tselina-O series began its test flights, KB Yuzhnoe continued design work on the heavier and more complex Tselina-D series. These satellites weighed 1750 kg and had a payload mass of 630 kg. The SIGINT detectors were mounted on four panels at the base of the satellite bus. Extending from both sides of the bus were solar panels that could be turned towards the Sun. In orbits where the satellite was continuously exposed to the Sun, the panels provided 350W of power (diminishing to 315W by the end of its active lifetime) and in orbits where the satellite spent a maximum amount of time in the Earth's shadow these values were 200W early on in the mission and 180W towards the end. Tselina-D was a three-axis oriented spacecraft with the base petals facing downward. Assisting in stabilization were gyroscopes, star sensors and an extendable boom on top of the satellite. Accuracy in roll was better than 5° and accuracy in pitch and yaw was better than 10°. The pressurized bus was 3.2 m high and tapered from 1.0 m at the top to 1.35 m at the bottom. Information picked up by the satellite could be stored on board and then replayed to ground stations. Design lifetime was six months [65].

Tests flights of Tselina-D began with the launch of Kosmos-389 from Plesetsk on 18 December 1970. The satellite was placed into a 638x687 km orbit inclined 81.1° to the equator by the Vostok-2M booster (8A92M). This was an R-7 derived launch vehicle specially tailored for launches into high-inclination orbits that had been used since 1967 to orbit Meteor weather satellites. Actually, since the orbital parameters of Tselina-D were virtually identical to those of the Meteors, Western analysts initially interpreted them either as failed Meteors or military versions of Meteor. However, as more and more satellites appeared in orbit, it became clear that they had nothing to do with the Meteor programme. Moreover, Meteor switched to higher orbits at 900 km in 1971, while the Kosmos satellites continued to be launched into roughly 600 km orbits. Also, by 1975 it emerged that the satellites were launched into orbital planes spaced 60° apart (as opposed to 90° for Meteor). By this time the Russians had two of the satellites operational at any one time in conjunction with about five to six Tselina-OM area survey satellites.

In 1978 all six orbital planes of the Tselina-D constellation were filled for the first time and this also coincided with a decrease in the launch rate of Tselina-OM satellites, which were gradually phased out. A government decree on 10 December 1976 had declared the Tselina-D constellation operational, along with the Vostok-2M rocket [66]. The Tselina programme once again was the scene of a tragic launch pad accident on 18 March 1980, when a Vostok-2M exploded on the launch pad during fuelling, killing 48 people. Whether these accidents can at least partly be attributed to the high launch rate and resulting fatigue or complacency among launch pad personnel remains open to debate.

A major development in the programme took place in the late 1970s-early 1980s with a gradual switch from the Vostok-2M rocket to Yuzhnoe's own three-stage 11K68/Tsiklon-3 rocket. This switch had been in the works since at least 1967, when a government resolution had called for using the booster to launch "Meteor and Kosmos" satellites [67]. Final approval for the development of the 11K68 came with a government resolution on 2 January 1970, which mentioned Meteor and Tselina-D as the intended payloads [68]. However, work on the new rocket moved to the background as KB Yuzhnoe was too preoccupied with its ICBM projects and did not resume in earnest until 1975 with the release of yet another government decree [69]. Finally, in 1977 and 1978 the Tsiklon-3 carried out a series of four test flights, three of which flew mass models of the Tselina-D satellites (called EPN 03.0380). One of these was equipped with sensors to record the vibrations it was exposed to during launch. These inert payloads ended up in rather strange elliptical orbits with an inclination of 75.8° that had little in common with those used by Tselina-D. The Tsiklon-3 was declared operational for use in the Tselina-D and Meteor-2 programmes by a government decree in January 1980 [70]. The first launch of a "live" Tselina-D with the Tsiklon-3 seems to have taken place in June 1978 (Kosmos-1025), although it would not be until April 1983 that the Tsiklon-3 definitively replaced the Vostok-2M [71].

An analysis of the orbits of the Vostok-2M launched Tselina-D satellites shows a rather wide variety of altitudes. While the majority was launched into orbits higher than 600 km, there was also a significant group put into roughly 550 km circular orbits and a few even lower than 500 km. Although there must have been operational needs for such significant differences in orbital altitude, at least some of the variety seen within those three groups may have been caused by the inaccuracy of the direct-insertion launch profile used by the Vostok-2M, whose Blok-E upper stage was not restartable. The Tsiklon-3 was able to achieve much higher accuracy by using its restartable S5M upper stage to circularise the orbit once apogee was reached. The orbits of most of the satellites were chosen such that the ground track repeated itself every three days (a 44 circuit repeater pattern), which given the 82.5° inclination required them to orbit at an average altitude of 647

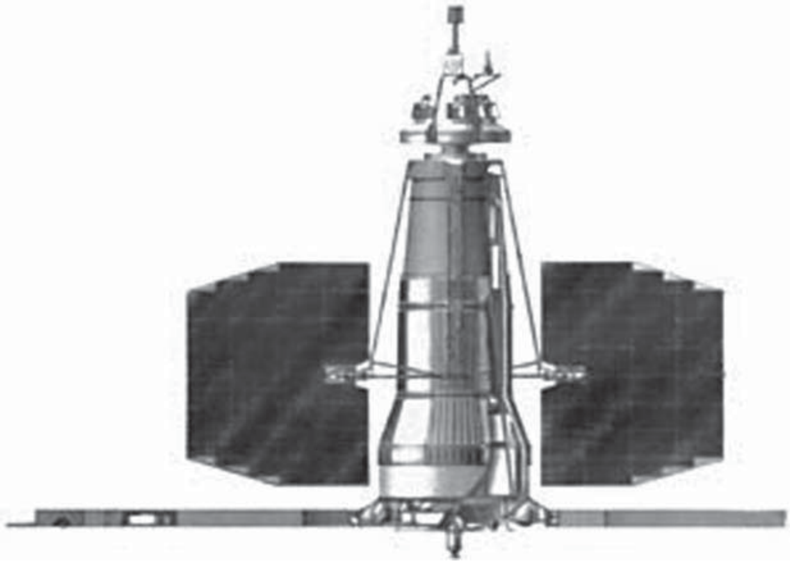

Fig. 15 Tselina-D satellite.
(source: GKB Yuzhnoe)

Fig. 16 The Tsiklon-3 launch vehicle.
(source: GKB Yuzhnoe)

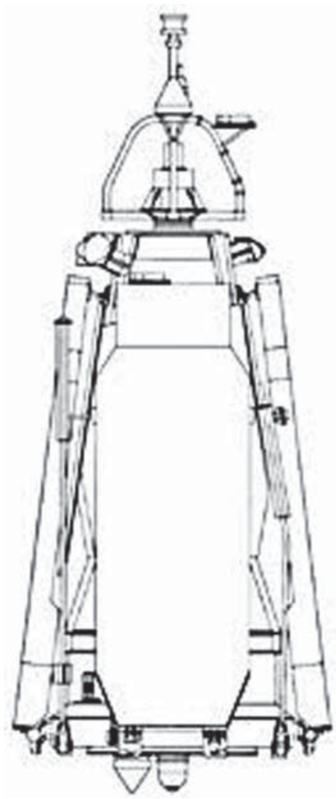

Fig. 17 Tselina-D mass model (EPN 03.0380).
(source : GKB Yuzhnoe)

km. This repeating pattern ensured multiple listening opportunities within a short time and thereby provided a greater probability of detection and quicker positioning.

Because of the slightly different orbital inclination (82.5° vs. 81.2° for Vostok-2M), a new constellation of Tselina-D satellites had to be gradually built up. Initially, the Tsiklon-launched satellites were placed into orbits spaced 45° or 90° apart before the standard pattern of 60° intervals was picked up again in 1983. Analysis of telemetry from the satellites picked up by the Kettering Group showed that there regularly was more than one functional satellite in a given orbital plane, indicating that some were launched as back-ups rather than to replace defunct satellites. By 1985 all the six newly created orbital planes were fully occupied and they were scrupulously maintained the following three years with an annual launch rate of four to five. A major target of the satellites during the 1980s may have been the PAVE PAWS radars that gradually came on line in the US to provide early warning of Soviet SLBM attacks. The capabilities of the Tselina-D satellites were gradually improved over their 20-year tour of duty

TABLE 2: *List of Tselina-D Launches.*

Official name	Launch date/time (UTC)	Launch site and vehicle	Inclination	Perigee/Apogee	Comments
Kosmos-389	18.12.1970 16.15	Plesetsk 8A92M	81.1	638x687	Re-entered 24.11.2003
Kosmos-405	07.04.1971 07.10	Plesetsk 8A92M	81.2	672x679	
Kosmos-476	01.03.1972 11.15	Plesetsk 8A92M	81.2	613x633	Re-entered 25.10.1991
Kosmos-542	28.12.1972 11.00	Plesetsk 8A92M	81.2	524x640	Re-entered 09.10.1983
Kosmos-604	29.10.1973 14.00	Plesetsk 8A92M	81.2	609x636	Re-entered 19.02.1992
Kosmos-673	16.08.1974 03.41	Plesetsk 8A92M	81.2	604x635	Re-entered 01.06.1991
Kosmos-744	20.06.1975 06.54	Plesetsk 8A92M	81.2	598x636	Re-entered 12.10.1991
Kosmos-756	22.08.1975 02.11	Plesetsk 8A92M	81.2	476x490	Re-entered 05.11.1992
Kosmos-808	16.03.1976 17.22	Plesetsk 8A92M	81.2	490x512	Re-entered 20.11.1993
Kosmos-851	27.08.1976 14.35	Plesetsk 8A92M	81.2	565x635	Re-entered 05.08.1989
Kosmos-895	26.02.1977 21.18	Plesetsk 8A92M	81.2	609x632	Re-entered 22.03.1992
Kosmos-921	24.06.1977 10.30	Plesetsk 11K68	75.8	598x666	Tselina-D mass model (EPN 03.0380) on maiden test launch of Tsiklon-3
Kosmos-925	07.07.1977 07.25	Plesetsk 8A92M	81.2	483x498	Re-entered 29.04.1993
Kosmos-955	20.09.1977 01.01	Plesetsk 8A92M	81.2	559x568	Re-entered 07.09.2000
Kosmos-956	24.09.1977 10.15	Plesetsk 11K68	75.8	352x861	Tselina-D mass model (EPN 03.0380) on test launch of Tsiklon-3
Kosmos-972	27.12.1977 08.00	Plesetsk 11K68	75.8	712x1159	Tselina-D mass model (EPN 03.0380) on test launch of Tsiklon-3
Kosmos-975	10.01.1978 13.23	Plesetsk 8A92M	81.2	550x563	Re-entered 19.09.2001
Kosmos-1005	12.05.1978 04.07	Plesetsk 8A92M	81.2	536x547	Re-entered 15.06.2000
Kosmos-1025	28.06.1978 17.35	Plesetsk 11K68	82.5	604x630	
Kosmos-1043	10.10.1978 19.44	Plesetsk 8A92M	81.2	530x544	Re-entered 27.02.1998
Kosmos-1063	19.12.1978 01.35	Plesetsk 8A92M	81.2	555x556	Re-entered 25.11.2001
Kosmos-1077	13.02.1979 21.41	Plesetsk 8A92M	81.2	535x542	Re-entered 26.06.2000
Kosmos-1093	14.04.1979 05.27	Plesetsk 8A92M	81.2	550x556	Re-entered 23.03.2000
Kosmos-1116	20.07.1979 11.58	Plesetsk 8A92M	81.1	475x504	Re-entered 11.03.1993
Kosmos-1143	26.10.1979 18.12	Plesetsk 8A92M	81.2	623x640	Re-entered 17.02.2002

TABLE 2: *List of Tselina-D Launches (Contd).*

Official name	Launch date/time (UTC)	Launch site and vehicle	Inclination	Perigee/Apogee	Comments
Kosmos-1145	27.11.1979 09.55	Plesetsk 8A92M	81.2	622x631	Re-entered 16.06.2000
Kosmos-1154	30.01.1980 12.51	Plesetsk 8A92M	81.2	629x641	Re-entered 05.11.2000
-	18.03.1980	Plesetsk 8A92M	-	-	Launch vehicle explodes during fuelling. 48 people killed
Kosmos-1184	04.06.1980 07.34	Plesetsk 8A92M	81.2	619x645	Re-entered 29.04.2002
Kosmos-1206	15.08.1980 05.34	Plesetsk 8A92M	81.2	628x631	Re-entered 13.01.2002
Kosmos-1222	21.11.1980 11.53	Plesetsk 8A92M	81.2	628x629	
Kosmos-1242	27.01.1981 14.58	Plesetsk 8A92M	81.1	625x653	
Kosmos-1271	19.05.1981 03.49	Plesetsk 8A92M	81.1	590x608	
Kosmos-1300	24.08.1981 21.40	Plesetsk 11K68	82.4	606x630	
Kosmos-1315	13.10.1981 23.01	Plesetsk 8A92M	81.1	591x623	
Kosmos-1328	03.12.1981 11.47	Plesetsk 11K68	82.5	609x636	
Kosmos-1340	19.02.1982 01.42	Plesetsk 8A92M	81.2	629x647	
Kosmos-1346	31.03.1982 16.27	Plesetsk 8A92M	81.1	622x658	
Kosmos-1356	05.05.1982 08.01	Plesetsk 8A92M	81.1	631x667	
Kosmos-1378	10.06.1982 17.37	Plesetsk 11K68	82.5	633x663	
Kosmos-1400	05.08.1982 06.56	Plesetsk 8A92M	81.1	629x648	
Kosmos-1408	16.09.1982 04.55	Plesetsk 11K68	82.5	631x666	
Kosmos-1437	20.01.1983 17.26	Plesetsk 8A92M	81.1	627x655	
Kosmos-1441	16.02.1983 10.03	Plesetsk 8A92M	81.1	629x638	
Kosmos-1455	23.04.1983 14.30	Plesetsk 11K68	82.5	632x661	
Kosmos-1470	22.06.1983 23.58	Plesetsk 11K68	82.5	632x667	
Kosmos-1515	15.12.1983 12.25	Plesetsk 11K68	82.5	635x663	
Kosmos-1536	08.02.1984 09.23	Plesetsk 11K68	82.5	633x666	
Kosmos-1544	15.03.1984 17.05	Plesetsk 11K68	82.5	632x665	
Kosmos-1606	18.10.1984 17.46	Plesetsk 11K68	82.5	608x642	

TABLE 2: *List of Tselina-D Launches (Contd).*

Official name	Launch date/time (UTC)	Launch site and vehicle	Inclination	Perigee/Apogee	Comments
Kosmos-1626	24.01.1985 16.45	Plesetsk 11K68	82.5	629x662	
Kosmos-1633	05.03.1985 15.39	Plesetsk 11K68	82.5	636x657	
Kosmos-1666	08.07.1985 23.40	Plesetsk 11K68	82.5	611x641	
Kosmos-1674	08.08.1985 11.49	Plesetsk 11K68	82.5	630x665	
Kosmos-1703	22.11.1985 22.20	Plesetsk 11K68	82.5	633x665	
Kosmos-1707	12.12.1985 15.51	Plesetsk 11K68	82.5	633x665	
Kosmos-1726	17.01.1986 07.21	Plesetsk 11K68	82.5	630x664	
Kosmos-1733	19.02.1986 23.04	Plesetsk 11K68	82.5	631x662	
Kosmos-1743	15.05.1986 04.26	Plesetsk 11K68	82.5	631x664	
Kosmos-1758	12.06.1986 04.43	Plesetsk 11K68	82.5	628x671	
Kosmos-1782	30.09.1986 18.34	Plesetsk 11K68	82.5	634x665	
Kosmos-1812	14.01.1987 09.05	Plesetsk 11K68	82.5	633x665	
Kosmos-1825	03.03.1987 15.03	Plesetsk 11K68	82.5	630x665	
Kosmos-1842	27.04.1987 00.00	Plesetsk 11K68	82.5	633x667	
Kosmos-1862	01.07.1987 19.35	Plesetsk 11K68	82.5	630x668	
Kosmos-1892	20.10.1987 09.09	Plesetsk 11K68	82.5	633x665	
Kosmos-1908	06.01.1988 07.41	Plesetsk 11K68	82.5	633x665	
Kosmos-1933	15.03.1988 18.50	Plesetsk 11K68	82.5	634x661	
Kosmos-1953	14.06.1988 03.18	Plesetsk 11K68	82.5	631x668	
Kosmos-1975	11.10.1988 08.01	Plesetsk 11K68	82.5	629x664	
Kosmos-2221	24.11.1992 04.10	Plesetsk 11K68	82.5	635x664	
Kosmos-2228	25.12.1992 20.08	Plesetsk 11K68	82.5	632x667	
-	25.05.1994 10.15	Plesetsk 11K68	-	-	Launch failure

Launch times (some estimated) and orbital elements are from Jonathan McDowell's Launch Log and Satellite Catalog. See http://planet4589.org/space/jsr/jsr.html and much of the experience gained was put to use in developing the second generation Tselina-2 satellites [72]. In 1989, as Tselina-2 finally became operational, the launch rate of Tselina-D abruptly dropped to zero. After two more launches in 1992 and a launch failure in 1994 the programme was closed down.

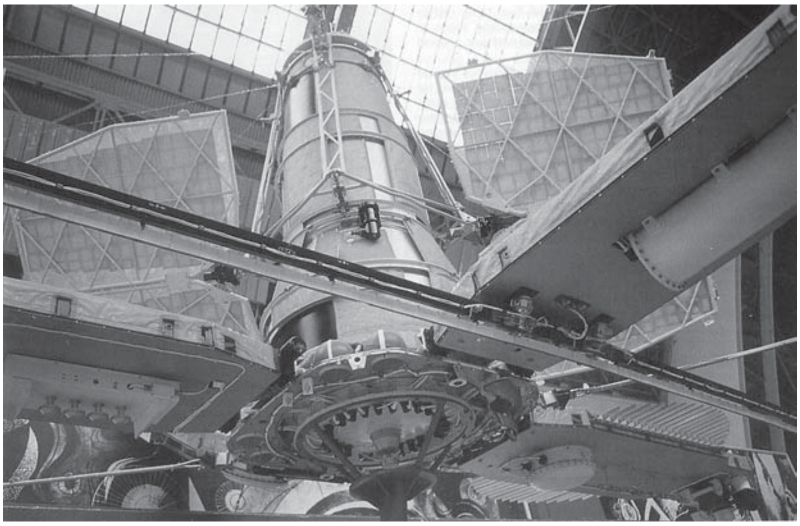

Fig. 18 Okean satellite on display at the "Kosmos" pavillion in Moscow. The bus is identical to that of Tselina-D. (source: B. Harvey)

US intelligence data indicates that although Tselina-D's ELINT suite was roughly the same as that of Tselina-O (ten scanning receivers and two tape record/playback units), it was a much more capable satellite. Its data storage and transmission capability was about twice as high and its capacity to change attitude allowed it to stay fixed on one target if needed. However, as its area survey cousin, it virtually had no realtime intelligence reporting capability, being programmed once a day to collect information on between 7 to 15 targets. The satellites provided detailed electronic-order-of-battle reconnaissance and technical intelligence and also augmented the data on shipborne radars gathered by Tselina-O. The data intercepted on foreign radars included characteristics such as radio frequency, pulse repetition interval and pulse duration data. Analysis of the early missions pointed to a direction finding capability to within 25 nautical miles and possibly within 5 nautical miles if the target was close to the satellite's nadir [73]. In 1983 the CIA estimated that the direction finding accuracy ranged from 8 to 220 km depending on the number of passes and the distance to the target [74]. One newspaper article reported that the location of an emitter could be determined with an accuracy of within 10 km on the first orbit [75].

In a 1980 CIA assessment of Soviet military space capabilities Tselina-D was compared with Tselina-O. It could not only monitor the radar environment of SAM missiles and early warning systems, but also identify specific types of missiles and early warning systems and locate newly deployed systems. Just like Tselina-O, it was capable of monitoring the radar environment of surface ships and identifying radar types used on ships, but in addition to that it could more accurately pinpoint the location of ships at sea. Another mission of Tselina-D reportedly was to locate and determine the composition and status of ground forces [76].

As had long been suspected by Western analysts, the Tselina-D bus was used for the first generation of KB Yuzhnoe's Okean civilian oceanographic satellites, which were approved by a government decree dated 5 May 1977 [77]. The first experimental version (Okean-OE/Kosmos-1076) was launched in February 1979. The three-axis stabilized Tselina-D bus turned out to be an ideal platform for remote sensing equipment. Actually, the parameters and the external features of the two satellites are strikingly similar, the only obvious difference being the replacement of the SIGINT antennas by ocean monitoring devices on the four lower payload panels. Just like Tselina-D, the first-generation Okeans had a design lifetime of six months, but in practice this was always exceeded, with the satellites remaining functional from one up to three years [78]. Therefore, it can be assumed that many of the Tselina-D satellites also operated longer than six months. The above quoted US intelligence sources mentioned lifetimes of between 10 and 16 months.

9.3 Tselina-R

Another subclass of Tselina satellites known as Tselina-R was introduced in 1986. Actually, this was a variant of Tselina-D, using a lighter SIGINT payload (350 kg). However, the overall mass was the same as that of Tselina-D (1750 kg), indicating the bus was heavier. All that has been revealed about the purpose of these satellites is that they were designed to "observe radio emission sources" and made it possible "to carry out SIGINT tasks in full". Just four were launched (in 1986, 1990, 1991 and 1993). Two were placed into existing Tselina-D orbital planes and two others exactly midway between two Tselina-D planes. Since the orbital altitude and inclination of these satellites were identical to those of Tselina-D, no one had ever distinguished the four satellites from Tselina-D until they were recently identified [79].

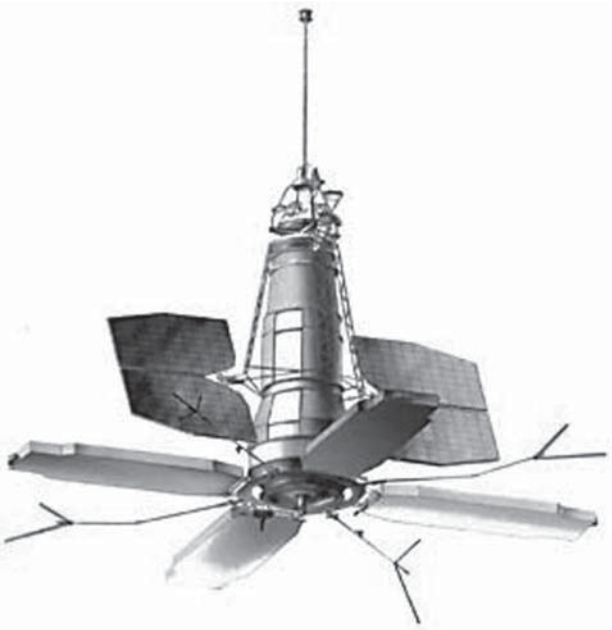

Fig. 19 Tselina-R. **(source: GKB Yuzhnoe)**

Two explanations may currently be offered for the need to fly this short-lived series. One possibility is that they were designed to test systems for a constellation of third-generation SIGINT satellites that was planned in the mid-1980s. More specifically, they could have been used to test sensors for a geostationary COMINT satellite that would be part of that constellation [80]. Problems with this explanation are that plans for this constellation had probably already been abandoned in the early 1990s (when three of the four Tselina-R satellites were flown) and that design features of COMINT sensors for a geostationary satellite may have been difficult to test on low-orbiting satellites.

Another possibility is that Tselina-R was seen as an interim solution to provide area-survey electronic intelligence until the Tselina-2 satellites became fully operational. Tselina-2 was supposed to combine the functions of Tselina-D and Tselina-O by conducting both detailed and wide-area ELINT, but the programme suffered numerous setbacks in the mid-1980s and early 1990s, exactly the time when the Tselina-R satellites were launched. It is also notable that the antennas seen on Tselina-O(M) and Tselina-R look quite similar. Still, the real motives for flying these satellites may well have been very different and still await clarification from Russian sources.

10. Second-Generation Tselina

10.1 Origins

Even as the first-generation Tselina satellites were in their initial stages of deployment, studies conducted at the Soviet Union's main military space research institute TsNII-50 (set up in April 1972) showed that a much more capable follow-on system would be needed to satisfy future needs. The new satellites would have to detect a wider range of frequencies, have more sensitive receiving devices and have improved capability for on-board processing of intercepted signals [81]. Called Tselina-2 (11F644), they had to combine the functions of the Tselina-O and Tselina-D satellites, conducting both area-survey and detailed SIGINT [82].

The Tselina-2 system was first mentioned in the government's five-year plan of space exploration for 1971-1975, which included proposals for several second-generation military satellites. In March 1973 responsibility for the project was divided among the same design bureaus as those involved in the first-generation Tselina: TsNIRTI (the former TsNII-108) was placed in charge of the project as a whole and of the development of the SIGINT equipment (chief designer M. Zaslavskiy), KB Yuzhnoe was to provide the bus and the launch vehicle, OKB MEI (headed by A. Bogomolov) was to deliver systems for relaying the highly classified information to Earth and TsNII-50 was to work out the system's specifications. The preliminary design of

TABLE 3: *List of Tselina-R Launches.*

Official name	Launch date/time (UTC)	Launch site and vehicle	Inclination	Perigee/Apogee	Comments
Kosmos-1805	10.12.1986 07.30	Plesetsk 11K68	82.5	634x662	Launched midway between two existing Tselina-D orbital planes.
Kosmos-2058	30.01.1990 11.20	Plesetsk 11K68	82.5	629x665	Launched into existing Tselina-D orbital plane.
Kosmos-2151	13.06.1991 15.41	Plesetsk 11K68	82.5	635x663	Launched into existing Tselina-D orbital plane.
Kosmos-2242	16.04.1993 07.49	Plesetsk 11K68	82.5	633x667	Launched midway between two existing Tselina-D orbital planes.

Launch times and orbital elements are from Jonathan McDowell's Launch Log and Satellite Catalog. See http://planet4589.org/space/jsr/jsr.html

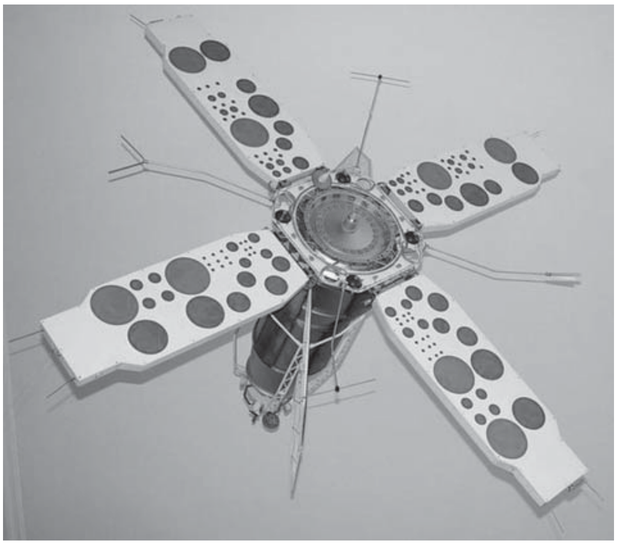

Fig. 20 Unidentified Tselina (D or R). (source: Arsenal magazine/Intervestnik)

Tselina-2 was finished in the first quarter of 1974 and specifications were sent to the contractors in May 1974. In July 1975 the Military Industrial Commission (VPK) approved a timetable for development of the system. In December 1976 the government issued a decree which called for test flights to begin in the first quarter of 1980, with the system to be declared operational in 1982 [83].

Although the initial goal may have been to launch Tselina-2 with the Tsiklon-3 booster, the requirements placed upon the satellite eventually dictated the use of a heavier launch vehicle. The choice fell on a medium-lift rocket being developed by KB Yuzhnoe, known as 11K77 and later dubbed "Zenit". Studies of an 11K77 class rocket at KB Yuzhnoe began in the early 1970s and initially focused on developing an uprated version of the R-36M ICBM (with hypergolic propellants) and then on a modular LOX/kerosene booster. The preliminary design for this booster was finished in December 1974, but in the following months the idea emerged to unify the first stage of the rocket with the strap-on boosters of the heavy-lift Energiya rocket under development at NPO Energiya. A government decree approving the development of that version of the 11K77 was issued in March 1976 [84].

The use of the heavy Zenit made it possible among other things to equip the satellites with a system to relay information to the ground via geostationary data relay satellites (which themselves had been approved by a government decree in February 1976, the same one that gave the go-ahead for Energiya/Buran) and to install new equipment "to measure the position of the spacecraft". The final configuration of Tselina-2 and the use of Zenit was approved by the VPK on 27 April 1979 [85].

Fig. 21 Tselina-2. (source: GKB Yuzhnoe)

Sometime in the late 1970s there appears to have been another attempt to unify the Tselina and electronic ocean reconnaissance programmes, but the Navy began working on a second-generation ocean reconnaissance system known as Ideogramma/Pirs (consisting of the Pirs-1 satellites for detecting ships and Pirs-2 for detecting submarines). The system was approved by a government decree in June 1981 but was ultimately never deployed [86].

10.2 Design

In its final configuration Tselina-2 weighed 3250 kg with a SIGINT payload of 1120 kg. Actually, Tselina-2 was far underweight for the Zenit (which could place up to 8 tons into the orbit required for Tselina-2), but it was the only booster in KB Yuzhnoe's inventory capable of launching the satellite. The use of Zenit-2 misled some analysts into believing that Tselina-2 was similar in design to the 6.2 ton second-generation Okean ("Okean-O") launched in 1999. In the early 1990s Yuzhnoe *did* plan to develop an Okean derived from the Tselina-2 bus (Okean-M or Okean-O2), but this was never flown.

Tselina-2 basically is an enlarged version of Tselina-D. Its pressurized bus is 4.46 m high with a diameter ranging from 1.2 to 1.4 m. Power is provided by two turnable solar panels extending from both sides of the satellite bus and what appears to be a third panel mounted over the bus. Maximum power output in a "solar orbit" is 900W (decreasing to 720W at the end of the active lifetime) and in

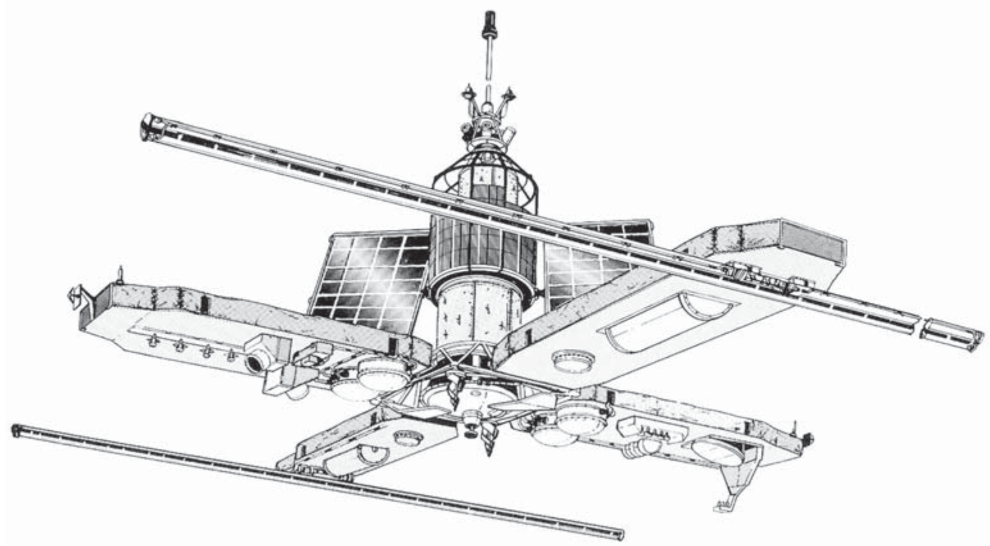

Fig. 22 Unflown Okean satellite (Okean-M/Okean-O2) derived from the Tselina-2 bus. (source: N. Johnson)

orbits where the spacecraft spends most of its time in the Earth's shadow this is reduced to 450W (down to 360W by the end of the active lifetime). Pointing accuracy of the three-axis stabilized spacecraft is said to have been improved, although no further details are given. Design lifetime is one year, double that of the Tselina-O and D satellites [87].

Little has been revealed about the SIGINT payload, only that it is named "Korvet" and combines the "close look" and "area survey" functions of Tselina-O and Tselina-D. It is said to be capable of detecting a wider range of frequencies and the "ground swath for detailed observations has been widened". Data can be sent to ground stations much more regularly and timely by relaying them via the Geizer data relay satellites [88]. The lower inclination used by Tselina-2 (71°) made it possible to increase the frequency of detection in the temperate zones, while the higher altitude (850 km) meant that polar coverage was retained as well [89]. Possibly it was planned to eventually launch Tselina-2 into orbits with higher inclinations from Plesetsk, but the construction of a Zenit pad at the northern cosmodrome (begun in 1986) was discontinued in 1994.

10.3 Missions

The original goal of launching the first Tselina-2 test flight in the first quarter of 1980 turned out to be overly optimistic. On 29 April 1979 the VPK rescheduled the beginning of test flights for the second quarter of 1981, but even that goal proved unattainable, mainly because of the unavailability of the new Zenit rocket. The March 1976 government resolution on the Zenit had set the maiden launch of the booster for the second quarter of 1979, but there were serious problems with the development of the RD-171 first-stage engine, culminating with the explosion of a Zenit first stage during a test firing at the facilities of NIIKhimMash in Zagorsk in June 1982.

With the first Tselina-2 satellites ready for launch long before the Zenit, a decision was made in 1983-1984 to launch the first three satellites using the Proton rocket with a Blok-DM2 upper stage [90]. In order to reach the planned orbit, the Proton had to follow a rather unusual launch profile requiring three firings of the Blok-DM2 upper stage. The first took place as the assembly passed through the descending node of its orbit some 30 minutes after launch, placing it in a 51.6°, 190-835 km orbit. A second burn followed 50 minutes later when the assembly passed through the ascending node, raising the orbit to 815-855 km with an inclination of 66.6°. Another 25 minutes later a third manoeuvre, a non-equatorial plane-changing manoeuvre over the Plesetsk cosmodrome, put Tselina-2 into its final 850 km orbit at 71° [91]. Eventually, two of the three planned Proton launches were carried out (Kosmos-1603 and 1656 in September 1984 and May 1985). The State Commission for these and following Tselina-2 test flights was headed by former cosmonaut Gherman Titov, the deputy head of the Military Space Forces.

Meanwhile, the Zenit was gearing up for its first test flights. Just like the test flights of the Tsiklon-3, these were to carry mass models of satellites instrumented to record the vibrations and noise produced by the launch vehicle. Yuzhnoe developed two types of mass models, one called EPN 03.0694 that simulated the shape and mass of Tselina-2 and another called EPN 03.0695 that had an additional mass

Fig. 23 Tselina-2 mass model (EPN 03.0694).
(source: GKB Yuzhnoe)

attached to the basic Tselina-2 mass model to simulate a maximum payload [92]. For the Zenit launches of Tselina-2 the Russians returned to a direct-ascent launch profile, but one that achieved much higher insertion accuracy than the Vostok-2M thanks to the use of a vernier system with four gimballed thrust chambers on the second stage. After the second stage main engine shut down, the verniers would continue to fire until the second stage and attached payload had both the velocity and direction needed to maintain a 850 km circular orbit [93].

After a one-day delay, the first Zenit lifted off from the left pad of Complex 45 at Baikonur on 13 April 1985, but some 6.5 minutes into the flight the second stage engine shut down prematurely because of a faulty "fuel flow regulator" which had caused a higher than normal fuel consumption. The second launch attempt on 21 June 1985 also ended in failure due to a clogged filter in an oxidizer valve of one of the second stage vernier engines. Although the resulting explosion did throw three short-lived pieces of debris into low Earth orbit, the launch was not announced by the Soviet Union at the time. Both unsuccessful launches almost certainly carried EPN mass models, but it has not been confirmed exactly which ones. Finally, third time was the charm when another launch attempt on 22 October 1985 successfully placed an EPN 03.0694 model into a Tselina-2 type orbit. The stage was now set for the first launch of a "live" Tselina-2 by the 11K77 in December 1985, but once again disaster struck, when the payload fairing failed to jettison and the satellite ended up in a useless orbit. The Tselina-2 programme was not resumed until March 1987 with the launch of another 03.0694 mass model and, finally, in May of the same year a "live" Tselina-2 was successfully placed into orbit by a Zenit for the first time [94].

Three more launches in 1988-1990 established a 45° orbital plane separation pattern, the eventual goal being to have four satellites in operation simultaneously. The Zenit and Tselina-2 were officially declared operational by a government decree dated 1 December 1988, although many at the Baikonur cosmodrome felt that more test flights were needed [95]. This probably did not pertain only to the Zenit, but also to Tselina-2. By this time only five satellites had been launched and one report says the first "really functioning" spacecraft wasn't orbited until late 1988 [96]. This contrasts sharply with the official assessment of the test flights given in the history of the Military Space Forces: "not only did the system demonstrate its big potential to timely obtain valuable data on a whole range of strategic objects in likely land and sea-based military theatres, it was also possible to use the information to send targeting data to various combat means in near real time" [97].

At any rate, the fears of the cosmodrome personnel turned out to be prophetic when the Zenit suffered an amazing string of catastrophic launch failures in 1990-1992. The first (on 4 October 1990) ended with the rocket crashing back onto the launch pad just seconds after liftoff, completely destroying one of the two Zenit pads, which has never been repaired since. The next Tselina-2 launch attempt on 27 July 1991 was aborted with just seconds left in the countdown, forcing the rocket to be shipped back to KB Yuzhnoe for repairs [98]. Another Zenit lifted off on 30 August 1991, but this time the second stage failed, a scenario repeated during the next launch attempt on 5 February 1992. It wasn't until November 1992 that another Tselina-2 safely reached orbit, more than 2.5 years after the previous success. Unless the older satellites significantly exceeded their one-year design lifetime, the constellation of operational Tselina-2 satellites may well have dwindled to zero during this period.

The constellation was gradually replenished in 1992-1995, with a total of seven satellites being launched into orbital planes spaced 40° or 45° apart, although one of them (Kosmos-2237) is said to have

TABLE 4: *List of Tselina-2 Launches*

Official name	Launch date/time (UTC)	Launch site and vehicle	Inclination	Perigee/Apogee	Comments
Kosmos-1603	28.09.1984 14.00	Baikonur 8K82K	71.0	850x854	Maiden launch of Tselina-2 on Proton/Blok-D.
-	13.04.1985 ?	Baikonur 11K77			Possible mass model of Tselina-2 (EPN 03.0694) on Zenit test launch. Second stage failure.
Kosmos-1656	30.05.1985 14.59	Baikonur 8K82K	71.1	807x858	Second launch of Tselina-2 on Proton/Blok-D.
-	21.06.1985 08.29	Baikonur 11K77	64.4	194x339	Possible mass model of Tselina-2 (EPN 03.0694) on Zenit test launch. Second stage failure. Three pieces of debris reached orbit and were catalogued as 1985-53A-C.
Kosmos-1697	22.10.1985 07.00	Baikonur 11K77	70.9	848x855	Mass model of Tselina-2 (EPN 03.0694) on Zenit test launch.
Kosmos-1714	28.12.1985 09.16	Baikonur 11K77	70.9	160x699	First “live” Tselina-2 launched on Zenit. Wrong orbit.
Kosmos-1833	18.03.1987 08.30	Baikonur 11K77	71.0	848x852	Mass model of Tselina-2 (EPN 03.0694) on Zenit test launch.
Kosmos-1844	13.05.1987 05.40	Baikonur 11K77	71.0	848x852	First succesful launch of “live” Tselina-2 by Zenit.
Kosmos-1943	15.05.1988 09.20	Baikonur 11K77	71.0	847x852	
Kosmos-1980	23.11.1988 14.50	Baikonur 11K77	71.0	848x854	
Kosmos-2082	22.05.1990 05.14	Baikonur 11K77	71.0	847x856	
-	04.10.1990 04.28	Baikonur 11K77	-	-	First stage failure. Launch pad destroyed.
-	30.08.1991 08.58	Baikonur 11K77	-	-	Second stage failure.
-	05.02.1992 ?	Baikonur 11K77	-	-	Second stage failure.
Kosmos-2219	17.11.1992 07.47	Baikonur 11K77	71.0	848x855	Second stage failure.
Kosmos-2227	25.12.1992 05.56	Baikonur 11K77	71.0	848x854	
Kosmos-2237	26.03.1993 02.21	Baikonur 11K77	71.0	848x852	May have failed a few days after launch.
Kosmos-2263	16.09.1993 07.36	Baikonur 11K77	71.0	847x855	
Kosmos-2278	23.04.1994 08.02	Baikonur 11K77	71.0	848x855	
Kosmos-2297	24.11.1994 09.16	Baikonur 11K77	71.0	848x854	
Kosmos-2322	31.10.1995 20.19	Baikonur 11K77	71.0	848x852	
Kosmos-2333	04.09.1996 09.01	Baikonur 11K77	71.0	848x852	
-	20.05.1997 07.07	Baikonur 11K77	-	-	First stage failure.

TABLE 4: *List of Tselina-2 Launches (Contd).*

Official name	Launch date/time (UTC)	Launch site and vehicle	Inclination	Perigee/Apogee	Comments
Kosmos-2360	28.07.1998 09.15	Baikonur 11K77	71.0	846x855	
Kosmos-2369	03.02.2000 09.26	Baikonur 11K77	71.0	846x854	
Kosmos-2406	10.06.2004 01.28	Baikonur 11K77	71.0	847x865	

Launch times (some estimated) and orbital elements are from Jonathan McDowell's Launch Log and Satellite Catalog. See http://planet4589.org/space/jsr/jsr.html.

Fig. 24 Zenit-2 with Tselina-2 satellite (Kosmos-2369) on its way to the launch pad. (source: Federal Space Agency)

failed only days after launch [99]. Kosmos-2333, launched in September 1996, deviated from the established pattern by settling into a plane located 60° east of the existing constellation. The next Tselina-2 was then apparently targeted to be placed 45° east of Kosmos-2333, but was lost in yet another Zenit launch failure in May 1997. The next launch in July 1998 saw Kosmos-2360 entering an orbital plane midway between that of Kosmos-2333 and its predecessor Kosmos-2322 [100]. The next Tselina-2 was originally scheduled for launch in late December 1999, but eventually went up as Kosmos-2369 on 3 February 2000.

During a visit to the Yuzhmash plant in February 2001, Vladimir Putin reportedly reached agreement with Ukrainian President Leonid Kuchma (who, incidentally, headed Yuzhmash from 1986 to 1992) on launching two more Tselina-2 satellites, the assembly of which was apparently already underway at the time [101]. In early 2004 reports started appearing about the impending launch of a Zenit-2 with a military satellite, which could only be a Tselina-2. The rocket and satellite were delivered to Baikonur on 20 January for a planned launch in March, but didn't arrive on the launch pad until 24 April. Two subsequent launch attempts on 25-26 April had to be scrubbed due to problems with launch pad equipment, forcing the rocket to be rolled back to the assembly building on 27 April. The rocket returned to the pad on 9 June, finally inserting the Tselina-2 (Kosmos-2406) into orbit the following day [102]. Its orbital plane is 90° to the east of that of Kosmos-2369 [103].

Despite this latest launch and the prospect of at least one other, it looks likely that the Tselina-2 programme will be terminated in the near future. Not only could it be problematic for Yuzhmash to keep open the production line, twenty years after their initial deployment these satellites are undoubtedly out-of-date. It should also be taken into account that the satellites are dependent on the Geizer satellites for quick data relay to the Earth. The last of these (Kosmos-2371) was launched in July 2000 and no other launch is immediately in sight. Geizer satellites have operated for about five years on the average, meaning Kosmos-2371 may be nearing the end of its operational lifetime [104].

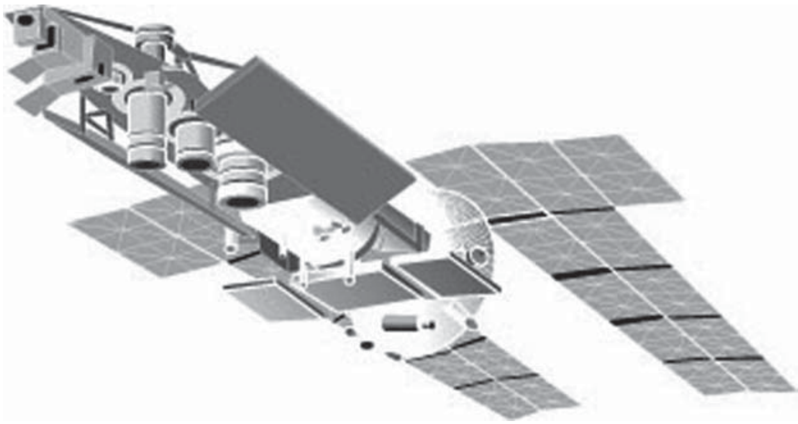

Fig. 25 Possible multi-purpose SIGINT satellite built at KB Arsenal. Based on a drawing obtained by Anatoliy Zak. (source: Novosti Kosmonavtiki)

11. Third-Generation Tselina

In the late 1970s, even as the Tselina-2 system was still being defined, designers already began thinking about a third generation of SIGINT satellites that would further expand the detectable frequencies [105]. A VPK decision on the development of the Tselina-3 system appeared as early as 27 August 1981 [106]. In January 1985 an interdepartmental commission headed by Gherman Titov reviewed various technical proposals that had been put forward and final development got underway during that same year. In order to speed up work, it was decided to perform some experiments related to the new system on two unidentified Tselina-D satellites flown in 1986-1987, which reportedly had a positive outcome. Apparently, the idea was that the new satellite would be used both for ELINT and COMINT, but it proved difficult to combine those functions on a single satellite. This is why it was decided in 1988 to develop two different constellations of satellites, one for ELINT in orbits between 800 and 2000 km and another for COMINT in geostationary orbit. Prime contractors for the ELINT system would be KB Yuzhnoe and a previously unidentified organization known as NPO Palma. Development of the COMINT system was assigned to NPO PM in Krasnoyarsk, the prime designer and manufacturer of Russian communications satellites. The COMINT satellite was to use the same bus as the Luch data relay satellites built by NPO PM [107].

Based on declassified CIA reports from the early 1980s, US intelligence thought there was “a moderate likelihood” that the Soviets would deploy a high-altitude SIGINT system by the mid to late 1980s. The deployment of a 10-metre diameter radio telescope on the Salyut-6 space station in 1979 was seen as a possible indication that the military were sponsoring work on similar high-gain antennas with the sensitivity necessary to detect low-power signals from high orbits. However, the system was expected to be used primarily for ELINT, because it was felt COMINT could be collected by other means [108].

Eventually, plans for the two Tselina-3 constellations were never realized, most likely because of the changing financial climate after the break-up of the Soviet Union in 1991. Besides that, there was the politically sensitive issue of having a Ukrainian design bureau (KB Yuzhnoe) build a military satellite for Russia. While the Russians had little choice but to rely on a continuing supply of the already flight-proven Tselina-2 satellites from Yuzhnoe in the 1990s, entrusting the bureau with the development of a new generation of SIGINT satellites was probably another matter.

12. Future Plans

The latest available information indicates that once again an attempt is being made to develop a multi-purpose low-orbiting SIGINT satellite for monitoring both land-based and ocean-based targets, a trend now also observed with low orbiting American SIGINT satellites.

In the early to mid-1990s the Arsenal design bureau in St. Petersburg was ordered to develop a satellite called “Liana” that would combine the functions of US-P, US-A and Tselina [109]. The Arsenal factory was placed in charge of manufacturing the US-A and US-P satellites in 1969 and the associated design bureau officially became the lead organization in charge of developing these satellites in 1980 [110]. Apparently, Liana was to use a new bus developed at KB Arsenal for the Ideogramma-Pirs ocean reconnaissance system. Originally intended for launch by Zenit, it looks like this platform was retailored for launch by the Soyuz-2 rocket after the collapse of the USSR [111]. Liana was at least temporarily considered as a platform to mount a cosmic ray experiment called “Nuklon”, developed by the Skobeltsyn Institute of Nuclear Physics in Moscow [112].

Work on Liana was suspended due to a lack of financing and also because the Military Space Forces, who had ordered the new satellite, were absorbed by the Strategic Rocket Forces in 1997 [113]. Even though the Space Forces were resurrected as an independent branch of the armed forces in 2001, the current status of the project is unclear. Talking to reporters after a visit to Arsenal in June 2001, the head of the Russian Space Forces Anatoliy Perminov seemed to indicate that an advanced ELINT satellite built by Arsenal would be launched later that year, but those plans did not materialize [114]. In March 2003 a representative of KB Arsenal told a seminar in Russia that work was continuing on an advanced "Kosmos" satellite to be placed into a roughly 500 km orbit inclined 70° to the equator [115]. One recent report suggests that Liana will be the payload for the first test flight of the Tsiklon-2K rocket, a Tsiklon-2 with an apogee propulsion stage (ADU-600) to be launched from Baikonur [116]. This would indicate that the satellite weighs just over 2 tons and may be rather similar in design to the US-P satellites. However, only time will tell if Russia can afford to field a new constellation of satellites able to fully meet its signals intelligence requirements.

13. Conclusion

With signals intelligence being a very sensitive area, one can only be surprised at the amount of data that the Russians have so far released about their SIGINT satellites. Whereas the United States has declassified only its very first SIGINT satellites flown in the early 1960s, the Russians have published basic design details and even drawings of *all* their SIGINT satellites, even the ones that are still flying today. Nevertheless, countless questions remain to be answered, not only about the technical aspects of the satellites and their exact capabilities, but – perhaps more importantly - about the decisions that were made behind the scenes and the people who shaped the course of the programme. Therefore, this article should be seen as no more than an attempt to collect the relatively sparse information currently available and make some educated guesses. Unfortunately, there are unmistakable signs that the policy of relative openness regarding Russia's current and former military space systems is coming to an end and that it may be many more years before the true story can be told [117].

14. Acknowledgements

The author would like to thank Matthew Aid, Dwayne Day and Asif Siddiqi for their comments.

References

1. Other components of SIGINT are RADINT (radar intelligence), LASINT (laser intelligence) and non-imaging infrared. RADINT is generally considered to be intelligence obtained *by means* of radar (although sometimes it is interpreted as electronic intelligence of radar signals). See J.T. Richelson, "*The US Intelligence Community*", New York, Ballinger, 1989. The chapter on signals intelligence is on-line at http://www.ozpeace.net/OldSite/pinegap/richelson.htm
2. Information on KGB/FAPSI/GRU is from the Russian-language website http://www.agentura.ru
3. The existence of SOUD was revealed by KGB defector Oleg Gordievskiy in his book "*KGB – razvedyvatel'nye operatsii ot Lenina do Gorbacheva*", Moscow, Tsentrpoligraf, 1999, but has never been publicly acknowledged.
4. "Lourdes Signals Intelligence Facility", article on the website of the Federation of American Scientists at http://www.fas.org/irp/imint/c80_04.htm; D. Emery, "Russian SIGINT", on-line at http://www.jya.com/rusigint.htm; A. Shcherbakov, "Major Loss of Intelligence Capability" at http://www.fas.org/irp/world/russia/fapsi/shcherbakov.htm; K. Lantratov, "Space Matters, Military Matters" (in Russian), *Novosti Kosmonavtiki*, 12/2001, pp.54-55.
5. D. Day, "Tinker, Tailor, Radar, Spy: Early American Ferret and Radar Satellites", *Spaceflight*, 43, p.288, 2001. ELINT satellites used for radar monitoring are sometimes also referred to as "ferrets", but this is not correct in the sense that satellites never provoke the enemy to switch on its radars. On the contrary, since their flight paths are predictable, the enemy can switch *off* the radars when such satellites pass over. The same goes for COMINT-gathering satellites. For instance, the Russians are known to have observed radio silence during certain operations at the Baikonur Cosmodrome when American SIGINT satellites were flying over the launch site. See for instance an account of preparations for the April 1981 launch of Kosmos-1267 in N.Chugunova, "Chelomei's cosmonauts" (in Russian), *Ogonyok*, January 1993, p. 28.
6. E-mail correspondence with intelligence historian Matthew Aid, 9 August 2004.
7. A. Fomov, "*How Dudayev was killed*" (in Russian), Stringer news agency, July 2000. On-line at http://www.compromat.ru/main/chechya/dudaev.htm
8. For a comprehensive history of Soviet ocean reconnaissance satellites (both passive and active) see A. Siddiqi, "Staring at the Sea: The Soviet Rorsat and Eorsat Programmes", *JBIS*, 52, pp.397-418, 1999. A Russian history of these programmes was published in 2002: A.B. Zemlyanov, G.L. Kossov, V.A. Traube, "*Sistema morskoy kosmicheskoy razvedki i tseleukazaniya (istoriya sozdaniya)*", St. Petersburg , 2002.
9. S. Lekarev, "Two types of Russian intelligence services are being unified" (in Russian), *Nezavisimaya Gazeta*, 31 August 2001. On-line at http://nvo.ng.ru/spforces/2001-08-31/7_unification.html
10. A.I. Kolpakidi, D.P. Prokhorov, "*Imperiya GRU: ocherki istorii rossiyskoy voennoy razvedki*", Olma-Press, Moscow, 1999. On-line at http://www.agentura.ru/dossier/russia/gru/imperia/
11. V.V. Favorskiy, I.V. Meshcheryakov, "*Voenno-kosmicheskie sily (kniga 1)*", Moscow, Izdatelstvo Sankt-Peterburgskoi tipografii, p.122, 1997.
12. N. Friedman, "*Seapower and space*", Naval Institute

Press, Annapolis, MD, 2000, p. 162. Via Matthew Aid.

13. N.A. Anfimov (ed.), "*General'nyi konstruktor: kniga o Vladimire Fyodoroviche Utkine*", TsNIIMash, Korolyov, 2003, p.42. OKB-586/KBYuzhnoe was headed by:
1955-1971 Mikhail K. Yangel
1971-1990 Vladimir F. Utkin
1990- Stanislav N. Konyukhov
KB-3 was headed by
1965-1977 Vyacheslav M. Kovtunenko
1977-1984 B.E. Khmyrov
1984-1989 Stanislav N. Konyukhov
1989- Vladimir I. Dranovskiy
14. V. Gubarev, "Southern Start" (in Russian) (interview with the former head of KB Yuzhnoe Vladimir Utkin), *Nauka i zhizn'*, 2/1998, p.51; L. Andreyev, S. Konyukhov, "*Yangel': uroki i nasledie*", Art Press, Dnepropetrovsk, 2001, pp.51-52 - the relevant chapter is also on the website "Aerokosmicheskiy Portal Ukrainy" at http://www.space.com.ua/gateway/news.nsf/0/D81A0298A534348FC3256BA7004D1854?open
15. N.A. Anfimov (ed.), "*General'nyi konstruktor: kniga o Vladimire Fyodoroviche Utkine*", op. cit., p.231. The relevant chapter is also on-line at "Aerokosmicheskiy portal Ukrainy" at http://www.nkau.gov.ua/nsau/newsnsau.nsf/0/ED78310C5ADBCC8BC22-56DBA004A6E06?OpenDocument&Lang=U; V. Platonov, "The Shield and Sword of Satan" (in Russian), on-line at "Aerokosmicheskiy portal Ukrainy" at http://www.space.com.ua/gateway/news.nsf/0/4EDA49323BD980EAC2256DBA004F0EF8?open
16. V.V. Favorskiy, I.V. Meshcheryakov, "*Voenno-kosmicheskie sily (kniga 1)*", op. cit., pp.120-121, 209; V.V. Favorskiy, I.V. Meshcheryakov, "*Voenno-kosmicheskie sily (kniga 2)*", op. cit., p.340; A.B. Zemlyanov, G.L. Kossov, V.A. Traube, "*Sistema morskoy kosmicheskoy razvedki i tseleukazaniya (istoriya sozdaniya)*", op. cit., pp.66-67; A. Garavskiy, "Leading Lights of Electronic Warfare" (in Russian), *Krasnaya Zvezda*, 4 July 2003, online at http://www.redstar.ru/2003/07/04_07/2_03.html; TsNIRTI website at http://www.cnirti.ru/fr-rus.htm. According to Garavskiy the institute was named VNIIR (All-Union Scientific Research Institute of Radars) and VNII-108 before being named TsNII-108, but this is not confirmed by other sources. The directors of TsNIRTI were:
1943-1958 Axel Berg
1958-1964 Pyotr Pleshakov
1964-1968 Nikolai Yemokhonov
1968-1985 Yuriy Mazhorov
1985-1987 Yuriy Spiridonov
1987-2003 Aleksei Shulunov
2003-2004 Gennadiy Kazantsev
2004- Sergei Lukyanov
17. V.V. Favorskiy, I.V. Meshcheryakov, "*Voenno-kosmicheskie sily (kniga 2)*", op. cit., p 19.
18. "*Soviet Military Capabilities and Intentions in Space*", National Intelligence Estimate, 6 August 1980, p. 45. On-line at the "Electronic Reading Room" of the CIA website at http://www.foia.cia.gov/search_options.asp
19. K. Lantratov, "Russian satellite will be watching the Taliban" (in Russian), 3 October 2001. On-line at http://www.gazeta.ru/2001/10/03/rossijskijsp.shtml
20. RTR stands for "*radiotekhnicheskaya razvedka*". SIGINT is called "radioelectronic surveillance" or RER (*radioelektronnaya razvedka*) and COMINT is referred to as "radio surveillance" or RR (*radiorazvedka*). See V. Agapov, "USA-171: A New 'Ear' in Orbit" (in Russian), *Novosti Kosmonavtiki*, 11/2003, p.29.
21. V.V. Favorskiy, I.V. Meshcheryakov, "*Voenno-kosmicheskie sily (kniga 2)*", op. cit., p 19.
22. N.A. Anfimov (ed.), "*General'nyy konstruktor: kniga o Vladimire Fyodoroviche Utkine*", op. cit., p.45.
23. N. Johnson, "*Soviet Military Strategy in Space*", Jane's Publishing Company, London, 1987, p.60.
24. E-mail correspondence with Matthew Aid, 9 August 2004.
25. A good overview of US air defence radar systems can be found in Roy J. Fletcher, *Military Radar Defence Lines of Northern North America: An Historical Geography*, October 1989, available on-line at http://www.pinetreeline.org/articles/resartg.html; W.J. Boyne, "*The Rise of Air Defense*", Air Force Magazine, December 1999, on-line at http://www.afa.org/magazine/dec1999/1299rise.asp
26. "NATO Air Defence Ground Environment", on-line at the website of the NATO Programming Centre at http://www.npc.nato.int/booklet/c06.htm; "NATO Air Command and Control System", on-line at the NATO website at http://www.nato.int/issues/accs/
27. See the Nike, Hawk and Patriot pages in Andreas Parch's *Directory of US Missiles and Rockets*, on-line at http://www.designation-systems.net/dusrm/index.html; Exhaustive information on the Nike missiles can be found on the website of Ed Thelen at http://ed-thelen.org/
28. PAVE is an Air Force programme name and PAWS stands for "Phased Array Warning System".
29. A good overview of US missile defence radars can be found on the GlobalSecurity.org website at http://www.globalsecurity.org/space/systems/track.htm; also see the Air Force Space Command's PAVE PAWS website at http://www.pavepaws.org/Default.htm
30. A good overview of early US ABM systems can be found on the website "Nuclear ABMs of the USA" at http://www.paineless.id.au/missiles/
31. wesbite of the Missile Defense Agency at http://www.acq.osd.mil/mda/mdalink/html/mdalink.html; missile website of the Claremont Institute at http://www.missilethreat.com/
32. See for instance I. Sellevag, "Vardo Exposed", *Bulletin of the Atomic Scientists*, March/April, pp.26-29, 2000, on-line at http://www.thebulletin.org/issues/2000/ma00/ma00sellevag.html; T. Postol, "The Target Is Russia", *Bulletin of the Atomic Scientists*, March/April, pp.30-35, 2000, on-line at http://www.thebulletin.org/issues/2000/ma00/ma00postol.html
33. Information on most of the radar systems discussed in this section can be found on the website of the Federation of American Scientists at http://www.fas.org/spp/military/program/nssrm/initiatives/
34. V.V. Favorskiy, I.V. Meshcheryakov, "*Kosmonavtika i raketno-kosmicheskaya promyshlennost'(1): zarozhdenie i stanovlenie (1946-1975)*", Mashinostroeniye, Moscow, 2003, pp.89-90.
35. B. Raushenbakh and G. Vetrov, "*S.P. Korolyov i ego delo*", Nauka, Moscow, 1998, p.264.
36. "Information on the course of work on the Vostok-1 object" (in Russian), 6 February 1960. From the Russian State Archive of the Economy, document obtained by Asif Siddiqi.
37. Yu. N. Yerofeyev, "How the 'Sonata' was performed" (in Russian), on-line at http://www.computer-museum.ru/connect/sonata.htm
38. One veteran claims the equipment was installed in the instrument module. See Yu. Frumkin, "The First Spy Satellite" (in Russian), *Aviatsiya i Kosmonavtika*, 3/1993, p.42; Yu. Frumkin, *Priroda*, April 1993, pp.72-78 (translated in *JPRS Report*, 5 October 1993, pp.15-20); One source claims that the data was sent back to Earth aboard the return module. See B. Chertok, *Rakety i lyudi: goryachie dni kholodnoi voiny,* Mashinostroeniye, Moscow, p.76. A declassified 1975 CIA report says

"the ELINT payload apparently is recovered together with the photographic capsule". See *Soviet Dependence on Space Systems*, Interagency Intelligence Memorandum, 1 November 1975, p.11. On-line at the "Electronic Reading Room" of the CIA website at http://www.foia.cia.gov/search_options.asp
39. "Information on the course of work on the Vostok-1 object", op. cit.
40. V. Agapov, "Launches of Zenit-2 Satellites" (in Russian), *Novosti Kosmonavtiki*, 10/1996, pp. 65-77.
41. *"The Soviet Space Program"*, National Intelligence Estimate, 1 November 1971, p.35; "*Soviet Dependence on Space Systems*", Interagency Intelligence Memorandum, 1 November/7 November 1975, p.11; "*Soviet Military Capabilities and Intentions in Space*", National Intelligence Estimate, 6 August 1980, p. 26. All reports on-line at the "Electronic Reading Room" of the CIA website at http://www.foia.cia.gov/search_options.asp. Statistics for Zenit-2M launches are from Jonathan McDowell's Launch Log at http://planet4589.org/space/log/launchlog.txt.
42. "Information on the course of work on the Vostok-1 object", op. cit.
43. The drawing is published in Y. Semyonov (ed.), *"Raketno-kosmicheskaya korporatsiya Energiya imeni S.P. Korolyova, 1946-1996"*, RKK Energiya, Moscow, 1996, p.101.
44. V.V. Favorskiy, I.V. Meshcheryakov, "*Voenno-kosmicheskie sily (kniga 2)*", op. cit., p. 340
45. "*The Soviet Space Program*", National Intelligence Estimate, 27 January 1965, p.23. On-line at the "Electronic Reading Room" of the CIA website at http://www.foia.cia.gov/search_options.asp
46. "Tselina" literally means uncultivated or unexplored territory and is often used to refer to vast stretches of land (mainly in Kazakhstan and Western Siberia) that were extensively cultivated in the 1950s.
47. This entire section based on S.N. Konyukhov (ed.), "*Rakety i kosmicheskie apparaty konstruktorskogo byuro Yuzhnoe*", GKB Yuzhnoe, Dnepropetrovsk, 2000, pp.110, 118-119, 122-123, 201. Dates of the unsuccesful DS-K40 launches are from V. Agapov, "Anniversary of the launch of the first satellite in the DS series" (in Russian), *Novosti Kosmonavtiki*, 6/1997, p.63.
48. A. Siddiqi, "Staring at the Sea: The Soviet Rorsat and Eorsat Programmes", op. cit.
49. A.B. Zemlyanov, G.L. Kossov, V.A. Traube, "*Sistema morskoy kosmicheskoy razvedki i tseleukazaniya (istoriya sozdaniya)*",op. cit., pp.62-63. According to this source the commission that studied the idea was headed by "a Deputy Minister of the Radio Industry", but it is unclear whether this was Pleshakov himself or another deputy.
50. V.V. Favorskiy, I.V. Meshcheryakov, "*Voenno-kosmicheskie sily (kniga 1)*", op. cit., pp.120-121.
51. N.A. Anfimov, "*General'nyy konstruktor…*", op. cit., p.44.
52. Ibid.
53. B. Gubanov, "*Triumf i tragediya Energii. Tom 2: Kosmos priotkryvaet dveri*", Izdatelstvo Nizhegorodskogo instituta ekonomicheskogo razvitiya, Nizhniy Novgorod, 1999, p.33.
54. S.N. Konyukhov (ed.), "*Rakety i kosmicheskie apparaty konstruktorskogo byuro Yuzhnoe*", op. cit., pp.202-203.
55. V.V. Favorskiy, I.V. Meshcheryakov, "*Voenno-kosmicheskie sily (kniga 1)*", op. cit., p.124.
56. N.A. Anfimov, "*General'nyy konstruktor…*", op. cit., p.44.
57. The two are listed as mass models in Jonathan McDowell's Launch Log at http://planet4589.org/space/log/launchlog.txt. However, no mention is made of any Tselina-O mass models in Yuzhnoe's rocket and satellite history.
58. V. Pallo-Korystin *et al*, "*Dneprovskiy raketno-kosmicheskiy tsentr*", KB Yuzhnoe, Dnepropetrovsk, 1994; B. Gubanov, "*Triumf i tragediya Energii. Tom 2: Kosmos priotkryvaet dveri*", op. cit., p.33. Two other sources say Tselina-O was adopted into the armaments in 1971. See V.V. Favorskiy, I.V. Meshcheryakov, "*Voenno-kosmicheskie sily (kniga 1)*", op. cit., p.121; N.A. Anfimov, "*General'nyy konstruktor…*", p.45.
59. N. Johnson, "*Soviet Military Strategy in Space*", op. cit., p.60.
60. V.V. Favorskiy, I.V. Meshcheryakov, "*Voenno-kosmicheskie sily (kniga 1)*", op. cit., p.122.
61. US intelligence data from *USAF, A History of Strategic Arms Competition: 1945-1972, Vol. III, A Handbook of Selected Soviet Weapon and Space Systems*, 1976, pp.424-425, declassified and on file at the Department of Defense FOIA Reading Room; *EUCOM Intelligence Report*, U.S. European Command, Office of the Director of Intelligence, 24 March 1969, p. 6, National Security Archives, Washington, D.C. Information obtained via Matthew Aid.
62. "*Soviet Space Programs*", National Intelligence Estimate, 20 December 1973, p.7; "*Soviet Dependence on Space Systems*", Interagency Intelligence Memorandum, 7 November 1975, p.12; "*Soviet Military Capabilities and Intentions in Space*", National Intelligence Estimate, 6 August 1980, p.44. All reports on-line at the "Electronic Reading Room" of the CIA website at http://www.foia.cia.gov/search_options.asp
63. S.N. Konyukhov (ed.), "*Rakety i kosmicheskie apparaty konstruktorskogo byuro Yuzhnoe*", op. cit., p.203.
64. V.V. Favorskiy, I.V. Meshcheryakov, "*Voenno-kosmicheskie sily (kniga 1)*", op. cit., pp.124-125. The TsUKOS officer is identified as S.A. Kolesnik.
65. S.N. Konyukhov (ed.), "*Rakety i kosmicheskie apparaty konstruktorskogo byuro Yuzhnoe*", op. cit., pp.202-204.
66. V. Pallo-Korystin *et al*, "*Dneprovskiy raketno-kosmicheskiy tsentr*", KB Yuzhnoe, Dnepropetrovsk, 1994; B. Gubanov, "*Triumf i tragediya Energii. Tom 2: Kosmos priotkryvaet dveri*", op. cit., p.33; V.V. Favorskiy, I.V. Meshcheryakov, "*Voenno-kosmicheskie sily (kniga 1)*", op. cit., p.121.
67. S. Sergeyev, "Tsiklon" (in Russian), *Aviatsiya i Kosmonavtika*, March-April 1994, p.38. Possibly, this was part of a wider ranging government resolution released on 21 July 1967, which also mentioned the use of the two-stage 11K69 ("Tsiklon-2") for launching naval reconnaissance satellites of the US type and besides that dealt with some other unmanned as well as manned programmes. See A. Siddiqi, *"Challenge to Apollo"*, NASA, 2000, p.949.
68. A. Siddiqi, *Challenge to Apollo*, op. cit., p.951; I. Afanasyev, "The Rocket Carrier Tsiklon" (in Russian), *Novosti Kosmonavtiki*, 2/2001, p.38.
69. B. Gubanov, "*Triumf i tragediya Energii. Tom 2: Kosmos priotkryvaet dveri*", op. cit., p.39.
70. I. Afanasyev, "The Rocket Carrier Tsiklon" (in Russian), op. cit., p.38.
71. According to Jonathan McDowell's authoritative "Launch Log" Kosmos-1025 was a mass model. See http://planet4589.org/space/log/launchlog.txt However, the recently published Yuzhnoe satellite/rocket history identifies it as a regular Tselina-D, although it is mistakenly listed as Kosmos-1035. See S.N. Konyukhov (ed.), "*Rakety i kosmicheskie apparaty konstruktorskogo byuro Yuzhnoe*", op. cit., p.204, 226.
72. V.V. Favorskiy, I.V. Meshcheryakov, "*Voenno-kosmicheskie sily (kniga 1)*", op. cit., p.122.
73. *"USAF, A History of Strategic Arms Competition: 1945-1972, Vol. IIIA*", op. cit., p.432. Via Matthew Aid.

74. *"Key Conclusions About Present and Future Soviet Space Missions"*, A Reference Aid, 1 June 1983, p. 13. On-line at at the "Electronic Reading Room" of the CIA website at http://www.foia.cia.gov/search_options.asp.
75. Jack Anderson, "GAO Audits Soviet Spy Satellites", *Washington Post*, 11 February 1985, p. C-12. Via Matthew Aid.
76. "*Soviet Military Capabilities and Intentions in Space*", op. cit., p.44.
77. V.V. Favorskiy, I.V. Meshcheryakov, "*Voenno-kosmicheskie sily (kniga 2)*", op. cit., p.40.
78. V. Agapov, "On the Occasion of the Launch of the Okean-O1 Satellite", *Novosti Kosmonavtiki*, 22/1994, p.49.
79. S.N. Konyukhov (ed.), "*Rakety i kosmicheskie apparaty konstruktorskogo byuro Yuzhnoe*", op. cit., p.202, 204.
80. One source does mention tests of third-generation Tselina components in 1986-1987 on "two Tselina-D satellites". See V.V. Favorskiy, I.V. Meshcheryakov, "*Voenno-kosmicheskie sily (kniga 2)*", op. cit., p.185.
81. V.V. Favorskiy, I.V. Meshcheryakov, "*Voenno-kosmicheskie sily (kniga 1)*", op. cit., p.209.
82. S.N. Konyukhov (ed.), "*Rakety i kosmicheskie apparaty konstruktorskogo byuro Yuzhnoe*", op. cit., p.202, 205.
83. V.V. Favorskiy, I.V. Meshcheryakov, *"Voenno-kosmicheskie sily (kniga 1)"*, op. cit., p.203, 209.
84. B. Gubanov, "*Triumf i tragediya Energii. Tom 3: Energiya-Buran*", Izdatelstvo Nizhegorodskogo instituta ekonomicheskogo razvitiya, Nizhniy Novgorod, 1998, pp.55-58.
85. V.V. Favorskiy, I.V. Meshcheryakov, "*Voenno-kosmicheskie sily (kniga 2)*", op. cit., pp.19-20.
86. Ibid, pp.19-20, 131. A proposed merger of the global and ocean SIGINT systems under Defence Minister Ustinov (late 1970s/early 1980s) is also mentioned in : E. Buynovskiy, "*`Povsednevnaya zhizn' pervykh rossiyskikh raketchikov i kosmonavtov*", Molodaya Gvardiya, Moscow, 2004, pp.272-274.
87. S.N. Konyukhov (ed.), "*Rakety i kosmicheskie apparaty konstruktorskogo byuro Yuzhnoe*", op. cit., p.202, 205-206.
88. V.V. Favorskiy, I.V. Meshcheryakov, "*Voenno-kosmicheskie sily (kniga 2)*", op. cit., p.20.
89. N. Johnson, "*Europe and Asia in Space 1993-1994*", Kaman Sciences Corporation, Colorado Springs, p.339.
90. V.V. Favorskiy, I.V. Meshcheryakov, "*Voenno-kosmicheskie sily (kniga 2)*", op.cit., p.130.
91. P. Clark, "Launch Profiles Used by the Four-Stage Proton-K", *JBIS*, 53, pp.203-204, 2000.
92. S.N. Konyukhov (ed.), "*Rakety i kosmicheskie apparaty konstruktorskogo byuro Yuzhnoe*", op. cit., p.212.
93. P. Clark, "Zenit Launch Vehicle Marks Lucky 13th Year", *Satellite Times*, April 1998, p.18; "Kosmos-2333 Launched", *Novosti Kosmonavtiki*, 18/1996, p.22. According to the latter source this launch profile restricts deviations from the planned orbit to about 1 km for altitude, less than 0.01° for inclination and less than 0.01 minutes for orbital period.
94. Information on early Zenit/Tselina launches is from V. Antipov, "15th Anniversary of the First Zenit Launch" (in Russian), *Novosti Kosmonavtiki*, 6/2000, p.71; B. Gubanov, "*Triumf i tragediya Energii. Tom 3: Energiya-Buran*", op. cit., p.60; S.N. Konyukhov (ed.), "*Rakety i kosmicheskie apparaty konstruktorskogo byuro Yuzhnoe*", op. cit., p.206, 212, 227-228. Since the latter source does not list satellites lost in launch failures, there continues to be uncertainty over the exact nature of the payloads flown on the first two launches. Antipov confirms the first launch carried an EPN, but does not say which one. The second launch almost certainly carried an EPN as well. The inclination of the fragments resulting from this launch (64.41°) was similar to the one used by three of the four confirmed EPN 03.0695 payloads (64.8°). The four EPN 03.0695 payloads confirmed by Konyukhov are Kosmos-1767, 1820, 1871 and 1873.
95. V. Antipov, "15th Anniversary of the First Zenit Launch", op. cit.; B. Gubanov, "*Triumf i tragediya Energii. Tom 3: Energiya-Buran*", op. cit., p.60.
96. "Zenit-2 rocket launches Russian military satellite" (in Russian). Report on the launch of Kosmos-2369 on 3 February 2000. On-line at http://www.nsau.kiev.ua/infosystema/Pressa.nsf/0/be622bf31a8123de42256-87b0027e4fe?OpenDocument
97. V.V. Favorskiy, I.V. Meshcheryakov, "*Voenno-kosmicheskie sily (kniga 2)*", op.cit., p.184.
98. B. Gubanov, "*Triumf i tragediya Energii. Tom 3: Energiya-Buran*", op. cit., p.60
99. N. Johnson, "*Europe and Asia in Space 1993-1994*", op. cit., p.340.
100. M. Tarasenko, "Kosmos-2360 launched" (in Russian), *Novosti Kosmonavtiki*, 15-16/1998, p.25.
101. See the Tselina page on Anatoliy Zak's website RussianSpaceWeb.com at http://www.russian-spaceweb.com/tselina.html
102. Yu. Zhuravin, "Kosmos-2406 in orbit" (in Russian), *Novosti Kosmonavtiki*, 8/2004, pp.25-26.
103. P. Clark, "Satellite Digest-384", *Spaceflight*, 46, p.380, 2004.
104. K. Lantratov, "Space Geyser" (in Russian), *Novosti Kosmonavtiki*, 9/2000, p. 25.
105. V.V. Favorskiy, I.V. Meshcheryakov, "*Voenno-kosmicheskie sily (kniga 2)*", op. cit., p.185.
106. K. Lantratov, "Kosmos-2383 launched" (in Russian), *Novosti Kosmonavtiki*, 2/2002, p. 44. This source says that Tselina-3 was supposed to take over the ocean reconnaissance task of the US-P satellites, but this is unlikely given the concurrent development of the Ideogramma-Pirs system.
107. V.V. Favorskiy, I.V. Meshcheryakov, "*Voenno-kosmicheskie sily (kniga 2)*", op. cit., p.185.
108. "*Soviet Military Capabilities and Intentions in Space*", op. cit., pp.26-27; "*Soviet Space Programs: Future Missions and Capabilities, Vol. 1 (Key Judgments and Summary)*", National Intelligence Estimate, 19 July 1983, pp.13, 15; "*Soviet Space Programs: Future Missions and Capabilities, Vol. 2 (The Estimate)*", National Intelligence Estimate, 19 July 1983, pp.III-6, III-7. On-line at at the "Electronic Reading Room" of the CIA website at http://www.foia.cia.gov/search_options.asp
109. L.T. Baranov *et al*, "*Voenno-kosmicheskie sily (kniga 3)*", Izdatelskiy dom "Vestnik Vozdushnogo Flota", Moscow, 2001, p.62.
110. A.B. Zemlyanov, G.L. Kossov, V.A. Traube, "*Sistema morskoy kosmicheskoy razvedki i tseleukazaniya (istoriya sozdaniya)*", op. cit., pp.72-76.
111. See the US-A/US-P page on Anatoliy Zak's website RussianSpaceWeb.com at http://www.russian-spaceweb.com/us.html. Zak's source for this is an interview in August 2001 with Vladimir Kalabin, the chief designer of US spacecraft at KB Arsenal. In the early 1990s KB Arsenal proposed a Soyuz-2 launched radar Earth observations satellite called "Obzor", but it is not clear if this was to use the new bus. The Obzor bus seems to have been almost identical to that of US-P and the use of Soyuz-2 rather than Tsiklon-2 (the standard US-P launch vehicle) may have been necessitated by the higher orbit and inclination.
112. "Project Nuklon". In A.A. Boyarchuk (ed.), *Rezul'taty fundamental'nykh kosmicheskikh issledovaniy v Rossii 1999-2001 / The Results of Fundamental Space Research in Russia 1999-2001*, Nauka, Moscow, 2004, p.83. Also

on-line at http://www.npi.msu.su/projinc/projects/nucl11_2.html. Considered alongside with Liana was a modified version of the US-P spacecraft called US-PU (17F120).

113. L.T. Baranov *et al*, "*Voenno-kosmicheskie sily (kniga 3)*", op. cit., p.62; V. Ivanov, "Tenth anniversary of the Military Space Forces", *Novosti Kosmonavtiki*, 10/2002, p.63.

114. V. Mokhov, "New satellites for the Space Forces" (in Russian), *Novosti Kosmonavtiki*, 8/2001, p.61. Perminov may also have been referring to what is believed to be a new type of photographic reconnaissance satellite jointly developed by TsSKB and Arsenal. The first such satellite was launched as Kosmos-2410 on 24 September 2004.

115. M.I. Kislitskiy, "Possibilities of performing space research using satellites developed by KB Arsenal" (in Russian), paper presented at a space seminar in Tarusa, 25-27 March 2003. An audio recording of the presentation is on-line at http://www.iki.rssi.ru/seminar/tarusa2003/progr.htm

116. T. Furniss, "Russia and Ukraine work on a new booster", *Spaceflight*, 47, p.209, 2005

117. For instance, information on the Tselina satellites was recently removed from the official website of TsENKI (Centre for Ground-Based Space Infrastructure Facilities Operation). Also, the leading Russian space magazine "Novosti Kosmonavtiki" is now apparently forced to restrict its articles on Russian military space launches (including EORSAT and Tselina) to accounts of launch preparations rather than provide technical and historical background on the satellites themselves.

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