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COLD WAR MILITARY SPACE HISTORY: Programmes

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THE SOVIET CO-ORBITAL ANTI-SATELLITE SYSTEM: A SYNOPSIS

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The Soviet Union experimented with a dedicated orbital anti-satellite system which achieved full operational status in 1979. Programme development began in 1960 and there were eventually 20 intercept tests conducted in its history. At least two engagements in the late 1960s were the first instances of actual active destruction of targets. Although the system was decommissioned for a few years beginning in 1983, the available evidence suggests that as late as 1993 this co-orbital capability was still operational.

1. INTRODUCTION

Some of the most exotic technologies developed by the United States and the Soviet Union were developed for so-called anti-satellite (ASAT) programmes. For obvious reasons, during the Cold War era, details of the Soviet programme were kept secret from the general public and there was little or no official word from Soviet authorities on the existence of such a project. By observing the behaviour of selected satellites in the Kosmos series, Western analysts had been able to discover and establish important aspects of the Soviet co-orbital ASAT programme [1]. Recently a significant amount of information has been published in Russia on this topic, thus adding an important element to the literature on Cold War weapons systems. The present article is an early attempt to collect some of the newly published information and combine it with previous Western analyses.

2. BACKGROUND

Early Soviet ASAT studies probably began around 1955-56, around the same time as the first proposals were floated for a dedicated military photo-reconnaissance satellite. By 1956, work had begun at Chief Designer Sergey P. Korolev's Special Design Bureau No. 1 (OKB-1) on a modest observation spacecraft initially designated the OD-2 [2]. The ASAT studies were presumably undertaken at the Ministry of Defence's Scientific Research Institute No. 4 (NII-4) at Bolshevo near Moscow, in much the same way that early satellite proposals were studied at the Institute in the late 1940s and early 1950s. Further research to determine requirements was also most likely carried out at the Special Scientific Research Institute (SNII) of the Troops of Air Defence (PVO Strany) which was established in 1959 for this specific purpose. Despite an increased interest in ASAT projects in the late 1950s, no governmental action on a dedicated programme appears to have been taken until 1960.

The first major catalyst for the early Soviet ASAT programme appears to have come from concurrent U.S. plans to deploy an operational ASAT system. Beginning with the *Bold Orion* programme (or Program 7795) in 1959, the U.S. Air Force, Navy, and Army explored several proposals, none of which ultimately reached an operational stage [3]. In the 1959-62 period, perhaps the most prominent of these was the Satellite Inspector (SAINT). The SAINT project came about as a result of original studies conducted in 1956 by the U.S. Air Force's Air Research and Development Command to combat hostile satellites in Earth orbit [4]. After Sputnik, the project was taken over by the Department of Defense's Advanced Research Projects Agency which awarded a $600,000 contract to the Radio Corporation of America on 11 June, 1959 to assess "satellite interception techniques" [5]. Even before this six-month study was completed, the Air Force Ballistic Missile Division put forward a development plan in August 1959 for a satellite interceptor and inspector under the new programme name SAINT. After an extensive series of discussions on the issue, the project was formally approved by the Eisenhower administration on 25 August, 1960. The vehicle was primarily designed to be an *inspection* spacecraft for hostile satellites in Earth orbit, although the Air Force hoped that later SAINT models would be equipped with a "kill" capability. The latter facet of the programme was subsequently dropped from the project due to budgetary constraints, and the programme itself was terminated on 3 December, 1962 due to a variety of political, technical and monetary reasons [6].

The original award to RCA in June 1959 for an interceptor spacecraft was the subject of a Department of Defense press release, and it is quite likely that Soviet officials were fully aware of the general aspects of SAINT [7]. Although SAINT was essentially designed as an inspection satellite for photographing hostile spacecraft, Soviet authorities were apparently unconvinced of the benign nature of the project, believing the programme to be the first step in a war in space [8].

A second rationale for proceeding with a ASAT project, for which the Soviets used the term 'anti-space defence' (PKO), came from concerns from the Soviet leadership of allowing U.S. reconnaissance satellite missions over the landmass of the USSR. Soviet leader Nikita S. Khrushchev was reportedly personally upset over the possibility of 'spy' flights over the Soviet Union. Sometime in 1959-60, at Khrushchev's request, the problem had been assigned to a group of scientists and engineers [9]. As reported back to Khrushchev, the problem was essentially seen as a two-fold issue, the identification of lethal satellites in orbit, and their elimination. Questions of international law were also clearly a concern for the Soviets, since questions of 'overflight' were only coming to the fore at the time among the two superpowers.

A very high-level meeting in early April 1960 in Crimea finally paved the way for the first Soviet ASAT system. Among those attending the session were Petr V. Dementyev (Chairman of the State Committee for Aviation Technology), Boris Ye.

Butoma (Chairman of the State Committee for Shipbuilding), Admiral Sergey G. Gorshkov (Commander-in-Chief of the Soviet Navy), Chief Designer Viktor I. Kuznetsov (Director of the NII-944 responsible for the development for high-precision gyroscopes for missiles), Soviet leader Khrushchev, and his son Sergey N. Khrushchev [10]. Also present was General Designer Vladimir N. Chelomey, the head of the Special Design Bureau No. 52 (OKB-52), a new entrant to the emerging Soviet space programme. With Khrushchev's son as a deputy for navigation systems at his Design Bureau, Chelomey had managed to overcome several years of obscurity before embarking on a number of ambitious projects in the late 1950s. Among the many projects discussed at the meeting, several focused on means to attack or capture foreign satellites in Earth orbit. Chelomey informed Khrushchev he could bring an offensive space-based orbital system to fruition as early as 1962-63. The General Designer, however, cautioned that, "...to knock down a satellite is significantly easier than recognising whether it is a reconnaissance [vehicle] or not. It would be very easy to camouflage a spy as a harmless research object" [11]. Discussions also addressed a medium-sized spaceplane for capturing offensive objects in Earth orbit and bringing them back to Earth.

The April 1960 meeting appears to have spurred the Soviets to consider several options for military operations in space, and it was only three months later in July 1960 that the Council of Ministers and the Central Committee of the Communist Party adopted a formal resolution for the development of an automated manoeuvring satellite for ASAT operations in Earth orbit [12]. No doubt, the decision was partly a response to the U-2 incident in May of 1960 which prompted U.S. officials to rely exclusively on space-based assets for overhead reconnaissance. The Soviet ASAT project was designated 'IS,' standing for the Russian acronym for 'Satellite Destroyer' (*'Istrebitel Sputnikov'*) [13]. Believing SAINT to be an offensive system, the Soviets themselves responded with a vehicle capable of specifically carrying out a "kill" in orbit. The matter of inspection and identification of U.S. military satellites was evidently left to two other means: a small-scale spaceplane informally designated the 'kosmoplan,' and ground-based observations of U.S. satellites. A further element of the July 1960 decree was approval to create an orbital launch vehicle for the IS system, to be developed using a new ICBM designated the Universal Missile No. 200 (UR-200) [14]. In a move dramatically emphasising his position in the new Soviet space programme, Chelomey's organisation was assigned as prime contractor for both elements of the system, the IS and the UR-200.

As proposed by Chelomey in the April 1960 meeting, the first flights of the IS system were set for 1962-63. It appears that the project encompassed at least three stages:

(1) an initial phase that would see the launch of individual IS vehicles for basic technology testing;

(2) a second phase with flights of both interceptor and target vehicles;

(3) and a final phase to bring the project to an operational state.

3. THE EARLY IS SPACECRAFT AND THE UR-200

Few details of the initial version of the IS satellite have been released to date. A photograph of the vehicle published in 1992, however, provides a good starting point [15]. The craft had a core section shaped like a stubby cylindrical drum, on which four large spherical propellant tanks were mounted. A cone-like truss structure was fitted above the tanks, at the apex of which were located two engines (figs. 1-2). At least four similar engine nozzles are visible fixed between each of the spherical tanks. What appears to have been a fifth tank was to have been

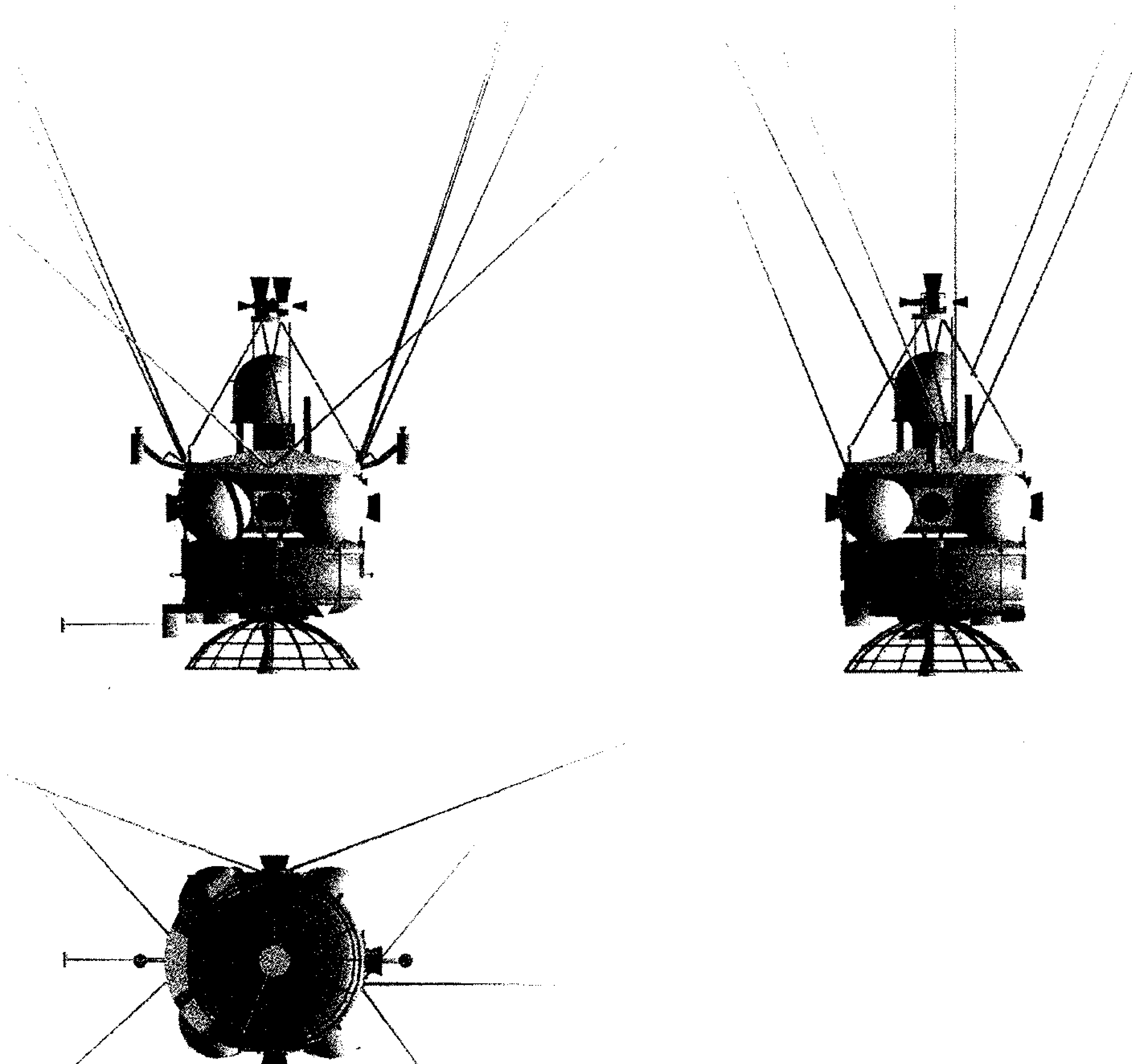

Fig. 1 These are three-view images of the Polet spacecraft. Note the two engines at the top, with four others located orthogonally around the spherical tanks.
(Image by Dennis Newkirk)

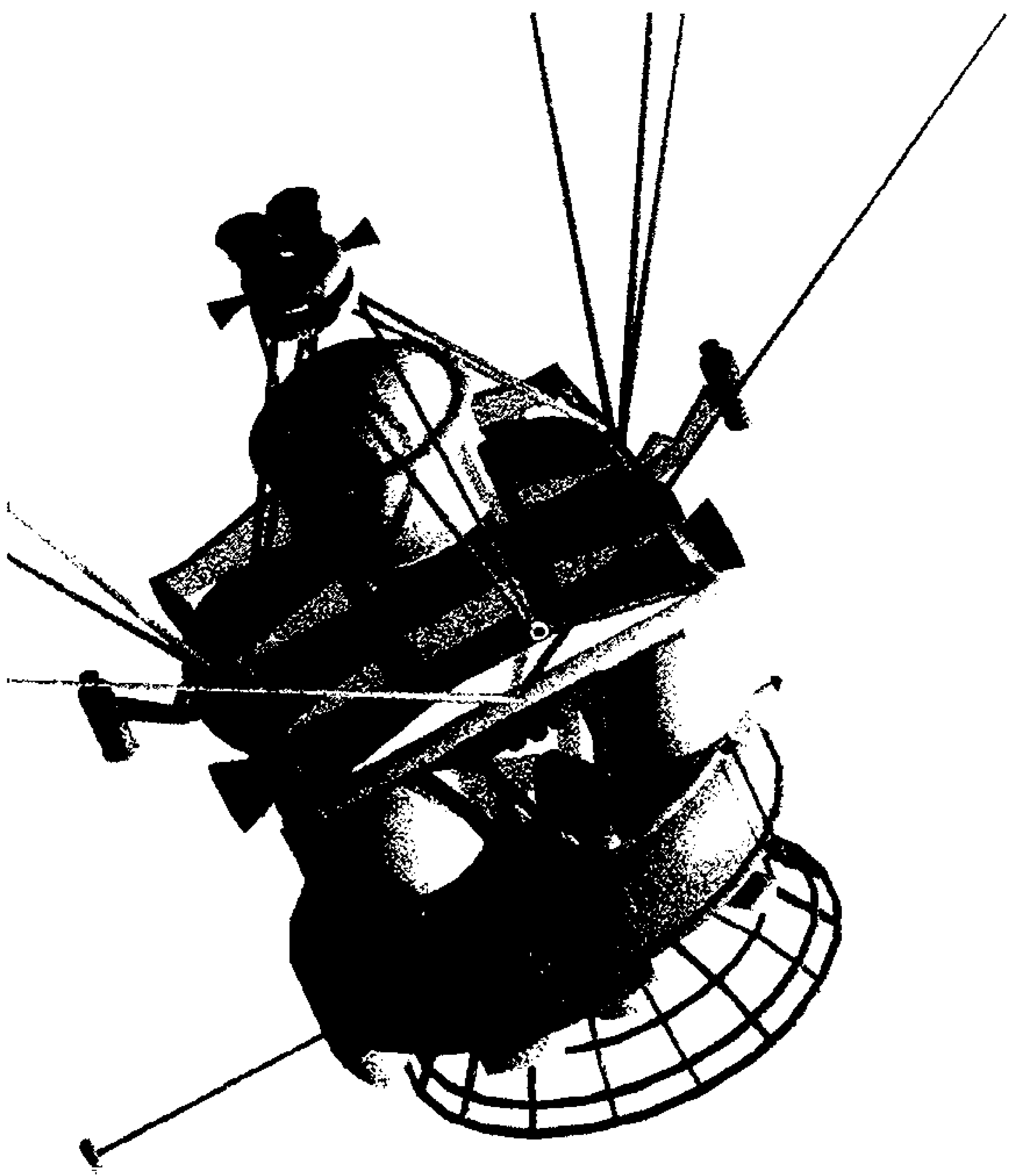

Fig. 2 A 3-D view of the Polet spacecraft. The later IS spacecraft was almost identical except for the omission of the tank within the cone-line structure at the top of the image.

(Image by Dennis Newkirk)

installed within the apex structure. Due to the need to perform several major manoeuvres, the propellants in the tanks presumably accounted for a significant part of the total spacecraft mass. Smaller attitude control thrusters were located at the base of the drum, in what appears to be groups of three. According to published data, the vehicle had six main propulsion units, each with a thrust of 400 kilograms, designed by the OKB-2 of Chief Designer Aleksey M. Isayev [16]. The smaller attitude control thrusters ranged in thrust from one kilogram to 16 kilograms and were developed by the OKB of Sergey K. Tumanskiy. The IS vehicle also carried a specially developed electrical control system for orientation and stabilisation which was fed commands automatically to perform the required manoeuvres and/or attitude control. This important aspect of the design was developed by the Central Scientific Research Institute Kometa (TsNII Kometa) led by Chief DesignerAnatoliy I. Savin. No explosives were apparently carried on the initial flight versions. The total mass of each of the initial IS is said to have been 2.4 tons [17]. The flight envelope was to cover altitudes between 150 and 2,000 kilometers.

Some data on the UR-200 (or 8K81) missile has been released. Intended to have a dual-role as an ICBM, the two-stage booster had a total length of 35 meters and a base diameter of three meters [18]. Total launch mass was about 140 tons. Engines for both stages were powered by storable hypergolic propellants and designed at the OKB-154 of Chief Designer Semen A. Kosberg. There has been much speculation that the UR-200 in fact comprised the two upper stages of the UR-500 (or 8K82) Proton booster, and this hypothesis has been seemingly supported by assertions of the leading designers involved in the development of the two vehicles [19]. The principal diameter of the upper stages of the Proton (4.15 meters) would, however, seem to suggest that they were of different design. On the other hand, it may be likely that elements of the propulsion systems used on the second and third stages of the UR-500 were common with those of the UR-200. It is well known that Kosberg's organisation designed and developed the second and third stage engines of the Proton booster.

4. THE FLIGHTS OF POLET

The first flight version of the IS vehicle was prepared in a relatively short period, and brought to launch readiness by the end of 1963. By this time, the SAINT project had been cancelled, negating one of the original reasons for proceeding with the IS programme. By this time, however, two newer U.S. ASAT programmes, Program 505 and Program 437 were ongoing, and these efforts clearly provided the rationale the Soviets needed to continue their own efforts.

The road to the launch of the first IS satellite was not completely smooth. By the time the first satellite was ready, a flight-ready UR-200 booster had not been certified for an operational launch. It was clear by this time that Chelomey's booster would be ready only for first stage firings by late 1963; an orbital version would be available in 1964. Instead of delaying the overall IS programme, Chelomey agreed to launch the initial IS test vehicles on a stripped down R-7A ICBM, much like the variants that had launched the early Sputnik satellites in the later 1950s [20]. The IS vehicle was to use its own engines to reach orbital velocity. Only the interceptor vehicle was meant for testing at this stage, with a regime of simple orbital changes designed to test out the attitude control and manoeuvring systems.

The first two test vehicles of the IS programme were publicly designated 'Polet' by the Soviet press, the Russian word for 'flight.' Naturally no indication was given at the time of the military nature of the missions. Part of the original launch announcement for the first launch is reproduced below:

> ...the guided manoeuvrable space vehicle Polet I was launched in the Soviet Union on November 1, 1963. It is fitted special equipment and a system of propulsive units ensuring its stabilisation and extensive manoeuvring in near-Earth space. Scientific equipment, a radiotelemetry system, and a transmitter operating on a frequency of 19.945 megacycles have been installed in the space vehicle....repeated extensive manoeuvring of a space vehicle under conditions of space flight has been realised for the first time. [21]

On the first mission in November 1963, the Polet IS spacecraft performed a large manoeuvre on the second day of flight, raising the apogee by about 850 kilometers. In addition at least 750 firings of the lateral thrusters were carried out during the mission [21a]. The second IS satellite launched on 12 April, 1964 performed at least one major manoeuvre, which raised the orbit by 10-20 kilometers accompanied by a small inclination change. Both flights were flown at roughly 58-60 degrees inclination and appear to have been successful.

5. EARLY PUBLIC STATEMENTS

Soviet officials were naturally very cryptic or evasive about any ASAT plans in the 1960s, and no specific or general information on the IS programme was revealed at the time. Despite the blackout on the project, from time-to-time there were fairly informative public statements that indicated a strong interest in such weaponry. In June 1960, just a month following the shoot-down of the famous U-2 reconnaissance aircraft, Soviet leader Khrushchev warned in a statement that U.S. reconnaissance satellites could be destroyed in a similar manner [22]. Note that this was around the time that the IS project was formally approved. Later in 1963, two months prior to the launch of Polet-1, USSR Minister of Defence Rodion Ya. Malinovskiy explicitly stated that the military had been assigned the goal of "combating an aggressor's modern means of nuclear attack and his attempt to reconnoitre our country from air and space" [23]. The 1963 edition of the definitive *Soviet Military Strategy*, released for publication in August added that:

> The rapid development of spacecraft and specifically of artificial Earth satellites, which can be launched for the most diverse purposes, even as vehicles for nuclear weapons, has put a new problem on the agenda, that of defence against space devices—PKO. It is still too early to predict what line will be taken in the solution of this problem, but surely as an offensive weapon is created, a defensive one will be too. [24]

6. CHANGES IN THE PROGRAMME

The fall of Soviet leader Khrushchev in October 1964 appears to have had some effect on the course of the IS/UR-200 programme. Without the traditional strong support from Khrushchev, Chelomey was unable to sustain funding for several important space and missile-related programmes. A few days prior to Khrushchev's removal from power, in early October 1964, the government had already decided to suspend work on the UR-200 ICBM [25]. The missile had flown its first launch on 3 November, 1963 (ironically just two days after the launch of Polet-1) [26]. Immediately after the beginning of the post-Khrushchev era, however, all work on the missile was permanently terminated. The last 'consolation' launchings of the booster took place in late October of 1964 [27].

The IS programme as a whole was, however, neither suspended nor terminated. With the UR-200 gone, the Soviet government quickly established a replacement launcher for the IS satellites. On 24 August, 1965, a formal resolution was adopted by the Council of Ministers and the Central Committee to use the R-36 (or 8K67) ICBM as a basis for a launch vehicle for the IS ASAT system [28]. Better known as the SS-9 Scarp in the West, the two-stage R-36 would eventually become one of the most potent and powerful ICBMs in the Soviet arsenal. Built at the OKB-586 headed by Chief Designer Mikhail K. Yangel, the initial version of the missile had flown its first successful test flight on 28 September, 1963 [29]. The Yangel organisation made some minor adjustments and modifications to this missile and prepared a draft plan for two related launch vehicles, both of which were planned to be used for launching some of the most high-security military payloads in the following decade. This draft was issued in March 1966 and described two new launch vehicles, the Tsiklon-2A (or 11K67) and the Tsiklon-2 (the 11K69) [30]. The Tsiklon-2A has not been described in any detail in published sources, although it is presumed that the vehicle was very similar to the Tsiklon-2, which is still an operational space launch vehicle at the time of writing. Details of the Tsiklon-2 are summarised in Table 1.

7. ORGANISATIONAL BACKDROP

The first two Polet/IS vehicles were designed and developed under the direction of General Designer Chelomey. It appears that following the leadership change in 1964, Chelomey lost his lead position in the project, although the OKB-52 retained the responsibility for designing the IS bus. The most critical elements of the ASAT system were clearly the development of self-contained radars to acquire and discriminate targets and advanced computers for co-ordinating the entire system. Thus, control of the IS programme eventually gravitated to noted engineering organisations in the radio and electronics industries. In 1962, a group at the TsNII Kometa within the Ministry of Electronics Industry headed by Chief Designer Savin had become involved in the IS ASAT programme to design electronics, control, and radar systems [31]. Savin's group had contributed to the Polet programme, and sometime soon after took over as the lead design organisation of the IS ASAT project.

While the TsNII Kometa had overall control of design and development, the client for the entire programme was one of the services of the USSR armed forces, the National Air Defence Forces (PVO Strany). The latter service had been hitherto responsible for all surface-to-air-missile and anti-missile defence elements of the military. In the initial years of development, there was no real need to form a separate division to manage ASAT programmes, but as the project neared its first test flights in the late 1960s, the PVO Strany structure was expanded to account for impending operational use of the system. On 30 March, 1967, by decree of the Central Committee of the Communist Party, a special 'sub-service' of the PVO Strany was established to manage operational control over all ASAT and anti-missile defence elements of the USSR armed forces [32]. The division was called the Anti-Missile Defence and Anti-Space Defence Forces of the PVO Strany, or the RKO. Its first Commander-in-Chief was Maj.-Gen. Yuriy V. Votintsev, a man who had been closely involved in early development of Soviet nation-wide surface-to-air missile defensive systems.

TABLE 1: *Details of Tsiklon-2 Launch Vehicle*

1st Stage		
	Engine	3XRD-251
	Total Thrust	270.4 tons sea level
	Propellant	nitrogen tetroxide/UDMH
	Length	18.9 meters
	Diameter	3.0 meters
2nd Stage		
	Engine	1XRD-252
	Thrust	97.5 tons vacuum
	Propellant	nitrogen tetroxide/UDMH
	Length	10.9 meters
	Diameter	3.0 meters
Total		
	Length	35.0-39.2 meters
	Launch Mass	182 tons
	Payload Mass	1.5 tons to 200 kilometer polar orbit 3.0 tons to LEO at 65 degrees

Sources: *(1) Lt.-Col. S. Sergeyev, "Domestic Space Hardware: 'Tsiklon'", Aviatsiya i kosmonavtika, Nos. 3-4, March-April, 1994, pp. 38-41; (2) S. Umanskiy, "Russian Space Launch Vehicles", Zemlya i vselennaya, No. 2, March-April, 1994, pp. 97-105.*

8. SUPPORT SERVICES

In the early years of ASAT development, it was realised that one of the biggest hurdles was the identification of enemy of objects. With the proliferation of debris in Earth orbit beginning in the mid-1960s, there was a greater need to conclusively identify hostile systems. Since an inspection mission had been abandoned early in the IS ASAT programme, engineers were left with little or no means to identify enemy spacecraft. The problem was compounded by an information blackout in

November 1961 on all U.S. high security military space programmes [33]. Partly in need to support the IS ASAT programme, and partly to build a reliable database on debris in Earth orbit, in the summer of 1963, the idea for a space monitoring system was formalised at the Special Scientific Research Institute (SNII) of the PVO Strany [34]. Under a co-ordinated plan with the Astronomy Council of the USSR Academy of Sciences, optical observation posts from all across the Soviet Union with favourable geophysical conditions were incorporated into the tracking system. Most of the sites had primary duties as radar stations for the anti-missile defence forces of the PVO Strany. The conceptual design for the monitoring system was finished in 1965 and by 1966 computer programmes for supporting the detection, tracking, and identification of satellites and debris were created; this was facilitated by the establishment of the Main Catalogue of Space Objects. The *Dnestr* missile early warning radar in Kazakstan became the first active element of the so-called System for Monitoring Space (SKKP) in 1967 when it began operational testing [35]. Within one year, a total of eight of these radars were co-ordinated into the SKKP; the radars were located in Kazakstan and Siberia and formed a continuous window for 5,000 kilometers, tracking altitudes as high as 3,000 kilometers.

In the early 1960s, the OKB-586 had developed a small passive spacecraft to assist in the calibration of anti-ballistic missile radars. The first of these satellites was launched as Kosmos-6 in June 1962 [36]. A later version, designated the DS-P1-Yu was specifically developed by the Yangel organisation in support of SKKP operations. Launched from the special *Raduga* launch complex, these small satellites were launched beginning in the mid-1960s for "adjusting the radars and confirming the characteristics specified for them" [37]. The system using the vehicles was officially declared operational in May 1967 [38]. Operations of this system and the SKKP as a whole were conducted from the Centre for Monitoring Space (TsKKP) located near Moscow. Construction began in 1965 and the first 5E51 computer was installed in 1968. Two years later in 1970, the SKKP acquired limited operational capability. The SKKP, including eight *Dnestr* radars, several DS-P1-Yu satellites, and the main TsKKP finally gained full operational capability in 1972 [39]. By that time, most of the focus was on U.S. military assets in space and tasks presumably included positive identification of satellites, their orbits, and their lifetimes. Almost all the developmental work on the complete system was performed by scientists and engineers at the SNII, with the help of Chief Designer Yuliy V. Polyak at the NII Radiotechnology.

Actual control of the IS spacecraft was originally undertaken from a brand new flight control centre near the region of Noginsk built specifically for Chelomey's satellites [40]. The centre was connected to a large communications network spread all over the USSR, created by the NII-4 for maintaining contact with all Soviet satellites. It appears that after 1964, all ASAT operations were moved from the centre at Noginsk to a control point of the Command-Measurement Complex (KIK) near the city of Pechora. According to one of the Chiefs of the KIK, "The KIK Centre was subdivided into sections, each being responsible for a particular satellite. Control of photo-reconnaissance, electronic intelligence, navigation satellites, meteorological satellites, and IS...[satellites] were all carried out separately from each other" [41].

9. THE IS SPACECRAFT

The first actual IS interceptor spacecraft was readied for launch in 1967. Although the vehicle has not been described in detail, a recently shown TV programme broadcast in Moscow included glimpses of the interceptor [42] (fig. 3). As one would expect, the vehicle bears a striking resemblance to the early Polet spacecraft, and clearly the same basic bus developed by the OKB-52 was used for the later missions.

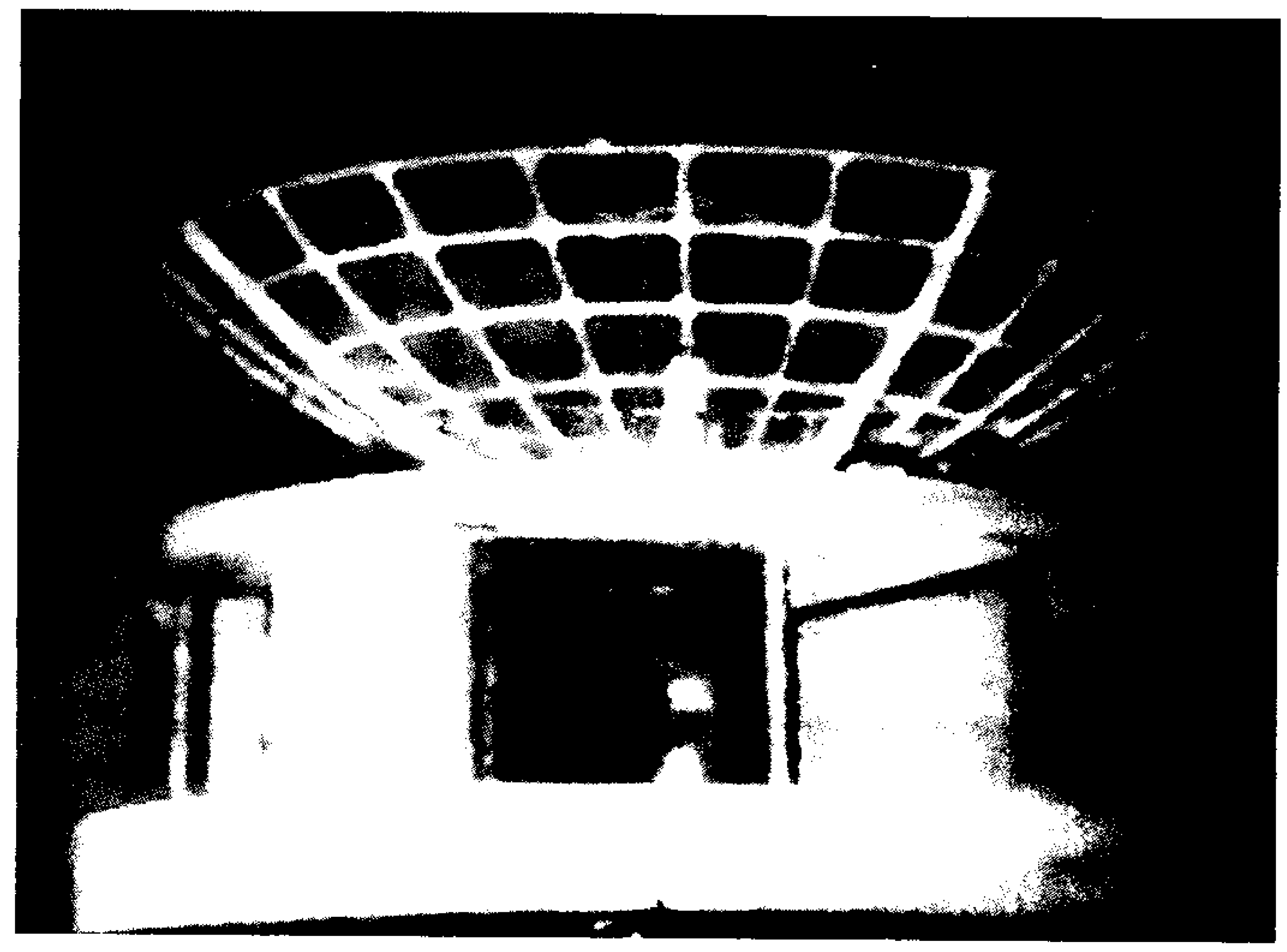

Fig. 3 The image clearly shows the base of the IS ASAT spacecraft with the truss-type antenna shpaed like a skirt. The object in the center of the skirt could be the explosive.

The vehicle was built around a central drum that presumably housed all control and power systems. Like the Polet, the later IS spacecraft had four large propellant tanks mounted on the drum-shaped structure, which framed four of the main engines directed orthogonally. A cone-like structure fixed on the tanks reached an apex that housed two further engines. These two engines were the primary units used for performing major orbital changes, while the remaining lateral engines were utilised to adjust intercept errors at encounter time [42a]. The primary difference from Polet was the omission of the fifth tank fixed inside the cone-like structure. Attitude control thrusters appear to be mounted at several locations on the IS vehicle, including the apex of the cone. Six to eight long antennae were fixed to the spacecraft. The 'rear' of the vehicle, at the base of the drum, included a truss-type antenna shaped like a skirt that housed what *may* have been an additional engine nozzle. In an animation of an attack profile of the IS spacecraft, it appears that the this antenna may have housed the actual destructive warhead of the vehicle [43]. In an unexplained scene, the spacecraft is shown with a large cylindrical extension from inside the metal skirt, which appears to be the origin of explosive action against a target vehicle. The IS spacecraft also carried two short side-mounted booms; a cylindrical appendage was mounted at the end of each boom. It has been suggested that these small objects were in fact (two) warheads; there is no evidence however to support or refute this hypothesis [44]. It is much more likely that they were TV cameras or other optical sensors. The mass of the vehicle is listed in a recently declassified U.S. Department of Defense (DoD) document as about 2.5 tons, which compares well with Russian accounts of 2.4 tons [44b]. Of the total mass, approximately one ton was propellant. In other Western sources, the vehicle was described as being 4.5 to 6 meters in length and 1.5 meters in diameter [45].

While the actual explosive on the IS spacecraft has not been conclusively described, it is possible to extrapolate on the nature of the payload. Initially, Soviet designers evidently settled on a small thermonuclear payload which would explode in the vicinity of the target [46]. Such a

TABLE 2: *Launches in the IS Programme*

IS PUBLIC IS DESIGNATION	LAUNCH DESIGNATION	LAUNCH DATE	LAUNCH VEHICLE	DECAY	COMMENTS
Polet-1	IS	Nov 1 1963	11A59	Nov 23 1966	interceptor testbed
Polet-2	IS	Apr 12 1964	11A59	Jun 8 1966	interceptor testbed
Kosmos-185	IS DU/IS GVM	Oct 27 1967	11K67	Jan 14 1969	interceptor model
Kosmos-217	IS-T/I-2M	Apr 24 1968	11K67	Apr 26 1968	target
Kosmos-248	IS-T/I-2M	Oct 19 1968	11K67	Feb 26 1980	target
Kosmos-249	IS DU	Oct 20 1968	11K67	exploded	interceptor
Kosmos-252	IS DU	Nov 1 1968	11K67	exploded	interceptor
Kosmos-291	IS DU/IS GVM	Aug 6 1969	11K69	Sep 8 1969	interceptor model
-	IS GVM	Nov 1 1969	11K69	-	model, suborbital
Kosmos-316	IS DU/IS GVM	Dec 23 1969	11K69	Aug 28 1970	interceptor model
Kosmos-373	IS-T/I-2M	Oct 20 1970	11K69		Mar 8 1980 target
Kosmos-374	IS DU	Oct 23 1970	11K69	exploded	interceptor
Kosmos-375	IS DU	Oct 30 1970	11K69	exploded	interceptor
-	-	Dec 23 1970	11K65M	-	target, l. failure
Kosmos-394	-	Feb 9 1971	11K65M	in orbit	target
Kosmos-397	IS DU	Feb 25 1971	11K69	exploded	interceptor
Kosmos-400	-	Mar 18 1971	11K65M	in orbit	target
Kosmos-404	IS DU	Apr 4 1971	11K69	Apr 4 1971	interceptor
Kosmos-459	-	Nov 29 1971	11K65M	Dec 27 1971	target
Kosmos-462	IS DU	Dec 3 1971	11K69	exploded	interceptor
Kosmos-521	-	Sep 29 1972	11K65M	-	target, l. failure
-	-	Dec 19 1975	11K65M	-	target, l. failure
Kosmos-803	-	Feb 12 1976	11K65M	in orbit	target
Kosmos-804	-	Feb 16 1976	11K69	Feb 16 1976	interceptor
Kosmos-814	-	Apr 13 1976	11K69	Apr 13 1976	interceptor
Kosmos-839	-	Jul 8 1976	11K65M	exploded	target
Kosmos-843	-	Jul 21 1976	11K69	Jul 21 1976	interceptor
Kosmos-880	-	Dec 9 1976	11K65M	exploded	target
Kosmos-886	-	Dec 27 1976	11K69	exploded	interceptor
Kosmos-909	-	May 19 1977	11K65M	in orbit	target
Kosmos-910	-	May 23 1977	11K69	May 23 1977	interceptor
Kosmos-918	-	Jun 17 1977	11K69	Jun 18 1977	interceptor
Kosmos-959	-	Oct 21 1977	11K65M	Nov 30 1977	target
Kosmos-961	-	Oct 26 1977	11K69	Oct 26 1977	interceptor
Kosmos-967	-	Dec 13 1977	11K65M	in orbit	target
Kosmos-970	-	Dec 21 1977	11K69	exploded	interceptor
Kosmos-1009	-	May 19 1978	11K69	May 19 1978	interceptor
Kosmos-1171	-	Apr 3 1980	11K65M	in orbit	target
Kosmos-1174	-	Apr 18 1980	11K69	exploded	interceptor
Kosmos-1241	-	Jan 21 1981	11K65M	in orbit	target
Kosmos-1243	-	Feb 2 1981	11K69	Feb 2 1981	interceptor
Kosmos-1258	-	Mar 14 1981	11K69	exploded	interceptor
Kosmos-1375	-	Jun 6 1982	11K65M	Oct 21 1985	target
Kosmos-1379	-	Jun 18 1982	11K69	Jun 18 1982	interceptor

design was apparently based on research in the late 1950s which prompted Soviet engineers to adopt nuclear explosives for operational versions of the 'first-generation' V-1000 anti-ballistic missile [47]. To conclusively ascertain the effects of nuclear explosions on target ballistic missiles, nearby satellites, and the space environment, a series of three nuclear explosions were conducted in October and November of 1962. Dubbed Operation K, the devices were launched on R-12 ballistic missiles and detonated at about 400 kilometers altitude [48]. Although primarily conducted in support of anti-missile operations, the results were also used to develop the IS warhead. In fact, Kosmos-11, launched two days prior to the first test may have been in orbit to monitor effects of radiation on itself.

The results of Operation K prompted engineers to search for other options. There were two major problems: the debilitating effects of the nuclear explosion on other Soviet space assets; and the lack of conclusive data on the "negating aspects of such an explosion" [49]. What was clearly needed was a more local kill-mechanism. The design eventually chosen for the IS vehicle appears to have been based upon the destructive device tested on the V-1000 anti-ballistic missile in the early 1960s during test interceptions. The latter explosive has been described in detail, and consisted of 16,000 pellets with a carbide-tungsten nucleus, a TNT filling, and a steel shell [50]. Such a device was first tested successfully on 4 March, 1961 when the V-1000 missile intercepted an R-12 ballistic missile, detonating its high-explosive warhead; the combined chemical and kinetic energy of the explosion was said to have "smashed the missile into smithereens" [51]. One Russian report suggests that such a device was in fact used on the early IS satellites [52]. There is a mention of a 360 kilogram fragmentation warhead in a previously classified U.S. DoD report, and this is implicitly confirmed in several other independent sources [53].

In the initial phase of IS flights, test targets were flown which were about the same size and mass as the IS spacecraft itself. It is probable that the design of the targets themselves were based on the basic IS bus. On these early flights, the targets displayed a capability to change orbits, actions which were not repeated in later phases of the programme. The designation 'I-2M' has been applied in a Russian source, the 'M' perhaps standing for the Russian word for 'target' [53a].

10. FLIGHTS IN 1967-1970: MANOEUVRING TARGETS

In the three year period from October 1967 to October 1970, a total of 11 launch attempts were conducted in the IS ASAT programme. Individual flights in the programme have been analysed in detail by Western analysts elsewhere, and only some of the more salient points are discussed in the present study [54]. The series was commenced by two solo flights in 1967 and 1968, evidently to test primary systems in orbital flight. The first in the series, the IS GVM (Full Dimension-Mass Model), was launched into orbit on 27 October, 1967 on a Tsiklon-2A launch vehicle. The spacecraft was an interceptor 'boilerplate' variant not intended to perform an actual interception, and was designated Kosmos-185 upon reaching orbit [55]. The vehicle was inserted into an initial low orbit after which it was successfully boosted into a higher orbit of 888 X 522 kilometers (as announced by TASS) where it remained until natural decay. The second craft was a target vehicle, the IS-T, launched on 24 April, 1968 as Kosmos-217. Once again, launched into an initial low orbit, the second spacecraft, however, failed to manoeuvre itself into a planned higher orbit of 520 X 396 kilometers [56]. Initial orbital inclination varied from 64.1 degrees (for Kosmos-185) to 62.2 degrees (for Kosmos-217).

These initial solo launches were followed by missions involving actual interception attempts. An IS-T (or I-2M) target vehicle, Kosmos-248, was launched into orbit on 19 October, 1968. Having successfully manoeuvred into the announced orbit of 551 X 490 kilometers at 62.3 degrees, the spacecraft served as a target for two operational IS DU (IS Engine Unit) interceptors, Kosmos-249 and Kosmos-252. The first interceptor, launched the day after the target, entered a low orbit, quickly manoeuvring into a highly eccentric orbit with perigee crossing that of the target's apogee. Following a sharp 'swoop-down' from its higher orbit, Kosmos-249 made a close pass-by of the Kosmos-248 target just after 0730 hours GMT on 20th October, only three-and-a-half hours following launch on its second orbit [57]. The IS DU spacecraft manoeuvred a final time at the time of rendezvous ending up in an orbit announced by TASS as 2,177 X 514 kilometers. The interceptor was finally commanded to explode its destructive charge as a test of the system; 80 pieces were tracked by Western sensors. The close pass-by was evidently too far to neutralise the target, and possibly ground controllers delayed detonation of the interceptor's explosive until the vehicle was in a higher orbit. In early November, the second interceptor, Kosmos-252, conducted an identical series of manoeuvres, eventually exploding into more than 120 tracked fragments in its 2,172 X 538 kilometer orbit (as announced) at 61.9 degrees [58]. Retired Artillery Maj.-Gen. Konstantin Patrin who was present at the control center recalled recently that the "world's first strike of a satellite-target was achieved" during the mission with the neutralisation of the I-2M vehicle (Kosmos-248) [58a]. As soon as news was received of the encounter, the entire control center apparently erupted in celebration. Western analysts with access to open information had previously believed that all interceptions in the Soviet ASAT program were 'passive,' i.e. the explosions occurred after the interception. It is now clear that up to and including the tests in 1970, all the IS tests were 'active' attempts at target encounter [58b]. Soviet or Russian authorities have not released any information on what criteria was used to determine success or failure of an intercept. Western analysts have used a standardised <1 kilometer distance as a complete success. Based on this criteria, U.S. intelligence sources later declared the Kosmos-248/249 mission a failure and the Kosmos-248/252 mission a success [59]

There was a significant change in the IS programme in 1969: the RKO abandoned further use of the Tsiklon-2A (or 11K67) booster in favour of the very similar Tsiklon-2 (or 11K69) booster [60]. Since the differences between the two launch vehicles remain unknown, is not possible to speculate on why such a decision was taken. It is, however, known that the very last Tsiklon-2A launch was attempted in January 1969 and ended with a failure; beginning in August 1969, *all* Tsiklon-type payloads, with the exception of those for the Fractional Orbit Bombardment System (FOBS) were moved to theTsiklon-2. Thus the decision to move the IS programme to the latter booster may have simply been an operational decision unrelated to the ASAT programme. Additionally, it has been reported that beginning in 1969, a lighter payload was introduced for the interceptors [60b]. At least three test launches were conducted in the programme in 1969, and all were related to the switch in launch vehicles and the use of a lighter interceptor.

On 6 August, 1969, the RKO launched a 'boiler-plate' IS GVM spacecraft into an orbit very similar to those of the earlier targets. Designated Kosmos-291, it appears that there was no interception planned for the vehicle, and the payload was in fact a complete dummy payload. The fact that this was the first IS mission on theTsiklon-2 variant suggests that the flight may have been mounted to test out the complete system with the new booster [61]. A second test launch during the year came on 1st November when another Tsiklon-2 was launched with a boiler-plate IS GVM payload. Orbital velocity was not achieved, and it appears that this attempt was meant to be suborbital rather than a failed orbital launch. A final flight was carried out in December 1969. The IS GVM spacecraft was launched on 23rd December as Kosmos-316 into an orbit with an inclination of 49.5 degrees, very different from previous or later IS-type missions. The inclination was in fact more similar to that used on the numerous FOBS launches in the late 1960s [62]. The reason for the strange orbital profile within the context of the IS programme remains unexplained. Rumours that the vehicle manoeuvred prior to reaching its 1,650 X 154 kilometer orbit have not been confirmed [63]. It now appears that the spacecraft was testing an uprated variant of the IS propulsion system [64]. Reports later surfaced that following decay, a large number of fragments from the Kosmos-316 vehicle ended up in Oklahoma, Kansas, and Texas. Some of the pieces recovered were said to be up to a meter in dimension and weighed tens of kilograms. As part of international agreements, the parts were reportedly shipped to Washington for transfer to the USSR, but officials from Moscow were unwilling to accept them as theirs. There were also unconfirmed rumours at the time that "some of the pieces more nearly resembled parts of a bomb casing than a normal rocket structure" [65].

Flights in the initial series came to an end in late 1970 with the accomplishment of an important milestone in the programme as a whole. The IS-T target, designated Kosmos-373, was launched on 20 October, 1970 accomplishing almost the exact same profile as the earlier target. Another 'swoop-down' profile was carried out by the IS DU interceptor, Kosmos-374, although the actual interception came about 600 kilometers lower than the previous tests in 1968 [66]. According to Western unclassified reports, the spacecraft did not succeed in making a pass at less than one kilometers range [67]. Like the earlier test in 1968, a second flyby was conducted with the Kosmos-373 target, which had remained in the same orbit, waiting for the interceptor. On 30 October, 1970, a second IS DU spacecraft, Kosmos-375, was launched into orbit, and once again performed an almost identical flight profile as its predecessor. On this attempt, the interceptor vehicle passed less than one kilometer by its target, achieving the second success in the IS ASAT programme. According to a recent Russian report, "for the first time in the world the ASAT hit a launched target vehicle *based on a target designation of the TsKKP*" [68]. Once again, contrary to previous Western analyses, the interceptor vehicle did in fact explode at the point of closest approach to the target. At the moment of destruction, a special receiver at the ASAT operations centre near Moscow registered that the majority of radio transmitters on board the Kosmos-373 target "ceased to operate": ground controllers registered a total "disabling" of the spacecraft [69].

11. FLIGHTS IN 1970-1971: NEW TARGET MODEL

In all the previous tests, the target vehicle had a similar mass as the interceptor, and had its own manoeuvring capability. In late 1970, the RKO began to fly a new series of target vehicles, which were much smaller and had a decreased mass. The new spacecraft were 1.2 meters in diameter and 1.0 meter long and had a mass of approximately 680 kilograms [69b]. The new targets were launched on the Kosmos-3M (or 11K65M) booster from a new site, the NIIP-53 or Mirnyy launch site, more commonly known as Plesetsk in the West. Due to the change in launch sites, the inclination used for the target was also changed to roughly 65.8 degrees, i.e. much higher and more northerly than the prior spacecraft [70]. The attack profiles of the interceptor were also significantly expanded from the modest plan followed in the early tests.

The first of the new, smaller, and passive targets was launched on 23 December, 1970 from Mirnyy. Unfortunately there was a first stage engine failure of the Kosmos-3M at T+0.24 seconds, resulting in an explosion that presumably destroyed the launch pad. The launch attempt, almost exactly two months following the earlier test, suggests that design of the new target vehicle had been conducted for some time, perhaps originating as early as 1968.

A second target, Kosmos-394, launched in February 1971, was the subject of an attempted interception by Kosmos-397 launched three days after the target's launch. The IS DU interceptor followed a similar pattern as previous tests: launch into a low orbit, followed by a boost into a high and elliptical orbit with perigee matching that of the target at the point of interception, just two orbits after launch. Unofficial Russian reports suggest that the encounter was not a success [71]. Unlike both the earlier tests in 1968 and 1970, there was no second interceptor launched to the small target.

Instead, a third target was launched in March 1971 as Kosmos-400. Unlike any of the earlier target spacecraft, Kosmos-400 was inserted into a roughly circular 1,016 X 995 kilometer orbit at 65.8 degrees (as announced by TASS), close to the altitudes of Soviet and U.S. navigation satellites [72]. Furthermore, the flight profile of the interception was vastly different. The IS DU interceptor was launched in early April as Kosmos-404 into a low and eccentric orbit. Instead of conducting a 'swoop-down' approach, the spacecraft manoeuvred into an orbit relatively similar to the target's at 1,009 X 811 kilometers at 65.9 degrees (as announced). At the beginning of its second orbit, Kosmos-404 was just under three minutes ahead of its target, and by the end of the third orbit it was only a minute behind. The complete approach took about three-and-a-half hours to reach Kosmos-400 at an altitude of 1,005 kilometers. Since the orbital velocities were so similar for both the interceptor and the target, it has been suggested by Western analysts that the Kosmos-404 mission may have had an inspection role rather than an interception goal [73]. Russian reports suggest that the flight was not successful. The IS DU spacecraft subsequently made a final braking manoeuvre which allowed it to re-enter and burn up over the Pacific. With the exception of the active interception of Kosmos-375, this was apparently the first time that an interceptor vehicle had not been boosted into a higher orbit and exploded on command.

A final test of the IS ASAT system was conducted in 1971. Kosmos-459 was launched by an 11K65M booster in late November 1971 from Mirnyy. Unlike previous missions, the target was inserted into a very low orbit of 277 X 226 kilometers at 65.8 degrees (as announced), perhaps simulating a photo-reconnaissance satellite mission. The IS DU interceptor, Kosmos-462 was launched into a highly eccentric orbit in early December. The spacecraft conducted a standard 'swoop-down' profile, with interception at the perigee after two orbits. This time the closest approach was at an altitude of only 232 kilometers, the lowest conducted so far, displaying the capability to predict velocities and locations at such low altitudes given the relatively high air drag. The interception took place within direct line of sight from the Mirnyy launch site. Kosmos-462 was exploded on command, and at least 25 fragments were later tracked. The explosion was reportedly seen by observers in Sweden as a flare lasting about 20 seconds [74]. It is not clear if the explosion was in the vicinity of the target, although the Soviets apparently considered the mission a success.

The current phase ended with the solitary launch of Kosmos-521 on 29 September, 1972 into an orbit announced by TASS as 1,030 X 973 kilometers at an inclination of 65.8 degrees. No interceptor launch was ever attempted against the target, and although it has been confirmed that the mission was part of the IS programme, it still remains unclear whether an interception was planned and cancelled at the last minute. It was on 14 December, 1971 that the IS system was declared commissioned for "temporary operations" with the RKO of the Soviet Air Defence Forces [75]. It would be a further three years before resumption of orbital testing.

12. BEHIND THE SCENES

Very little is known about the development of the IS programme after its transfer to the TsNII Kometa. The latter's General Designer Savin and his deputy Konstantin A. Vlasko-Vlasov themselves were responsible for designing the radar on board the IS interceptor spacecraft. Early on in the programme, they developed an original concept for a radar Station for Determining Coordinates (SOK) of the target and interceptor vehicles and for the Transmission of Commands (PK) for orbital corrections. "Portable receiving posts" were also designed and a special combat programme was loaded into the computer system. RKO Commander-in-Chief Votintsev goes on to recall that:

> Chelomey...determined the carrier-rocket from those already operational and designed a satellite interceptor vehicle with a homing head and fragmentation warhead, and also a special

> target spacecraft with radio transmitters accommodated in it; termination of their operation at the moment of destruction permitted objectively determining both the fact of destruction and the degree to which the target was removed from a working status. [76]

Damage effectiveness after interceptions were reportedly computed by assessing damage to solar panels on the target and by reading "hit monitors." The targets themselves also had a secondary role as radar calibration satellites which was performed both before and after the interceptor flybys [76a]. A DoD report from 1976 revealed details of the flight profile of the early interceptor missions:

> The interceptor is pre-programmed prior to launch to achieve a gross point-in-space rendezvous. It is then launched into a phasing orbit to achieve intercept two orbits later. An on-board radar is then used for search and acquisition. Upon acquisition by the radar, terminal guidance based on target position is used to manoeuvre the interceptor onto a collision course with the target. [76b]

The IS programme was only one of several high security military programmes which were supervised by the TsNII Kometa (now known as TsNPO Kometa). Savin also served as General Designer of the Soviet space-based early warning system named *Oko* which, according to recent information, began operating at "reduced strength" in 1978 and was fully operational by 1982 [77]. The spacecraft bus for that programme was developed by the Lavochkin State Machine Building Plant (GMZ Lavochkin), now known as the Lavochkin Scientific and Production Association (NPO Lavochkin), otherwise famous for designing almost all Soviet and Russian deep space probes.

According to Votintsev, the primary elements of the IS system consisted of a ground command-computation and measurement facility near Moscow, a special launch pad at the Tyura-Tam site and the booster and spacecraft itself. Most earlier Western hypotheses, based on DoD information had suggested that there were two launch pads available for Soviet anti-satellite missions [78]. At least three sites at NIIP-5 (more commonly known as the Baykonur Cosmodrome) have been identified as locations for launch pads for R-36-based boosters: site 67, site 69, and site 90 [79]. Early launches, such as ones for the FOBS programme, were conducted from site 67 and 69 beginning in December 1965. In 1964, the Design Bureau of Transport Machine Building (KB TM) began the design and construction of two new launch pads at site 90. It appears that all IS programme-related launches were conducted from one of the pads at this site [80]. Located about 70 kilometers northwest of the original town of Leninsk (recently renamed Baykonur), it was part of the so-called 'Left Flank' of the missile range [81]. Despite a three-year gap in IS testing between 1972 and 1975, U.S. reconnaissance satellites evidently observed significant activity at the launch area during this period. Tsiklon-2 boosters evidently carrying IS payloads were seen wheeled out from "hangars," erected on the launch pad, fuelled and prepared for launch "on a schedule that on actual missions would result in a launch in less than 90 minutes from the start of booster transport to the pad" [82]. At the NASA Fiscal Year 1978 hearings, it was further revealed that "Although check-out of both ASAT and target systems was conducted in 1973 and 1974, the Soviets did not launch the booster" [83].

Continuing improvements were conducted in operations at the SKKP during the mid-1970s. In 1974, Marshall Pavel F. Batitskiy, the Commander-in-Chief of the Air Defence Forces promoted a plan to integrate the capabilities of the SKKP with those of the Soviet Missile Attack Warning System (SPRN) and the extensive system of anti-ballistic missile radars spread across the USSR. The task was assigned to Vladislav G. Repin, the Chief Designer of the SPRN since 1970, and the individual who had facilitated the earlier integration of the anti-ballistic missile and early warning radars in the Soviet Union [84]. Repin and his deputies eventually carried out this complex task over the ensuing few years, overcoming one of the primary obstacles, the positive identification of hostile military satellites in space. Scientists at the SNII of the Air Defence Forces developed complex algorithms which were no doubt used for targeting purposes in the IS programme. Apart from ground-based observations, cosmonauts in Earth orbit were also tasked with proving out special instruments for identifying U.S. spacecraft. In July 1974, cosmonaut Col. Pavel R. Popovich, the Commander of the Soyuz-14 crew on board the military Almaz OPS-1 space station (publicly called Salyut-3) used a special optical device designated *Sokol* in support of these goals. Given a target designation from the central Space Monitoring Centre (TsKKP) of the SKKP, Popovich detected the U.S. Skylab space station in orbit and performed "necessary measurements [85]." In order for cosmonauts to conduct similar training exercises on ground, a special laboratory simulator was also constructed on the SNII premises, where cosmonauts rehearsed detecting space objects against the background of a starry sky, in the process identifying them. A new computer, the *Belka*, for this experiment was developed by the Institute of Cybernetics of the Ukrainian Academy of Sciences. Cosmonauts also conducted tests to detect nuclear energy sources on board spacecraft being observed. All these exercises were carried out in support of SKKP operations, although clearly they had great importance for the IS programme, which relied on positive identification of hostile spacecraft.

Between 1972 and 1975, the RKO did not conduct any launch attempts in the anti-satellite programme. Openly published material in Russia still does not provide an explanation for this hiatus. Speculation in the West has focused on the beginning of detente between the two superpowers as a possible reason for the temporary halting of the tests [86]. The signing of the SALT I accords in 1972 may have served as the catalyst for a self-imposed moratorium. U.S. negotiators had raised the anti-satellite issue during the talks, although the Soviet diplomats who were involved were evidently unaware of any Soviet anti-satellite programme. As *Aviation Week and Space Technology* reported:

> One U.S. negotiator later said he would have been less concerned if he believed the Russian negotiators were simply lying. But during the months of discussion he had come to know his Russian counterparts and concluded that Soviet military officials had kept the killer-satellite tests secret from their own top civil officials. [87]

13. FLIGHTS IN 1975-1978: TOWARDS OPERATIONAL STATUS

Coming soon after the IS system had been adopted for use in "pilot operations," the time period also provided a relatively long time to design and update the entire ASAT system for future operations. The apparent slowdown of SALT II negotiations no doubt provided impetus to resume ASAT testing in orbit, and it was finally in late 1975 that the first target was prepared for launch. It would be the beginning of the most intensive series of tests in the IS programme, one that would lead to a fully operational capability. The new tests also included attempts to intercept targets within *one* orbit of the launch of the interceptor, the third profile introduced in the programme.

13.1 The 1975-1976 Period

The series was inaugurated by a launch failure. On 19 December, 1975, the IS target was launched on the 11K65M booster, but 448 seconds into its flight, a failure in the second stage prevented it from reaching orbit. It was two months before a backup target vehicle was wheeled out on to the Kosmos-3M launch pad at Mirnyy. The target, Kosmos-803 was the subject of a new profile for the programme, one that appears not to have been successful. Instead of a standard swoop-down profile with an interception over Eastern Europe and the USSR in the early morning hours, Kosmos-804, the interceptor, made its closest approach just south of Havana, Cuba on the target's 62nd orbit and the interceptor's fifth. Based on tracking data, U.S. observers believed that the closest approach between the two vehicles was as much as 150 kilometers [88]. Russian sources confirm the failure of the mission. Kosmos-804 was deorbited soon after the attempt. A leaked CIA report later stated that the test was evidently co-ordinated with military exercises conducted by the Soviet armed forces which were carried out between 29 January and 15 February, 1976. The day after the launch of Kosmos-804, strikes by naval and long-range aircraft were performed leading to a "simulated launch" of strategic ballistic missiles on 19th February [89].

The original target, Kosmos-803, was meanwhile used for a second time. Just four minutes following Kosmos-803's pass over the Tyura-Tam launch site at 1714 hours GMT on 13th April, a new interceptor, Kosmos-814, was launched into a low orbit allowing it to catch up with the target. At least one subsequent manoeuvre enabled Kosmos-814 to 'pop up' and pass by the target at less than one kilometer range prior to completion of its first revolution [90]. No explosion was carried out prompting Western analysts to speculate that the exercise was geared towards inspection rather than interception. It was the first successful demonstration of a 'quick reaction' anti-satellite system which effectively reduced the interception time by half, the flyby having occurred only one-and-a-half hours and one orbit after the launch of Kosmos-814. The interceptor was deorbited soon over the Pacific.

The year saw two more ASAT tests, the first of which occurred in July. Kosmos-839, was launched into the highest orbit yet for any target at about 2,101 X 984 kilometers at 65.9 degrees, as announced by TASS. The interceptor, Kosmos-843 was, however, unable to conduct the key manoeuvres required for interception due to an unknown malfunction on board the spacecraft [91]. Re-entry from the low orbit occurred on the same day of the launch. Later Western analysis hypothesised that the experiment was an attempt to conduct an intercept at an altitude of 1,630 kilometers, significantly higher than the previous altitude record of 1,005 kilometers set by Kosmos-404 in 1971 [92].

The fourth test of the year, in December, involved Kosmos-880 (the target) and Kosmos-886 (the interceptor). The latter spacecraft carried out a standard 'swoop-down' approach to the target's orbit, with interception coming two orbits following launch at an altitude of 570 kilometers. Russian sources report a successful mission, and immediate post-flight analysis by U.S. intelligence agreed with this prognosis [93]. Western sources later reported that unlike all the previous interceptor spacecraft which used radar seekers to track targets, Kosmos-886 was equipped with a new optical sensor, functioning either by sunlight or infra-red emissions from the target. There were clearly several advantages to using such an optical sensor: they are usually smaller and lighter and use less electrical power than radar sensors. Additionally, optical sensors are far more difficult to jam than radar sensors, which can be counteracted by numerous electronic means [94]. The year thus ended with at least two significant events in the series:

(1) the first successful single-orbit interception in the programme and

(2) the introduction of a new optical sensor on board the interceptor.

13.2 The 1977-1978 Period

There were five more tests in the period 1977-78. The first of the series was inaugurated by the launch of the Kosmos-909 target on 19 May, 1977 from Mirnyy into a highly elliptical orbit inclined at 66 degrees. A one revolution intercept on the target by the Kosmos-910 interceptor four days later failed when the chase spacecraft arrived at the intercept point at the wrong time [95]. The interceptor was de-orbited immediately after the attempt. Having failed to engage the target, a second interceptor was promptly dispatched into orbit from Tyura-Tam on 17 June, 1977 as Kosmos-918. A successful one revolution 'pop up' encounter using the traditional radar system was conducted at an altitude of about 1,575 kilometers (the target's apogee), an altitude record for the IS programme. Like all the other one-revolution intercept spacecraft, Kosmos-918 was deorbited and not exploded after the encounter.

Four months passed prior to the third IS test in 1977. This particular test once again extended the altitude envelope of the programme by focusing on the lowest altitude interception yet in the programme. Kosmos-959, a new target, was launched into a 891 X 153 kilometer orbit at 66 degrees (as announced by TASS) on 21st October, followed just five days later by a new interceptor, Kosmos-961. Only three hours following launch, the interceptor conducted a two-revolution pass by the target at an altitude of only about 150 kilometers before being deorbited successfully. The two back-to-back tests with different profiles were a dramatic demonstration of the capabilities of the ASAT system. As Soviet space analyst Nicholas Johnson noted, "new orbital extremes had been demonstrated: a maximum of 1,575 km and a minimum of 150 km, an envelope which easily covered all American low-altitude satellites" [96].

The next test in the new series was also the second use of the new optical sensor on the interceptor spacecraft. The standard target, Kosmos-967 was launched on 13 December, 1977 into a roughly circular orbit of 1,013 X 973 kilometers at 66 degrees inclination (as announced). Eight days later, the interceptor, Kosmos-970 lifted off from Tyura-Tam employing the slow pass-by approach, by matching orbital parameters with the target. The experiment was not successful, although the interceptor was exploded at the end of the exercise. The last test of the year used the same Kosmos-967 target, and once again the 2-orbit chase was not successful, although this time the interceptor, Kosmos-1009 was deorbited into the Pacific.

Of the nine tests performed in the period 1976-78, only four were considered successes. Of the four successes, two were of the 2-orbit profile, while the remaining two were of the 1-orbit profile. If one omits the catastrophic failure on Kosmos-843 which never attempted an interception, this gives a 50% success rating for each profile for the period in question. This apparently provided enough of a rationale for the Ministry of Defence to consider the IS system operational. According to

RKO Commander-in-Chief Votintsev, "after modifications and experimental operation the PKO complex was placed on alert duty on 1 July 1979" [97]." He goes on to describe the mission of the IS system:

> The mission posed was that under certain conditions of the military-political situation, by decision of the Supreme High Command, the PKO and SKKP forces would be capable of destroying the primary military space systems of the probable enemy in a short time and thereby substantially reduce the effectiveness of the use of strategic offensive forces and weapons on the battlefield. And this mission was performed successfully. [98]

It was during this same period that the United States and the Soviet Union began for the first time to engage in talks on limiting ASAT systems in space. There were three sets of discussions held: in Helsinki, Finland from 8 - 16 June, 1978; in Bern, Switzerland from 16 - 23 January, 1979; and in Vienna, Austria from 23 April to 17 June, 1979 [99]. Just 13 days after the end of the last session, the USSR declared its ASAT system operational, despite the hope at the time that meetings would resume later in 1979. In fact, the discussions were not further pursued, marred initially by vehement disagreements over what the Soviets considered the military potential of the Space Shuttle, and later by the worsening relations between the two powers as a result of the Soviet invasion of Afghanistan. The impasse provided an opportunity to continue in-orbit testing of the existing IS system in addition to extensions of its capabilities.

14. FLIGHTS IN 1980-1982: OPERATIONAL

There were four attempted intercepts during this period, the first two employing the optical sensor and the remaining two using the standard radar package. The first in April 1980 involved a two-orbit with optical tracking intercept when the Kosmos-1174 interceptor failed to pass close enough to the Kosmos-1171 target for it to be classified a success. Closest approach occurred over the Soviet Union on the interceptor's second orbit at an 8 kilometer range [100]. After the flyby, Kosmos-1174 was manoeuvred into a higher orbit and exploded on command. After a hiatus of eight months, a new target, Kosmos-1241, was launched in January 1981 and was the focus of two interceptor vehicles. The first one, Kosmos-1243, once again used the new optical sensor and a two-orbit intercept profile. At the very beginning of the interceptor's third revolution a close approach was attempted which appears to have been at least partially successful [101]. Reverting back to using the radar sensor, the same target was engaged once again, suggesting that the previous attempt had not been wholly successful.This time, Kosmos-1258 successfully passed by Kosmos-1241 at less than one kilometer range. Early reports suggested that the interceptor exploded close enough to the target for the latter to have been disabled. Later analysis by Western observers seem to refute that hypothesis since, based on available NORAD tracking information, the orbital parameters of the target remained unchanged.

The final ASAT test of the series took place in the summer of 1982 as part of a larger strategic exercise. Over a seven hour period in June, a variety of strategic offensive and defensive systems were deployed as part of a programme, designated the "Seven-Hour Nuclear War" [102]. The operation was inaugurated by the launches of two operational UR-100 (or SS-11) ICBMs from the Kamchatka peninsula followed almost simultaneously by the firing of a shorter range RSD-10 (or SS-20) missile. Two target ICBMs were also launched from Kapustin Yar which were intercepted upon re-entry by missiles of the then-experimental A-135 anti-ballistic missile system. Apart from an SLBM launch, the final strategic element of the exercise was the ASAT mission. The target, Kosmos-1375, was launched on 6th June into a 1,000 kilometer circular orbit used for the previous five IS missions. Following launch of the interceptor on 18th June as Kosmos-1379, a standard two-orbit chase ensued which culminated in a close flyby at about 1440 hours GMT, just over three hours after launch, when the interceptor was reaching its apogee. According to Western sources, although the interceptor flew by at lethal range, the spacecraft's fusing mechanism for the explosive malfunctioned, prompting a premature firing, thus failing to damage the target [103]. These two Kosmos satellites were not the only space assets used for the exercise. Two military satellites were launched between the orbiting of Kosmos-1375 and Kosmos-1379, one for navigation purposes and the other dedicated to photoreconnaissance goals. As one Western analyst suggested, "No previous space launch had ever occurred during a Soviet ASAT test or from Tyuratam on the day of the test, and the satellite may well have initiated the orbiting of replacements for residents destroyed by the US during the simulated conflict" [104].

15. AFTERMATH

This massive strategic exercise also signalled the effective termination of all Soviet ASAT tests. No further active interceptions have been attempted since then. Beginning in August 1981, the Soviet government launched a relatively aggressive effort in the international arena to formulate a treaty to prohibit weapons in outer space. This culminated in a pronouncement in August 1983 by then-General Secretary of the Communist Party Yuriy V. Andropov on a unilateral moratorium on launches of weaponry into space. It appears now, however, that there was significant opposition to such a decision within the Soviet military. RKO Commander-in-Chief Votintsev recalls a meeting in early August with the First Deputy Chief of the General Staff of the Ministry of Defence Marshall Sergey K. Akhromeyev when:

> it was stated in particular that in one of his upcoming speeches Yu. V. Andropov would announce our termination of tests of the PKO system on a unilateral basis. I categorically objected to this and said that we needed at least another three-four months to confirm experimentally the principles of modernisation being realised for the system. [105]

Akhromeyev was evidently not receptive to Votintsev's plea and according to the latter, the IS ASAT system was decommissioned from active duty on 18th August. The following day Andropov told a group of visiting U.S. senators that:

> The USSR assumes the commitment not to be the first to put into outer space any type of antisatellite weapon, that is, imposes a unilateral moratorium on such launchings for the entire period during which other countries, including the USA, will refrain from stationing in outer space antisatellite weapons of any type. [106]

Votintsev's remarks clearly indicate that the RKO was busy on developing an improved variant of the original IS spacecraft at the time, presumably the version with the optical sensor. Clearly, this model was never declared operational, although it was evidently close to reaching that status. Votintsev also recalls the after-effects of Andropov's order. Sergey S. Martynov, who was the commander of the IS system at the time, was transferred to another unit. All the others of the ASAT unit were either discharged or transferred to other elements of the Air Defence Forces. With underlying regret, Votintsev recalled in 1993:

> All this was occurring specifically when the technical and organisational unification of the PRO, the SPRN, the SKKP and the PKO systems had been completed and a unified missile-space defence...system that functioned automatically under unified software and algorithmic support had formed. [107]

16. STATUS IN THE EARLY 1990s

Votintsev's statements only provide part of the story. While the entire RKO system was decommissioned in 1983, at some point in the latter half of the decade, perhaps prompted by U.S. ASAT tests at the time, it was reactivated. In fact, just before the first U. S. Air-Launched Miniature Vehicle (ALMV) test against a target in space in September 1985, the Soviet news agency TASS announced that if the test was allowed to proceed, the Soviet Union "would consider itself free of its unilateral commitment not to place anti-satellite systems in space" [108]. Presumably the IS system was restored to operational status soon after, despite the ALMV programme itself having been cancelled in March 1988. Although the Soviets continued to refrain from testing their co-orbital ASAT system in space, high officials in the USSR Ministry of Defence believed that the U.S. airborne system was far more superior than the Soviet programme [109]. A number of oblique references in the CIS media in the early 1990s indicate in fact that the IS programme was fully operational as late as 1993. The three factors to support this hypothesis are considered below.

Since the 1970s, the RKO routinely launched spacecraft intended for supporting the goals of the Air Defence Forces. Some of these spacecraft were designated to aid in the calibration of ground based radars for the ABM system, while others were used to maintain settings of the radars for the so-called System for Monitoring Space (SKKP). Given the integration of the major radar systems (PRO, SPRN and SKKP), it is clear that the support and calibration services for any of the major radar systems would also clearly help to maintain readiness of tracking for ASAT operations. These so-called radar calibration satellites, within a variety of subgroups, have continued to be launched well into the 1990s. Recent declassification by Russian authorities have also shed light on the different classes of these satellites. For example, there have been seven spacecraft of the *Vektor* class launched since 1974, the last being Kosmos-2292 in September 1994. It was announced that these spacecraft were for "the determination of spacecraft characteristics with the use of ground facilities of measurement, reception, and transmission of radiotechnical signals" [110]. Cursory details of another type of *Vektor* spacecraft and others such as *Yug* and *Romb* have also been revealed (See Table 3). While it is likely that the primary goal of their missions were for supporting ABM operations, it can be conjectured that given the existence of an integrated national radar system, they also played major roles in the continuing upkeep of ASAT operations in the late 1980s and early 1990s. The CIS also continues to maintain an extensive tracking network for observing the behaviour of space objects. Currently the SKKP relies on *Dnepr* and *Daryal-UM* radars operating in the VHF range near 150 MHz at eight different sites at Irkutsk, Murmansk, Pechora (all in Russia), Sevastopol, Uzhgorod (both in Ukraine), Balkhash (in Kazakstan), Migechaur (in Azerbaijan), and Riga (in Latvia). These stations have been working intermittently although several sensors were temporarily inoperational in 1993-94 as a result of an inability to pay power bills to the

TABLE 3: *Vektor and Yug Support Satellites for ABM and ASAT*

VEKTOR SATELLITE	NO.	LAUNCH DATE	LAUNCHER	DECAY	COMMENTS
Kosmos-660	(n1)	Jun 18 1974	11K65M	in orbit	-
Kosmos-807	(n2)	Mar 12 1976	11K65M	in orbit	-
Kosmos-1238	(n3)	Jan 16 1981	11K65M	in orbit	paired w/ Kosmos-1263
Kosmos-1263	(n4)	Apr 9 1981	11K65M	in orbit	paired w/ Kosmos-1238
Kosmos-1508	(n5)	Nov 11 1983	11K65M	in orbit	-
Kosmos-2098	(n6)	Aug 28 1990	11K65M	in orbit	-
Kosmos-2292	(n7)	Sep 27 1994	11K65M	in orbit	-
YUG					
Kosmos-1146	(n1)	Dec 5 1979	11K65M	Nov 25 1981	-
Kosmos-1179	(n2)	May 14 1980	11K65M	Jul 18 1989	-
Kosmos-1418	(n3)	Oct 21 1982	11K65M	Sep 30 1983	-
Kosmos-1427	(n4)	Dec 29 1982	11K65M	Oct 5 1989	-
Kosmos-1463	(n5)	May 19 1983	11K65M	Jan 24 1993	-
Kosmos-1502	(n6)	Oct 5 1983	11K65M	Aug 29 1985	-
Kosmos-1578	(n7)	Jun 28 1984	11K65M	Jan 10 1993	-
Kosmos-1615	(n8)	Dec 20 1984	11K65M	Apr 15 1990	-
Kosmos-1786	(n9)	Oct 22 1986	11K77	Mar 6 1988	-
Kosmos-1868	(n10)	Jul 14 1987	11K65M	Mar 3 1989	-
Kosmos-2137	(n11)	Mar 19 1991	11K65M	Apr 3 1995	-
Kosmos-2164	(n12)	Oct 10 1991	11K65M	in orbit	-
Kosmos-2265	(n13)	Oct 26 1993	11K65M	in orbit	-
Kosmos-2332	(n14)	Apr 24 1996	11K65M	in orbit	-

Sources: *(1) M. Tarasenko, "Launch of Kosmos-2322 [sic]", Novosti kosmonavtiki, No. 9, April 22-May 5 1996, pp. 54-55; (2) V. M. Agapov, "Commentary on Kosmos-2292 Launch", Novosti kosmonavtiki, No. 22, October 22-November 4, 1994, pp. 48-49.*

TABLE 4: *Attempted Interceptions in the IS PKO Programme*

	DATE	TARGET	INTERCEPTOR	INC.	ALTITUDE	ORBIT	TYPE	OUTCOME RUSSIAN SOURCE	OUTCOME WESTERN SOURCE
Phase I									
1.	Oct 20 1968	Kosmos-248	Kosmos-249	62.2	525 km	2	r	failure	failure
2.	Nov 1 1968	Kosmos-248	Kosmos-252	62.3	535 km	2	r	success	success
3.	Oct 23 1970	Kosmos-373	Kosmos-374	62.9	530 km	2	r	failure	failure
4.	Oct 30 1970	Kosmos-373	Kosmos-375	62.9	535 km	2	r	success	success
5.	Feb 25 1971	Kosmos-394	Kosmos-397	62.8	585 km	2	r	failure	success
6.	Apr 4 1971	Kosmos-400	Kosmos-404	65.8	1005 km	2	r	failure	success
7.	Dec 3 1971	Kosmos-459	Kosmos-462	65.8	230 km	2	r	success	success
Phase II									
8.	Feb 16 1976	Kosmos-803	Kosmos-804	65.8	575 km	5?	r	failure	failure
9.	Apr 13 1976	Kosmos-803	Kosmos-814	65.9	590 km	1	r	success	success
10.	Jul 21 1976	Kosmos-839	Kosmos-843	65.8	1630 km	-	r	failure	failure
11.	Dec 27 1976	Kosmos-880	Kosmos-886	65.8	570 km	2	o	success	failure or success?
12.	May 23 1977	Kosmos-909	Kosmos-910	65.9	1710 km	1	r	failure	failure
13.	Jun 17 1977	Kosmos-909	Kosmos-918	65.9	1575 km	1	r	success	success
14.	Oct 26 1977	Kosmos-959	Kosmos-961	65.8	150 km	2	r	success	success
15.	Dec 21 1977	Kosmos-967	Kosmos-970	65.8	995 km	2	o	failure	failure
16.	May 19 1978	Kosmos-967	Kosmos-1009	65.8	985 km	2	o	failure	failure or success?
Phase III									
17.	Apr 18 1980	Kosmos-1171	Kosmos-1174	65.8	1000 km	2	o	failure	failure
18.	Feb 2 1981	Kosmos-1241	Kosmos-1243	65.8	1005 km	2	o	p. success	failure
19.	Mar 14 1981	Kosmos-1241	Kosmos-1258	65.8	1005 km	2	r	success	success
20.	Jun 18 1982	Kosmos-1375	Kosmos-1379	65.8	1005 km	2	o	success	failure

SOURCES: The two Western sources used have been: (1) Nicholas L. Johnson, Soviet Military Strategy in Space, Jane's Publishing Company Limited, London, 1987; and (2) "Soviets Test Killer Spacecraft", Aviation Week and Space Technology, October 30, 1978, p. 17. In the column for outcomes, the Russian data were provided via Jonathan McDowell. In the case of two of the missions, for Kosmos-886 and Kosmos-1009, the data differ according to the Western source used. The 'r' and 'o' denote radar and optical tracking by the interceptor. The altitudes listed are derived from Western analyses.

TABLE 5: *Organisations Involved in the IS Programme*

Operations and Testing:	Organisation: Heads:	RKO of the PVO Strany Yu. V. Votintsev, then V. M. Smirnov
Overall IS Programme:	Organisation: Head:	TsNII Kometa (now TsNPO Kometa) A. I. Savin
IS Interceptor Bus Design:	Organisation: Heads:	OKB-52 (now NPO Mashinostroyeniya) V. N. Chelomey, then G. A. Yefremov
Tsiklon-2 Launcher Design & Development:	Organisation: Heads:	OKB-586 (now NPO Yuzhnoye) M. K. Yangel, then V. F. Utkin, then S. N. Konyukhov
Kosmos-3M launcher Design & Development:	Organisation: Heads:	OKB-10 (now NPO Prikladnoy Mekhaniki), then AKO Polet M. F. Reshetnev (for OKB-10), A. S. Klinyshkov (for AKO Polet)
Launch Pad Design and Development:	Organisation: Heads:	KB Transpornogo Mashinostroyenia V. N. Solovyev, then G. P. Biryukov
Computer Design and Development:	Organisation: Heads:	Instituta tochnoy mekhaniki i vychislitelnoy tekhniki S. A. Lebedev, then V. S. Burtsev
Basic Sciences:	Organisation: Heads:	Spetsialnoye NII (now Tsentralnoye NII PVO) I. M. Penchukov, then Yu. G. Yerokhon, then G. S. Batyr
Main Propulsion:	Organisation: Heads:	OKB-2 (now KB Khim Mash) A.M. Isayev, then V.N. Bogolomov

newly commercial power industry [111]. These dedicated radar stations are augmented by over 20 optical and electro-optical stations at 14 locations.

The second piece of evidence appeared in an obscure publication about NPO Yuzhnoye, the largest Ukrainian space enterprise, and one which built all the boosters for the interceptors in the IS programme. It was stated that in April 1991, a "decree from the government accepted into operation the anti-space defence complex IS-MU" which uses the Tsiklon-2 rocket-carrier and the 14F10 artificial Earth satellite [112]. The statement clearly suggests that the original IS spacecraft had been uprated to IS-MU (or 14F10 which is the standard Russian designation system of naming weapons systems). Furthermore, given that there was not a single interception test between 1982 and 1991, three explanations are possible: other satellites, such as the *Vektor*, *Yug* and *Romb* tested support systems; all testing was ground based using computational models; or that interceptors were launched, but did not carry out any active interceptions. The first possibilities are likely true, but it is more difficult to prove the last assertion [113]. The missions of all Tsiklon-launched spacecraft in the 1980s have been accounted for and unless some spacecraft had multiple-mission objectives, one must assume that there were no IS spacecraft launched between 1982 and 1991.

The final piece of evidence that suggests that the IS system was operational as late as 1993 came during a Moscow TV show focusing on the TsNPO Kometa, the organisation that has led the development of the co-orbital ASAT since the 1960s. During an interview with Kometa General Designer Savin, the narrator stated that "A space target action system has been developed for the purpose of detecting and destroying military facilities deployed in space. It is operational" [114]. Curiously, Votintsev in 1993 is quoted as saying that "with respect to the PKO system, it is now out of work, as they say" [115]. It is possible that having retired in the mid-1980s, Votintsev was unaware of the current status of the IS system.

There were a total of 20 ASAT tests in the period 1968 to 1982. According to a Russian source, nine of them were total successes, one was a partial success and the remaining ten were failures (see Table III) [116]. Western analysis suggest a similar, but not identical record of failures and successes. An otherwise reliable recent French source suggests 13 successes out of the 20 trials, but does not give further details [117]. Until further conclusive revelations from official Russian sources, it is impossible to judge the operational capabilities of the system. However, the fact the system went through a prolonged period of experimental operation and then was finally adopted as armaments suggest a relatively high degree of confidence in the system. The Soviets rarely accepted weapons into inventory until technical problems were eliminated via extensive testing processes, as demonstrated by a number of ICBM projects which were never accepted into the inventory.

17. CONCLUSIONS

The Soviet Union experimented with a number of anti-satellite weapons systems during the first thirty years of the space age. These included the co-orbital IS system, a ground-based ABM system, ground-based lasers, radio-electronic combat systems, and a MiG-31 programme. Of these, only the co-orbital system was tested during an extensive programme in space. Other vague reports have alluded a piloted one-person spaceplane interceptor which was allegedly developed in the 1980s for use against the Space Shuttle. All Russian reports have unanimously denied such a programme ever existed, although there continue to be sporadic reports in the Western media describing such a programme.

The IS programme was still clearly operational in 1993, but its status in 1996 must be questioned. Occasional reports suggest that the system is no longer operational. Furthermore, given the poor state of the launch complexes at Baykonur and the general deterioration of the nation-wide tracking capability necessary for upkeep of such a capability, it would be surprising if the programme was still active. While Russia presumably has no co-orbital ASAT capability at present, the expertise and the stored hardware involved in the programme have been put up for sale. TsNPO Kometa General Designer Savin in 1992 proposed the use of the IS system in an international effort to limit the effects of the proliferation of orbital debris [118]. Titled "A System for the Ecological Safety of Outer Space," the Kometa proposal appears to go far beyond the capabilities exhibited by the earlier IS programme [119].

There have been a number of different proposals by Russian scientists to utilise Russian and U.S. technology from various space defence programmes to develop a common global ballistic missile defence system. With the collapse of the Soviet Union and the ensuing financial chaos, collaborative programmes as the one proposed by TsNPO Kometa may be the only avenue available to Russian scientists to guarantee funding for these exotic and advanced space projects. It is a curious and some would say, hopeful legacy of over forty years of cold warfare.

18. ACKNOWLEDGEMENTS

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47. O. Golubev and Y. Kamenskiy, "Moscow's Missile Shield Without the 'Secret' Stamp", *Novoye vremya*, No. 11, March 1994, pp. 46-49. The V-1000 was known as the Griffon in the West and was developed by the OKB-2 of P. D. Grushin as part of the System A. The overall systems integrator for the ABM system was the top-secret KB-1 organisation headed by G. V. Kisunko.
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74. Ibid.
75. M. Rudenko, "Designer Chelomey's Rocket Plane", *Vozdushniy transport*, No. 2 (2289), 1996, pp. 10-11. See also Tarasenko, "The U.S. and Soviet Space Systems Developments As Driven by the Cold War Competition", op. cit.
76. Votintsev, "Memoirs and Essays: Unknown Troops of an Extinct Superpower: IV", op. cit.
76a. *A History of Strategic Arms Competition 1945-1972: Volume 3*, op. cit., p. 394.
76b. Ibid., p. 388.
77. Col-Gen. (Ret.) Yuriy Vsevolodovich Votintsev, "Memoirs and Essays: Unknown Troops of an Extinct Superpower: III", *Voenno-istoricheskiy zhurnal*, No. 10, October 1993, pp. 32-42.
78. See for example, *Soviet Strategic and Space Programs*, U.S. DoD, Washington, D.C., 1990, p. 22.
79. K. Lantratov, "The Past, Present and Future of KBTM", *Novosti kosmonavtiki*, No. 7, March 26-April 8, 1995, pp. 43-46.
80. Ibid. This source states that the pads were built for both 11K67 and 11K69 versions of the Tsiklon, with the latter vehicle starting launches there in 1969. Additionally, it notes that the site 67 was used for 11K67, 11K69, and 11K68 boosters, although no dates are given.
81. Major-General V. Menshikov, "Cosmodromes: Rockets and People: Baykonur", *Aviatsiya i kosmonavtika*, No. 4, April 1993, pp. 8-9.
82. "Satellite Killers", *Aviation Week and Space Technology*, June 21, 1976, p. 13.
83. U.S. Congress, Senate, Subcommittee on Science, Technology and Space on the Committee on Commerce, Science and Transportation, *NASA Authorization for Fiscal Year 1978*, Hearings, 95th Congress, 1st Session (1977), Part 3, p. 1636, referenced in Stares, op. cit., p. 306, footnote 10.
84. Votintsev, "Memoirs and Essays: Unknown Troops of an Extinct Superpower: IV", op. cit.
85. Ibid.
86. Johnson, op. cit., pp. 147-148.
87. "USSR Military Secrecy", *Aviation Week and Space Technology*, November 11, 1974, p. 16.
88. "Soviets Resume Satellite Intercept Tests", *Aviation Week and Space Technology*, February 23 1976, p. 20. See also Stares, op. cit., p. 143, where the miss distance is given as 80 nautical miles, although the intercept is said to have taken place over Soviet territory. Note also that Johnson, op. cit., p. 149, suggests that, the "intercept was attempted at the end of the *first* revolution [of the interceptor], less than two hours after launch." Author's emphasis. It appears now that the intercept was planned for the first orbit, but did not succeed.
89. Stares, op. cit., p. 145.
90. "Another Soviet Space Intercept Test Conducted", *Aviation Week and Space Technology*, April 26, 1976, p. 21.
91. "Soviet Anti-Satellite Mission Fails to Reach its Target", *Aviation Week and Space Technology*, August 2, 1976, p. 24.
92. Johnson, op. cit., p. 150.
93. For the Western analysis, see "Soviets Test Killer Spacecraft", op. cit. Note that later Western analysis revised this assessment and suggested that there was a failure of a tracking sensor on board Kosmos-886 preventing completion of a successful mission. See for example, "Cosmos 1174 was 4th Failure of Optical-Thermal ASAT", *Soviet Aerospace*, April 28, 1980, p. 127, referenced in Johnson, op. cit., p. 150.
94. Johnson, op. cit., pp. 150-151.
95. Ibid., p. 151.
96. Ibid.
97. Votintsev, "Memoirs and Essays: Unknown Troops of an Extinct Superpower: IV", op. cit.
98. Ibid.
99. Stares, op. cit., p. 196.
100. C. Covault, "New Soviet Antisatellite Mission Boosts Backing for U.S. Tests", *Aviation Week and Space Technology*, April 28, 1980, p. 20. Note that in this source, it is stated that the attempted intercept occcurred on the interceptor's first revolution. Other sources, notably, Johnson, op. cit., p. 154, and Stares, op. cit., p. 262, suggest this was a two-orbit profile.
101. Johnson, op. cit., p. 152.
102. *Poligon*, Moscow Ostankino Television First Channel Network, 0915 GMT, October 3, 1993.
103. "Soviets Stage Integrated Test of Weapons", *Aviation Week and Space Technology*, June 28, 1982, pp. 20-21. See also, Tsarev, op. cit. for general details of the entire exercise.
104. Johnson, op. cit., p. 153.
105. Votintsev, "Memoirs and Essays: Unknown Troops of an Extinct Superpower: IV", op. cit.
106. Stares, op. cit., p. 231.
107. Votintsev, "Memoirs and Essays: Unknown Troops of an Extinct Superpower: IV", op. cit. The PRO was the anti-ballistic missile system, the SPRN was the missile early warning system, the SKKP was the space objects monitoring system and the PKO was the anti-satellite weapons system.
108. P. B. Stares, *Space and National Security*, The Brookings Institution, Washington, D.C., 1987, p. 21.
109. Tarasenko, "The U.S. and Soviet Space Systems DevelopmentsAs Driven by the Cold War Competition", op. cit.
110. V. M. Agapov, "Commentary on Kosmos-2292 Launch", *Novosti kosmonavtiki*, No. 22, October 22-November 4, 1994, pp. 48-49.
111. A. Wilson, ed., *Jane's Space Directory, 10th ed., 1994-95*, Jane's Information Group Limited, Coulsdon, Surrey, 1994, p. 152. See also N. L. Johnson and D. M. Rodvold, *Europe & Asia in Space: 1993-1994*, Kaman Sciences Corporation, Colorado Springs, CO, 1996.
112. Pallo-Korystin, Platonov and Pashchenko, op. cit., p. 106.
113. It may be of interest to note that a radar-calibration mission was launched in March 1991 as Kosmos-2137. A month later the IS-MU system was declared operational.
114. *Secret Space: Part 1*, op. cit. Note that at the same time, in 1993, author Nicholas Johnson pointed out in a publication that the Soviet co-orbital anti-satellite system was operational *until* 1993. See, N. L. Johnson, *The Soviet Reach for The Moon*, Cosmos Books, 1995, p. 13. The U.S. Department of Defense has maintained that the system has always been operational. A 1990 publication, for example, states that "[the ASAT system] is assessed to be operational, deployed, and combat ready." See *Soviet Strategic and Space Programs*, op. cit., p. 21.
115. Votintsev, "Memoirs and Essays: Unknown Troops of an Extinct Superpower: IV", op. cit.
116. The list of outcomes from Russian sources was provided via personal correspondence from Jonathan McDowell.
117. *Baikonur: La porte des etoiles* (Paris: Armand Colin, 1994), p. 124. This source also correctly states the dates of operational status of the IS system as 1979-1983.
118. M. Tarasenko, "Russia's place in space: a home view", *Space Policy* **10** (2), 115-120, 1994.
119. Tarasenko, "The U.S. and Soviet Space Systems DevelopmentAs Driven by the Cold War Competition", op. cit.

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