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*Front Cover:* **The photo shows Discovery on 1 October 1997, when it was being rolled over from the Orbiter Processing Facility (OPF) to a side-bay of the Vehicle Assembly Building (VAB) to make room for Atlantis on its return from mission STS-86, which landed 6 October 1997. At the time of the photo, Discovery was without its main engines. Discovery is currently being readied for its launch on 28 May 1998, the ninth and last Mir docking mission (STS-91).** E. RUDOLF VAN BEEST

# Cold War In Space: A Look Back at the Soviet Union

**Both the United States and the Soviet Union engaged in the development of various weapons systems for engaging in battle in space during the Cold War. While much has been written on US plans, very little was known until recently about the efforts on the Soviet side. What was known was based on speculation, rumour, or by observing the behaviour of certain satellites in orbit. The most well-known of these weapons systems was the 'IS' co-orbital anti-satellite programme whose history has been covered extensively by Western analysts [1].**

**The more exotic systems, such as orbital bombs, lasers, radio-electronic warfare have, however, been obscured behind intense secrecy. In the early 1990s, a remarkable series of articles in the Russian media finally revealed details of some of these systems including some previously unknown glimpses into how the Soviets experimented with lasers on the US Space Shuttle. The present article is a brief synopsis of newly published information from open sources focusing only on automated battle systems.**

BY ASIF A. SIDDIQI
Philadelphia, USA

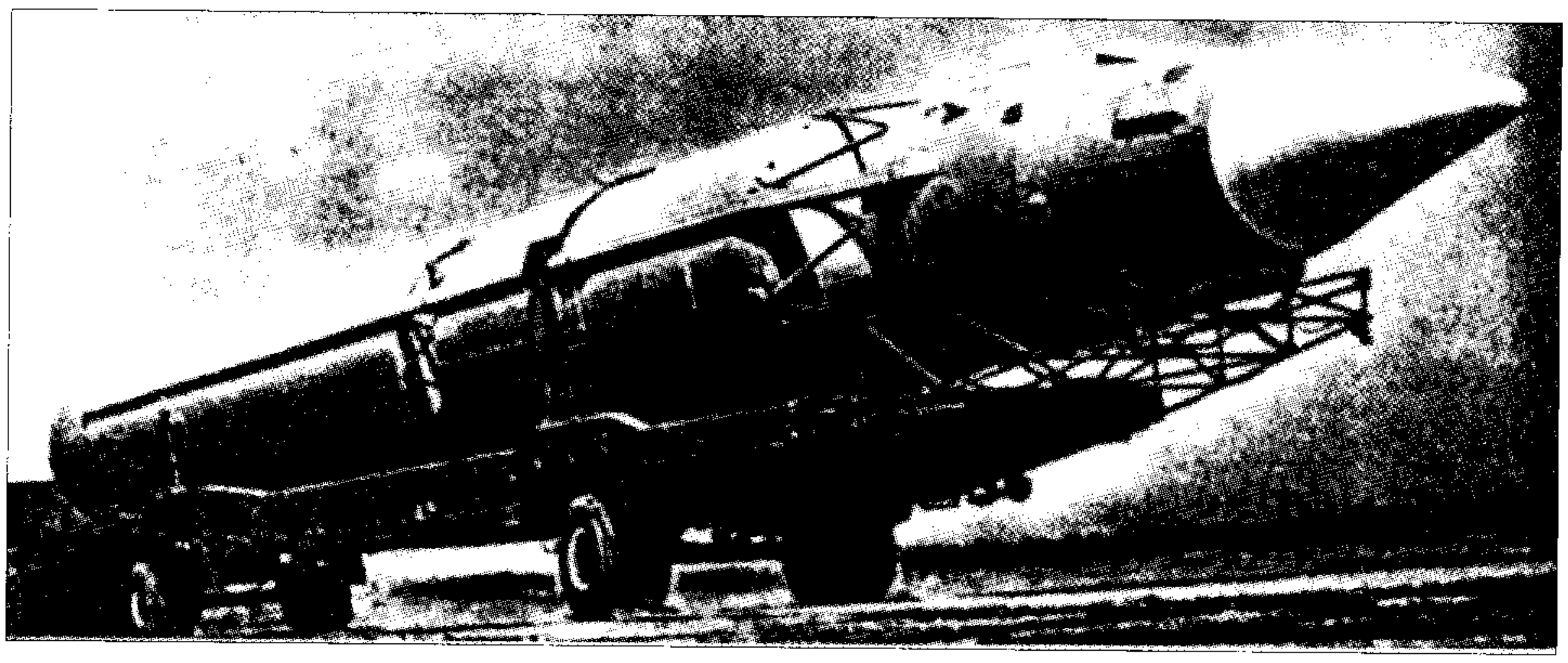
### *The Fractional Orbit Bombardment System*

The Fractional Orbital Bombardment System (FOBS) was an orbital nuclear weapons system designed to attack the continental United States via the 'back door,' i.e. via the South Pole instead of passing through the net of radar systems at the northern approach corridor. The Soviet programme name for the project has still not been revealed, although it is known that FOBS-related ideas were discussed as early as 1959 at the highest levels of the Soviet leadership [2].

By 1962-63, there appear to have been at least three major orbital weapons projects ongoing in the USSR. All were variations of the concept of launching nuclear weapons into Earth orbit and then waiting for the 'opportune' moment to re-enter into the atmosphere, targeting the US mainland. The Soviets used the term 'global missiles' for such weapons.

The earliest concrete proposal originated from OKB-1 Chief Designer S.P. Korolev who began preliminary work on the so-called Global Missile No. 1 (GR-1) in 1960. The project was given the formal go-ahead by a decree dated 24 September 1962 [3].

The development of the three-stage missile was deeply intertwined with the development of the famous N-1 Moon rocket with which it shared many common design elements. These included the engines for the first two stages, the NK-9 and the NK-9V, which were used as the basis for engines on the N-1. These units were designed by the OKB-276 headed by Chief Designer N.D. Kuznetsov, originally an aviation engine designer who was making an entry into the rocketry industry. The third stage of the GR-1 used the 8D726 engine, which was also later used in much modified form as the engine of the famous Blok D stage of the N-1. As is well-known, the Blok D, continues to be used to the present day on the Proton launch vehicle.



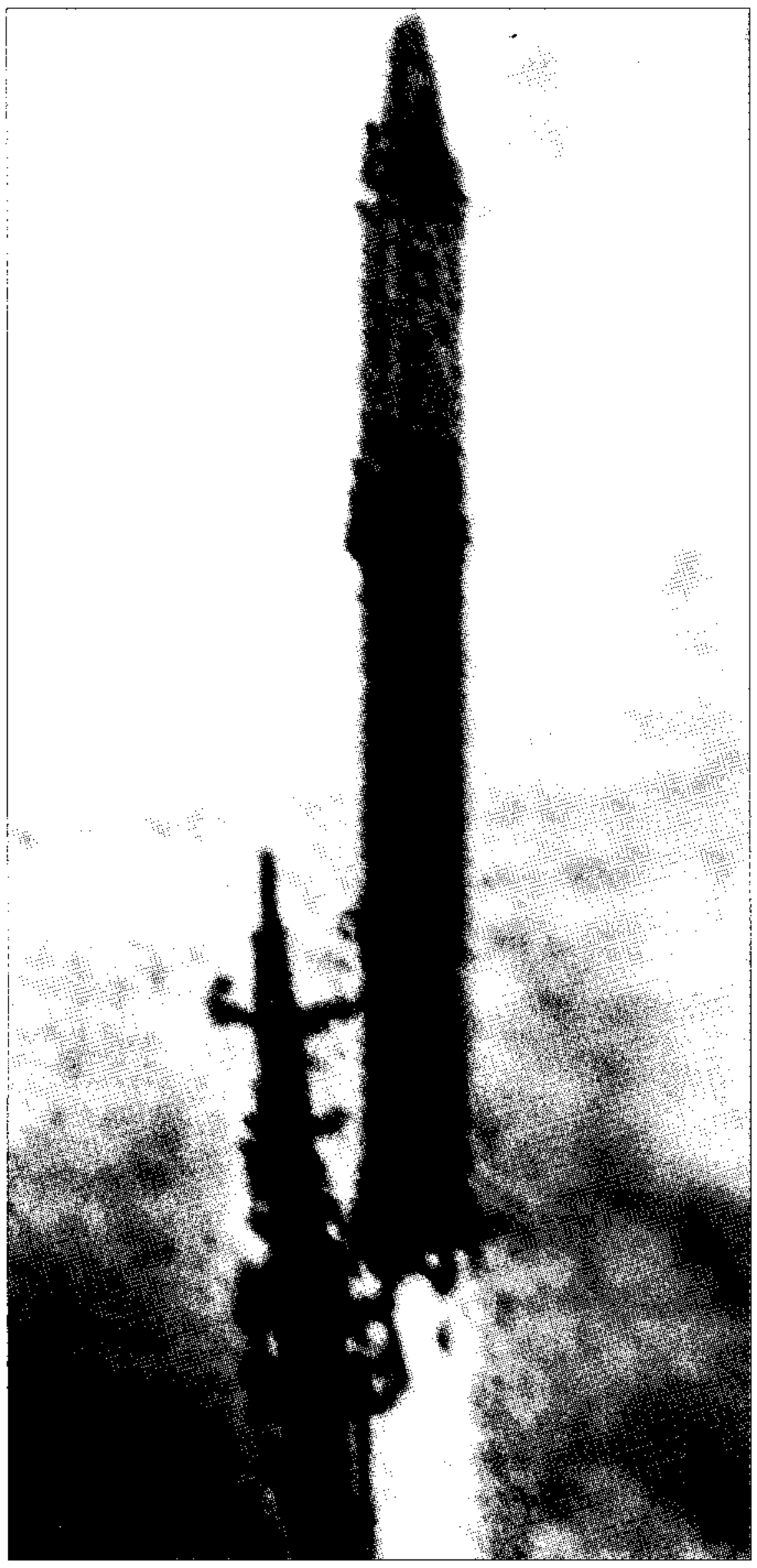
The GR-1 missile, although never launched, was displayed prominently at several Moscow parades in the 1960s.
P. GORIN

The GR-1 missile itself had a launch mass of 117 tons and was capable of lifting a 2.2 megaton warhead into low Earth orbit. Circular Error Probability was estimated at ± 3-5 km [4]. Due to a variety of political, technological, and financial problems, the programme ran into significant delays. The NK-9 and NK-9V rocket engines were apparently major bottlenecks in the programme. Although the missile was displayed at various Moscow parades, it never flew and the programme was cancelled in 1965-66. Engineers working on the project jokingly called the booster the "intercontinental missile from Moscow to Leningrad" since that was about how far it had ever travelled, i.e. from one plant to another plant [5].

The second orbital bombardment project originated at the OKB-52 headed by General Designer V.N. Chelomey. He had originally proposed use of the UR-200 ICBM as a global missile but by 1962, the focus had shifted to the more powerful UR-500 ICBM which was to be modified to carry a 30 megaton warhead into orbit in an uprated version known as the Global Missile No. 2 (GR-2) [6]. This option was not carried through to fruition since the UR-500 ICBM project was terminated upon Khrushchev's fall from power in October 1964. The missile was used as a basis for the Proton launch vehicle, which is still in use at the time of writing.

The only successful project for a global missile came from the organisation of M.K. Yangel, the OKB-586. Some recently released information has provided for the first time the important milestones in this top-secret programme. The Yangel effort was approved by a governmental decree passed on 16 April 1962 which originally called for the first flight tests in the third quarter of 1964 [7]. Work on a draft plan on the missile variant, the R-36-O (or 8K69) was finished in December 1962. The rocket was later named the SS-9 Mod 3 by US intelligence.

There were a total of 24 attempted launches in Yangel's FOBS programme, all using the R-36-O variant of the heavy R-36 ICBM. The firings began on 16 December 1965 and ended with the flight of Kosmos-433 on 8 August 1971. (Of the seven which never reached orbit some were apparently deliberate suborbital flights while others were orbital launch failures.) Recently declassified documents suggest that US intelligence services tracked at least four of the non-orbital ones, although strangely enough some of the FOBS orbital launches in the programme were not identified as being part of the project [8]. The payloads themselves were



**This is an extremely rare picture of an R-36-0 FOBS launch, which has never been published in the West before.**
P. GORIN & A. SIDDIQI

given the generic name of Orbital Payloads (OGCh) by the Soviets, and none of them is believed to have been a live nuclear explosive. The system was declared operational by a decree of the Soviet government dated 19 November 1968 after the 20th launch attempt in the programme [9]. Testing was, however, continued sporadically until 1971. The complete system was eventually dismantled as a result of the never-ratified SALT II treaty. The actual governmental order came in January 1983 and all of the 18 R-36-O launchers at Tyura-Tam were apparently destroyed or dismantled. All the FOBS test launches were conducted from sites 67 and 69 at the Scientific Research Testing Range No. 5 (NIIP-5) better known as the Baykonur Cosmodrome; the current status of the pads at these sites is unknown.

While the launch vehicles were all built by the Yangel organisation (renamed NPO Yuzhnoye in October 1986), the orbital bomb payloads were designed and built by General Designer Chelomey's OKB-52 Branch No. 1. Recently declassified US intelligence reports described the FOBS spacecraft as weighing 4,000 kg. The re-entry vehicle itself had a mass of 1,450 kg which included a 1,200 kg warhead with a yield of 2.0-3.5 Mt. The OGCh was said to be equipped with "an inertial guidance system, and a storable-liquid retro-rocket orbit propulsion system with enough fuel for about one minute of engine operation" [10]. The mission profile of a typical FOBS mission was as follows:

> "The system is targeted before launch and it does not require nor can it use tracking or external guidance updating during a mission. The mission profile consists of three phases: (1), launch, (2) coast, and (3) reentry. During the launch phase, the booster and second-stage engines of the SS-9 place the spacecraft into orbit. After the spacecraft separates from the second stage, the coast phase begins. During the coast phase, just prior to retrofire, the spacecraft initiates a pitch manoeuvre to reorient itself for reentry. After approximately one minute of retro-engine operation, shutdown occurs and the reentry vehicle separates from the spacecraft. The RV then continues on a ballistic trajectory until impact, which occurs about 1.5 to 2.0 minutes after separation." [11].

The FOBS buses were offered in 1992-93 by KB Salyut (the name of the branch at the time) for use for a joint German-Japanese experiment designated Express [12]. Drawings at the time revealed a small Gemini-shaped re-entry capsule one meter in diameter and two meters in length. The Express spacecraft itself was said to have a mass of 756 kg, significantly less than the value reported by US intelligence [13].

Other declassified CIA documents provide a unique perspective on US perceptions of both Fractional and Multiple Orbital Bombardment Systems. In a document from late 1962, the CIA states that "the Soviets have the capability to develop an orbital bombardment satellite and might decide to launch and deorbit a space weapon at an early date for propaganda or political reasons" [14]. There was a strong implication that such weapons would only be effective as propaganda weapons and be seen as militarily ineffective by the Soviets. In mid-1963, a dedicated report on Soviet orbital bombs was prepared which did not deviate significantly from the findings of the earlier pronouncement, although US concerns were apparently focused more on a multiple orbital system:

> "We have thus far acquired no evidence that the USSR plans to orbit a nuclear- armed satellite in the near term, or that a program to establish an orbital bombardment capability is at present seriously contemplated by the Soviet leadership. However the USSR does have the capability of orbiting one or possibly a few nuclear-armed satellites at any time, and at comparatively small cost." [15].

A later intelligence report from 1967 clearly identified the early FOBS launches as part of an orbital bombardment system which was designated the 'SS-X-6.' According the report:

> "We believe that these tests [in 1966-67] relate to the development of a fractional orbit bombardment system, a depressed trajectory ICBM, or both. Either would serve to degrade the value of the US BMEWS and complicate the US problem of developing effective ABM systems. The tests could also relate to the development of a multiple orbit bombardment system." [16].

### *The A-135 Anti-Ballistic Missile System*

Various Western reports have suggested through the years that the Moscow anti-ballistic missile (ABM) system was nominally capable of hitting low-altitude satellites in Earth orbit. Most of these suggestions originated from Department of Defense (DoD) reports on Soviet strategic arms through the 1980s and early 1990s. For example, one DoD publication stated that "The nuclear-armed [exoatmospheric] Galosh ABM interceptor deployed around Moscow has an inherent ASAT capability against low-altitude satellites" [17]. While information in unprecedented detail has been revealed on the history and technology of the first generation ABM systems around Moscow, data on the current system is still sparse.

The initial requirements and characteristics of the A-135 ABM system were defined by June 1975. The overall systems integrator of the system was the Central Scientific Production Association Vympel (TsNPO Vympel) which was established in 1970 by unifying several organisations involved in the development of the Soviet ABMs [18]. A radar and control systems expert at the subordinate OKB Vympel, A.G. Basistov, was named the General Designer of the system in 1976. The Director of the NII Radio Technology, V.K. Sloka, was named the Chief Designer of the phased-array Don radars of the system [19]. With a long development period, the system was finally declared operational in late 1989.

The A-135 system (designated ABM-3 by the DoD) is composed of two levels of missile defence using the modified Galosh (later called Gorgon) and the Gazelle missiles. According to the DoD, the Gorgon "is capable of exoatmospheric or high-altitude, long-range intercepts," while the Gazelle is "used for endoatmospheric or terminal range intercepts of ballistic missile reentry vehicles that penetrate the outer defensive overlay" [20]. According to a Russian source, the system is capable of "the interception (close and long-distance) of the enemy's warheads and their destruction, with the aid of nuclear atmospheric explosions" [21]. Basistov himself has recalled that:

> "The system will not allow a single nuclear explosion dangerously close to Moscow. It has been designed to

automatically detect warheads in flight without human involvement, distinguish them from clutter - decoys or combined ABM countermeasures - and destroy them unerringly in the air, preventing the charge from detonating." [22].

The Gorgon/SH-11 missile, the larger of the two missiles, is about 18.3 m in length with a main body diameter of 1.8 m [23]. It was developed by the Fakel Machine Building Design Bureau (MKB Fakel) located at Khimki near Moscow headed by General Designer V.G. Svetlov [24]. According to Western analysis, the "silo launched Gorgon is probably capable of intercepting very low altitude (only a few hundred kilometres) satellites which pass above the Moscow region" [25]. Although based around Moscow, additional Gorgon missiles may be installed at the Sary Shagan ABM test range in Kazakstan. The primary A-135 radar is said to be located at Pushkino.

### *The Fon-1 and Fon-2 Programmes*

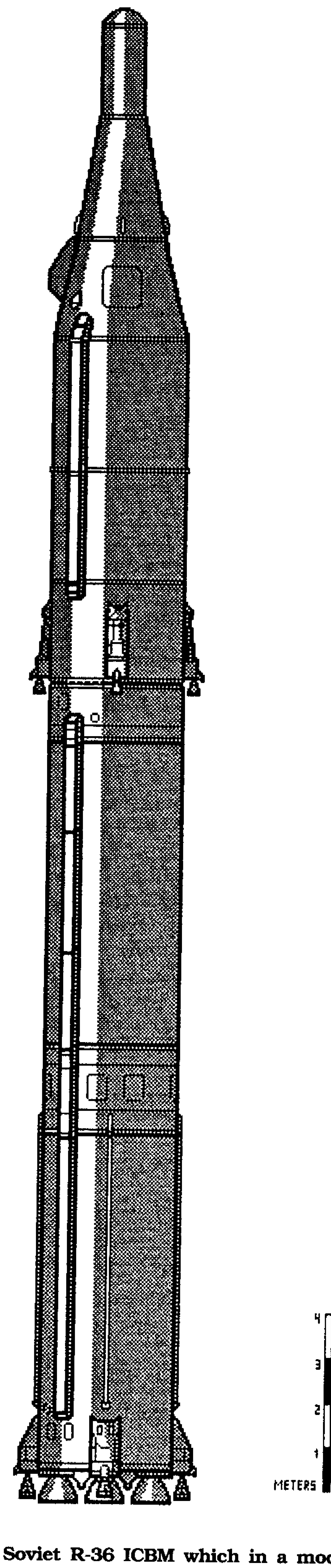
The Soviets spent many years on an effort that mirrored the US Strategic Defense Initiative (SDI) programme. Details are still lacking, but a general overview of the project is now possible.

There have been sporadic reports of work that advanced technology weapons programmes began as early as the mid-1950s. KB-1 Chief Designer G.V. Kisunko, the leader of the early ABM effort in the USSR, recalled recently that an American newspaper report in 1956 on "a method of destroying missiles with focused radio waves in a superhigh frequency band" prompted officials to initiate a Soviet programme at the time [26]. After studying the topic, the KB-1 apparently proved that such a programme was "physically not feasible" given the current technology.

In the 1960s General Designer Chelomey was at the forefront of a number of proposals for space-based defensive and offensive systems. At an important April 1960 meeting in Crimea which effectively set the stage for the development for the co-orbital ASAT, Chelomey tabled several ambitious space-based systems for official approval. The centre of his ideas was a massive Earth-orbital space station armed with a huge number of nuclear-tipped rocket projectiles capable of hitting enemy satellites and spaceships. The entire system would be augmented by orbital bombs and space-based missile defence systems [27]. Khrushchev evidently declined to proceed with Chelomey's ambitious ideas, although the latter continued to offer a variety of different proposals over the following two decades. For example in 1962-63 he drafted a proposal designated Taran which was to incorporate the use of UR-100 ICBMs and missiles from the Yangel design bureau for a nationwide ABM programme. Despite appeals from other scientists that technical aspects of the plan were "unsubstantiated", Chelomey was given the green light to proceed with the preparation of a draft plan on 3 May 1963 [28]. The programme was, however, cancelled a year later after Khrushchev's fall [29].

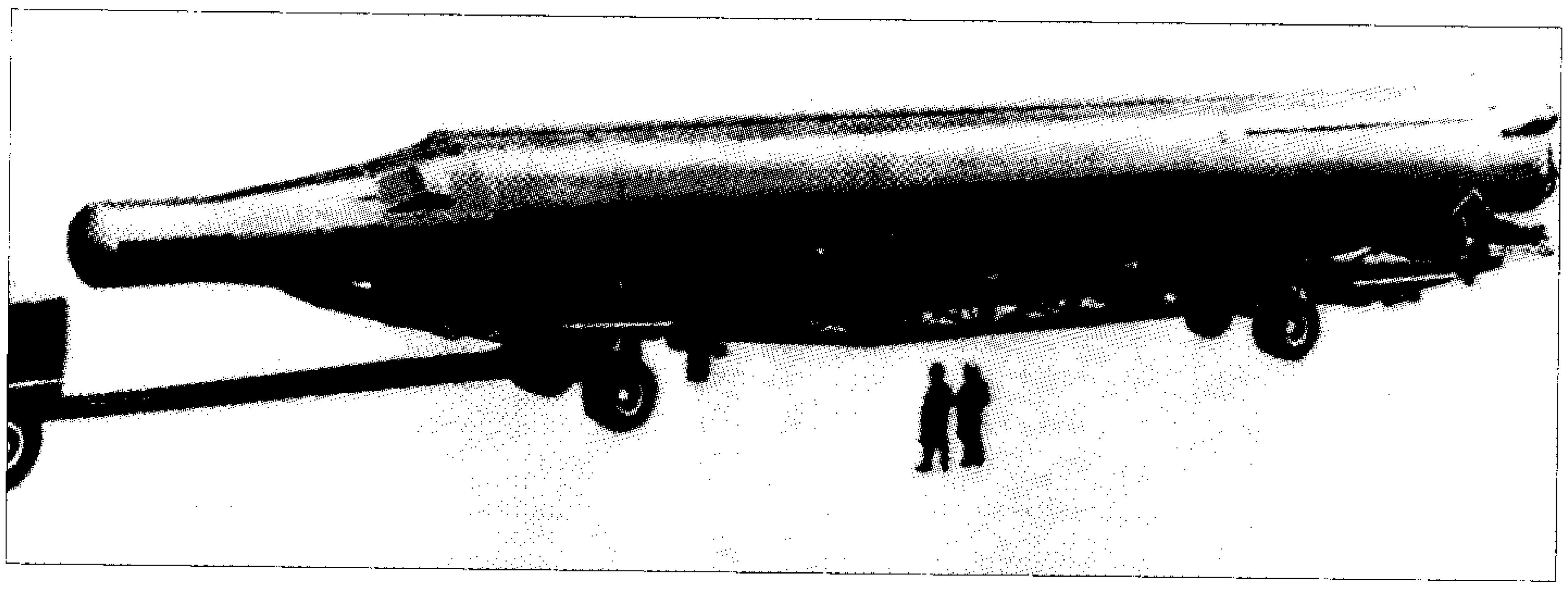
Another proposal came from Korolev's successor, V.P. Mishin. In the autumn of 1969, Mishin visited the Institute of Nuclear Physics at Akademgorodok to discuss space-based particle beam accelerators. Scientists at the institute were asked whether they could design particle beam accelerators small enough to be launched into space for use as defence against incoming enemy missiles. It is likely that the giant N-1 lunar rocket was to be used for the programme. The project was never carried through following a peer review by some famous Soviet scientists, although a "modest" contract was tasked to the institute [30].

Soviet scientist Andrey Budker, one of the founders of the Institute of Nuclear Physics, was reportedly among many in the early 1970s who were advocating research on "particle accelerators in space to generate neutron beams that would allow conflicts to be sorted out away from the Earth" [31]. These proposals were not taken seriously until the late 1970s when Chelomey once again emerged with a new ballistic missile defence project. Chelomey authored a letter to Soviet leader L.I. Brezhnev which described the placement of hundreds of small interceptor rockets on space-based platforms, an idea that later was at the core of US strategic defence planning [32]. According to Ye.P. Velikhov, the noted scientific advisor to the Soviet leadership and a Vice-President of the USSR Academy of Sciences, "Chelomey proposed [a Soviet version] of Brilliant Pebbles to solve all the problems of strategic defence...It took almost two years to stop this because he went directly to [Leonid] Brezhnev" [33]. The recommendations of a special commission, which included




**The Soviet R-36 ICBM which in a modified form was used as the launch vehicle for the Fractional Orbital Bombardment System.**
Image © P. GORIN 1993

**The R-36 ICBM shown at a Red Square parade in the 1960s. The missile was evidently disguised by the Soviet authorities with a different payload fairing and interstage structures.**
P. GORIN



A very rare picture of L.V. Smirnov, the Chairman of the VPK between 1963 and 1985. He not only directed the Soviet space weapons programme, but was also manager of the Soviet defence industry during this period. This picture dates from 1968.
(files of ASIF SIDDIQI)

Velikhov, prompted the Soviet government to terminate work on the project.

The Chelomey proposal may have been part of a much larger programme. It has been revealed that all advanced space and ground-based ballistic missile defence programmes were grouped under a large-scale project designated Fon-1 which was begun in the late 1970s [34]. The programme was a coordinated effort of several institutes from the USSR Academy of Sciences, a number of military institutes and the General Staff of the Ministry of Defence. Overall direction was the responsibility of the Ministry of Radio Industry headed at the time by P.S. Pleshakov. The Military-Industrial Commission (VPK) led by L.V. Smirnov was responsible for monitoring and approving the programme. The Fon-1 project primarily consisted of theoretical research on a variety of topics, including "different kinds of beam weapons, electromagnetic rail guns, anti-ballistic missiles, including multiple warheads with subprojectiles, systems for salvo fire, and other systems" [35].

One of the early proposals of the Fon-1 program was an effort to devise a comprehensive defence system against the entire US nuclear arsenal. TsNPO Kometa, the same organisation which had developed the IS co-orbital ASAT system, was tasked with studying a space-based system capable of destroying all US nuclear warheads before they were launched from submarines, bombers, and missiles. Kometa's research proved by the late 1970s that "it would be impossible to destroy the entire nuclear potential that the Americans had on all types of carriers [about 10,000 warheads] over the course of a 20-25 minute approach time" [36].

At some point soon after the Fon-1 programme was started, at a review meeting, several of the designers involved recommended that the effort be terminated since in their opinion, the project had "no prospects." This most likely was the same commission that curtailed Chelomey's Brilliant Pebbles analog effort. Despite strong objections from some high-ranking military officers, Fon-1 was cancelled.

US President Ronald Reagan's famous 'Star Wars' speech in 1983 appears to have prompted the Soviets to take a second look at advanced missile defence systems. The same year, the Fon-2 programme was secretly initiated. According to the then Missile and Space Defense Forces (RKO) Commander-in-Chief Yu.V. Votintsev, the follow-on effort was "more practical and required major state funding." He recalled that in-depth research was conducted on:

> "The area of the application of alternative systems capable of neutralising the American SDI. . . with 'nonlethal weapons': an electromagnetic pulse that instantaneously disrupts the work of electronic hardware, the effects of lasers...and powerful microwave field changes." [37].

According to one Soviet journalist:

> "Suggestions were made that billions of roubles not be spent on our own Strategic Defense Initiative...but rather that our efforts be channelled into the creation of an anti-SDI - that is to say, a system for intercepting and destroying the enemy's spaceborne systems." [37a].

The eventual results of the Fon-2 programme are unknown. It is unclear if the effort was terminated and/or succeeded by a third programme. The scale of the Fon-2 programme has also been the subject of much debate. For example, Velikhov has insisted that the Soviets did not have a programme to develop lasers for space, although they did develop "lasers, but mostly for tactical purposes...which is what the Americans are returning to today." He adds that they "continued to work on the land-based interceptors and achieved good results...and on radar" [38].

Like the US, the Soviets have engaged in at least three types of advanced ASAT efforts: high-energy lasers, particle beams, and radio electronic warfare. The US DoD has continued to maintain for over a decade that the Soviets were engaged in a significant programme to develop ground-based lasers. With respect to ASAT systems, a DoD publication reported in 1987 that there were several air defence lasers at the Sary Shagan facility in Kazakstan, in addition to two lasers capable of damaging some components of satellites in orbit [39]. More information on these lasers came to light in 1989 during a visit by US Congresspersons to Sary Shagan. The two major laser installations at that location were described as a 0.7μm ruby laser and a 10.6μm pulsed $CO_2$ laser. Both lasers utilised a common beam director of one meter diameter and were developed by the TsNPO Vympel. Officials involved admitted that the lasers had been used to track satellites (the last time being August 1988), but emphasised that the units had no lethal capability [40]. At the same time, during the same Congressional delegation's visit to the I.V. Kurchatov Institute of Atomic Energy, an experimental one megawatt laser was shown to the visitors at the institute's Troitsk facility [41]. Constructed around 1980 by the NPO Astrofizika, the laser was said to have been built to experiment with the military applications of lasers in space. It was not clear if the laser had actually been used on any target in space.

Allegations that the Soviets had used lasers against spacecraft had emerged as early as 1975, when the trade publication Aviation Week and Space Technology reported that at least three US military spacecraft had experienced problems with their infrared sensors. The DoD subsequently vehemently denied this had ever happened [42]. Further reports in 1980 suggested that the USSR possessed a ground-based ASAT laser system. The following year, a US Senator seemed to confirm these findings [43].

Reports in the Russian media in 1993 reported that lasers had been used to track US spacecraft in orbit, but emphasised that all tracking was non-lethal. Perhaps the most interesting of all the tracking incidents was one involving the US Space Shuttle. RKO Commander-in-Chief Maj.-Gen. Votintsev recalled that at the suggestion of USSR Minister of Defence D.F. Ustinov, the RKO was instructed to attempt tracking the Space Shuttle with lasers in the fall of 1983. The Chief Designer of the laser system at TsKB Luch was N.D. Ustinov, the minister's own son, and the latter appar-

D.F. Ustinov, the de facto head of the Soviet space programme between 1965 and 1976. His son was a major participant in Soviet space weapons programmes.

ently initially refused to attempt the experiment on account of other obligations. The experiment eventually took place during the STS-41G mission in 1984 with the laser operating at its minimum emissive power levels. On 10th October, when Challenger was flying over the National Air Defence Forces State Range near Lake Balkhash (at Sary Shagan), a precise target designation was forwarded from the Argun radar measurement system which allowed the laser to track the Shuttle. Orbital altitude was 365 km and the slant range of detection and tracking was 400 to 800 km [44]. According to Votintsev, "as the crew later reported, when the shuttle flew over the region of Balkhash, that communications and part of the equipment on the spaceship were cut off and they themselves did not feel very well." The US government apparently filed a formal protest as a result of the incident after which the "laser facilities and part of the radio engineering complexes of the test range were no longer used for tracking shuttles" [45].

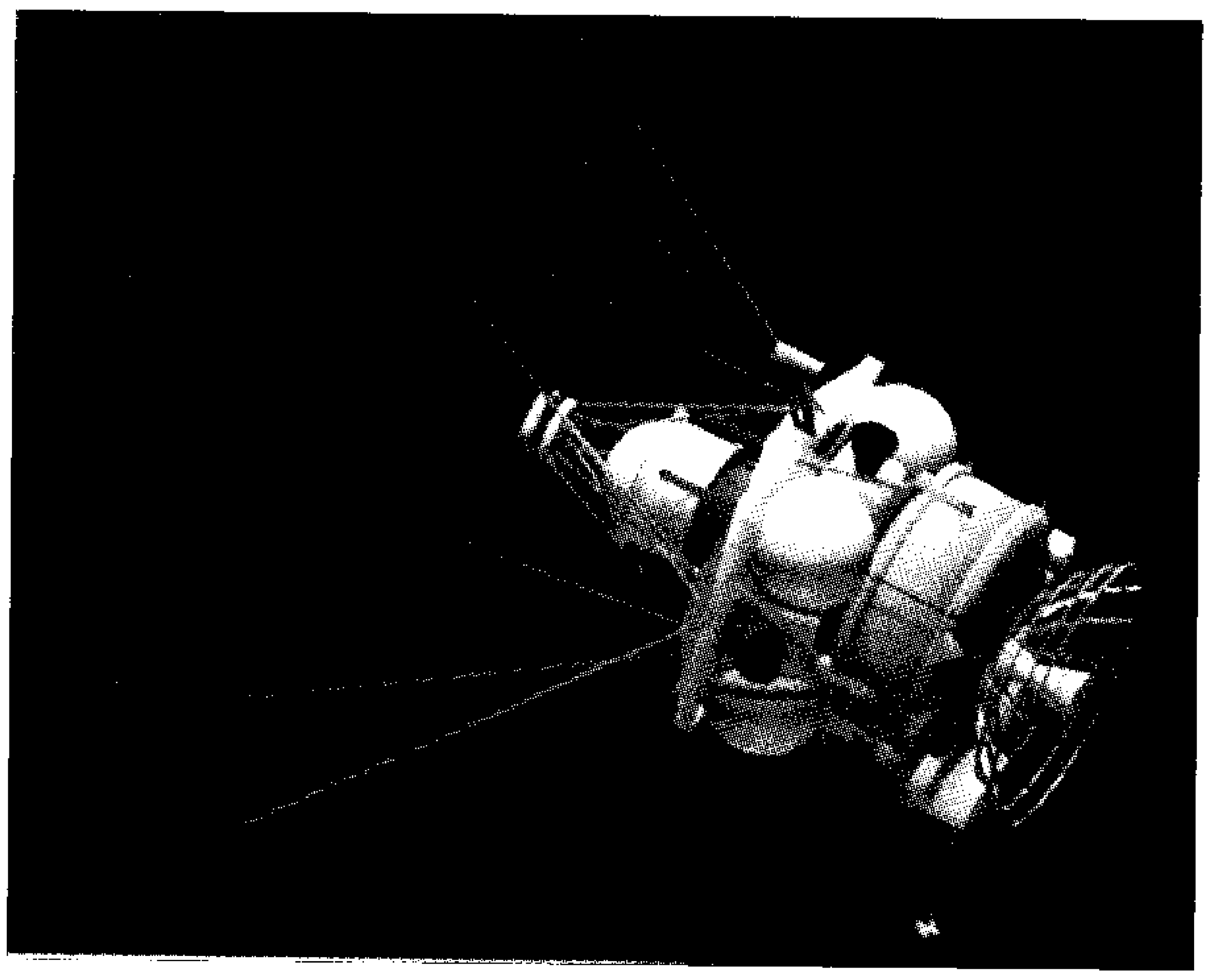
TsNPO Kometa officials in 1994 claimed that the Shuttle incident was exaggerated. A journalist investigating the incident was told by Kometa that:

> "The laser complex was used to measure distance from the Earth to the vehicle. "Communications were shut down, equipment performance irregularities occurred" - this is all nonsense. I was told authoritatively: neither in Russia nor in the US do the technical capabilities exist for destroying targets in space with a laser." [45a].

### *Polyus/Skif-DM*

The Polyus/Skif-DM experiment in 1987 was apparently the one-and-only attempt to test a space-based laser device. The history of the programme is still clouded in mystery, but some general conclusions can be reached. In July 1985 when it was realised that the Soviet space shuttle Buran would not be ready for the first flight of the new Energiya heavy-lift launch vehicle, the Soviet leadership requested the KB Salyut entity (which at the time was a branch of NPO Energiya), to develop a 100 ton mockup to take its place. Soon after, the head of the Ministry of General Machine Building (MOM) O.D. Baklanov altered the request into a vehicle for "performing geophysical experiments in near-Earth space" [46]. As is well-known the Polyus vehicle was launched on the maiden flight of Energiya on May 15, 1987, but failed to reach orbit due to a malfunction in the payload itself. The mystery on the nature of the payload was rekindled by a 1991 report in the Soviet media which stated that Polyus "wasn't some sort of cheap mockup, but an intermediate, partially equipped version of the Skif-DM space vehicle, which, on the one hand, served as a test payload and, on the other, was intended for perfecting the design and on board systems of a future military space complex with laser weaponry". [47].

The Polyus spacecraft itself was 37 m long and 4.1 m in diameter and consisted of two main sections, an 'operations/service unit,' and a special purpose module. The total mass was around 80,000 to 90,000 kg. It appears that the 'operations/service' unit was simply the so-called Functional Cargo Block (FGB) element of the Transport Supply Ship (TKS) from the military Almaz space station project, which had been abandoned several years prior. The TKS FGB used on Polyus was, in fact, the unused article (serial number 162S) between Kosmos-929 (number 161S) and Kosmos-1,267 (number 163S). Subtracting the mass of the FGB from the total of Polyus one can extrapolate the mass of the laser payload as about 60,000 kg. According to the lead designer of Polyus, Yu. P. Kornilov, the mission had a purely civilian goal, i.e. "to study the interaction of artificial gas and plasma formations with ionospheric plasma" [48]. These experiments were to be conducted in coordination with several airborne and seaborne receiving stations. Other reports suggested that the Skif-DM laser device was actually designed and built by the Scientific Research Institute of Thermal Processes (NII TP) where a 100 kW laser had been constructed in the early 1970s [49].



**The Soviet 'Polet' satellite which was a prototype of the anti-satellite system developed by TsNPO Kometa.**
Image © DENNIS NEWKIRK, 1994

Kornilov recalls that the experiment earmarked for Polyus was postponed prior to the launch. General Secretary M.S. Gorbachev was at Tyura-Tam days before the launch and at a meeting in his presence, the experiments programme for Polyus was cancelled:

> "Fearing that they would compromise the peaceful declarations of the country's leadership, they cancelled the entire programme of in-orbit research aboard the Polyus spacecraft...they could have easily interpreted it is an attempt to create a space weapon." [50].

The payload was apparently left intact on board the spacecraft, the mission now presumably reduced to testing the performance of the Energiya vehicle itself. In the event, during the launch, although the booster performed flawlessly, due to a software error involving the incorrect mix-up between a '+' and a '-' the FGB service module fired in the wrong direction, depositing the payload into the Pacific after burnup in the atmosphere [51]. Plans for further tests of the laser weapon were cancelled.

### *Other Programmes*

Recent reports in the Russian media have admitted significant advances in Radio Electronic Combat (REC). Some officials have acknowledged the capability to use REC against Earth orbiting satellites [52]. Rimil Avramenko, the Chief Designer of the NII RP had also described a weapon using super high frequency emission generators which are capable of destroying incoming missiles and satellites [53]. At the same time, another leading General Designer, A.A. Kuzmin of MAK Vympel (the current name of the TsNPO Vympel), responsible for the missile attack early warning system, suggested that previous comments on Russian plasma weapons were gross exaggerations [54].

Finally, there have also been reports of an ASAT system much like the one using the F-15 ALMV. At least two MiG-31 interceptors, built by MZ Mikoyan, were apparently modified by 1987 for an ASAT role using a kinetic-kill warhead [55]. The twin-seat MiG-31 was originally designed as a high-altitude long-range interceptor with a normal operating ceiling of about 17,000 m; in its ASAT version, the aircraft showed only a few visible external modifications. Early reports suggested that the impact weapon was affixed under the main fuselage of the aircraft in the centre position [56]. Later it emerged that the aircraft, the MiG-31D (or article 07) was equipped with two missiles installed on wing pylons. There were two prototypes built although the programme was cancelled soon after [57]. The missiles themselves were designed and built by the GNIP OKB Vympel (a completely different organisation than the TsNPO Vympel) currently headed by Chief Designer D.K. Dragun.

### *Conclusions*

The Soviet Union experimented with a number of automated space-based weapons systems during the first thirty years of the space age. These included the co-orbital IS system, a ground-based ABM system, the Fon-1 and Fon-2 programmes, and the MiG-

31D programme. Of these, only the co-orbital system was tested during an extensive programme in space. It should be noted that there were also several crewed space-based battle systems studied by the Soviet Union in the past 30 years. These, however, fall outside the scope of the present study.

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