New Vanguard

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Scud Ballistic Missile and Launch Systems 1955–2005

Steven J Zaloga • Illustrated by Jim Laurier and Lee Ray

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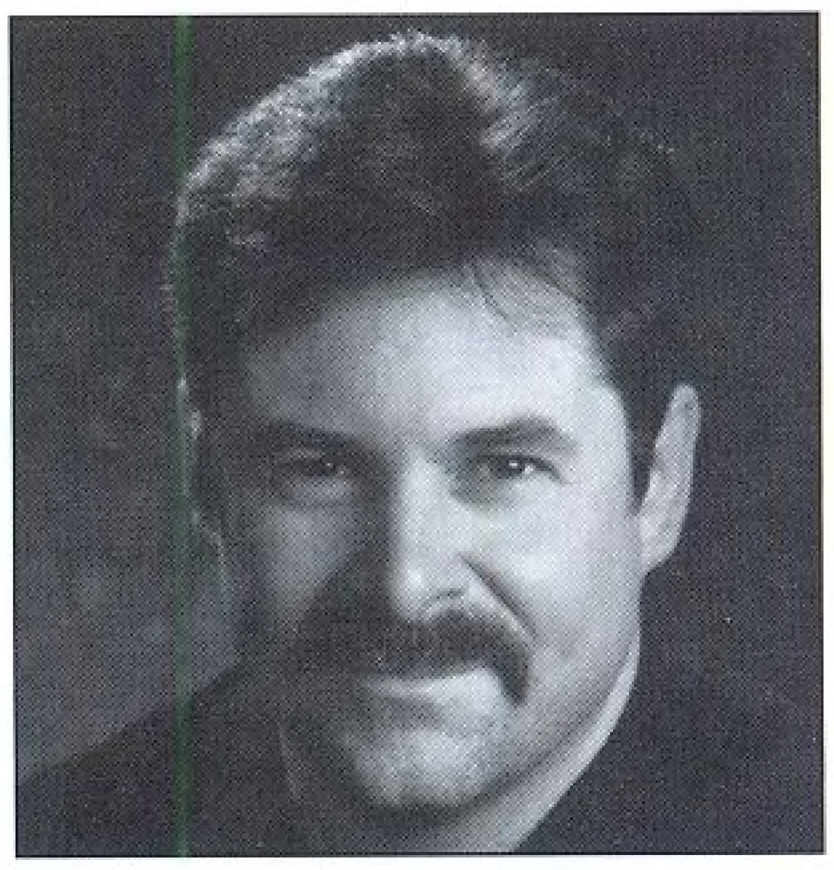

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CONTENTS

New Vanguard • 120

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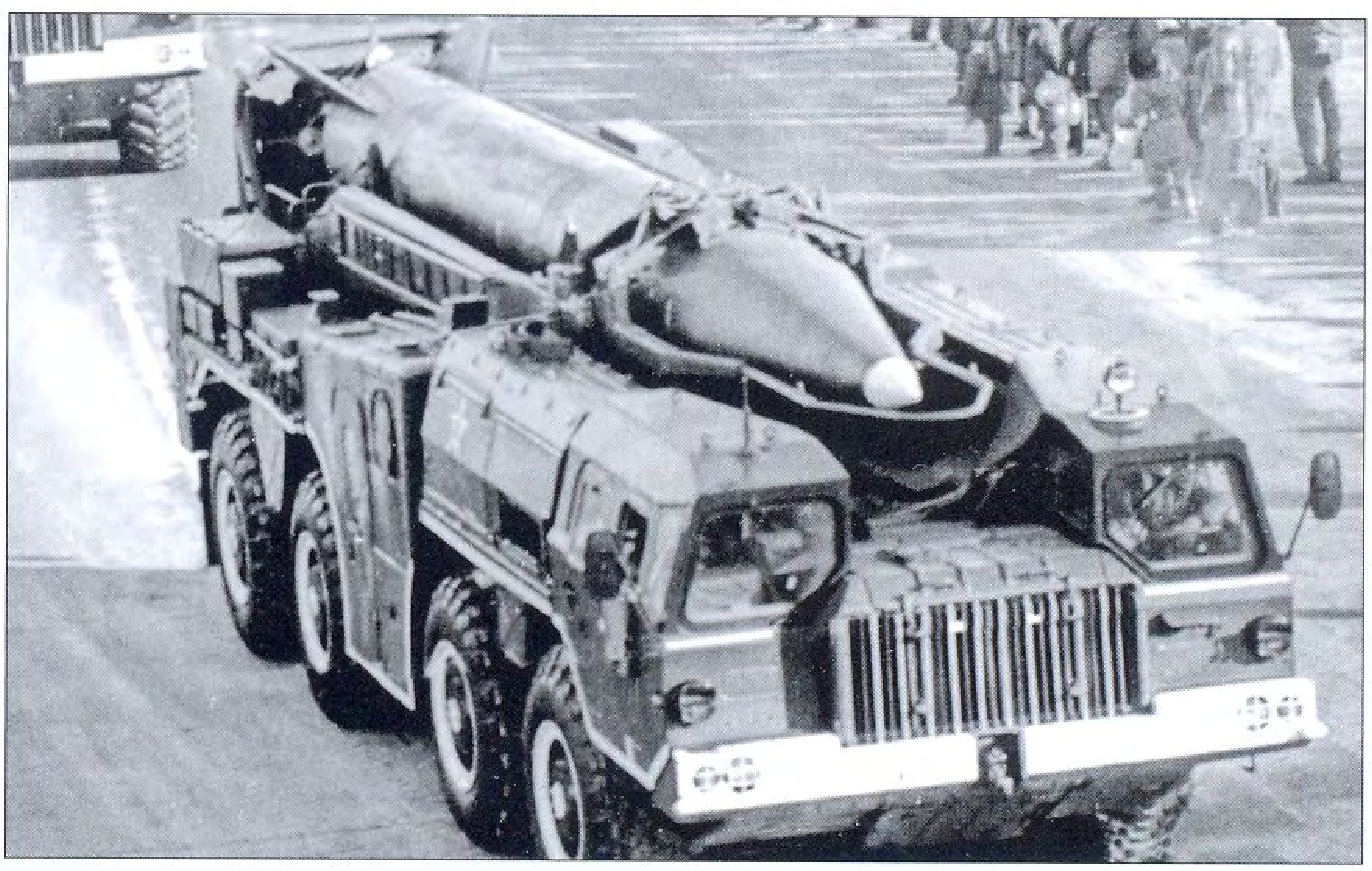
SCUD BALLISTIC MISSILE AND LAUNCH SYSTEMS 1955–2005

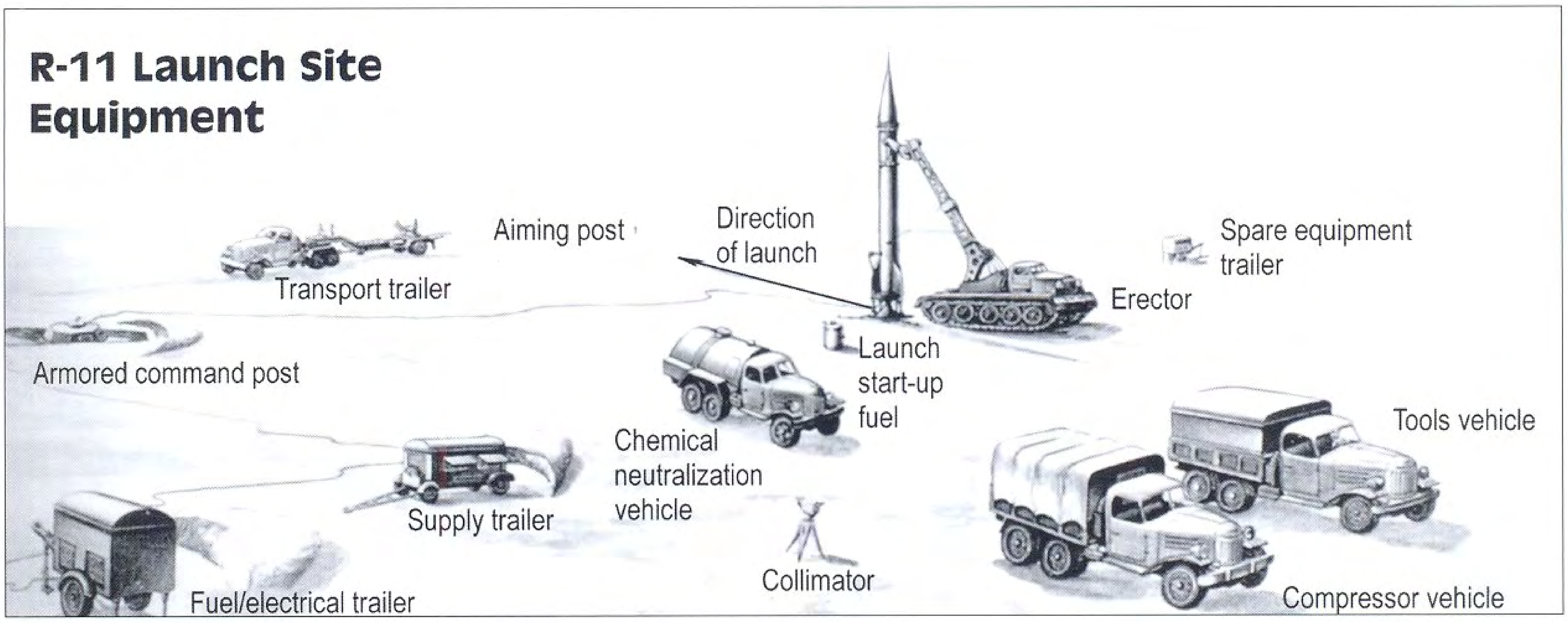
INTRODUCTION

Over the past decade, the Scud has become the world's most infamous missile. Although it was first used in combat more than 25 years ago, it only attracted public attention in the past decade, starting with the Gulf War in 1991. More Scuds have been fired in combat than any other ballistic missile since the German "V" weapons of World War II.

The history of the Scud is an echo of a nightmare only recently forgotten; it was a centerpiece of Soviet plans to fight nuclear war in the heart of Europe. Paradoxically, the more lethal such weapons became, the less conceivable that they would ever be used. Neither NATO nor the Warsaw Pact were foolish enough to precipitate such a war, and, in the end, the Scud was never used in its intended role in nuclear warfare. Instead, it has become a symbol of the changing nature of warfare in the aftermath of the Cold War. In the new world disorder, the world's attention has been shifting to nasty little regional wars. In these conflicts, Scuds have become the ultimate weapon, able to deliver destruction where no other weapons are effective. Saddam Hussein's vaunted Iraqi armed forces, advertised at the time as the world's fourth largest, were helpless in the face of the Coalition forces in the 1991 Gulf War. The only weapon that Iraq could use to injure the Coalition forces was the Scud missile. The Scud has become entangled with the controversy over weapons of mass destruction, since such weapons are ineffective unless they can be delivered to their target.



The 8K72 Elbrus tactical ballistic missile system, better known in the West as the SS-1c Scud B, was developed in the 1960s to deliver tactical nuclear warheads. It gained notoriety during its use in regional conflicts in the 1980s and 1990s. (US DOD)



The original R-11 ballistic missile system required a host of support vehicles, as seen here. Few were deployed while awaiting a more mobile configuration.

The Scud is long since out of production, but its legacy continues with a menagerie of copies and clones produced in North Korea, China, and Pakistan. Russia has attempted twice to replace the Scud, with the new Iskander missile coming into service nearly a half-century after the Scud first flew.

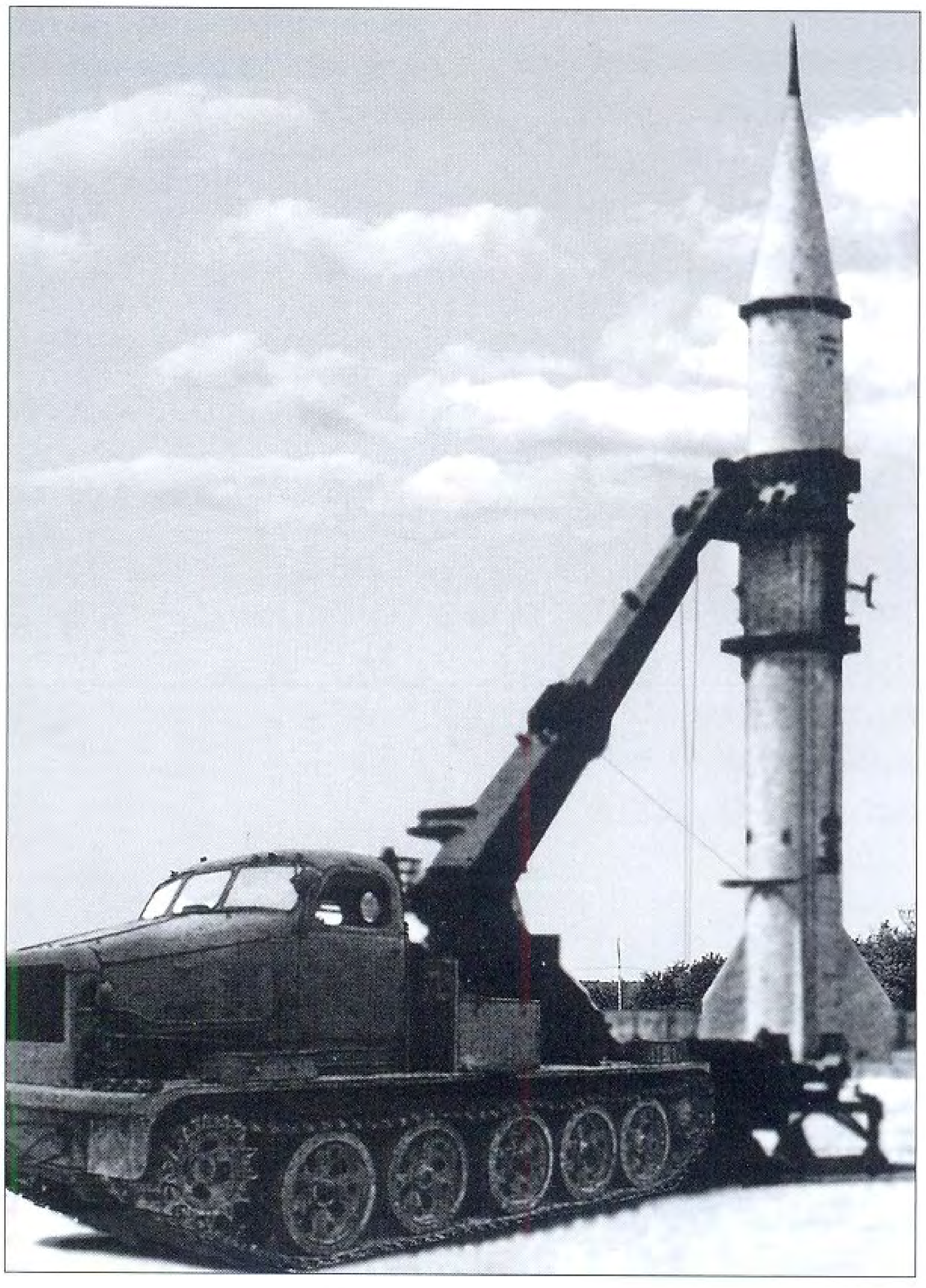
R-11: THE SCUD A

Although the Scud is often described as little more than a clone of the World War II German V-2 missile, its German roots are far more complicated and less direct than may at first appear. In the aftermath of World War II, the Soviet Army dispatched teams of specialists to gather advanced German technology, including the V-2 missile. Sergei Korolev headed the Soviet V-2 team and this effort would be the seed of the future Soviet space and missile programs. Korolev's engineers began test firing V-2 missiles in 1947 at the Kapustin Yar proving ground near Stalingrad with the help of captured German personnel. Production of a Soviet copy, dubbed R-1 (Raketa-1: Missile-1), began in 1948 and the R-1 missile system was accepted for army use in November 1950.

The R-1 missile was not well received by senior Soviet generals. The head of the Main Artillery Directorate (GAU), Marshal N.D. Yakovlev, felt that the new missiles were inordinately expensive, too cumbersome to use, and not militarily effective. One general remarked that if his troops were given as much alcohol as was used to fuel a single R-1 missile, his troops could capture any town. Many of their complaints were well founded. The V-2 and its R-1 copy were fueled with alcohol and liquid oxygen as the oxidizer, a combination called cryogenic fuel. Liquid oxygen is difficult to produce and difficult to store in field conditions, since it must be refrigerated to maintain its super-cold state. Furthermore, a missile cannot be left fueled with liquid oxygen for more than a short time, since the liquid oxygen quickly begins to boil off. On top of this, V-2/R-1 performance was appallingly bad – on average, about half the missiles fired crashed and even those that reached the target area had an average accuracy of 7–17km (4–11 miles) from their intended target. In spite of these problems, the Soviet Army pressed ahead with the missile program, recognizing that it was only a baby step towards a more ambitious goal to field long-range missile weapons. The next evolutionary step was the R-2 missile, an extended-range version of the R-1 using the same troublesome cryogenic fuel and poor accuracy. Six special missile brigades were formed to operate these weapons, but at peak strength there were only 24 launchers in service, a clear recognition of the shortcomings of these missiles.

From a technical standpoint, a key breakthrough in missile technology was the advent of alternative fuel systems, called hypergolic fuels. In 1945 the German Luftwaffe had developed an antiaircraft missile called the Wasserfal that used red-fuming nitric acid as the oxidant instead of liquid oxygen. The main advantage was that it could be used at normal temperatures without refrigeration. One disadvantage was that the nitric acid oxidizer combined with a kerosene-based fuel was not as energetic as the alcohol/liquid oxygen combination. The other disadvantage was that nitric acid was extremely corrosive and reacted violently in contact with hydrocarbons, including human flesh, which led Korolev to dismiss it as "the devil's venom." By the early 1950s, fuel technologies had improved, and the combination of the new inhibited red-fuming nitric acid (IRFNA) and improved kerosene derivatives delivered nearly as much energy per weight as the alcohol/liquid oxygen combination.

The original R-11 missile was towed into position and erected using the 8U227, based on the AT-T heavy tractor, seen here with the 8U22 launch pad behind it.



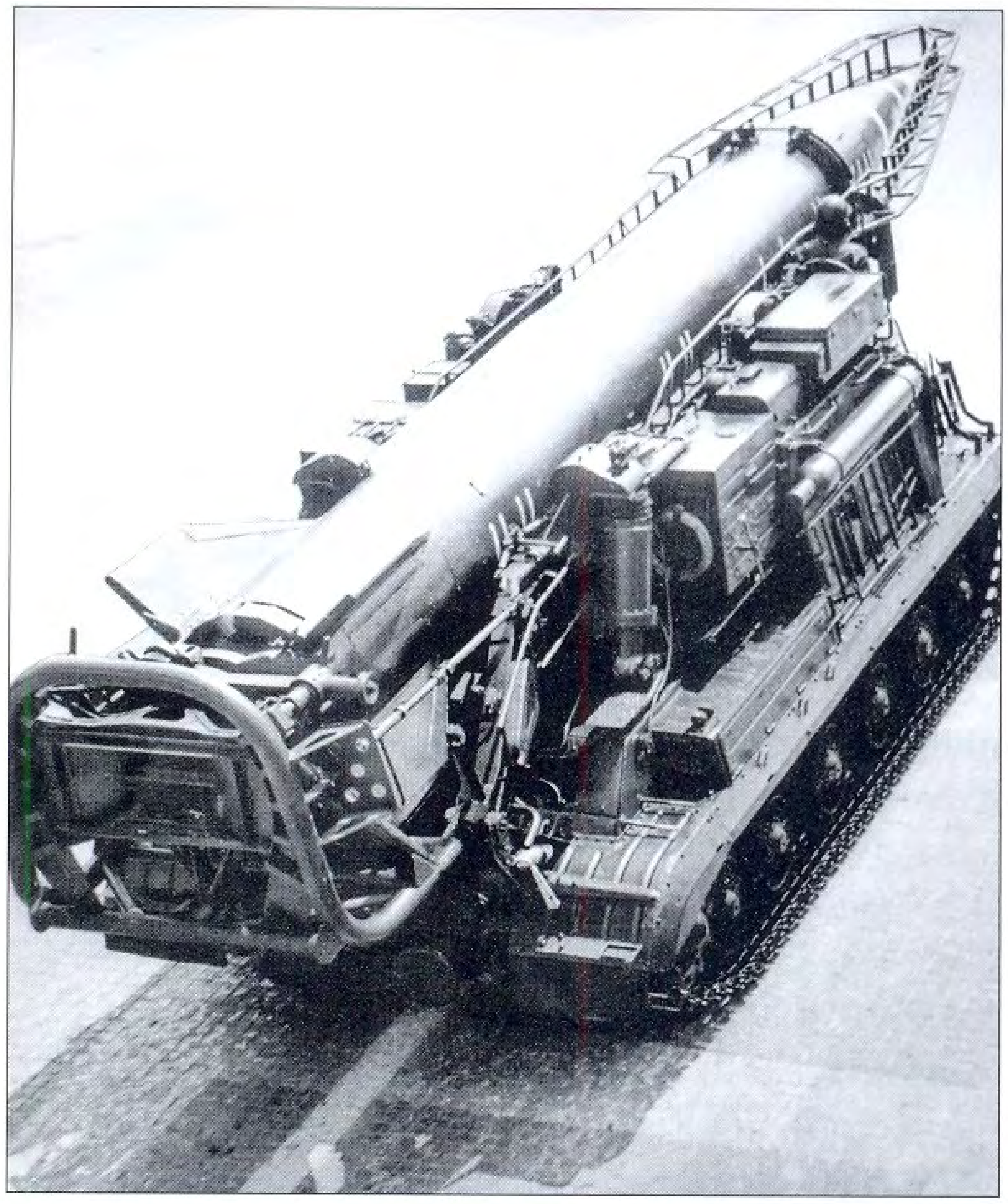
Development of a tactical ballistic missile using the new fuels began in November 1951 with Korolev's OKB-1 (Special Design Bureau-1) responsible for the overall R-11 missile design and A.M. Isayev's OKB-2 responsible for the development of the associated S2.253 rocket engine, an improvement of the German Wasserfal engine. The new missile used TG-02 Tonka fuel, an equal mixture of dimethylanaline and triethylamine. Owing to its relative simplicity, R-11 development was brief, and testing began in April 1953. Improvements were gradually introduced and by 1954 the R-11 had met its accuracy requirements with an average range error of 1.19km and an average azimuth error of 0.66km. After a final set of test launches in December 1954–February 1955 the R-11 missile was accepted for Soviet Army service on July 13, 1955. The missile was also known by its army designation of 8A61.

The first R-11 unit, the 233d Engineer Brigade of the High Command Reserve (RVGK), was formed in May 1955. At this stage, the R-11 missile was armed only with high-explosive warheads, though work was under way on a nuclear-armed version. The initial launcher configuration was considerably different from later Soviet operational-tactical ballistic missiles, being an interim step from the cumbersome V-2/R-1 type of trailer launchers to the later self-propelled missile launchers. The missile was towed into the launch site using a version of the AT-T heavy tractor, designated as the 8U227, which was fitted with a small crane to assist in erecting the missile. The missile was then transferred to an 8U22 launch pad, much like the type used earlier on the V-2 and R-1. Overall, the configuration was time-consuming and cumbersome and so very few of these launch batteries were actually fielded.

By the time the R-11 had proven itself to be a mature design, the attitudes of the Soviet Army leadership towards missiles had changed because of improvements in nuclear weapon designs. The early fission bombs of the late 1940s were much too large and heavy to be launched using the early missiles, but by the mid-1950s atomic weapons were growing smaller, cheaper, easier to use, and more powerful. With a nuclear warhead, the ballistic missile's poor accuracy was irrelevant, since even a near miss was enough to destroy most targets. The first Soviet nuclear missile was the R-5M, an evolutionary development of the R-1 and R-2 using the same fuel system but with improved engines and guidance. Like the R-1 and R-2, it was a complex weapon system and so was reserved for use against strategic targets. The Soviet Union had not begun to mass-produce nuclear warheads in large numbers until 1953–54 when most of its new nuclear facilities had come on line. By the late 1950s, the numbers of nuclear weapons had increased to the point where there were more than enough for strategic missions. As a result, their use on the tactical battlefield could be more seriously considered. Soviet military thinkers began to speak of the "revolution in military affairs." The presumption was that nuclear weapons would soon become so cheap and plentiful that they would be used on the tactical battlefield in place of conventional artillery. Although the Soviet Army had resisted ballistic missiles in the early 1950s because of their technological immaturity, by the mid-1950s the artillery marshals embraced tactical nuclear warfare and wanted weapons capable of delivering nuclear warheads on the battlefield.

Development of a nuclear-armed version of the R-11 began in August 1954 under the designation of R-11M. The main aim of the program was to improve the reliability of the missile to reduce the hazard of expensive

The standard R-11M was launched from the 8U218 TEL, based on the ISU-152K assault gun. The 8K11 (Scud A) can be distinguished from the later 8K14 (Scud B) 2P19 TEL by the presence of a single air pressure cylinder on the side superstructure.



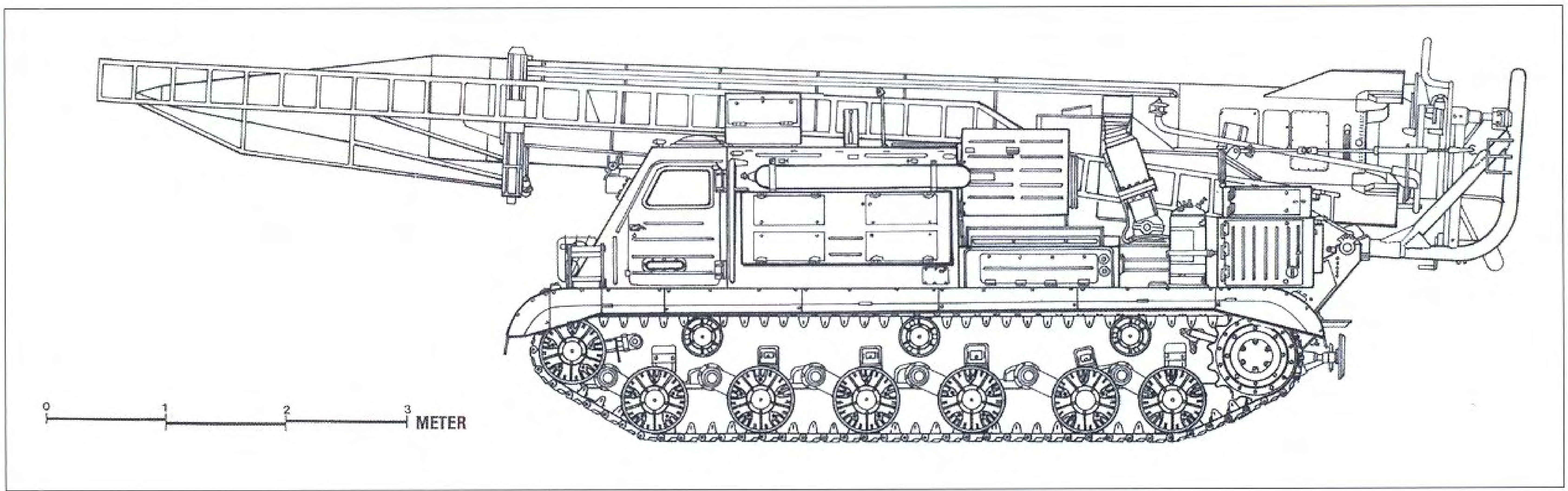
The 8U218 TEL was a self-contained launcher system for the R-11M (Scud A) missile system, and was much more convenient to operate than the earlier 8U227. This is a Polish TEL on parade in Warsaw in the 1960s. (J. Magnuski)

and deadly nuclear payloads crashing because of technical problems. A major part of the effort involved adding redundant features so that if one component failed, another would take its place. By this time, Sergei Korolev was trying to shed some of the missile programs his bureau had accumulated in order to focus on higher-priority efforts such as the R-7 intercontinental ballistic missile and the first Sputnik satellite. Since R-11 missile production was scheduled to begin at Experimental Plant No. 385 in Zlatoust, further work on the R-11 was handed to a young engineer, Viktor Makeyev, who headed the plant's SKB-385 (Special Design Bureau-385). The flight trials of the R-11M were conducted in three phases, totaling 27 launches from December 1955 to early 1958, including one test with a live nuclear warhead. The R-11M was officially accepted for Soviet Army service on April 1, 1958. The whole weapon system including the R-11M missile, its nuclear and conventional warheads, the launch system, and all support equipment were designated as 8K11. The cost of a conventional missile system was R800,000, with a single R-11M missile costing R42,000 to R53,200. The nuclear-armed missiles cost 4–8 million rubles depending on the type of nuclear warhead, which were available in the 20–100 kiloton range. The standard warhead used on the initial production missiles was a derivative of the RDS-4 nuclear device, the first standard Soviet tactical nuclear warhead. Using a lightweight high-explosive warhead, the R-11M had a range of 270km, but with the heavier nuclear warheads only 150km.

With missile development well under way, the Soviet Army began considering a launch system better suited to mobile field operations. Rather than the motley assortment of vehicles and trailers used with the initial R-11 system, the army preferred a unified launch system based on an all-terrain vehicle. The assignment was given to the Kirov plant in Leningrad along with a similar assignment to develop a launcher for the short-range Filin nuclear artillery rocket (FROG-1). The Kirov plant decided to base both on a tracked chassis derived from the ISU-152K assault gun still in production at the plant. The Obiekt 803 design was rugged and reliable, and without its heavy armored superstructure, it could easily accommodate the heavy missile and launcher equipment. The Obiekt 803 was accepted for service under the army designation 2U218, though later the designation changed to 8U218.

THE SCUD NAME

The R-11M was first publicly paraded in Moscow in November 1957 at the October Revolution parade in Red Square. The Soviet Army did not disclose the designations of its missile systems at this time, and, as a result, Western intelligence agencies began a practice of assigning names for reporting purposes. Under the original system, the R-11M was called the



Scale plan of the 8U218 transporter-erector launcher. (Author)

T-7A. The R-11 was never publicly displayed, and so never received a Western intelligence designation. By the early 1960s, Western intelligence agencies began using a new designation system that has remained in effect to the present day. The US Director of Central Intelligence's Weapons and Space Systems Intelligence Committee (WSSIC) began to assign an alphanumeric designation to each missile. The R-11 was given the designation SS-1b (Surface-to-Surface missile); SS-1a referred to both the R-1 and R-2, as Western intelligence did not have a clear appreciation of the difference between the two types. The SS-1b designation referred to the whole missile system, not the missile itself. Subsequently, NATO's Air Standardization Coordinating Committee (ASCC) decided to adopt its own separate reporting system, based on practices in use since World War II for naming enemy aircraft. Ballistic missiles were given names starting "S," and the R-11 was designated as Scud. The names were assigned in a random pattern and had no inherent connection with the missile. In general, NATO attempted to use words that were obscure and not used in daily conversation, while at the same time being easy to pronounce and to distinguish during radio conversation. "Scud" is an archaic nautical term meaning a sudden light shower, or when used as a verb it means to skim along easily like a fast light rain. This is the name that would be most closely associated with this family of ballistic missiles. It became common practice for the US and NATO systems to be used collectively in the form of "SS-1b Scud," though in fact the nomenclatures were not assigned jointly.

THE SCUD AT SEA

Although the Scud is best known as a land-based ballistic missile, it also has an important place in missile history as the world's first submarine-launched ballistic missile (SLBM). The Soviet Navy had considered a submarine-launched version of the V-2 missile as early as 1947, but this project never proceeded beyond studies. The studies were revived in January 1954 as Project Volna (Wave), which examined winged cruise missiles as well as ballistic missiles. The ballistic missile portion of the effort was handed to Korolev at OKB-1, while N.N. Isanin's Central Design Bureau-16 (TsKB-16) in Leningrad undertook the work on the associated submarine. Owing to the urgency of the program, a decision was made to rapidly field an SLBM, even if not an ideal configuration.

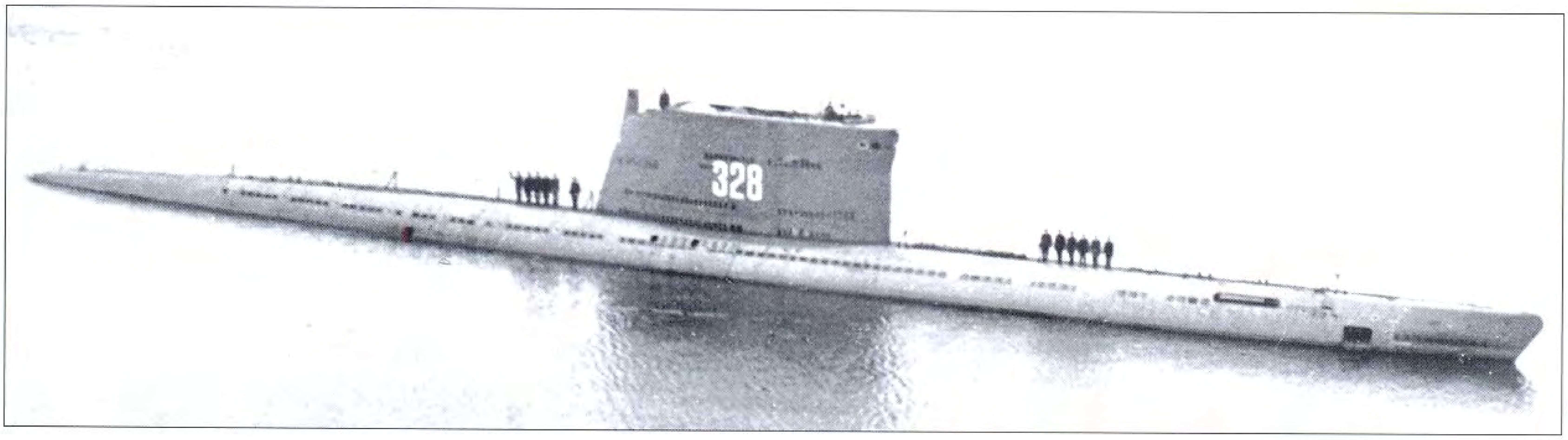
So rather than develop an entirely new missile, the navy decided to base the design around an existing missile. The R-11M was the only Soviet ballistic missile small enough to fit inside a submarine, so it was selected more by default than by intent.

Having selected the R-11M missile, the next issue to be resolved was the launch method. Ideally, the missile should be launched from a submerged position, but this posed an enormous technological challenge. It was not clear what the interaction of the missile and an underwater environment would entail – whether the thin outer skin of the missile would be crushed by water pressure, whether water would impede the ignition of the rocket engine, or whether water rushing into the missile tube at launch would form strong eddies that would deflect the path of the missile's ascent. Since Korolev's bureau was already burdened with the higher priority R-7 ICBM program, the less risky and more predictable option of a surface-launch system was selected. Submerged launch would be delayed until a future SLBM was developed.

The major technical difficulty of such a surface-launch system for the R-11M was sea motion. The R-11M's accuracy was entirely dependent upon the missile being steady and completely vertical at the moment of launch. Because of its simple inertial navigation system, the R-11's accuracy could not be adjusted after launch. Should the missile be tilted even a fraction of a degree at the moment of launch, it would miss its intended target by miles. The solution was a stabilized launch platform similar to that used in battleship turrets. Such a platform was controlled by a set of gyroscopes, which monitored the motion of the submarine in all three axes. The missile would only be released at the precise moment when it was in a true vertical position. The SM-49 launch system was nicknamed the "Horn and Hoof" and was developed by E.G. Rudniak's TsKB-34 naval artillery design bureau in Leningrad. The naval version of the R-11M missile was designated as the R-11FM, while the entire system including the launcher was designated as the D-1 missile system.

To test the new missile, a special platform was erected at the Kapustin Yar test range to simulate the natural motion of a submarine at sea with the SM-49 Horn and Hoof launcher fastened to this. When fitted to a submarine, the launch tubes were contained within the hull and sail of the submarine, so the missile would be resting precariously above the sail. To conduct a launch, the missile was elevated from its storage tube to a position on top of the sail where the hot exhaust gases could escape. A series of eight test flights were conducted from ground launchers at Kapustin Yar from September 26 to October 20, 1954. To test the missile

The Project AV-611s were the world's first ballistic missile submarines. They were based on the Project 611 (Zulu) attack submarines but had an extended sail containing two missile launch tubes. (US DOD)



at sea, Isanin's design bureau modified a Project 611 (Zulu class) diesel-electric submarine with a test version of the SM-49 launcher at the Sudomekh shipyard in Severodvinsk. This submarine, the B-67, was transferred to the navy's test range on the White Sea in the Russian Arctic. The world's first ballistic missile launch from a submarine was conducted on September 16, 1955. The White Sea proved ill suited for trials during the winter months, so the B-67 was transferred to Severomorsk on the Barents Sea, where eight further test launches took place in 1955. The testing was prolonged and troubled. The R-11FM missile was loaded into the submarine with its fuel tanks already filled, and a special coating on the fuel tanks was supposed to be durable enough for three months' storage inside the submarine. However it often proved inadequate, and the nitric acid oxidizer ate its way through joints and piping and leaked, creating both a fire hazard and a danger to the crew. Poor quality control of other components led to a string of launch failures and accidents.

The clumsy launch system provided poor accuracy. The R-11 missile in its land-launched version had a CEP (circular error probability) accuracy of about 4km (3 miles), meaning that half of all R-11 missiles fired at a given target would strike within 4km of the target. Owing to sea motion and the poor accuracy of Soviet naval navigation systems of the time, the CEP of the R-11FM was significantly worse than its land-based counterparts – only 7km. Poor accuracy and the other problems uncovered in testing made the Soviet Navy very reluctant to accept the new submarine weapon into service, but the minister of the defense industries, Dmitri Ustinov, and Soviet leader Nikita Khrushchev both supported the program as an initial step in fielding a missile-armed navy. There was recognition that the D-1 system was far from ideal, but Khrushchev wanted the navy to leap into the nuclear missile age.

The D-1 missile system armed a new submarine, the AV-611, also called Project 611AV, or Zulu V by NATO, which carried two missiles. A total of seven AV-611s was built, one converted at the Dalzavod yard in Vladivostok on the Pacific, the remainder at Sudomekh at Severodvinsk. The first became operational with the Northern Fleet in August 1956, the last with the Pacific Fleet in August 1959. During the Khrushchev years, the typical deployment pattern was four submarines with the Northern Fleet and two with the Pacific Fleet, with one submarine kept for testing.

The D-1 system was very awkward to employ. The submarine had to maintain a steady course, speed, and depth for 2–4 hours prior to launch. On surfacing, it took five minutes to erect and launch the missile, and a further five minutes to launch the second missile. In reality, the submarines were seldom deployed with live missiles, except during

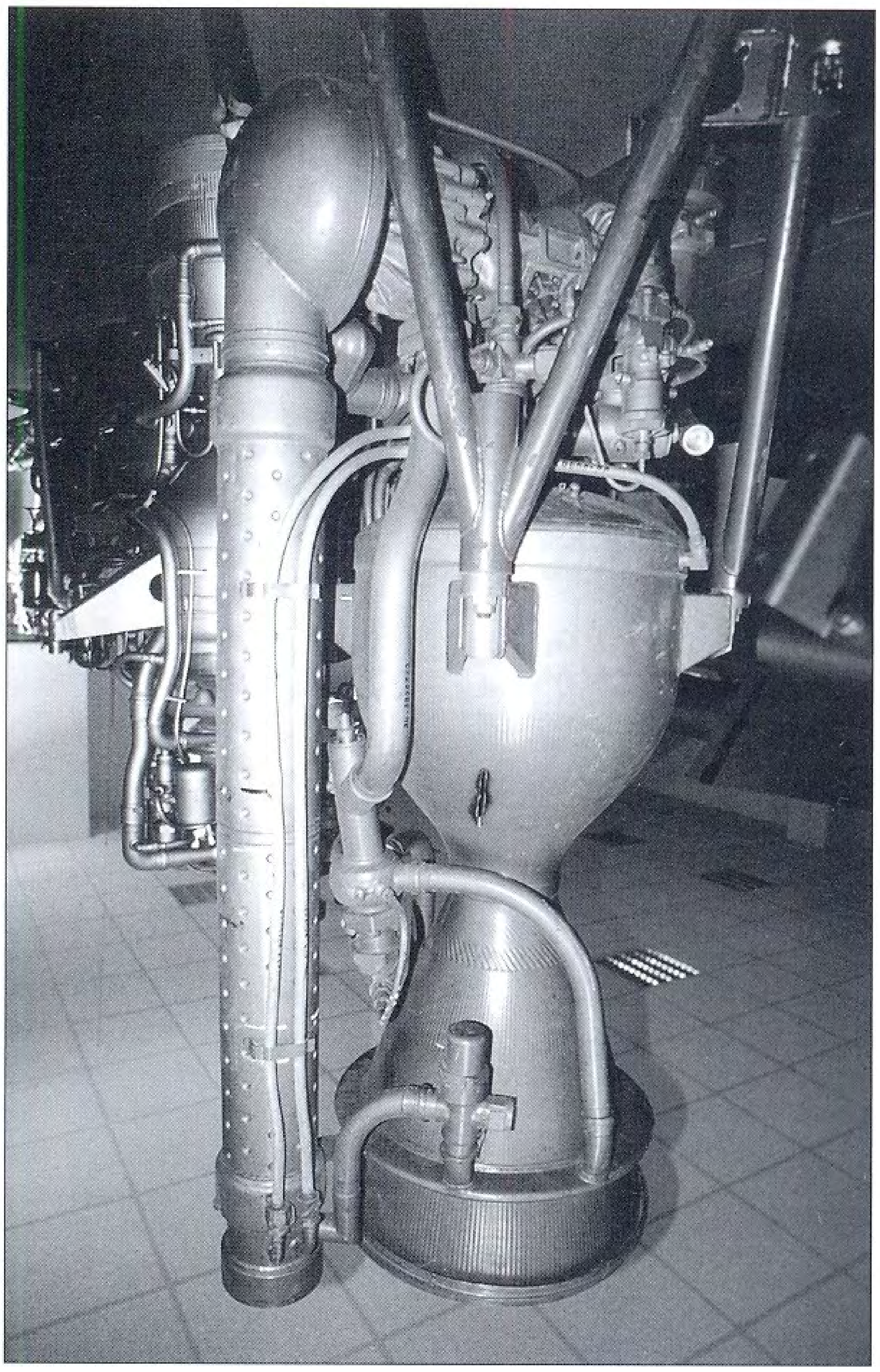
This R-17 missile is currently preserved at the Central Army Museum in Moscow. (Author)

annual launch exercises, because of the hazard their corrosive propellants posed. During the career of the AV-611 submarines in service, a total of 77 R-11FM launches were conducted at sea, of which 86 percent were successful. In hindsight, the R-11FM was not a particularly successful weapon system. Its short range and relatively low reliability made it a dubious element of the strategic arsenal and so it was quickly retired. However, in the broader sense, the Volna program was successful. It was a useful first step in the development of the naval leg of the Soviet Union's strategic nuclear triad.

R-17: THE SCUD B

When the R-11M was first deployed in the late 1950s, its use was limited to a small number of special brigades, directly under command of the general staff, and not under normal ground forces control. They were still so expensive that they were considered to be assets for general nuclear war, and were not intended for army tactical support. The new Soviet leader Nikita Khrushchev regarded nuclear-armed missiles as the fulcrum for change in the Soviet armed forces. Like Gorbachev in the 1980s, Khrushchev was convinced that the Soviet armed forces had to be trimmed back so that more resources could be channeled into the impoverished and backward Soviet economy. By the late 1950s, the Soviet Union began to experience the demographic shock wave caused by the massive loss of young men during World War II and the resulting shortage of draft-age men a generation later. The Soviet economy could no longer afford to divert so much of its waning human resources to the armed forces. Unwilling to diminish the strength of the Soviet armed forces, Khrushchev saw nuclear weapons and missiles as a revolutionary breakthrough in military power. Instead of massive conventional forces demanding large numbers of troops and conventional weapons, Khrushchev envisioned a future Soviet armed force manned by far smaller numbers of troops and equipped with a smaller number of powerful missile weapons with nuclear warheads. Instead of conventional cannon artillery, Khrushchev saw the future army equipped with nuclear missile artillery. The R-11M was a natural fit within this new doctrine.

The Scud B is powered by the Isayev 9D21 open-cycle rocket engine. Above the combustion chamber is the turbo-pump that feeds its fuel, while the tube to the left is a turbo-pump exhaust. (Author)



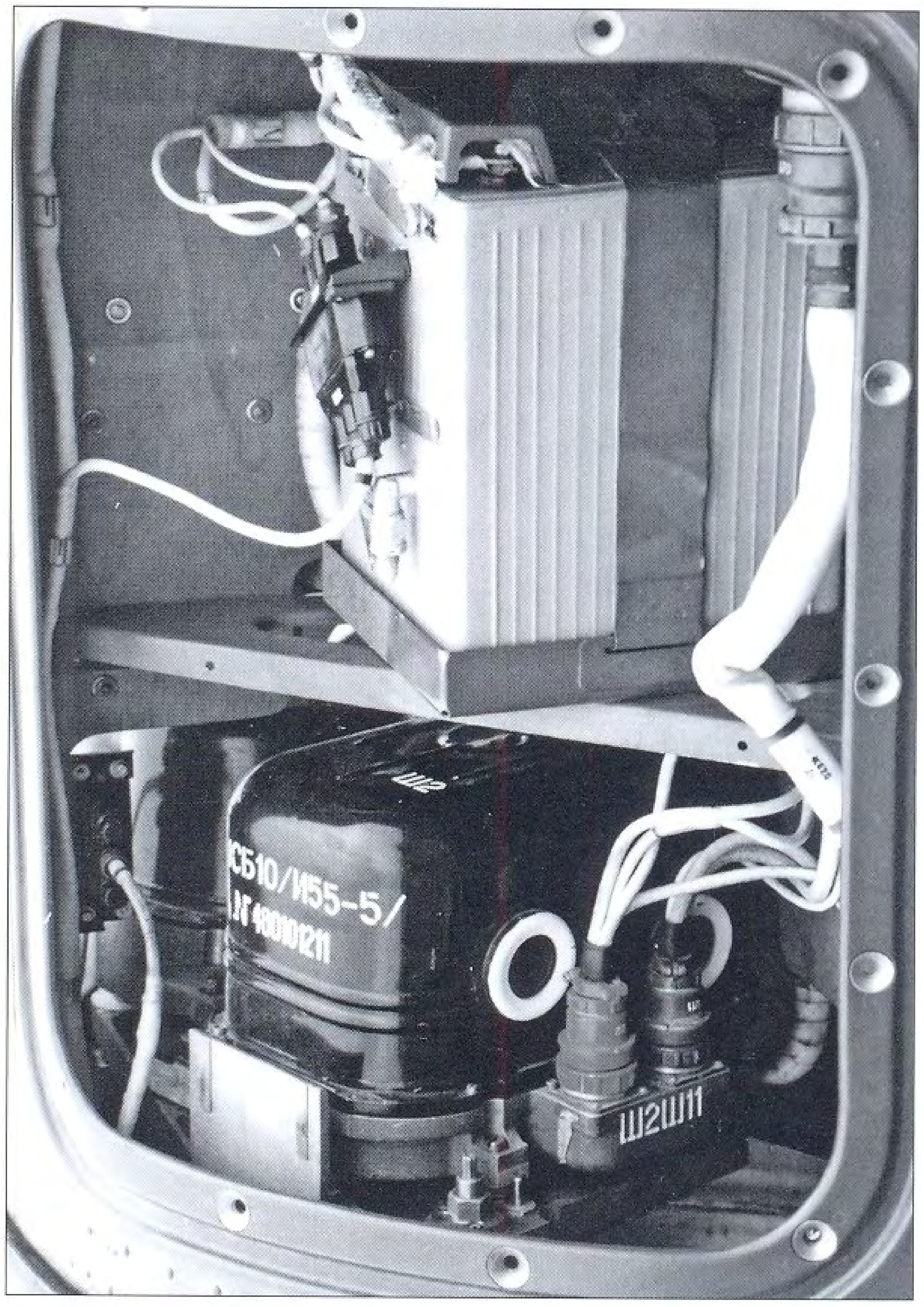
Khrushchev decided to convert the existing RVGK missiles brigades into the new Strategic Missile Force (RVSN), responsible for strategic nuclear missiles. As a result, the short-range missile brigades, including the R-11M units, were renamed as Operational-Tactical Missile Brigades (OTBR) and put under ground forces control. The term "operational-tactical" indicated the mission – tactical missiles were assigned to support army divisions, operational-tactical missiles were assigned

The 9P19 TEL of the 8K14 (Scud B) system was relatively rare, as it went out of production in 1962 very shortly after it was accepted for service. It is seen here in use by a Soviet missile brigade in the 1960s.

to armies, and operational missiles were assigned to fronts. The Soviet ground force's artillery branch was renamed the "Missile and Artillery Forces" (RAV: *Raketniy i artilleriskiy voisk*) as a consequence of these changes. Each R-11M brigade typically had nine launcher vehicles each, supported by about 200 trucks and 1,200 troops. About five brigades were in service at this time, none of which were forward deployed against NATO. These brigades were first deployed with the Group-of-Soviet-Forces-Germany (GSFG) in 1962, by which time they were armed with the later 8K14 (Scud B) system.

The shift of the R-11M from the strategic missile forces to the army's artillery branch in 1959 led to a greater demand for ease of operation. After some experience with the R-11M, the Soviet Army would have preferred the deployment of a solid-fuel operational-tactical missile to replace it. The liquid-fueled missiles were awkward to deal with in field conditions when manned by poorly trained conscript troops. In 1958–59, a program began to develop a new generation of solid-fuel missiles for these missions – the tactical 70km-range Onega missile, the operational-tactical 250km-range PR-2, and the operational 300km-range Ladoga missile. Although there was the hope that these designs would provide a new generation of more flexible and effective weapons, there was also the recognition that, to date, Soviet solid-fuel technology had been very troublesome. As a result, an evolutionary liquid-fuel missile based on the R-11 was authorized at the same time, first called the R-11MU. In the event, the solid-fuel missiles never entered production, so a second-best solution, the Scud B, emerged.

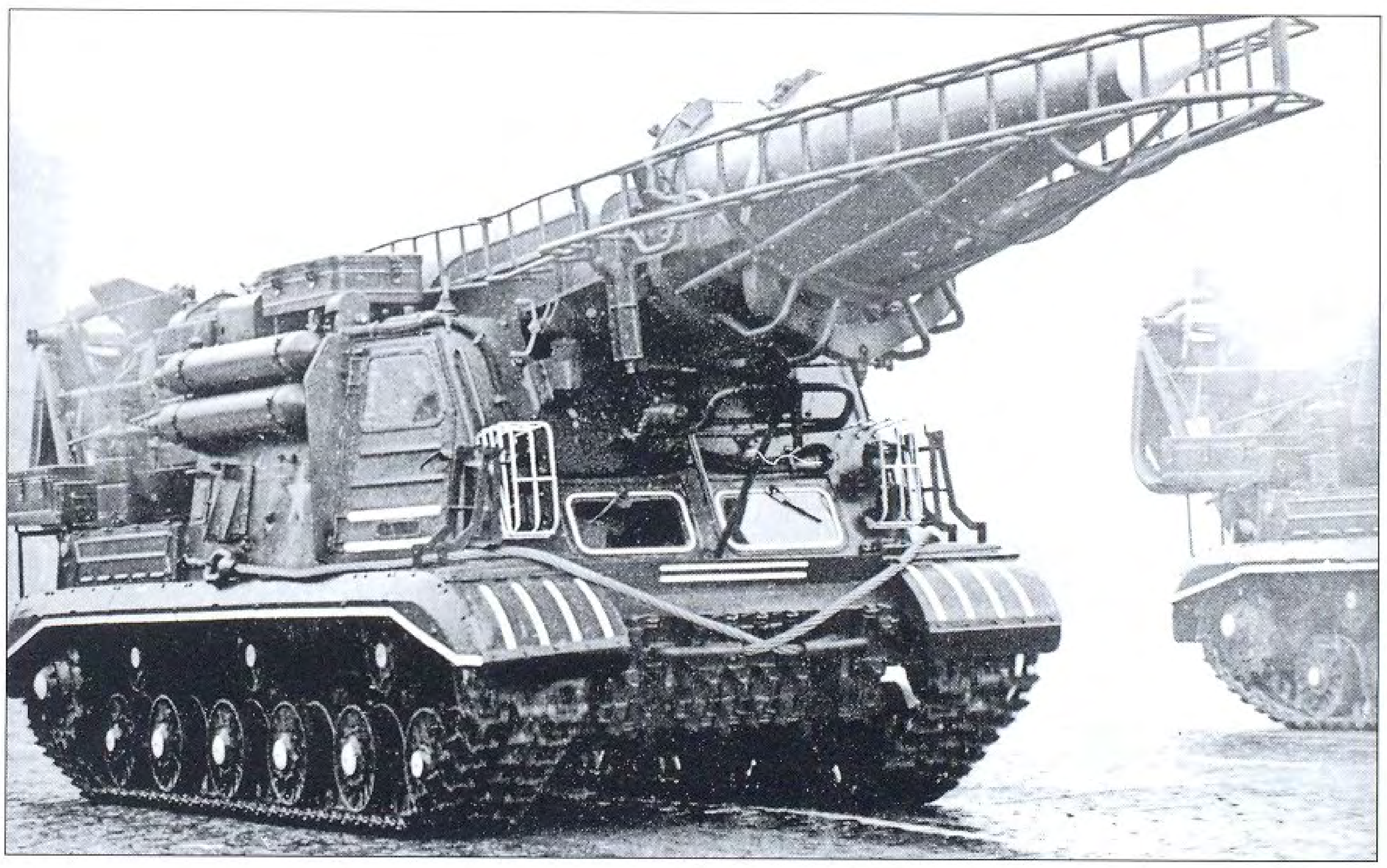
Makeyev's SKB-385 began work on the R-11MU in April 1958. The missile was slightly larger than the R-11, and due to a more sophisticated engine and fuel system its range was almost doubled from the R11's 180km



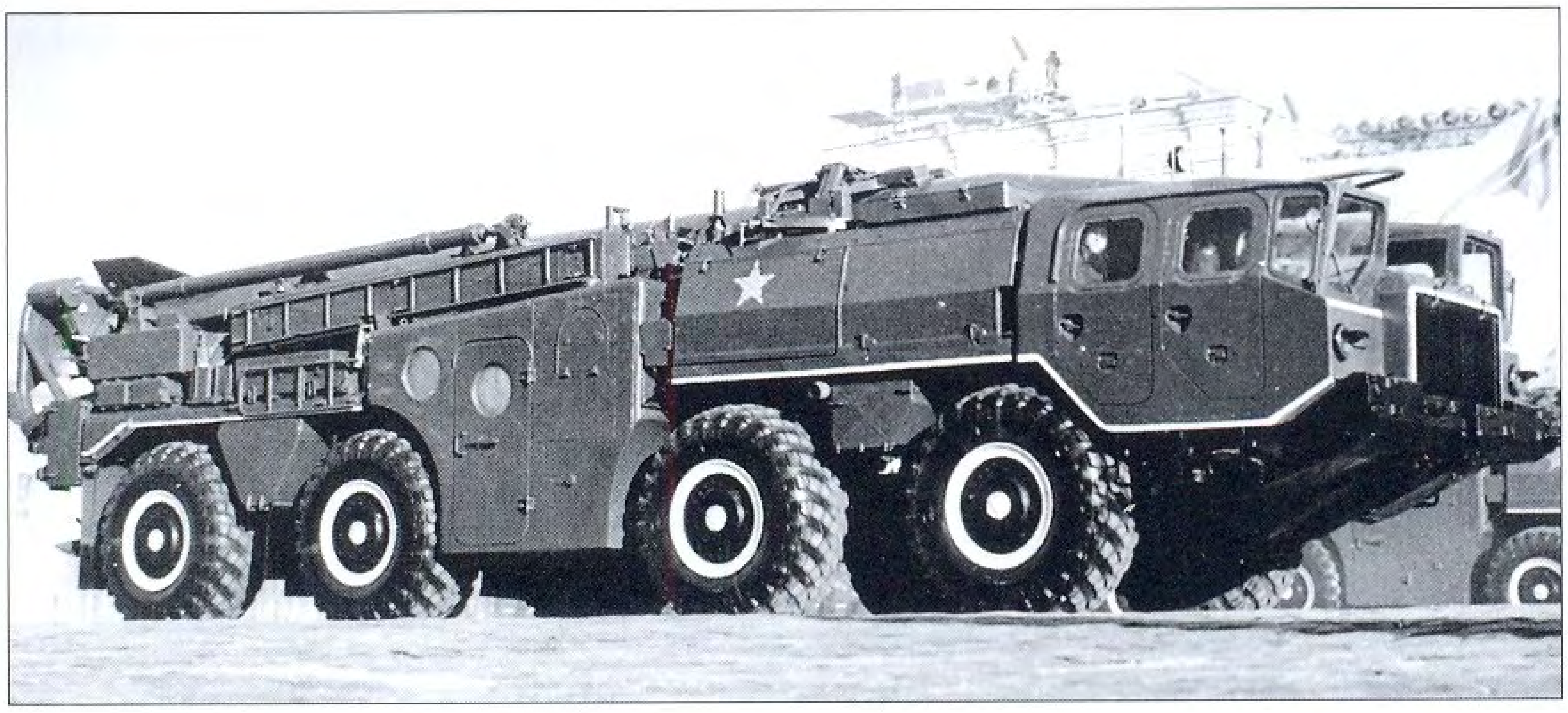
This is a view inside the guidance section of a Scud B through access port 1. The device on the bottom is the 1SB10 vertical gyroscopic package with lateral adjustment integrator, while above it is one of the guidance system batteries. (Author)

to 270km. The range extension was made possible by adopting a turbo-pump for the engine, instead of the air pressure fuel injection system of the R-11. The pressurized fuel system of the R-11 meant that the fuel tanks had to be substantially reinforced, so by moving to a more efficient but expensive turbo-pump, much weight could be saved in the missile fuselage. A new guidance system was also developed, improving accuracy from the R-11's dismal 4km CEP, first to 3km and eventually to 1km. The test missiles were first built in the workshops in Zlatoust but were eventually transferred to the Votkinsk Machinery Plant (VMZ) for series production. The first test launch was conducted in December 1959 at Kapustin Yar, continuing through to September 1961. In the meantime, the VNIITF nuclear weapons bureau in Kasli developed its new nuclear warhead. During the course of development, the missile designation was changed from R-11MU to R-17, since it eventually became a whole new design with little in common with its predecessor.

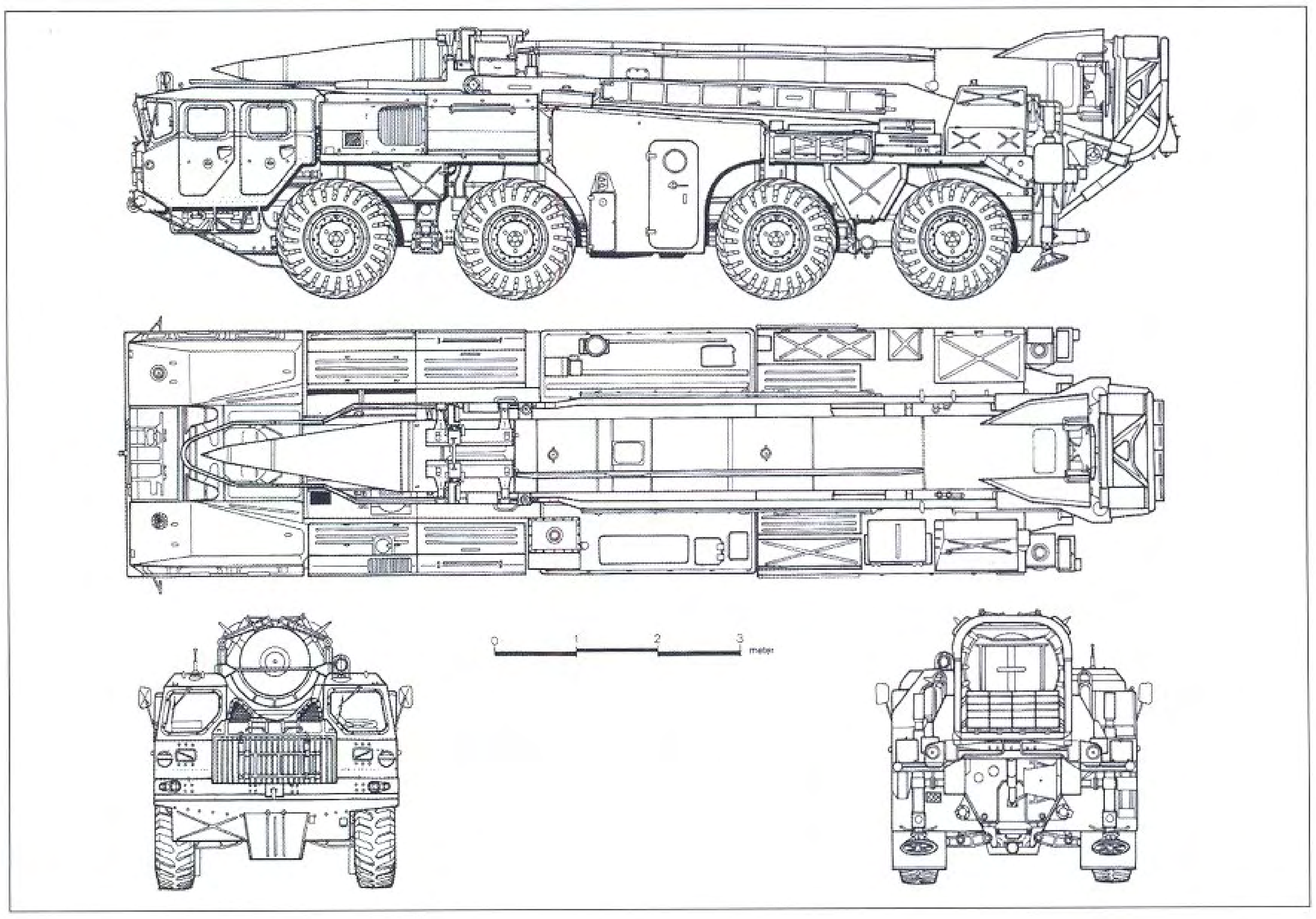
The R-17 missile was initially launched from a modified version of the 8U218 TEL (transporter-erector launcher) used with the earlier R-11M missile. The Kirov plant began design work on two new designs in 1958: the Obiekt 816, which was similar to 8U218, and the Obiekt 817, which added a crane to permit the vehicle crew to load the missile from a transporter. The simpler Obiekt 816 entered series production in 1961 under the army designation 2P19. The 2P19 closely resembled the earlier 8U218 but had a number of detail changes. The most noticeable external change was the use of a pair of compressed air cylinders on either side of the superstructure, compared to a single cylinder on the earlier type. It also had a substantially strengthened



The R-17 missile was initially launched from the 2P19-tracked TEL, seen here on parade in Moscow. It can be distinguished from the earlier 8U218 of the 8K11 (Scud A) system by the twin pressurized cylinders on the superstructure side, and the more extensive framing on the hull front needed for the longer and heavier missile. (J. Magnuski)



The initial production version of the 9P117 TEL was based on the MAZ-543 heavy truck. It can be distinguished from the later production batches by the absence of cooling vents on the battery access panel over the first wheel station. (US DOD)



Scale plan of the 9P117M1 transporter-erector launcher. (Author)

frame on the hull front to support the longer and heavier missile. The new R-17 missile with the associated 2P19 TEL was officially accepted for service on March 24, 1962 and designated as the 8K14 Elbrus missile system. The US/NATO nomenclature for the new system was SS-1c Scud B.

SCUD IMPROVEMENTS

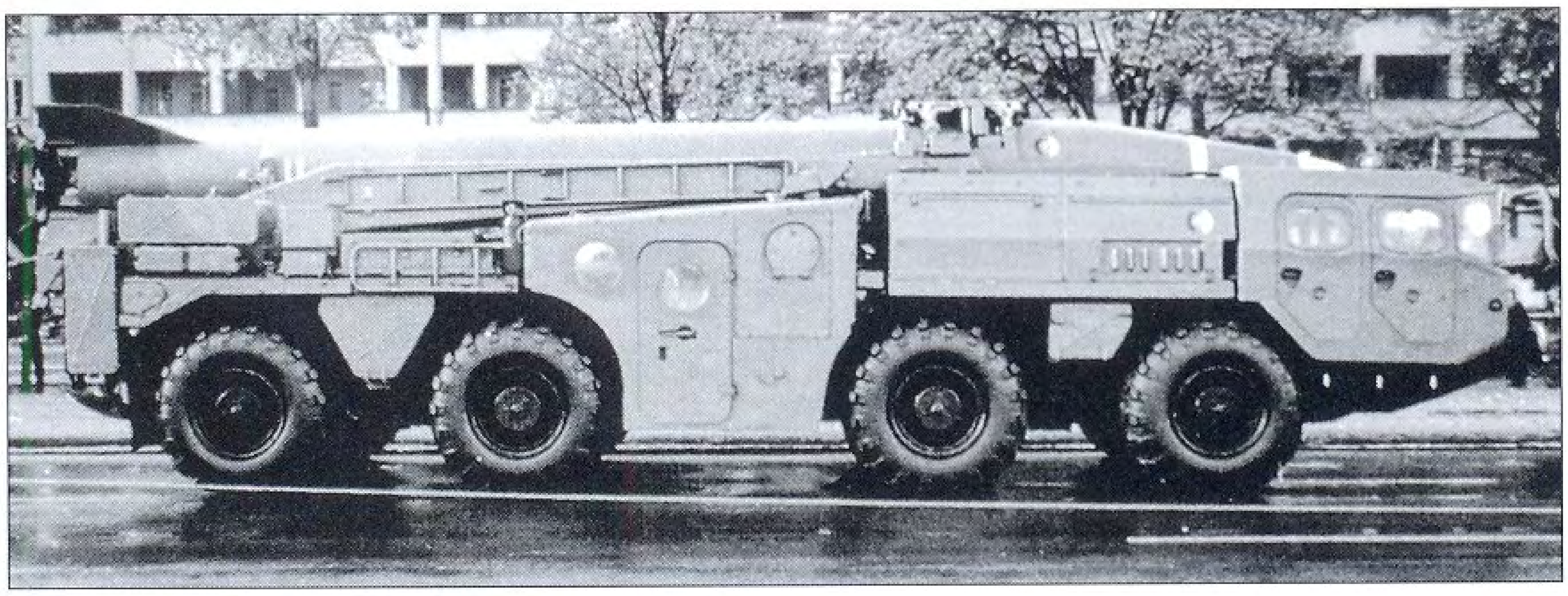
Production of the 2P19 TEL was short-lived, as the government ordered production of the launcher halted on October 10, 1962 after only a small number had been manufactured, because of Khrushchev's decision to stop heavy-tank production. This was not entirely unwelcome by the army, as the tracked chassis was far from ideal for a missile launcher. The vibration induced by steel tracks on steel road-wheels was transmitted to the delicate launch electronics in the vehicle and to the missile as well, leading to premature technical failures. The Titan Central Design Bureau in Volgograd developed a wheeled TEL replacement. The 2P20 (later 9P117) TEL was based on the MAZ-543 8x8 heavy truck. The wheeled chassis caused less vibration to the missile, as well as offering better reliability and

The 9P117M TEL introduced a simplified erector frame that lacked the self-loading feature along with its associated hydraulic actuators. (US DOD)

lower operating costs, with only a modest decrease in cross-country performance compared to a tracked TEL. Prototypes of the system began to be deployed in 1965 for operational trials, and the new launcher was accepted for service in 1967. The system nomenclature for the R-17 with the 9P117 launcher vehicle was later changed to 9K72 Elbrus, although the designation 9K14 remained in common use. The 9P117 launch vehicle was officially named *Uragan* (Hurricane) but was popularly called *Kashalot* (Sperm Whale) by its Russian crews because of its enormous size.

The 9P117 TEL underwent continual evolutionary development during its service. The basic 9P117 had a special reinforced erector frame that enabled the missile to be loaded independently of heavy cranes, with an array of hydraulic actuators visible above the frame. This proved cumbersome to use, and, as a result, a simplified version of the TEL was then developed, the 9P117M. This version required the use of a 9T31M crane to load the missile from the 2T3 trailer on to the TEL. As in the case of the 9P117, there was some detail variation during the production run of the 9P117M that is shown here in the photographs. The third and final

A pair of 9P117M TELs at a parade in Prague in September 1972. The simplified erector frame is clearly evident in this view. (US DOD)



This East German 9P117M is from the initial production batch, which can be distinguished by the second porthole behind the door on the pumping station cabin in the center of the vehicle. (US DOD)

production type, the 9P117M1, was based on an improved MAZ-543, later known as the MAZ-7911, which had the up-rated 650hp D12AN-650 in place of the earlier 525hp D12A-525 engine as well as other automotive improvements. Another change on this version was the substitution of the APD-8-P/28-2M auxiliary power unit with a GAZ-69 radiator instead of the older APD-8-P/28-2 with Pobeda radiator. This new radiator required a noticeable change in the vent on the left side of the vehicle, which helps distinguish this variant.

As was the case with the launcher, there were incremental improvements on the R-17 missile. The original version of the R-17 had an effective range of 270km. One of the first changes was to switch to a more energetic fuel, shifting from the AK-20I oxidant and TG-02 Tonka fuel to AK-27I oxidant and TM-185 fuel. Combined with other changes, this boosted the maximum range of the new R-17M missile to 300km. The R-17M was introduced with the improved 9K72 Elbrus-M system. Many other changes took place in the R-17M during its production at the Votkinsk Plant No. 235. In the 1970s, the fuel tanks were improved by the addition of a special liner that permitted the missiles to be stored, fully fueled, for up to 90 days. During their periodic policy changes, the Soviet Army issued a new set of designations for its tactical missiles in the early 1970s, the R-11 becoming the R-170 and the R-17 becoming the R-300.

The 9P117M1 TEL used a new power plant and engine with different radiator venting, as seen on this Polish TEL. The 2Sh2 thermal insulating blanket on the warhead is electrically warmed to maintain the nuclear warhead's temperature, and is removed shortly before launch. (W. Luczak)

Besides the basic R-17 and R-17M, the Makeyev OKB developed an extended-range version of the R-17 capable of reaching 500–600km, first tested from the Kapustin Yar test range in 1965. It had much poorer accuracy than the basic R-17. Its performance overlapped with that of the 9M76 Temp (SS-12 Scaleboard) operational missile, so it apparently did not enter standard service use. It was first given the temporary US intelligence designator of KY-3, but was later called the SS-1d Scud C.

Russian accounts have not disclosed the total production of the Scud missile, but US sources have estimated that about 10,000 were manufactured, of which about 5,000 to 6,000 were still in inventory worldwide in 1997. The total number of 9P117 launcher vehicles manufactured has also not been officially disclosed. Russian accounts have stated that there were 661 Scud-B launchers and 1,370 associated nuclear warheads in the Warsaw Pact countries in 1991. This would suggest that total launcher production was at least 800, given the inventory size, export, and likely attrition.

SOVIET SCUD TELS IN SERVICE 1970–89

	1970	*1971*	*1972*	*1973*	*1974*	*1975*	*1976*	*1977*	*1978*	*1979*
Scud A	50	40	20	10						
Scud B	250	260	280	340	400	400	450	500	530	550
	1980	*1981*	*1982*	*1983*	*1984*	*1985*	*1986*	*1987*	*1988*	*1989*
Scud B	550	550	550	550	590	620	620	620	620	620

SCUD WARHEADS

The R-17 missile was developed primarily as a means for the delivery of tactical nuclear warheads. During peacetime, these were stored separately from the missiles at special GRAU (Main Missile Artillery Directorate) arsenals. For example, in the 1970s, of the 1,125 R-17 missiles on storage in GRAU arsenals in the Soviet Union, there were 1,080 nuclear warheads. The general pattern was for one chemical warhead for every 25 missiles, with the remainder being equipped with nuclear warheads. Nuclear warheads were under the custody of the 12th Main Directorate of the Ministry of Defense (12 GUMO), the organization responsible for the custody, maintenance, and handling of nuclear weapons. Nuclear warheads for units facing NATO were deployed in special depots called Missile Technical Bases (RTB), referred to as Mobile Missile Technical Bases (PRTB) during wartime. For example, in East Germany there were two such arsenals at Meyenburg and Stolzenhain, and in Poland one near Stargard Szczecinski.

The 9K72 (Scud B) used a family of standardized 1 metric ton (2,205lb) warheads so that the missiles would require only one set of computation manuals and one set of ballistics. Nuclear warheads were generally transported in special vehicles such as the 9F21 or 9F233, which were standard Soviet trucks fitted with an isothermic shelter on the back to control the temperature of the warhead. Personnel from a special warhead custody brigade of the 12 GUMO accompanied the warhead from the RTB to the unit in the field. The Soviet system of control for nuclear warheads required that the special brigade personnel install an AK-1 and AK-2 plug into the warhead, which activated the safe and arming system of the nuclear warhead. The basic warhead fielded for the missile system was the 8F14 standardized bus, which originally carried the same nuclear physics package as the 8K11M (Scud A) with yields of 5–80 kilotons. The All-Union Scientific Research Institute for Physics Technology (VNIITF) in Kasli, near Chelyabinsk, developed the Scud nuclear warhead. This was short-lived and was followed in 1964 by the 9N33 warhead, which was a combination of the 8F14 warhead bus and the new *Izdeliye* 269A physics payload, packaged in 10, 20, 40, or 100 kiloton yields. The final nuclear warhead family fielded in the 1970s was the 9N72, which combined the 8F14 with an improved RA-17 physics package with much "cleaner" warheads with higher yields of 200, 300, and 500 kilotons.

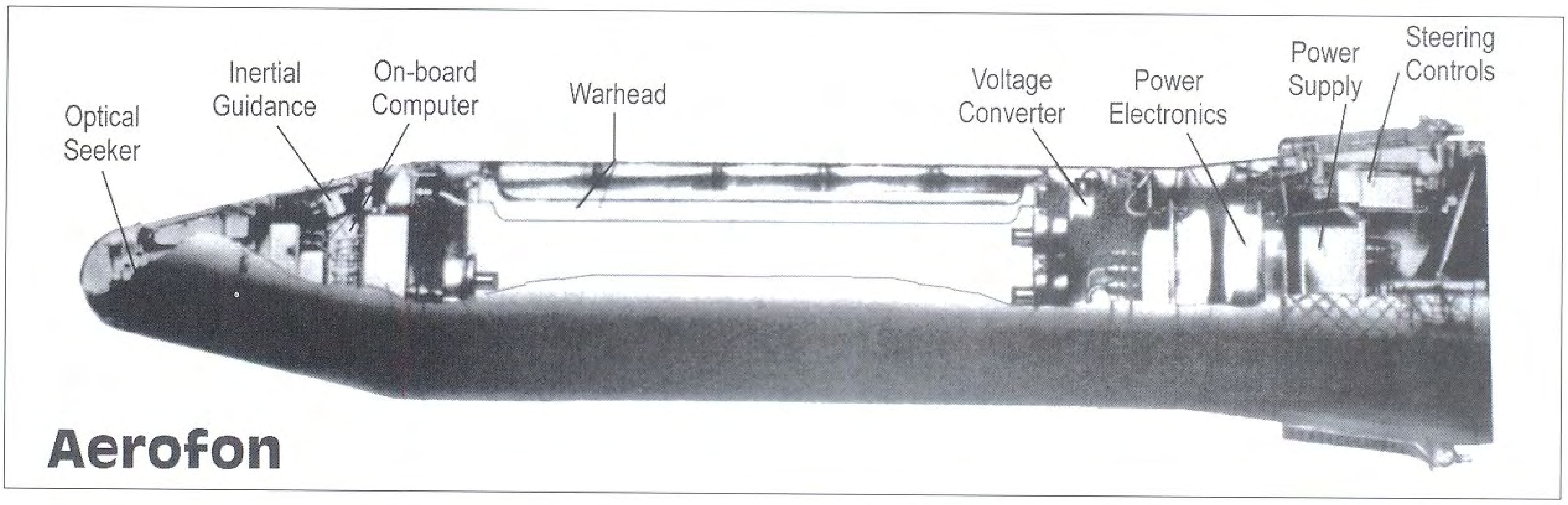
This rear view of a Soviet 9P117M1 TEL clearly shows the large 9N117 launch pad, which folds up behind the missile during transit. (US DOD)

A family of 8F44 non-nuclear warheads was also developed, mainly to arm the R-17E export missile. The 8F44F was the conventional high-explosive warhead. When launched at the full 300km range, it impacts at a speed of 1.4km/s and typical damage is a crater 1.5–4 meters deep and 12 meters wide. The 8F44G Tuman-3 was the standard chemical warhead containing a payload of 555kg of thickened VX agent. It used a proximity fuse and a burster charge to disperse the agent before impact with the ground. Depending on the burst altitude and ground wind conditions, the warhead could contaminate an area up to 4km long and about 600m wide. The 8F44K Kasetka was a submunitions warhead fielded in the late 1970s that carried 42 122mm diameter high-explosive fragmentation submunitions.

SCUD B: THE SECRET VARIANTS

One of the most secret Scud versions was the 9K73 helicopter-mobile missile system. The development of this weapon in 1963 stemmed in part from the experience of the Cuban missile crisis. Although there were plans to deploy the Scud to Cuba, this proved impossible because of the weight of the system. So a program was started in 1963 to develop lightweight, simplified versions of three nuclear missiles: the Luna-M (FROG-7), the 9K72 Elbrus (Scud), and the FKR-2 Progress (SS-C-1 Sepal). When facing NATO, the new versions were light enough that they could be rapidly deployed by helicopter to new and secret locations, making them more difficult to target. The 9K73 system used the slightly modified R-17V missile, the "V" indicating *vertoletniy,* or helicopter. The launcher was a special lightweight four-wheel semi-trailer and erector small enough to be carried in the Mil Mi-6RVK helicopter. A small number of 9K73 missile systems were built and they were deployed for a few years in the Soviet Army on an experimental basis.

The other secret Scud variant was the 9K720 Aerofon project. The accuracy of the basic R-17 missile system was too poor to hit precision targets with conventional warheads. So in 1967, the Central Scientific Research Institute for Automation and Hydraulics (TsNIIAG) began



The 9K720 Aerofon was the final derivative of the Scud B and used an electro-optical guidance sensor developed by the Central Scientific Research Institute for Automation and Hydraulics (TsNIIAG). This shows the new guided warhead section that was substituted for the usual Scud warhead.

development work on a precision-guided version codenamed R-17-VTO Aerofon. The guidance technique was optical comparison, requiring the use of a photograph of the target. This did not prove very practical and in 1974 the program was reorganized to take advantage of advances in computer technology. The new system relied on digital images, and so targets could be easily changed in the warhead from a computer library. A prototype was completed in 1975 and tested under an Su-17 strike aircraft. The first live test of a missile took place on September 29, 1979 with the Aerofon hitting within a few meters of the designated target. The Aerofon was modified so that the warhead compartment separated from the missile fuselage, and new control surfaces were added so that the warhead could make terminal corrections. This version of the Aerofon was first test-fired on September 24, 1984, but both this launch and a subsequent one on October 31 were unsuccessful. It was finally realized that the problem stemmed from the build-up of a thin layer of dust in the inner surface of the optical lens at the nose of the missile, and tests in 1985 were successful. By 1989, the missile had passed its preliminary state testing, and had received an initial approval for acceptance as the 9K720 system. However, it never went into large-scale production – by the 1980s, the more advanced Tochka (SS-21 Scarab) and new Oka (SS-23) were in service. Curiously enough, the Aerofon warhead option was offered for export in the 1990s to clients of the Scud missile.

SCUD ORGANIZATION

In the early 1960s, the R-11 and R-17 operational-tactical missile brigades (OTRB) were deployed at both front level with two brigades per front, and at army level with one brigade per army. Brigades assigned to armies had two battalions with a total of six launchers, while brigades assigned to fronts usually had three battalions and nine launchers. Owing to the complexity of the early 8K11 (Scud A) and 8K14 (Scud B) systems, each brigade had a personnel strength of about 3,500 men, with about 700 assorted vehicles, and their launch battalions had about 745 men and 265 vehicles and motorcycles. The brigade organization included a headquarters and staff, two launch battalions, a technical battery, meteorological battery, repair battery, supply battery, engineer vehicle company, chemical defense platoon, and medical platoon. Its major equipment included six 2P19 launchers, eight 2T3 missile trailers, three 9F21 nuclear warhead shelter trucks, ten command vehicles, six VAZ-452 survey vehicles, four 8T210 crane vehicles, three 8G1 fuel trucks, and four 8G17 oxidizer trucks.

As the new Temp (SS-12) missile became available to support fronts in the late 1960s, many Scud brigades were reassigned to support combined-arms armies. By 1967, brigades were standardized with three battalions, each now with two batteries but two launcher sections per battery, for a total of 12 launchers per brigade. Brigade strength was reduced to around 1,200 men, thanks to the advent of the 9P117 TEL and improved handling equipment. In the late 1970s and early 1980s, some Scud frontal brigades opposite NATO were increased to 18 launchers by the addition of a third battery per battalion. When one of these brigades was dissolved in 1979, as a political gesture connected to the debate over the intermediate nuclear forces treaty, its launchers were distributed to the two other brigades in East Germany, creating two "super-brigades" of

SOVIET SCUD BRIGADE DEPLOYMENT (1990)

Military District	Brigade	Assignment	No. of TEL
Western Group of Forces (Germany)	164th Missile Brigade	Front	27
	175th Missile Brigade	Front	27
	181st Missile Brigade	1st Guards Tank Army	12
	112th Missile Brigade	2d Guards Tank Army	12
	36th Missile Brigade	3d Shock Army	12
	27th Missile Brigade	20th Guards Army	12
Northern Group of Forces (Poland)	114th Missile Brigade	Front	12
Baltic Military District	149th Missile Brigade	Front	12
	152d Missile Brigade	Front	12
Byelorussian Military District	22d Missile Brigade	Front	18
	76th Missile Brigade	7th Tank Army	12
Carpathian Military District	35th Missile Brigade	Front	18
	38th Missile Brigade	13th TA	12
	177th Missile Brigade	66th Artillery Corps	12
	199th Missile Brigade	8th TA	12
Kiev Military District	123d Missile Brigade	1st Combined Arms Army	12
Moscow Military District	95th Missile Brigade	Front	12
Volga Military District	187th Training Missile Brigade	Army	12
Leningrad Military District	21st Missile Brigade	Front	12
	131st Missile Brigade	Front	12
	6th Missile Brigade	6th Combined Arms Army	12
Odessa Military District	9th Missile Brigade	Front	12
	34th Missile Brigade	Front	12
	106th Missile Brigade	Front	12
	189th Missile Brigade	Front	12
	173d Missile Brigade	14th Combined Arms Army	12
North Caucasus Military District	47th Missile Brigade	Front	12
	99th Missile Brigade	12th Army Corps	12
Transcaucasus Military District	90th Missile Brigade	Front	12
	119th Missile Brigade	Front	12
	136th Missile Brigade	4th Combined Arms Army	12
	176th Missile Brigade	7th Combined Arms Army	12
Transbaikal Military District	U/I Missile Brigade	Front	12
Far East Military District	U/I Missile Brigade	Front	12
	U/I Missile Brigade	Front	12
	U/I Missile Brigade	5th Combined Arms Army	12

27 launchers each, with three battalions, each with nine launchers. At the time of the breakup of the USSR in 1991, the Soviet Army numbered about 35 Scud brigades of both army and front-level assignment, with about 450 launchers.

LAUNCHING THE SCUD

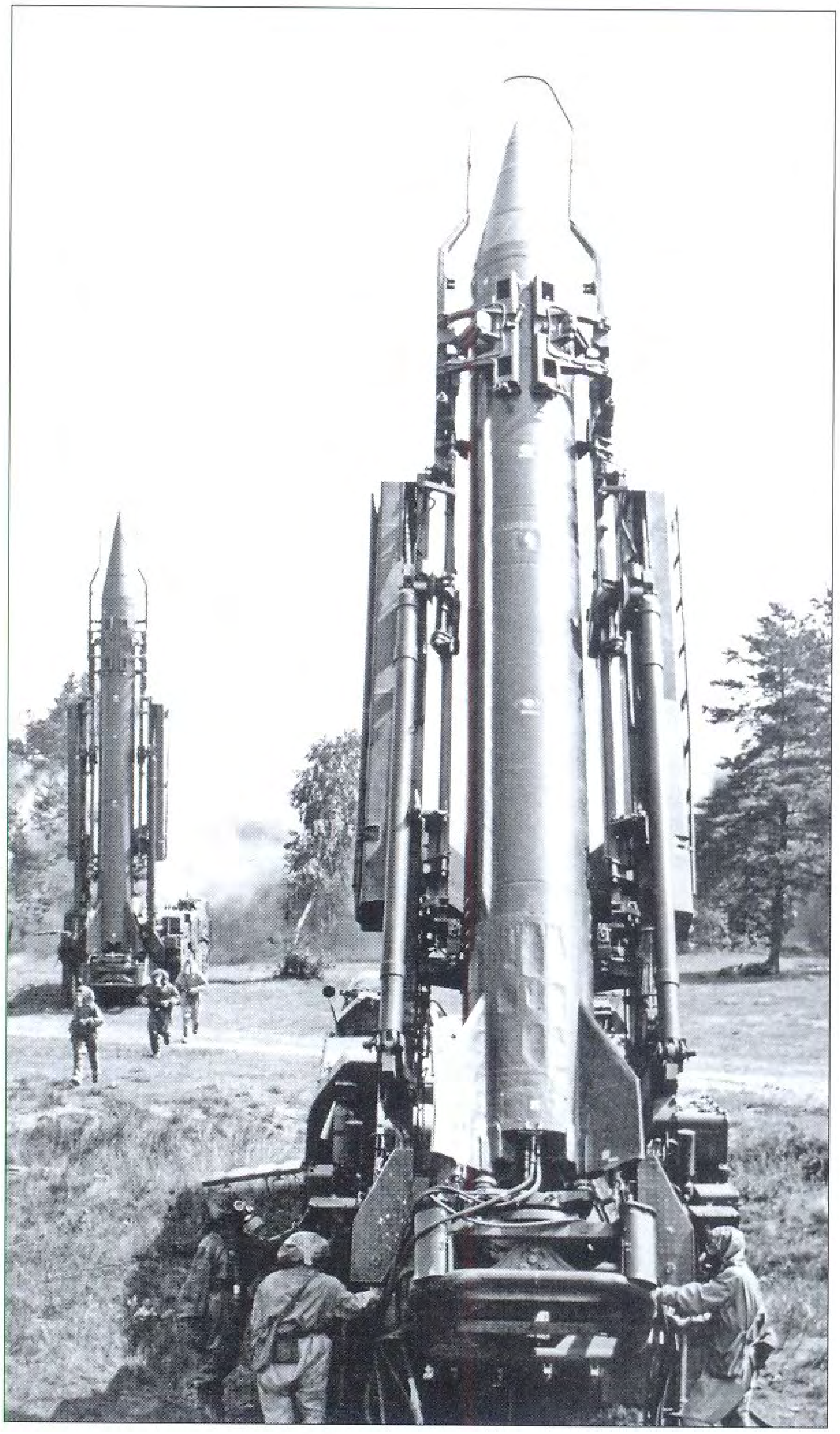
Each 9P117 TEL was assigned a launch crew of seven, consisting of an officer as launch section commander, two warrant officers (one in charge of aiming the missile, the other responsible for missile status checks), a sergeant driver-mechanic, and three enlisted men for various supporting tasks.

The preparation of the Scud missile for launch is broken down into six readiness levels, the first three called arsenal readiness, and the last three called field readiness levels. At **Readiness Level 6**, the missile is in storage, and periodic maintenance and testing are conducted every two years. At **Readiness Level 5**, the missile and its components are removed from storage, transferred to the brigade technical battalion, and the brigade prepares to move to its initial assembly areas. At **Readiness Level 4**, the warhead is mated to the missile fuselage and the missile is fueled with propellant and oxidizer. The brigade moves to the field to begin combat operations.

At **Readiness Level 3** the launch section proceeds to the missile loading site, and loads the missile from the 2T3M semi-trailer on to the 9P117 launcher vehicle using a 9T31M crane, which takes about 45 minutes. In the meantime, the survey teams in VAZ-452 vehicles conduct surveys of the launch site, and the battery command vehicles are positioned near the sites. **Readiness Level 2** begins when the 9P117 launcher vehicle arrives at the launch site. The 9P117 TEL is usually aligned 45 degrees to the right of its direction of fire, since the missile guidance is aligned with its number one fin. To ensure accuracy, the launcher needs weather data up to more than 60,000m, including wind direction and speed, air pressure, and humidity. The brigade's meteorological section launches RKZ-1 radiosondes attached to a balloon that are tracked by a meteorological radar such as the RMS-1 (End Tray), RPS-1 (Bread Bin), or the improved ARMS-3 Ulybka (Leg Drive). The meteorological data is passed to the 9S436 command vehicle for computation of necessary guidance corrections and then sent to the launchers.

Once the 9P117 is aligned on its basic direction of fire, the crew members begin to carry out a carefully choreographed set of tasks. While 9P117 TELs can set up several kilometers apart, in most combat situations they usually are within 50 to

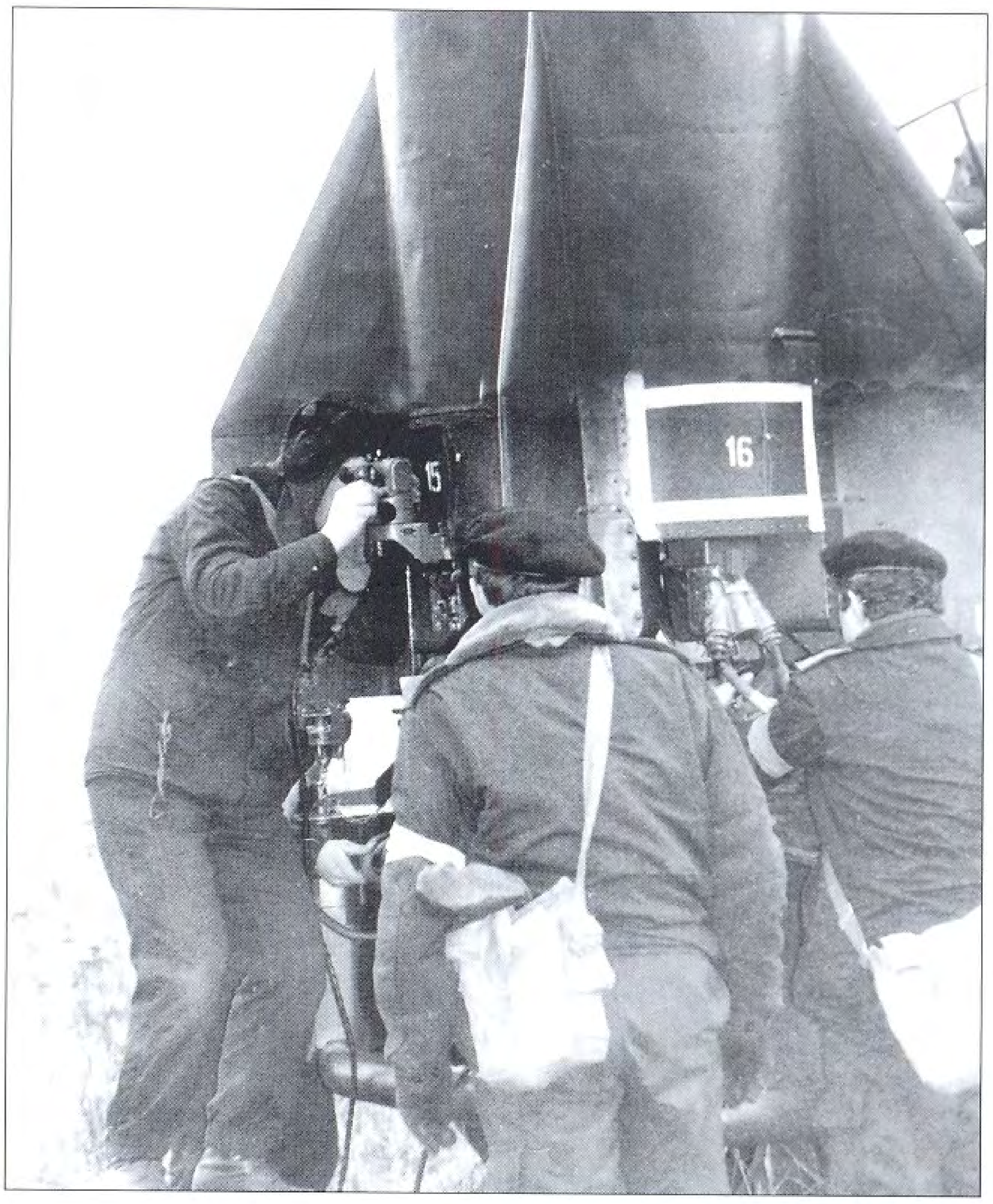
A pair of Soviet 9P117 TELs on exercise in the Byelorussian Military District in the 1970s. This is the original version of the TEL with the more elaborate erector frame, which is very evident in this view. The crewmen are wearing chemical protective "slime suits" owing to the toxicity of the fuel used with the R-17 missile – not because of the presence of a chemical warhead, as is so often claimed. (W. Luczak)



150m of the battery command post, with one launcher on each side of the command vehicle. The battery command vehicle, with an R-142 radio station, is the link to the battalion or brigade's 9S436 command vehicle. The missile erection process begins by lowering the rear stabilizer jacks, pumping starter fuel to the engine turbo-pump, and checking the missile batteries. The missile alignment is checked using a theodolite collimator and gyroscopic alignment device, since the missile has to be set at a precise 90-degree angle. Erection of the missile takes about three minutes. The erector cradle is then lowered back on to the TEL roof. The final precision aiming of the missile takes place and the crew positions the 8V117 launch control box a safe distance from the missile. If the missile is carrying a nuclear warhead, the last step is to remove the 2Sh2 thermal insulating blanket from the warhead via ropes connected to quick-release pins. With missile checks complete, the crew moves away from the TEL and the

When first deployed in service, the R-17 missile was towed to loading areas using the 2T3 semi-trailer towed by the ZIL-151 truck, as seen here. The missiles were loaded on to the TEL by means of a crane.

An essential aspect of Scud missile operations is meteorological reconnaissance, since wind can deflect the Scud from its intended ballistic path. The 1B44 Ulybka radar is used as part of the RPMK-1 meteorological radar system and tracks radiosonde balloons to determine wind velocity in the upper atmosphere. (Author)

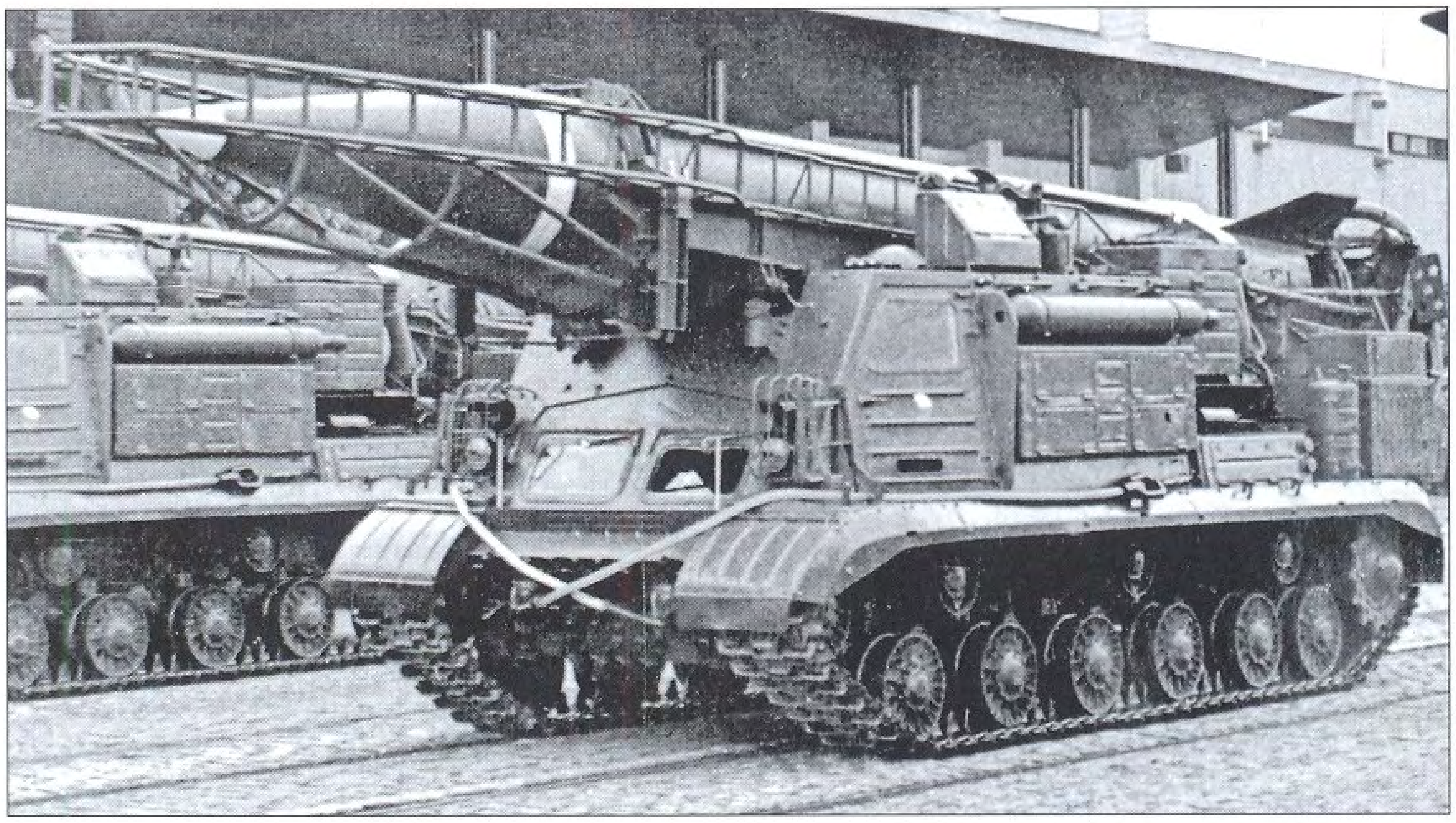


ABOVE **Once the missile is erected, one of the launch officers uses an artillery panoramic sight fitted near access port 15 to make certain that it is aligned properly towards the target. The Scud depends on precise surveying and aiming to ensure its accuracy on impact. (W. Luczak)**

section commander informs HQ that they have achieved **Readiness Level 1**. Prior to launch, the missile batteries are turned on and the internal gyros of the guidance system begin to spin up. Once the batteries are activated, the missile must be launched within 15 minutes.

The launch sequence begins at 12 seconds prior to lift-off, when the turbo-pump begins to power up; the fuel and oxidizer are pumped into the rocket engine, which operates at 30 percent power for four seconds; then the engine switches to full power, and the missile lifts off. Shortly after clearing the launcher, the missile begins to arc over towards the target. Guidance is provided by the inertial guidance system, which operates four graphite fins in the thrust nozzle of the missile engine. Once the engine shuts down, the missile continues on a ballistic path. The missile is under power for a maximum of 68 seconds. If the range is set for less than maximum, explosive squibs shut off the flow of fuel and oxidizer at a predetermined time to cut the engine off at once. The range envelope for the Scud B is 50–300km, and it requires 165–313 seconds to reach those ranges respectively. At short range, the missile has an apogee of 24km over the earth, while at full range the apogee is 86km.

An 8U218 TEL of the Polish People's Army on field training in the late 1960s. (J. Magnuski)



An 8U218 TEL of the Czechoslovak Army on parade in Prague in the 1970s. Two Czech brigades used this weapon, the 311 BROT at Stara Boleslav and the 321 BROT at Hranice, before switching to the later 8K72 Elbrus system. (US DOD)

WARSAW PACT SCUDS

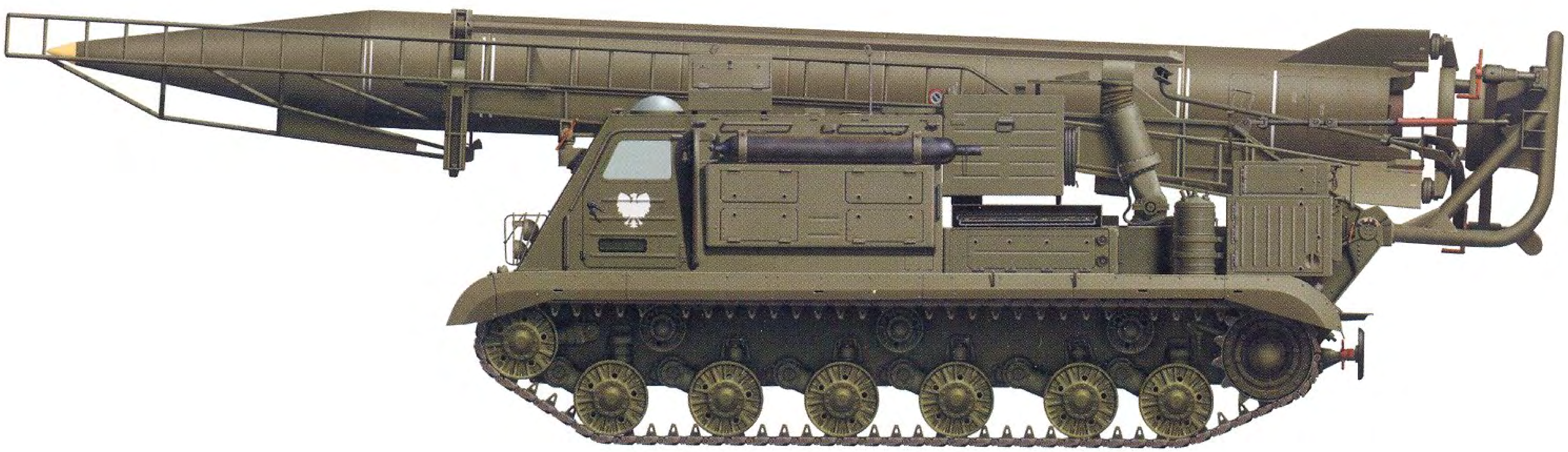
Khrushchev saw the nuclear missile as the basis of all modern armies, and in 1961 decided to equip the Warsaw Pact armies with the short-range Luna (FROG) tactical rockets, the 8K11 missile system, and nuclear-capable strike aircraft. There was some resistance within the Soviet Army's general staff to the transfer of nuclear-capable systems, since there was some fear that in a crisis they might be aimed east instead of west. But the Warsaw Pact armies did not have access to actual nuclear warheads, which were stored on their soil in Soviet-controlled Missile Technical Bases (RTB). Export of the 8K11 system to the members of the Warsaw Pact began in 1961. The usual pattern was to transfer small numbers of the old, second-hand 8U218 TELs for the 8K11 (Scud A) system as a first step, followed by some of the more modern 2P19 launchers (Scud B) a few years later. Training for the Warsaw Pact troops was conducted in the Soviet Union at the Kapustin Yar proving ground. As the newer 9P117 TEL

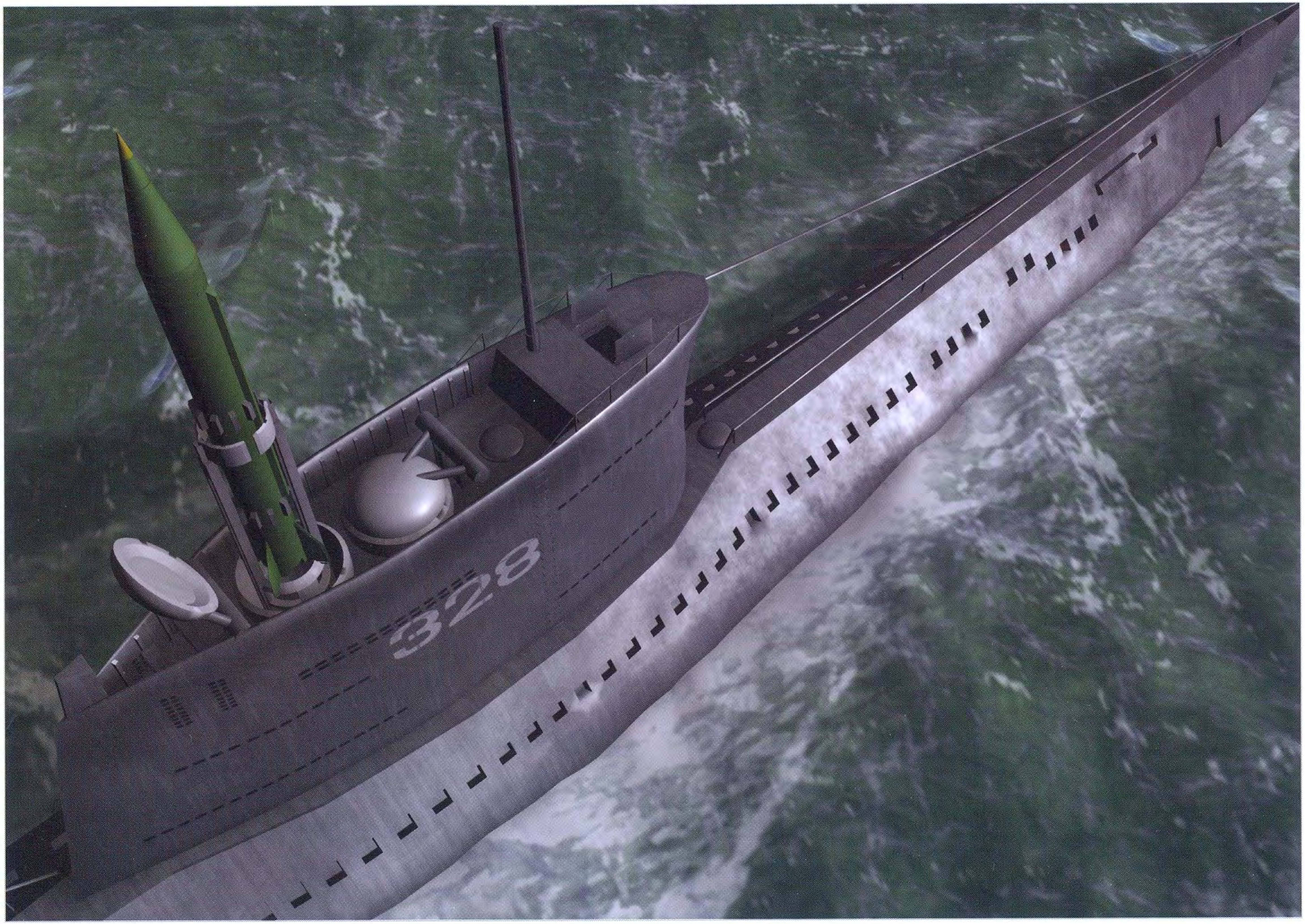
WARSAW PACT SCUD MISSILE BRIGADES 1989

Country	Unit	Location	Subordination
Poland	3d Warsaw OT Missile Brigade	Biedruszko	High Command
	2d Pomeranian OT Missile Brigade	Choszczno	Pomeranian District
	18th OT Missile Brigade	Boleslawiec	Silesian District
	32d OT Missile Brigade	Orzysz	Warsaw District
Czechoslovakia	311th OT Missile Brigade	Jince	High Command
	321st OT Missile Brigade	Rokycany	1st Army
	331st OT Missile Brigade	Jicin	4th Army
East Germany	5th Missile Brigade "Bruno Leuschner"		Demen 5th Army
	3d Missile Brigade "Otto Schwab"	Tautenhain	3d Army
Hungary	5th Ind. Mixed Missile Brigade	Varpalota	5th Field Army
Romania	32d Operational-Tactical Missile Brigade	Tecuci	2d Army
	37th Operational-Tactical Missile Brigade	Ineu	4th Army
Bulgaria	46th Artillery Technical Brigade	Samokov	1st Army
	129th Artillery Technical Brigade	Karlovo	2d Army
	66th Artillery Technical Brigade	Yambol	3d Army

A1: 8U218 Launch Vehicle, Selbstandige Artillerie Brigade 2,
East German National People's Army, Stallberg, East Germany, 1970

A2: 8U218 Launch Vehicle, 18 ABROT, Polish People's Army,
Boleslawiec, Poland, 1965





B: Project 611AV (Zulu V) Ballistic Missile Submarine, Soviet Northern Fleet, 1959

C: The Scud missile and its successors 1959–99

C1: R-11M (SS-1b Scud A)
C2: R-17 (SS-1c Scud B)
C3: R-17VTO Aerofon
C4: Al-Hussein
C5: 9M714 Oka (SS-23 Spider)
C6: Iskander/Tender (SS-26 Stone)

C

D: 9K72 OPERATIONAL-TACTICAL MISSILE SYSTEM (SS-1C SCUD B), 1975

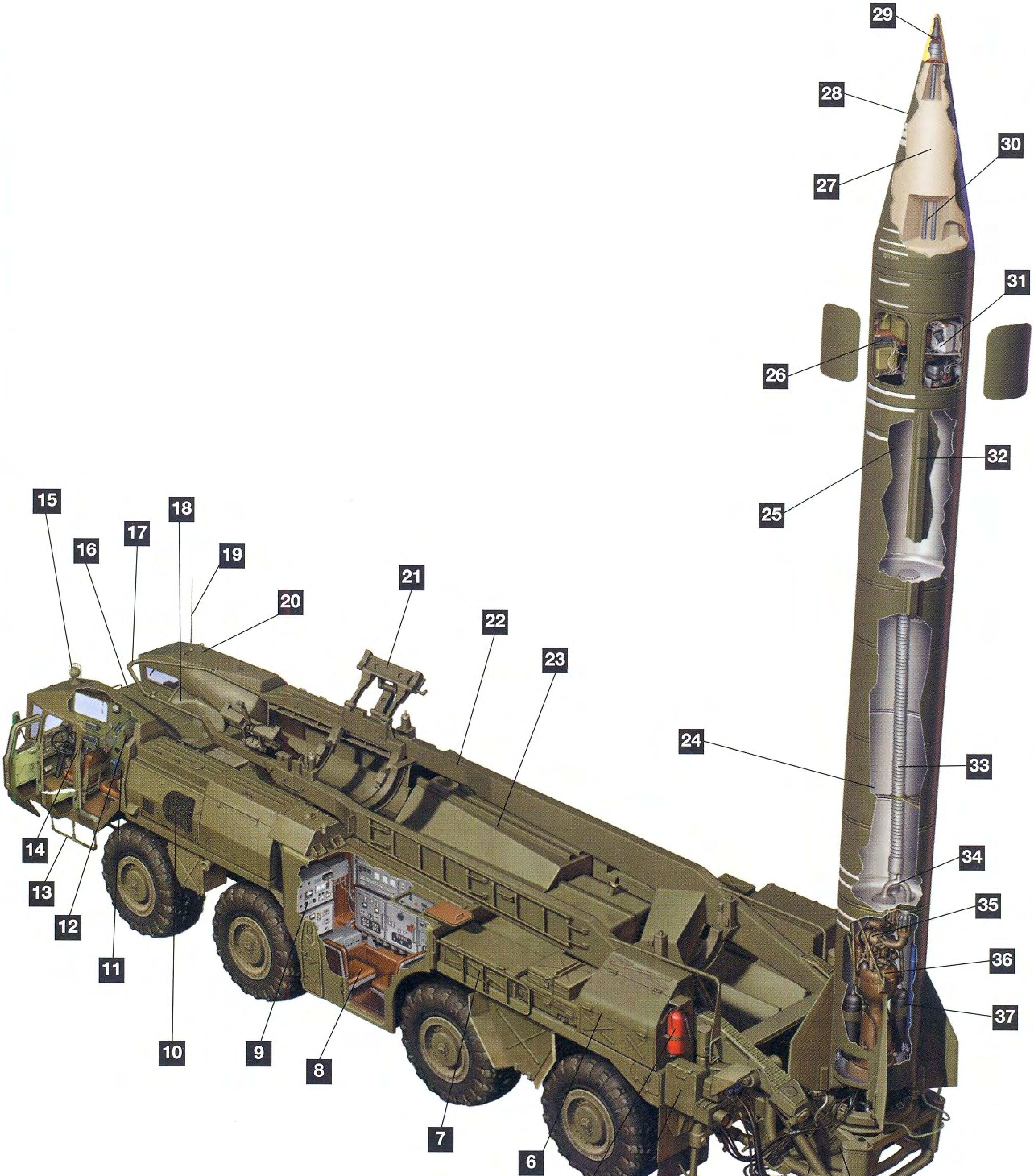
KEY

1 Blast deflector plate
2 9N117 launch pad
3 Stabilizing pad
4 Control panel for stablizing system/launch pad
5 Fire extinguisher
6 Pad erection control panel
7 Tool container
8 Crew seats in combat cabin
9 Combat cabin for launch computation and controls
10 Radiator air intake
11 Crew seat
12 Air pressure bottles for cold weather engine starting
13 Step for crew
14 Driver's seat
15 Searchlight
16 Engine compartment
17 Brushguard for missile erector frame
18 Engine air intake
19 Radio aerial
20 Crew compartment/radio station
21 Locking arms for erector frame (open)
22 Erector frame (in folded position)
23 Pump control cabin
24 Oxidizer tank
25 Fuel tank
26 Guidance compartment 1
27 High explosive warhead filling
28 8F44F high explosive warhead
29 Proximity fuse
30 Detonator for rear 8V53 impact fuses
31 Guidance compartment 2
32 Interstage electrical conduit channel
33 Fuel hose through oxidizer tank
34 Fuel flow pipe for oxidizer
35 Engine turbopump
36 9D21 rocket engine
37 Air pressure cylinders for propulsion system

SPECIFICATION

(Missile)
Length 11.2–11.4m (depending on warhead type)
Diameter 885mm
Span 1.8m
Launch weight 5,862–5,950kg
Empty weight 2,076kg
Fuel weight 3,771kg (852kg fuel + 2,919kg oxidizer)
Payload 1,016kg
Guidance Strap-down inertial, efflux vanes in exhaust for steering
Engine type Isayev /KBKhM 9D21 liquid rocket engine with thrust of 13,380kg/s and specific impulse of 226s (SL); 258s (vacuum)
Propellant AK-27I (nitric acid + 27 percent nitrogen tetroxide) + TM-185 (kerosene derivative)
Range 300km (max); 50km (min)
CEP (300km) 610m in range, 350m in azimuth @ 300km
Speed 1.500km/s (max.); 1.13km/s (apogee), 1.4km/s (impact)

(9P117M TEL)
Crew 7
Length 13.36m
Width 3.02m
Height 3.3m
Ground clearance 0.44m
Overall weight 30.6/37.4 metric tons (without/with missile)
Engine D-12-525A diesel; 580hp (385kW)
Max road speed 45km/h
Road range Empty: 650km; cross country: 500km; fully loaded: 450km



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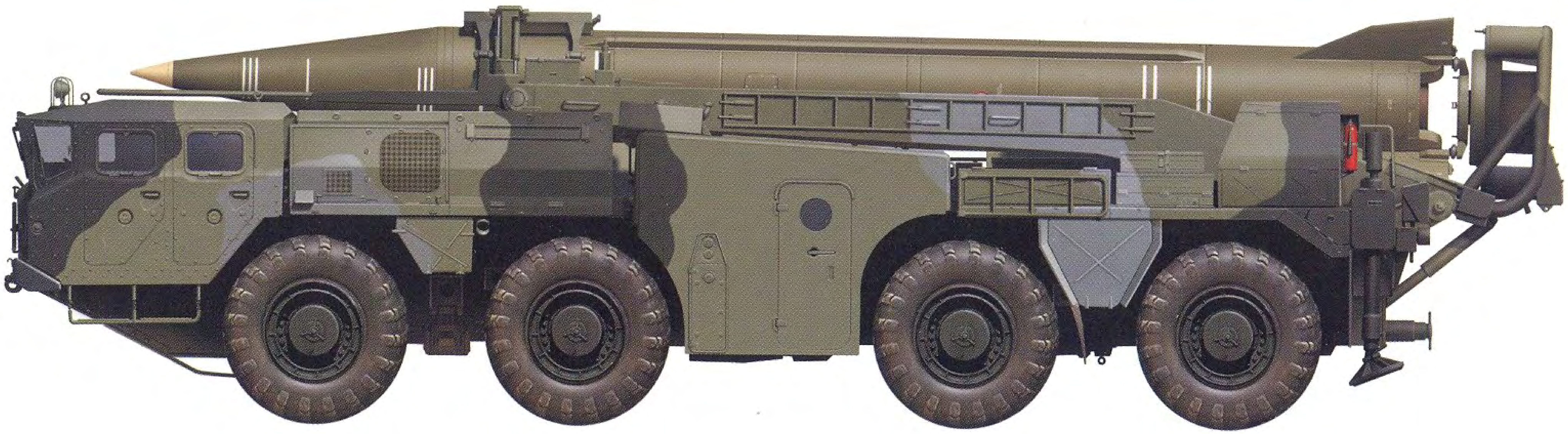
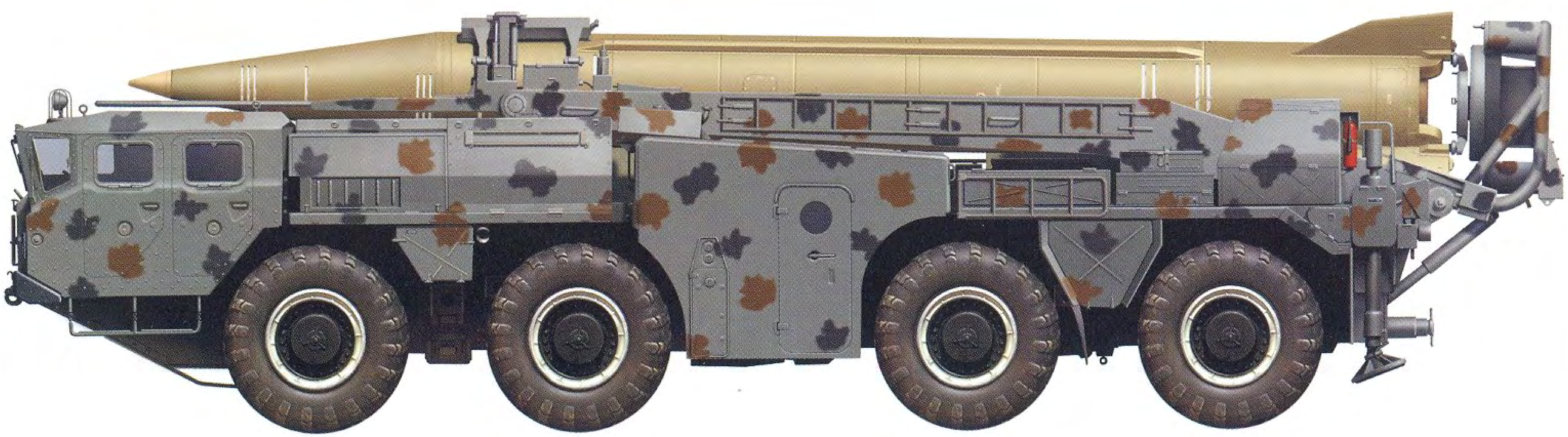
F1: 9K72 Elbrus (SS-1c Scud B), 181st Operational-Tactical Missile Brigade, 1st Guards Tank Army, Western Group of Forces, East Germany, 1975

F2: 9K72 Elbrus (SS-1C Scud B), 5th Missile Brigade "Bruno Leuschner," East German Army, 1990



G1: 9K72E Elbrus-E (SS-1c Scud B), Libyan Army Missile Brigade, Tripoli, 1975

G2: 9K72E Elbrus-E (SS-1c Scud B), Islamic Revolutionary Guards Corps, Iran, 1985



became available, the Warsaw Pact brigades were re-equipped with these. By the 1980s, about 140 launcher vehicles had been exported to the Warsaw Pact armies, equipping 15 brigades. Some of the brigades were organized on the lower basis of two launch battalions with eight TELs per brigade, but the front-line armies – Germany, Poland, Czechoslovakia – were equipped at the higher establishment of three battalions and 12 TELs per brigade. Most of the Warsaw Pact countries disbanded the Scud brigades in the early 1990s, as the equipment was wearing out and ineffective without a nuclear warhead.

SCUD PROLIFERATION

The Soviet Union made little effort to export the 8K72 Elbrus missile system outside the Warsaw Pact, since it was complicated, expensive, and not militarily effective without a nuclear warhead. However, the Egyptian government expressed interest in obtaining the Scud B in the late 1960s because of the failure of its own indigenous ballistic missile program, which had been conceived as a symbolic counterweight to Israel's Jericho ballistic missile. Ballistic missiles offered the veneer of military modernity, so part of the reason for obtaining Scuds was the military prestige. But it also had some tactical rationale, as several of the Arab states near Israel had found that their air forces were incapable of conducting ground attack missions in the face of the much better-trained Israeli air force, and the missiles offered the possibility of carrying out deep strikes. The export version of the Elbrus system used the conventionally armed R-17E missile and a modified 9P117 launcher vehicle with a less accurate manual command and control interface. Following the initial sale to Egypt in 1971, further sales continued in the Middle East through the 1980s. The scale of Soviet Scud exports has not been precisely detailed. One Russian account has stated that 2,300 missiles had been sold to 11 countries through 1989, which seems low, as Warsaw Pact inventories probably accounted for over 1,000 missiles, and sales to the Middle East and Afghanistan probably accounted for more than 3,000.

SOVIET SCUD EXPORT 1970–90

Country	Arrival	TELs (Missiles)	Units
Afghanistan	1988	24 (1,700)	1 brigade
Egypt	1971	24	2 brigades
Iraq	1974	11 (819)	1 brigade
Libya	1974	72 (200–300)	6 battalions
Syria	1974	9	3 battalions
Vietnam	1979	12	1 brigade
Yemen	1978	12	1 brigade

THE SCUD AT WAR: EGYPT

Egypt received the first nine TELs and about 18 R-17E missiles in 1973, shortly before the outbreak of the October War with Israel. These equipped the 65th Artillery Brigade, attached to the 3d Field Army at the time. During the conflict, President Sadat of Egypt threatened to use the new missiles against Israeli cities. Israel deployed its nuclear-armed Jericho missiles in plain view of Soviet reconnaissance satellites, and when Sadat was informed of this he was forced to reconsider. Later the brigade was assigned to destroy the vital Israeli pontoon bridges over the Suez Canal near Deversoir, which were allowing the Israeli army to outflank the Egyptian forces in Sinai. A total of three missiles were launched with the help of Soviet advisers, but the point of impact was so far from the bridges that the Israeli Army was unaware of the attacks until the craters were found in the desert some days later. Following the war, the Soviet Union completed the equipment of the 65th Artillery Brigade, but support ended in the 1970s because of strained political relations. As a result, Egypt turned to North Korea to locally refurbish and improve Scud missiles in the 1990s.

Syria also attempted to acquire the Scud system before the 1973 war, but they were not delivered until 1974. The poor performance of Syrian strike aviation in the 1973 war against the better-trained Israeli air force was a strong incentive for the missile effort. By the end of the 1970s, Syria had deployed three Scud battalions with the 115th Missile Brigade alongside two Luna-M (FROG-7) rocket battalions. The end of Scud production in the USSR limited further acquisition, so Syria turned to North Korea and China to strengthen and support the force. Syria purchased the North Korean Hwasong 5 and 6, as well as new TELs.

THE SCUD AT WAR: IRAQ

Iraq acquired a Scud B brigade shortly after Egypt. When war broke out with Iran in 1980, Brigade 224 saw some scattered use but most strikes against Iranian targets were conducted by the Iraqi air force. The Iraqi air campaign was one of the most inept in recent military history, and so when the ground campaign stalemated in 1983, Brigade 224 was

This R-17E missile launched by the Iraq Brigade 244 is seen crashed in Saudi Arabia in 1991 after being hit by a Patriot missile of the US Army's 3/43d Air Defense Artillery. It broke up during its descent, and this is the aft section consisting of the oxidizer tank and engine compartment. (US DOD)

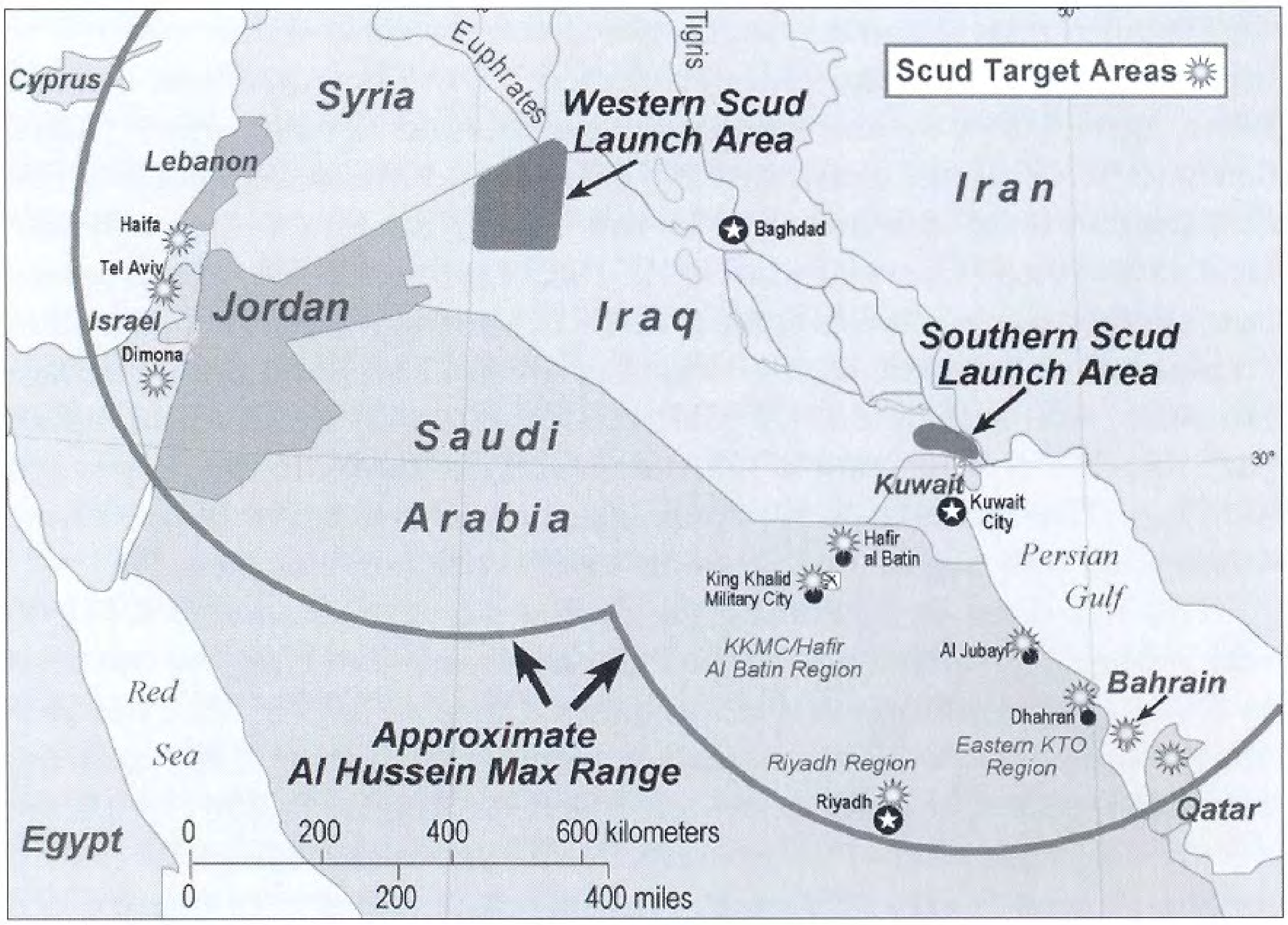
deployed to attack Iranian targets along the frontier, mainly cities. The missile strikes on Iranian cities prompted Iran to respond, and in 1982 Libya agreed to provide training to the Islamic Revolutionary Guard Corps (IRGC) along with two 9P117 TELs and about 20 missiles. The first Iranian Scud was launched by the IRGC's Khatam al-Anbya Missile Unit in the early hours of March 12, 1985 against Kirkuk. The Iranians launched 13 more missiles against Baghdad through June 1985, and Iraq responded with missile launches against Dezful and Bakhtaran. Saddam Hussein was infuriated by the missile attacks against Baghdad, particularly since the Iraqi R-17E missile did not have the range to reach Teheran. The Soviet Union rebuffed attempts to acquire longer-range missiles, so Iraq began a program to extend the range of its R-17E.

This was done by extending the fuel tanks of the standard R-17E to add 985kg of propellant, while at the same time reducing the warhead by 335kg. The resulting missile was dubbed the Al-Hussein after the Shia martyr Imam Hussein. Flight-testing began in February 1987 and the first fully successful flight test took place on August 3, 1987, with the missile reaching 650km compared to the maximum range of 300km for the normal R-17E. At first, the Al-Hussein missiles were constructed by cannibalizing other Scud missiles, consuming three Scuds for every Al-Hussein. The Project 144 production facility at Taji managed to reduce this to a one-to-one ratio by substituting some locally manufactured components. After another shipment of 118 R-17E missiles from the Soviet Union in 1988, Iraq was able to construct about 250 Al-Hussein missiles.

Iraq developed its own launchers for Brigade 223 including the Al-Walfed, seen here, which was a semi-trailer type using a commercial truck as the prime mover.

The second "War of the Cities" began on February 29, 1988, with most of the Iraqi missile attacks directed against Teheran. The missile attacks had a profoundly demoralizing effect on the civilian population of Teheran and about a quarter of the 10 million people living there evacuated the city by the early spring. Iran had a hard time retaliating, as the Soviet Union had pressured Libya to stop supplying missiles. Iran turned to North Korea, which was manufacturing an unlicenced copy of the R-17E as the Hwasong 5. Both sides agreed to halt the missile attacks on April 20, 1988, but Iraq emerged as the clear winner in the campaign, with the missile attacks forcing Iran to the peace table.

Iraq continued to develop modified Scud missiles after the war ended, including the extended-range Al-Abbas with a range of 860km, and the Al-Hijara with a concrete warhead intended for penetrating hardened targets such as Iranian or Israeli nuclear facilities. The most fantastic derivative was the Al-Abid "space launch vehicle," consisting of five Al-Hussein fuselages strapped together for the first stage, and topped by a second stage built from another Al-Hussein. This was far beyond the limited technical means of the Iraqi engineers, and the contraption disintegrated



This map shows the operating areas of Iraq's Brigade 244 in the 1991 Gulf War. (US DOD)

shortly after launch on December 5, 1989. The Iraqi facilities also attempted to manufacture Scud copies, but were unable to build complete missiles because of the difficulty of manufacturing some of the more complex components such as engine turbo-pumps and guidance gyros. Besides work on improved missiles, Iraqi engineers also attempted to expand the size of the missile force by building new launchers. Two types of mobile launchers were designed, the Al-Walfed semi-trailer launcher, and the simpler Al-Nida. Four Al-Nida launchers were completed prior to the Gulf War, equipping the new Brigade 223. A simple type of fixed-launch erector was also designed, and about 30 of these static launchers were deployed at airbases in the western Iraq desert, aimed at Israel.

At the time of the Iraqi invasion of Kuwait in August 1990, Brigade 224 was deployed in "Zone 4" in the western Iraqi desert as a counter-weight to any Israeli military action against Iraqi nuclear and missile facilities. The new Brigade 223 was activated in September 1990 but was only partially equipped with four Al-Nida launchers. When the US and Coalition forces began Operation *Desert Storm* on January 17, 1991, the incomplete fixed sites at the Zone 4 bases were among the first targets of air attack. Brigade 224 was dispersed in the western desert area, and received instructions to carry out missile attacks against targets in Israel. The first Al-Hussein attacks began in the early hours of January 18 against Tel Aviv and Haifa by Brigade 224, but the single attempt to launch a missile from the new Al-Nida launchers of Brigade 223 failed. On January 20, the brigades were dispersed and began missile strikes against Saudi Arabia from sites in southern Iraq. In total, some 93 missiles were launched, at least 42 against Israel and 46 against Saudi Arabia/Kuwait over the next few weeks, mainly by Brigade 224.

The Iraqi missile campaign was noteworthy as the world's first missile vs missile battle. The US Army had deployed MIM-104 Patriot batteries for air defense in Saudi Arabia and Israel, and the Israeli Defense Force was in the preliminary stages of deploying their own Patriots. The Patriot

Iraq established several fixed launch sites for the Al-Hussein missile in the western desert area facing Israel. None of these were operational at the time of Operation *Desert Storm* in January 1991, and most were hit by Coalition air strikes. This is a photo of one of the sites taken by an F-14A Tomcat with TARPS reconnaissance pod of Fighter Squadron 32. (US DOD)

system had been designed primarily as an antiaircraft weapon, but in the mid-1980s it had been modified to permit Patriot batteries to defend their sites against short-range Soviet ballistic missiles such as the Tochka (SS-21). The PAC-1 (Patriot Anti-Tactical-Missile Capability-1) was a software effort permitting the Patriot radar to track and engage missiles, while PAC-2 included a new fragmentation warhead better suited to defeating hardened warhead casings. The first Patriot vs Scud engagements started on the night of January 18 and continued for the next few weeks. Patriot had never been designed for area defense against ballistic missiles with the speed of the Al-Hussein, and that it could engage them at all was a remarkable testimony to the robustness of the Patriot design. One of the main problems in engaging the Al-Hussein was the Iraqi missile's poor design. By stretching the fuselage, the missile became unstable in the descent, disintegrating as it re-entered the atmosphere. Instead of facing a single target, the Patriot batteries were confronted with a stream of debris and so had to choose some element of the debris trail to attack. The largest pieces tended to be the warhead, fuel tank, and rear engine compartment, and these were sometimes engaged by multiple Patriot missiles. The Patriot radars detected 88 Scuds but only 53 entered areas defended by Patriot launchers. Of these, 51 were engaged, and the army assessed that 27 had been successfully engaged, meaning that the warhead was destroyed, the high explosive had been partially burned by damage to the casing, or the missile fuselage had been knocked off course. Critics later dismissed these assessments, since even when the Patriot detonated within the debris stream, the 1.8 tons of assorted missile debris still impacted the ground at very high speed causing significant damage regardless of whether the Scud warhead detonated. The ensuing controversy over Patriot performance served as a stalking horse for critics of the US Star Wars strategic missile defense program. Regardless of the technical merits of this controversy, the use of the Patriots over Saudi Arabia and Israel was an important morale booster, and served its political purpose of restraining an Israeli response to the Iraqi missile strikes that might have severely affected the cohesion of the allied Coalition against Iraq.

The use of Scuds by Iraq highlights the appeal of tactical ballistic missiles to armies in the developing world. Their conventional armed forces are nearly powerless against first-rate armies in the field, but a handful of ballistic missiles can wreak political havoc out of all proportion to their very modest military value. Mobile missile launchers proved to be very difficult military targets, and a major effort by Coalition air forces to bomb Iraq's 9P117 TELs failed to hit a single launcher even after 1,500 sorties. In the wake of the 1991 Gulf War, the Coalition forced Iraq to destroy its remaining inventory of Scud missiles, though this became a bone of contention for the next decade, with lingering suspicion that Iraq had failed to do so.

IRAQI SCUD LAUNCHES 1980–91

1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
69	13	26	37	63	120	0	36	189	0	0	93

THE SCUD AT WAR: OTHER CONFLICTS

Libya was one of the largest single export clients for the Scud missile, and in a series of bilateral agreements with the Soviet Union acquired 72 9P117 TELs and several hundred R-17E missiles. As mentioned earlier, Libya was the source of the Scuds used by Iran in the War of the Cities in the 1980s. Libya engaged in the only Scud attack against Europe after the US staged air raids against Tripoli and Benghazi on April 14, 1986 in retaliation for a terrorist bombing at a Berlin discotheque. In response, Libya launched two R-17E missiles against the Italian island of Lampedusa, trying to hit a US Sixth Fleet base. The missiles fell harmlessly into the sea. Libya had a fairly extensive domestic missile program through much of the 1990s, partly in cooperation with North

The 99th Missile Brigade, although nominally Afghan, was largely manned by Soviet troops. Here one of its 9M117M TELs is seen moving to the front in 1989. (W. Luczak)

Korea, but the program was largely abandoned in 2004 as part of a US/UK sponsored effort that traded off these weapons programs for a lifting of Western economic sanctions against Libya.

Yemen acquired a Scud brigade in the late 1970s. During the civil war in May–July 1994, southern Yemeni forces fired a number of Scuds at the northern capitol of Sanaa, prompting the northern forces to deploy their 1st Missile Brigade armed with the more modern Tochka (SS-21) missiles. In total, about 30 R-17E and 35 Tochka missiles were launched during the civil war.

THE SCUD AT WAR: AFGHANISTAN

The most extensive combat uses of the Scud took place at the conclusion of the Soviet–Afghanistan conflict in 1988. When the Soviet Army began withdrawing from Afghanistan in May 1988, the Afghan Army was reinforced by creating the 99th Missile Brigade armed with the R-17E missile at a base in Afshur. These were first deployed in November 1988 and in reality the brigade was operated mainly by Soviet troops with Afghan personnel gradually integrated into the unit. The first missiles were fired against Mujahidin ammunition dumps near the Pakistan border. The tempo of missile launches increased dramatically in March–June 1989 during the fighting for Jalalabad, with 438 Scuds launched over this four-month period, and 995 Scuds launched through October 1989. This was a tremendous expenditure of firepower considering that the export price of the R-17E missile at the time was about a million dollars, but served as a substitute for Soviet aircraft that had already been withdrawn. Soviet accounts later credited the exorbitant use of Scud missiles as an essential part of the successful defense of Jalalabad. The scale of Scud launches declined considerably as the Soviet Army undertook its final withdrawal and Afghanistan descended into protracted civil war. By May 1991, the 99th Missile Brigade had

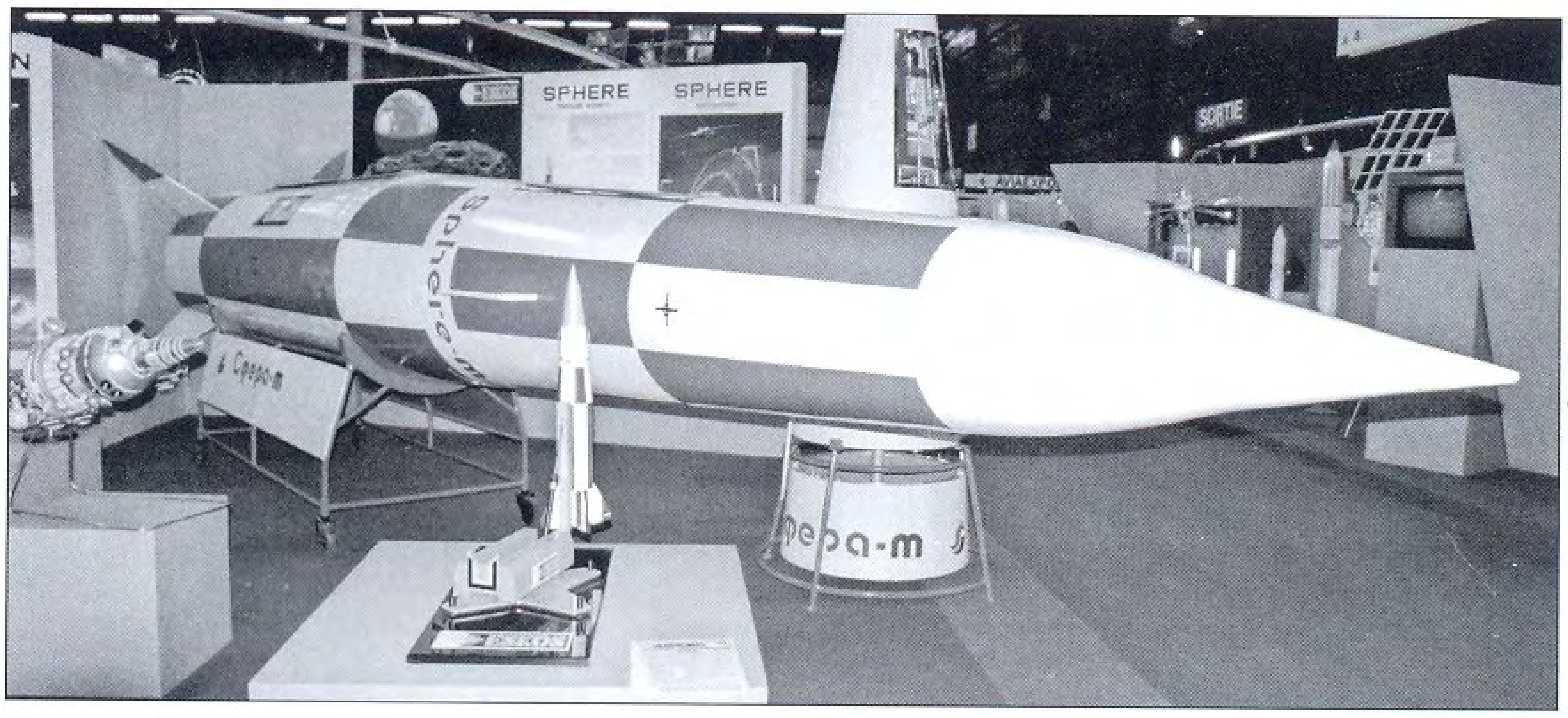
The 9P71 TEL of the Oka system carried a single 9M714 solid-fuel missile, and this example from the Slovak 5th Missile Regiment near Martin is seen in launch position at its garrison prior to its demilitarization. (Miroslav Gyurosi)

The 9T230 transloader is used to re-supply the 9P71 Oka TEL. It closely resembles the 9P71 TEL, since they are both based on the same BAZ-6950 Osnova heavy-truck chassis. The transloader can be distinguished from the launcher vehicle by the canvas tarp over the rear bed of the vehicle. (Miroslav Gyurosi)

launched 1,554 of the approximately 1,700 Scud missiles it had received. On April 24, 1992, the Mujahidin forces of Ahmad Shah Massoud captured the Afshur military base along with most of the remaining stockpile of about 50 missiles and the surviving 9P117 TELs. Other Mujahidin factions captured a few TELs and missiles, but there was considerable difficulty actually launching the missiles without help from the small number of trained Afghan veterans of the 99th Missile Brigade. During the period of civil war from April 1991 to the Taliban offensive against Kabul in the spring of 1996, about 44 Scud missiles were fired in various battles. By this time, the 9P117 launchers and R-17E missiles were scattered among factions, and the Taliban managed to capture part of the stockpile during the fighting in the late 1990s. However, only about five Scud missiles were fired after the summer of 1996 owing to the poor technical state of the equipment and the lack of trained personnel. US forces policed surviving Scud launchers and missiles after the military operations there in 2001, and the last four functional launchers were dismantled in the Panshir Valley in January 2005.

SCUD PROLIFERATION: NORTH KOREA

Production of the Scud halted in the Soviet Union in the 1980s with the advent of the new Oka system. However, there was growing interest in the Scud in the developing world, particularly after the Iran–Iraq War of the Cities showed that ballistic missiles could affect the outcome of regional wars. North Korea had been interested in fielding tactical ballistic missiles, but its indigenous programs failed. The Soviet Union refused to supply it with the Scud, so Pyongyang came to an agreement with Egypt to transfer a few missiles and launchers to establish a rogue production line. The copy of the R-17E missiles was called the Hwasong 5, and the first series of five test launches were conducted from the Musudan-ni proving ground in April–September 1984. Iranian interest in a supply of Scuds for its two Libyan TELs provided further financial backing for the effort. Full-scale production of the Hwasong 5 began in 1986 at the 125th Machine Factory in Pyongyang, and missiles were later sold to Iran and the United Arab Emirates. With production under way, the improved Hwasong 6 was



The intermediate step between the Oka and the Iskander was the Sfera, a civilian space booster version of the cancelled Oka-U missile. It was displayed at international air shows in the mid-1990s in the hope of drumming up money to keep the missile program alive. (Author)

developed, which used a lightened warhead, improved airframe, and modified guidance system, increasing the missile's range from 330km to 500km. Test launches of the Hwasong 6, sometimes called Scud C, began in June 1990 and full-scale production was under way in 1990–91. North Korea also began an effort to build new launchers for the Hwasong at the Sungni automotive plant, including direct copies of the 9P117 using imported MAZ-543 trucks, modified TELs using other heavy trucks, and mobile erector launchers using large flat-bed semi-trailers instead of trucks. Western intelligence agencies estimate that North Korea manufactured 600–1,000 missiles from 1985 to 2000, of which about 300–350 were exported to Egypt, Iran, Libya, Syria, and the UAE. The Hwasong program had important repercussions in worldwide proliferation of tactical ballistic missiles, since the economic problems in Korea encouraged the government to export missile technology as well as the actual weapons. North Korea became involved in cooperative missile development programs with Egypt, Iran, and Pakistan, with some of these efforts continuing today.

Although not a Scud copy, it is worth noting that North Korea scaled up the Hwasong 6 to create a larger missile, known by its Western intelligence designators as No-Dong or Scud D. While resembling the Scud, the missile is about 50 percent larger, has a range of 1,500km, and requires a larger launcher system. Foreign derivatives of the No-Dong include the Iranian Shahib 3 and Pakistani Ghauri/Hatf 5 missiles, a reminder of North Korea's key role in ballistic missile proliferation over

The Iskander/Tender ballistic missile system was first unveiled to the public in the summer of 2000 at the Urals Arms Exhibition near Nizhni Tagil. As can be seen, the 9P78-1 TEL carries two missiles and the associated launch rail. (Author) the past decade. China was also lured into the Scud market owing to international demand, and developed several Scud analogs such as the M-11 missile. These are not Scud copies, but they are a similar size with a launcher patterned after the 9P117.

This rear view of the 9P78-1 TEL of the Iskander system shows one of its solid-fuel ballistic missiles in the erected launch position. (Author)

SCUD REPLACEMENTS

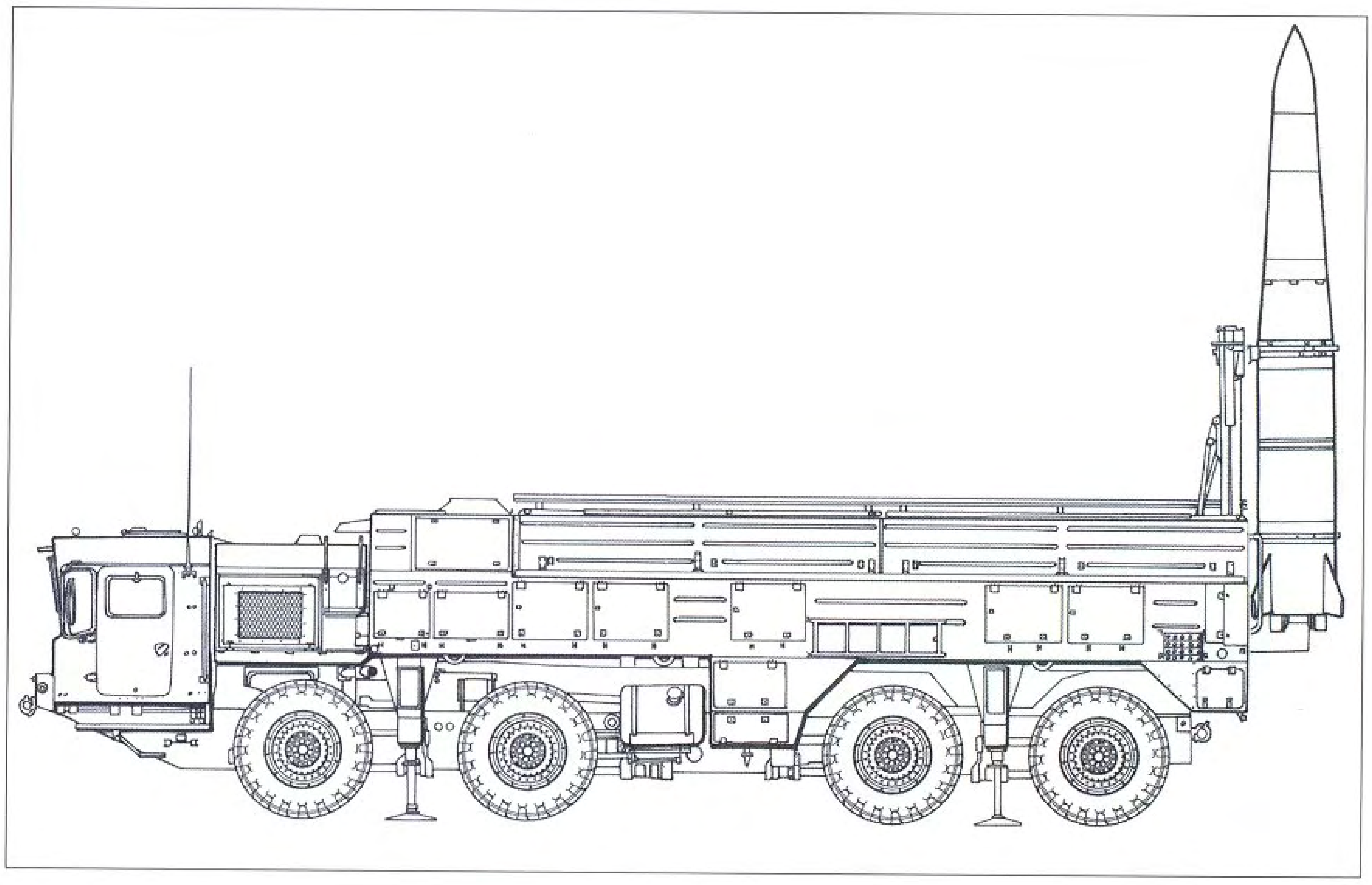
The Soviet Army began to develop a replacement for the Scud system in the mid-1960s. The main problems with the 8K72 Elbrus were its very slow reaction time, dangerous fuel, and poor accuracy. Starting with the Rota and Uran design concepts in 1965–71, the program transitioned to engineering development in 1972. Development took place at the Machine Industry Design Bureau (KBM) in Kolomna, since by this time the Makeyev bureau concentrated on strategic submarine-launched missiles. The new missile system received its codename, Oka, after a local river.

The 9K714 Oka system was designed around the new 9M714 solid-fuel missile, which could be quickly loaded and fired using a much smaller crew and fewer support vehicles. The Oka system had a reaction time of less than 30 minutes compared to a reaction time of about 90 minutes for the Scud. The Oka was accepted for service in 1980 and missile production was undertaken at the same Votkinsk plant as the Scud missile. The 9P71 TEL was built on the BAZ-6944 Osnova 8x8 truck chassis and the missile was fully enclosed during travel. A total of 450 Oka missiles and about 130 9P71 launchers was manufactured and used to re-equip seven Scud brigades by 1987. Sixteen 9P71 TEL and 70 Oka missiles were exported to Warsaw Pact countries beginning in 1985, including Germany (four), Bulgaria (eight), and Czechoslovakia (four). The Oka is known as the SS-23 Spider under the US/NATO designation system.

The Oka was short-lived owing to the Intermediate Nuclear Forces Treaty signed between the US and USSR in 1987. The US argued that the Oka was capable of ranges over 500km, bringing it under the INF

Unlike the 9P117 used with the Scud, the new 9P78-1 TEL used with the Iskander/Tender fully encloses the missile during transit, as seen here on this Russian vehicle at the Staratel artillery proving ground near Nizhni Tagil. (Author)

Scale plan of 9P78-1 transporter-erector launcher. (Author)



limitations. The Soviet delegation adamantly denied this, claiming a range of 400km. The Gorbachev administration finally decided to give in to the US demand, though this created a furor in the Soviet Army and amongst Russian military industrial leaders. This led to the destruction of all 106 Soviet 9P71 launcher vehicles and the remaining 239 9M714 combat missiles by 1989. The Oka launchers in the former Warsaw Pact countries were gradually eliminated following US pressure, with Bulgaria finally agreeing to demilitarize its launchers in December 2001.

A follow-on Oka-U program started in 1984 as a "reconnaissance-strike complex" like the US army's Assault Breaker. The system was intended to include both a weapon system and an integrated airborne intelligence gathering system based on the Myasishchev M-55 (Mystic-B) aircraft. The Oka-U was ready for trials in 1989 but fell into limbo following the collapse of the Soviet Union in 1991. The KBM design bureau tried to keep the program alive by offering a civilian space launcher based on the Oka-U, dubbed Sfera (Sphere). The missile program was gradually resuscitated in the mid-1990s, but to separate it from the banned Oka, it was renamed. The Russian Army's 400km-range version was designated as Tender, while an export version compliant with the Missile Technology Control Regime's 250km-range limit was dubbed Iskander, the Middle East version of the name of Alexander the Great.

The first test flight of the missile was conducted on October 25, 1995 using the 9P78 TEL derived from the 9P71 used with the Oka system. This single-rail TEL prototype was subsequently replaced by a substantially redesigned 9P78-1 TEL on the MAZ-7930 Astrolog heavy truck chassis, which enables two missiles to be carried and launched. A series of over a dozen test launches of the Iskander were conducted at Kapustin Yar from 1995 to 2000 and the development program was completed in the autumn of 2001. A shortage of funds delayed service entry, with the first production funding for a Tender brigade included in the 2005 Russian Army budget. Iskander has been widely promoted at Russian arms shows, and so could very well become the Scud's successor around the globe in years to come. It is known as the SS-26 Stone by NATO.

FURTHER READING

In spite of the widespread coverage of the Scud in the press following its use in recent conflicts, there have been no full-length accounts of its development and use even in Russian. This account has been pieced together from a wide range of sources including Russian design bureau histories, Scud technical manuals, intelligence reports, and many published accounts. On the use of Scud by various armies in the developing world, the articles by Joseph Bermudez in *Jane's Intelligence Review* and elsewhere are particularly useful.

Abd al-Razzaq al-Ayyubi, *Forty-Three Missiles on the Zionist Entity* (Baghdad: 1998). Originally published as a nine-part serial in Amman Arab al-Yawm, an English translation was done by the US government of this account of Scud operations by the commander of the Iraqi missile corps in the 1991 Gulf War.

Popov, N.S., *Bez tain i sekretov* (St Petersburg: 1995). This history of the Kirov plant provides one of the few histories of the development of the Scud tracked launchers.

Semenov, Yu. P., *Raketno-kosmicheskaya korporatsiya Energiya im. S. P. Koroleva 1946–1996* (Moscow: 1996). This anniversary history of OKB-1 provides a good overview of early Scud history, especially the R-11.

Velichkov, I.I., *Ballisticheskie rakety podvodnikh lodok Rossii* (Miass: 1997). This collection of essays on the history of the Makeyev design bureau covers the history of the R-11FM and the early evolution of the R-17 missile.

Vinokurov, V.P., *Avtomobilnye bazovye shassi agregatov raketnikh kompleksov* (Moscow: 1998). This handbook provides technical details of the truck chassis used in Russian mobile missile systems.

Stranger in a strange land. This 9P117M TEL is seen here in Roswell, New Mexico, in April 1994 during the Operation Roving Sands exercise. The US armed forces have operated a number of 9P117 TELs for training and testing purposes since the early 1990s, obtained mainly from former Warsaw Pact forces such as East Germany. (US DOD)

COLOR PLATE COMMENTARY

This East German 9P117M TEL is seen on parade in Berlin in the 1980s, one of two German Scud brigades with a total of 24 9P117Ms. (US DOD)

A1: 8U218 LAUNCH VEHICLE, SELBSTANDIGE ARTILLERIE BRIGADE 2, EAST GERMAN NATIONAL PEOPLE'S ARMY, STALLBERG, EAST GERMANY, 1970

The sABr-2 (Self-propelled Artillery Brigade 2), formed in September 1962, was the forerunner of the later Raketen Brigade 5 "Bruno Leuschner" in Military District 5, near Demen, and the Raketen Brigade 3 "Otto Schwab" in Military District 3, near Tautenhain. Although the 8U218 was delivered in the original Soviet dark olive green, the German NVA (National People's Army) eventually repainted most of its armored vehicles in its own shade of green (Olivgrun 2425) which was somewhat lighter and grayer than used elsewhere in the Warsaw Pact. The national insignia was carried on the side doors in the usual black/yellow/red colors.

A2: 8U218 LAUNCH VEHICLE, 18 ABROT, POLISH PEOPLE'S ARMY, BOLESLAWIEC, POLAND, 1965

The 18 ABROT (*Armijne Brygada Rakiet Operacyno-Taktycznych*: Army Operational-Tactical Missile Brigade) was formed in Boleslawiec in 1962 and first conducted live-fire exercises at the Soviet Kapustin Yar missile range in 1963. Polish armored vehicles were painted in a dark green (*ciemnozielony*) that was essentially similar to Soviet dark olive green. The national insignia was the white Piast eagle, as seen here, until the 1970s when the red and white diamond checkerboard (*szachownica*) similar to that used on aircraft was standardized. Markings on the vehicle tended to be plain, as the units were relatively small and so did not have a need for extensive tactical insignia.

B: PROJECT 611AV (ZULU V) BALLISTIC MISSILE SUBMARINE, SOVIET NORTHERN FLEET, 1959

A total of seven Project 611AV missile submarines was deployed with the R-11FM missile, of which four were usually deployed with the Northern Fleet and two with the Pacific Fleet. These submarines were finished in the usual fashion with pale gray upper surfaces and dark green antifouling paint below the waterline. The three-digit tactical number was in white and was periodically changed to confuse Western intelligence agencies. The R-11FM was delivered in one of two color schemes: the standard olive green scheme seen also on army R-11M missiles, and an overall white scheme.

C: THE SCUD MISSILE AND ITS SUCCESSORS 1959–99
C1: R-11M (SS-1b Scud A)
C2: R-17 (SS-1c Scud B)
C3: R-17VTO Aerofon
C4: Al-Hussein
C5: 9M714 Oka (SS-23 Spider)
C6: Iskander/Tender (SS-26 Stone)

Soviet tactical missiles are painted in the same overall olive green as tanks and other ground forces equipment. In the 1960s and 1970s, the missiles generally used white markings, as seen here. The white bands on the missile fuselage are used to line up the missile on the transport trailer on the erector on the TEL. Missile access panels are usually numbered to prevent confusion. Likewise, the fins are numbered to ensure a proper orientation of the missile during launch preparations. The fin numbering is in Roman numeral fashion (I to VIII). The tip of standard Scud missiles is a pale tan color, since it is unpainted dielectric material. In the 1980s, with the introduction of the Oka system, the markings became more muted, with black substituting for white. The Iraqi Al-Hussein missiles were generally repainted in a pale sand color instead of the usual Soviet dark olive green, a scheme also used on some R-17E export missiles.

ABOVE **Another view of an East German 9P117M TEL from the initial production series with the two portholes on the center-right pumping cabin. (US DOD)**

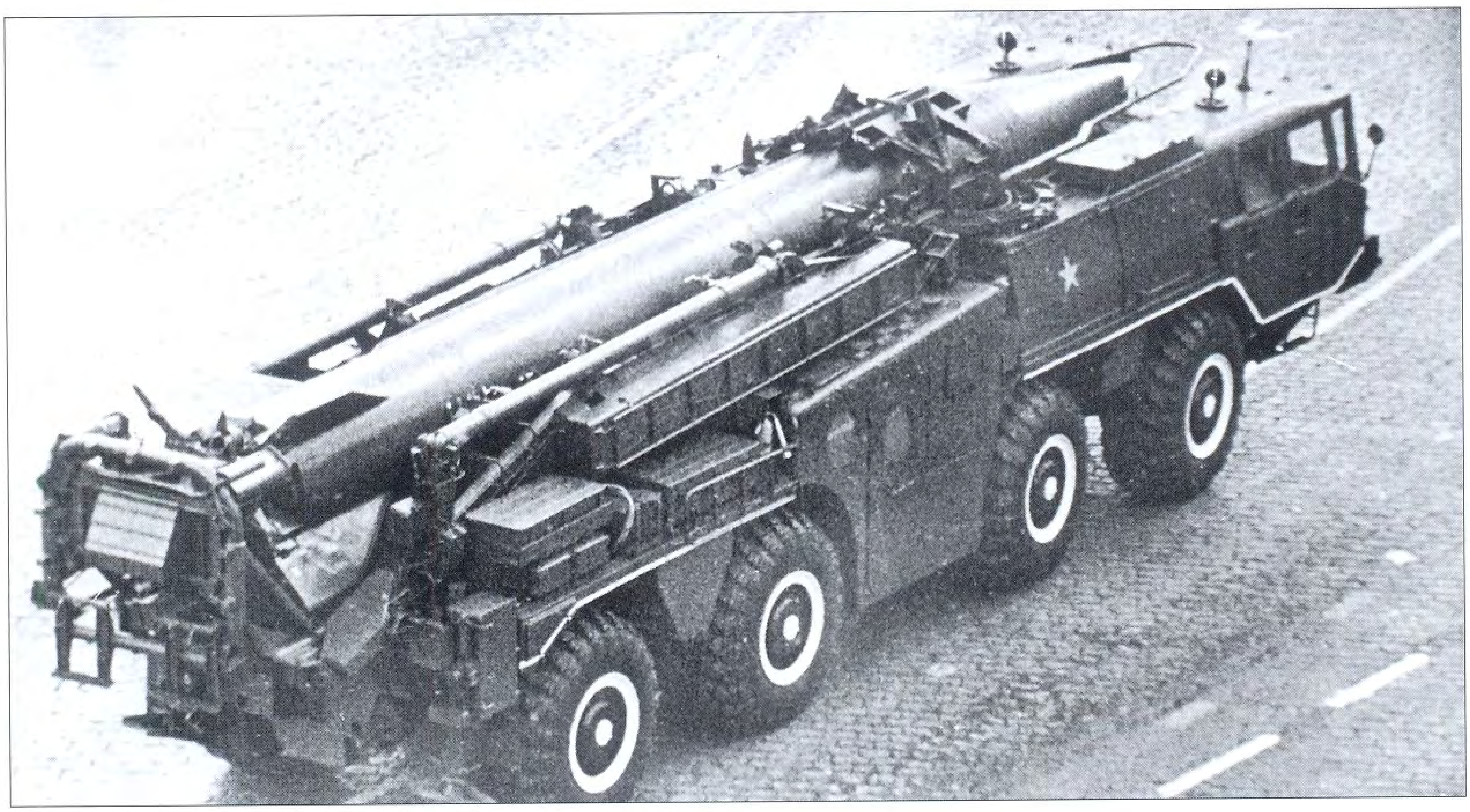
BELOW **The initial version of the 9P117 TEL had a heavier erector assembly than the subsequent 9P117M series with self-loading features. This feature is evident in the large hydraulic actuators and box structure on the erector side seen in this overhead view. (US DOD)**

D: 9K72 OPERATIONAL-TACTICAL MISSILE SYSTEM (SS-1C SCUD B), 1975

See plate for full details.

E: 9K73 HELICOPTER SCUD SYSTEM, 1970

The 9K73 was a lightweight version of the Elbrus missile system, designed to be portable on the modified Mil Mi-6RVK heavy-lift helicopter. The new launcher-erector was mounted on a simple trailer to reduce weight, and is finished in the standard Soviet dark olive green. The Mi-6 helicopter seen in the background is in its typical pale gray camouflage colors.



Another characteristic of the initial production series of the 9P117 TEL was the presence of three portholes on the computation cabin in the center of the vehicle between the middle wheels. This overhead view also shows the reinforced erector assembly with its prominent hydraulic actuators. (US DOD)

F1: 9K72 ELBRUS (SS-1C SCUD B), 181ST OPERATIONAL-TACTICAL MISSILE BRIGADE, 1ST GUARDS TANK ARMY, WESTERN GROUP OF FORCES, EAST GERMANY, 1975

The 9P117M1 TEL was finished in the usual fashion for Soviet Army tactical vehicles, with olive-green camouflage paint on the body and semi-gloss black on the lower chassis frame. Brigades attached to Guards armies were occasionally painted with the Guards insignia, as seen here, especially during parades.

F2: 9K72 ELBRUS (SS-1C SCUD B), 5TH MISSILE BRIGADE "BRUNO LEUSCHNER," EAST GERMAN ARMY, 1990

In the late 1980s, the East German Army adopted a new three tone camouflage scheme that added patches of *Schwarz-grau* 2402 (black-gray) and *Dammergrau* 2403 (medium-gray) over the usual *Olivgrun* 2425 (olive-green) camouflage color.

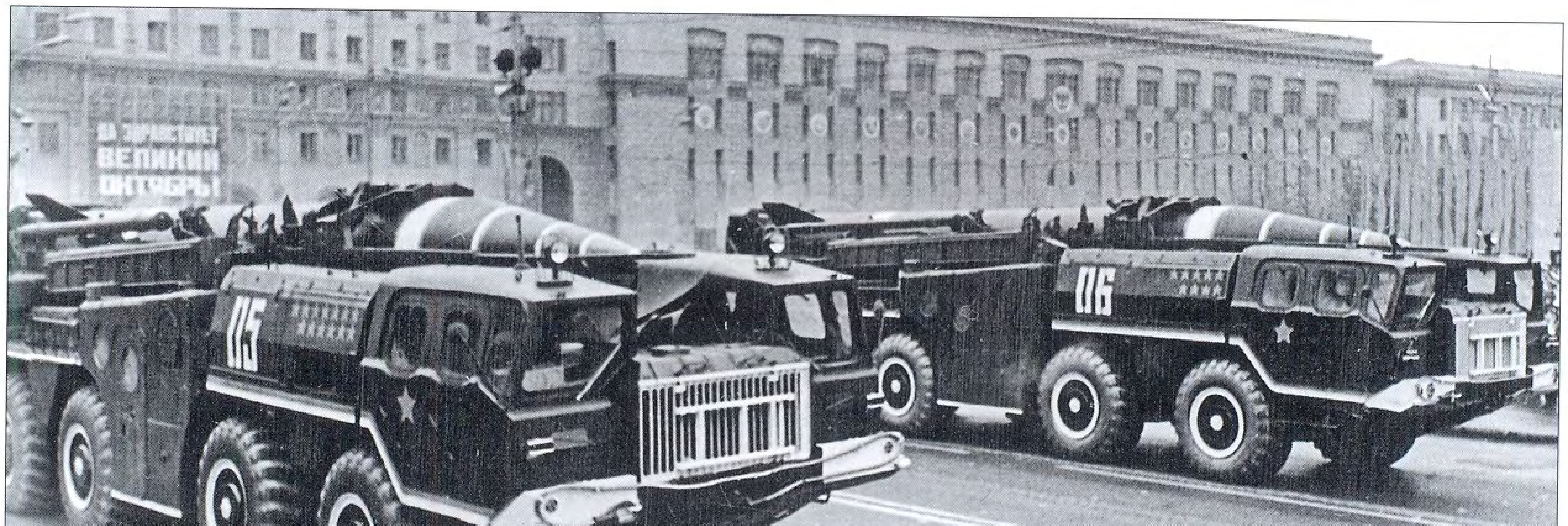
G1: 9K72E ELBRUS-E (SS-1C SCUD B), LIBYAN ARMY MISSILE BRIGADE, TRIPOLI, 1975

When delivered to Libya, starting in the late 1970s, the 9P117M TELs were finished in an overall pale sand color as were the missiles. Libyan units in some cases camouflage-painted the TELs with various colors, including the pattern seen here of dark green over the pale sand finish. The wheel hubs were in semi-gloss black, but the Libyans have added a white trim for a parade in Tripoli.

G2: 9K72E ELBRUS-E (SS-1C SCUD B), ISLAMIC REVOLUTIONARY GUARDS CORPS, IRAN, 1985

When Iran began receiving 9P117M TELs from Libya, they were finished in the usual Libyan schemes of pale sand, sometimes with blotches of spray-painted camouflage including pale brown. At least a few of the TELs were later repainted in this darker scheme, consisting of overall medium gray with brown and black blotches. The white wheel rims are a parade marking.

The final production batch of the original 9P117 TEL had vents added to the battery box over the front right-side wheel. These 9P117 are gaudily marked for one of the annual October Revolution parades.



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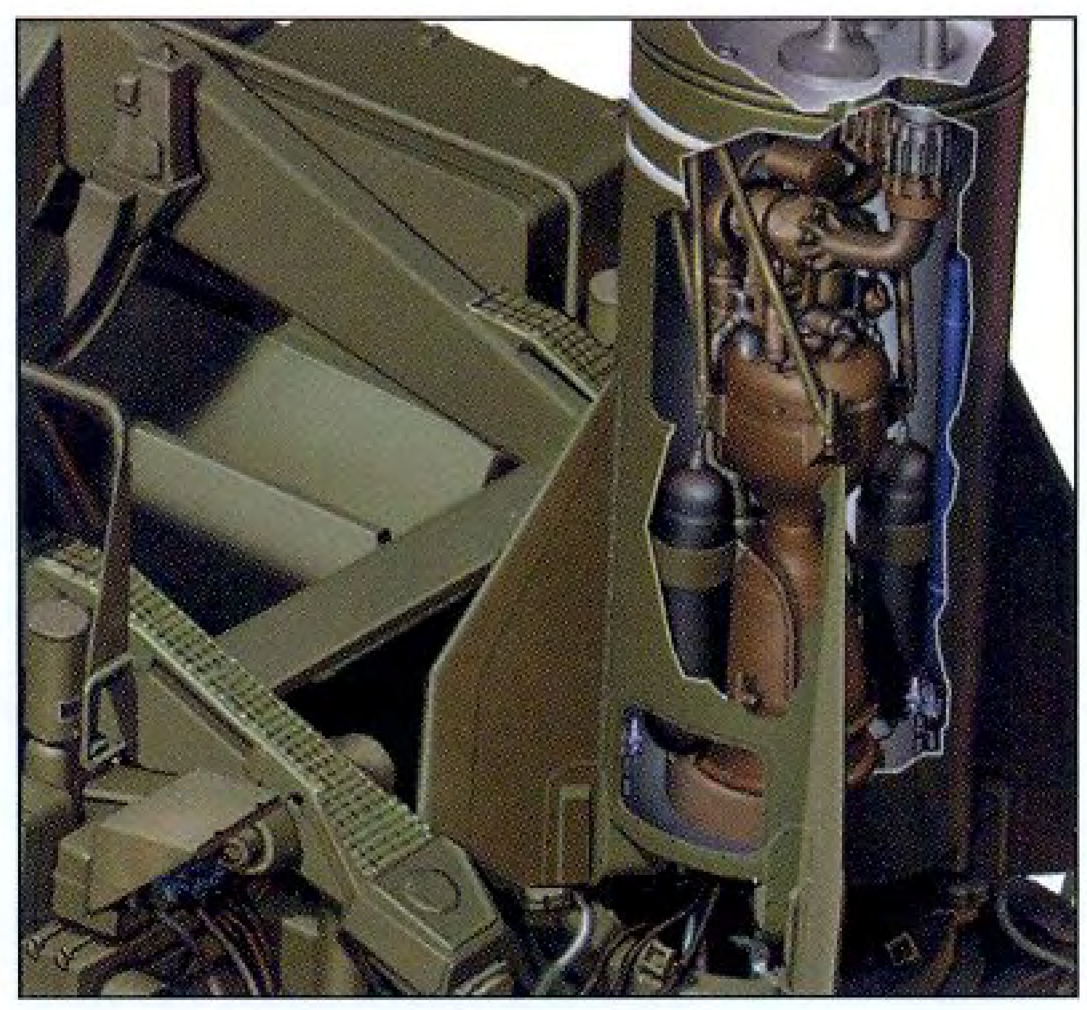

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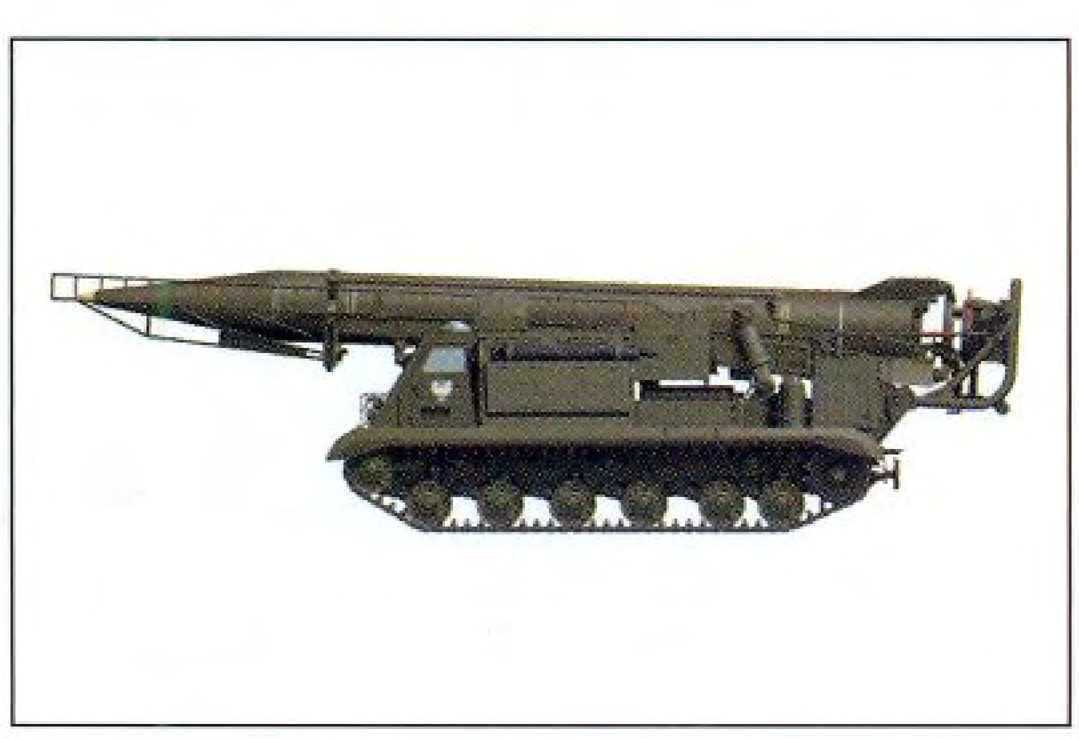

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