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NATIONAL SECURITY AGENCY
CENTRAL SECURITY SERVICE
FORT GEORGE G. MEADE, MARYLAND 20755-6000

Serial: MDR-85687
30 May 2017

Mr. John Greenewald
[redacted]

Dear Mr. Greenewald:

This responds to your request of 11 October 2016 to have "The Soviet Land-Based Ballistic Missile Program, 1945-1972: An Historical Overview dated 1973" reviewed for declassification. The material has been reviewed under the Mandatory Declassification Review (MDR) requirements of Executive Order (E.O.) 13526 and is enclosed. We have determined that some of the information in the material requires protection from public disclosure.

Some portions redacted from the documents were found to be currently and properly classified in accordance with E.O. 13526. The information denied meets the criteria for classification as set forth in Section 1.4 subparagraph (c) and remains classified TOP SECRET as provided in Section 1.2 of E.O. 13526.

Additionally, Section 3.5 (c) of E.O. 13526, allows for the protection afforded to information under the provisions of law. Therefore, the names of NSA/CSS employees and information that would reveal NSA/CSS functions and activities have been protected in accordance with Section 6, Public Law 86-36 (50 U.S. Code 3605, formerly 50 U.S. Code 402 note). The withheld information is exempt from automatic declassification in accordance with Section 3.3(b)(3) of the Executive Order.

Since your request for declassification has been partially denied you are hereby advised of this Agency's appeal procedures. Any person denied access to information may file an appeal to the NSA/CSS MDR Appeal Authority. The appeal must be postmarked no later than 60 calendar days after the date of the denial letter. The appeal shall be in writing addressed to the NSA/CSS MDR Appeal Authority (P133), National Security Agency, 9800 Savage Road, STE 6881, Fort George G. Meade, MD 20755-6881. The appeal shall reference the initial denial of access and shall contain, in sufficient detail and particularity, the grounds upon which the requester believes the release of information is required. The NSA/CSS MDR Appeal Authority will endeavor to respond to the appeal within 60 working days after receipt of the appeal.

Sincerely,

Blake C. B

BLAKE C. BARNES
Chief
Declassification Services

Encl:
a/s

Sep 77

TOP SECRET [redacted]

UNITED STATES CRYPTOLOGIC HISTORY

Special Series
Number —

# THE SOVIET LAND-BASED BALLISTIC MISSILE PROGRAM

1945-1972

An Historical Overview

PL 86-36/50 USC 3605

[redacted] [redacted]

## Foreword

The Soviet missile program has, throughout the years, been a major Sigint target. Ever more sophisticated Sigint collection, processing, analytic, and reporting systems and techniques have evolved to follow this program, calling for the commitment of vast amounts of personnel and material resources. Comint had begun to play a strong role in the development of the target by the early 1950s, and Telint and Elint had begun to play a significant role by the late 1950s, expanding rapidly after that time. Combined, these Sigint sources have accounted for the bulk of the intelligence available the last decade or so concerning developments, capabilities, and systems.

Although the Soviets employ a wide variety of missiles in their offensive and defensive forces with many and varying missions, this history is slanted mainly toward the development of their land-based surface-to-surface ballistic missile programs. To attempt to include all aspects of the over-all Soviet missile program under one cover would delay publication far into the future. Rather, it is considered more advantageous to publish particular segments as they are completed, making them available as soon as possible.

Subjects of other missile-related histories could deal with the Soviet Union's ABM program, its naval missile systems (both offensive and defensive), its defensive surface-to-air and air-to-air missile programs, and the like. Missile programs of other Sigint targets, such as the PRC--and of other major military and civil programs as well (ground forces, air forces, etc.)--could also be subjects of future histories. The editors invite experts in the various fields to consider the preparation of such studies for future issuance in the United States Cryptologic History Special Series.

Cutoff date for information in this history is the end of 1971. On occasion, later data are incorporated when available and pertinent, and where classification permits. Also, expansions of classified collateral source notations are available in E51, the National Cryptologic School Press. They will be made available upon written request which provides necessary justification.

Vincent J. Wilson, Jr.
Chief, Cryptologic History Program

## Summary

Before and during World War II, the Germans had developed a variety of missile systems. At the end of the war, they stood alone in the numbers and complexity of these systems. Some were used during the war with varying degrees of effectiveness; others were evolving when the war ended. Many of these missile systems, and the scientists who had developed them, were acquired by the Soviets after the war, permitting the USSR to quickly establish its own missile program.

At first the Soviets attempted to keep the missile-related facilities intact on German soil, using German scientists to the maximum extent possible while Soviet counterparts were gaining familiarity in a new field. Later, the Germans, and most of the missile-related facilities, were sent to the USSR, where work continued under Soviet control.

The V-2, a German rocket used operationally late in the war, was the system most extensively studied and emulated by the Soviets. It was the first such missile tested in the USSR, inaugurating the opening in 1947 of the Soviet Union's first missile test range at Kapustin Yar. Reflections of its design were seen years later in the evolving Soviet missile program. Other missiles, and missile-related systems and subsystems, also fell into Soviet hands after the war; they too provided the Soviets with technology and hardware that would serve them well in later years.

By 1953, most of the Germans had departed the USSR, and subsequent developments were by and large the result of indigenous Soviet programs--planned, engineered, developed, and produced by Soviet personnel. In 1957, the USSR successfully tested its first ICBM, and by the early 1960s it had available a variety of ballistic missiles, from short-range

ones to those capable of covering intercontinental distances. By this time, three additional major test ranges were operational or evolving, and the Soviets had launched earth satellites into orbit. They had also successfully conducted planetary probes, and they had launched the first man into space.

By the early 1970s, further significant developments had occurred in the Soviet missile effort. By this time, the Soviet Union had a major land-based ballistic missile force in being, capable of achieving ranges up to 7,000 nautical miles or more. Refinements in guidance and control systems saw missile accuracy improve steadily. Yields of nuclear warheads of deployed missiles varied up to 25 megatons. Multiple reentry vehicles, penetration aids, and multiple independently targetable reentry vehicles had evolved or were evolving by this time. Hardened, dispersed silos had come into widespread use, and mobile missile systems, mainly for tactical use, had been deployed in large numbers.

In the early 1970s, tests began of newer-generation missiles, further enhancing the Soviet Union's capabilities in this area. Incorporating refinements in a number of significant areas, these newer missiles, coupled with the older ones, provide the Soviet Union with an effective weapons mix. Thus, from the early German assistance, from technology gleaned from Western sources, and through its own efforts, it can be seen that the USSR progressed steadily throughout the years in the missile field, culminating in its advanced systems of today.

Just as the Soviets were embarking on a new and unfamiliar field in these early years, so did the Sigint establishment find itself faced with a new and unfamiliar problem. Organizations had to be built from nothing; personnel had to be trained; facilities and systems had to be developed; and a fragmented effort had to be streamlined and centralized.

To further complicate the problem, the main interest of the U.S. Comint establishment after World War II concerned communications signals, in particular those transmitted in the HF band and below. Equipment, systems, and facilities were not available to adequately handle telemetry signals from fast-moving missiles propagated in higher frequency bands. Also, no national-level Elint effort existed until 1952. And the Elint of that time was mainly radar-oriented; it had little interest in telemetry signals. Too, NSA did not come into the telemetry picture officially until 1958, and it did not acquire its over-all Sigint responsibility until 1959, some two years after the Soviets had launched their first ICBM.

In attempts to organize the numerous entities trying to exploit early Soviet developments, internal NSA organizations and reorganizations evolved. Collection, processing, and reporting programs were developed that combined the total Sigint effort against the target. Overseas collection facilities were organized, starting with the PREAKNESS and BANKHEAD systems in the late 1950s and early 1960s. Others followed, supplemented when necessary by mobile platforms of various kinds, to form a worldwide collection network.

Assistance was also obtained from a variety of sources outside the Sigint community. Collaborating agencies, the intelligence agencies, other Government agencies, the armed forces, and private contractors have made significant contributions throughout the years to various aspects of NSA's mission in this field. And, as missile- and space-related signals became more and more complex in later years, improved systems and techniques have been developed to keep pace with this sophisticated Sigint target.

EO 3.3b(3)
PL 86-36/50 USC 3605

# Contents

# I. The Early Years (1945-1953)

## The Spoils of War

Near the end of World War II, the Red Army moved into eastern Germany and captured V-1 and V-2 missile sites, rockets, supporting systems, and facilities, and many of the German scientists who had developed these, and other, special weapons systems. With the acquisition of these facilities, the weapons themselves, and the scientists and engineers who developed them, the USSR had quickly acquired the nucleus of its own missile program.

First used against London in June 1944, the V-1 inflicted severe damage and casualties on Great Britain, and particularly London, in the latter part of the war, at the same time significantly curtailing war-time production in the London area. It also posed a serious problem to the Allied invasion of Europe. The Allies found it necessary to place high priorities on countering this threat, diverting aircraft from support of their invading armies to attacks on V-1 sites and supporting facilities. It, and the V-2, were also used effectively against cities and port facilities on the continent after liberation by Allied forces. Antwerp, in particular, suffered severe damage from massive attacks by these missiles.

A cigar-shaped monoplane, the V-1 flew at subsonic speeds, and was designed for cheap and fast production, some even using wooden wings. It could be launched from either ground sites or aircraft. Being subsonic and subject to interception, many fell prey to anti-aircraft guns and intercepting aircraft, though their high speeds taxed capabilities of the interceptors to their limits. Others malfunctioned and crashed. But several thousand of these "buzz bombs" got through to their targets, until Allied armies on the continent forced them back out of range.

The V-2[1] presented a far more serious problem than the V-1. Being a ballistic weapon, it could not be intercepted. Nor could its guidance system be jammed, for it was electronically guided only during ascent. Deployed against Great Britain three months after the V-1 was first used, it caused grave concern among Allied leaders. With a warhead weighing 2,000 pounds, a range approaching 200 miles, speeds in excess of one mile a second, and invulnerability to interception or jamming, it was truly a formidable weapon. It, and the V-1, were aptly name~~s~~d: the "V" stemming from the word *Vergeltungswaffe*, or "reprisal weapon."

When the Soviets captured German test facilities toward the end of the war, their main interest was understandably in the V-2. But they also gained knowledge of a number of other German weapons systems either under development or operational. In addition to the V-1 and V-2, the Soviets captured missiles for air-to-air, air-to-surface, and surface-to-air use.

Two of these, both air-to-surface missiles, had been developed by the Germans in the late 1930s and were used successfully against ships during the war. One, the FX-1400 (called the *Fritz-X*), sank the 35,000-ton Italian battleship *Roma* in 1943. It went down within

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[1] Named *Aggregate 4* (A 4), it was the fourth in a series of tests of this type of missile begun in Germany in the early 1930s. During the war, it became known as the V-2, the second in the series of Hitler's "reprisal" weapons.

a half-hour of two direct hits by *Fritz-X* missiles. During the same year, in the Dodecanese Islands campaign in the Aegean Sea, the Germans sank seven Allied destroyers in two days using an air-to-surface missile called the HS-293. Both were captured by the Soviets at the end of the war.

Information about other German research and development projects was also obtained by the USSR, along with some of the equipment. For example, during the war the Germans had developed a submarine-towed barge for launching V-2s. Although never operationally tested, its purpose was the towing of a V-2 in a barge to a predetermined spot for firing. Both the submarine and the barge were to travel to the launching site submerged, and once there, the barge would be floated to the surface and upended, by flooding, into a vertical firing position. Vulnerability of the submarine while towing the barge, the possibility of rough seas disrupting fueling and launch, and design limitations of the V-2, made this concept a risky one at best. But it proved to be the forerunner of Soviet--as well as U.S.--submarine-missile systems of the future, and both countries proved the feasibility of the concept when they launched V-1s from surfaced submarines soon after the war.

Thus, by the end of the war, it is seen that the Germans had made impressive progress in the special weapons area, and in research and development of advanced concepts. This fact was not lost on the Soviets, as it was not on the Allies, and the USSR quickly took advantage of the availability of these men and equipment, even before hostilities had ended. Everything available--men, missiles, supporting systems, associated electronics, factories, and everything else of value--quickly found their way into Soviet hands.

## Soviet Exploitation of World War II Acquisitions

### Initial Efforts in Germany

After the war, the Soviets at first tried to salvage the remainder of Hitler's missile organizations and facilities, and, more or less, to keep them intact on German soil. This approach was first noted in 1945, when they established Institute Rabe in Bleicherode, East Germany. Included in this organization were many of the scientists who had developed the V-weapons, and it was here that the Germans were given the primary task of documenting the V-2 program for the USSR. This effort produced detailed studies on such subjects as stability theory, ballistics and aerodynamics, acceptance specifications, manufacturing directions and procedures, evaluations and applications of test instruments for use in the manufacturing process, and operational deployment and use by military units.

In addition to documenting the V-2 program, the Soviets investigated and exploited other facets of the German war-time missile effort. Sites and factories were carefully studied, some of which were also utilized by the Soviets in a number of missile-related functions, corresponding closely to their missions during the war. One, the Henschel Works, was involved with air-to-surface missiles, such as the previously mentioned HS-293. Another, a former German V-2 repair facility located at Kleinbodungen, was converted into a V-2 assembly area. Still another, at Lehesten, contained test stands for V-2 power units and was used for the same purpose after the war. Another, located at Niedersachenwerfen, contained underground V-1 and V-2 assembly facilities. In addition to the facilities themselves, the Soviets captured assembled V-1s here, and sufficient parts to assemble others. Other V-1s, and V-2s as well, abandoned by the Germans on trains and elsewhere, were also captured intact. The Soviets also acquired the facilities of the German firm Gema Haus, located in Berlin, subsequently renaming it Institute Berlin. It was here that guidance systems for surface-to-air missiles were worked on by the Germans during the war, and after the war under the auspices of the Soviets.

Forced Exodus from Germany to the USSR

In October 1946, some of the German missile specialists departed for the USSR, most against their will. The Germans were told they would be living in the Soviet Union for periods up to five years, but some were to stay at least eight years. With their departure, missile installations and factories were disassembled and shipped to the Soviet Union. This was done despite the fact that the Soviets had carefully organized, repaired, and, in some cases, rebuilt these facilities after the war.

This first group of Germans was referred to as "contract" specialists, because many of them allegedly had signed contracts to work in the USSR for specified periods of time. This was in contrast to another group of highly qualified Germans deported to the USSR in mid-1947. This latter group, which worked on the development of an air-to-surface anti-ship missile, was classified as being in

"POW status"; apparently the Soviets believed them to be a kind of war booty.

The group that arrived in the USSR in 1946, estimated to be about 50 in number, was sent to the Scientific Research Institute (NII) 88, located at Kaliningrad. (A few of the scientists in this group were also sent to such locations as Leningrad, Ilinskaya, Monino, Khimki, and Podlipki.) Those at NII 88 were subsequently organized into four groups. These groups, each with a Soviet chief, were named: (1) the Guidance and Control Group, (2) the Power Plant Group, (3) the Design and Drafting Group, and (4) the *Schmetterling* Group.[2] The man in charge of the Germans as a group was himself a German named Groettrup, whose specialty was high-frequency electronics. He had established a close working relationship with the chief Soviet engineer at NII 88.

The first six months in the USSR were devoted by the Germans to further documenting their war-time programs, a continuation of the studies begun at Bleicherode and other locations in Germany. Again, primary emphasis was placed on the V-2, but other systems were also documented, including, for example, the *Wasserfall* and *Schmetterling* surface-to-air missiles. Although extensively studied and documented, no significant modifications were apparently made to the V-2 during this period, nor previous to its first launch on Soviet soil in October 1947.

Final preparations for these initial tests had begun a month earlier at Kapustin Yar, the first ballistic missile test range in the

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[2]The *Schmetterling* was a German surface-to-air missile.

Soviet Union. Located about 100 kilometers east of Stalingrad (later named Volgograd), Kapustin Yar was used for these and subsequent tests of the V-2s. This initial series was completed by December 1947, during which period 12 missiles were launched. ~~fired~~ [redacted]

The Soviet Union had apparently acquired about 25 V-2s from the Germans. Exactly how many they themselves manufactured later on cannot be precisely determined. But a German specialist named Muennich, who had seen production parts for a pilot series of V-2s at a research facility at Novaya (NII 885), estimated that as many as 100 of these missiles were scheduled for production there. Also, the Soviets apparently manufactured V-2 components to at least 1951. In this regard, the Germans estimated that between 100 and 150 such missiles would be needed to make the transition from the V-2 to an improved version.

By the early 1950s, the Soviets had exploited the Germans to the fullest possible extent, while at the same time satisfying themselves that they could continue the effort on their own, and the Germans began departing the Soviet Union. By 1953, most had returned to Germany; a few remained until at least 1956.

## The Expanding Soviet Ballistic Missile Program

Following World War II, the USSR seemed determined not to make the same mistake the Germans had made early in the war, when, flushed with initial successes, they cancelled or curtailed many of their missile-related developmental programs, because they did not expect a long war. For example, developmental lags of one of these, the *Schmetterling* surface-to-air rocket, cost the Germans dearly in the latter part of the war, and, as many experts later commented, perhaps cost the war itself. Fortunately for the Allies their air supremacy was never seriously challenged by this missile, for the war had ended before full production, programmed for late summer of 1945, could be realized.

Consequently, after the war the USSR set a course that would permit rapid development in the missile area, and, in particular, the earliest possible development of operational ICBMs. They apparently believed that any major post-war threat to the USSR would be primarily from aircraft, rather than from ground attack, and they seemed determined to counter this threat by achieving technological superiority over their chief potential adversary, the United States, through the rapid development of an operational ICBM. U.S. Army Intelligence, aware of Soviet intentions and of their technological capability to accomplish them, speculated that the USSR could indeed accomplish its goal of acquiring operational ICBMs, possibly as early as 1958.

Thus, by the time the Germans departed the Soviet Union, the USSR had developed a highly-significant capability of its own, staffed by competent personnel. Although small in numbers when the Germans first arrived in the Soviet Union, and possessing almost no practical experience, these Soviet scientists and engineers steadily acquired awareness of and knowledge about inherent problems and detail. Overlap with the Germans also afforded them the necessary on-the-job exposure, and, as the Germans themselves later noted, "this group advanced with astonishing rapidity" thereafter.

Also, the Soviets apparently paralleled the work of the Germans with companion efforts of their own in a number of these early missile projects, permitting them to choose later between their own design innovations and those of the Germans. Virtually no information is available on these Soviet projects, because the Germans were isolated from them to the maximum extent possible. But Soviet scientists, who were not directly associated with the Germans on particular projects, frequently questioned them about technical matters in markedly similar areas, leading to suspicions by the Germans that the Soviets were indeed paralleling their efforts. Thus, precisely when, and to what extent, the Soviets themselves developed certain weapons systems in these early years is not always possible to discern. Nor can lines be finely drawn separating Soviet and German involvement in particular projects, independent of or in conjunction with each other.

## The R-10 Project

Following the initial V-2 tests at Kapustin Yar in late 1947, the 50 or so Germans at NII 88 again moved. This time they went to Gorodomlya Island in Lake Selinger, near Ostashkov. Located about midway between Moscow and Leningrad, the Gorodomlya Island facility was known as Branch 1 of NII 88. The island's isolation afforded an excellent location for classified operations. The move to Gorodomlya Island ended direct German involvement at NII 88 at Kaliningrad; apparently the Soviets believed they could continue work there on their own.

By 1948, it is estimated that between 350 and 400 German missile specialists were working in the Soviet Union, a significant increase over the 50 scientists who had first arrived in late 1946. About half of this German work force was located at Branch 1 of NII 88. It was mainly here that the Germans became involved in designing and developing a successor to the V-2—called the R-10—and in other programs that were to follow, the R-11 through R-15.

Though approved by the Soviets in 1948, initial plans for the R-10 Project had been proposed as early as the spring of 1947, months before the V-2 tests were begun at Kapustin Yar. But these plans were rejected as "unsatisfactory," and it was not until early 1948, following a major conference on the subject, that the project was finally approved. Although only five Germans were included at this conference, many Soviet specialists attended, including representatives of the Air Academy and the Central Aerodynamic Research Institute, attesting to the high priorities the Soviets early attached to their missile programs.

The Soviets already had a head start on development of this missile, for the Germans, during the latter part of the war, had done some preliminary research and development at Peenemunde on an improved version of the V-2. Additional work was also conducted at Bleicherode immediately after the war. Points stressed in designing and developing the R-10 were (1) improved accuracy, (2) a less complicated propulsion system, (3) increased range, and (4) cheaper production techniques.

The R-10 project was slow to evolve. Although its design stages had occupied the Germans for most of two years, by 1949 it remained a "paper project." Even by 1951, when direct German involvement in this and other projects ended because of suddenly imposed security restrictions, it was still estimated to be years away from actual deployment. At that time, Dr. Magnus, a top German scientist, estimated that lengthy periods of testing would be required before the missile could be mass-produced and operationally deployed.

Nevertheless, the R-10 project yielded a missile, at least in design, that was much improved over the V-2. It was capable of longer range, of carrying a heavier payload, was lighter, and incorporated a number of other technical refinements that enhanced its over-all performance. Specifically, the R-10 was designed for a range of about 500 statute miles, compared to the approximate 190-mile range of the V-2. The payload was increased slightly (by 150 pounds over the 2,000-pound weight of the payload of the V-2). An over-all weight reduction of 440 pounds was also realized. Though the size of the engine (and of the rocket itself) remained about the same as that of the V-2, significant changes were designed into the engine to enhance its performance and to make it lighter. Other changes and modifications were made to the internal configuration of the rocket, but the exterior, other than being somewhat longer, varied little from its predecessor in shape or design. Also, the Germans were well aware of shortcomings of the V-2's guidance system, and improvements to it were planned to enhance the accuracy of the one to be used for the R-10. But the fuel proposed for use in the R-10 remained the same as that of the V-2, liquid oxygen and alcohol.

Some tests of the R-10's guidance system were apparently made on the ground and with aircraft, and static tests of its booster engine were also probably conducted. As far as can be determined, however, the over-all system was not tested; nor did the R-10 project apparently progress beyond the "work project" phase.[3] But this missile, and the others that evolved in this time period, provided a foundation upon which future Soviet programs could be based. Certain design aspects of the R-10, for example, and of a companion project believed conducted by the Soviets, were incorporated into what became known as the *Korolev* short-range rocket (the SS-2).[4] Statements by Korolev, at a conference in Moscow early in 1950, corroborated this belief, when he noted that some design features of the R-10, including warhead separation, were in fact used in the *Korolev* rocket.[5] Another Soviet

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[3]Stages in these missile-design projects were clearly defined and labeled. They were designated as preliminary, sketch, and work projects. The preliminary project required a brief report, outlining the over-all project in general terms and describing what it was expected to accomplish. The sketch, or intermediate, project, usually evolved into a study of several hundred pages and called for fairly specific descriptions and drawings of the over-all missile configuration, showing, in considerable detail, component parts and their applications to the over-all system. The work project stage called for detailed descriptions and drawings of the entire system. It was to be in sufficient detail to permit factories to build components parts and assemble the missile in its final form.

[4]"SS" designators are assigned by U.S. authorities to identify Soviet surface-to-surface ballistic missiles. For reference purposes within NATO, they are identified by nicknames--e.g., *Shyster* (SS-3); *Sandal* (SS-4); etc.

[5]Sergej Pavlovich Korolev, born in January 1907, was long involved in aircraft design. A pioneer in Soviet rocket technology, he was often referred to as the "chief designer of space ships." Previous to his death in 1966, Korolev was head of NII 88 and director of the Central Design Bureau for Space and Intercontinental Rockets.

rocket, the SS-4, also incorporated technical innovations developed by the Germans during their involvement in the R-10 project.

## The R-11, R-12, R-13 Projects

None of these missile projects apparently progressed beyond intermediate developmental stages, and little is known about their design. It is believed, though, that the R-11 project was conducted mainly by the Soviets, as a parallel project of the R-10. Certain of its design innovations, along with some of the R-10, were probably incorporated into the R-14 project, and into the *Korolev* rocket as well.

The R-12 apparently served as a test bed, incorporating a number of designs and innovations and producing a number of widely differing variations. Some of the more promising of these were subsequently employed in designing follow-on missiles, and in particular the R-14. But the R-12 project itself, as noted above, did not progress beyond the intermediate stage and did not, therefore, yield an operational missile.

The R-13 was apparently the responsibility of the Germans. It too did not progress beyond the intermediate stage of development, and as such did not result in an operational missile. But, as in the case of the other two projects, certain of its concepts were used in subsequent Soviet missile projects.

Each of these missile projects had sub-projects--the R-11a and R-11b, for example--and, as noted previously, they produced a number of design concepts that would be used by the Soviets in later missile projects. For example, movable exhaust nozzles were designed to enhance steering, and multi-stage operation was incorporated into the design of at least one, the R-12, and possibly into another as well--the R-13.

Although these projects did not directly result in weapons systems, they nevertheless did provide a foundation upon which the Soviet Union could base future missile programs. Many troublesome technical problems had been extensively studied, and, to a significant degree, overcome, at least on paper. Also, these efforts afforded the Soviet scientists and technicians the initial experience they sorely needed in the early years of involvement in an unfamiliar field.

## The R-14 Project

Before direct German involvement in specific projects ended in 1951, they had worked on the design of two other Soviet surface-to-surface missile systems--the R-14 and R-15. The first of these, the R-14, was described in one report as a "scaled-up version of the *Korolev* project/R-10 endeavors." It was designed as a single-stage rocket, 77 feet in length and 12.5 feet in diameter at its base. With a range of 1,600 nautical miles, its payload was initially designed to weigh 6,600 pounds, but was later reduced by 30 percent, according to the Germans.

But the R-14 project was marked by haste, and, as far as the Germans were aware, did not progress beyond the work project phase. Work began about mid-1949, and concluded with completion of the work phase in the spring of 1950. Thus, as was the case with the R-10, research and development through the work project phase had been completed on paper, but actual production of the R-14 apparently did not materialize.

In levying the requirement for the R-14 in mid-19~~6~~49, Ustinov[6] stated only that the missile would have "a range of 1,600 nautical miles and a 6,600-pound warhead." The R-14 was apparently seen as a means of bridging the gap between short-range missiles (of the R-10 and R-11 types) and the longer-range missiles that were to follow.

Short deadlines placed on development of this missile by Ustinov (he directed that work on it be "started immediately") resulted in its progressing through the work project phase in record time. The preliminary phase was completed in one month, the intermediate stage in less than three months, and the work project phase in less than six months. But the haste that accompanied development of the R-14 project was probably a major factor in precluding its becoming a satisfactory missile system.

As was the case of other developments in these early years, the R-14 project yielded innovations that the Soviets would use in developing later missile systems. The R-14, for example, was to be designed so that it could be "launched in underground shafts 32 feet in diameter and 95-ft to 130-ft deep." This proposal represented the beginning of the USSR's missile-silo programs of the future. It was also proposed that a circular railway, with a radius of over 14 miles, be built

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[6] Dmitri F. Ustinov, appointed the Soviet Minister of Defense on 29 April 1976, held various positions in industry before World War II. During the war he supervised tank production as Stalin's Commissar of Armaments. Since then he has been totally involved with the defense sector, holding the posts of Minister of Defense Industry and Deputy Chairman of the USSR Council of Ministers. In these capacities he became deeply involved in missile research, assuming administrative control of the entire missile-development program in the postwar years.

around the launch site, enhancing target selection by permitting the ground-guidance system to be moved in a circle around the launch site.

Other techniques and subsystems were also unique to this missile, or represented refinements of those begun in earlier missile projects. The engine of the R-14, for example, was designed to tilt up to ± 5 degrees, and, when static tested in 1951, combustion was found to be unaffected by this process. The tilting of the engine enhanced over-all control and guidance of the rocket. Calculations of final engine cutoff were computed more precisely for this missile (measured in milliseconds), permitting a more precise trajectory. Techniques were also devised to gradually shut down the engine's thrust in the final stages of ascent, further enhancing control of the rocket. Fuel for the R-14 was to be kerosene, a departure from the alcohol-fueled V-2 and R-10 rockets. A regulator, controlling fuel mixture and flow, was designed for this missile, and actually tested on a V-2 in 1951.

Other techniques and subsystem refinements were explored by the Germans and Soviets in their work on this missile, and many of these innovations were employed in the development of missiles in later years. One in particular, the SS-5 (NATO nickname *Skean*), probably incorporated many of the techniques developed for the R-14. (The SS-5, a highly successful intermediate-range missile, was first flight tested in June 1960, and was one of the missiles involved in the Cuban missile crisis of 1962.) But the R-14 project, as noted previously, did not itself produce an operational weapons system.

The R-15 Project

The last Soviet surface-to-surface missile project in which the Germans were involved was the R-15. Despite much work on the part of the Germans in designing this missile (which was said to be a project initiated and vigorously supported by Stalin himself), it reached only the intermediate stage of development.

Labeled a "cruise" missile, the R-15 was designed to combine both the V-1 and V-2 into one system, with a V-2 boosting a V-1 to an altitude of 12 4 to 18 4 miles, where the V-1 would be launched toward the target. The range was planned to be over 3,700 statute miles (though one report placed it as high as 5,400 nautical miles), with a speed of 1,300 miles an hour and a warhead weighing three tons. An improved Soviet-designed version of the V-2 power unit was to be used as the booster, developing a thrust of 70,000 pounds. Another innovation, whereby the wings and warhead of the V-1 would separate during the final approach toward the target, was also proposed for the system. But the Germans doubted the practicality of the missile from the beginning, and a calculation that over-all accuracy would be no better than ± 12 to 24 statute miles at maximum range, apparently forced cancellation of the project at an early stage of development.

Other Early Soviet Missile Programs

Concurrent with their involvement in the ballistic missile field in the post-war years, the Germans worked on a number of other Soviet missile-related projects, including surface-to-air missile systems, air-to-surface anti-ship missile systems, and refinements to a German telemetry system developed during the war.

The Komet Project

One of these, called the *Komet* by the Germans, was designed solely as an air-to-surface anti-ship missile. It was probably based upon the wartime V-1 design and on the *Bat*, the U.S. Navy's "flying bomb" of World War II fame. Work on development of this missile was done at Leningrad, and some tests of it were believed conducted as early as 1948, and, according to one report, perhaps as early as late-1947.

A group of highly qualified Germans were "selected" to work on this project, and they were deported to the USSR under "POW status" about mid-1947. The Soviets apparently attached high priorities to the development of this missile, evidenced by the strong interest shown in it by high-ranking government and military leaders. Bulganin and Beria, for example, monitored its progress closely, as did senior navy and air force officers.

The Germans worked on five prototypes of the *Komet*, designated *Komet I* through *V*. Its size was described as 25- to-30 feet in length and 3- to-4 feet in diameter. The missile was to be carried by aircraft to within 80 nautical miles of the target, where it would be launched toward the objective. Initially controlled by the aircraft by radio beam-riding techniques, the missile would switch to radar control when within 10- to 15-miles of the target.

Two basic *Komet* designs apparently evolved from these periods of testing; one yielding missiles of "medium" speed, another of "fast" (though subsonic) speed. Tests of the former design were begun in the autumn of 1950, and were proclaimed a success; the faster version was probably first tested in the summer of 1952.

German involvement in this project also ended in 1951, when the Soviets suddenly imposed rigid security restrictions upon them, but the USSR continued to place emphasis on development of this type of missile in subsequent years. One report, for example, described the *Komet* as representing "a point of departure from which greater Soviet weapons could be developed."

The *Schmetterling* Project

Work on the *Schmetterling* surface-to-air missile was begun by the Germans in the late-1930s, continuing with varying degrees of urgency throughout the war. Designated the HS-117 by the Germans, the *Schmetterling* was designed as a "remote-controlled anti-aircraft rocket."

After the war, the Soviets showed strong interest in this missile, and quickly set about reconstructing as many as possible from war booty, though apparently making no significant modifications to it. Some of the guidance and control equipment for this missile was also acquired by the Soviets from "Test Bed No. 9" at Peenemunde, where static testing of the *Schmetterling* and *Wasserfall* had been conducted during the war. This guidance equipment was subsequently shipped to NII 88 for further study and documentation.

About 50 of the missiles were rebuilt by the Soviets and Germans in Berlin after the war, and were subsequently shipped to the USSR and tested near Moscow in 1948. According to a German associated with the project, the tests were labeled by the Soviets as "satisfactory." Two separate test periods were apparently conducted; the first dealt with launch aspects; the second, possibly six months later, was concerned mainly with flight control.

Though labeled a "rocket," the *Schmetterling* more closely resembled the V-1 in design, operating at subsonic speeds. After launch from ground sites, it was designed to fly toward approaching enemy aircraft to intercept their flight path, exploding when in their proximity by radio command from the ground. Though radar was used in the ground complex to locate and track the targets, the *Schmetterling* itself was visually tracked to the targets by a ground controller. Each launch site controlled four missiles, which could be fired as a group or individually. The sites also had reload capability.

In late 1950, an audit was conducted at NII 88 of the missile projects being worked on there. One casualty of this review was probably the *Schmetterling* project. The Soviets apparently believed that speed limitations--and other shortcomings of this missile--rendered the concept obsolete and precluded further study.

The *Wasserfall* Project

During the war, the Germans developed still another surface-to-air missile that represented, at least in design, a far more formidable threat to Allied aircraft than did the *Schmetterling*. Patterned after the V-2 design (producing essentially a scaled-down version of the V-2 referred to as a "V-2 *Wasserfall* hybrid"), about 20 of these rockets were tested by the Germans during the latter part of the war. The war ended, however, before the *Wasserfall* could be mass-produced.

After the war, the USSR also showed strong interest in this missile, and immediately confiscated all available remnants, test facilities, and related systems (though they did not acquire enough parts to build a complete rocket). A number of Germans who had worked on it during the war were sent to Podlipki in the Soviet Union to continue work there. Tests of the engine were apparently begun in early 1949, and continued until at least 1951. Guidance tests were also apparently conducted in 1951.

Two kinds of guidance systems were designed by the Germans for this missile. The first employed radars to track the target and guide the missile. A second, called *Emden* by the Germans, used infrared-homing techniques. Another infrared-homing system, the *Madrid*, was possibly also intended for use in this missile. Both of these infrared systems had been developed by the Germans to the point of mass production when the war ended.

When the Soviets took over the *Wasserfall* effort after the war, they gave the project the designator of R-113. Although they extensively studied and tested the missile and its subsystems, they apparently had no strong intention of incorporating the missile itself into their post-war weapons arsenal. Rather, they apparently attempted to learn as much as possible about its advanced techniques. This belief was substantiated by the chief German engineer of the project, a man named Hoch. He noted that Soviet efforts in developing a follow-on missile to the *Wasserfall* had reached only the sketch project stage by 1950, when he was transferred from the R-113 project to another area. But the basic *Wasserfall* engine was used later in two surface-to-surface short-range ballistic missiles, the SS-1b and SS-1c.

## The *Messina* Project

During the war, the Germans had designed and developed a telemetry[7] system at Peenemunde for use in their missile programs. All available systems, subsystems, components, and technical literature were acquired by the Soviets after the war, along with many of the German experts who had worked on it. Called *Messina* by the Germans, and later referred to as *Don* by the Soviets, it was first used in the Soviet Union in 1947 in the V-2 tests at Kapustin Yar.

Study of the *Messina* began at NII 885 shortly after the Germans arrived in late-1946. But the Soviets quickly interjected themselves into the project, to the virtual exclusion of the Germans, evidenced, for example, by the V-2 tests in 1947, when the telemetry aspects were strictly a Soviet-run operation. (These telemetry operations, the Germans later noted, were plagued by problems, caused mainly by improper use and adjustment of equipment, resulting in many and lengthy delays during launch operations.)

The German *Messina* had a capacity of 16 information channels, as did the *Don*. Later modifications by the Soviets expanded its capacity.

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[7]Telemetry, as it relates to the missile area, is a means of measuring various aspects of the missile's flight performance, and of relaying results to a distant location where it is displayed or recorded.

By 1949, at least three prototypes of the Soviet version had been built, along with a half dozen or so operational units. Serial production had also begun by this time, with about 50 being manufactured. (It was later reported that the Soviet group responsible for development of the follow-on *Don* system was formally commended by Stalin for its work in this area.) And, as predicted by the Germans, the Soviets used this system during the early developmental years of their missile program.

Missile-Related Projects

In addition to assisting in the development of missile and telemetry systems in these early years, the Germans worked on a number of other projects while in the Soviet Union; some were directly missile-related, others were related in peripheral ways.

One concerned the design and development of a "vibration table" for use in testing the ability of electronic equipment to withstand shock and vibrations. A German named Salm did extensive work in this area for the Soviets after the war.

German wartime radio equipment was also thoroughly investigated by the Soviet Union after the war, and a number of Germans worked in this area while in the USSR. For example, Salm additionally aided the Soviets in developing and testing a multichannel radio-relay communications system between 1945 and 1948. Employing pulse modulation, this microwave system was designed to provide up to eight voice-grade channels, and, by secondary multiplexing, additional telegraphic channels. The system's effective range was reported to be 100 kilometers.

The Soviets also acquired data about a number of electronic missile-control systems developed by the Germans during the war. One, which became operational near the end of the war, was a mid-course guidance system named *Burgund*. The system used a telescope for optical tracking, a transmitter at the control point to send command signals to the missile in flight, and a receiver and command controls in the missile to receive the signals and activate appropriate missile-related functions. A magnesium light in the tail of the missile assisted in optical tracking. Two other electronic-control systems developed by the Germans during the war were called *Darmstadt* and *Mosel*. With these systems, as with *Burgund*, signals were transmitted to the missile to change a control function. But these signals were of short duration--37 milliseconds for *Darmstadt* and 10 milliseconds for *Mosel*.

Work on television-guidance systems for missiles also received high priority in the USSR after the war, and a German war-time system, in particular, received close scrutiny. Called the *Tonne*, it was used by the Germans as a "tracking aid" in their HS-293 and *Fritz-X* air-to-surface anti-ship missiles. After confiscating all available equipment and personnel, the Soviets conducted follow-on research of this technique in an atmosphere of utmost secrecy, working in compartmented areas. As a means of availing themselves of German technology on the subject, however, without "revealing" their own strong interest in it, the Soviet scientists and engineers saw to it that the Germans were located in an area close by, ostensibly to work on "non-military TV" projects.

Another task given the Germans was the development of a coastal defense missile. Begun in 1949, its goal was the design of missiles with a range of 60 miles. Plans also called for "an altimeter-controlled altitude of approximately 100 feet" en route to the target, and for radar guidance. But it remained only a "paper project" as far as the Germans were aware, and they were excluded from further work on the project shortly after it began.

An early report also mentions work by the Germans on a "digital computer" while in the USSR. A professor Gutenmacher was given credit in the report for starting work on the project in Moscow sometime between 1951 and 1952. Gutenmacher was also given credit for designing an analog computer that was "in use during 1951." Work on the digital computer was apparently still in the experimental stage by 1953.

The Germans worked on a number of other missile-related techniques while in the USSR, concerning, for example, such subjects as navigation, fuels, velocity measurement, pitch-and-yaw control, cathode-ray tube development, altimeters, and the like. But by 1953, German work in the Soviet Union had ended, after nearly a decade of effort. All of the Germans, except for a dozen or so, departed the Soviet Union by the end of that year.

Of the missile systems the Germans were involved with, not one was actually produced or deployed while they were in the USSR. This was also the case with many of the other missile-related projects in which the Germans were involved. But these projects--especially the R-10, R-14, *Komet*, *Wasserfall*, and *Messina*--laid the groundwork for future Soviet programs. The Germans provided the USSR a solid base upon which to expand, and, in so doing, enabled the Soviet Union to leap years ahead of what otherwise would have been the case.

# II. Missile Test Ranges

Throughout the years, the Soviet Union has developed a number of missile test facilities for various purposes. Four of these--Kapustin Yar, Tyuratam, Plesetsk, and Sary Shagan--are briefly discussed in this section to show their early history. The first two were developed mainly to test surface-to-surface ballistic missiles, the last mainly for anti-ballistic missile test purposes. Plesetsk was initially established as an ICBM complex, later evolving into a missile and space complex. All four also participated to one degree or another in various other Soviet missile- and space-related events and programs. Additional information and detail of their development and operations are incorporated into later sections of this history.

## The Kapustin Yar Missile Test Range (KYMTR)

Kapustin Yar, the first missile test range in the Soviet Union, was initially used in October 1947 to test V-2s, although one intelligence report notes that some Germans and their V-2 rockets arrived there as early as 1946. The Germans confirmed its operational status in late-1947, but communications intelligence concerning this range was not obtained in appreciable quantity until after about 1953. Earlier intercepts, however, reported some pertinent traffic (pertaining to unusually heavy air activity to and from Kapustin Yar, for example). Aerial photography also provided detail concerning its early development, and about the early history of the other test ranges. Electronic intelligence provided only sparse information of the missile tests until about 1958, mainly because of the lack of intercept facilities in this time period.

When the Germans first viewed the facilities at Kapustin Yar, they were not impressed, noting that it had obviously been quickly established, with only a few permanent structures. Also, most of the operations equipment and systems were of the mobile variety. The surrounding terrain was sparsely populated, and the Soviets had further diluted the local population by closing down several small villages, apparently as both security and safety measures.

The Germans noticed other evidence that Kapustin Yar had not been used previous to 1947 for missile test purposes. For example, a concrete launch platform was only partially completed, and a stand for static tests of rocket engines had not yet been completed. Wire-connected field telephones--markedly similar to German war-time versions--provided intra-rangehead communications, with no radio facilities for such communications noted or used by the Germans.

In these early years, Kapustin Yar was also a dumping ground for a hodgepodge of war booty, some of which the Soviets apparently had little intention of testing or using. (The Germans recognized much of it as having come from Peenemunde.) Most of it had been dumped in piles along a railroad spur, where it was gradually being covered by shifting sands. Much of the equipment was missile-related, but some was not. The Germans, for example, recognized some of their war-time torpedoes in the rusting piles along the rail spur.

The initial V-2 tests at Kapustin Yar were conducted under the direction of Korolev. Though details of these tests are lacking, it is known that many technical problems were encountered, and some, to a degree, overcome. Also, many Soviet scientists and technicians were deeply involved, but only about 16 Germans were included. Nor were the V-2 rockets that were used in these initial tests apparently modified to any significant degree by the Germans or Soviets; but, rather, they were almost without exception copies of the war-time versions. Korolev further directed that, initially, the rockets were to be fired according to procedures the Germans used during the war.

Of the 12 V-2s launched during the 1947 tests, about eight ~~flew~~ operated normally. The first three reached ranges between 250 and 300 kilometers, despite some guidance problems with two of them. (Guidance and control reportedly improved with subsequent launches. At least three of the rockets failed completely, because of engine malfunction. Some of the missiles were permitted to go as far as their fuel allowed, apparently in attempts to determine their maximum possible range. Small aircraft (also of German origin) were used to locate the impact areas, and although Korolev promised the Germans data provided by the aircraft, none was given to them. A radar station (probably mobile) was located several miles from the launch site. The Germans, however, were isolated from the radar site and its operations, and from results of tracking data as well. The V-2s were carried to the launch site on the same mobile vehicles used by the Germans during the war--the Meillerwagen.

Before launch, the various subsystems of the V-2s were tested in two large buildings at the range. Four rockets could be accommodated in each of the buildings. The rockets themselves, however, had been [redacted] shipped from Germany [redacted] to the Soviet Union for testing.

A major V-2-related system was also acquired by the Soviets after the war and sent to Kapustin Yar. It was a special train designed to carry and launch the rockets. Called the FMS train (Fahrbare Meteorologische Station, or mobile meteorological station), it was completely self-contained and carried, in addition to the V-2s, all necessary equipment and fuels to effect launch. At least two were sent to Kapustin Yar. No V-2s were launched from them while the Germans were at Kapustin Yar, nor had they apparently been used operationally by the Germans during the war.

For these initial tests at Kapustin Yar, about 25 V-2s had been brought from Germany, though only 12 were actually launched. Of the 25 rockets, 13 had been captured intact at the end of the war, and a dozen had been assembled in East Germany. Subsequent tests of V-2s at Kapustin Yar were, for the most part, of rockets built from Soviet-manufactured and assembled components.

Tests of the V-2 probably continued at Kapustin Yar into the early 1950s. The exact number launched cannot be determined; but, as noted previously, the Soviets themselves probably manufactured as many as 100, and possibly as many as 150, after the war. The tests were observed by many high-level government and military leaders of the USSR. According to the Germans, Soviet officers of all the military services attended these early missile firings. Apparently the primary objective of the tests was to acquaint Soviet personnel with the intricacies of the rockets and launch programs, and to "sell" the concept to Soviet military and government leaders. In these respects, the tests were successful. These early tests gained for the Soviet scientists and technicians experience in an unfamiliar field, and, once they had acquired sufficient exposure, they quickly excluded the Germans from active involvement in V-2 launches, barring them from further participation after the tenth V-2 had been launched at Kapustin Yar.

Beginning in 1953, Comint began to play an increasing role in monitoring activities of this and other missile-related activity, showing a pattern of sharply expanding activity on the Kapustin Yar range. The USSR continued to attach high significance to Kapustin Yar throughout the years, with one U.S. intelligence report noting, in commemoration of its first 10 years of operation, that it "has been continuously active since 1947."

The Tyuratam Missile Test Range (TTMTR)

In 1955, Comint reflected construction of a new range at Tyuratam, with major construction continuing through 1956. [redacted] And on 21 August 1957 the Soviet Union tested its first ICBM on this range.

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Although it would have been possible to test ICBMs on the Kapustin Yar range, major changes and additions would have had to have been made to its facilities; the down-range orientation would have had to have been modified; and additional risk would have been added since ~~and~~ the missiles would have flown over more densely populated areas en route to impact on the Kamchatka Peninsula. Although the Kapustin Yar range could have been extended to accommodate missiles of intermediate range without major changes to its down-range orientation, the Soviets apparently believed it to be impractical to modify the facility for intercontinental-range missile tests.

Comint between 1955 and 1956 showed other aspects of construction and control at Tyuratam. The work, for example, was being done under the auspices of the Ministry of Defense. High-ranking government and military officials closely monitored its progress, and electronics specialists were deeply involved throughout. Concurrent with work at the rangehead, construction began of an impact area on the Kamchatka Peninsula. Comint also showed that the construction at Tyuratam was of facilities to accommodate ICBMs, attesting to the significance attached to the new range. [redacted] Kapustin Yar and Tyuratam indicated that the two ranges were to operate virtually independent of each other.

While work was progressing at Tyuratam and on the Kamchatka Peninsula, Comint revealed a related project at Kyzl Orda, southeast of Tyuratam. It was here that the headquarters for construction of the range was apparently located. The two military groups involved in the construction were also shown to be subordinate to the Chief Directorate of Special Construction, in turn subordinate to the Ministry of Defense.

Comint further revealed that huge amounts of concrete were being used at Tyuratam in the construction of blockhouses and launchpads, and that missile service towers, complex systems of water piping, intricate lighting systems, and service railroads were being built. When compared with construction of similar ICBM test facilities in the U.S., they virtually matched. Further, many of the personalities identified as being involved at Tyuratam had long histories of involvement in the missile field. Two, for example, were previously associated with a factory that produced missile-guidance radars and other missile-related components. Another was identified as the former chief mechanical engineer at Plant 456 in Khimki. (Plant 456 was identified by the Germans as an assembly and research center for V-2 booster engines.)

By 1958, a rather clear picture of the entire Tyuratam range had emerged. It extended over 3,400 nautical miles across the Soviet Union from Tyuratam to Kamchatka, with the impact area mainly centered in the Klyuchi area. [redacted]

Construction at Klyuchi began about the same time as that at Tyuratam. Beginning in September 1955, Comint showed [redacted] Comint further revealed that construction at Klyuchi was also being conducted under the authority of the Chief Directorate of Special Construction. Additional data, further linking the Klyuchi construction with the missile field, [redacted] when it was noticed that [redacted] from Kapustin Yar for shipment to Klyuchi. Some personnel were also transferred from Kapustin Yar to the Kamchatka location.

Klyuchi was ideally located for its function as a missile-impact area. Sparsely populated, an area of several hundred square miles was available without posing unacceptable risk to the local populace, settlements, and industry. Also, radar and weather facilities were already available in the Klyuchi area.

Activity on the range in the first half of 1957 was apparently mainly of the practice variety, of facilities at both Tyuratam and Klyuchi. And on 21 August 1957, the Soviet Union successfully launched its first ICBM on this range. Tass commemorated the event with the following announcement a few days later:

> A super-long-range intercontinental multi-stage rocket was launched a few days ago. The tests of the rocket were successful. They fully confirmed the correctness of the calculations and the selected design. The rocket flew at a very high, unprecedented altitude. Covering a huge distance in a brief time, the rocket landed in the target area.

A second ICBM was successfully launched on 7 September 1957, and the USSR followed this event on 4 October when the first artificial earth satellite (Sputnik I) was placed into orbit. At least 16 more launches were attempted through December 1958, including ICBMs, ESVs, and lunar probes. Nine were believed successful, six failed after launch, and one was cancelled.

These activities led to speculation within the U.S. intelligence community that ICBM production had actually begun in the Soviet Union by 1958. This was substantiated to a degree on 14 September 1958, when Khrushchev commented in Pravda that "...production of the ICBM has been successfully set up." And he followed this with a statement in Pravda on 28 January 1959 that "series production of the ICBM has been successfully organized."

By October 1960, Sigint and aerial photography showed at least three launch areas were operational at Tyuratam--designated areas A, B, and C by U.S. authorities for identification purposes. The launch pad at area A was the only one noted in use prior to mid-April 1960, when launch area B was also noted active. Area C probably began operation in October 1960.

(On 1 May 1960, the Soviets downed Gary Powers' U-2, ending aerial photography of the ranges and of other locations in the USSR.)

Association of the Strategic Rocket Forces (SRF)[1] with Tyuratam was [redacted]

Expansion and refinement of the Tyuratam complex progressed steadily throughout the years. And its range was subsequently extended to approximately 8,000 nautical miles, through the stationing of Soviet Missile Range Instrumentation Ships at impact areas in the Pacific Ocean.

## The Plesetsk Missile and Space Complex (PMSC)

In 1960, the SRF established an ICBM complex at Plesetsk, and by 1961 [redacted] ICBM launches from Plesetsk to Kamchatka. In 1963 and 1965, two [redacted] significant ICBM test periods were noted on this range: one during October 1963--when the first SS-7 ICBM was noted being launched on this range--and another in December 1965. In the latter case, two SS-6 and three SS-7 ICBMs were fired from Plesetsk to Kamchatka, probably mainly for range-instrumentation test purposes.

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[1]In May 1960, Marshal of the Soviet Union, Andrej A. Grechko stated that the rocket forces had become "the main branch of the armed forces," and that the Soviet Government had determined it "should become a separate, special branch of the armed forces." Labeled [redacted] the Strategic Rocket Forces (SRF), Grechko further stated that it would have "its own command and organizational structure."

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On 17 March 1966, a space event occurred at Plesetsk, inaugurating the addition of this function to the complex. A year later (in April 1967) [redacted]

In its first full year of operation as a missile and space complex, the Plesetsk test range was not overly active, handling only about 15 per cent of the volume noted at Tyuratam. For example, 20 "operations" were noted on the Plesetsk range in 1966, compared to 124 at Tyuratam. But activity on the Plesetsk range increased sharply thereafter, and in the next four years (1967-1970), Plesetsk handled about 40 per cent of the activity taking place on both ranges.

Plesetsk, as noted previously, was established as one of the earliest of the Soviet ICBM complexes. SS-7 ICBMs--and probably SS-6 and SS-8 ICBMs--were operationally deployed there. Also, between 1967 and 1970, SS-6,

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[redacted]

SS-7, and SS-8 ICBMs were launched from Plesetsk for troop-training purposes. In this time period, earth-satellite vehicles (ESVs) were also launched from Plesetsk by SL-3, SL-4, SL-6, SL-7, and SL-8 launch vehicles,[3] including payloads for photo-reconnaissance and _Molniya_ communications satellites. A small number of unidentified satellites were also launched, some of which may have been used for radar calibration, while others were probably communications-related.

In 1969 and 1970, Plesetsk's share of missile firings declined as the SS-7 was phased out. While large numbers of SS-9 and SS-11 ICBMs were fired from Tyuratam, neither of these missiles had been launched on the Plesetsk range. Conversely, the proportion of ESV launches was increased at Plesetsk from parity with Tyuratam in 1968 and 1969 to almost double as many launches in 1970. This increase was due partly to [redacted] also provided the Soviets with greater flexibility in their photo-reconnaissance ESV program, and Elint-reconnaissance and navigational satellites were unique to Plesetsk. In 1969 and 1970, as a result of the decline in missile firings and the increase in ESV launches, the latter outnumbered the former at Plesetsk.

Two missile research and development programs--the SS-13 and SS-X-15 ICBMs--were undertaken at Plesetsk, both apparently with limited success. Only eight missiles were launched there in the SS-X-15 test and development program. The SS-13 program, which was moved to Plesetsk from Kapustin Yar in 1966, continued at a fairly slow rate, including one launch in 1966, ten launches in 1967, nine in 1968, six in 1969, and sixteen in 1970. The increase in 1970 was

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[3]"SL" is the U.S. designator for "space launcher."

due to a series of firings of a modified SS-13, in addition to apparently routine--possibly troop-training--firings of standard SS-13s. The development of these two missiles at Plesetsk, a range with presumably limited facilities compared to Tyuratam, implies that the Soviets expected neither program to become a large one.

[redacted] coincided with tests of a new naval missile--the SS-N-8.

In summary, the Plesetsk Missile and Space Complex, the existence of which has never been publicly admitted by the Soviets, was probably set up to relieve Tyuratam of some of its burden at a time when the SS-7 troop-training program was expanding rapidly and when Tyruatam could expect heavy SS-9 and SS-11 commitments in the near future. Troop-training programs involving SS-6, SS-7, and SS-8 ICBMs; test and development programs of the SS-13 and SS-X-15 missiles; and launches of ESVs for a variety of purposes characterized activity at the Plesetsk missile and space complex in these early years.

The Sary Shagan Missile Test Complex (SSMTC)

In 1960, aerial photography corroborated earlier Sigint data indicating that a missile-related facility was being developed in the Sary Shagan area, west of Lake Balkhash. Comint concerning large-scale construction in the Sary Shagan area was obtained as early as 1956, and probable test firings had been conducted in 1957, but it was not until 1960 that a rather clear picture of the activity could be pieced together.

Located about 1,000 nautical miles east of the Kapustin Yar rangehead, the new site at Sary Shagan encompassed a large area of about 8,400 square miles, with a [redacted] An airfield was located at the base, as well as extensive [redacted] and radar facilities. On the basis of this photographic and Sigint evidence, it became apparent that the Sary Shagan facility would serve a major future role in the Soviet Union's development of anti-ballistic missile systems (ABMs). This was confirmed to a degree in mid-1960 during an "integrated weapons demonstration" at Sary Shagan. Following the demonstration, Marshal Kozakov, First Deputy Commander of Soviet Artillery, remarked that the Soviet Union now had rockets which could "hit high speed aircraft and pilotless offensive devices at great altitudes."

Though the activity at Sary Shagan was not confirmed as being ABM-related until 1960, special Soviet interests in such systems, and in the Sary Shagan area as well, were seen much sooner. In 1949, for example, a Soviet named Spiridonov, of the Ministry of Armaments, had held lengthy discussions of such a system with the Germans at NII 88. And in 1953, a railroad was completed from Mointy to Chu, passing through the Sary Shagan area. Too, the Sary Shagan area was closed to foreign visitors in 1953.

First Comint concerning suspect activity at Sary Shagan was obtained in August 1956, when [redacted]

Comint also provided the first evidence that an ABM had been launched against a target missile (probably an SS-3) on 24 November 1960. It also revealed the locations of launch points on the Sary Shagan range. One [redacted] [redacted] was established near Bajkonur in 1957, from which the 330-nautical-mile SS-2 could be launched to impact in the Sary Shagan area. Another launch point, [redacted] was located near Chelkar, from which SS-3s, with a range of 630 nautical miles, could be fired to impact in the Sary Shagan area at a point [redacted] Longer-range missiles (the SS-4 with a maximum range of 1,050 nautical miles, and the SS-5 IRBM) also impacted at the [redacted] after launch from Kapustin Yar.

[redacted]

In July and August 1957, launches also occurred of SS-2s [redacted] impacting at Sary Shagan. As many as eight SS-2s were possibly included in this series. By this time both the SS-2 and SS-3 were considered to be operational, and these firings to Sary Shagan were therefore believed to have been conducted for two main reasons: (1) to further test and refine the terminal-flight aspects of

[redacted]

Similar tests were also conducted during October and November 1962; however, no ABM launches were noted during these tests.

On 7 November 1963, the Soviets paraded a new missile through Moscow. Labeled an anti-missile missile by the Soviet commentator, to Western observers the missile (NATO nickname Griffon) looked more like a surface-to-air missile (SAM), designed primarily for defense against aerodynamic targets such as bombers and air-to-surface missiles. The Griffon was big, and it was believed

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~~to have too much aerodynamic wing/fin surface to function in the role of a high-~~ acceleration anti-ICBM weapon; it was not comparable to its U.S. "counterpart," the Sprint.[4] [redacted]

On 7 November 1964, the Soviet Union paraded another new missile through the streets of Moscow. This missile, named Galosh by NATO, was also called an ABM by the Soviet commentator. Although enclosed in a metal canister, the Galosh was estimated to be about 58 feet in length and about 6 feet in diameter. Also, the aft end of the canister was not covered, and it could be seen that the booster stage had four probable solid-propellant motors, and that fold-out fins were attached to the motor casings, presumably for attitude stabilization during the boost phase of flight. Beyond that, there was a great deal of speculation [redacted]

[4] The U.S. Sprint ABM was designed as a high-acceleration missile to intercept ballistic missiles at low altitudes and short ranges from the defended area.

[5] The U.S. counterpart to the Galosh is the Spartan ABM, designed to engage and destroy offensive ballsitic missiles at long ranges--several hundred miles-- ~~from the defended area. The over-all U.S. ABM system, however, is currently in~~ moth balls, following a short period of operation.

[redacted]

Thus, it can be seen that Sary Shagan also evolved into a major missile-test facility, [redacted]

## III. Soviet Land-Based Ballistic Missiles

As noted previously, the Soviet Union inherited impressive missile technology developed by the Germans before and during the war. In this field the Germans had no equal by 1945, and the USSR took full advantage of everything available--scientists, technology, and hardware.

Initially, they employed German techniques and missiles, later developing follow-on systems of their own. The V-2 in particular was extensively studied, tested, modified, and emulated in the years immediately after the war, and the early Soviet ballistic missiles distinctly resembled this weapon.

Other German missile-related systems were also documented and tested after the war. Such systems, and related subsystems of many types, were carefully studied in attempts to isolate the ones showing promise for the future, and to weed out those that had been rendered obsolete by advances in technology. In addition to surface-to-surface ballistic and cruise missiles, the Soviets spent vast amounts of time and resources in laying foundations for future developments in the broad spectrum of missile and space technology.

Beginning with the early tests of the V-2 at Kapustin Yar in 1947, the Soviet Union conducted subsequent tests at this and other missile ranges of a wide variety of such systems. By the early 1960s they had developed at least 10 land-based surface-to-surface ballistic missile systems. Included were SRBMs, ~~MRBS,~~ MRBMs, IRBMs, and ICBMs,[1] with ranges from

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[1]Short-Range Ballistic Missiles (SRBMs) - up to 600 nautical mile ranges.
Medium-Range Ballistic Missiles (MRBMs) - about 600 to 1,500 nautical miles.
Intermediate-Range Ballistic Missiles (IRBMs) - about 1,500 to 3,000 nautical miles.
Intercontinental-Range Ballistic Missiles (ICBMs) - about 3,000 to 8,000 nautical miles.

75 to 6,500 nautical miles, giving the Soviets a weapon mix that could threaten a variety of targets world-wide. A submarine-launched ballistic missile (SLBM) with a range of 300 nautical miles was also operational by 1960. Also, by this time they had launched into orbit earth satellites, and they had successfully conducted lunar probes. In 1960, the USSR conducted its first planetary probe, and on 12 April 1961 Yuri Gagarin became the first man in space aboard Vostok I. Thus, by 1961 the Soviet Union was well on its way toward achieving its goal--the development of a modern and versatile missile and space effort.

SS-1~~A~~ (Scunner)

The SS-1a short-range ballistic missile was, essentially, an elongated version of the German V-2. Early U.S. intelligence reports, for example, referred to it as "the Soviet V-2..." and, because of its extended length, the Germans called it the "flying chimney." The missile is considered to be obsolete, and has been deleted from the Soviet Missile inventory.

Korolev, while in Germany in 1946, directed a project that produced several of these elongated V-2s. They were later sent to NII 88, and were reportedly first tested at Kapustin Yar in 1949. The extended length of the Soviet version was apparently mainly for the purpose of increasing the range of the German V-2, and during the tests in 1949 the Germans estimated that a range of "about 350 nautical miles" had been attained.[2]

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[2]Toward the end of the initial Soviet tests of the German V-2 in 1947, the few Germans at Kapustin Yar were assigned elsewhere. Consequently, their estimates of the accomplishments of these early tests of the SS-1a (and of other early Soviet missiles tested at Kapustin Yar) did not result from personal observation or involvement. As a result, ranges attributed by the Germans to these early tests of the SS-1a are not considered to be overly reliable, and a maximum range of about 170 nautical miles was believed to be the true capability of the missile.

Paralleling Soviet work on the SS-la was the German R-10 project, which also had as its main purpose the refinement of the V-2, among other things extending its range to 500 nautical miles. As noted earlier, however, the R-10 project did not itself produce an operational missile.

Modifications to the German V-2 that were incorporated into the SS-la yielded an increase in fuel capacity (from 8,400 to 8,820 pounds), in oxidizer capacity (from 10,800 to 11,025 pounds), and in thrust (from 55,300 to 57,600 pounds).

Like the V-2 the SS-la was a single-stage missile with a nonseparating nosecone, the nosecone weighing about 2,200 pounds. It used a cryogenic oxidizer and storable fuel. Missile control was maintained by jet vanes and movable aerodynamically configured control surfaces on the fins. Carrying a 1,720 pound high-explosive warhead with a circular error probability (CEP)[3] of about 1.5 nautical miles, the SS-la was road transportable and designed for tactical applications.

The single liquid bipropellant main engine of the SS-la, as noted previously, developed about 57,600 pounds of thrust. Gross weight of the missile was about 30,000 pounds with an over-all length estimated at 48.8 feet (compared to the 46-foot length of the V-2). Maximum diameter was assessed at 5.4 feet (excluding the fins).

The transportable launch facility of the SS-la was similar to that used for the German V-2. The launch platform consisted of a ring-type frame to support the missile and a flame deflector below the ring. The launch platform was probably placed on a concrete pad at the launch site.

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[3] Circular error probability is the radius of a circle, centered on the intended target, within which 50 percent of the missile warheads are expected to fall.

During its developmental period, the SS-1a [redacted] a Comint report concluding at that time [redacted] is an advanced version of the German V-2 missile..." The SS-1a was probably not operationally deployed in significant numbers, and, as noted previously, it is considered to be obsolete and deleted from the Soviet missile inventory.

SS-1~~B~~ (Scud A)

Design of the short-range, mobile, tactical SS-1b began in the early 1950s, and by 1957 the missile was believed to have been operationally deployed in limited numbers. Employing a design utilizing the basic Wasserfall storable propellant engine, the single-stage SS-1b probably was developed to replace the SS-1a. The SS-1b, in turn, is believed to have been largely replaced by the SS-1c.

Two types of nonseparating nosecones are employed by the SS-1b. One, a high-explosive/chemical-warfare version, permits a range of about 160 nautical miles.[4] The other, a nuclear version, restricts the range to about 85 nautical miles. Nosecone weight of the 85-nautical mile version is 2,850 pounds, and nosecone weight of the 160-nautical mile variant is 1,545 pounds.

Over-all length of the SS-1b is 34.5 feet, with a diameter of 5.9 feet including the fins, and 2.9 feet excluding the fins. Gross weight of the 85-nautical mile version is 13,000 pounds; gross weight of the

[4] Ranges shown for missiles in this history reflect "non-rotating-earth" distances. Thus, because of the earth's rotation, actual (rotating-earth) ranges for missiles launched toward the east will be greater than their non-rotating earth ranges; the opposite would be the case for missiles fired toward the west. To convert distances from non-rotating-earth to rotating-earth, the latitude of the launch point, the launch azimuth, and the non-rotating-earth range must be known. Conversion charts are available for these purposes.

160-nautical mile version is 11,700 pounds. Booster engine thrust is assessed at 16,800 pounds.

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The missiles' propulsion system consists of a single chamber, fixed-position engine using a liquid bipropellant pressure-fed system. Guidance is inertial, with nonmovable aerodynamically configured fins serving as stabilizers in the denser atmosphere. With a nuclear yield estimated between .01 and .04 megaton, CEP is believed to be .7 nautical mile at two-thirds maximum range.

The missile is transported by a tracked transporter-erector-launcher (TEL) derived from the Stalin-class tank. Over-all weight of the TEL is about 41 tons, with a cruising speed of about 25 miles an hour and a maximum cruising range (with external tanks) of about 187 nautical miles.

First Comint pertaining to the SS-lb became available in May 1954, when references were seen [redacted] On the basis of this Comint, it was concluded at the time that the [redacted] is of Soviet origin or a second generation missile probably intended to replace the [redacted]

In 1956, first intercepts were obtained of telemetry associated with the SS-lb program, and between 1956 and 1959 at least 15 such intercepts were obtained. Also, on 7 November 1957 the missile was paraded publicly for the first time in Moscow, revealing additional data concerning its design, capabilities, and intended operations.

SS-1C (Scud B)

The SS-lc, a short-range tactical missile, was first seen in a Moscow parade on 7 November 1961. It was probably operational at that time, and it is deployed today in the Soviet Union and the satellite nations.

Designed as a highly mobile missile system, the SS-1c represents significant refinements over the SS-1b. The range of the nuclear-armed SS-1c, for example, has been extended to about 150 nautical miles, compared to the approximate 85-nautical mile range of the nuclear-armed version of the SS-1b. In addition to a tracked TEL, a wheeled TEL is available to the SS-1c, providing greater mobility, higher speeds (an increase of about five miles an hour), less maintenance, and a self-loading capability. The SS-1c is also about three feet longer than the SS-1b, though their diameters are the same. Gross weight is assessed at 13,000 pounds, the same as that of the nuclear-armed SS-1b, but thrust of the SS-1c has been increased to about 20,200 pounds.

As was the case with the SS-1b, two types of payloads are available for the missile; one is a nuclear version, the other a high-explosive/chemical-warfare type. Maximum range of both versions is the same--about 150 nautical miles. The single-stage SS-1c employs a nonseparating nosecone, with a CEP estimated a .5 nautical mile at two-thirds maximum range, and a nuclear warhead yielding .01 to .10 megaton.

Inertial guidance[5] is used for the SS-1c, with four jet vanes employed to assist in controlling the missile in flight. As was also the case with the SS-1b, the SS-1c uses aerodynamically configured nonmovable fins to serve as stabilizers in the denser atmosphere. The missile's thrust is generated by a liquid bipropellant turbopump-fed system.

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[5]As defined by the Soviets in 1955 in their unclassified publication Red Star, inertial guidance is "accomplished by an apparatus, installed in the missile itself, the flight program of which is preset before launching."

The SS-1c also reflects technology and design of the German wartime missiles, particularly the <u>Wasserfall</u>[6] and V-2. The engines of the SS-1b and SS-1c are believed to be virtually the same, both evolving from that used by the <u>Wasserfall</u>. The guidance systems of these two missiles are probably similar to that designed for the V-2. The vanes, as well as steering motors for the vanes, are also similar to those used on the V-2.

Military deployment of the SS-1c, and of the SS-1b as well, is believed to center around a brigade with nine missiles assigned to it. Each brigade is further divided into three battalions, with three missiles assigned to each battalion. Each brigade is believed to be deployed in a 30- by 50-kilometer rectangular area, located no closer than about 30 kilometers from the forward edge of the battle area. The missile brigades are believed to be subordinate to army or higher headquarters.

First indications of research and development of the SS-1c were [redacted] in December 1959, and, as noted previously, the SS-1c was believed to have been operational by 1961. By 1963, it was seen replacing some of the SS-1b missiles in the USSR and Warsaw Pact countries, and today it is believed to have largely replaced the SS-1b.

<u>SS-2 (Sibling)</u>

The design of the SS-2 was basically patterned after the V-2, though somewhat longer. Work on the design of this missile was begun after the war in Germany under the direction of Korolev. Because of his personal involvement in the development of this missile, it was

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[6] As noted previously, the <u>Wasserfall</u>, a surface-to-air anti-aircraft missile, was essentially a scaled-down version of the V-2. Also called the C-2 by the Germans, the <u>Wasserfall</u> was about 26 feet in length (compared to the 46-foot length of the V-2).

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referred to as the Korolev rocket for identification purposes within the U.S. intelligence community in its early developmental period. Prototypes of the missile were sent to the Soviet Union between 1946 and 1947, along with V-2s and other war booty. First Soviet tests of the SS-2 reportedly occurred at Kapustin Yar in late-1949, though "unsuccessfully," and small-scale military training with the missile had begun by 1954. But it was not until 1957 and 1958 that extensive military-training exercises were noted in regard to this missile. The SS-2 is considered to be obsolete today.

Two versions of the missile evolved. The first, called the Korolev I, was similar to the V-2, except that it was about 10 feet longer. The other version, the Korolev II, was about two feet longer than the Korolev I. It was also believed to incorporate an "improved guidance system." Other than in these areas, the two versions of the rocket were "essentially identical." [redacted]

Aerial photography of the Kapustin Yar rangehead in December 1959 provided some data concerning the SS-2's dimensions and supporting systems. Its maximum length was determined to be about 57.7 feet, with a maximum diameter of about 5.4 feet (excluding the fins). Also, liquid oxygen trailers, of the type formerly associated with the German V-2, were seen grouped around the missile. Ground mobile support equipment, also of German World War II design, was seen in the area, indicating that the rocket was designed for a mobile tactical capability. The missile was located at the [redacted] of the Kapustin Yar rangehead, at that time containing two separate launch facilities—[redacted] Area [redacted] was still under construction, but at least two launch sites were evolving, spaced about 800 feet apart. [redacted] had three launch sites, spaced approximately 2,000 feet apart.

The short-range SS-2 was capable of carrying a 3,300 pound separating reentry vehicle (with a warhead weighing 2,200 pounds)[7] to a range of about 330 nautical miles. The original reentry vehicle was believed to have been designed for a high-explosive charge, although a nuclear capability was also believed to have been available to the missile. The SS-2 was road transportable, and when first paraded publicly in May 1962, it was seen mounted on a modified version of the V-2 transporter/erector (the <u>Meillerwagen</u>). The SS-2 launcher was believed to have been supported on concrete pads and located at presurveyed sites.

Although basically an "upgraded" version of the V-2, the extended length of the SS-2, and internal modifications, permitted it to carry more fuel. The engine was also modified over that of the V-2, increasing engine-chamber pressure and yielding a booster thrust of about 81,500 pounds. Over-all weight of the missile was assessed at 44,750 pounds. Alcohol and liquid oxygen were probably used to fuel the missile. Missile control was maintained by jet vanes and movable control surfaces on the aerodynamically configured fins. Reentry vehicle separation was probably accomplished by explosive bolts with the reentry vehicle pushed away from the booster by mechanical springs. CEP was estimated at about one nautical mile.

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[7]The reentry vehicle is that part of the missile designed to reenter the earth's atmosphere in its final stages of flight. Included are the weights of the warhead, the weights of necessary shielding and structure, and of other required components. The warhead is that part of the reentry vehicle containing an explosive, chemical, nuclear or other such device.

Beginning on 27 June 1959, tests of another missile were noted on the Kapustin Yar range, overlapping to a degree the test period of the SS-2. [redacted] closely related to the SS-2 in performance and capabilities. [redacted] missile, it was noted being launched in subsequent tests to distances of about 30, 85, and 300 nautical miles. Its flights and burn times at the longer distance were virtually the same as that of the Korolev II. At that time, U.S. Army intelligence reports speculated that the [redacted] missile was being developed "as a 300-nautical-mile rocket to be launched from submarines."

The [redacted] missile-test program was divided into two phases. The first lasted from 27 June to 1 October 1959; the second from 24 December 1959 to 25 February 1960. Eleven launches were noted during the first series; five in the second. [redacted] missiles also occurred on 28 July 1959 and 3 February 1960, when they were either launched vertically or launched to the very short distances noted above. [redacted] during these early tests, indicating, according to a U.S. Army report, "an improved model of the [redacted] or an experimental reentry vehicle." (Apparently the [redacted] became the R-13 when it was actually produced and deployed--the U.S. designator for the R-13 is the SS-N-4). The [redacted] test program probably terminated in February 1960; apparently the Soviets believed the rocket had been developed to the point where further testing and refinement could

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[8] The Soviets give their missiles an "R-series" designator when they reach operational status. These designators, however, are not to be confused with the R-10 through R-15 projects discussed earlier in this history, which were separate and distince nomenclatures used in the early years of German involvement in the Soviet missile program. As noted previously, none of these earlier "R-series" missiles in which the Germans were involved were actually produced or deployed by the Soviets.

be conducted from submarines "simultaneously with the checkout of launch equipment."

By the end of February 1961, at least 200 launches of the SS-2 had been conducted by the Soviets, most on the Kapustin Yar range. Twenty-eight SS-2s were also observed being fired on the Sary Shagan range. And, as noted previously, the SS-2 is no longer an operational missile.

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SS-3 (Shyster)

The SS-3 was still another Soviet missile patterned to a considerable degree after the V-2. First tested in 1955, it was plagued with problems almost from the start, and by 1962 was no longer believed to be operationally deployed.

First Comint concerning this missile became available in 1954, and [redacted] obtained in June 1955. By 1956 it had achieved initial operational capability[9]; production had also probably begun by that year.

The maximum range of the SS-3 was 630 nautical miles, and it was designed for a 3,300-pound reentry vehicle (with a warhead weighing 2,200 pounds). The circular error probability was believed to be one nautical mile, the same as that of the SS-2. It, and associated equipment, were also "transportable." But the system had major drawbacks. Up to five hours were required to prepare it for launch, and a concrete pad was necessary, making it a poor candidate as a mobile weapons system.

[9]Initial operational capability (IOC) equates to the time the first operational unit is believed to have been trained and equipped with missiles and the necessary launch facilities.

In addition to its role as a medium-range missile, the SS-3 was used by the Soviets in a variety of other areas. It was used in vertical launches for research and development of space-related efforts, and it was used in ABM tests on the Sary Shagan range. Although no longer deployed operationally by 1962, it continued to be used well into that year, and possibly as late as 1965, mainly in military-training exercises. Also, after 1961 launches of SS-3s were associated with an [redacted] making identification of the missile difficult thereafter.

The SS-3 was approximately 68 feet in length, about 10 feet longer than the SS-2; its diameter also slightly exceeded that of the SS-2. Over-all weight of the SS-3 was about 65,000 pounds, and its booster engine was capable of generating about 100,000 pounds of thrust. It used liquid oxygen and alcohol as fuel, as was probably also the case with the SS-2. Fuel capacity of the SS-3, however, was assessed at 60 percent greater than that of the SS-2. Whereas the SS-2 was labeled a tactical missile, the SS-3 was probably designed mainly for a strategic role. Earlier versions probably carried a high-explosive warhead, but operational versions were nuclear-armed.

Initially employing a radio-inertial guidance system, the SS-3 was assisted early in flight by radio, the transmitter located 11- to 16-nautical miles to the rear of the launch site and sighted on a line with the intended launch azimuth. (This technique was also employed with early versions of the SS-2 and of other early Soviet missiles as well.) As more reliable inertial components became available, an autonomous inertial guidance system possibly became available for the missile. The SS-3 was controlled in flight by aerodynamically configured fins and by jet vanes.

Reflections of German technology were also seen in this system. Parts of the launch platform were similar to those used for the V-2, and engine shutdown techniques employed by this missile--and by the SS-1a, SS-2, and SS-4--were first used in the German V-2. This technique permitted a reduction in thrust prior to engine burnout, the missile continuing at this reduced capacity until the desired speed and trajectory had been obtained, at which time complete engine shutdown occurred. Aerial photography also showed that design of the exhaust segment of the SS-3 was similar to that of the V-2.

Between June 1955 and April 1959, at least 68 SS-3s had been launched by the Soviets to accomplish a variety of missions. Thirty-two more were seen being launched between 1959 and 1962 on the Sary Shagan range, some as target vehicles for the evolving ABM effort. In the latter case, ranges of about 525 nautical miles were achieved.

Although no longer operational after 1962, the SS-3, as noted previously, was still being launched after that date, including vertical firings at the Kapustin Yar test range. Its early obsolescence as an operational missile was probably mainly the result of the successful development of the SS-4, and because of shortcomings of the over-all missile system itself.

SS-4 (Sandal)

[redacted] in its developmental stages, the SS-4 MRBM was [redacted] of Kapustin Yar in mid-1957, and again in December 1959. First launched in June 1957, the SS-4 was shown publicly for the first time in a parade in November 1960. Several distinct stages were noted in regard to the development of this missile; the first, in 1957, was of "feasibility tests"; the last, in 1960, involved its use in military-training exercises. In between, two periods of research and development were noted.

The SS-4 is a single-stage missile capable of delivering a 3,300-pound reentry vehicle to a maximum range of about 1,050 nautical miles. Weighing about 87,200 pounds, it is slightly over 74 feet in length, with a diameter at its base of 5.4 feet excluding the fins, and 10 feet with the fins. Booster thrust is assessed at 135,200 pounds. CEP is believed to be about 1.25 nautical miles, with a nuclear yield of .5 to 2 megatons.

Like its predecessors, the SS-4 employs some of the older V-2 techniques. Its liquid bipropellant turbo-pump-fed system, for example, employs a two-phase cutoff sequence similar to that used in the German V-2. Also, thrust modulation is used by the fixed-position engine to control velocity, and it also appears that the gas generator is similar to that used on the V-2.

Preliminary design of the missile was probably begun by the Soviets in late 1952, and, as noted previously, it subsequently evolved through a number of distinct developmental phases. The first began on 22 June 1957 and ended on 29 August of that year. These "feasibility" tests were of the over-all missile system, including guidance, and missiles were launched to impact areas 950- and 1,050-nautical miles distant. Following completion of these early tests, a lull of nine months occurred, apparently to permit an evaluation of the results and to make necessary modifications.

The second phase of the developmental program began on 27 May 1958. Missiles were fired to 450-, 950-, and 1,050-nautical mile distances. [redacted] associated with these tests, during which period 13 missiles were noted being launched.

The third test and development phase began in late-1958. [redacted] indicating the missile had evolved into an "advanced research and development phase." (A limited operational capability was also possibly achieved by this time.) These tests were characterized by a relatively high number of failures, 5 of 23 failing between July 1959 and February 1960. By comparison, only three were known to have failed in the earlier test periods. Many other "operations" were cancelled previous to launch. [redacted] Also, a number of the missiles (at least eight) were fired to 650-nautical mile impact areas, indicating that this would possibly be the SS-4's minimum range.

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On 28 July 1959, Chief Marshal of Artillery Mitrofan I. Nedelin[10] witnessed the launch of two [redacted] missiles to a 950-nautical-mile impact area. These missiles were launched in less than three hours of each other, apparently with no associated [redacted]

Military training for operational deployment probably began in earnest with a launch on 26 July 1960, and the first probable launch of a deployed SS-4 took place on the Tyuratam range on 4 November 1960.

By 1961, at least 150 of these missiles had been launched for a variety of purposes, including tests of the ABM program on the Sary Shagan range. The SS-4 figured prominently in the Cuban Missile Crisis of 1962, and it remains an operational missile today, deployed in the peripheral areas of the USSR. Also, since 1966 the SS-4 has been used extensively as a carrier vehicle for a variety of ballistic missile test efforts.

## SS-5 (Skean)

The SS-5 is an intermediate-range missile that also inherited some of the techniques developed by the Germans in World War II. Its design and capabilities additionally reflect work done by the Germans after the war, and in particular in regard to their involvement in the R-14 Project in the late 1940s and early 1950s. [redacted] during its developmental period, the SS-5 was first noted

[10] According to an article in the 16 October 1965 issue of The Manchester Guardian, Nedelin, and 300 others, were killed in the fall of 1960 when a missile exploded on its launch pad. Quoting as its source the "secret reports" of Oleg V. Penkovsky, a Soviet citizen sentenced to death in 1963 for spying for the West, The Guardian noted that the countdown for the missile—described as one with "a nuclear propellant"—went smoothly, but the "new missile failed to leave the ground." After waiting 20 minutes, the observers left the shelters, at which time the missile exploded. The Soviets publicly attributed Nedelin's death to "an air accident."

being tested on the Kapustin Yar range in June 1960. It probably achieved initial operational capability in 1961, and the missile was shown publicly for the first time in a parade in Moscow on 7 November 1964. The SS-5 remains an operational missile today.

Although the missile probably did not achieve operational capability until 1961, reflections of its development were seen earlier. System design was probably begun in 1953, as a follow-on project to the R-14. Aerial photography of the Kapustin Yar rangehead in the late 1950s also showed related developments, when it revealed a complex with three launch areas. The center launch area was still under construction, but enough had been completed to show its orientation toward the 2,000-nautical-mile impact area near Krasnoyarsk, making it a likely candidate for testing [redacted] missiles. Also, Khrushchev, in May 1960, alluded to the imminency of a Soviet IRBM, and it had been speculated by U.S. intelligence analysts that such a missile would evolve from the R-14 Project.

The single-stage SS-5 is capable of delivering a 3,500-pound reentry vehicle to a maximum range of about 2,200 nautical miles. Its over-all length is 79 feet, with a diameter of eight feet (excluding the fins). Weighing about 216,000 pounds, its booster engine is capable of developing 360,000 pounds of thrust. The propulsion segment of this liquid-fueled rocket consists of four thrust chambers and two turbopump units, each consisting of a turbine, fuel pump, and oxidizer pump.

Two reentry vehicles are associated with the missile; one, designated the Mod 1, is 9.3 feet in length, the other, the Mod 2, is 7.5 feet long. CEP is estimated to be about one-half nautical mile, and warhead yield of both the Mods 1 and 2 is assessed at 1.5 to 5 megatons. Inertial guidance is employed for the SS-5, and velocity control is maintained by engine throttling. Jet vanes on the exhaust nozzles are used for attitude control. A technique successfully used for this missile pertained to reentry vehicle separation. Solid-fueled retrorockets were employed to accomplish separation of the reentry vehicle.

During its developmental period, from June 1960 to April 1963, the missile was launched to distances of 1,050, 2,000, and 2,500 nautical miles. The first two launches of the SS-5--on 6 and 25 June 1960--were to the 1,050 nautical mile distance. The first full-range launch occurred on 3 August 1960, impacting in the vicinity of Krasnoyarsk, a distance, as noted previously, of about 2,000 nautical miles. These three launches were monitored [redacted]. The extended-range launches to 2,500 nautical miles occurred on 26 and 29 November 1960, both of which were successful. Two additional extended-range tests were also noted on 14 July and 6 August 1965. The missile launched in August, however, failed to reach the intended impact area because of [redacted] It fell short after reaching a distance of about 1,880 nautical miles.

[redacted] associated with these initial SS-5 events were very limited in 1960. [redacted] Also, the employment of a [redacted] of the SS-5 was first noted on 20 August 1960. [redacted] was no longer used for SS-5s following a launch on 4 October 1965.

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Though not yet operational in early 1961, sufficient information had become available by that time to discern some aspects of its intended usage. On the basis of aerial photography of its launch pad at Kapustin Yar, for example, it was determined that a degree of mobility was designed into the missile, making it "road transportable." One indication of this capability was the sparseness of permanent construction near the SS-5 launch pad at Kapustin Yar. Another indication was the pad itself, which was flat and hard-surfaced with no apparent provisions for venting rocket exhaust gases. On the basis of these observations, it was estimated at the time that the rocket could be transported and that launch facilities would be of the soft variety--that is, above ground. The rocket, however, is believed to be deployed at both soft and hard sites (silos).

Probable user trials for the SS-5 were first held in 1962, [redacted] the first lasted from February 1963 to January 1967, the second from March 1967 to April 1969, and the third from June 1969 through at least June 1970.

The first launch of an SS-5 from a deployed site probably occurred on 22 October 1963 on the Kapustin Yar range. This launch coincided with the first launch of a deployed SS-7 ICBM by the SRF on the Plesetsk range, impacting on the Kamchatka Peninsula. Also, launches of the SS-5 occurred most frequently during its system-development period. During this period, of almost three years duration, at least 63 missiles were launched. A sharp decline was noted between June 1963 and August 1966, when only 27 missiles were noted being launched.

The SS-5 (and the SS-4 as well) figured prominently in the Cuban Missile Crisis of 1962. Although no SS-5s were actually photographed in Cuba, site preparations for them revealed a number of aspects concerning their intended deployment and operation.

Two sites were chosen by the Soviets for initial deployment of the SS-5s in Cuba. One was located in the extreme western part of the island, the other was positioned near the center of the country. Both locations were within eight miles of seaports, apparently because of the difficulty of transporting this large missile and its supporting systems any considerable distance. Each SS-5 battalion in Cuba consisted of two launch pads and a control building. Also, special arch-roofed buildings were seen under construction to house the nosecones.

SS-6 (Sapwood)

First launched on the Tyuratam range on 21 August 1957, the SS-6 gave the Soviets their initial ICBM capability. It also enabled them to pioneer in space operations. The missile is considered to be obsolete today as an ICBM, although it continues to be used as a booster for various space-related operations.

A large missile, the SS-6 is capable of developing nearly a million pounds of thrust, with a gross weight of about 558,000 pounds. It is about 102 feet in length over-all, with a maximum range of about 6,500 nautical miles. Called a "one and one-half stage rocket," the SS-6 uses parallel staging of its booster engines which were jettisoned during flight. In this configuration, the first stage consists of four booster engines (each 8.8 feet in diameter) and one sustainer engine, all of which are ignited simultaneously. In addition, the missile has four liquid vernier/control chambers on the sustainer engine and two on each of the booster engines. Differential throttling of the booster engines provides initial attitude control.

Designed and manufactured at NII 88 and Factory ~~II~~ 88 at Kaliningrad, the missile was first deployed operationally in early 1960 at soft sites in the USSR, with a reentry vehicle weighing about 15,000 pounds and a range believed to be less than 5,000 nautical miles. Later, a lighter reentry vehicle had been tested, and this version was probably fitted to deployed missiles to give them a range in excess of 6,000 nautical miles.

Although the first launch of an SS-6 occurred on 21 August 1957, [redacted] was a prelude to the imminency of such an event. From 15 May through 19 August 1957 in particular [redacted] culminating in the first launch on 21 August. A second SS-6 was successfully launched on 7 September 1957, these first two launches probably representing the "feasibility" aspects of the SS-6 missile program.

Following these two initial launches, the SS-6 was extensively tested from January 1958 through July 1960, the number of launches peaking in 1959 and early 1960. In this time of peak activity, three distinct test periods were noted. The first, which lasted from March through June 1959, [redacted] Six launches were noted during these tests. A second test series, from July to November 1959, [redacted] when at least eight missiles were launched. During these tests, weights of the reentry vehicles were assessed at about 15,000 pounds. Two of the missiles in the latter test series were also launched to a Pacific impact area on 22 and 25 October 1959, representing the first extended-range launches involving the use of [redacted] The third test series began in December 1959, lasting into July 1960. Thirteen missiles were noted being launched in this period, of which at least five impacted in the Pacific (three launched on 20, 24 and 31 January 1960 and two on 5 and 7 July 1960). All of these extended-range flights to the Pacific were successful, except for the one on 24 January which failed in flight. The other missiles were launched to Kamchatka.

The missiles launched during this "final phase of research and development" of the SS-6 program differed from earlier versions in a number of ways. The weight of the reentry vehicle, for example, had been reduced to about 9,000 pounds. An all-inertial guidance system had been successfully developed and tested for it, and in-flight control of the missile had been improved. The reduction in reentry-vehicle weight also permitted longer range.

Despite these later improvements, the missile continued to have major shortcomings, severely hampering its role as an operational ICBM. It was, for example, deployed at soft sites, making it vulnerable to attack and sabotage. Also, its use of a cryogenic oxidizer permitted the missile to be held in a high state of readiness for only about one hour. And lengthy periods of time were required to prepare it for launch.

These drawbacks, coupled with a CEP assessed at no better than two nautical miles, severely curtailed its deployment. Also, by this time other ICBMs were evolving that incorporated significant improvements over the capabilities of the SS-6, further speeding its obsolescence as an ICBM. Following the "final" test and development series, launchings of the SS-6 ICBM steadily declined, averaging only about two a year after 1961. The last observed launch of an SS-6 in its ICBM role occurred in 1966.

SS-7 (Saddler)

The SS-7 is an ICBM deployed in the Soviet Union at both soft and hard sites. From a rather inauspicious beginning (the first three launches of SS-7s were failures), the missile evolved into an effective weapon system, capable of achieving intercontinental ranges between about 4,000 and 7,000 nautical miles. First tested on 24 October 1960 on the Tyuratam range, this missile was believed to have reached initial operational capability by early 1962, and the first missiles (perhaps as many as 10 in number) could have been deployed at soft sites by this time.

Although test and development phases of the SS-7 missile program were conducted at Tyuratam, [redacted] for the operational deployment of the missile were mainly conducted on the Plesetsk range. High trajectories were flown from Tyuratam (370-500 nautical miles); lower trajectories were flown from Plesetsk (330-365 nautical miles). Both high- and low-ballistic coefficient reentry vehicles[11] were tested

[11] The speed of a reentry vehicle is gauged through its ballistic coefficient, which is a reentry-vehicle characteristic whose value is a function of reentry-vehicle weight and shape. The speed with which a reentry-vehicle passes through the atmosphere increases as the ballistic coefficient increases.

at Tyuratam. Only the high-speed reentry vehicles were tested at Plesetsk.

A number of variations of the SS-7 have evolved. Designated Mods 1, 2, 3, and 4, these variants are distinguished mainly by varying reentry vehicle weights and configurations. The first, the Mod 1, was tested during initial phases of the SS-7's development. The Mod 2 reentry vehicle, which weighed about 3,500 pounds, the same as that of the Mod 1, was first noted tested in October 1962 to 3,400- and 6,500-nautical mile distances. A heavier reentry vehicle, the Mod 3, was first tested during November 1962 to Kamchatka (a distance of 3,400 nautical miles) and to the Pacific (4,800 nautical miles). The weight of the Mod 3 was about 4,200 pounds. A still heavier reentry vehicle, the Mod 4, was first tested during the summer of 1963, to 3,400- and 4,800-nautical mile distances. Weighing about 4,800 pounds, its intended purpose could not be discerned, and it was not believed to have been deployed operationally. Subsequent SS-7 tests in 1964 and 1965 employed mainly Mod 2 and 3 reentry vehicles, making them the most likely candidates for deployment. Further, comparisons of the SS-5 reentry vehicle with that of the SS-7 Mod 1 indicated that they were probably the same. Since both of these missiles evolved in about the same time period, and since both reached initial operational capability at about the same time, it is likely that the Soviets had decided upon a standard reentry vehicle for use on both the SS-5 and SS-7.

The SS-7 is about 100 feet in length, with a maximum diameter of 10 and 8 feet for the first and second stages respectively. Gross weight of the missile is about 327,000 pounds, with a second stage weight of about 100,000 pounds. Maximum range for Mod 1 and 2 variants is 7,000 nautical miles; the Mod 3 variant has a maximum range of 6,000 nautical miles. First stage thrust is about 570,000 pounds; second stage thrust is about 203,000 pounds.[12]

A two-stage missile, the SS-7's first stage has three liquid-fueled engines and four liquid-fueled vernier engines to assist in control of the missile during first-stage operation. The second stage has one liquid-fueled main engine with four liquid-fueled vernier (or control) engines. Possibly four solid-propellant retrorockets provide first and second stage separation; reentry vehicle separation from the second stage is also probably accomplished by four solid-fueled retrorockets. Guidance is inertial, and velocity control is accomplished by main-engine throttling and vernier-engine cutoff. The SS-7's circular error probability is believed to be between 1 and 1.25 nautical miles.

As was the case with other Soviet missiles, the SS-7 developmental program was divided into a number of distinct test phases. The first, of "feasibility" tests, extended from about October 1960 to September 1961. A second period, from about October 1961 to December 1962, was of tests to discern the over-all capabilities of the missile and its supporting systems. A third, from 29 November to an undetermined termination date, was of series-production models, during which missiles were apparently selected randomly and tested to verify that they satisfied design specifications. Subsequent test periods, from January to December 1962, March 1963 to February 1967, and March 1967 to March 1969, [redacted] During these

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[12] First stage thrust depicts sea-level measurements; second stage thrust (and that of other upper stages where applicable) reflects measurements in a vacuum.

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[redacted]

The technique of deploying missiles in silos was relatively new to the Soviets by the time the SS-7 reached operational status. Also, inherent costs, and time-consuming construction that delayed deployment, caused silos to lag behind missile development in these early years. Consequently, the first SS-7s were probably deployed above ground at soft sites--but with major drawbacks. The launch site itself was highly vulnerable to attack and sabotage. Also, lengthy periods of time were required to prepare the missile for launch. It had to be moved from storage to the launch pad, erected, fueled, and subsystems checked out, causing from one to two hours delay. Conversely, between five and twenty minutes were required to prepare the missile for launch when it was stored in a silo, and it could be held fully fueled for extended periods in a high state of readiness.

Preliminary design of the SS-7 was probably begun in 1958, and production of test models had probably started by 1959. As noted previously, the first missile tested, on 24 October 1960, failed, as did subsequent launches on 2 February and 3 March 1961. But by early 1962 the Mod 1 was probably operational and deployed, and the Mods 2 and 3 probably achieved initial operational capability in late 1962 and 1963 respectively. The Mod 4 apparently was not deployed operationally. By mid-1966, production of the SS-7 was believed to have terminated [redacted]

SS-8 (Sasin)

The SS-8, a two-stage liquid-fueled ICBM, was probably initially deployed in 1963. It remains an operational missile today, although its deployment is believed to be limited, due mainly to its use of a cryogenic oxidizer.

The SS-8 development program was associated with a high failure rate from the beginning. Thirteen of the first 29 launches resulted in failures, including the initial launch on 9 April 1961. Following the initial launch, a spasmodic test program ensued. Most of the tests were conducted on the Tyuratam range, but some missiles were also launched on the Plesetsk range.

Although the first test of an SS-8 failed, the second test, on 21 April 1961, was a success. A third launch, on 29 May 1961, was also successful. And from July to October of that year, nine more launches of SS-8s were attempted, but with four failures. Three of the launches in October were from Tyuratam to the Pacific, a test series that also included firings of the SS-6 and SS-7 to the same impact area.

After completion of this test series, a lengthy pause of five months occurred in the SS-8 test program, ending with a launch in March 1962. In March and April, a total of five launches were attempted, with two failures. A pause of six weeks was again noted, ending with the rapid firing of 10 missiles between 9 June and 29 July 1962. Again, the failure rate was high, with four failing in flight.

It was apparent from [redacted] of these tests that significant modifications had been made to the SS-8 and [redacted] But no additional launches were noted for the next six



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months; apparently the Soviets had temporarily stopped testing of the SS-8 to permit time to reassess its technical design and capabilities in view of the presistently high percentage of failures the missile was experiencing in its developmental program.

Launches of the SS-8 resumed in February 1963 when two missiles were fired to Kamchatka. [redacted] But on 14 March another SS-8 was successfully launched, [redacted] that was markedly similar to the one used for the Pacific launches in 1961. (The [redacted] on nine flights of SS-8s between 5 November 1963 and 2 February 1964.) The appearance of [redacted] for the SS-8 was probably the result of two different production models, one for ICBM usage, the other for space-related operations.

On 22 January 1964, three SS-8s were launched within a period of 30 minutes. The first impacted in the Pacific, the second failed in flight, and the third impacted on Kamchatka. These launches possibly represented the "final acceptance" of the SS-8 by the SRF.

The SS-8 is capable of a range of about 6,000 nautical miles. Its over-all length is about 77 feet, with a first-stage diameter of about ten feet and a second-stage diameter of about eight feet. Gross weight of the missile is approximately 167,000 pounds, with the reentry vehicle weighing between 3,000 and 3,500 pounds. First stage thrust is about 290,000 pounds; second stage thrust is about 67,000 pounds. The first stage employs a liquid-fueled propulsion system with four combustion chambers, which are thrust-modulated to match a programmed velocity. Thrust vector and roll control are probably provided by vernier engines or jet vanes. The second stage is believed to have a single bipropellant main engine and four vernier engines; its propulsion system is started prior to first-stage cutoff and separation. The reentry vehicle is probably separated from the booster by a pneumatically or explosively actuated system. With a length of about 6.6 feet and a diameter at its base of about 4.4 feet, the circular error probability of the reentry vehicle is about one nautical mile.

Although troubled throughout its developmental program by a high failure rate, and although its role as an ICBM is severely hampered by its use of a cryogenic oxidizer, the SS-8, as noted earlier, remains an operational missile today. Its deployment as an operational ICBM, however, is believed to be limited.

SS-9 (Scarp)

The SS-9 provides the Soviet Union with a very reliable ICBM, capable of delivering huge payloads to intercontinental distances with a high degree of accuracy. Reaching operational capability in the mid-1960s, the SS-9 is capable of ranges between about 5,200 and 7,000 nautical miles. Some 300 SS-9s are believed to have been deployed in hardened silos.

Although first launched on 3 December 1963, the initial design of subsystems for the SS-9 was probably started as early as 1958, with over-all design of the missile probably begun about the same time the SS-7 reached initial operational capability. It is believed that the same team that designed the SS-7 was also responsible for the design of the SS-9.

Apparently the Soviets had placed urgent priorities on the deployment of an improved ICBM in the 1961-to-1962 time period, evidenced by the SS-7 and SS-8 programs, which were marked by haste and an unusually high rate of failures. The SS-9 developmental program, however, seemed to be more deliberately planned and managed, and more carefully and methodically pursued. Within a year of the first test of an SS-7, for example, an average of four missiles a month were being launched. But this firing rate was not achieved in the SS-9 program until two years after the initial launch.

Following the initial launch in December 1963, 12 SS-9s were fired in the next 10 months. Eight of these were launched to Kamchatka, with one in-flight failure, and four to the Pacific, again with one in-flight failure. When compared to the initial 10-month test program of the SS-7, the percentage of in-flight failures of the SS-9 was slightly over 15 percent, contrasting sharply with an in-flight failure rate of about 35 percent for the SS-7.

Early in its developmental program, the SS-9 was involved in two demonstration exercises. The first, occurring on 30 May 1964, involved a launch from Tyuratam to Kamchatka. An SS-7 and SS-10 were also fired as part of this exercise. The three missiles were fired within a four-hour period, representing the first time the Soviets had successfully launched three different categories of ICBMs in one exercise. At the time, the SS-9 and SS-10 were still early in their developmental programs, these launches representing only the sixth of an SS-9, and the third of an SS-10.

The second demonstration involving an SS-9 early in its test program occurred on the Tyuratam range on 24, 25, and 26 September 1964. Two Soviet teams were apparently responsible for these efforts. The first, designated Group A, handled activities on the first day, when an SS-10, SS-8, and SS-6 were launched, the SS-6 as a booster for Kosmos 46. The second day saw the launch of an SS-9 to the Pacific, a distance of 7,000 nautical miles, and an SS-7 to Kamchatka. Group B apparently handled these efforts. On the final day an SS-7 was launched to Kamchatka. These events, probably held for visiting dignitaries, were highly significant for a number of reasons. First, all ICBMs that had been tested on the Tyuratam range to that time were involved, representing "one of the most intensive periods of operations ever conducted on the range in such a short time." Also of significance was the launch of the SS-9 to the extended-range Pacific impact area, after only 11 previous firings of the missile.

For this early beginning, the SS-9 evolved into a missile capable of performing a variety of functions. Four separate reentry vehicles have been associated with it (called Mods 1, 2, 3 and 4).

The first of the reentry variants, the Mod 1, weights about 9,500 pounds and is capable of 7,000-nautical mile ranges. The Mod 2 carries a heavier payload (13,500 pounds) to a range of about 5,300 nautical miles. Test and development programs of these variants were conducted between December 1963 and December 1965, and both reached initial operational capability in 1966. [redacted] Also, the SS-9's Mod 2 version was involved in a number of special events in later years, including one launched during a demonstration for the French Premier on 8 October 1972.

The Mod 3 variant is an FOBS/DICBM (Fractional Orbital Bombardment System/Depressed Trajectory ICBM). First tested in December 1965, the Mod 3 is believed to be capable of ranges up to 7,400 nautical miles. [redacted] for Mod 3 deployment reportedly began in September 1969, and between that date and September 1970 three launches were noted involving [redacted]

The Mod 4 is a multiple reentry vehicle (MRV), capable of delivering three 3,200-pound payloads to a maximum range of about 5,200 nautical miles. The Mod 4 was the first such multiple reentry vehicle developed by the Soviets. First launched on 28 August 1968, developmental launches to the Pacific and to Kamchatka continued to at least 5 November 1971. Twenty-one launches of the Mod 4 were noted in this period. Of note were two launches on 2 and 19 December 1969, when the Soviets [redacted]

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Tests of another "phase" of the Mod 4 began on 24 January 1973. Six tests of modified reentry vehicles of the Mod 4 category were noted in that year. These reentry vehicles were lighter and capable of higher reentry speeds than previous Mod 4 models. This modified version is referred to as the SS-9 Mod 4A.

In 1972, five SS-9s were also noted being launched in tests of what was apparently a new type of reentry vehicle, the forerunner of multiple independently targetable reentry vehicles (MIRVs).

[redacted]

accuracy. Also, radio guidance, used early in the SS-9 test program to [redacted] supplement the missile's inertial guidance system, was discontinued in 1965 with the improvement of [redacted][13]

The SS-9 is assessed as being one of the most accurate operation ICBMs in the Soviet arsenal. The circular error probability (CEP) of the missile's warhead is estimated at between .4 and .5 nautical mile; whereas, for example, CEPs of the SS-7 and SS-8 are estimated at 1-to-1.25 and 1-nautical miles respectively. Also, as noted previously, the SS-9 is capable of delivering huge warheads. The Mod 1 warhead, for example, has a yield estimated to be between 12 and 18 megatons, and the Mod 2 has a yield between 18 and 25 megatons. By comparison, the explosive force of the nuclear warhead of the SS-7 is estimated to be between 2 and 5 megatons, and that of the SS-8 between 2 and 3.5 megatons.

Over-all length of the two-stage SS-9 is about 107 feet, including the reentry vehicle, with a maximum diameter of about 10 feet. Its first stage has three double-chambered liquid bipropellant main engines, with four liquid bipropellant vernier-thrust units providing attitude control. Retrorockets are used for separation. Weighing an average of about 410,000 pounds,

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13 Prior to 1965, a radio-guidance system augmented the inertial-guidance systems in certain Soviet missiles, enhancing missile performance. However, this radio-guidance technique was not seen in use after 1965, when it was last observed in [redacted] associated with the SS-9. The development of more reliable all-inertial guidance systems apparently made the concept unnecessary.

[redacted]

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the first stages of the Mods 1, 2 and 4 are capable of developing about 540,000 pounds of thrust. The gross weights of the second stages of the Mods 1 and 4 variants average about 127,000 pounds, with a main-engine thrust averaging about 210,000 pounds. [redacted]

Operational SS-9 missiles are located in hardened, dispersed silos.

[redacted]

## SS-10

The SS-10[14] two-stage ICBM was first tested on the Tyuratam range on 11 April 1964. The program was discontinued after only the eighth launch on 20 October 1964. During this brief test series, seven of the eight missiles were launched successfully, six impacing on Kamchatka and the last in the Pacific. However, only the flight to the Pacific--a distance of about 6,500 nautical miles--apparently demonstrated the full potential of the missile's capabilities, and it was therefore believed that the SS-10 program was discontinued by the Soviets "before the initial test-flight phase was completed."

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14 The SS-10 is referred to as the SS-X-10 in some source documentation.

Despite its promising beginning, and despite its demonstrated capability of delivering a 7,000-pound reentry vehicle to operational ranges of over 6,000 nautical miles, the program, as noted above, was cancelled after only about six months of testing. As a result, the missile was not deployed operationally, though evidence suggested that it was--at least initially--included in Soviet space-related planning.

Preliminary design of the missile was probably begun in 1958 or 1959, with emphasis apparently directed toward the design of improved propulsion systems and techniques. In most other aspects, however, the SS-10 appeared to be mainly a hybrid missile, incorporating a variety of the components and techniques of the other Soviet ICBMs developed in that time period--the SS-6, SS-7, SS-8 and SS-9.

An innovation of the SS-10 was a [redacted]

The SS-10 was about 95 feet long, with a first-stage diameter of about 10 feet. The first stage employed four engines, capable of developing about 400,000 pounds of thrust. The second stage employed one main engine. Gross weight of the missile was estimated at about 280,000 pounds. [redacted]

The SS-10 was designed to fly a precomputed trajectory. Measurements of the velocity of the missile were compared in flight to precomputed, stored velocity magnitudes, the resultant signals actuating various control functions to keep the missile aligned in accordance with positions and velocities of the precomputed trajectory.

Though not new to this missile, a "propellant utilization system" was used to insure that the fuel and oxidizer tanks would be emptied at the same time. With this technique, fuel and oxidizer flows were adjusted proportionally in flight. This technique apparently originated with the Germany-designed R-14 missile of the early 1950s, referred to at that time as the "alpha stabilizer."

Although the first SS-10 failed, the next seven launches were successful. With such a promising beginning, it is difficult to discern the reasoning behind its sudden demise. But the relatively successful development of the SS-7, the development of the highly successful SS-9, and the other ICBMs that were evolving at that time, possibly led the Soviets to the belief that the SS-10 program was redundant and therefore unnecessary, and that additional expenses could be avoided by cutting off further development and testing.

<u>SS-11 (Sego)</u>

The SS-11, a comparatively small liquid-fueled ICBM, was first launched on the Tyuratam range on 19 April 1965, impacing on Kamchatka. It underwent intensive testing in a relatively short period, culminating in its early initial deployment in 1966. Hundreds have been manufactured and deployed throughout the years.

The SS-11 evolved into a versatile weapons system. Its range, for example, varies between about 500 and 6,000 nautical miles. Also, three reentry-vehicle variants have been developed. The first, the Mod 1, consists of a single reentry vehicle weighing about 1,500 pounds. With this reentry vehicle, the missile's range is believed to be 6,000 nautical miles. With the Mod 2 variant, the missile is capable of delivering a reentry vehicle and two penetration aids to a 6,000-nautical mile range. Over-all weight of the Mod 2 is about 2,100 pounds, with the reentry vehicle weighing about 1,500 pounds. The Mod 3 variant, with an over-all weight of about 2,300 pounds, is capable of delivering three reentry vehicles (MRVs). With this variant, the missile is capable of a distance of about 5,500 nautical miles. Some tests of Mod 3 variants have additionally included up to four cylindrical objects leading the reentry vehicles, probably employed as penetration aids.

As noted previously, the two-stage SS-11 is a comparatively small missile, measuring 64 feet in length with a first-stage diameter of eight feet and a second stage diameter of six feet. Over-all weight of the missile is 105,000 pounds for the Mod 1 variant, and about 121,000 pounds for the Mods 2 and 3. First-stage thrust is estimated to be about 190,000 pounds for all three variants; second-stage thrust is estimated to be 30,000 pounds for the Mod 1, and 31,000 pounds for the Mods 2 and 3. Short reaction times--30 seconds to three minutes--and unlimited hold times characterize the missile, along with CEPs of 1 nautical mile for the Mod 1, and about .6 nautical mile for the Mods 2 and 3. Warhead yield, however, is relatively small when compared to other ICBMs developed to that time: an estimated .6 to 1.2 megatons for the Mods 1 and 2.

Following the first launch in April 1965, an intensive test period ensued. In 1966, for example, at least 44 missiles were launched. By early 1966, series production had probably started, and in March 1967, intensive [redacted] for the missile's deployment began. One-hundred and forty-five launches of SS-11s had been [redacted] to the end of 1969. [redacted] further showed that by 1967 approximately 200 missiles were being produced annually, and U.S. intelligence sources estimated that about 1,700 had been produced by the end of 1972. Also, an estimated 61 battalions were trained in its operation.

The first stage of the SS-11 employs four main engines. The second stage has one main engine similar to first-stage design though smaller. All-inertial guidance is used for the missile. The first-stage main engines may be hinged or employ hinged attitude control chambers using propellants bled from the main engines. [redacted] Separation of the first and second stages is probably accomplished by retrorockets. [redacted]

Testing of penetration aids (penaids) was first noted on 20 September 1967, with Radint revealing "new separation sequences and the appearance of additional objects." Tests of penaids continued until at least July 1968, during which month five launches were made to ranges of only 500 to 600 nautical miles.

A new test phase began on 23 July 1969 (of the Mod 2 described previously). [redacted] This Mod 2 variant was tested to ranges of 500, 3,400, and 4,800 nautical miles (as was also the case early in the Mod 3 test program).

On 12 September 1969, tests of the Mod 3 variant were first noted. Carrying three reentry vehicles (MRVs), it was seen being launched into 1971. On two such flights, on 21 and 22 August 1970, U.S. surveillance ships visually observed the three separate vehicles reentering the atmosphere. A reduction of reentry vehicle-associated telemetry in 1971 probably signaled "the completion of basic research and development." Like the Mod 2, the Mod 3 reentry vehicles had higher ballistic coefficients that that of the Mod 1, enabling a reduction in the time required to penetrate the earth's atmosphere, thereby enhancing penetration capability. Also, certain tests of the Mod 3 showed a capability to space out reentry vehicles along a common trajectory, rather than their release simultaneously at the same point.

Beginning in February 1971, still another testing phase began, possibly representing a new variant of the Mod 1. These tests were characterized by a higher apogee, second-stage pitching, and the appearance of unidentified objects trailing the second stage by 10 to 14 nautical miles. Use of second-stage pitching in these flights was unique to the Mod 1, though all Mod 2 and 3 variants employ this technique.

SS-11 reentry vehicles launched to Kamchatka (a distance of 3,400 nautical miles) impacted in areas other than those used for other ICBM tests.

[redacted] that two, and possibly three, impact areas near Klyuchi were used, all outside the "normal" impact area. One was located about 30 nautical miles south of Klyuchi, a second one 10- to 15-nautical miles southeast, and a possible third impact area about 15 nautical miles northeast of the second location.

Three SS-11s were launched from deployed sites on 11 November 1970 during an SRF exercise, and by 1973 it was estimated that the SS-11 comprised up to two-thirds of the Soviet ICBM missile force. The missiles are deployed in hardened silos, with, as noted previously, short reaction and unlimited hold times. And because of the varying ranges of the missile, the Soviets probably realized the additional option of augmenting their SS-4 MRBM and SS-5 IRBM forces with the SS-11.

SS-12 (Scaleboard)

First launched on the Kapustin Yar range on 5 February 1964, the SS-12 SRBM attained initial operational capability in mid-1965. With a minimum and maximum range of about 100 and 500 nautical miles respectively, the liquid-fueled SS-12 evolved quickly through a testing program associated with no lengthy pauses, indicating the probable use of proven technology in its design.

A single-stage missile with a separating reentry vehicle, the SS-12 is 39 feet long and 3.3 feet in diameter. Gross weight of the missile is 18,800 pounds, with a reentry-vehicle weight of about 1,300 pounds. Maximum thrust is assessed at about 31,000 pounds. All-inertial guidance is used for the SS-12, with jet vanes employed for directional control. In addition to a nuclear warhead, a high-explosive warhead is possibly also available for the missile. CEP is estimated to be about .3 nautical mile at two-thirds maximum range.

Designed for mobile tactical applications, two transporter-erector-launchers (TELs) have been associated with the SS-12. The first, mounted on a MAZ 543 chassis, was seen in a Moscow parade in 1965. The second version is similar except that the missile is enclosed in a protective canister. Named Scaleboard, the latter version was first seen in a Moscow parade in 1967.

The research and development program of the SS-12 was also marked by distinct test phases. [redacted] Radint showed that the missiles had been tested primarily to ranges of about 285, 325, and 450 nautical miles. A possible fourth impact area, [redacted] was approximately 200 nautical miles from the Kapustin Yar rangehead. Following completion of the third test phase in 1965, an [redacted] began almost immediately, reflecting the apparent high priority placed by the Soviets on the rapid deployment of the SS-12.

By the end of 1968, at least 71 SS-12s had been launched, a collaborating agency estimating that approximately 380 missiles had been manufactured to that time. Production continued into at least 1969.

## SS-13 (Savage)

The SS-13 was the first solid-propellant ICBM to be deployed by the Soviets. A three-stage missile, the SS-13 evolved into a highly reliable system, one study showing a launch-reliability factor of 95 percent, and an in-flight reliability factor of 90 percent (on the basis of only seven failures of the first 55 missiles tested). The SS-13 is probably deployed in hardened and dispersed unmanned silos.

Flight tests of probable solid-propellant missiles were first noted in late 1965, when three were launched on the Kapustin Yar range. The first, on 16 September, was given the arbitrary designator of KY-5 for identification purposes. Two more tests of KY-5s followed on 12 October and 16 November 1965. The impact area of the missile tested on 16 September could not be determined by Radint, [redacted] a possible distance of between 130 and 150 nautical miles had been achieved. Two impacts were revealed by Radint concerning the 12 October test. The first impact location, probably of the booster state, was about 288 nautical miles down range. The other impact location, probably of the reentry vehicle, was about 197 nautical miles from the launch site. Radint showed a single impact for the 26 November launch of "approximately 203 nautical miles down range."

On 26 February 1966, another test of a probable solid-fueled missile was seen on the Kapustin Yar range, to a distance of 1,050 nautical miles. Five more flights of this missile (given the designator KY-6) were noted to mid-1966 on the Kapustin Yar range. Although no firm relationship could be established at the time between the KY-5 and KY-6, it was speculated, [redacted] that they were "part of the same test program." [redacted] 26 February, 15 March, and 11 April 1966, further showed the KY-6 to be a three-stage tandem missile "with the two upper stages using solid propellants."

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[15] It would later be seen that the two programs were in fact related, the KY-5 being the forerunner of the SS-14 MRBM, and the KY-6 the forerunner of the SS-13 ICBM. The SS-14, essentially, consisted of the second and third stages of the SS-13.

When compared to a three-stage solid-fueled ICBM which had been displayed in a Moscow parade in May 1965, the one on display--referred to as the Savage--and the KY-6 were believed to be the same missile.

Resembling to a degree the U.S. Minuteman ICBM in design, the SS-13 was launched for the first time on the Plesetsk range on 4 November 1966, to a distance of 3,100 nautical miles. Following this transfer of the test and development program from Kapustin Yar to Plesetsk, the missile was subsequently noted being launched on the latter range to a variety of impact areas, including Kamchatka and the Pacific Ocean.

As was true of other ICBMs in the Soviet missile test programs, variants of the SS-13 evolved. Distinct test phases also characterized the missile's development. The first test phase (of feasibility aspects) of the over-all missile system began with the initial launch of the KY-6 on the Kapustin Yar range on 26 February 1966, continuing into July of that year. Six missiles were noted being launched in this test phase to distances of 1,050 nautical miles. The first launch on the Plesetsk range, on 4 November 1966, possibly also concerned feasibility tests of the missile.

Following the 4 November 1966 launch, a pause of five months occurred in the SS-13 test program. The lull ended when [redacted] began in April 1967, this phase continuing to August 1968. Fifteen launches were noted on the Plesetsk range in this test phase, four of which were to 4,700-nautical mile distances. At least four other launches in late-1968 were probably for the purpose of [redacted] and five launches between October 1968 and February 1968 [redacted]



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Two variants of the SS-13 have been identified. The first, or Mod 1, probably achieved initial operational capability in 1969. It is capable of delivering a reentry vehicle of about 1,200 pounds to a maximum range of 5,500 nautical miles, with a CEP estimated at one nautical mile. Research and development tests of another version, the Mod 2, were essentially completed by 1971. Characterized by a change in reentry vehicle design and a CEP of about .7 nautical mile, the Mod 2, so far as is known, was not operationally deployed, and this aspect of the program has probably been terminated. Its maximum range, like the Mod 1, was estimated at 5,500 nautical miles.

First-stage thrust of the SS-13 is about 210,000 pounds, second-stage thrust about 98,700 pounds, and third-stage thrust about 45,000 pounds. Gross weight of the missile is about 111,000 pounds, with an over-all length of 66.5 feet. First-stage diameter is 5.85 feet, second-stage 4.9 feet, and third-stage 3.3 feet. Approximate warhead yield is .6 to 1.5 megatons.

The three stages of the all-inertial-guided SS-13 employ solid-propellant motors and movable nozzles. Third-stage thrust [redacted]

In addition to its being the first solid-fueled ICBM deployed by the Soviets, the SS-13 test and development program was associated by other noteworthy happenings. Relocation of the program to Plesetsk in November 1966, for example, represented the first effort at that facility for missile test and development purposes. Of additional note were launches of SS-13s in August 1970 to 1,000-nautical mile distances, suggesting a variable role for the missile. These firings, on 7 and 29 August, were from Plesetsk to the Norilsk impact area of the Northern Fleet Missile Complex. They further



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represented the first time missiles had been launched from Plesetsk to distances of less than 3,100 nautical miles. Also, the display of a prototype of the missile in the Moscow parade in May 1975--months before it was first flight-tested--represented a departure from normal Soviet practice. Public displays of missiles usually trail their operational deployment, if they are shown at all.

SS-14 (Scamp)

As noted in the preceding section, the SS-14 (or KY-5) was essentially the two upper stages of the SS-13. First flight tested in September 1965, the solid-fueled missile could have reached initial operational capability in 1970. So far as is known, however, the missile was not deployed operationally and is believed to have been deleted from the Soviet inventory.

A two-stage mobile MRBM, the SS-14 was first seen in a Moscow parade in November 1967. It was associated with the Scamp transporter-erector-launcher (TEL), which had been seen in Moscow parades since 1965. Capable of delivering an approximate 1,200-pound reentry vehicle to a maximum range of about 1,600 nautical miles, the all-inertial-guided SS-14 was assessed as having a CEP of .5 nautical mile at 1,500-nautical-mile distances. Gross weight of the missile was about 35,800 pounds, with a second-stage weight of about 10,800 pounds. First-stage thrust was approximately 86,000 pounds, with a second-stage thrust of about 45,000 pounds. Over-all length of the missile was 34.2 feet, with a first-stage diameter of 4.9 feet and a second-stage diameter of 3.3 feet.

Other than three probable launches of an SS-14-type missile in late 1965, only two other distinct test and development phases were noted of the missile. Launches on 9 February, 22 March, and 30 May 1967 were assessed as feasibility tests. The first launch was to a range of 960 nautical miles; the next two were to distances of 1,050 nautical miles. Following a lengthy pause, the next test of an SS-14 was not seen until February 1968. Eight launches were noted between February and October of that year, labeled as "general systems tests." Distances achieved for these tests were mainly 1,050 nautical miles, though a launch of 485 nautical miles was also noted. Another missile traveled only 330 nautical miles when the reentry vehicle failed to separate. Over-all, only 19 flights of SS-14s have been noted, and none were observed that could be labeled as being [redacted] or of production models.

The last observed launch of an SS-14 occurred on 14 March 1970 and was categorized as an operational suitability flight. [redacted] during this last flight, and it is believed that the program was discontinued shortly thereafter. One reason speculated for its early demise was the successful development of the SS-11, its variable-range capability enabling it to fulfill an MRBM role as well as that of an IRBM and ICBM.

<u>SS-X-15 (Scrooge)</u>

Designed as a mobile ICBM, the two-stage SS-X-15 was first noted being launched on the Plesetsk range on 12 February 1968, though unsuccessfully. Following this initial flight, two additional launches were noted in 1968--on 18 June and 2 July. Both of these launches were successful, impacting on Kamchatka. The SS-X-15 test and development program apparently progressed slowly following these 1968 launches, with infrequent tests noted into 1969. 89

The missile was estimated to be capable of carrying a reentry vehicle weighing between 1,000 and 1,500 pounds, with a maximum range of approximately 4,200 nautical miles. Employing inertial guidance, the CEP of the probable liquid-fueled SS-X-15 was estimated at one nautical mile.

A missile believed to have been the SS-X-15 was seen in a Moscow parade in 1967, housed in a 65.5-foot-long canister on a Scrooge-type TEL. On the basis of this observation, the missile was estimated to be about 59 feet in length, with a diameter between 5.5 and 6.3 feet.

Only sparse information is available concerning this missile. It can not be discerned on the basis of available data how far it progressed into its test and development program, or if it in fact reached operational capability.

## Newer-Generation Missiles

From the foregoing, it can be seen that, in the years following World War II, the Soviets advanced steadily in the missile field. By the early 1970s they had a major land-based ballistic missile force in being, capable of accomplishing a variety of missions. Ranges of their deployed missiles extended from short-range varieties (150 nautical miles or less) to those capable of ranges up to 7,000 nautical miles or more. Some also employed variable ranges, giving them wider applications. Nuclear yields had been achieved varying from a megaton or less to that of the SS-9--up to 25 megatons. Refinements in guidance and control systems saw CEPs improve as newer missiles evolved. Multiple reentry vehicles, penetration aids, and multiple independently targetable reentry vehicles had evolved or were evolving in this time span. Hardened, dispersed silos had come into widespread use, and mobile missile systems, mainly for tactical applications, had been developed and deployed in large numbers. Thus, from its meager beginning in the mid-1940s, the Soviet Union had developed, by the 1970s, an impressive land-based ballistic missile force.

But even as some of these missiles were being deployed operationally, the Soviets were planning and developing newer-generation missiles that would further enhance their over-all capabilities. Incorporating refinements in a number of significant areas, these newer-generation missiles--the SS-X-16, SS-17, SS-18, SS-19 and SS-X-20--promise for the Soviet Union continuing significant progress in the ballistic-missile field. It is not the purpose of this article to define in detail their evolution, capabilities, deployment, and the like. But certain of their highlights should be mentioned by way of conclusion.

The first of these, the SS-X-16, is a three-stage solid-propellant ICBM, assessed as being capable of delivering a throw weight[16] of about 2,100 pounds to a range of 5,000 nautical miles. It was first noted being tested on 14 March 1972 on the Plesetsk range. Initial operational capability could have been achieved by late 1975, and deployment would probably be in hardened and dispersed unmanned silos, and possibly in a mobile capacity as well. Believed to employ a single reentry vehicle, the SS-X-16 employs a post-boost-vehicle (PBV) capability. Operating after third-stage operation terminates, the PBV provides an additional range of about 500 nautical miles for the 1,000-pound reentry vehicle (extending the range to 5,500 nautical miles with the PBV). The PBV employs four small solid-propellant motors and is capable of providing both forward and reverse thrust. With a nuclear warhead yielding between .6 and 1.5 megatons, the approximate 67-foot-long SS-X-16 is estimated to be capable of achieving a CEP of about .4 nautical mile.

[16]Throw weight is all weight located above the final booster stage of the missile, including that of the PBV, of the payload (reentry vehicles, penetration aids, telemetry, instrumentation), and of PBV subsystems (guidance and control, separation, propulsion systems, propellants, etc.).

A second newer-generation missile, the SS-17, is a two-stage canister-launched liquid-fueled ICBM. A PBV with a maximum of four positions for reentry vehicles provides a MIRV capability, each of the four reentry vehicles weighing about 900 pounds. A single reentry vehicle has also been tested--on the first five launches--but it has not been seen in launches since 6 April 1973, indicating that it is not intended for the primary mission. Assessed as being capable of delivering a throw weight of approximately 6,000 pounds to a range of 5,500 nautical miles, the SS-17 employs the "sabot" launch technique.[17] Initial operational CEP is estimated at .34 nautical mile at 5,000-nautical mile range, with a future (1980) potential of .28 nautical mile believed possible. First noted being tested on 15 September 1972 on the Tyuratam range, the SS-17 will probably be deployed in hardened and dispersed silos. The approximate 67-foot-long missile is a candidate for partial replacement of SS-11 ICBMs.

A third newer-generation missile, the SS-18, is a large two-stage liquid-bipropellant ICBM. Three reentry-vehicle variants are available to the missile. One of these, the Mod 1, is assessed to be capable of a maximum range of 6,200 nautical miles with a 13,500-pound reentry vehicle. Another, the Mod 3, is believed capable of delivering an 11,000-pound reentry vehicle to a range of about 8,000 nautical miles. The Mod 2, a MIRVed version, has demonstrated a capability to deploy up to 10 reentry vehicles. The SS-18 also employs a PBV capability (for the MIRVed variant only), and the launch-assist sabot technique for ejection of the missile from the silo. Nuclear yields of the single-reentry vehicle variants are assessed at between 18 and 25 megatons; the

[17] The "sabot," or "cold launch," technique enables the missile to be ejected from the silo prior to main-engine ignition. This technique permits a reduction in the diameter of the silo.

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yields of the MIRVed variants are assessed at between .3 and 2.3 megatons (Mod 2A) and .4 to 1.3 megatons (Mod 2B). The Mod 1 variant was probably initially tested on the Tyuratam range in October 1972, the Mod 2 in August 1973, and the Mod 3 in June 1973. The Mod 1 probably attained initial operational capability (IOC) by early 1975, and the Mods 2 and 3 by late 1975. [redacted] Deployment of the SS-18 is occurring in large new silos and modified SS-9 silos.

First tested on the Tyuratam range on 9 April 1973, the SS-19 probably reached initial operational capability in 1975. Characterized by a highly successful test and development program (only three failures in the first 30 launches), the SS-19 is probably intended to partially replace the SS-11 ICBM missile force. A two-stage liquid-fueled missile, the SS-19 incorporates significant improvements over its predecessor, the SS-11, with, among other things, a considerable improvement in throw weight and the employment of six independently targetable reentry vehicles, each weighing about 750 pounds. Nuclear yield is estimated at one megaton for each of the six reentry vehicles. The CEP of operational versions at 5,000-nautical-mile distances is estimated at .3 nautical mile, with a potential CEP of .25 nautical mile estimated possible by 1980. Though employing a PBV capability, as far as is known the SS-19 does not use the sabot launch technique; rather, the missile is probably "hot launched" from the silo. The SS-19 is assessed as being capable of delivering--with the PBV capability--all six reentry vehicles to a maximum range of 5,200 nautical miles. Some of the reentry vehicles could achieve 5,800-nautical mile ranges, but with significant reduction of impact-pattern flexibility. The SS-19 uses a new inertial-guidance system, which affords better accuracy and could provide flexibility against selective strategic targets. Believed to be transported to the silo in a canister which also serves as the launch tube, the 80-foot-long missile is probably launched from modified SS-11 silos.

First launched on the Kapustin Yar range on 21 September 1974, another new missile, the SS-X-20, is a two-stage solid-propellant IRBM. Comprising the lower two stages of the SS-X-16 ICBM, a PBV, and MIRVs, the missile is assessed to be capable of a maximum range of about 2,500 nautical miles. With a gross weight of approximately 83,000 pounds, and an approximate 53-foot length, the SS-X-20 is believed to be capable of achieving a CEP of .25 nautical mile. Employing three MIRVs weighing about 620 pounds each, the SS-X-20 could have reached IOC in 1976. It is probably intended as a replacement for the SS-4 MRBM and the SS-5 IRBM, and will probably be deployed in a mobile mode, most likely using presurveyed and prepared launch sites within a reasonable distance of a common logistics support area.

## IV. Sigint and the Expanding Soviet Ballistic Missile Problem

### Early Sigint Developments

To the early 1950s, collateral sources provided most of the information on evolving Soviet ballistic missile programs. But by 1953, Comint began to play a role, its significance increasing sharply thereafter. Elint [redacted]

An early Comint report, addressing the period 15 April 1950 to 31 December 1951, discussed unusual air activity concerning Kapustin Yar. Although there was "no firm evidence linking this activity with the Soviet guided missile program," the report did provide an assessment of [redacted] a concentration of military aircraft at Kapustin Yar during the summer months of June and July 1951. These planes, which for the most part were military transports, originated from Moscow-area bases. Additional information on flights of military transports between Moscow and Vladimirovka during the latter half of July was also discussed in the report.[1]

[1] This information was also to have later implications, for Vladimirovka was evaluated in 1957 as a range of probable Air Force subordination. Tests of air-to-surface missiles were revealed in Comint on this range, as were other types of operations.

And later in the year (November and December 1951) Kapustin Yar was mentioned [redacted] "in terms of degrees and distances from Vladimirovka." [redacted] representing the first Comint that "firmly identified" this test range. One [redacted]

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[2] Net - In telecommunications, a number of associated groups of links, all controlled at a common location and presumably serving the same immediate superior headquarters.

Network - The total telecommunications system of an organization, or a major part of it, including all subordinate or related nets.

Group - One or more radio links whose stations work together under a common operating control.

Link - Any single direct system of telecommunications between two stations.

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[redacted]

By 1958, Comint had revealed the locations of six downrange impact areas on the Kapustin Yar range. [redacted]

[redacted]

[redacted] For example, during an eight-month period, from December 1956 to August 1957, references were seen in Comint to the use of seismic equipment at the 630-nautical-mile impact area, to assist in determining the missile's point-of-impact. In this same time period, references were seen [redacted] to acoustical equipment at this impact area. And information analyzed in 1957 [redacted] optical and photographic equipment probably located near impact areas. [redacted]

A Comint report of March 1955 gave further indications of increasing [redacted]

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References to an operation involving the [redacted] (SS-1a) missile, as noted previously, were first seen in Comint on 7 May 1954. From this date until 30 August 1957, Comint revealed a total of 32 operations related to the [redacted] missile. Sixteen missiles were successfully launched in this time period to the C impact area (130-to-150 nautical-mile area), and eight to the B area (30-to-85 nautical-mile area). Six operations were cancelled previous to launch; one missile failed at launch; and the results of another operation could not be determined.

In this time period, tests of the [redacted] (SS-1b) missile were also noted, a total of 48 operations occurring between 14 October 1954 and 31 May 1958. Thirty-three launches resulted in successful flights to the C impact area; nine were cancelled; and the results of six could not be determined.

Also, unidentified launches occurred on the range as early as 19 October 1953, overlapping the [redacted] tests and continuing at least to 20 November 1956. A total of 38 operations were noted in this regard. On the basis of impact-area participation, they were believed to have involved "either or both the [redacted] missiles..." Thus, in the period 19 October 1953 through 31 May 1958, the following [redacted] had been noted in Comint in regard to these missiles:

| Missile | Successful Launches | Cancellations | Failures | Undetermined Results | Impact Areas |
|---|---|---|---|---|---|
| [redacted] | 8 | 6 | 1 | - | B |
| | 16 | - | - | 1 | C |
| | 33 | 9 | - | 6 | C |
| Undetermined | 13 | 9 | - | 16 | C |

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Comint provided other information concerning these two missiles. It revealed, for example, that the research and development program of the [redacted] was essentially completed by February 1955. It also indicated that the [redacted] attained "an advanced stage of development" before the [redacted] and that, initially, the [redacted] probably attained a higher degree of reliability than the [redacted] But as launches of the [redacted] increased after January 1957, the ratio of successful launches, when compared to the number of operations, indicated a "greater firing efficiency..." than that attained by the [redacted] missile. Nevertheless, an over-all analysis of both missile programs indicated that a high degree of weapon-systems reliability was realized by both the [redacted] evidenced by the comparatively small number of cancellations and failures in both programs.

[redacted] revealed that still another missile was being tested [redacted] in this period. Referred to as the [redacted] the missile was launched to 150-nautical-mile distances. Comint later revealed the [redacted] to be a probable modification of the [redacted] missile. And, as noted previously, such Comint also revealed data concerning early test programs on the range of the [redacted] (SS-3), [redacted] (Korolev I--S-2), and [redacted] (Korolev II--S-2) missiles.

[redacted]

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In 1955, Comint revealed construction of the new Tyuratam range. This happening, in conjunction with the rapidly evolving Kapustin Yar range, caused the establishment within NSA of organizations specifically responsible for following this expanding Soviet effort.

The first of these organizations, the Guided Missile Branch of the Office of Exploitation (NSA-934), was established on 1 March 1955. Elevated to division status on 1 November 1955, it was redesignated as NSA-96.

In July of the following year, the problem was subdivided and placed in the Office of General Studies (GENS). The three Service Cryptologic Agencies--USASA, NAVSECGRU, and USAFSS--in agreement with NSA, controlled GENS-1, GENS-2, and GENS-3. The services were mainly concerned with indications of the deployment of operational missile systems or of other advanced weaponry by an individual Soviet military service.

On 1 November 19~~6~~58, the Advanced Weaponry and Astronautics Division, GENS-6, was created to follow Sigint developments concerning Soviet Bloc advanced weapons and space programs. The purpose of the move was to concentrate the responsibility for all phases of the Soviet Bloc space and special weapons programs, while leaving to the service divisions of GENS the responsibility for operational special weapons deployed by individual Soviet military services. Included in the mission of GENS-6 (also referred to as AWAD) were Soviet research, development, testing, and production in the advanced weapons and space fields, and, with the exception of those advanced weapons employed by an individual Soviet military service, searching for--and supporting the rest of GENS in the search for--the operational deployment of all advanced weapons.

GENS-6 was subdivided into five branches. The first, GENS-61 (formerly GENS-12), was responsible for the research and production aspects of advanced weaponry and astronautics—e.g., nuclear, biological,

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and chemical warheads and testing, missile systems, delivery vehicles, earth-satellite vehicles, scientific research and development, and the entire Soviet industrial complex, with emphasis placed on those plants, factories, installations, and other industrial or economic facilities and activities which may have been related to the Soviet special weapons and space program. Sections within GENS-61 included GENS-611, the Warhead Section; GENS-612, the Advanced Weaponry Production Section; GENS-613, the Scientific Section; and GENS-614, the Industrial Section.

Another subdivision, GENS-62 (formerly GENS-14), was labeled the Test Ranges Branch. It was established to report on testing programs at the various missile ranges and to study the relationships among them. [redacted] the Kapustin Yar Missile Test Range Section (GENS-622); the Vladimirovka-Lake
the Tyura Tam Missile Test Range Section (GENS-624);
Balkhash Test Range Section (GENS-623); and the Special Studies Section (GENS-625).

[redacted]

GENS-64, the Deployment Branch, studied special construction activity, air, shipping, and rail movements and logistics patterns, address systems, and other sources in an attempt to learn the locations of Soviet IRBM and ICBM launch sites and national-level warhead stock-piles. Under this division, GENS-641, the Net Analysis Section, was responsible for traffic analysis of Russian unidentified [redacted] links suspected of having special weapons significance. Other sections were GENS-642, the [redacted] Section, GENS-643, the Site Analysis Section, and GENS-644, the Logistics Section.

The last major organization within GENS-6, the Analytic Support Branch (GENS-65), [redacted] Additionally, GENS-65 was responsible for collecting information about U.S. missile test programs and production (and for the procurement of certain other collateral intelligence), to provide background data for use by the GENS-6 analytic branches. GENS-65 was divided into four sections--GENS-651 through GENS-654.

A research directorate was also established in GENS in this time period. It was responsible for all problems related to advanced weapons and astronautics, directing that portion of the research program of the other GENS divisions which were concerned with the space and special weapons fields. Specifically, the research directorate was responsible, in these fields, for the over-all research program of GENS, for the correlation of programs among the GENS divisions, and for ensuring that appropriate resources were allocated to those programs. Named the Advanced Weaponry and Astronautics Research Directorate (GENS/AWARD), the group was headed by the Chief, AWAD (GENS-6).

<u>PREAKNESS</u>

The launch by the Soviets of their first ICBMs in 1957, the imminence of ICBM production and deployment in the last 1950s, and indications of the strong effort the Soviets were placing on other missile programs, triggered additional actions within the intelligence community in attempts to keep pace. In this time frame, the United States Intelligence Board (USIB) was especially concerned with the lack of adequate intelligence concerning the locations and construction of operational launch sites, the manufacture and deployment of missiles, and the training of personnel required to launch deployed missiles. The organizational make-up of the missile forces, how they fit into the Soviet military establishment, and their command-and-control structure, were also of primary concern. To cope with these problem areas, expansion and refinement of Sigint collection and processing were deemed necessary, and USIB tasked NSA with devisi~~on~~NG ways to plan and implement appropriate programs.

A planning group, called Operation TOTEBOARD, was subsequently convened in NSA to respond to the USIB requirement. Meeting in April and May of 1959, its primary goal was the development of a plan which would permit the concentration of intercept efforts "to the saturation point" in likely target areas, while at the same time proportionally expanding processing, analytic, and reporting functions.

At [redacted] in June 1959 (called [redacted] recommendations of the TOTEBOARD group were reviewed in attempts to further refine the problem, discussions centering around the "saturation coverage" aspect and its effect on available collection resources. The elimination of duplicate coverage, and the assignment of available Sigint resources to certain targets that promised the best results, were extensively discussed at the Conference, laying the groundwork for a project called PREAKNESS.

[redacted] planning conference was held at NSA from 28 to 31 July 1959. Its main purpose was to find the communications of the Soviet operational strategic rocket forces by pursuing a few clues through a mass of unidentified traffic. The total Sigint effort was to be directed against the target, by combining Comint and Elint [redacted] to the maximum extent possible into one coordinated effort. [redacted] however, was not intended to provide solutions to early warning aspects of possible Soviet ICBM attack; rather, its primary goal was the isolation of target entities and the determination of the mechanics necessary to systematically target and develop relevant Sigint aspects.

The responsibility for managing the [redacted] project was vested in GENS, specifically in the AWARD staff. The AWARD group was also responsible for staff supervision of research and analysis projects. The responsibility for collection and support projects was given to GENS-02, the operations staff. Three covernames identified associated projects: (1) STEEPLECHASE, which was concerned with research and analysis projects directed against operational Soviet missile deployment, (2) DOPESHEET, which involved the development of support projects, such as working aids, and (3) FRONTRUNNER, which pertained to Sigint collection projects for target areas. [redacted]

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[7] For years it was debated whether or not telemetry was a form of communications or noncommunications, and, as such, should be subcategory of Comint or Elint. In an attempt to settle the matter, USIB, in 1959, proclaimed that telemetry would be "treated like Elint." But debate continued, fueled [redacted] And on 25 January 1973, DoD Directive S-3115.7, "Signals Intelligence," directed that, effective October 1973, Elint, Comint, and Telint would be treated as separate and distinct subcategories of Sigint.



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[redacted]

To be successful, it was recognized that [redacted] analysts would have to study and correlate massive amounts of data. Also, analytic studies would have to cross Soviet service lines to detect and follow developments of the over-all missile program. And new machine programs would be required to process huge, unprecedented volumes of material. Analytic problems to be anticipated and resolved would include: [redacted]

But even with a concentrated effort such as [redacted] by early 1961 Sigint information about the Soviet rocket forces make-up, deployment, training, production, etc., remained, for the most part, unrewarding. [redacted]

[redacted]

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[redacted]

Organizing the Telemetry Collection Effort[9]

After World War II the U.S. Government was aware of the basic nature of the radio telemetry that had been used by the Germans at Peenemunde in the test firings of the A 4 (V-2) missiles. This 16-channel telemetry system, called *Messina* by the Germans, was of the PPM/AM type. It was

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[9] Much of the information in this section, and in the preceding section [redacted] is taken from articles on these subjects in the Cryptologic Spectrum and the NSA Technical Journal. Entitled "Talomatry and How it Grew," the article in Spectrum was written by Mr. Melville J. Boucher. It appeared as a two-part article in the Fall 1971 and Winter 1972 issues, Vol. 1, No. 3, and Vol. 2, No. 1, respectively. The article in the Technical Journal, entitled [redacted]" was written by [redacted] It appeared in the Winter 1976 issue of the Journal, Vol. XXI, No. 1.

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believed to use frequencies in the five-meter band (60 MHz).[10] But the U.S., in subsequent tests of the V-2 at the White Sands Proving Ground in New Mexico, designed and used its own telemetry system, employing a different type of modulation and operating at higher frequencies than did the *Messina*. Consequently, in the years after the war little use was made of U.S. knowledge of the *Messina* system.

Also, in this time period, no national-level Elint effort existed until the summer of 1952, when the Army-Navy Electronics Evaluation Group (ANEEG) was established. However, the Elint of the day was almost totally radar-oriented. It had little interest in instrumentation-data systems. Too, the dominant interest of the U.S. cryptologic effort after the war concerned communications entities, and its collection efforts were directed mainly against the HF and lower bands. Comint, in this time period, was just beginning to become aware of VHF potentialities through the discovery of signals emanating from Soviet-operated, lend-lease-furnished multichannel equipments.

[redacted]

[redacted]



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[redacted]

NSA did not come into the telemetry picture officially until 1958, when the Agency's Comint mission was expanded to an over-all Sigint role.

[redacted]

In 1959, NSA assumed responsibility for ASA's telemetry analysis effort, including its analytic- and technical-support agreements with [redacted]

[11] U.S. Army Elint operations were officially subordinated to the Army Security Agency in November 1955, but the phasing-in process had not been completed by June 1956. USASA Comint operators provided tip-off information to the Elint personnel during the operation. [redacted]

contractors, giving the Agency a nucleus which would train and support a true in-house effort. During the same period, members of the joint-service Elint processing and collection support organization moved to NSA, rounding out the cryptologic capability.

NSA, in an attempt to organize the numerous entities attempting to exploit these signals, organized the Telemetry and Beaconry Analysis Committee (TEBAC) in the spring of 1960. TEBAC was, and is, one of the few organizations in which government analysts of member agencies, industrial contractors, and collaborating agencies meet to exchange analytic results, applying the best available expertise to the problem of finding out what these Soviet missiles and satellites are doing. TEBAC

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[redacted]

Along the way, NSA learned two lessons. First, it learned that adapting a "free" system can be as expensive as building your own from scratch, and less satisfactory. Second, it learned that SCA planners, R&D engineers, and people from PROD operational analysis and collection elements could work together effectively--in this case as a [redacted]--to translate national intelligence requirements into a working manpower and equipment system. This was NSA's first such across-the-board--collection, processing, deployment, manning, training, etc.--system-design effort, an approach which is taken for granted today but which was rather revolutionary at the time.

[redacted]

charged with producing a working system by 1965. But economy constraints again forced modifications to the plan. By cutting out some sites, using the two existing [redacted] systems, and trimming a number of technical features, budgetary limitations were met, and the first station became operational in 1965. Others followed, supplemented when necessary by mobile platforms of various kinds, to form a [redacted] network that brings in [redacted] on a worldwide basis.

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Later Developments (1961-1973)

On 1 July 1961, an internal NSA reorganization resulted in GENS-6 becoming A4. Labeled the Office of Advanced Weaponry and Astronautics, A4's mission called for the production of Sigint on all phases of the Soviet missile and space program. Included were such functions as following Soviet progress in the design, development, and testing of missiles, in the construction of launch facilities, and in the production of special weapons and space vehicles.

Although A4 was to be the focal point where Sigint resources would be directed against the Soviet missile program, to accomplish its objectives a wide variety of support was needed and obtained from other organizations in the Sigint establishment. Internally, A4 was supported in these early years, among others, by such organizations as C12, the Collection Facilities Division; C13, the Signals Conversion Division; C15, the Advanced Signals Analysis Division; C3, the Office of Central Reference; C4, the Office of Machine Processing; T1, the Office of Telecommunications; M61, the Communications Processing Division; M64, the Central Reproduction Services Division; and R3, R5, and R6, the Office of Radio Equipment Development, the Office of Analytic Equipment Development, and the Office of Special Program Management, respectively. Within A Group, assistance was obtained from A1, Soviet Ground Forces; A2, Soviet Naval Forces; A3, Soviet Air Forces; [redacted]

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A6, Soviet Technical Problems.

A4 itself was subdivided into three divisions. A41, the Soviet Missile Ranges and Space Vehicles division, concentrated on the Soviet test ranges, and in particular Tyurantam, Kapustin Yar, Sary, Shagan, and Vladimirovka. A42, the Soviet Rocket Forces division, had the job of following this Soviet strike organization, which is responsible for deploying MRBMs, IRBMs, and ICBMs. Three main objectives of the Sigint effort directed against this target were (1) determining the state of readiness of the SRF, (2) reporting changes concerning its state of readiness, and (3) identifying operational deployment sites. A43, the Atomic Energy and Missile Production division, had as its objective the determination of the design, production, and development of missiles and related systems. [redacted]

Additionally, various Sigint ground sites, located on the periphery of the USSR, were targeted against Soviet missile and space operations. Supplementing these Sigint ground-based sites were specially equipped Sigint airborne and shipborne platforms, along with facilities of other U.S. agencies and of the military services. Special efforts conducted by private contractors also contributed significantly to the over-all effort in these early years, and in particular in regard to technical studies conducted on Telint and Elint matters.

In 1961 and 1962, Admiral Frost, then Director of NSA, sent letters to various Government organizations soliciting their assistance in resolving certain technical problems--in particular those pertaining to Soviet missile- and space-related telemetry. Included were the National Aero-

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nautics and Space Administration (NASA), the Defense Atomic Support Agency (DASA), and the Army, Navy, and Air Force. The results of their assistance were "very beneficial to NSA and the over-all telemetry analysis effort."

In 1963, the new Director, General Blake, expanded this intra-government cooperation by consummating an agreement between NSA and the Air Force Systems Command for further "scientific and technical consultant support and services." During the same year, similar arrangements were made between NSA and the North American Air Defense Command (NORAD). And, as noted previously, the Telemetry and Beaconry Analysis Committee (TEBAC) was created in 1960. Chaired by NSA, its purpose is to bring together experts from the Government, the private sectors, and the collaborating agencies to study the problem and recommend solutions. Additionally, an NSA member and alternate member are appointed to attend meetings of the Guided Missile and Astronautics Intelligence Committee (GMAIC) of USIB. Meetings are held weekly or whenever deemed necessary by the Chairman. NSA is responsible mainly for contributing Sigint-derived information.

In 1963, the Deputy Secretary of Defense for Research and Engineering, in further attempts to insure that the best possible effort was being conducted against this high-priority target, levied a requirement on NSA to produce a summary of the Sigint programs directed against Soviet missile and space targets. NSA's response was to be part of the input to a DoD review group responsible for evaluating missile- and space-related intelligence. In particular, the review group wanted to insure that (1) collection was fully responsive and supported, (2) relevant "raw data" was made available rapidly to analytic elements in Defense and CIA, (3) analysts were of the highest caliber available, and (4) analytic results would be exchanged freely and rapidly between DoD and CIA. NSA's response, submitted to

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DoD in late 1963, recommended, among other things, the establishment of a Department of Defense Soviet Missile and Astronautics Center to be located at NSA. Although an NSA effort of this type was already in operation (NSA/SMAC), the Agency recommended that it be expanded to include personnel from DIA, noting that the end result would "improve the coordination of the planning for and tasking of all DoD collection" in regard to Soviet missile and space programs. Sharp enhancement of reporting concerning the Soviet missile and space program was also envisioned in the NSA response, and realized with the subsequent establishment of a joint NSA-DIA effort (DEF/SMAC).

In 1971, A4 became W1 in an internal NSA reorganization. And in 1973 a reorganization within Group W resulted in a new alignment of W1, and of other organizations and functions within Group W.

Labeled the Office of Space and Missiles, W1 is responsible for (1) analyzing and reporting Sigint on foreign space and missile systems, (2) furnishing the NSA operational element of DEF/SMAC, (3) furnishing trajectory and ephemeris support for all NSA elements, (4) analyzing and processing foreign missile and space signals, and (5) assuring tasking and supporting collection activities are directed effectively against foreign missile and space systems.

W1 is subdivided into a staff (W109) and five divisions. The first of these, the Collection Management and Current Reporting Division (W11), is responsible, among other things, for tasking space and missile collection entities, for providing tip-off, support, and control to DoD collection entities, for analyzing and reporting current space and missile data from foreign tests and operations, for developing and maintaining the data base for DEF/SMAC, for performing administrative support to DEF/SMAC, and for developing and coordinating special plans with DoD for missile- and space-event collection in coordination with the JCS and various DoD elements.

W14, the Space Division, is responsible for determining the producer, operators and users, the methods of operation, and the over-all technical capabilities of foreign space systems, by analyzing Sigint on these systems in coordination with other appropriate Sigint analysis groups. It is also responsible for reporting the resulting intelligence and for providing guidance to collection and processing elements.

W15, the Missiles Division, is responsible for analyzing and reporting Sigint on foreign missile systems and for providing guidance to collection and processing elements in coordination with other appropriate Sigint analysis groups.

The Trajectories and Ephemeris Division, W16, analyzes and reports Sigint based on trajectories and ephemerides of foreign missile and space vehicles. It is also responsible for developing tasking and supporting collection of Sigint tracking data, and for furnishing trajectory and ephemeris support to NSA elements.

The last organization under W1 is the Production Division, W17. Its functions include data extraction, conversion, and externals analysis of intercepted foreign missile and space instrumentation signals for distribution to the intelligence community. The preparation of technical feedback to appropriate collection systems is also its responsibility.

Other organizations within Group W also provide support, to varying degrees, to the Sigint missile and space effort. One, the Office of Elint (W2), is responsible for managing Elint processing, analysis, and reporting. Another, W3, the Office of Search, is responsible for discovering and analyzing new signals--and for reporting results. Still another organization, W4, the Office of Production Controls, advises and assists the Chief, W, in the general operation of the Group. And, as was the case with its predecessor organizations, W1, to accomplish its objectives, requires continuing support from a variety of other organizations, both within and outside the Sigint establishment.

## Conclusion

It can be seen from the foregoing chapter that the Sigint establishment, as was the case with the Soviets, was embarking on a new and unfamiliar field in these early years. Just as the Soviet missile program did not evolve instantly into a modern and sophisticated target, nor could the Sigint community be expected to suddenly attain maximum effectiveness against it. Both grew rather spasmodically in the beginning years, and both experienced successes and failures. And because of stringent security procedures practiced by the Soviets, the Sigint effort was forced, on more than one occasion, to react belatedly to Soviet missile programs, some of which were in relatively advanced stages of development when they were first discovered. Also, budget constraints, and time-lags in developing state-of-the-art equipment, ~~and~~ facilities, and systems, forced the Agency to make-do with less-than-optimum resources in these early years.

Starting virtually from scratch, NSA, and the other organizations involved in the collection and processing of missile and space signals, had to acquire and train employees, design and implement effective collection systems and facilities, find and isolate, in a maze of traffic, relevant aspects of the Soviet missile establishment, and streamline and refine processing and reporting capabilities. Huge amounts of data had to be

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acquired, processed, analyzed, and correlated, and difficult analytic problems had to be resolved. And, as telemetry, beaconry, data, voice, video, command and other signals became more and more complex in subsequent years, improved collection and processing systems and techniques were needed to keep the state of the cryptologic art equal to the challenge of this sophisticated Sigint target.