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Soviet Military Buildup in the 1970s

Pavel Podvig

The decline of détente in the second half of the 1970s and the subsequent deterioration of relations between the United States and the Soviet Union brought the nuclear arms race between the two countries to a particularly dangerous level. One of the key developments that shaped this slide to confrontation was the strategic modernization program that the Soviet Union undertook in the 1970s and the growing sense of vulnerability that it caused in the United States.[1] Largely as a reaction to the Soviet program, in the late 1970s and early 1980s, the United States launched a massive military buildup that was supposed to restore the balance and force the Soviet Union to restrain its military and political aspirations.

At the center of the Soviet Union's modernization effort was a substantial increase in the number of nuclear warheads carried on its intercontinental ballistic missiles (ICBMs). That increase was made possible by the deployment of multiple independently targeted reentry vehicles (MIRVs), which were not constrained by the SALT treaty (named after the Strategic Arms Limitation Talks), signed in 1972, and were only moderately limited by the follow-on agreement, SALT II, which the United States and the Soviet Union concluded in 1979. Combined with the Soviet Union's traditional reliance on its land-based ICBM force and the relatively large size of its missiles, the deployment of multiple warheads allowed the Soviet Union to overcome the United States in the size of the land-based leg of its nuclear triad. By the mid-1970s, the United States had completed deployment of its MIRVed missiles, the Minuteman III, and its ICBM force contained about 2,200 warheads.[2] Around this time the Soviet Union, which first deployed a MIRVed ballistic missile in 1974, had caught up with the United States and was adding about 500 warheads to its ICBM force annually. According to some intelligence projections, the Soviet Union was expected to have as many as 14,000 ICBM warheads by the mid-1980s.[3]

Although the United States maintained an advantage in the overall number of strategic nuclear warheads, as well as in other important areas (e.g., the survivability of its nuclear forces), it increasingly viewed the growing size of the Soviet ICBM force as a threat to the U.S.-Soviet strategic balance. Some measures of that balance appeared to demonstrate that the Soviet Union had a significant advantage that it could use to exert political pressure on the United States.[4] According to one of the arguments raised in the mid-1970s, the Soviet Union had an advantage in "residual potential"—that is, the combined throw weight of the strategic launchers remaining after an initial nuclear attack.[5] Although a number of U.S. experts questioned the relevance of this kind of measure, it nevertheless became a notable part of the public discussion in the United States.[6] Around 1976–77, the U.S. intelligence community adopted the use of measures based on residual potential.[7]

Over time, the argument about residual potentials and the U.S.-Soviet disparity in throw weight evolved into a more complicated discussion about the vulnerability of U.S. land-based ballistic missiles to a preemptive Soviet strike. In the late 1970s, the U.S. discussion of the strategic balance often assumed that "the Soviets will shortly have the theoretical capability to destroy about 90 percent of the U.S. ICBM force . . . by firing as few as 210 of their 1400 ICBMs."[8] This perceived vulnerability of U.S. land-based ICBMs gave rise to doubts about the effectiveness of U.S. deterrence, even though the two other components of the United States' strategic triad (and, to a large extent, the ICBMs that would survive an attack) had the capability to independently destroy "more than 70 percent of the Soviet economic value."[9] Critics of the SALT II treaty, which largely preserved the Soviet advantage in ICBM throw weight, argued that having lost the only component of the strategic triad capable of attacking Soviet ICBM silos, the United States would be unable to initiate a retaliatory strike against Soviet cities, because the Soviet Union would still have enough missiles to respond with an attack against U.S. cities. This perceived vulnerability significantly influenced the U.S. decision to seek a survivable counterforce capability made up of land-based missiles that would allow the U.S. military to launch a retaliatory attack against Soviet silos. Still, U.S. proponents of this new capability argued that from the early 1980s—when the Soviet Union was expected to deploy ICBMs that could target U.S. silos—to the mid to late 1980s—when the United States planned to field its new missiles—the United States would confront a dangerous "window of vulnerability," which the Soviet Union could exploit, if not to attack the United States then to challenge it on a range of international security issues, for example, by seeking to expand its area of influence.[10]

Even assuming that the Soviet Union had the theoretical capability to destroy the U.S. ICBM force, there was still the question of whether the Soviets could take advantage of it. Given the highly uncertain outcome of such an attack and the formidable deterrent potential of the U.S. strategic nuclear force, this theoretical capability probably could not have produced tangible political gains.

Nevertheless, an influential group of experts and politicians in the United States, many of whom were associated with organizations such as the Committee on the Present Danger, argued that the Soviet modernization program proved that Moscow was striving to obtain a first-strike capability against U.S. forces.[11] This view figured prominently in a report written by a panel known as "Team B," which was formed in 1976 to provide an alternative assessment of U.S. intelligence data on the subject.[12] The conclusions of the panel influenced U.S. intelligence estimates of Soviet strategic intentions. According to these estimates, the Soviet Union "reject[ed] U.S. notions of strategic stability and sufficiency" and perceived mutual assured destruction as "neither desirable nor a lasting basis for the U.S.-Soviet relationship." The goal of the Soviet Union, U.S. intelligence reported, was to "fight, survive, and win a nuclear war."[13]

Although the Soviet Union denied that the purpose of its modernization program was to acquire a counterforce capability or to achieve military advantage, its protests had virtually no impact on the debate in the United States. Some experts in the United States did, however, question the alarmist interpretation of the Soviet program or point out that because of the uncertainties associated with any nuclear attack, it would be impossible for the Soviet Union to take advantage of its alleged counterforce potential.[14] Nevertheless, the issue of the United States' "window of vulnerability" achieved prominence on the U.S. political agenda in the late 1970s and early 1980s, opening the way for the United States to launch its own strategic modernization effort, which included development of the MX ICBM and Trident II sea-launched ballistic missile, and eventually the Strategic Defense Initiative missile defense program.

Evaluation of the motives behind the Soviet modernization program of the 1970s has always been a difficult task. Testimonies of senior Soviet military officers involved in military planning in the 1970s and 1980s, collected after the end of the Cold War, strongly supported the view that the Soviet Union did not seek a first-strike or war-fighting capability for its strategic forces.[15] To be convincing, however, such testimonies require corroboration, including documentary evidence on the direction of the Soviet Union's missile development efforts, as well as on technical details of its missile programs, in particular details about the accuracy of its missiles, warhead yields, and the hardness of its silos. Although there have been publications that describe some of these aspects, most of their relevant data were taken largely from U.S. sources.[16]

This situation has recently changed, as archival documents of the Soviet period have become available for the first time.[17] These documents, combined with information from other sources, such as official historical accounts published by various design bureaus within the Soviet defense complex and by the military, allow a reconstruction of key developments in the Soviet strategic modernization programs of the 1970s and 1980s. This essay introduces this new evidence and discusses some of its implications for the analysis of Soviet capabilities and intentions at the time.

Capabilities of the Soviet ICBM Force

The main contours of the Soviet modernization program in the 1970s were determined during an intense debate in the late 1960s to early 1970s, known as the "small civil war," in which the Soviet Union's military, industrial, and political leadership had to make a number of fundamental decisions regarding the country's nuclear strategy—decisions that would determine the shape of its strategic forces for more than a decade. The focus of the debate was on whether the Soviet Union should continue to maintain the force of vulnerable missiles that it had built in the 1960s, effectively restricting itself to a first strike posture, or whether it should move toward the deployment of more survivable missiles, as required by strategies based on retaliation. The outcome of the debate was a decision to concentrate on the deployment of multiple-warhead missiles in hardened silos that would provide the Soviet Union a second-strike capability.[18]

The modernization effort would involve three types of MIRVed ICBMs—the MR UR-100 (SS-17), the UR-100N (SS-19), and the R-36M (SS-18). These missiles carried four, six, and eight independently targeted warheads, respectively.[19] In addition, the Soviet Union would deploy UR-100K and UR-100U missiles, which were moderate upgrades of the original UR-100, deployed in the 1960s. Most of these missiles carried multiple, but not independently targeted, warheads.[20] The Soviet Union also kept a small number of solid-propellant single-warhead RT-2 (SS-13) missiles.[21] Table 1 shows the changes in the composition of the Soviet ICBM force after 1970: by 1978–79, when the Soviet Union had completed the first wave of its MIRVed missile deployment, its ICBM force included almost 500 multiple-warhead ICBMs, which carried more than 3,000 warheads.

Table 1. Soviet ICBM Force, 1970-90.

System	WH	Yield, MT	1970	1971	1972	1973	1974	1975	1976

R-36	1	20	162	202	202	210	210	202	173
	1	8.3	46	46	46	46	46	46	43
	1	6.9	12	12	12	12	12	12	12
R-36orb	1	2.3	12	18	18	18	18	18	18
R-36M	8	4x1.0 +4x0.4					10	16	56
	10	0.4							8
	1	20							16
R-36MUTTH	10	0.5							
	1	20							
R-36M2	10	0.8							
RT-2	1	0.43	40	40	60	60	60	60	50
RT-2P	1	0.8							10
UR-100N	6	0.4						60	90
UR-100NUTTH	6	0.4							
MR UR-100		0.4						10	50
MR UR-100UTTH		0.5							
Perimeter[d]									
UR-100	1	?	982	990	955	830	610	390	350
UR-100K	1	1				75	200	200	200
	3	0.22						150	220
UR-100U	3	0.22						100	120
RT-23UTTH silo	10	0.4							
RT-23UTTH rail	10	0.4							
Topol	1	0.8							
Total			**1,254**	**1,308**	**1,293**	**1,251**	**1,166**	**1,264**	**1,416**

System	**WH**	**Yield, MT**	**1977**	**1978**	**1979**	**1980**	**1981**	**1982**	**1983**
R-36	1	20	122	62+ (60)[a]	(60)[a]				
	1	8.3	40	10					
	1	6.9	12						
R-36orb	1	2.3	18	18	18				
R-36M	8	4x1.0 +4x0.4	104	136	148	148	106	52	
	10	0.4	8	10	10	10			
	1	20	22	30	30	30	30	30	30
R-36MUTTH	10	0.5			60	120	172	226	278
	1	20							
R-36M2	10	0.8							
RT-2	1	0.43	40	30	20				
RT-2P	1	0.8	20	30	40	60	60	60	60
UR-100N	6	0.4	140	170	190	190	190	190	
UR-100NUTTH	6	0.4			20	110	110	140	330
MR UR-100		0.4	80	110	120	120	80	40	10
MR UR-100UTTH		0.5							
Perimeter[d]									
UR-100	1	?	270	210	100+ (90)[a]	100[b]	100[b]	100[b]	100[b]
UR-100K	1	1	200	200	200	200	200	200	200
	3	0.22	220	220	220	220	220	220	220
UR-100U	3	0.22	120	120	60	60	60	30	30
RT-23UTTH silo	10	0.4							
RT-23UTTH rail	10	0.4							
Topol	1	0.8							
Total			**1,416**	**1,416**	**1,416**	**1,398**	**1,398**	**1,398**	**1,398**

System	**WH**	**Yield, MT**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**
R-36	1	20							
	1	8.3							
	1	6.9							
R-36orb	1	2.3							
R-36M	8	4x1.0 +4x0.4							
	10	0.4							
	1	20	30	30					
R-36MUTTH	10	0.5	278	278	278	278	268	238	220
	1	20			30	30	30	30	30
R-36M2	10	0.8					10	40	58
RT-2	1	0.43							
RT-2P	1	0.8	60	60	60	60	60	60	40
UR-100N	6	0.4							
UR-100NUTTH	6	0.4	360	360	360	360	350	300	300
MR UR-100		0.4							
MR UR-100UTTH		0.5	140	140	140	130	110	90	37
Perimeter[d]			10[c]	10[c]	10[c]	10[c]	10[c]	10[c]	10[c]
UR-100	1	?	100[b]						
UR-100K	1	1	200	248	248	248	248	248	248
	3	0.22	220	172	172	130	122	112	78
UR-100U	3	0.22							
RT-23UTTH silo	10	0.4					20	56	56
RT-23UTTH rail	10	0.4				3	12	24	33
Topol	1	0.8		99	99	149	158	190	288
Total			**1,398**	**1,397**	**1,398**	**1,398**	**1,398**	**1,398**	**1,398**

SOURCE: Figures are drawn from Vitalii Leonidovich Kataev, papers, 10 boxes, Hoover Institution, Stanford University, box 8, doc. 13.8. Older ICBMs are not shown. [a] Silos are undergoing reconstruction. [b] Missiles are deployed without warheads. [c] Only six out of ten missiles are Perimeter missiles. [d] MR UR-100UTTH missiles.

Although the numerical composition of the Soviet force was well known to U.S. intelligence, the capabilities of the deployed missiles were much harder to assess. Gradually, the question of the counterforce potential of the new force became increasingly contentious among U.S. analysts. Different assumptions about the accuracy of the Soviet missiles and therefore their ability to attack hardened targets, or about the ability of Soviet silos to withstand a U.S. attack, led to dramatically different conclusions about the intent of the Soviet military buildup.

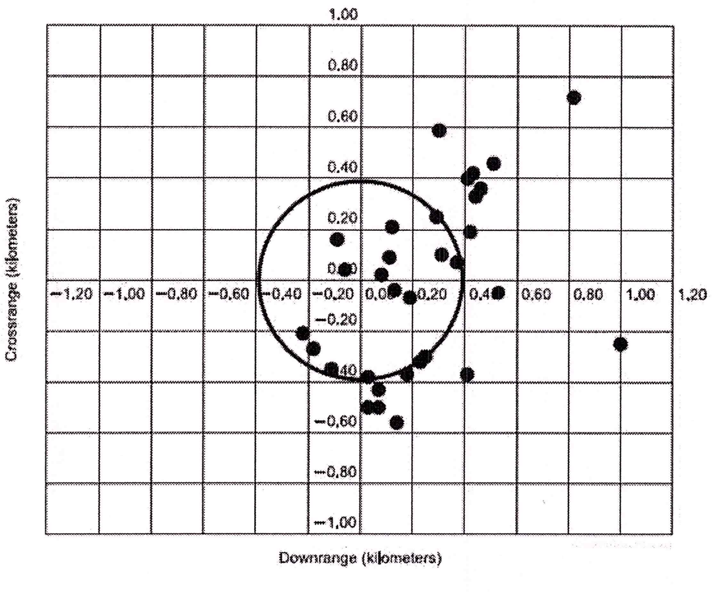
When the Soviet Union began deploying its first MIRVed ballistic missiles in 1974, the consensus of the U.S. intelligence community was that the accuracy of these missiles, though better than those deployed in the 1960s, was no greater than about 0.25 nautical miles (470 meters) circular error probable (CEP). At that time, the U.S. intelligence community estimated that the Soviet Union could improve the accuracy of its next generation of missiles, to be deployed in the early 1980s, to 0.15 nautical miles (280 meters).[22] These estimates meant that the Soviet Union did not have a significant counterforce capability and likely would not achieve one until the mid-to-late 1980s.

This consensus was challenged by the Team B panel, which had been charged with evaluating the Soviet missiles' accuracy as part of its mandate. Although the U.S. intelligence community initially contested the conclusions of the panel, National Intelligence Estimates (NIEs) issued after 1976 generally assumed a higher level of accuracy (about 400 meters) for the first-generation of Soviet MIRVed missiles.[23] The revised estimate of the missiles' accuracy from 470 meters to 400 meters was not a significant change in itself, for it did not fundamentally alter the estimate of the counterforce capability of the Soviet ICBM force. Combined with other developments, however, this revision proved highly consequential.

One development was the apparent change in the timeline of the Soviet missile modernization program. In October 1977 the Soviet Union began flight tests of the modified versions of its SS-18, SS-19, and SS-17 missiles with "improved tactical-technical characteristics." These versions were known as the R-36MUTTH, the UR-100NUTTH, and the MR UR-100UTTH, respectively.[24] The U.S. intelligence community apparently considered these to be modernized versions of missiles that were not expected to arrive until the early-to-mid-1980s. Accordingly, U.S. intelligence estimated that the "UTTH" missiles had achieved a level of accuracy of 0.12–0.15 nautical miles (220–280 meters).[25]

Improved accuracy was indeed a main goal of the "UTTH" modernization program. According to Russian sources, most of the improvements were concentrated on the post-boost vehicle and the missile guidance system. Missile frames were almost unaffected, although the number of warheads carried by the R-36MUTTH missile increased from 8 to 10.[26]

Figure 1. Results of Flight Tests of the MR UR-100UTTH (SS-17 Mod 3) Ballistic Missile



SOURCE: Data drawn from Vitalii Leonidovich Kataev, papers, 10 boxes, Hoover Institution, Stanford University, box 8, doc. 13.8, p. 46.
NOTE: Figure shows miss distances of individual warheads. Radius of the circle is equal to the circular error probable as demonstrated in this series.

The Soviet modernization program did result in improved missile accuracy, but it remained significantly lower than in U.S. estimates. Figure 1 shows the results of flight tests of the MR UR-100UTTH missile, which indicate that the CEP, demonstrated in the test series, was about 400 meters. The R-36MUTTH and UR-100NUTTH missiles demonstrated similar performances.[27] Based on the results of these tests, Soviet military planners estimated that the accuracy of the

"UTTH" missiles was 350–400 meters. These values, as well as the accuracies of other Soviet ICBMs, are presented in Table 2, along with data on the yield of the missiles' warheads.[28]

Table 2. Characteristics of Soviet Ballistic Missiles Deployed in the 1970s and 1980s.

System	Beginning of development	Years in service	Warheads per missile and warhead yield	Accuracy (CEP), km
UR-100K	1969	1971-1991	1x1Mt 3x0.22Mt MRV	0.96 MRV: 1.2
UR-100U	1970	1974-1980	1x1Mt 3x0.22Mt MRV	0.96 MRV: 1.1-1.2
RT-2, RT-2P	1968	1972-1991	1x0.8Mt	1.8
Temp-2S	1969	(1976)	1x0.8Mt	1.0
MR UR-100	1970	1975-1983	4x0.4Mt	0.7
MR UR-100UTTH	1976	1979-1994	4x0.5Mt	0.35-0.43
R-36M	1969	1974-1983	1x20Mt 4x1Mt+4x0.4Mt 10x0.4Mt	0.7
R-36MUTTH	1976	1979-present	1x20Mt 10x0.5Mt	0.37
R-36M2	1983	1988-present	1x8.3Mt (1x20Mt) 10x0.8Mt (4x0.8Mt+ 6x0.15Mt GRV[a])	0.22 (GRV: 0.08-0.13)
UR-100N	1970	1975-1983	1x5.3Mt 6x0.4Mt	0.65
UR-100NUTTH	1976	1979-present	6x0.4Mt	0.35-0.43
RT-23 silo (15Zh44)	Single warhead: 1976 MIRV: 1979	Canceled in 1983	1x3.4Mt	0.3
RT-23 rail (15Zh52)	1979	1983-2002	(1x3.4Mt) 8x0.32Mt	0.35-0.43
RT-23UTTH silo (15Zh60)	1983	1987-2001	10x0.4Mt	0.22
RT-23UTTH rail (15Zh61)	1983	1988-2005	10x0.4Mt	0.3-0.35[b]
Topol	1977	1985-present	1x0.8Mt	0.35-0.43
Kurier	1983	Canceled in 1991	1x0.5Mt	0.35-0.43
Topol-M silo	1989[c]	1997-present	1x??Mt	n/a
Topol-M road	1989[c]	2006-present	1x??Mt	n/a

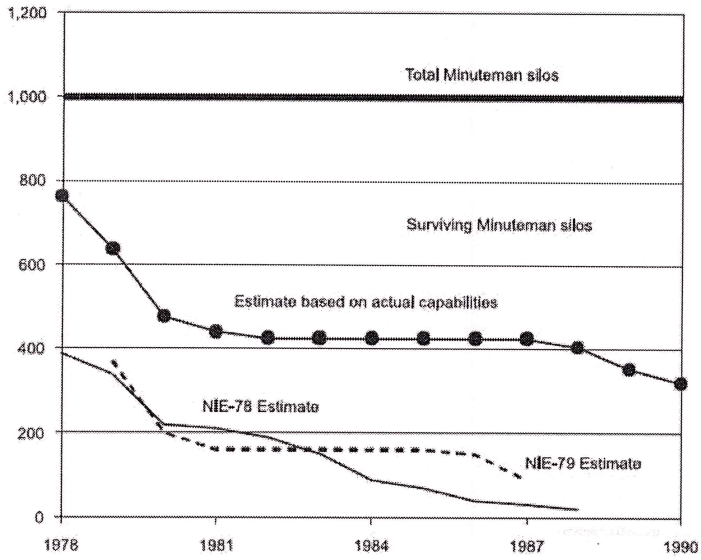
SOURCE: Figures drawn from Vitalii Leonidovich Kataev, papers, 10 boxes, Hoover Institution, Stanford University, box 8, doc. 13.8, pp. 34, 37, 60.

NOTE: Systems and modifications that were never deployed are in parentheses. [a] GRV—reentry vehicle with terminal guidance. [b] This may be an early estimate of the accuracy of the missile. The actual accuracy may be comparable to that of the silo-based version of the RT-23UTTH (SS-24) missile. [c] As RT-2PM "Universal."

As the data indicate, the U.S. estimates significantly overestimated the accuracy that Soviet missiles were able to demonstrate in the late 1970s and early 1980s. The Soviet Union did indeed develop missiles with accuracies as high as 220 meters, but these missiles—the R-36M2 (SS-18 Mod 5) and the RT-23UTTH (SS-24)—were not deployed until 1988. In fact, the Soviet Union had not made the decision to proceed with the development of these two missiles until 1983.

U.S. estimates of the accuracy of the Soviet missiles had a direct effect on the projections of the counterforce potential of the Soviet ICBM force. Figure 2 shows projections made by the U.S. intelligence community in 1978 and 1979 of the number of Minuteman silos that could survive a two-on-one Soviet attack.[29] These estimates remained largely unchanged in the early 1980s; for example, in 1981 an NIE reported that "in a well-executed strike Soviet ICBMs would have the potential—using two RVs [reentry vehicles] against a Minuteman silo—to achieve a damage expectancy of about 75 to 80 percent today, and about 90 percent by the mid-1980s."[30] Figure 2 offers a comparison of these estimates, with the estimate of the missiles' actual capability that takes into account the data on accuracies and yields presented in table 2, as well as the actual composition of the Soviet ICBM force.[31] As Figure 2 demonstrates, only in 1991 did the Soviet Union barely reach the counterforce capability that the U.S. intelligence community reported it had achieved a decade earlier.

Figure 2. Counterforce Capabilities of the Soviet ICBM Force (2-on-1 attack. U.S. projections vs. estimated actual capability)



Vulnerability of the Soviet ICBM Force

Another important element of the Soviet Union's missile modernization program in the 1970s was the hardening of its missile silos, which was designed to improve the missiles' capability to withstand a nuclear attack. Although not directly related to the counterforce capability of the ICBM force, silo hardness influenced the strategic balance estimates of the late 1970s indirectly, through calculations of the residual potentials of Soviet and U.S. forces that could survive a first counterforce strike.[32] According to U.S. intelligence estimates made in 1978, about 650 of the Soviet Union's 1,400 silo-based ICBMs could have survived a U.S. first strike, with this number gradually increasing throughout the 1980s. U.S. intelligence data projected that by 1988 the total number of Soviet silos would decrease to about 1,250, of which about 670 could withstand a two-on -one attack. The same estimate projected that by 1988 no more than about 17 of the United States' 1,000 silo-based ICBMs could survive a two-on-one strike, painting a picture of alarming disparity. [33]

The Soviet Union did invest significant resources into hardening its ICBM silos, but its goal was relatively modest. Table 3 lists the distribution of silos by hardness and missile type in 1979 and in 1985: silos of UR-100 (SS-11) and R-36 (SS-9) missiles, which constituted the core of the Soviet ICBM force in the late 1960s and early 1970s, were extremely vulnerable, with their hardness not exceeding 30 pounds per square inch (psi). By 1979, about 40 percent of the Soviet Union's 1,400 silos remained "soft." Of the more than 800 silos that had undergone refurbishing, only about 330 were hardened to withstand 100 atm (1,500 psi), while the remaining 480 were hardened to 30 atm (450 psi) and 60 atm (900 psi). These figures differ dramatically from the U.S. estimates, which put the hardness of the Soviet missile silos at 5,000 psi and even 15,000–25,000 psi.[34]

Table 3. Number of Soviet ICBM silos by hardness, 1979 and 1985

System and silo hardness	1979	1985
100 atm (1,500 psi)		
R-36M	54	-
R-36MUTTH	120	204
UR-100NUTTH	110	170
MR UR-100	20	
MR UR-100UTTH	30	50[a]
Total 100 atm	**334 (24%)**	**424 (31%)**
60 atm (900 psi)		
R-36M	104	-
R-36MUTTH	-	104
UR-100N	110	-
UR-100NUTTH	-	110
MR UR-100	70	-
MR UR-100UTTH	-	70
Total 60 atm	**284 (20%)**	**284 (20%)**
30 atm (450psi)		
R-36M	30	-
UR-100N	80	-
UR-100NUTTH	-	80
MR UR-100	30	-
MR UR-100UTTH	-	30
UR-100U	60	-
Total 30 atm	**200 (14%)**	**110 (8%)**
10 atm (150 psi)		
RT-2P	60	60
2 atm (30 psi)		

UR-100	100	80[b]
UR-100K	420	420
Total 10 atm and 2 atm	**580 (41%)**	**560 (41%)**
Total number of silos	1,398	1,378

SOURCE: Figure drawn from Vitalii Leonidovich Kataev, papers, 10 boxes, Hoover Institution, Stanford University, box 8, doc. 13.8, p. 48. [a] Ten are Perimeter silos. [b] Missiles deployed without warheads.

Even though a substantial number of its missiles were deployed in soft silos, by 1979 the Soviet Union could expect that more than 200 of its MIRVed missiles could survive a U.S. first strike. The total number of ICBMs available for a retaliatory strike was about 300—still substantial, but about 40 percent lower than the U.S. intelligence estimate. This number would steadily decline after 1979, as the United States began introducing more accurate missiles with higher-yield warheads.

The Soviet Union continued its silo-hardening program after 1979, with the deployment of the "UTTH" generation of MIRVed missiles. This program did not, however, result in significant changes in the number of hardened silos or in the level of protection. In 1985 less than one-third of the silos were hardened to 1,500 psi, and 40 percent were hardened to 150 psi or less. According to Soviet plans from 1985, all silos were to be reinforced to the level of 100 atm (1,500 psi) in the 1990s, but it appears that these plans were not implemented.[35]

As these data show, the U.S. "window of vulnerability" did not exist. The Soviet ICBM force never had the capability to destroy most of the U.S. Minuteman force in a counterforce strike. The residual potential of the Soviet ICBM force, and therefore the Soviet Union's ability to use its advantage in missile throw weight to implement various war-fighting strategies, also was seriously exaggerated.

Soviet Intentions

Did the United States correctly assess the Soviet Union's intentions in launching its modernization program? An argument can be made that even though U.S. intelligence overestimated the capabilities of the Soviet strategic forces, the judgment about Soviet intentions may have been correct. The documentary evidence, however, strongly contradicts this interpretation of the Soviet program.

The U.S. estimates of the Soviet Union's intent were largely based on the scale of the Soviet missile buildup in the 1970s. For example, the 1977 NIE concluded that "neither the creation of an acknowledged Soviet deterrence nor the achievement of acknowledged rough equivalence has caused any observable reduction in the trend and vigor of the Soviet program."[36] The U.S. intelligence community observed that the Soviet military programs "have grown at a more or less steady pace for two decades," a trend that it expected would continue.[37]

The increase in the number of missile warheads in the Soviet arsenal was indeed substantial. Yet, this increase was a direct result of decisions to deploy multiple-warhead missiles, which was motivated primarily by the need to expand the number of warheads that would be available in a retaliatory strike. Furthermore, the decision to proceed with three specific MIRVed systems—the MR UR-100 (SS-17), the R-36M (SS-18), and the UR-100N (SS-19)—was made largely to satisfy the design bureaus and to minimize the cost of silo conversion, which was apparently the main factor in limiting the systems' deployment.[38] This established the basic structure of the Soviet ICBM force and set the pace as well as the limits of its growth.

According to plans developed during the "small civil war" debate of the late 1960s to the early 1970s, the Soviet Union wanted to increase its number of ICBM warheads to 6,200–6,500 by the early 1980s and to maintain that level throughout the decade.[39] U.S. intelligence, on the other hand, projected constant growth and predicted in 1981–82 that the Soviet Union would deploy about 10,000 ICBM warheads by 1988.[40] This figure, which assumed that the Soviet Union would not comply with the SALT II treaty, indicates that the United States did not understand the Soviet program. Documents suggest that the program was driven primarily by internal inertia, not by an effort to go beyond acknowledged rough equivalence with the United States. Similarly, the scale of the Soviet ICBM program was limited by internal factors and not necessarily by constraints imposed by arms control agreements.[41]

The Soviet Union's intent in the area of qualitatively improving its ballistic missile force—that is, MIRVing its ICBMs, improving their accuracy, and hardening their silos—is somewhat harder to judge. Substantial investment in these areas might indeed suggest the intent to build a missile force capable of a first counterforce strike. The documentary evidence strongly suggests, however, that the Soviet modernization program in the 1970s concentrated on measures that would increase the retaliatory capability of the missile force, not its potential.

First, the Soviet Union paid special attention to ensuring that the newly deployed missiles could operate after being subjected to a nuclear attack. A program that provided this capability was part of every new Soviet missile development effort.[42] This included hardening missile silos against the physical effects of a nuclear blast, as well as improving the radiation hardness of ballistic missiles and their warheads.[43] Guidance systems that were developed in the 1970s were designed to support missile launch after a nuclear attack on the silo.[44]

In 1976 the Soviet Union initiated a program aimed at hardening its strategic launchers, warheads, and silos against the radiation effects of nuclear weapons.[45] As part of this program, in the late 1970s the Soviet Union conducted a series of nuclear tests that examined the radiation hardness of the missile bodies, warheads, electronics of its guidance systems, and basic electronic equipment.[46] The results of these tests identified electronic components as a weak point, which led the Soviet Union to initiate a large-scale program in the early 1980s targeted at improving the radiation hardness of the missiles' electronics.[47] This work involved redesigning the missiles' guidance systems, which proved to be a costly and complex task, mostly because of the inferior performance of the radiation-hardened components and their lower reliability.[48] The work was largely completed by 1985–86, and the missiles developed in the mid-1980s used radiation-hardened electronic components.

Moreover, Soviet missiles that were developed in the 1980s were also required to be hardened against the mechanical effects of a nuclear explosion, so that they could perform successful launches when adjacent silos were attacked or when the launch area was subjected to a disabling high-altitude nuclear explosion.[49] This was an important part of both of the Soviet Union's silo-based missile development programs of the 1980s, involving the RT-23UTTH and R-36M2.[50]

Second, realizing the limits of silo hardening, the Soviet Union launched its mobile missile development program. The significant attention that this program received throughout the 1970s and 1980s, despite a number of serious setbacks, provides strong evidence of the emphasis on survivability. Early Soviet attempts to build a mobile ICBM that could be transported on either a truck or a rail car date to the 1960s. The first such missile considered for deployment was the Temp -2S (SS-X-16), whose development began in 1969. In the mid-1970s, the Soviet Union planned to deploy about 260 of these single-warhead missiles by 1985.[51] The missile was not considered satisfactory, however, and the Soviet Union agreed to eliminate it during the SALT II negotiations.

Nonetheless, the Soviet Union continued with its other mobile missile development programs; the Topol (SS-25) road-mobile missile program began in 1977, and the RT-23 (SS-24) railroad-based missile began development in 1979.[52] Both systems were high-priority projects. The Topol missile was first flight-tested in 1983, and began deployment in 1985. Work on the RT-23 continued despite significant technical difficulties. In 1983, however, the RT-23 was replaced by the RT-23UTTH (SS-24), which was eventually deployed in silos and as part of a railroad-mobile system in 1987-88.[53]

Finally, in addition to missiles that could operate in a nuclear environment, the Soviet Union wanted to develop a command and control system and an early-warning system that would allow it to execute a retaliatory strike while under attack or after withstanding an attack. Soviet development of an automated command and control system dates to the late 1960s, but most of the work was done in the 1970s.[54] This system included a number of important components—the Signal-M system, which provided a high degree of automation in commanding the ICBM force; systems that provided proper authorization from the leadership; and communication systems designed to provide the required redundancy in the event of a nuclear attack.[55]

The concentrated effort to build an early-warning system began in the early 1970s. By the end of the decade, the Soviet Union had completed deployment of a network of first-generation early-warning radars.[56] Construction of new, large, Daryal-type phased-array radars was under way, with the first radars in Pechora and Gabala expected to be operational by the early 1980s.[57] Another important element of the early-warning system—satellites that could detect missiles shortly after launch—was also in the last stages of development. Limited operations of that system began in 1978, and it was operationally deployed in 1982.[58]

Compared to the programs aimed at increasing the survivability of its missiles, the Soviet Union's efforts to strengthen the counterforce potential of its ICBM force were relatively modest. Although improvement of missile accuracy was part of the modernization program of the 1970s, the available evidence suggests that it was not a high priority. For example, in the late 1970s the Soviet Union was developing a guided reentry vehicle that would have significantly improved the accuracy of its ballistic missiles.[59] Sometime in 1977–79 it apparently considered deployment of guided warheads.[60] These plans were not implemented, however, and none of the missiles deployed in the late 1970s and early 1980 carried guided warheads. It is unlikely that the Soviet Union would have canceled this project had it been pursuing a counterforce capability.[61]

Overall, this analysis of the Soviet Union's missile modernization program of the 1970s strongly suggests that its main goal was to build a strategic force that could survive a nuclear strike or launch a retaliatory strike while under attack. Nothing in the documents or in the details of the individual programs suggests that a first strike against the United States was an objective.

Conclusion

The Cold War was a complex phenomenon that cut across virtually every aspect of the U.S.-Soviet relationship. It would therefore be wrong to assume that issues related to strategic nuclear weapons were solely responsible for the changes in the course of the confrontation. At the same time, these issues often played a central role, and the decisions about strategic nuclear forces, whether made in the United States or in the Soviet Union, were highly consequential. The legacy of the Cold War remains, in the thousands of nuclear weapons deployed by Russia and the United States and the host of nuclear proliferation problems that were inherited from that time or that emerged more recently. Understanding the dynamics and the driving forces of the Cold War nuclear confrontation would facilitate the two countries' ability to tackle the problems confronting us today.

The data presented here demonstrate that concerns about the U.S. "window of vulnerability," which figured so prominently in U.S. political discussions of the Soviet Union's missile modernization program in the late 1970s and early 1980s, were unjustified. Contrary to the perception that existed at the time, the program did not have the potential to pose a serious threat to U.S. strategic forces. The evidence also strongly suggests that the Soviet Union had neither a plan nor the capability to fight and win a nuclear war.

This is not to say that the Soviet military programs were benign or that the Soviet Union did not strive for military or political advantage, or at least parity with the United States. As documentary evidence of the Soviet programs continues to emerge, however, it is becoming increasingly clear that the Soviet military buildup was driven primarily by the inertia of the military industrial complex and by a lack of mechanisms to contain the country's military programs. Political and ideological considerations also played a role, but that role was limited at best.

Overall, the data presented in this essay provide important new details about the Soviet Union's strategic nuclear forces, facilitating scholarly understanding of one of the key episodes of the Cold War. This information should spur better understanding of U.S. and Soviet national security policies and force a critical look at the strategies the United States adopted to deal with the Soviet Union during that crucial period.

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[1] For a detailed history of that period, see Raymond L. Garthoff, *Détente and Confrontation: American-Soviet Relations from Nixon to Reagan*, rev. ed. (Washington, D.C.: Brookings Institution Press, 1994).

[2] For the data on U.S. forces, see Natural Resources Defense Council, Archive of Nuclear Data: NRDC's Nuclear Program, http://www.nrdc.org/nuclear/nudb/datainx.asp.

[3] This was the high projection made in the 1974 National Intelligence Estimate. The low projection made that year was in the range of 7,000 ICBM warheads. Projections made in 1975-79 predicted 6,500-9,000 ICBM warheads. Directorate of Intelligence, "Intelligence Forecasts of Soviet Intercontinental Attack Forces: An Evaluation of the Record," Research Paper (Washington, D.C.: CIA, April 1989), p. 8.

[4] For example, Secretary of Defense Rumsfeld in his posture statement for 1978 stated, "The Soviets give evidence of moving toward a fundamental shift in the 'correlation of forces' that would give them peacetime and crisis leverage over the United States." Quoted in John Prados, *The Soviet Estimate: U.S. Intelligence Analysis and Soviet Strategic Forces* (Princeton, NJ: Princeton University Press, 1986), p. 254.

[5] Paul H. Nitze, "Assuring Strategic Stability in an Era of Détente," *Foreign Affairs*, Vol. 54, No. 2 (January 1976), pp. 207-232 and Paul H. Nitze, "Deterring Our Deterrent," *Foreign Policy*, No. 25 (Winter 1976-77), pp. 195-210.

[6] For a discussion of the concept of residual potentials, see Jan M. Lodal, "Assuring Strategic Stability: An Alternative View," *Foreign Affairs*, Vol. 54, No. 3 (April 1976), pp. 462-481. For a critical analysis of the residual potential methodology, see Garry D. Brewer and Bruce G. Blair, "War Games and National Security with a Grain of SALT," *Bulletin of the Atomic Scientists*, June 1979, pp. 18-26.

[7] For example, the National Intelligence Estimate (NIE) issued in 1978 stated that "the trends in total remaining forces and destructive potential are highly relevant to the deterrence, strategic capabilities, and perceptions." Central Intelligence Agency, "Soviet Capabilities for Strategic Nuclear Conflict Through the Late 1980s, Vol. 1: Summary Estimate," NIE 11-3/8-77 (Washington, D.C.: CIA, February 1978), p. 36.

[8] Warner R. Schilling, "U.S. Strategic Nuclear Concepts in the 1970s: The Search for Sufficiently Equivalent Countervailing Parity," *International Security*, Vol. 6, No. 2 (Fall 1981), p. 69.

[9] Central Intelligence Agency, "Soviet Capabilities for Strategic Nuclear Conflict Through 1990, Volume 1 – Summary Estimate," National Intelligence Estimate NIE 11-3/8-80 (Washington, D.C.: CIA, December 16, 1980), p. B-15.

[10] For an overview of the issues involved, see Lawrence Freedman, *The Evolution of Nuclear Strategy*, 3rd ed. (New York: Palgrave Macmillan, 2003), pp. 369-377. The "window of vulnerability" issue was put to rest only in 1983 by the Scowcroft commission, which reported that a disarming Soviet attack was virtually impossible and recommended deployment of MX missiles in existing Minuteman silos. Scowcroft Commission, "Report of the President's Commission on Strategic Forces" (Washington, D.C.: Government Printing Office, September 1984), p. 17-18.

[11] Richard Pipes, "Why the Soviet Union Thinks It Could Fight and Win a Nuclear War," *Commentary*, July 1977, pp. 21-34; and Fritz W. Ermarth, "Contrasts in American and Soviet Strategic Thought," *International Security*, Vol. 3, No. 2 (Fall 1978), pp. 138-155. For a critical

analysis of the approach that led to these assessments, see Raymond L. Garthoff, "On Estimating and Imputing Intentions," *International Security*, Vol. 2, No. 3 (Winter 1978), pp. 22-32.

[12] Intelligence Community Experiment in Competitive Analysis, "Soviet Strategic Objectives: An Alternative View: Report of Team B" (Washington, D.C.: CIA, December 1976), pp. 2-3. For the effect of the Team B report on intelligence estimates, see Prados, *The Soviet Estimate*, pp. 248-257. For a detailed history of Team B, see Anne Hessing Cahn, *Killing Détente: the Right Attacks the CIA* (University Park: Pennsylvania State University Press, 1998).

[13] CIA, NIE 11-3/8-77, p. 4.

[14] See, for example, Raymond L. Garthoff, *A Journey through the Cold War: A Memoir of Containment and Coexistence* (Washington, D.C.: Brookings Institution Press, 2001), pp. 325-334.

[15] The interviews were conducted in the early 1990s under a contract from the Office of Net Assessment of the Office of the Secretary of Defense. John G. Hines, Ellis M. Mishulovich, and John F. Shull, *Soviet Intentions, 1965-1985, Volume 1: An Analytical Comparison of U.S.-Soviet Assessments during the Cold War*, and *Volume 2: Soviet Post–Cold War Testimonial Evidence* (Germantown, Md.: BDM Federal, September 22, 1995). For an overview of the results of the project, see John A. Battilega, "Soviet Views of Nuclear Warfare: The Post-Cold War Interviews," in Henry D. Sokolski, ed., *Getting MAD: Nuclear Mutual Assured Destruction, Its Origins and Practice* (Carlisle, Pa.: Strategic Studies Institute, U.S. Army War College, November 2004), pp. 157-159, 164.

[16] Pavel Podvig, ed., *Russian Strategic Nuclear Forces* (Cambridge, Mass.: MIT Press, 2001); and E.B. Volkov and A.Yu. Norenko, *Raketnoye protivostoyaniye (Missile standoff)* (Moscow: SIP RIA, 2002).

[17] The main source of these data is the archival collection of Vitalii Kataev at the Hoover Institution Archive at Stanford University: Vitalii Leonidovich Kataev, papers, 10 boxes. The collection contains copies of official documents and notes taken at the time that describe various aspects of a number of Soviet strategic programs. Kataev was a senior adviser to the Secretary for the Defense Industry of the Central Committee of the Communist Party from 1974 to 1990.

[18] A detailed analysis of the deliberations of the late 1960s is beyond the scope of this article. This description is based on V.F. Utkin, Yu.A. Moszhorin, "Raketnoye i kosmicheskoye vooruzheniye (Missile and space armament)" in A.V. Minayev, ed., *Sovetskaya voyennaya moshch ot Stalina do Gorbacheva (Soviet Military Power from Stalin to Gorbachev)* (Moscow: Voyennyy Parad, 1999), pp. 232-237; Podvig, *Russian Strategic Nuclear Forces*, pp. 130-131; G.K. Khromov, an official with the Military Industrial Commission (1966-1990), interview by author, Moscow, May 15, 2002; E.B. Volkov, acting director (1968-70) and director (1970-82) of the Central Research Institute of the Strategic Rocket Forces (TsNII-4), interview by author, Moscow, November 27, 2002.

[19] Some R-36M missiles were deployed with 10 warheads, and about 30 missiles of this type carried a single 20 Mt warhead. See Table 1.

[20] UR-100 missiles are known as SS-11 Mod 1. Some UR-100K missiles that carried single warheads would be classified as SS-11 Mod 2. UR-100U and UR-100K missiles that carried three not independently-targeted reentry vehicles would be SS-11 Mod 3. UR-100U missile was essentially the same missile as the UR-100K, but was deployed in a hardened silo.

[21] They were replaced by the RT-2P from 1976 to 1980.

[22] Robert L. Hewitt, John Ashton, and John H. Milligan, "The Track Record in Strategic Estimating: An Evaluation of the Strategic National Intelligence Estimates, 1966-1975" (Washington, D.C.: CIA, February 6, 1976), p. 8-9, in Gerald K. Haines and Robert E. Leggett, eds., *CIA's Analysis of the Soviet Union, 1947-1991* (Washington, D.C.: Center for the Study of Intelligence, 2001).

[23] Prados, *The Soviet Estimate*, p. 252.

[24] "UTTH" stands for "uluchshennyie taktiko-technicheskiye kharakteristiki" (improved tactical-technical characteristics). In the U.S. Department of Defense designation scheme, these missiles are known as the SS-18 Mod 4, SS-19 Mod 3, and SS-17 Mod 2 respectively. Podvig, *Russian Strategic Nuclear Forces*, p. 582.

[25] See, for example, an overview of the data on accuracy presented in Robert R. Soule, *Counterforce Issues for the U.S. Strategic Nuclear Forces* (Washington, D.C.: Congressional Budget Office, January 1978) pp. 16-17. See also Prados, *The Soviet Estimate*, p. 305, which indicates that in 1985 the accuracy of the SS-19 was revised downward from 0.12 to 0.21 nm.

[26] For some missiles, the upgrade was performed in silo and consisted of replacement of the warhead section of the missile without affecting the rest of the missile systems. S.N. Konyukhov, ed., *Prizvany vremenem: Rakety i kosmicheskiye apparaty konstruktorskogo buro "Yuznoye" (Called up for Service by the Time: Missiles and Spacecraft of the "Yuzhnoye" Design Bureau)*, (Dnepropetrovsk, Ukraine: ART-PRESS, 2004), pp. 244-253.

[27] The flight tests in question were conducted from the Baykonur test site to the Kura test site at the Kamchatka Peninsula. The distance between these test sites is about 6,300 km, which is less than the 8,000-9,000 km distance between U.S. and Soviet ICBM bases. The CEP obtained in the

flight tests would have to be recalibrated to reflect full-range accuracy. Details of the flight tests that would allow to do that, however, are unavailable.

[28] In the Soviet tradition, maximum error is used as a measure of missile accuracy. Maximum error is 2.7 times the standard deviation of the distribution of miss distances and is about 2.3 times larger than CEP. The CEP values listed in Table 2 are the maximum error values found in documents divided by 2.3 with subsequent rounding.

[29] Central Intelligence Agency, "Soviet Capabilities for Strategic Nuclear Conflict Through the Late 1980s, Vol. 1 – The Estimate," NIE 11-3/8-78 (Washington, D.C.: CIA, January 16, 1979), p. 10; and Central Intelligence Agency, "Soviet Capabilities for Strategic Nuclear Conflict Through the Late 1980s, Vol. 1 – Summary," NIE 11-3/8-79 (Washington, D.C.: CIA, March 17, 1980), p. 13.

[30] Central Intelligence Agency, "Soviet Capabilities for Strategic Nuclear Conflict, 1981-1991. Vol. 1 – Key Judgments," NIE 11-3/8-81 (Washington, D.C.: CIA, March 23, 1982), p. 13. Charts that would show the evolution of projections were redacted from NIEs issued after 1979 during declassification.

[31] This estimate was obtained using a simple model that assumes that a Minuteman silo would be destroyed by a nuclear explosion if it fell within the range corresponding to overpressure of 1,500 psi. Overpressure values were calculated using the model described in Matthew G. McKinzie, Thomas B. Cochran, Robert S. Norris, and William M. Arkin, *The U.S. Nuclear War Plan: A Time for Change* (New York: Natural Resources Defense Council, June 2001), pp. 161-189. The model used here also assumes that Soviet missiles have 85 percent reliability and that no fratricide takes place. Although the calculations used for the NIE projections employed a different procedure, the simple model used here agrees with the NIE results when it is used with the same assumptions about accuracy and warhead yields in NIEs. If anything, simple models tend to underestimate the counterforce potential of the attacking force. See, for example, John D. Steinbruner and Thomas M. Garwin, "Strategic Vulnerability: The Balance between Prudence and Paranoia," *International Security*, Vol. 1, No. 1 (Summer 1976), p. 142 n. 3.

[32] See, for example, CIA, NIE 11-3/8-77, p. 36. Discussion of residual potentials was dropped from NIEs only in 1981.

[33] CIA, NIE 11-3/8-78, p. 10.

[34] McKinzie, Cochran, Norris, and Arkin, *The U.S. Nuclear War Plan*, p. 43. The authors estimated silo hardness based on the vulnerability numbers that they obtained from an official NATO target inventory publication.

[35] See Kataev, box 8, doc. 13.8, p. 48.

[36] Central Intelligence Agency, "Soviet Strategic Objectives," NIE 11-4-77 (Washington, D.C.: CIA, January 12, 1977), p. iii.

[37] Ibid., p. 2.

[38] The MR UR-100 and the R-36M used modified UR-100 (SS-11) and R-36 (SS-9) silos respectively, while UR-100N required construction of a new silo.

[39] The overall numbers remained the same even as the Soviet Union was changing specifics of the plan. For example, the 1977 plan called for the deployment of about 300 Temp-2S (SS-X-16) mobile missiles. The 1980 plan called for the development of a follow-on to UR-100NUTTH (SS-19). These systems were abandoned in favor of the Topol (SS-25) and the RT-23UTTH (SS-24) respectively. See Kataev, box 8, doc. 13.8, p. 37; and G.K. Khromov, interview by author, Moscow, May 15, 2002.

[40] Directorate of Intelligence, "Intelligence Forecasts of Soviet Intercontinental Attack Forces: An Evaluation of the Record," Research Paper, (Washington, D.C.: CIA, April 1989), p. 8.

[41] One successful instance of arms control limitations was the ban on an increase in the number of warheads on existing missiles, negotiated as part of the SALT II treaty. Prior to that agreement, the Soviet Union considered a possibility of developing versions of the R-36MUTTH and UR-100NUTTH missiles with as many as 38 and 18 warheads respectively. Kataev, box 8, doc. 13.8, p. 34. But even in this case, it is possible that the cancelation of these projects was simply a realization that these highly fractionalized missiles are impractical, rather than a response to arms control limitations.

[42] Kataev, box 8, doc. 13.7, p. 53.

[43] The first nuclear test that tested the ability of a R-36M missile warhead to withstand a nuclear blast was conducted in 1973. Kataev, box 8, doc. 13.8, p. 47. (Most likely it was the test of October 26, 1973. See Podvig, *Russian Strategic Nuclear Forces*, p. 523.)

[44] R-36M, UR-100N, and MR UR-100 missiles could be launched 2.5 to 3 minutes after an attack on a silo. Kataev, box 8, doc. 13.8, p. 53.

[45] The program was outlined in the Decree of the Central Committee and the Council of Ministers "On main directions of development of nuclear weapons in 1976-1985," February 9, 1976. Kataev, box 8, doc. 13.8, p. 47.

[46] The nuclear tests conducted within this program began in 1977. The purpose of the only test in 1977 (most likely the one on October 9) was to study the radiation hardness of electronics of some missiles. Three tests in 1978 studied the effects of hard X-ray radiation on electronics of missiles and their warheads, the capability of a R-36MUTTH warhead to withstand neutron flow, and the effects of hard X-rays on missile bodies (most likely these were the tests of September 20, October 15, and October 31). The purpose of the two tests in 1979 (one of these is most likely the test of September 27) was to study the effects of electromagnetic impulse and the radiation hardness of more than 1,000 various electronic components used in missile guidance systems. Kataev, box 8, doc. 13.8, p. 47.

[47] Kataev, box 9, doc. 14.3; Utkin and Moszhorin, "Raketnoye i kosmicheskoye vooruzheniye," p. 198. G.K. Khromov, interview by author, May 15, 2002.

[48] Utkin and Moszhorin, "Raketnoye i kosmicheskoye vooruzheniye," pp. 199-200.

[49] Because of the geographic position of the Soviet Union it did not have the capability to implement a true launch-on-warning option, in which missiles would be launched before first attacking warheads arrive to their targets. A launch-from-under-attack, in which launches would be conducted in the environment of nuclear explosions at adjacent silos, was a more realistic option. See Pavel Podvig, "Reducing the Risk of an Accidental Launch," *Science and Global Security*, Vol. 14, Nos. 2-3 (June 2006), pp. 75-115.

[50] Konyukhov, *Prizvany vremenem*, pp. 300-305, 305-316. Hardening against effects of a nuclear explosion was also part of the RT-2PM/Topol-M program, which began in 1989.

[51] Kataev, box 8, doc. 13.8, p. 37.

[52] The RT-23 was initially developed as a single-warhead silo-based missile (known as 15Zh44). In 1979 the program was reoriented toward producing two multiple-warhead versions of the missile — silo-based 15Zh44 and rail-mobile 15Zh52. The 15Zh44 development was canceled in 1983 without producing an operational missile. The 15Zh52 program was suspended as well. One train with three missiles was accepted for "experimental service." Kataev, box 8, doc. 13.8, p. 48; and Konyukhov, *Prizvany vremenem*, pp. 256-273.

[53] The RT-23UTTH program also called for development of a road-mobile version of the missile, known as Tselina. This project was canceled in 1984.

[54] Valery E. Yarynich, *C^3: Nuclear Command, Control, and Cooperation* (Washington, D.C.: Center for Defense Information, 2003), pp. 138-141; and I. Dmitriev, head of the Defense Industry Department of the Central Committee of CPSU, "On Assessment of the Capability to Control Nuclear Forces of the Country during Military Actions," Memo, February 1982, in Kataev, box 2.

[55] The 15A11 Perimeter missile, which was part of the Perimeter command and control system, designed to provide the necessary redundancy, was accepted for service in 1985. During the flight tests the missile and its payload were extensively tested for vulnerability to nuclear explosions. Konyukhov, *Prizvany vremenem*, pp. 253-256. See also Bruce G. Blair, *Global Zero Alert for Nuclear Forces* (Washington, D.C.: Brookings Institution Press, 1995), p. 51; and Yarynich. *C^3*, pp. 156-159.

[56] These were Dnestr- and Dnepr-type radars, also known as Hen House. Pavel Podvig, "History and the Current Status of the Russian Early-Warning System," *Science and Global Security*, Vol. 10, No. 1 (2002), p. 29.

[57] These radars became operational in 1984 and 1985 respectively. Ibid., p. 30.

[58] Ibid., p. 35.

[59] The warhead, known as 8F678, used a radar for terminal guidance. Flight tests of the warhead were conducted in 1978-1980. Konyukhov, *Prizvany vremenem*, pp. 324-328.

[60] Among the options that were considered in 1977-1978 was deployment of nineteen 500-kt guided warheads on a missile of the R-36M-class (SS-18) or nine 500-kt warheads on a missile of UR-100N class (SS-19). Kataev, box 8, doc. 13.8, p. 34.

[61] The guided warhead project, shelved in 1980, was resumed in 1984, with the development of a "next-generation" 15F178 warhead for the R-36M2 missile. Flight tests of this warhead began in 1990, but it was never deployed. Konyukhov, *Prizvany vremenem*, pp. 324-328, 300-305.

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