Good work!

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A STABLE DETERRENT FORCE DESIGN

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April 15, 1987

What are Soviet intentions in the world? We can never have absolute certainty about this, and so it is necessary that our strategic plans take into account the entire range of motivations and behaviors which the USSR might exhibit. Knowing the terrifying consequences of nuclear war, we seek to design a triad which will deter a Soviet first strike (assuming that they seek world domination and will stop at nothing to achieve it), but which will not unduly frighten them and exacerbate their paranoia (assuming that they are in fact xenophobic).

To achieve our design, then, we must find the answers to two questions:

1) What are the requirements for an effective deterrent force?
2) What quality or qualities will a deterrent have (or lack) that will make it clearly incapable of being an effective first-strike force?

Of course, a deterrent force <u>can</u> always be used for a first strike, but an <u>effective</u> first strike is quite another matter: by effective we mean a strike which so disarms our opponent that he cannot subsequently threaten us with enough nuclear force to prevent us from launching in the first place. Conversely, a nuclear force which cannot maintain deterrence-level striking power after it is hit by an all-out attack automatically becomes a first-strike force precisely because it is so threatened. "Use it or lose it" becomes the watchword in this case. This triad must fulfill the first requirements, and must absolutely not fulfill the other set.

The deterrent assumptions and operating specifications are as follows:

1) Our forces will not launch weapons until we have been hit and have ascertained without any doubt the origin of the attack.

2) Therefore, even assuming that the USSR launches all of the weapons at its disposal, enough of our forces must survive the first strike to still be able to inflict unacceptable levels of damage upon our opponent. By unacceptable, we mean the destruction of 3/4 of the USSR industrial capacity and 1/2 of the population.

This can be accomplished by arming our deterrent with high-yield, low-accuracy warheads suitable for countervalue strikes. Enough warheads must be available to do this even after an all-out USSR strike.

So, what are the essential distinctions between deterrent and first-strike forces? One such difference is in accuracy. A first-strike force absolutely must have very high accuracy--in the equations (see the appendix) it turns out that high accuracy far outweighs high yield as an effective way of killing hard targets like silos. I will go so far as to say that without accuracy, a disarming first strike is an impossibility. To wipe out industrial targets, however, requires very little accuracy because the targets (cities, essentially) are so big and so soft. A CEP of one nautical mile ought to be sufficient for such a weapon, as opposed to a few hundred feet or less for a first-strike weapon.

assuming the strike is aimed at missile silos - Against Bombers speed is most important factor because a near miss will still kill a soft plane.

assuming little is put underground

Can another such distinction be found in the number of warheads available in the triad? Not necessarily. Both types of forces require a fairly large number of warheads: A first-strike strategy cannot succeed without many warheads simply because of the sheer number of counterforce targets that must be hit. Additionally, cross-targeting of two or more warheads for every silo and hardened command and control bunker is required. The deterrent force has far fewer targets (only a few hundred, as we will see), and no real cross-targeting requirements. But it must ride out an enemy first strike. Therefore, it must have enough excess warheads to still be able to retaliate afterward. This might or might not require as many warheads as the first-strike force, depending upon the deterrent force's degree of pre-launch invulnerability.

What about delivery speed? It, too, is useful in both types of forces, albeit for different reasons: First-strike weapons should be fast enough to give almost no warning to the enemy (and possibly even decapitate the adversary's command structure). Deterrent weapons do not require any element of surprise. However, the high speed of ICBMs and SLBMs provides post-launch invulnerability that may not be shared by bombers; speed is a desirable quality in at least some of the deterrent triad as well. The accuracy of those missiles can still be kept low enough to prevent their being used effectively against counterforce targets. The slowness of airbreathers makes it difficult for them to catch the enemy's force before launch.

Can survivability distinguish between first-strike and deterrent weapons? As pointed out above, lack of survivability can automatically force a first strike regardless of other weapon characteristics. Obviously a deterrent force must have high survivability. But although first-strike weapons might not have to have high survivability, they can have it (as with the Trident II D-5). Thus survivability is not necessarily a distinguishing characteristic, either.

Out of all of this comes the conclusion that low accuracy is a central hallmark of deterrent weapons which is not shared by first-strike weapons. An opponent who is faced by a large number of low-accuracy, high-yield warheads knows that his land-based missile force cannot be disarmed, and also that his country's industry and population can be wiped out. Low accuracy will be central to my strategy.

Next, the targeting requirements for the triad are defined: The first thing to consider is the number of points to hit. In thumbing through an atlas at the library, I determined that the USSR's population is fairly urban, and its industry even more so. Something like 40% of the population is in cities of 50,000 or more. There are about 250 such cities. Those same cities contain at least 3/4 of the country's industry. So, assume that we have to knock out 250 soft targets (see maps). To be really safe, assign two warheads to each target. A good choice is the W78 (Y = 335 Kt, weight = 800 lb[1]). It will knock down houses out to a radius of about 5.5 miles[2], for an areal destruction of 80 sq. mi/warhead. Each triad leg must be independently capable of delivering 500 W78s after an all-out Soviet first strike.

Consider the submarine leg first. Its pre-launch invulnerability is so high that it is safe to assume that not more than 20% of the subs could be sunk at sea. Assume that all of the subs in port at the time of the attack are hit, however. With even a 60% at-sea readiness (a low number for US subs) and a 20% failure rate for the missiles, we only need a total of 250*2*(1/0.8)*(1/0.6)*(1/0.8) = 1,300 warheads in the whole SLBM arsenal.

The Poseidon C-3 is plenty accurate (0.3 nm) for our purposes, but is not accurate enough to attack hard targets with the W78 (see appendix). And it can carry up to 3300 lb of payload. So, with three W78s on the end of each missile, (I checked the dimensions of the warhead and the missile body, and they will fit easily) we still have 900 pounds of payload capacity left over for penetration aids and/or extended missile range. A total of 434 missiles are required. With 16 missiles per boat, that comes to about 27 boats altogether, with 14 or more at sea at any one time.

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1 All references to warhead and missile characteristics are from Nuclear Weapons Databook, Vol 1, Cochran, Arkin, Hoenig eds, Ballinger Publishing, Cambridge, 1984.

2 Warhead effects are from "Nuclear Bomb Effects Computer" in the back of Glasstone and Dolan, The Effects of Nuclear Weapons, US Govt Printing Office, 1977.

Figure 1. The 250 largest population/industrial centers in the USSR.

Figure 2. Fallout patterns downwind from strikes on the 250 largest population/industrial centers of the USSR about 1 hour after attack.

Figure 3. The 250 largest population/industrial centers of the USA.

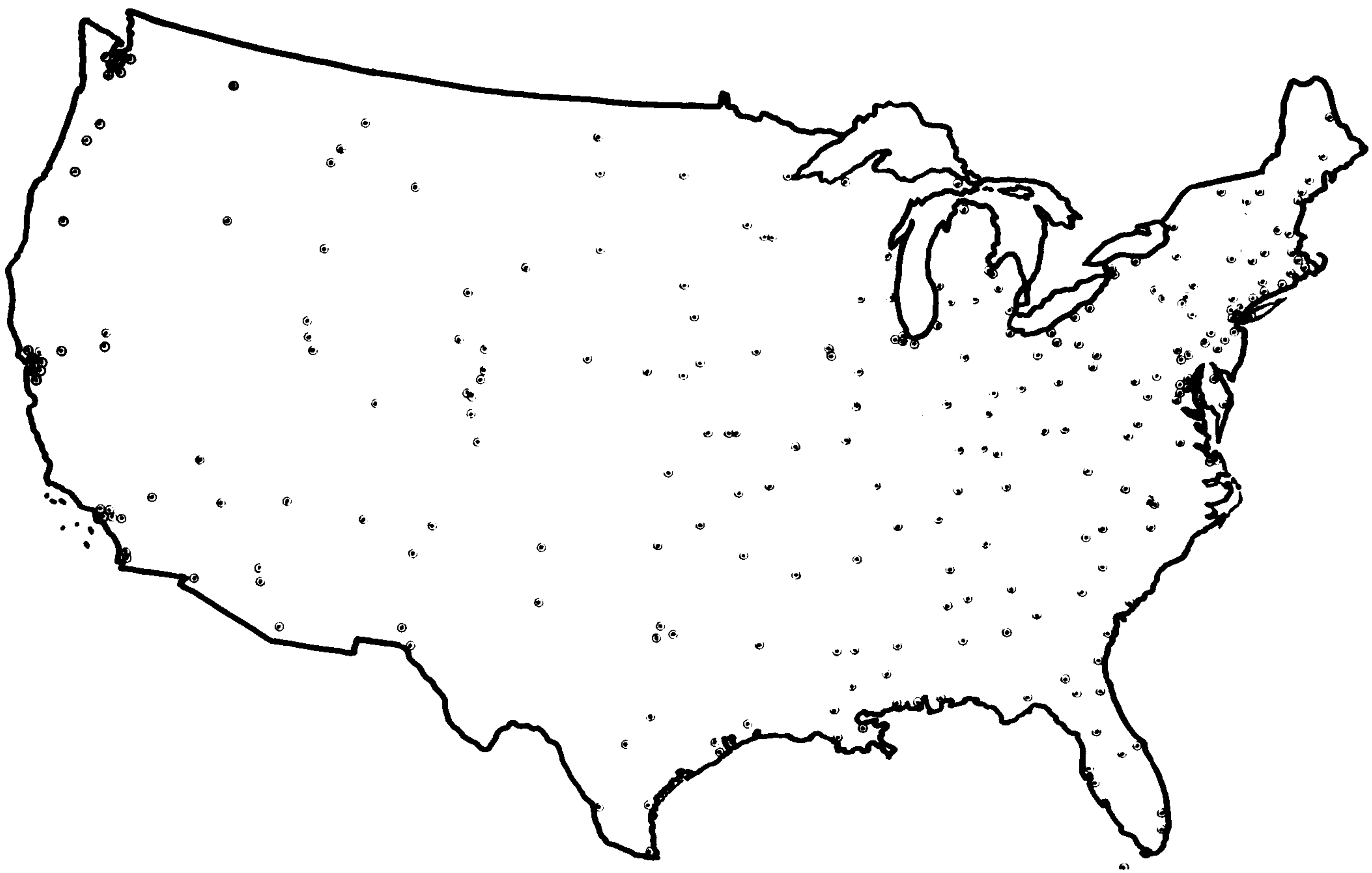
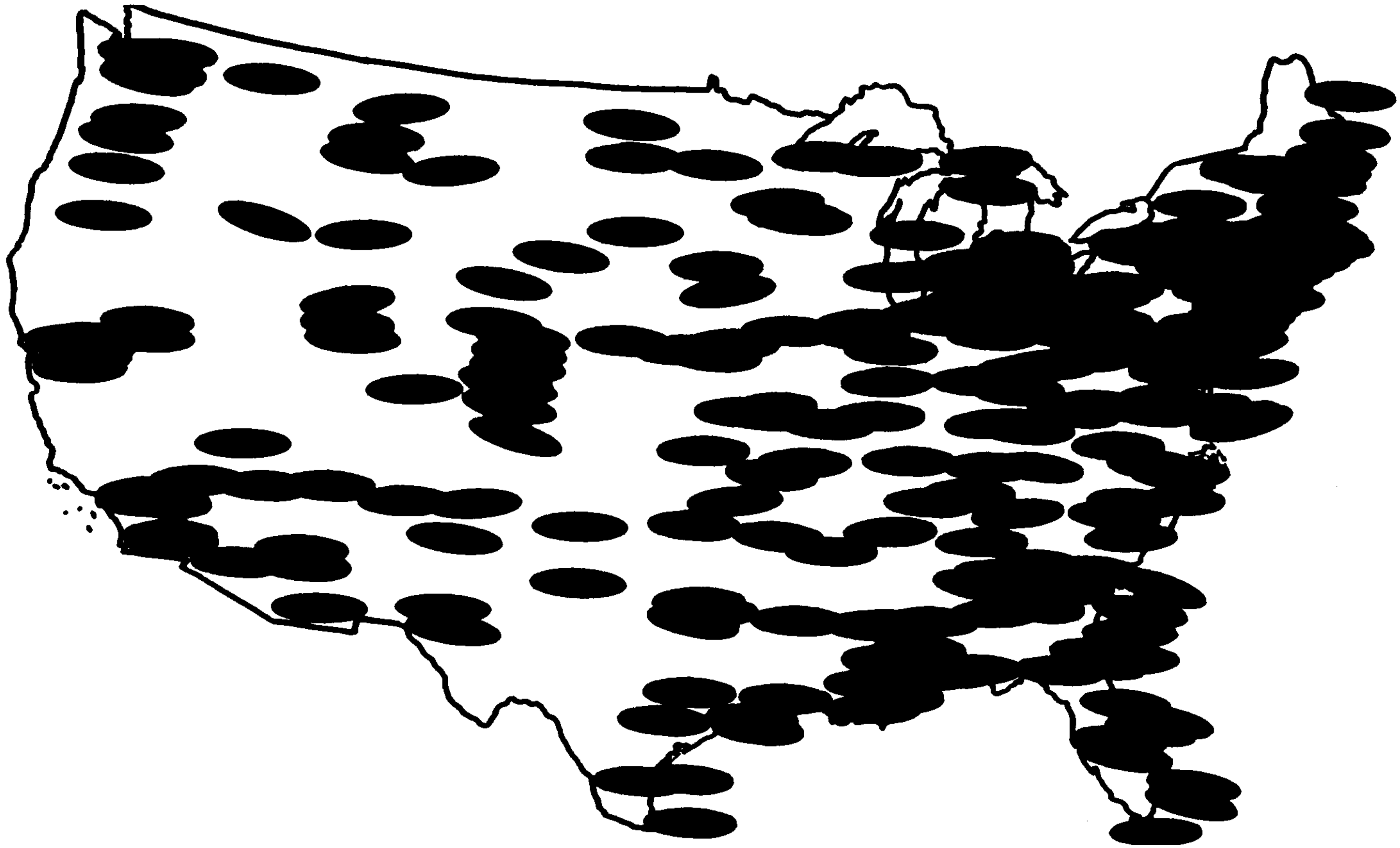


Figure 4. Fallout patterns downwind from strikes on the 250 largest population/industrial centers of the USA about 1 hour after attack.



Next comes the bomber leg. Here we have to worry about both pre- and post-launch vulnerability. The worst possible pre-launch scenario would be one in which the USSR managed to launch a first strike with SLBMs and hit all of the bomber bases 8 minutes later, with no bombers in the air before the attack. It should still not be unreasonable to assume that 20% of the force could be maintained in a "cocked" condition on the tarmac at all times, and that just 5 min of warning from PAVE PAWS radars would allow that much of the force, at least, to get off the ground. Subsequently, assume that 50% of the airborne force is shot down. This is probably grossly pessimistic, since
% would increase if Soviets are using nuclear warheads on their SAMs.
losses in WW II never went above 20-30% per mission. Remember, too, that subsonic commercial airliners (like the Korean plane over Murmansk in 1977 and flight KAL-007 years later) have wandered for hours inside Soviet airspace without benefit of chaff, ECM, or low-level approaches before being detected, identified and intercepted.

The number of warheads in the bomber leg of the triad must then be 250*2*(1/0.2)*(1/0.5) = 5,000. If ten warheads are assigned per plane, then 500 bombers must be available. Allowing for 50% of the force to always be ~~done~~ down, for maintenance, and for an additional 10% force of ECM aircraft, we need 1,100 planes (1,000 bomb-carriers and 100 ECM) in this triad leg. 110 of these (100 bomb-carriers and 10 ECM) should be kept on 5-minute alert at all times at highly dispersed airfields.

Post-launch survivability with gravity bombs may be poor. For higher post-launch survivability, the planes will carry the warheads in mach-3+ short-range attack missiles (SRAMs). Each missile carries a single W69 200-Kt warhead and has a 200-km range at high altitude and 60-80 km range at low altitude. Unfortunately, SRAMs have extremely high accuracy. This violates our low-accuracy criterion. However, the range is so short that the subsonic delivery planes (B-52s or B-1Bs) would still have to penetrate nearly all the way to their targets before launching the SRAMs. Russia is a big country; assuming that they have radars on the national periphery and C^3I centers deep in the interior (like in Moscow, for example), there would be no possibility of using these missiles to cut off the Soviet head or attack silos. Even with the bombers loitering just outside the USSR during a tense period, the Soviet high command would know that they still had an hour or more available to them after any bomber penetration to get their missiles off the ground. Thus they would not be pushed to launch unless an actual penetration (meaning attack) were a half-hour or more underway. We do not want air-launched cruise missiles (ALCMs) on the planes precisely because they combine high accuracy with very long (2,000 km+) range. "Stealthy" ALCMs could potentially decapitate the Soviet high command. We do not want to use true stealth bombers for the same reason. B-52s and B-1Bs are "stealthy" enough to get 50% or more of the warheads to the target cities, but detectable enough to preclude the possibility of using them for a surprise attack.

Finally, we come to the land-based leg. Post-launch survivability is not a problem here, but pre-launch survivability is. The total available Soviet KN is about 107,000 (see appendix). Thus the US ICBM force must be able to launch 500 or more warheads after being hit by a force of this lethality. (See the appendix for a much more realistic (and lower) assessment of their KN.) I wrote a program named DETERRENCE (a listing is shown after the appendix) which I used to find a force composition for which even twice this KN would be inadequate to kill the last 500 warheads.

The force is built this way: Scrap our existing ICBM force, and build in its place a force of 1,000 single-warhead missiles. Each missile will have an accuracy of 1 nm for its 335-Kt W78 warhead. Then, deploy the missiles as follows: each missile site consists of a set of railroad tracks that would look like a giant "+" from the air. Each leg of the cross will be 2.8 miles long and will terminate in a shelter hardened to 3500 psi. This leaves 4 miles between shelters. 4,000 shelters conceal 1,000 missiles. DETERRENCE calculates that the KN required to knock out 50% of this force is 204,000. Such an assault, even though it would require twice the KN presently available to the USSR (even if 100% of her forces worked), would still leave half of the shelters (and hence half of the missiles) intact. Thus at least 500 warheads would always survive to destroy Russia. The missiles will be handled as with the earlier proposal for MX: there will be an assembly building with a transparent roof, dummy missiles for the other three shelters, and removable shelter roofs for satellite verification. My proposal differs from the MX idea in two important ways, however: these missiles are not MIRVed and have low accuracy (removing the old objection to MX that it is a first-strike weapon), and each site requires just 32 sq. mi. of land (a square 5.6 mi. on a side). Because the individual plots would be much smaller than for MX sites (which each had over 20 shelters), many locations outside Utah and Nevada would be suitable for individual missile sites. The end result would be far fewer shelters in those states (and thus far less impact there) and a lessened impact at all other possible sites in the US as well.

But how do the Soviets know that the SLBM and ICBM forces in the triad I have constructed will have accuracies of only 0.3-1.0 nm (and are thus inadequate for counterforce attacks)? yes The answer is simple. No guidance system is ever considered for deployment unless it has passed ten or twenty flight tests between Vandenburg and Kwajalein successfully. These tests are observed by the Soviets. During these observations, it is possible to measure the degree to which the warhead deviates in flight from a free-fall (inertial) path. The higher the accuracy, the more maneuvering is required and hence the greater the deviations from a pure ballistic trajectory. If a warhead is tested with a certain degree of accuracy (and hence a certain amount of maneuvering, or lack thereof), then that is the only accuracy that can ever be expected of it when it is operational. Sneaking a more accurate system into the missile afterward will do no good if the integrated missile and guidance package is not flight-tested, and it is impossible for either side to prevent the other from observing these tests. Are you sure?

This triad, with 30% of existing ICBM and SLBM warheads (2,300 vs 7,600) and only 6% of the present hard-target lethality of those same missiles (KN value of 7,500 vs 130,000, as calculated by DETERRENCE) could more than perform its necessary duty as a deterrent while at the same time unequivocally satisfying the USSR that it could never be used to launch a disarming first strike. Stability would be enhanced because the Soviets would know that they could not survive as a society if they ever launched a preemptive attack, and we would never have to launch on warning or under attack, because we would know that our forces could always ride out such an attack and subsequently respond at a time of our own choosing.

Appendix: Technical Aspects of Deterrence

It is not possible to construct an effective, survivable triad without assessing the USSR's first-strike capability. This, in turn, means that we must understand something of the physics of counterforce and countervalue attacks. What we want to obtain is a parameter that tells us the ability of an attacking force to destroy hardened targets like missile silos. I will only present the final equations here; anyone who wants the derivations may consult numerous sources[1].

The lethality, K (for "kill"), of a reentry vehicle against a hardened target is defined to be

$$K = Y^{(2/3)}/(CEP)^2$$

where Y is the yield of the warhead in megatons and CEP is the circular error probable in nautical miles. Note that K varies only as the 2/3 power of yield, but as the inverse square of CEP; high accuracy adds to lethality much more than high yield. To get the K available for a missile force, multiply the K per reentry vehicle by n, the number of warheads per missile, and then by m, the number of missiles. K*n*m (typically written K*N) gives a much better idea of the actual strength of an ICBM force than, say, the throw weight or total megatonnage in that force. (See Table I.)

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1. See, for example, Kosta Tsipis, "Physics and Calculus of Countercity and Counterforce Attacks", Science, Vol 187, no 4175, 7 Feb 1975, pp. 393-97, with criticism and reply "Strategic Arms Debate", Science, 12 December 1975, pp. 1117-19.

   Other sources include M. Bunn and K. Tsipis, Ballistic Missile Guidance and Technical Uncertainties of Counter-Silo Attacks, MIT Report #9, Cambridge, Mass: Program in Science and Technology for International Physics, MIT, 1983; and "The Uncertainties of a Preemptive Nuclear Attack", Scientific American, Vol 249, no 5, November 1983, pp. 38-47.

Table I. US and USSR strategic nuclear missile forces.

	MISSILE	Y(MT)	CEP(nm)	n	m	H(psi)	rel	read	β	βKN
US	MINUTEMAN II	1.50	0.30	1	450	1700	0.8	1.0	0.8	5,240
US	MINUTEMAN III	0.17	0.10	3	250	2000	0.8	1.0	0.8	18,415
US	MINUTEMAN IIIA	0.34	0.10	3	300	2000	0.8	1.0	0.8	35,077
US	PEACEKEEPER (MX)	0.30	0.07	10	50	2000	0.8	1.0	0.8	6,586
US	POSEIDON C-3	0.04	0.30	10	304	N/A	0.8	0.55	0.44	1,739
US	TRIDENT I C-4	0.10	0.25	8	240	N/A	0.8	0.67	0.54	3,574
US	TRIDENT II D-5	0.15	0.07	14	0	N/A	0.8	0.67	0.54	0
USSR	SS-11 MOD 1	0.65	0.75	1	28	300	0.7	1.00	0.70	26
USSR	SS-11 MOD 2 & 3	0.16	0.60	3	420	300	0.7	1.00	0.70	722
USSR	SS-13 MOD 2	0.40	1.10	1	60	300	0.7	1.00	0.70	19
USSR	SS-17 MOD 1	0.30	0.25	4	120	1500	0.7	1.00	0.70	2,409
USSR	SS-17 MOD 2	2.00	0.25	1	32	1500	0.7	1.00	0.70	569
USSR	SS-18 MOD 1	10.00	0.25	1	58	1500	0.8	1.00	0.80	3,455
USSR	SS-18 MOD 2	0.40	0.25	8	175	1500	0.8	1.00	0.80	9,729
USSR	SS-18 MOD 4	0.50	0.15	10	75	1500	0.8	1.00	0.80	16,800
USSR	SS-19 MOD 2	3.00	0.15	1	60	1500	0.8	1.00	0.80	4,437
USSR	SS-19 MOD 3	0.50	0.15	6	300	1500	0.8	1.00	0.80	40,319
USSR	SS-N-5	1.00	1.50	1	18	N/A	0.6	0.15	0.10	1
USSR	SS-N-6	0.50	0.50	1	400	N/A	0.7	0.15	0.10	101
USSR	SS-N-8	1.00	0.50	1	270	N/A	0.7	0.15	0.10	108
USSR	SS-N-17	1.00	0.80	1	12	N/A	0.7	0.15	0.10	2
USSR	SS-N-18	0.20	0.32	7	208	N/A	0.7	0.15	0.10	486
USSR	SS-N-20	0.15	0.20	9	20	N/A	0.7	0.15	0.10	127

There are several uncertainties in the numbers in Table I. For example, silo hardnesses are not well-known outside the intelligence community. Most sources agree, however, that American silos are hardened to something like 2000 psi. And although a few people have claimed hardnesses for Russian silos of as much as 3000 psi, most observers say that their silos are typically not as hard as their US counterparts. Indeed, missiles deployed before 1970 may only be built to withstand 300 psi. Later silos are probably mostly in the range of 1000 psi, but I decided to be generous and used 1500 psi in my calculations. And we will see that the vulnerability of a structure is not all that sensitive to its hardness, anyway.

You may also note that some of the Soviet warhead yields in the table are considerably less than most sources quote. This is a reflection of a reassessment (now endorsed by the US government) of the interpretation of seismic data from USSR underground tests[2].

The last column of Table I shows not the KN for each missile type, but rather the quantity βKN. The factor β is the percentage of existing warheads that can expected to be available for launching at any given time. This number, like silo hardness, is not well-known outside intelligence circles, but most sources[3] agree that US missiles are about 80% reliable while USSR missiles have reliabilities of 60-80%. In Table I, I assigned a reliability of 60% to the SS-N-5 (a notoriously poor system), 70% to most of the rest,

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2. Lynn R. Sykes and Dan M. Davis, "The Yields of Soviet Strategic Weapons", Scientific American, Vol 256, no 1, Jan 1987, pp 29-37.

3. For example, Robert Aldridge, First Strike, South End Press, Boston, 1983, pp. 56, 59-60, 96.

and (maybe too generously) 80% to the newer-generation SS-18 and SS-19. Also factored into β is the readiness of a force. This number is applicable to submarines. About 2/3 of US subs are available for launching at any given time; the USSR sub force is so badly constructed and operated that only about 15% can be used at any given time. Thus, the β factor for American vehicles ranges from a low of 44% (Poseidon SLBMs) to 80% for ICBMs. Soviet forces have much more variability, from 10% (all SLBMs) to 80% for the newest ICBMs. Note that although about 1/4 of the USSR forces are on submarines, their contribution to the total USSR KN is only about 1% (!). This factor can be improved, of course, if SLBMs in port can still be launched, but in that case the pre-launch invulnerability of the missiles would be lost.

The final numbers are interesting. In spite of the fact that Soviet rockets carry about 8,300 warheads vs. 7,600 US warheads, their lower accuracy and reliability result in an available KN that is only about 80% of the American KN: 79,300 vs. 100,000. And even if reliability is not considered, the Soviet KN is still 107,000 vs. a US KN of 130,000. This is due to the much higher accuracy of US missiles. (All of the calculated quantities in this report are from DETERRENCE.)

Given that we know the KN available in the arsenals, what is the KN required to knock out those same strategic forces? Assuming that the bomber and SLBM forces have nearly complete pre-launch invulnerability, I used the following formula for finding the KN required to knock out various percentages of the ICBM forces:

$$K_{req}*n = 2H^{2/3}[f(H)]^{2/3}*ABS\{\ln[1 - P_K(n)]\}$$

where

$$P_K(n) = 1 - \exp\{ -Kn/[2H^{2/3}[f(H)]^{2/3}] \}$$

and

$$f(H) = 0.19H^{-1} - 0.23H^{-1/2} + 0.068$$

for n warheads striking a target hardened to H pounds per square inch. Listed below are the K_{req} values to knock out various percentages of each country's land-based forces, assuming a value of n=1 in the above equations:

Table II. K (n=1 per silo) required to kill percentages of US ICBMs

% killed	97	95	90	80	70	60
K_{req}	176,000	150,000	116,000	81,000	60,000	46,981

(This force faces a USSR βKN of about 79,000.)

Table III. K (n=1 per silo) required to kill percentages of USSR ICBMs

% killed	97	95	90	80	70	60
K_{req}	140,000	121,000	90,000	65,000	50,000	28,000

(This force faces a US βKN of about 100,000.)

There are some caveats here. At first glance, it appears that both of the superpowers' land-based forces are becoming rather vulnerable: a naive reading of the numbers would imply that the US can knock out 90-95% of USSR missiles while the USSR can kill about 80% of US missiles. But this would only be true if the K on the ends of all of the attacking rockets were perfectly distributed on the targets. This is not true: some excess K will fall on many targets, and a better calculation would account for this "wasted" kill ability. Of course, this assumption is somewhat offset by the fact that we probably cross-target n=2 or more warheads per target, in effect reducing the K_{req} values above. One fact is apparent from these numbers, however: the US ICBM force is far more threatening and formidable than the USSR force. This should not necessarily be seen as a reflection of our intentions. But it is a reflection of our superior technical abilities.

In fact, the situation for the Soviets is even worse than our 100,000 to 79,000 βKN lead implies, because the only leg of the triad that this number threatens is the land-based ICBM part. Whereas our most powerful leg is secure under the oceans, and on top of that our bomber leg can independently launch a sufficient deterrent strike against the USSR, the USSR only has 1/4 of its forces (and, almost incredibly, only 1% of its βKN) on submarines, and does not have a very effective bomber force. To lose even the worst-case 80% of our ICBMs would still leave 20% of that force intact (quite sufficient to wipe out Soviet industry and population), while not impairing the other two legs (each independently capable of a deterrence strike). But when the USSR sees 90-95% of its land-based forces threatened, she must be much more nervous because her other two legs are so relatively weak. To put it another way: the USSR's strategic nuclear eggs have almost all been put in one basket (probably not so much because of doctrine as because that country has never been very successful with its airplane and submarine design and maintenance). If we threaten that basket unduly, they are pushed that much closer to a launch-on-threat or launch-on-warning posture, and deterrence is weakened.

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FTN77,Q
      PROGRAM DETERRENCE

************************************************************************
*  This program allows the operator to input the pertinent characteristics
*  (i.e., accuracy, yield, warheads per missile, hardness) for a nuclear
*  force.  The program then calculates both the KN for the force in a
*  strike mode and the KN that an enemy must have to reduce it to various
*  percentages of its pre-attack strength.
************************************************************************

      REAL RHO(20), K(20), Kn(20), Knm(20), pKnm(20)
      REAL CEP(20), NWARperMISS(20), YperWAR(20), MISSILES(20), H(20)
      REAL Pk(7), TOTreqKn(7)
      CHARACTER*20 MISS(20)  !Program will handle up to 20 missile types
      CHARACTER*1 ANSWER

      FnHARD(H)= (0.19/H) - (0.23/(H**0.5)) + 0.068  !Hardness function
      Pk(1)= 0.97
      Pk(2)= 0.95
      Pk(3)= 0.90
      Pk(4)= 0.80
      Pk(5)= 0.70
      Pk(6)= 0.60
      Pk(7)= 0.50

10    I= 0
      ANSWER= 'Y'
      DO WHILE (ANSWER .EQ. 'Y')
          I= I+1
          WRITE (1,'(" ")')
          WRITE (1,'("The name of the ",I2,"th missile type is? _")') I
          READ  (1,15) MISS(I)
15        FORMAT (A20)
          WRITE (1,'("Give yield/warhead (MT), CEP (nm), and warheads/mi
     +ssile: _")')
          READ  (1,*) YperWAR(I), CEP(I), NWARperMISS(I)
          WRITE (1,'("How many of these are in the arsenal? _")')
          READ  (1,*) MISSILES(I)
          WRITE (1,'("What is the estimated reliability? _")')
          READ  (1,*) RHO(I)
          WRITE (1,'("What is the silo hardness (psi)? _")')
          READ  (1,*) H(I)
          WRITE (1,'(" ")')
          WRITE (1,'("Do you want to enter more missiles? _")')
          READ  (1,*) ANSWER
          CALL CASEFOLD (ANSWER)
      END DO

      MISSILE_TYPES= I
      TOTALKN= 0.0
      TOTALpKN= 0.0

      WRITE (1,'(" ")')
      WRITE (1,'("MISSILE",14X," Y(MT)  CEP(nm)  n/   K/     m",4X,"KN
     +    pKN")')
      WRITE (1,'("--------------------------------------------------------
     +--------------")')
      DO I=1,MISSILE_TYPES
          K(I)   = (YperWAR(I)**0.6666)/(CEP(I)**2)
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      Kn(I)   = K(I)*NWARperMISS(I)
      Knm(I)  = Kn(I)*MISSILES(I)
      pKnm(I)= RHO(I)*Knm(I)
      WRITE (1,'(A20,1X,F6.3,2X,F7.4,2X,I2,2X,F4.1,2X,I4,2X,F6.0,2X,
+F6.0)') MISS(I),YperWAR(I),CEP(I),NWARperMISS(I),K(I),MISSILES(I),
+Knm(I),pKnm(I)
      TOTALKN= TOTALKN+Knm(I)
      TOTALpKN= TOTALpKN+pKnm(I)
 END DO
 WRITE (1,'(54X,"-------  ------")')
 WRITE (1,'(45X,"Totals= ",F7.0,1X,F7.0)') TOTALKN, TOTALpKN
 WRITE (1,'(" ")')
 WRITE (1,'(" ")')
 WRITE (1,'(" ")')
 DO J=1,7
 DO I=1,MISSILE_TYPES
      reqKn= -2.*(H(I)**0.666)*((FnHARD(H(I)))**0.666)*LOG(1.-Pk(J))
      reqKn= reqKn*MISSILES(I)
      TOTreqKn(J)= TOTreqKn(J) + reqKn
 END DO
 END DO
 WRITE (1,'("Pk=     0.97      0.95      0.90      0.80      0.70      0.
+60      0.50")')
 WRITE (1,'("-----------------------------------------------------------
+------------")')
 WRITE (1,'("Kreq ",F7.0,2X,F7.0,2X,F7.0,2X,F7.0,2X,F7.0,2X,F7.0,2X
+,F7.0)') TOTreqKn(1),TOTreqKn(2),TOTreqKn(3),TOTreqKn(4),TOTreqKn(
+5),TOTreqKn(6),TOTreqKn(7)

 END
```