CASE STUDY 3

THE ORIGIN OF MIRV

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The development of counterforce nuclear weapon capability, in particular against very hardened ICBM missile silos, was greatly aided by the development of MIRV's — Multiple Independent Reentry Vehicles — and of increasing missile warhead accuracy. The United States deployed its first MIRVed ICBM — the Minuteman III — in 1970, and the first MIRVed SLBM — the Poseidon — in 1971. The USSR followed suit in 1975 (ICBM) and 1978 (SLBM), respectively. MIRV technology was developed first in the United States. The genesis of the ideas for MIRV warheads in the United States goes back to the period 1960-1964, and it is these early decisions that one wants first to examine. The process and its successive development is recorded in great detail in several excellent studies: by Greenwood and by Tammen for the MIRV (1), and by Sapolsky for the Poseidon (2). This chapter will only incidentally remark on developments in accuracy.

One should also think back to the strategic environment during which these decisions were made:

- The United States had just deployed its first generation of ICBM and SLBM missiles.
- The first SIOP was in preparation, counterforce and damage limitation concepts had primary emphasis, and a nuclear strike would have been a massive one.
- It was now clearly known that the "missile gap" — a prospective USSR superiority in ICBM launcher numbers that had been projected to occur around 1963-64 — did not and would not exist. On the contrary, US strategic delivery vehicles outnumbered those of the USSR by 10:1 in the early 1960's. USSR ICBM serial production rates began extremely slowly, and did not achieve 1960 US production rates till around 1966. A major portion of the reason for this was an early and compensatory high USSR production rate for medium range bombers and IRBMs and MRBMs with ranges sufficient to reach US overseas-deployed IRBMs and strategic bomber bases.
- All US long-range strategic cruise missile development programs had been cancelled, and the existing systems of this type were being decommissioned.
- All US IRBM and MRBM missiles were withdrawn from Europe, development concepts for a MMRBM (Mobile Mid-Range Ballistic Missile) and for MLF were cancelled.
- There was a continuous reduction of US strategic air defence through the 1960's. The new B-52 bomber was deployed, and the Polaris system was

continuously improved through the decade.

- Pressure for procurement of an ABM system would build continuosly.
- The Berlin crisis had already occured, involving three strategic alerts within 18 months,
- and the Cuban missile crisis would occur in late 1962.
- The comprehensive nuclear test ban treaty was under negotiation.
- The US would become heavily engaged in a war in Vietnam.
- The first conceptions of a missile freeze would be developed.

By 1962 the Mark 12 warhead was in development, but the authorized design did not yet include independent guidance capability. In the Navy, too, a MIRV configuration was not yet included in the baseline design of Special Projects' new missile, the Polaris B-3, for which the Navy unsuccessfully sought funding for FY 1965. 1964 was, however, the year in which major decisions set the framework for the systems that eventually appeared. During the FY 1966 budget review in the fall of 1964 the decision was made to proceed with development of a Mark 12 MIRV system for Minuteman II and with a larger version of the Navy's B-3, later renamed Poseidon C-3, which would also carry a MIRVed front end. In November 1964, the Navy's Special Projects Office was instructed to include both MIRV and accuracy improvements in the design for its new missile.

The most widespread notion concerning US development and deployment of MIRV is that the program was conceived and developed in order to insure penetration of a USSR ABM system. The following two quotations from Dept. of Defense testimony to Congress in the 1968-69 period provide very strong evidence that this was not the case, and that the driving force behind MIRV development and deployment was in fact the desire to obtain increased target coverage. The first quotation is a question from Senator Mansfield to Dr. John Foster, Director, Defense, Research and Engineering, US Dept. of Defense:

> MIRV System
>
> Question No.10. Is it not true that the U.S. response to the discovery that the Soviets had made an initial deployment of an ABM system around Moscow and possibly elsewhere was to develop the MIRV system for Minuteman and Polaris?
>
> Answer. Not entirely. The MIRV concept was originally generated to increase our targeting capability rather than to penetrate ABM defenses. In 1961-62 planning for targeting the Minuteman II force, it was found that the total number of aim points exceeded the number of Minuteman missiles. By splitting up the payload of a single

missile (deleted) each (deleted) could be programmed (deleted) allowing us to cover these targets with (deleted) fewer missiles. (Deleted) MIRV was originally born to implement the payload split-up (deleted). It was found that the previously generated MIRV concept could equally well be used against ABM (deleted). (3)

The second is from Senator Pell to Defense Secretary Laird:

Reason for U.S. MIRV Development

Now, in connection with the system around Moscow, the so-called Galosh, the existence of which we discovered, I think, in the early 1960s, haven't we responded to that with our MIRV program? Wasn't it the Titan MIRV at that time?

Secretary Laird. Well, I don't believe that necessarily is the case, Senator Pell. I would like to agree with you but having worked on these programs through the years ——

Senator Pell. Much more closely than I have because you were on the Armed Services Committee.

Secretary Laird. As much as I would like to agree with you, I can't.

Senator Pell. You feel it is a separate response, a normal outgrowth of regular research and development.

Secretary Laird. Yes; it was a separate response and it was something we had under development and under consideration for several years even prior to the time that we knew of the deployment of the Galosh. I would not want to mislead anyone, as much as I would like to agree with you.

Senator Pell. Would it not be fair to say that with the escalation in the balance of terror, whatever you want to call it, in the discovery of Galosh what with the development of MIRV shortly afterward, we now have that degree of sufficiency which we would like to have? .

Secretary Laird. Well, I think the MIRV is important, and it is important for all of us to know that the Soviets have gone forward with their research and development, and they have even a greater capability for the deliverability of warheads because of the — I am sure this committee has been briefed on this point — because of the size and the thrust of the SS-9.

Senator Pell. But our basic reason for developing MIRV was to increase our own deterrent power, not related, in your view, then to Galosh?

Secretary Laird. It was not related to Galosh because we started appropriating funds for the development of this program prior to the time we knew Galosh was in being. That is why I cannot respond that way to that question.

I happen to have been involved in the appropriation process, and we were funding the research and development on the MIRV, and we knew about these possibilities and had funded work on it prior to the time that the Soviet deployment of Galosh around Moscow was discovered. (4)

More recently Dr. Richard Garwin had the following to say regarding the two different policy goals for MIRV development:

But consider the history of MIRV in the 1960s, the multiple independently-targeted re-entry vehicle that Secretary McNamara revealed in a Life

> magazine article inverview in 1965. The Secretary of Defense wanted to deploy MIRV because the Soviets might sometime in the future build an ABM system, and it was better to have more warheads for penetrating than less. MIRVs would be 100% certain, whereas other kind of penetration aids, decoys, and so on, might be distinguished ("discriminated") by a sufficiently capable ABM system. However, the military wanted MIRVs simply because more warheads are better; you can destroy more targets with them. (5)

It is not difficult to reconcile the Garwin and Foster descriptions. Foster specifically says that "the MIRV concept was originally generated to...", while Garwin says "that the Secretary of Defense wanted to ...", that is used the ABM penetration argument in support of MIRV in policy deliberations. It is well known that Secretary McNamara was a strong opponent of demands by the Joint Chiefs of Staff for procurement of an ABM system, and simultaneously a strong supporter of MIRV development for two reasons:

- first, precisely to demonstrate the unfeasibility of ABM,
- second, to oppose the demands by the same military leadership for sizably increasing the number of US ICBM launchers. MIRVs would enable him to hold the ceiling on US ICBM launchers while simultaneously increasing target coverage through the multiplication of warheads.

One of the policy goals arising out of the RAND Corporations Project Forecast prepared for the US Air Force was the need for "very precise target location and on-target controlled delivery." (6) A somewhat later but very interesting study prepared by the Dept. of Defense's Institute for Defense Analysis measured the improvement obtained in US ICBM systems — particularly comparing Minuteman II and Minuteman III — of four different targeting capabilities, according to R & D expenditure (7). The four situations were:

1. US first-strike capability against soft targets;
2. US first-strike capability against hard targets;
3. US second-strike capability against soft targets;
4. US second-strike capability against hard targets.

Repeated descriptions of the Poseidon system stated that each missile would have double the payload of the Polaris A-3, and twice the accuracy, producing an eightfold increase in effectiveness against hard targets. The famous example provided in Congressional testimony in 1967 by Paul Nitze for the increased counterforce capability of MIRV's compared the damage inflicted by a "hypothetical" MIRV package of ten fifty-kiloton warheads — i.e., the Poseidon package — with that from a single ten-megaton warhead. The MIRVs

would destroy:

- 10 times the number of airfields, soft missile sites, or other soft military targets.
- 1.2 to 1.7 times the number of hardened missile silos. (8)

If CEPs can approach an eighth of a mile, calculations published by D. Ball, indicate that the kill probability of a single 50 KT warhead against a 300 PSI target becomes about 62%, three 50 KT warheads raise the probability to 95%. (9) With improvements in accuracy MIRVs raise the kill probabilities against a single hard target, as compared with a single larger warhead. But MIRVing also increases the counterforce capability of a missile force against a given set of targets through the technique of 'cross-targeting'.

Contrary to general public understanding — and in part due to a good deal of misrepresentation by a wide variety of sources — the previous discussion pertains in good part to the submarine-launched ballistic missile systems as well. The Navy has always had nuclear counterforce missions. (10) In 1948, the Key West agreement granted it the use of nuclear weapons against 'specifically naval targets'. However, no effort was made to define what constituted a 'naval' target or to distinguish the use of atomic bombs against port facilities from strategic bombing. During the planning of the Polaris system, submarine pens and port facilities were persistently mentioned in system statements as probable FBM targets, and the phrase 'striking targets of naval opportunity' was often used to describe the FBM objective. According to Admiral Arleigh Burke, then the Chief of Naval Operations, the calculations which determined the eventual size of the Polaris fleet were based 'entirely on military targets', though a large number of these were adjacent to urban areas.

At least since the Johnson Administration, the United States has pursued a significant counterforce capability for its FBM system. In particular, the Special Projects Office was directed in November 1964 to include the MIRV concept and advanced guidance systems in its B-3 (Poseidon) designs, with a hard-target counterforce capability as a development goal. According to Sapolsky,

> The Poseidon is not simply an extrapolation of the Polaris technology, a bigger and better missile system. The Poseidon will, if the development objectives are achieved, possess strategic capabilities in terms of targeting options that are different from those of the Polaris. In November 1963, the Special Projects Office was authorized to proceed with the definition of a Polaris follow-on (known initially as the B-3) that would enhance FBM penetration of defended urban-industrial targets. Just as work along these lines was beginning in the summer of 1964, the concept of multiple individually targeted warheads (MIRVs) launched

> from a single missile was proposed by an Air Force contractor. MIRVs, by their number and spacing, increase significantly the ABM penetration capability of incoming warheads. Combined with possible improvements in guidance systems, MIRVs offer the potential for attacking hard military targets (for example, missile launchers) as well as soft city targets. Faced with continued strategic uncertainties, defense officials directed the Special Projects Office in November 1964 to include the MIRV concept and advanced guidance systems in its B-3 designs, giving the next generation FBM the potential for both a hard-target (described often as 'time urgent') and soft-target capability. This change in strategic emphasis for the B-3 (designated by the President in January 1965 as the Poseidon) was said at the time to be an insurance measure, though precisely what the insurance would buy in strategic terms was not extensively discussed with or among Special Projects Office personnel. Although the President's Poseidon announcement did, in fact, mention increased target flexibility for the missile, and subsequent statements of the Secretary of Defense discussed a damage limiting role (necessarily a capacity to attack hard or time urgent targets) for the FBM force, apparently only a few persons involved in the FBM program and even fewer in the general public were fully aware of the possible alteration of the original B-3 mission... The hard-target counterforce capability was added to the B-3 proposal (in) quasi-secrecy. (11).

The projected B-3 FBM missile was redesignated the C-3 upon its alteration from a single-target to one with MIRV capability.

Sapolsky's description was authenticated and some further details added in an official Lockheed history of the Fleet Ballistic Missile Program released in 1978. (12) The Chief of Naval Operations had expressed interest in a potential hard-target FBM capability in November 1962 and designs for a multiple-body, single-target capability were evaluated for both hard and soft target coverage, with and without penetration aids. However, the hard-target mission was deleted. In 1962 the Air Force generated the requirement for the future Mk 12 warhead, and in March 1964 its development was authorized for both Minuteman and Polaris. Fuhrman somewhat grandiosely — and not altogether correctly — claims that "This revolutionary multiple target per missile concept changed the course of national policy, strategic force structures, targeting doctrines, and operational planning."(13) In conjunction with considering a potential hard-target role, initial evaluations of a stellar-inertial guidance system were conducted in early 1966. Advanced development of a Mk 4 stellar-inertial guidance system were started in 1968 but were subsequently dropped in 1970. However, in September 1971 the new ULMS (Underwater Long-Range Missile System) program was approved. Its advanced development began in December 1971, and it was redesignated the Trident I (C4) containing a new stellar-intertial guidance concept and improved target accuracy. Improved navigation and fire-control systems also led to increases in accuracy.

Innumerable sources over the years have repeated that SLBM s, the Polaris/Poseidon missiles, were too inaccurate to hit "military targets" — or its yield/accuracy combination too low for the hard target counterforce role — and that the weapon was therefore necessarily relegated to a countercity role. This is actually wrong for a large number of different and very elementary reasons:

- First, it overlooks the counterforce role against numerous USSR military targets aside from hard silos.
- Second, the very large number of warheads in the SLBM fleet — over 5,000 once the MIRVed Poseidon missile became operational in 1970 — made the notion that such a number of warheads could be solely for urban or even industrial/economic targets extremely unlikely. (14)
- Third, the estimate of 70% of the SIOP targets being military again meant that a substantial number of SLBM warheads would have to be assigned counterforce roles.
- Fourth, both these previous conclusions are circumstantially reinforced by the indication of the very large proportion of the Polaris/Poseidon force that was assigned to NATO targeting. The counterforce nature of that targeting is indicated elsewhere. (15)
- Fifth, it is often said that the inability of the Polaris/Poseidon submarines to know their precise location was the major factor leading to their "poor accuracy," and hence to their inability to strike counterforce targets. This too, seems to be very greatly overstated. The US Transit SLBM Navigation satellite system provides position location to FBM submarines to within a few meters.
- Sixth, one sees that Poseidon accuracy is not much different from that of Minuteman II; Trident accuracy not much different from Minuteman III.
- Seventh, US bomber bases, early warning radars, etc., are routinely presumed to be the target of USSR SLBM's.
- Finally, the counterforce capability of Polaris/Poseidon warheads would have varied in different years depending on which USSR IRBM's and ICBM's had or had not already been put underground in silos, and on what the hardness of such silos were. (16) In addition, crosstargeting and the number of warheads that were targeted on USSR silos in the years before the effects of fratricide were properly appreciated would also have been factors in SLBM counterforce capabilities. The fact that fewer redundant attacking warheads might survive, particularly if timed to arrive in close proximity to each other, is not an indication that they may not have been targeted that way in certain years.

The November 1964 directive to the Navy's Special Project Office, cited earlier, specifically connected the MIRVing of the Poseidon re-entry system with a hard-target counterforce capability. In the spring of 1968 Dr. John S.Foster, Jr., Director of DDR & E, testified that

> Recently... we found ways of improving the accuracy of Poseidon so as to be able to get much greater kill capabilities even though the warhead yields were reduced, and so in fact we are beginning to get a rather effective damage limiting capability.

In April 1969, three months after the new administration assumed office, Sec. Def. Laird requested funds to "significantly improve the accuracy of Poseidon missiles." The request was withdrawn later in the year under pressure from the Senate. The Administration repeated this request in the FY 1971 defense budget, but the funds were eliminated by Congress. However, by mid-1973 Sec. Def. Schlesinger initiated additional programs to enhance missile accuracy. Information supplied to the Senate Foreign Relations Committee by the Defense Department in March 1974 listed "technology development (deleted) of Poseidon warheads to give SLBMs an increased flexibility" as a principal claimant on the $98m. in the FY 1975 Defense Budget for the implementation of Schlesinger's "new" targeting policies. Schlesinger himself testified before the same Committee on 4 March 1974 that SLBMs were adaptable to his "selective strategy," and that the SLBM was no longer primarily "an anti-city missile." (17) By mid-1975 the Navy was pursuing a wide range of projects designed to improve the overall accuracy of its SLBM missile. (18)

Much of this analysis, based on inference, was confirmed in large part by Dr. Perry's (DDD-DDR & E) Senate testimony in 1981 after PD-59 focused US Congressional attention on the question of US nuclear weapon targeting. The following excerpt makes this perfectly clear.

> Senator Cohen. Could you stop that at all levels because if you assume the total destruction of the ICBM force and you now talk about the submarines or the cruise, don't you really have to inflict damage upon their industrial urban base? That is what secretary Brown said last year.
>
> Industrial/urban complex. I said the word city: he said no. I assume it does involve cities.
>
> Dr. Perry. No. A substantial part of our response even in that case would be directed to military targets. There are many military targets which are reasonably hard targets that are not ICBM silos. The whole class of military targets, for example, that would be confronting us in NATO. The air bases and the military bases all around the Soviet Union, those would be important targets and some of them would be attacked by bomber forces and some by the SLBM forces. As I indicated, even silos might be attacked by the submarine launched missiles to deny them an ability to have a reload capability. (19)

The evidence supplied in the foregoing material which derives from more recent years takes us beyond that deriving from the period 1960 to 1964, or 1966, but has been included as it demonstrates a consistent, cohesive development sequence. In a few brief sentences Garwin makes two additional related points:

> And when the ABM threat disappeared in 1972 with the SALT I Treaty, we had MIRVs. We did not really consider giving them up. We argued that the Soviets would not accept the abandonment of MIRVs when we had tested and they hadn't. (20)

Put more bluntly, there was never the slightest consideration in the Nixon administration of not deploying MIRV. (21) On the contrary. The deployment schedule may have been somewhat hastened by the new administration. (22)

Writing in 1972, Dr. Herbert York had examined the technology development of the "Post Boost Control System", the basic technological ingredient of the MIRV system, as an example of the inability to "control... the momentum of weapon technology". He had stressed the independent but parallel development of the Transtage section for the Titan III launch vehicle used by NASA, and its use in launching multiple satellites, and he came to the following conclusion:

> This report traces the history of the development and deployment of MIRV in the United States. A number of independent and quite disparate military requirements led to several different lines of technological developments, each of which made its contribution to the MIRV programme. As time went on, ideas and personnel were interchanged among the various programmes, which resulted in a complex web of technological developments and inventions. Thus, it is unlikely that the development of MIRV could have been successfully stopped by a conscious administrative decision to do so. The development sequence would simply have bypassed any barrier by moving along alternative but unpredictable paths.
>
> Similarly, there were a number of quite different arguments favouring the deployment of MIRV once it had been developed, and apparently several of these would have been sufficient in themselves. This whole complex network of development and decisions could have been cut in a number of places but the ultimate result — MIRVs developed on ICBMs at the beginning of the 1970s — would have remained about the same. (23)

York's conclusions can be seen as an archetypical example of the argument of "technological imperative", that the development of a technological capability makes anything but the subsequent deployment of a weapon system utilizing that capability absolutely impossible, and that such factors are the driving elements in the strategic-arms competition between the US and the USSR. In view of the evidence presented here and in the studies of Greenwood, Tammen and Sapolsky, these conclusions, whether or not they may apply in other cases, seem to be essentially misleading in the very case of MIRV development which York is describing. (24) York himself emphasized

that the motives for the Transtage development had no relation to weapon-system requirements. At the same time it is absolutely clear that there were explicit independent and decisive demands for the development of a multiple nuclear missile warhead delivery capability, and that these arose more or less simultaneously with, but independent of, the Transtage program. The success of a multiple satellite deployment capability developed in parallel certainly may have eased the arguments of those who sought to demonstrate that MIRVs were technically feasible, but it was just as certainly not the cause of MIRV development. MIRVs as weapons were being explicitly sought. Without the explicit reasons that MIRV was sought there is no inherent reason that Transtage technology would have led to a deployed MIRV, by 1970 or later. Development and deployment are two different things. The last line of York's conclusions combines weapons development and government deployment decisions, as if they were all one and the same, as if the latter added nothing to the former, and as if government decision-making processes to deploy did not even exist. There is no reason to do this. The decisions to deploy are far too important and far too visible — at least in the United States — simply to be omitted in this way. If, on the other hand, one wanted to argue that there exists a strong intention to deploy even in the development decisions, that is another argument altogether, the consequences of which, however, would demonstrate to an even greater degree the decisiveness of political decisions rather than technological determining factors arising out of the development of a capability.

There is also the interesting point to note that early in the 1960s the USSR had demonstrated a technological capability that must have been, at least in rudimentary form, analogous to the development of the US Transtage program. That was in demonstrating the technology to eject a second vehicle from a satellite in parking orbit in the early Venus probes. This did not, however, lead to Soviet MIRV development, though the USSR strategic weapon development program has on several prominent occasions given evidence of even a greater degree of "technological imperative" than that of the United States.

It is also significant that once MIRVs were initially deployed by both the US and the USSR, both nations maintained major and continuous R & D programs for the improvement of the systems. Technological improvements — increasing accuracy, yield, and control and retargeting capabilities — were retrofitted into the systems as their development and testing sequences were completed. (25) (See table 1.) In some cases, particularly for the Soviet

MIRV improvements, the R & D programs that were intended to provide additional accuracy and hard-target capabilities clearly must have been initiated long before the initial MIRV deployment itself took place. Though such subsequent improvement development patterns could theoretically have followed any of several possible reasons for the genesis of the original systems, they strongly support the assumption of a clear and definite original purpose — improved counterforce capability for the systems. Perhaps it would have been surprising if the USSR had decided on anything else given the substantial initial MIRVing of US systems, though it is notable that the MIRVing of US land-based missile systems has been only piecemeal, and additional improvements also piecemeal. Only 550 of the 1,000 Minuteman II's were converted to MIRVed Minuteman III's, and of these only 300 were retrofitted with a second higher yield and accuracy warhead. (See table 1.)

As for the USSR, it is unquestionable that USSR ICBM acquisition policy for the last generation of two has emphasized "damage limiting" — hard target counterforce — capability. The many "Mods" of the SS-17, SS-18 and SS-19 have been notable, with large numbers of MIRVs per missile, relatively high MIRV yields, and rapid retrofitting of accuracy improvements.

IOC AND INSTALLMENT SCHEDULES OF SYSTEM IMPROVEMENTS

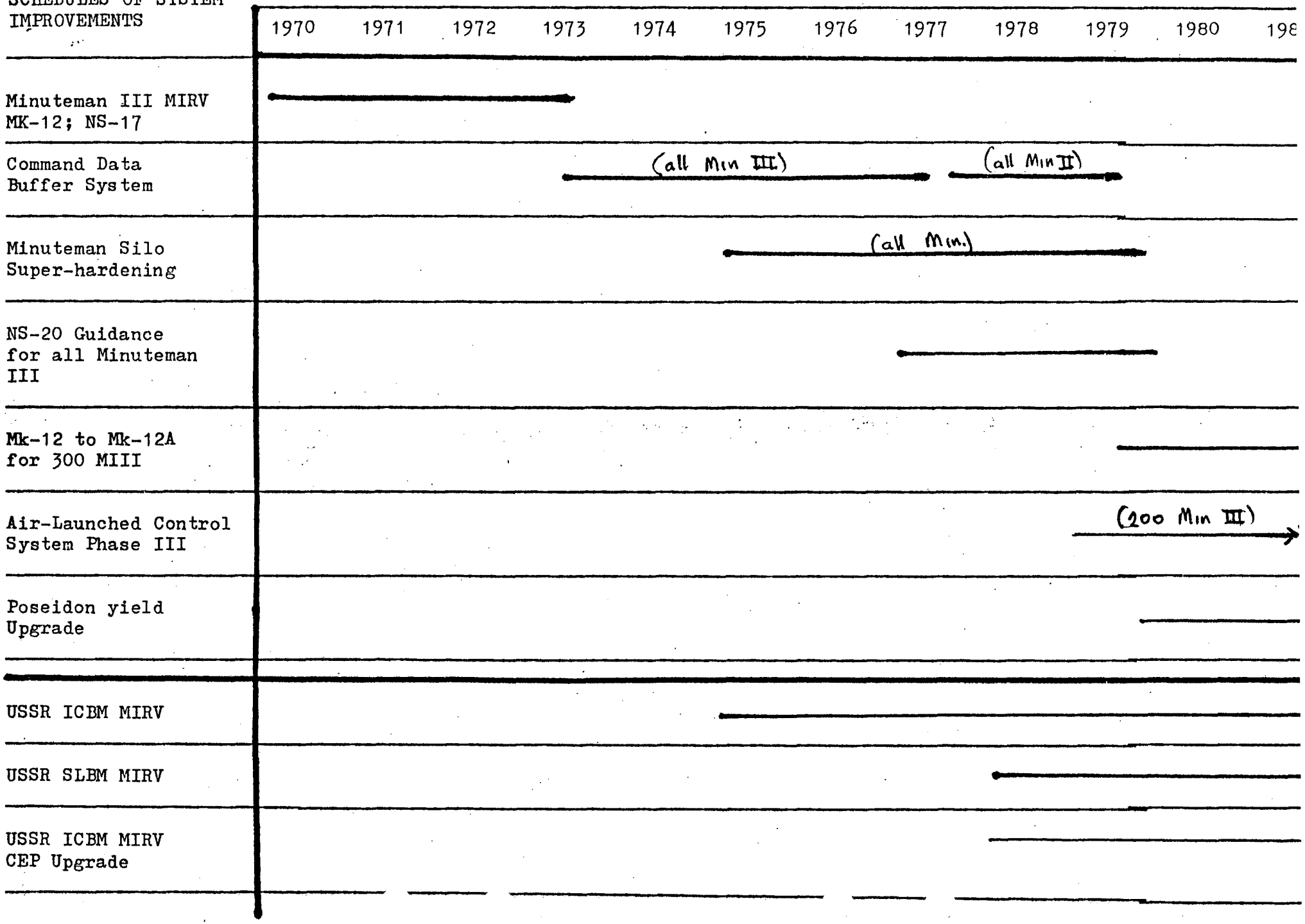

Table **Characteristics of Soviet Land-based, Intercontinental-range Missiles**

Generation and missile[a]	*Design bureau*	*Year design began*	*First flight test*	*Propulsion system*	*Guidance system*	*Warhead type*	*Launching mode*	*Base*	*Year operation began*	*Number of warheads*	*Yield per warhead (megatons)*	*Accuracy (nautical miles)*	*Range (nautical miles)*	*Throw weight (pounds)*	*Number of missiles deployed*
First generation															
SS-6 Sapwood	Korolev	1949–50	1957	Non-storable liquid fuel	Radio command	Single	n.a.	Fixed site	1959–61	1	5.0	2.0	3,200	7,000–9,000	4
Second generation															
SS-7 Saddler															
Mods. 1 and 2	Yangel	1954	1961	Liquid fuel	Radio command	Single	n.a.	Fixed site	1962	1	3.0	1.5	5,900	3,000–4,000	197
Mod. 3									1963	1	6.0	1.0			
SS-8 Sasin	Korolev	1954	1961	Non-storable liquid fuel	Radio command	Single	n.a.	Fixed site	1963	1	3.0	1.0	5,400	2,500–4,000	23
Third generation															
SS-9 Scarp															
Mod. 1	Yangel	1957	1964	Liquid fuel	Fly-the-wire, inertial	Single	Hot	Hardened silo	1967	1	20.0	0.5	6,500	9,000–11,000	288
Mod. 2			1964–65			Single			1966	1	20.0	0.5			
Mod. 3			1965			Single			1969	1	20.0	n.a.			
Mod. 4			1968			Multiple			1971	3	3.5	1.0			
SS-11 Sego															
Mod. 1	Chelomei	1955–58	1965	Liquid fuel	Fly-the-wire, inertial	Single	Hot	Hardened silo	1966	1	0.95	0.76	5,900	1,000–2,000	1,030
Mod. 2			1969			Single			1973	1	1.10	0.59	6,500		
Mod. 3			1969			Multiple			1973	3	0.35	0.59	5,700		
Mod. 4			1974			Multiple			n.a.	3–6	n.a.	n.a.	n.a.		
SS-13 Savage															
Mod. 1	Nadiradize	1958–62	1965–69	Solid fuel	Fly-the-wire, inertial	Single	Hot	Hardened silo	1967–69	1	0.6	1.0	5,075	1,000	60
Mod. 2			1970			Single			1972	1	0.6	0.82			
Fourth generation															
SS-X-16	Nadiradize	1965	1972	Solid fuel	Fly-the-wire, onboard digital computer	Single	Hot	Mobile and hardened silo	...	1	0.65	0.26	4,970	2,000	...
SS-17															
Mod. 1	Yangel	1965	1972	Liquid fuel	Fly-the-wire, onboard digital computer	Multiple	Cold	Hardened silo	1975	4	0.75	0.24	5,400	8,000	150
Mod. 2			1976			Single			1977	1	3.6	0.23	5,900		
Mod. 3			n.a.			Multiple			1979	4	0.75	n.a.	n.a.		
SS-18															
Mod. 1	Yangel	1965	1972	Liquid fuel	Fly-the-wire, onboard digital computer	Single	Cold	Hardened silo	1974	1	24.0	0.23	6,500	16,000	308
Mod. 2			n.a.			Multiple			1976	8–10	0.9–0.55	0.23	5,900		
Mod. 3			n.a.			Single			1976	1	20.0	0.19	8,640		
Mod. 4			n.a.			Multiple			n.a.	10	0.55	0.14	5,400		
SS-19															
Mod. 1	Chelomei	1966	1973	Liquid fuel	Fly-the-wire, onboard digital computer	Multiple	Hot	Hardened silo	1975	6	0.55	0.19	5,200	8,000	300[b]
Mod. 2			n.a.			Single			1978	1	4.3	0.21	5,450		
Mod. 3			n.a.			Multiple			1979	6	0.55	0.14	5,200		

n.a. Not available.
Mod. Modification.
a. Missile numbers are those used by U.S. military services; names are those used by NATO forces.
b. Another 60 in preparation.

SOURCE: R.P. Berman and J.C. Baker, Soviet Strategic Forces: Requirements and Responses, Washington, DC: The Brookings Institution, 1982, pp. 104.

As regards the implications for R & D it is interesting that in the case of the MIRVed USSR ICBM, the US had predicted an initial operating capability (IOC) in 1971, much closer to that of the US, whereas the actual IOC occurred in 1974 (or 1975). However, the US then "underestimated the pace with which the USSR would introduce much improved performance in their systems. Such a surprisingly rapid advance came in the case of new generation guidance systems for Soviet ICBMs (especially the SS-18) tested in late 1977" — and then quickly deployed and retrofitted in 1978. (26) Again as regards the implications for R & D, though the USSR may have had to carry out the complex research program that must stand behind missile warhead accuracy improvements after the US had done so — developing nose cone materials for advanced warhead reentry vehicles, geodetic satellites for discovering gravitational anomaly course overflight corrections, star-tracking systems, and numerous other supporting systems — it had to do all these things for itself just the same. (27).

This brief study also indicates the inadequacy of most statements that one finds in the literature that are meant to explain the genesis of new generations of strategic nuclear-weapon delivery systems, even explanations that purport to go beyond a simple allusion to "action-reaction" phenomena. The following quotation is a good example:

> The pace, character, and scope of Soviet strategic programs influence our own strategic programs to some extent, but, these are not the primary considerations in establishing our requirements... The motivation for the MX program then is threefold: (1) to respond to expanded Soviet strategic capabilities, considering the contribution each of our systems makes toward meeting our retaliatory requirements; (2) to advance technology and incorporate these advancements into deployed systems thereby improving total force effectiveness; and (3) to accomplish an orderly modernization of our strategic forces by replacing older ICBM's with newer, more capable systems. (28)

This statement is so general that it explains little or nothing. In addition, it takes only a moment's thought to think of other major determinents of strategic weapon acquisition that are not represented by the example of decision making on the MIRV that we have examined in slightly more detail:

1. The interests of the particular military services in particular delivery systems.
2. Their opposition — in some cases — to others, as exemplified in the following two examples given by Richard Garwin. [The first is in a comment on the Scowcroft Commission's recommendation to initiate the development of very substantially smaller ballistic missile submarines, in which the Office of Secretary of Defense was interested as early as 1972,

"... the Scowcroft Commission, which has finally come around to view the technical merit in a program which was anathema to the Air Force and unpopular with the Navy, we should begin the development of small submarines, because a reasonable number of warheads on Trident submarines with 24 missiles — billions of dollars in a single submarine — is not a sensible way to have submarines remain indefinitely invulnerable." (29

In the second example, Garwin states:

"I had a lot to do with the advent of the air-launched cruise missile, having pushed it since the mid-1960s, although the Air Force continually cancelled it because it posed a threat to the B-1 bomber." (30)

The decision to procure the Air Launched Cruise Missile (ALCM) was crucially paired to the decision not to procure the B-1 penetrating strategic bomber by the Carter administration — although the B-1 cancellation decision was eventually revoked by the succeeding Reagan administration. The decision on procurement of an advanced manned penetrating bomber — long after its development — is a bureaucratic battle between the Office of the Secretary of Defense on one side and the Air Force and its allies in the Congressional Armed Services and Appropriations Committees on the other side that actually goes back to the earlier B-70, the developmental predecessor to the B-1 in the Kennedy/McNamara administration. This sixteen-year long bureaucratic dispute is an excellent example of the difference between development and deployment (or procurement) decisions, at least in the United States government.

3. The recommendation of the same Scowcroft Commission that the US should procure and deploy 100 M-X ICBM missiles, a recommendation that clearly ran counter to the remainder of their report. It was, however, a recommendation that was clearly considered politically necessary for two reasons. The first was the embarrassment that would otherwise be caused to the incumbent Reagan administration, as well as to the preceeding one of Pres. Carter, both of which had argued for the missiles' necessity. The second reason was the wishes of the military services and some of their congressional supporters who sought the additional counterforce capability — though even this could be achieved in other far less expensive ways.
4. The decisions to procure the Pershing II missile and the Ground Launched Cruise Missiles, both of which were dependent on the wishes of the NATO allies in the period 1977-79, a pressure which the United States had at first opposed. (31)

5. Most recently one had the example — fortunately many years away from a procurement decision but therefore all the more pertinent to R & D questions — of a technically ignorant and incompetent President(Reagan)and his, for the most part, unadvised but also partly ill-advised request for a massive funding increase for space-based strategic defense systems.

   "The morning of the speech, Pentagon officials testified before a Senate committee on strategic technology that the kind of exotic technology the president seemed so taken with was way down the road and held very little promise. They were administration officials from the Pentagon." (32)

All of these examples — in addition to the case study of MIRV deployment itself — demonstrably contradict the notion of "technological imperative". Attributing government weapon procurement decisions to technological imperative tends to disregard political and military determinants, even in the cases when these are explicitly known. The concept is used in part by individuals who find it simpler to disregard the realities of bureaucratic and political policy process, and for whom it is a convenient way to explain all cases — particularly when the argument is linked to theories of corporate profit, as is often also done. To others, the complexities of policy process with such "irrational" components as interservice rivalry, are uncomfortable subjects which they would rather avoid discussing in detail. Technological imperative is politically "cleaner"; it does not imply any direct, explicit "bad" motives, such as desires for greater target coverage or counterforce capability. It portrays decision-makers, however, as something of robots, as if they had no more human — albeit flawed — motives, which one knows to be the case in numerous and frequent occasions. It is also much harder for arms controllers to argue against decisions when it is acknowledged that they were willfully taken — but for opposite goals.

If MIRVs would nevertheless have been deployed in the long run, consequent to technological discoveries such as those developed in the Transtage program, that would in the very greatest likelihood have happened because someone sooner or later proposed the nuclear force delivery requirements that had already in fact been established by 1964. To argue otherwise is to claim, explicitly or implicitly, that the political and military determinants for weapon-system development — the goals that the weapon are intended to achieve, whether or not the goals are realized to be faulty or counterproductive or impossible of achievement — are nothing more than a sham excuse to produce a system that has been demonstrated as technically feasible (and

in some cases not even so demonstrated). There is no reason to invoke such an explanation. There is sufficient evidence for a more realistic although more complicated understanding of the processes involved. Technology supplies the means, not the reasons.

REFERENCES and NOTES

1. Ted Greenwood, Making the MIRV: A Study of Defense Decision Making, Ballinger Cambridge, Massachusetts, 1975. The study appeared earlier as (Ted Greenwood) Qualitative Improvements in Offensive Strategic Army: The Case of MIRV. C/73-7, Center for International Studies, Massachusetts Institute of Technology, August 1973, 311 pages.

   Also, R.L. Tammen, MIRV and the Arms Race, An Interpretation of Defense Strategy, Praeger, 1973.

2. Harvey Sapolsky, The Polaris System Development, Cambridge, Massachusetts Harvard University Press, 197

3. US Congress, Dept. of Defense Appropriations, Fiscal Year 1969, Senate Hearings, Appropriations Committee, 90th Congress, 1968, Part 4, page 2310, US GPO, Washington, D.C.

4. US Congress, Strategic and Foreign Policy Implications of ABM Systems Hearings, Committee on Foreign Relations, US Senate, Part 1, March 1969, pp. 200-201, US GPO, Washington, D.C.

5. Dr. Richard L.Garwin, Physics and Technology of the Arms Race, April 17, 1983 mimeographed, page 10.
   Garwins reference to "The Military wanted"... is something of a gloss, at least for the very earliest stages of MIRV concept development. The Joint Chiefs of Staff had expressed strong preference for a single, larger, higher yield warhead. It was senior Dept. of Defense civilian officials such as McNamara's deputy, Harold Brown, who reportedly "educated" the military to the advantages of multiple warheads.

6. Gen.B.A.Schreiver, "Forecast," Air University Review, March-April 1965, p.3

7. "R & D Effectiveness Case Studies: Missile System Effectiveness Trends," in W.J. Schultis, et al. Analysis of Research Trends in the US and the USSR Vol. II, Appendices, Institute for Defense Analysis, Study S-387, July 1971 pp. E-21-E-48, Washington, D.C.

8.

9. D.Ball, "The Counterforce Potential of American SLBM Systems," Journal of Peace Research, 14 (1), 1977, pp. 23-40: table, page 27

10. This section is based on a more detailed study, "The Counterforce Potential of American SLBM Systems," Chapter in Milton Leitenberg, United States Counterforce Nuclear Weapon Capabilities for the Ministry of Defense, Sweden, 1984.

11. Sapolsky, The Polaris System Development, op. cit. pp. 219-222.

12. R.A.Fuhrman, "Fleet Ballistic Missile System, Polaris to Trident," Lockheed Missiles & Space Co. Inc., Sunnyvale, AIAA paper 78-355, February 1978, 26 pages.

13. Ibid., p. 19.

14. One source, apparently referring to missile warheads only (and the situation that could pertain following a pre-emptive USSR counterforce strike) estimated that "By the 1980s five out of every six nuclear re-entry vehicles that could reach the Soviet Union would be launched by US submarines." (N.Polmar, Capt. D.A.Paolucci, "Sea-Based Strategic Weapons for the 1980's and Beyond," US Naval Institute Proceedings 104(5), May 1978, pp. 98-108.) The phrase "that could reach the Soviet Union" apparently refers to the situation following a Soviet counterforce attack, and may originally have been made by secretary of Defense Harold Brown. Another source, presumably including bomber warheads in its estimate, stated "According to some Pentagon studies, the SLBM force will make up 70-85% of the surviving strategic retaliatory warheads after a Soviet counterforce strike in the mid-1980s, and virtually all of its prompt retailiatory systems". Anthony H.Cordesman, "Reagan and Strategic Forces: The Importance of the Devil's Alternative," Armed Forces Journal International, 118 (8), April 1981, of which pp. 67-69 pertain to the Trident.

15. In 1980 the fact that 400 Poseidon warheads were assigned to NATO for targeting purposes was made public. It was earlier considered that the number of US FBM submarines assigned to NATO might be five, an arrangement going back to 1962 and the earlier Polaris vessels. Perhaps more remarkable still was the disclosure in Sec. of Defense McNamara's May 1962 address to the NATO Ministerial Meeting in Athens — which was declassified in 1979 — that the entire Polaris fleet operational by the end of 1963, 12 vessels, would be committed to NATO targets, and that in subsequent years all Polaris submarines which operated in NATO waters, i.e., the bulk of the Polaris fleet, were to be committed to NATO targets.
Remarks by Secretary R. McNamara, NATO Ministerial Meeting, May 5, 1962, restricted Session, (Declassified, August 17, 1979, with exceptions), 26 pages.
Writing nearly twenty years later, Adm. Zumwalt stated that "... US Navy Poseidon missiles, not a tactical system, ... had to be taken off Soviet strategic targets in the early 1970's, and directed against Warsaw Pact targets ...." Adm. Elmo R. Zumwalt Jr. (Ret.) "Heritage of Weakness, An Assessment of the 1970's", (in) W.S.Thompson (Ed.) National Security in the 1980's: From Weakness to Strength, Inst. for Contemporary Studies, San Francisco, 1980, p. 26.

16. This simple interaction between US counterforce capabilities that may have been available against the first and second generation USSR ICBM, IRBM and MRBMs and the degree of hardening they had is also commonly overlooked. Tsipis reported that some 1,000 USSR missile silos built before 1969-1970 were originally hardened to no more than 100 psi. Those built between 1970 and 1974 were hardened to 300 psi, while the newer Soviet silos built for the SS-17, SS-18 and SS-19 missiles were reportedly first hardened to only 450 psi — but then so substantially increased, to approximately 2,500 psi, that these first estimates for SS-17, SS-18 and SS-19 silo hardness may not be correct. Kosta Tsipis, Offensive Missiles, Stockholm, paper No.5,

Stockholm International Peace Research Institute, 1974. Thus a US ICBM — or SLBM — can very well have had a reasonable counterforce capability against an early, relatively unhardened USSR missile or missile silo, and subsequently lost such a capability as the USSR superhardened the silos in the mid-1970s.

17. US Congress, US-USSR Strategic Policies, Hearing, Committee on Foreign Relations, US Senate, 93rd Congress, March 1974, USGPO, Washington, D.C., pp. 29, 37. See also J.W.Finney, "Pentagon Seeking Funds for More Deadly Trident," New York Times, February 7, 1975.

18. "Range Instrumentation Advances Spurred," Aviation Week and Space Technology, ( )" November 3, 1975, p. 34.

19. US Congress, Senate, Committee on Armed Services, Hearings: Department of Defense Authorization for Appropriations for Fiscal Year 1981, Part 5: Research and Development, Washington, D.C.: US Govt. Printing Office, 1980, p. 2724.

20. R.C.Garwin, 1983, op. cit. p.10.

21. "SALT, A MIRV Mistake," and "SALT, A Mistake Becomes a Policy," Chapters 12 and 13 in Seymour M.Hersh, The Price of Power, Kissinger in the Nixon White House, New York (Summit Books, 1983), and Doubletalk The Story of SALT I, Gerard Smith, (New York, Doubleday & Co Inc.) 1980. An earlier volume on SALT, Cold Dawn, by John Newhouse, is grossly misleading and unreliable on questions surrounding US MIRV deployment and SALT.

22. Milton Leitenberg, "The SALT II Ceilings, and Why They are So High," British Journal of International Studies, 2 (7), 1976, pp. 149-163.

23. Herbert York, The Origins of MIRV, SIPRI Research Report No.9, Aug. 1973, 24 pages, Stockholm International Peace Research Institute.
(The phrase in the last line of the York quotation is reproduced as it was originally printed, but presumably should read "... MIRVs deployed on ICBMs at the beginning of the 1970s..." i.e. not "developed").

24. York devotes five and half pages to the description of the Transtage development history, three pages to Poseidon, and a bit over two pages to the Minuteman III. He has no reference to the studies of Greenwood, Tammen and Sapolsky and he has none of the detail of the decision making processes on Minuteman and Poseidon contained in their studies. In addition, he is relatively discreet in his discussion of the "... number of independent and quite disparate military requirements..." that he himself refers to, and counterforce and the expansion of target coverage are dealt with very circumspectly.

25. See Milton Leitenberg, United States Counterforce Nuclear Weapon Capabilities, 1984.
The pattern is very similar to that which took place with the original Polaris system, which underwent continuous improvement throughout the first decade of its deployment. See Milton Leitenberg, "Submarine Launched Ballistic Missiles," in SIPRI Yearbook of World Armaments and Disarmaments, 1968-1969, Stockholm, Almquist and Wiksell, 1969, pp. 96-111.

26. See Allocation of Resources in the Soviet Union and China, 1975 Hearings. Joint Economic Committee Part 1, pp. 32-33, 97-98. See also Committee on Appropriations, US. Senate, FY 1981. Special Hearing. MX Missile Basing Mode, p. 55-56.

27. Even here however "technology transfer" of a more or less "covert" nature may come into play, for example by the USSR purchase of particular ballbearing grinding machines used for MIRV construction in the US, and by the procurement of microcomputer components as well as main frame computers used in testing programs.

28. Committee on Armed Services, US Senate, Authorization Hearings, US Dept. of Defense, FY 1977. Research and Development, Part II, pg.6520

29. Dr. Richard L.Garwin, "Physics and Technology of the Arms Race," 1983. op. cit. pg. 14.

30. Dr. Richard L.Garwin, in Seeds of Promise: The First Real Hearings on the Nuclear Arms Freeze, Andover, Mass: The Brick House Publishing Company, 1983, p. 63.

31. Milton Leitenberg, "The Genesis of the Long Range Theatre Nuclear Forces Issue in NATO," in, The Military Balance in Europe, Conference Papers No.2, The Swedish Institute of International Affairs, 1982, pp. 57 to 94.

32. Another symposium participant was a bit more specific:

> The very day the president made his speech, the space systems program manager appeared before the House Armed Services Committee and was asked, "Do you need any more money for this stuff?" He said, "Gee, no, we have quite enough." He added that under the right circumstances, we could probably get 50, maybe 60 percent effectiveness out of existing systems, projecting them forward about 12 years.

See David N.Schwartz, "Ballistic Missile Defense, Reflections on Current Issues", In Nuclear Armament and Disarmament, Annals American Academy of Political and Social Science, 469, Sept. 1983, pp. 66-67.