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Assessments and the B-1 bomber network

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In current practice arms control focuses on (non) deployment of specific weapon systems rather than on their development. Although the far reaching implications of military technological innovations are widely recognized, many analysts and politicians consider research and development as a process that is outside the scope of arms control. This article analyzes certain episodes in the development of the B-1 bomber to illustrate that, for effective arms control, the R&D phase cannot be ignored.

The contours of an approach to the analysis of weapon innovations are sketched, that can be used as the backbone for the development of a method for arms control assessments. It is argued that, when such assessments are made an integral part of weapon innovation processes, they can be used as an important instrument for arms control.

Keywords: weapon systems; arms control assessments; international security

Bert Enserink, Wim A Smit and Boelie Elzen are at the Centre for Studies of Science, Technology and Society TW/RC building; RC-310, University of Twente, PO Box 217, 7500 AE Enschede, The Netherlands.

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THE DRAMATIC CHANGES in Europe in 1989/90 open up remarkable new opportunities for shaping the future development of military technology so that it enhances, rather than, as it often has in the past, undermines (international) security and stability. These opportunities will not, however, be seized unless we change both our way of thinking about military technology and our organizational arrangements for controlling it. This article is about how both of these are possible.

In our opinion an effort should be made to develop ways to influence military technology in the early stages of the R&D process, before a technological course becomes too deeply entrenched to allow interference or guidance. We would suggest that clues to this problem might be found by seeing military technological developments, and in particular the weapon innovation process, as a socio-technical process, in which attention is paid to both the shaping of the technology and the shaping of the social network around a technological artefact.1

Below we use a network approach, which will allow a more flexible and dynamic understanding than the traditional schools of weapon innovation provide. It will also help to determine where and how technology is being shaped, which will subsequently be used to sketch the contours of a possible intervention strategy.

Current development and deployment of new weapon systems do not always contribute to a more stable international security, nor in many cases, do they enhance national security. For nuclear weapons, for instance, Herbert York has forcefully argued that the ever increasing US nuclear inventory has resulted in a rapid decrease of national security. The main effects of the development of the H-bomb in the 1950s and of MIRVing in the late 1960s has been a vast increase
Many analysts and politicians consider R&D as an autonomous process with an intrinsic momentum that is outside the scope of control: others think the innovation process is so dispersed that it cannot be steered.

of American and Soviet capabilities to destroy each other completely. York called this process the “ultimate absurdity.”

Likewise counterproductive effects may occur in the area of conventional weapons, which can be illustrated by the European security situation. Since the INF (Intermediate Nuclear Forces) Treaty of December 1987 more emphasis has been put on conventional weapons in Europe. The numerical superiority in conventional weapons of the USSR, it has been argued, not only has to be compensated by unilateral reductions of numbers, but also by introducing new and technologically advanced weaponry.

Some of the weaponry, for instance conventionally-loaded, highly accurate surface-to-surface missiles, due to their short flight times, pose a threat to crisis stability. One may say that these weapons have an inherently destabilizing character.

The present path of weapon innovation, meant to increase national security, may actually undermine it in two ways. First, new developments in weapons technology may undermine existing arms control treaties (as cruise missiles undermined SALT-I (Strategic Arms Limitation Treaty) and long range stand-off weapons may undermine the INF Treaty). Secondly, particular types of weapons, because of certain operational characteristics, may have a destabilizing effect.

The present Vienna arms control negotiations on CFE (Conventional Armed Forces in Europe) focus on reductions of troops and of existing conventional weapons. In a future situation of reduced levels of armament, qualitative changes by particular weapon innovations may pose an even greater threat to stability and thus to (inter) national security.

Although the far reaching implications of military technological innovations are widely recognized, they are not yet part of arms control negotiations. One reason for this is the perceived lack of instruments for steering the process of weapon innovation.

The problems encountered are that many analysts and politicians consider research and development as an autonomous process with an intrinsic momentum that is outside the scope of control. Others think that the whole technological innovation process is so much dispersed that it cannot be steered. More insight into the possibilities of coupling assessments of weapon systems to the military technological innovation process can be obtained by studying the dynamics of this process.

Below we start by sketching various current and past schemes for the control of weapon innovation and procurement. For the sake of brevity we limit ourselves to the situation in the United States. We will demonstrate the limitations of these attempts and subsequently present our own approach to the problem.

In the empirical part of this article we describe certain episodes of the development of the B-1 bomber. Although decisions not to deploy it as a weapon system have been taken, the program did stay alive until the B-1 was deployed many years later. It is a clear illustration that focusing on procurement has only limited value from the perspective of arms control. We will finish by discussing how our approach to the problem can be more effective.

Attempts at control

SAO: Systems Analysis Office

In the early 60s, Robert McNamara, the then US Secretary of Defense, introduced analyses into the defense decision-making process, to meet the need for a more rational foundation of procurement decisions. Weapon systems were brought into a process of continuous evaluation in which the formulation of alternatives and cost-effectiveness became central elements.

McNamara’s Systems Analysis Office (SAO) had a central position in the Planning-Programming-Budgeting System, interacting with all other groups of actors in the research, development and procurement cycle. The SAO acquired this central position, in the policy process especially, at the expense of the role of the military establishment. It became very influential and its assessments were disruptive for several important weapon programs, including the Air Force’s B-70 bomber and Skybolt air-launched ballistic missile (ALBM).

Although SAO merely focused on cost-effectiveness, some arms control issues were occasionally touched upon. The 1961 analysis of the B-70 bomber program illustrates this. The outcome of the analysis in which the proposed bomber was compared to ICBMs (intercontinental ballistic missiles) and Polaris SLBMs (submarine-launched ballistic missiles), as strategic delivery systems, was very negative: not only was it not a flexible system, it was also vulnerable on the ground and lacked penetration aides for flying over enemy territory. Moreover, according to SAO, the B-70 would increase tension because of its high ground alert and early take-off.

However, although potentially a rather effective instrument for guiding military R&D, systems analysis was hardly used as a means of arms control policy and it was not very effective in that respect. The establishment of a real arms control agency was enacted by the US Congress some years later.
The establishment of the Arms Control and Disarmament Agency by the US Congress was an effort to influence the weapon innovation process. One of its tasks was to provide Congress with information on the arms control impacts of existing and forthcoming weapon systems in the inventory.

During the mid-1970s Congress enacted a wide range of legislation intended to give ACDA a stronger voice in policy-making, for instance by requiring submission of arms control impact statements (ACIS). ACDA was situated within the Executive branch and had to fulfill the thankless task of assessing (and therefore criticizing) the arms control impacts of the procurement propositions of the Department of Defense.

ACDA, for information on military R&D, understandably depended on a not very co-operative Defense Department. Most of its time it led (and in this respect still leads) an ailing life. Although the Carter administration made an effort to comply with the letter and spirit of the Arms Control and Disarmament Act (section 36), a 1979 Congressional Research Service study evaluating ACIS practice concluded:

"Arms control impact statements submitted in connection with the fiscal year 1977 and fiscal year 1978 Presidential budget requests did not comply with the law. These statements failed to report many programs for which impact statements were required and lacked complete, detailed analysis requested by Congress".6

During the remaining Carter years the quality of the ACISs improved, and plans were made to replace them with an institutionalized role for ACDA and the State Department in the existing Department of Defense acquisition process. This was not implemented before Carter left office, and the Reagan administration lacked the interest to do so. ACIS then became more and more a legitimizing tool for defense expenditures. Philip J Farley in his statement delivered before the Committee of Foreign Affairs on 8 April 1981, said about ACDA and its ACISs:

"The deletions in the published document are frustrating and at times infuriating. The elaborate dissection of weapons programs and their implications, and the methodical listing and balancing of pros and cons, are often tedious. The guarded conclusions (the standard format appears to be the double negative, e.g., "Modernization of NATO battlefield nuclear weapons is not inconsistent with U.S. arms control policy") sometimes cause a wry smile by their bureaucratic caution."8

The content of the ACISs, although following a well-defined schedule, depends very much on the political will of the composer. In 1984, for instance, the ACIS on airborne strategic offensive systems, a category including the B-1 bomber and Air-Launched Cruise Missiles (both subjects of this article), was merely a superficial description, culminating in the conclusion that:

"Programs to ensure the continued effectiveness of the airborne strategic offensive force support US arms control and national security goals of deterring nuclear war or coercion, and maintaining international stability through the preservation of a credible threat of assured retaliation. These programs contribute to the reliability, survivability, and penetrativity of the air-breaching element of the strategic Triad and are consistent with US arms control objectives."9

One may say, without discounting its important work on international arms control negotiations, that ACDA, because of both its organizational setting and its main focus on systems already in the inventory, has provided hardly any incentives for guiding military R&D.

OTA: Office of Technology Assessment

About ten years ago a new effort to get some grip on the weapon innovation process was initiated by members of Congress by allowing the OTA to do assessments on military technology. OTA, a Congressional agency renowned for the thoroughness and objectivity of its analyses, usually gets its commissions from full Committees. As a consequence, the topics of analysis are generally formulated at high levels of abstraction and therefore lack a political barb. Alan Shaw, OTA's International Security and Commerce Program Manager explained:

"...political contentious issues will be politically contentious within the Board and will only be approved with great difficulty ...[T]his means that they may be modified or they may be rejected."10

OTA formally has access to all necessary military information and even to researchers in military laboratory and industrial consortia. But also in this respect

Without discounting its work in international arms control, ACDA, because of its organizational setting and its focus on systems already in the inventory, has provided hardly any incentives for guiding military R&D
there are some limitations. Having been asked for the possibilities of an assessment of the B-2 (Stealth) bomber Shaw answered:

"To do a complete job on the B-2, we would have to have access to very highly classified information, that we are ultimately unlikely to get access to. We would be very reluctant to do a job knowing that there was important information that we could not get our hands on."

OTA does not monitor technological developments, but assesses technological issues on request. It has no formal arms control task and will only assess these implications if explicitly asked to do so, which, because of political controversies in connection with weapon development, is seldom the case. Because OTA was set up as an analytical agency to inform Congress, it has, institutionally, a greater potential for successfully influencing the course of the innovation process than ACDA ever had, if only it would deal with the issue of weapon R&D and its possible future (arms control) implications.

On the other hand our estimation is that, even if OTA focused on informing Congress about military R&D, this would not really have a big impact on the weapon innovation process. By the time Congress has to decide on the funding of crystallized and established R&D programs, the development may already have become entrenched. Moreover, both ACDA and OTA are outsiders to the innovation process: whereas they may interpret the activities occurring within the military technological area and inform the members of Congress, they do not actually participate in activities directing technology.

In view of the virtual lack of political guidance to military R&D, it is important to get a clear picture of the process in which research, development and procurement do take place. That might provide clues for improving this situation. Therefore the next section focuses on the explanation of the dynamics of weapon innovation.

**Dynamics of the arms race**

The problem of development of new weapon systems can be referred to as the 'dynamics of the arms race'. Until recently two main approaches could be distinguished. One, the 'action-reaction' school, focuses on inter-state interactions, the other, the 'bureaucratic-politics' school, emphasizes intra-state processes. The two approaches, however, are not mutually exclusive.

In the inter-state approach the emphasis is on the competition in weaponry between the two power blocs NATO (North Atlantic Treaty Organization) and WTO (World Trade Organization). Central is the idea that the military and politicians of each bloc feel pressed to promote weapons innovations in order to counter those of the other party. The process is even more forceful than a simple action-reaction mechanism, in the sense that a party often 'reacts' not only to what the other has done or is planning to do, but to what he thinks the other party might possibly do in the future.

This points to the second approach in which the intra-state processes are perceived as the main driving force in the weapon innovation process. The fact that, after World War II, research and development of new weapons has been institutionalized, on a scale never seen before, has brought many analysts to the conclusion that technological development itself (often called 'technological momentum') constitutes the driving force.

What is lacking in the various approaches within both schools is a link between the described social and organizational processes and the technological characteristics of the weapon systems developed. Consequently there are hardly any proposals for how to control (or regulate) the innovation process.

Of interest is the recent work of Evangelista because it can be viewed both as a reaction to, and an integration of, the approaches of the two 'schools' mentioned above. Evangelista has developed a five-phase model for describing the innovation process of 'break-through' military technologies. The major advantage of this model is that it has an open eye both to processes internal to the technological community and to the interactions of this community with a wider community of military and politicians.

However, Evangelista has not addressed the question how his model can be used in connection with the problem of control of weapon innovation. As will be illustrated below, one of its shortcomings appears to be that technological development is still too much conceived of as a linear process.

One has to conclude that, on the analytical level, the dominating schools studying the dynamics of the arms race hardly pay attention to the problem of guiding weapon innovation. Moreover, on the practical level, the currently existing official assessments of military technology aim primarily at procurement decisions and do not focus on the actual choices on the level of research and development. A third problem is that the agencies conducting arms control oriented assessments of military R&D are actually outsiders in the R&D policy process.

**Guiding principles**

As mentioned earlier, an effort should be made to develop ways of influencing military technology in the early stages of the R&D process, before a technological course becomes entrenched too deeply to allow interference or guidance. Using a network approach will allow a flexible and dynamic understanding of the innovation process and will be helpful in determining where and how technology is being shaped. We will try to trace which factors guided the various actors in their roles, in particular in their interactions with other actors.
Guiding principle is an analytic concept used to describe and analyze processes of military technological development and an element in the design of intervention strategies for control of these developments.

In recent publications, the concept of 'guiding principle' has been developed to facilitate a further elaboration on the idea of steering and regulation of military R&D within the framework of arms control. Guiding principle is, on the one hand, an analytic concept used to describe and analyze processes of military technological development, while, on the other hand, it is intended to be an element in the design of intervention strategies for control of these developments.

Because of our interest in control, we are primarily interested in those guiding principles that are relevant to guiding technological development and that are shared by various actors in different positions in the weapon innovation process and that, either explicitly or implicitly, play a role in the interactions between these actors. We are, for instance, interested in guiding principles shared by politicians and military, or by industrialists and politicians, and so forth. So it is basically an inter-organizational concept.

A second aspect of this concept is that it should function specifically as an 'interface' between military technological developments and military doctrines and strategies. In order to make it a potentially useful instrument for arms control measures the problem, to be addressed more specifically in later studies, becomes how considerations of arms control can be made an integral part of guiding principles.

Because of this 'interface-character' we will pay attention to the role of military requirements, as these may provide some kind of materialization or crystallization of the concept. In this way we hope our analysis will show to what extent military technological developments are an expression of guiding principles that are shared in the interaction between the various actors in the B-1 network.

The importance of evaluating the meaning of a military technology in relation to the military strategy in which it has to function has recently been shown rather extensively by John Grin. Using Defense Technology Assessment (DTA) as a method to assess technological options for Command and Control he showed that, depending on whether one favours the established NATO posture or a posture of non-provocative defense, certain technological options are more appropriate than others. This also implies that, once a specific scheme has been implemented, implementing a different defense posture becomes more difficult.

Framework of analysis — networks

Given our criticism of the traditional analytical schools, our framework should acknowledge the heterogeneity of the weapon innovation process in the sense that both the technological and the social aspects are subject to continuous change. We try to account for this by using the notion of a network.

In our approach the nodes in a network are considered to be either individual human actors or (representatives of) groups of human actors. A network is further characterized by the interactions between the actors, which can be of a very heterogeneous nature. These interactions give shape to the technology that is being developed, but at the same time the technological development (partly) shapes the interaction.

In a recent publication we described the dynamics of the genesis and stabilization of the international European Fighter Aircraft (EFA) network. Our analysis showed how the shape and content of the new 'EFA-network-in-the-making' was determined by the characteristics of the underlying (national governments - national defense industries) networks in the participating countries. We showed how in this early stage of the EFA network military requirements were formulated both as a vehicle for interaction and as a guideline to give shape to the technology.

Our analysis also showed that, after some time, the new EFA network gained resilience, which meant that the shape and content of the network itself, as well as the technology, became more crystallized and more difficult to change. Once the EFA network was established we were able discern the emergence of more or less stable patterns of interaction among two principal sets of actors: the 'dedicated' network builders (the national governments) and the other more 'reactive' actors (in this case the military and (defense) industrial corporations).

The military requirements in later stages of the EFA development process became less dominant and merely another element in the dynamics of the EFA network. They had to compete with other (industrial/economic/budgetary) requirements and, thus were subject to continuous change. Clearly they had become less important as determining elements for the shape of the technological artefact.

Several lessons can be learned from this case. One is that, in order to understand the dynamics of a (new) network, it is important to look at pre-existing underlying networks rather than at individual actors.

Secondly in order to successfully influence the course of the innovation path, one has to be aware of the dynamics within the network. For instance, in trying to introduce a defense technology assessment that effectively influences the weapon innovation process, one should not focus solely on the procurement decision, but should take action in the early phases of the development process, when the requirements are being formulated that will largely determine the future technological course.
Assessments and the B-1 bomber network

B-1 bomber case

In this article the analysis of the control and guidance of R&D will focus on the dynamics of a now well-established military-industrial network — that of the American B-1 bomber. The large scale of this project enables us to focus on networks at a high level of aggregation, such as those in which military strategy is formulated and implemented (in which especially various military actors play an important role), those in which weapon systems are conceived, developed and produced (especially industry) and those with a broader political agenda (Executive branch, the US Congress). These (underlying) networks may overlap to a certain extent and become linked to each other.

We will show the existence and resilience of similar established patterns of interaction, as we did in the EFA case, and show how the socio-technological network shapes the technology. The resilience in this case manifests itself in a tendency of the interaction patterns in the network to preserve themselves by 'adaptation' of the content of interaction (for instance, the development of new and different weapons). We will see how, in an attempt to keep the network going, the technology is adapted to changing requirements and/or how the requirements are adapted to changing (technological) circumstances.

A general overview of the history of the B-1 and the central actors will show how the dedicated network builders, sometimes successfully, sometimes not, were continually looking for political support for their project. Depending on their degree of success we will see an expanding or retracting B-1 network and pay attention to the effects of these network dynamics on the requirements and the technological artefact itself. Subsequently, focusing on a particular episode of the B-1 history, we will illustrate how the network succeeded in countering attacks from outside by being very flexible in connection with the technology to be used and, finally, by more or less literally swallowing a potential threat to its existence — the cruise missile.

This approach shows the relevance of the interaction between the participating social groups of network actors as well as the considerable influence of pre-existing underlying networks on the interaction within the B-1 network. The case study will also show how guiding principles, crystallizing in the form of new requirements for the bomber, played a role in shaping and re-shaping the bomber technology.

Finally, we will discuss what lessons can be learned from an analysis of the B-1 case in network terms, and in terms of implications for effective schemes of arms control. We will focus on how technology is being shaped in the interaction between the various groups of actors in the B-1 network and emphasize periods of change and periods of relative stability in the network as well as in the technology.

The relation between strategy and doctrines on the one hand and requirements on the other will be highlighted. This will provide insight into where intervention in weapon R&D might be successful, for instance to counter development and production of destabilizing weapon systems. Recommendations will be made to influence the course of the innovation process, in order to give arms control assessments and other forms of defense technology assessment a greater impact in the process of political control.

Strategic bombers

We now make an excursion into the world of strategic bombers. This case study describes the dynamics of the US strategic bomber program, which started in the mid-1950s. We will give an overview of the 25 years of its research, development and procurement (RD&P) history. This sketch will give an impression of the dynamics of the program, and some of its major social and technological characteristics. We will introduce the different groups of actors involved in the bombers RD&P process and focus on how technology is being shaped in their interactions.

This general picture will be used as a background to a specific episode in the life of the B-1 bomber, the period starting with the cancellation of the B-1 procurement program by President Carter in 1977, until its resurrection by President Reagan in 1981. The reason for focusing on this period is that the existing B-1 network came under great stress, which meant that, in the interaction, the content of the technology was under discussion and, to a large extent, given shape in the same process as the social relations in the network were being (re)shaped. Focusing on such an episode may thus provide insight into possibilities for letting arms control considerations influence the course of technological development.

A variety of groups and individuals took part in the discussion about the modernization of the bomber, but the content and intensity of their interactions changed considerably over time. There was a hard core of dedicated network builders: the United States Air Force, especially the Strategic Air Command (SAC); and the aerospace company Rockwell International. Over time one striking feature of the network is its expansion or shrinkage depending on the success or failure of the efforts of SAC and Rockwell to maintain the existing support and/or to enrol new groups, such as Congressmen or DOD officials, in their network.
To bring the bomber to the production stage SAC and Rockwell needed the support of other groups, for instance the Executive Branch and members of Congress. At times this enrolment of groups with often deviating ideas failed, at times it was successful: it was frequently accompanied by changes in the technology to accommodate the expectations of the new participants. These changes and the pulsating character of the supporting social network contrast with Evangelista's more linear model, and point to the necessity of a framework of analysis that allows a more dynamic relation between the shaping of the technology and the shaping of the accompanying social networks.

For reasons of transparency we will limit ourselves to the interactions between the four most prominent network actors. So, apart from Rockwell and USAF/SAC, we will pay attention to the Executive Branch (Pentagon officials, the Secretaries of Defense and Presidents of the United States) and the legislators in the US Congress (sometimes divided into House and Senate, Republicans and Democrats). When necessary other groups, such as opponents and subcontractors, will be involved.

Little or no attention will be paid to the established arms control agencies, ACDA and OTA. On the one hand, they are implicitly included in the description because they are professional branches of respective- ly the Executive and Congress, on the other hand they did not really play an important role in the B-1 network. As illustrated earlier, ACDA's yearly ACISs on the B-1 bomber were no more than a bureaucratic obligation: a vague description of the program, legitimizing the budget request. The agency stood outside the B-1 network.

Network dynamics

Weapon procurement in the USA has the US government as the principal customer, and a series of prime contractors as main developers and principal salesmen of defense hardware. In the case of strategic weapon systems this national orientation is even stronger than in the conventional tactical weapon area, because export of strategic systems (with some exceptions for the UK) is considered to undermine national security.

Most of the US weapon research and development is carried out by large defense firms. This situation has developed into a lasting mutual dependence between client and salesman. The government is funding R&D and buying the products, the industry is offering technology and knowledge, is trying to survive and so make profits.

US government policy is directed both at preserving national security and at maintaining a sound national defense industrial base. Although these are important policy issues, especially in election years, they are in competition with foreign policy-making and domestic problems that have to be solved within the same limited budget. Mallin has analyzed the US procurement policy in terms of a permanent competition between national security planning and budget constraints, where sometimes defense requirements and, at other times, budget constraints, take the upper hand. This is important because it tells us that the US government participates in a variety of underlying policy-making networks, that are to be coupled to the B-1 network.

The US Department of Defense, in co-ordination and co-operation with the Services that formulate their requirements, prepares the annual defense budgets which need approval by the US Congress. The Services are individually responsible for the spending of the appropriated money and therefore play a central role in weapon procurement processes. They are formally responsible for spending the appropriated money on weapon RD&P. In exercising this responsibility, they formulate weapon requirements, evaluate and select systems, and supervise weapon RD&P programs.

Formally, the US Congress exercises political control on the government's national security policy and on defense spending. Budgetary decisions are taken in Congress and carried out by the Executive. To push a new weapon system through the development process, Congressional support for program funding is a necessity. This support is interlinked with other policy issues such as pork barrel politics (jobs and money for the constituents) and political trade-offs.

Political approval of new weapon programs is therefore considered to be a major hurdle for those wanting to procure new weapon systems. In Congress the defense-related committees are the principal defense policy-makers. Participating Congressmen are frequently lobbied by the Services and by representatives of the defense industry.

Rockwell and SAC co-operated in organizing support for the B-1 program. Because of the long lead times of large-scale military projects and the multiple decisions that are made during this time, they had to cultivate the existing support, and, time and again, had to establish new bonds with other groups. In this respect it is important to notice that both the USAF and Rockwell needed good contacts in Congress, because support for B-1 bomber procurement in Congress and the Executive was not self-evident.

In the mid-70s, Rockwell and SAC explicitly joined forces to save the B-1 experimental program in a contentious lobbying effort. Rockwell also made use of a common strategy of big industrial firms to win
political support: they subcontracted parts of the job to many places all around the USA. In this way Rockwell spread jobs over a great number of constituencies but also in money and jobs for their constituencies, in order to get some influence over individual Congressmen.

This strategy is an example of how the dedicated network builders try to hook on to themes that are important to other groups of actors. Representatives are not only interested in maintaining national security but also in money and jobs for their constituencies, because this might improve their own chances of re-election.

**Indispensable system**

The Air Force considered the bomber to be an indispensable weapon system, that, in contrast to ballistic missiles, fitted within their definition of the situation: the Air Force wanted to fly and did not want to be reduced to 'silent silo sitters'.

This was even more evident at the Strategic Air Command: the strategic bomber was their very reason for existence. In SAC circles the idea was kept alive that the strategic bombing of Germany and Japan in World War II had forced these enemies to their knees, owing to the psychological effect and the fast destructive power of bombardments. This traditional view, with an emphasis on high altitude and high speed, was very persistent within the SAC. Douhet's adage was still popular:

"The guiding principle of bombing actions should be this: the objective must be destroyed completely in one attack, making further attack on the same target unnecessary." (emphasis in original)

SAC people all through the years wanted to make sure that the manned penetrating bomber was a permanent part of the strategic force structure. This persistence of traditional doctrinal ideas was reflected in the requirements as formulated for the various follow-ons to the B-52, like the B-70 in the late 50s, AMSA and B-1 in the 60s, as well as the B-1B in the late 70s and early 80s. In all cases the bomber's penetration capacity and payload were regarded as a dominant requirement.

In their quest for support, the Air Force had to convince Congress and the Executive of the necessity of replacing the high-subsonic B-52 by a new bomber. The B-52 was operational from 1955 onward and 744 aircraft had been produced through June 1962. Because of its huge size and radar cross-section, doubts were rising about its future penetration capacity, in view of the ever-improving Soviet air defense.

The new bomber not only would have to compete with its predecessor the B-52, but would also have to compete with new strategic delivery systems coming into the inventory, like the ICBM's in the early 60s and cruise missiles in the late 70s. Throughout the years, the Air Force, in her communication with the US Congress and the US DOD has been stressing "operational flexibility" as the important characteristic that distinguishes the bomber from other delivery systems:

"With the manned systems, you can manoeuvre them, you can launch and recall them, you can change their position, you can threaten with them, and you have all the flexibility in the world necessary to do things that might well prevent the war from ever starting." Flexibility, as McNamara's systems analyses had made clear, was the single argument the Air Force could use in favour of the bomber and against the use of the cheaper, faster, less vulnerable and more accurate strategic missile. In defending the need for the B-70, Senator Cannon and General White, the Chief of Staff of the USAF, had an illuminating interaction illustrating the Air Force's stance and its aversion for missile warfare:

Cannon:"Is it not a fact, General, that if we proceed in getting only missiles, we will limit ourselves completely in the strategy that we are able to follow? We will have no flexibility in strategy?"

White: "That is correct .... The strategy then would be a static psychology."

Flexibility was not only being used to stress the operational difference between missiles and bombers, but it also served as a vehicle of interaction between the Air Force staff and the Office of the Secretary of Defense. McNamara developed the 'Flexible Response' doctrine, in which hostilities should not be answered by an all-out counter attack but at a level tailored to the situation. The flexibility of the manned penetrating bomber force during the 60s and 70s and its adaptability to new tasks during the 70s and 80s became popular Air Force arguments for the sale-ability of the bomber to unbelieving Pentagon officials.

Seamans, as Secretary of the Air Force involved in starting the B-1 development program in 1969, explained that at that moment:

"It seemed as though we got to have the flexibility of the manned bomber and we should also
have the capability to carry much larger payloads."\textsuperscript{34}

The flexibility of the bomber, if compared with other delivery systems, even nowadays proves to be a valuable argument for maintaining an effective deterrent as Donald Rice, the US Secretary of the Air Force, explained in a recent article:

"The manned penetrating bomber is the most efficient, flexible, and effective system in the triad against non-time-sensitive targets ... which must be held at risk to ensure deterrence."\textsuperscript{35}

It is clear that, although for different reasons, Rockwell and the Strategic Air Command together kept pushing on a production decision for a new bomber. But the history and the critical episode that follow will show that there were important opponents as well.

From B-52 to B-1B

Rockwell and SAC, although they had different interests, over the years became close allies. Rockwell needed to build a bomber for keeping its aerospace division going (and for the expected profits). SAC felt it needed a follow-on bomber to replace the old B-52s, to ensure that the manned bomber would keep its place in the strategic triad.

Contacts between SAC and Rockwell date back to 1954, when North American Aviation (NAA), that in 1967 merged with Rockwell Standard, participated in a design competition with Boeing for a new chemically-powered, long distance, high speed, high altitude bomber (GOR 38/WS 110-A), later called B-70.\textsuperscript{36} The requirements formulated for the B-70 reflected the Air Force's prevailing doctrinal ideas of that era: high speed, high altitude, high payload — it was supposed to fly at 70,000 feet at Mach 3 (2,300 mph) all the way to Russia to deliver high payloads on predesignated targets.\textsuperscript{37}

Because of the technological problems that had to be overcome, this competition did not at first bring what was expected from it and the project was halted. After a series of aeronautical breakthroughs in the utilization of sonic wave technology\textsuperscript{38} in 1957, by both Boeing and NAA, it became technologically feasible to build this supersonic long distance bomber and the competition was reopened.\textsuperscript{39} After examining the proposals the USAF selected NAA to work on the aircraft and General Electric on its power plant.\textsuperscript{40}

The US Air Force, in the aftermath of Sputnik, skillfully exploited the sentiments aroused by the 'missile gap' hysteria and managed to organize support in Congress as well as (initially) from president Eisenhower.\textsuperscript{41} About a year later Eisenhower, denying the existence of a gap cut back the bomber development program. But, in the advent of coming presidential elections, he had to restore support, because of Kennedy's accusation of fixing arbitrary ceilings for defense expenditures.\textsuperscript{42}

The Kennedy administration, after concluding there was no actual missile-gap, decided that the rapid development and production of new strategic bombers to fill that imaginative gap was no longer imperative. Congress, on the other hand, supported bomber procurement and was heavily influenced by the USAF/SAC bomber advocates and insisted on the bomber being procured.

But the opposition to B-70 procurement was fierce and was led by the Secretary of Defense, Robert McNamara himself, who favoured ICBMs as principal strategic delivery systems.\textsuperscript{43} McNamara's Systems Analysis Office showed the B-70 not being a cost-effective, nor a very efficient, but instead a very vulnerable (on the ground), weapon system, when compared to ICBMs. Although Congress still favoured production of the B-70, the production decision was not taken. President Kennedy announced that the B-70 program would be executed only as an exploratory development program.\textsuperscript{44} As a result of this controversy, NAA in the end only built two prototypes of this new delta-winged B-70 bomber. The first flight took place on 21 September 1964.\textsuperscript{45}

This B-70 episode, shows how the dedicated network builders, especially the SAC, initially succeeded in getting a broad Congressional support. Assisted by sentiments deriving from the missile gap, they convinced Congress that the bomber deterrent should be maintained by potential high-speed, high-altitude penetration of enemy territory. McNamara and the Systems Analysis Office opposed bomber procurement and were not receptive to the Air Force's arguments. They could not be enrolled and effectively blocked a production decision.

McNamara in the first years of his tenure got the opportunity to introduce the new strategic concept of Flexible Response as a replacement for Eisenhower's New Look doctrine. In the New Look-era, the prevailing view on future wars was of massive and, later, selective nuclear retaliation, symbolized by the capacities of the Strategic Air Command.

Flexible Response acknowledged the nuclear stalemate between the Soviet Union and the USA and the importance of a conventional and more flexible approach of local or regional clashes. It stressed the importance of rapidly deployable ground forces and tactical air forces in addition to the strategic retaliatory forces.\textsuperscript{46} Next to this it placed a premium on system flexibility and multi-mission capabilities.\textsuperscript{47}

It is in this period that the Air Force started to emphasize the operational flexibility of the bomber, because it became politically expedient and politically necessary to do so. The Air Force in an (transparent and unsuccessful) attempt to save the B-70 even promoted a derivative called RS-70 (Reconnaissance-Strike),\textsuperscript{48} to show the weapon system flexibility and operational flexibility of the bomber. The interest in operational flexibility coincided with the Air Force's interest in preserving the high-altitude strategic bomber mission.
Assessments and the B-1 bomber network

Technological problem

In the absence of sufficient support for B-70 or RS-70 acquisition in the Office of the Secretary of Defense, the Air Force, between 1962 and 1969, initiated a series of studies for a new bomber aircraft. These were carried out by various defense contractors. The most well-known was called by the acronym AMSA, mockingly known as 'America's Most Studied Aircraft'.

The 1960 Gary Powers incident by then had fed the belief, at least in Congress and the Executive, that high-altitude penetration was passed and that what was needed in the future was very low-level penetration. The Air Force responded to this: the basic performance requirements in the AMSA concept called for a bomber with a high-altitude, Mach 2.2 capability, as well as low-altitude penetration capabilities at speeds up to Mach 1.2. Also required were, a quick start, a high-aspect ratio, high lift and power to make the plane less vulnerable on the ground.

The AMSA posed a technological problem to all of the competitors, because these military requirements involved contradictory aerodynamical requirements. North American Rockwell, as one of the competitors, solved this problem by designing an airframe with a variable wing, which was very different from the earlier high-speed, high-altitude B-70.

According to Bastian 'Buzz' Hello, Rockwell's B-1B program manager, there were many AMSA studies made at Rockwell's design bureau, finally resulting in a concept with a variable geometry with movable wing. When the wing was moved forward the geometry would develop a high lift very favourable for rapid take-off. When they were all back in the aft position, the geometry was more suited for cruising at high speed and developed just enough lift to support the airplane during low-level penetration.

McNamara, still favouring ICBMs as principal strategic delivery systems, kept the AMSA on a low funding level to prevent it from stepping up to full-scale development. He explained these funds were not for purchasing the AMSA but rather for speeding up preliminary designs. By the end of 1969 the requirements for the bomber had been modified: the low-altitude speed requirement was set at Mach 0.85 for sustained operations over rolling terrain and its payload capacity lowered from 36 to 24 Short Range Attack Missiles.

In December 1969, this led to the Air Force's Request for Proposal (RFP) for full-scale engineering development to industry for a new bomber, based on the AMSA concept, which was to be called B-1. North American Rockwell Corporation, Boeing Airplane Company and General Dynamics submitted proposals for the aircraft; General Electric providing the F-101 turbofan engines.

Political turmoil

In the first years of the B-1 bomber R&D program, the political turmoil lessened. A short spell of détente, the bomber to be redesigned with a high degree of technological freedom.

Between 1962 and 1968, several big defense industries started partaking in the design competition, putting forward a variety of technological solutions to the USAF-formulated requirement.

After McNamara left Office, in February 1968, Clark Clifford became the new Secretary of Defense and the political climate changed slightly. The Air Force's plea for a follow-on bomber for the B-52 did get an extra impetus from the experience during the Vietnam war, in which heavy losses occurred because of the B-52's vulnerability to (Russian made) SAM (surface-to-air missiles) air defense.

On the other hand the Air Force was forced by Clifford to scale down the low-altitude speed requirements for a follow-on bomber. Within the System Analysis Office doubts had arisen about the cost-effectiveness of the USAF claimed additional survivability originating from the low-level, high-speed requirement.

When the Nixon administration came in, in January 1969, the Deputy Secretary of Defense, David Packard, accelerated the program, but first the requirements, once again, were re-evaluated by the staff of the Office of the Secretary of Defense. On 19 March 1969, the new Secretary, Laird, announced that additional funds were added to the defense budget to develop AMSA. He explained these funds were for rapid take-off and its payload capacity lowered from 36 to 24 Short Range Attack Missiles.

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Political turmoil

In the first years of the B-1 bomber R&D program, the political turmoil lessened. A short spell of détente,
caused partly by the signing of the SALT agreements, no longer made the strategic inventory the centre of public debate. On the other hand, questions were being raised as to the strategic need of new delivery systems. Because of the problems encountered during the production of the first B-1 prototypes (such as designing a crew escape module instead of traditional ejection seats) the projected costs were rising fast. This was one more reason why the bomber came into political trouble in the mid-70s.

As the Air Force began stepping up its production planning activities, delays at subcontractor level and management problems (caused by the concurrence of development and production programs) heated the political fire. There was a shrinking supporters’ network and a growing opposition to bomber procurement in the US Congress and in the White House.

Moreover, doubts were rising, and questions were being asked, about the USAF-proclaimed necessity of overflying enemy territory for strategic bombing missions because of the expected future use of stand-off weapons that were being developed and because of the rising doubts about the bombers future penetration capacity.

The Air Force, confronted with shrinking support, conducted an intrusive review to get the rising cost under control. This Corona Quest review ordered fixed engine inlets to replace the movable ones, it simplified the avionics system and advised the elimination of the crew escape module. These measures not only were saving weight and cost, but also reduced the B-1’s top speed at high altitudes from Mach 2.1 to Mach 1.6.

Although it lowered the cost, it opened the program up to new criticism in the US Congress. Opponents posed that the B-1 was not the bomber it once was. Moreover, doubts were rising about the strategic rationale for the bomber, because the original Mach 2.2 requirement was significantly lowered and questions were asked as to whether or not the original Mach 2.2 requirement was organizationally driven.

Congress was now very sceptical about the bomber. This was fed by an influential cost-effectiveness critique published by the Brookings Institution, a Democratic think-tank. The Ford administration, however, changed its attitude. In the Republican contest, former California Governor Ronald Reagan, challenging President Ford from the right, made his chief point of attack the charge that Ford was weak on national defense. Subsequently, Ford abandoned missile reduction plans, called for a large increase in defense spending and, in mid-1976, six months before tests were due to be completed, committed himself to build the B-1 bomber.

Ford won the Republican nomination but lost the election to the Democrat Jimmy Carter. Congress thereupon limited the spending on the program to allow the incoming Carter administration to decide anew about the B-1 production program. The debate on the modernization of the US bomber force finally, in June 1977, culminated in cancellation by President Carter.

He opted for intercontinental strategic missiles, such as the MX as primary delivery system, and favoured a stand-off mission for the American bomber fleet. Although Carter enthusiastically supported cruise missile deployment, he allowed Rockwell to continue R&D on the B-1 airframe as a hedge against possible cruise missile failures.

This episode shows an expanding B-1 network after a major obstacle, Secretary of Defense McNamara, was removed. The entrance of new actors, especially the civilians in the Office of the respective Secretaries of Defense, forced the Air Force to redesign the original bomber requirements, sacrificing its low-altitude high-speed penetration capacity. The interaction between the still small-sized B-1 network and others, directed the technology that would be applied.

Because of its dependency on other groups to move the bomber into full-scale engineering, the B-1 network had to respond to technological claims formulated in these other networks. To accommodate these claims, technical adaptations, changing the characteristics of the artefact, were made. Once a new consensus on the characteristics was established within the expanding network supporting the B-1, deviations of the established R&D trajectory were less easily made.

Problems in the development phase of the project caused tension in the B-1 network, and Congressional support for the production program eroded. The Air Force tried to meet Congressional reservations by cutting the high-altitude, high-speed requirement in half and by removing exotic technologies. Cutting the technological capabilities only contributed to the Congressional sceptical reactions towards bomber procurement. The shrinking B-1 network was confronted with growing outside opposition and did not succeed in pushing the system into full-scale production.

Clinical death

After this overview of the development of the B-1 network, we will concentrate on the dynamics of the network during the episode, starting with Carter’s production cancellation. We will sketch how the USAF/SAC-Rockwell core, the dedicated network.

The Air Force tried to meet Congressional reservations by cutting the technological capabilities, but this only contributed to the Congressional sceptical reactions towards bomber procurement.
Assessments and the B-1 bomber network

builders, managed to make the bomber survive by linking their system to the new 'item' — the cruise missile — and gain new political support for B-1 procurement.

Through technical adaptation to the new requirements, in the form of the incorporation of cruise missile carrying capacity (despite the Air Force's initial reluctance towards stand-off missions) they tried to move the B-1 bomber into production. This episode shows the enormous resilience of this military-industrial network (superseding parochial SAC interests) and illustrates how technology was exploited to make the B-1 network survive.

In the mid-1970s, support for B-1 procurement in Congress waned due to rising costs, meager management and the introduction of new competing delivery systems. The Ford administration on the other hand was supporting B-1 procurement and preparing a production decision. When this administration was nearing the end of its term and elections were dawning, pressure to cancel the B-1 was building up from different sides, one of which included peace groups nearing the end of its term and elections were dawning, pressure to cancel the B-1 was building up from different sides, one of which included peace groups that were trying to turn the US away from the arms race.60

Other opponents were influential members of Congress.61 most of them liberals looking for ways to cut defense spending. Their opposition gained momentum because of the continuing stream of reports and rumours about unresolved technical problems, delays, management problems and rising cost of the B-1 experimental program.

Furthermore, there was a growing support, within the Executive, for stand-off missions, especially for Air Launched Cruise Missiles (ALCMs). The ALCM is an unmanned, small-sized, self-propelled weapon delivery vehicle which, in contrast to ballistic missiles, has an air breathing engine. Cruise missiles demonstrated a high survivability because they are hard to detect by air-defense, due to low-altitude flight trajectories guided by a sophisticated terrain contour matching scheme. ALCMs by that time were expected to provide the B-52G with a nuclear armed air-to-ground missile that could be launched while the planes were outside enemy territory.

The Defense Advanced Research Projects Agency (DARPA) within the Department of Defense that is responsible for the co-ordination and management of non-traditional technological innovations, together with the civilian leaders in the Pentagon (especially the Director of Defense Research and Engineering), were pushing cruise missiles as a new, cheap and reliable delivery system for strategic weapons.

The Congressional debate in fact focused on a procurement choice: shall we build the B-1 or cruise missiles? For many, the cruise missile seemed to offer a much more effective and less expensive delivery system as it could be carried by adapted B-52s.62 In Congress the opposition to the B-1 gained momentum, recruiting influential senators like Scoop Jackson, Sam Nunn and Robert Byrd.63

The Strategic Air Command resisted the idea of giving up their traditional task of penetrating enemy territory for bombing missions and therefore regarded the cruise missile option as unacceptable. The USAF and its congressional supporters responded that it would be more cost-effective to build the B-1 than to update outworn B-52s, stressing that cruise technology was still unproven and very inflexible. As General Russell Dougherty explained to Senator Barry Goldwater:

"As an alternative for the B-1, the [cruise missile] concept suffers from serious inflexibility since the standoff aircraft are by design, unable to penetrate under any circumstances."64

General David Jones, Chief of Staff of the Air Force, also stressing the B-1's operational flexibility in contrast to cruise missiles, advanced in his FY 1977 posture statement:

"...the B-1 will provide a hedge against failure of other strategic systems, [and] ... the B-1 will be a flexible system with high unit performance and multi-purpose capability, including conventional and nuclear mission contributions."65

The opposition to B-1 procurement in Congress, led by liberal Senator Democrat John Culver, was gaining momentum. The anti-B-1 lobby was expanding and produced its own group of experts, including former Secretary of Defense Clark Clifford, former Kennedy aide McGeorge Bundy, General Maxwell Taylor and Jeremy Stone, who testified that the B-1 either was unneeded, ineffective, or both.66

The B-1 opposition tried to halt the Executive's B-1 production decision and, after several attempts, succeeded in doing so by approving an amendment named after Senator Culver, on 20 May 1976, which delayed the B-1 production decision until February 1977, after the elections.

During election periods national security and the strategic posture can become central issues in the campaigns of the presidential candidates. This occurred again in the 1976 Ford-Carter contest, when the political controversy on the highly visible B-1 project once again rose high. Because of the delay in the production decision the B-1 became a highly politicized object. Rockwell's Hello said about this:

"You have to remember that during the election campaign in 1976, the then-president Ford, had strongly espoused the B-1 and even had a campaign swing through the factories: had his picture taken in the mock-up of the airplane... The unfortunate thing is that this made it a Republican airplane, the presidential candidate at the other side took his political revenge and cancelled the thing."67

Carter was effectively lobbied by the B-1 opponents and he finally spoke out against the B-1, calling it an
After his election, Carter was confronted with an anti-B-1 coalition that was strongly pushing him to keep his campaign promises: in June 1977 the B-1 production program was cancelled.

example of a proposed system that would be wasteful to taxpayers' dollars. After his election, Carter was confronted with an anti-B-1 coalition that was strongly pushing him to keep his campaign promises.

After ordering several studies to evaluate the B-1 and cruise missile options, President Carter on instigation of his Secretary of Defense, Perry, on 30 June 1977 announced the cancellation of the B-1 production program. B-52s would be modernized to carry cruise missiles; R&D on cruise missiles and production of 3,400 of them would proceed at maximum speed and R&D on a possible wide-bodied jet to carry cruise missiles would be started. Although production of the B-1 was cancelled, R&D would continue as a hedge against possible failure of the cruise missile effort.

This episode shows a shrinking B-1 network. Rockwell and SAC, the dedicated network builders, that eluded to their favourite technological artefact — the B-1 penetrating bomber — were confronted with diminishing support in Congress as well as in the Executive. At the same time outside pressure to cancel B-1 production was building up. In addition, a new network was in the making, a network centred around the air-launched cruise missile. The Director of Defense Research and Engineering, William Perry, and the civilian leadership in the Pentagon were important actors in this network.

Swallow your enemy

Although the extended flight testing program could continue, Rockwell immediately laid off 8,000 people of the total of 15,000 working on the B-1 development and flight testing programs, after Carter's production cancellation. Because of the purely military focus of Rockwell’s aerospace division, building the B-1 bomber was the only way for this division to survive.

The dismissals, immediately after the announcement, were a first step in Rockwell's attempt to reverse the decision and to get the production line going. But first the production capacity and technical know-how had to be secured. Rockwell International itself invested heavily: it spent US$ 35 million of its own money to keep the B-1 R&D program alive. In close co-operation with the Air Force, research and development money was funnelled to Rockwell to keep the engineering on the B-1 going. This involved programs carrying labels like 'Bomber Penetration Evaluation', 'Strategic Bomber Enhancement', 'Electronic Countermeasures Studies' etc.

At the same time, manufacturing capabilities were subcontracted to other aerospace companies (like Douglas) and Rockwell engineers were being leased to Boeing to assist in developing the 757 and 767 airplanes. In this way Rockwell managed to keep its team 'together'. Bastian Hello, the B-1 program manager, said about this episode:

"We knew they were short-term measures: you cannot keep on doing that and retain all these high skills that you need for building airplanes, but it is a way of keeping your team together." Concurrently, Rockwell started a drive to get any form of a bomber on the production line. In the years to come, Rockwell would make several attempts to re-establish its B-1 strategic bomber manufacturing capability by proposing a whole family of B-1 derivative aircraft that could be used as conventional bombers, manned penetrators and in other military roles.

The most promising strategy, however, seemed to be, to hook on to the emerging cruise-missile network by anticipating Carter's announcement of an R&D effort for a new wide-bodied jet to carry them. Within a few months of production cancellation, in testimony before the House Armed Services Committee, Hello declared:

"the B-1 could carry 16 cruise missiles of the largest variety now postulated internally, and could carry an additional 10 to 12 externally." Hello, and a Congressional team consisting of former B-1 advocates such as Ichord, Dickinson and Battista (a Congressional staffer) together decided to play what they referred to as 'Carter's game'. The President had asked Congress for money for the so-called Cruise Missile Carrier Aircraft (CMCA) study, meant to investigate the development of a new airplane to serve as a launching platform for cruise missiles.

What Carter had in mind was an adaptation of an existing commercial wide-bodied jet, such as Boeing's 747, Lockheed's L-1011 or C-5, and not an entirely new plane. But for the B-1 advocates, playing 'Carter's game' meant that the B-1 would become that cruise carrier — or at least the B-1 would adopt this disguise until the time was politically ripe to emerge once again as a penetrating bomber.

This is how the SWL or Strategic Weapon Launcher was born. The B-1's variable swing wing was eliminated to lower the price, and the competition was skilfully eliminated, either by strategic moves of B-1 advocates or by pressure from the Air Force.

The Air Force, in her quest for a new bomber (and the B-1 still being the only short-term candidate), supported Rockwell in keeping the B-1 production line warm in the shared hope that Carter's successor
would reverse the 1977 cancellation. The Air Force officials, only a year before, had expressed, very clearly, their dislike of stand-off missions. Within the Strategic Air Command the old ideas and ideal of a penetrating bomber force was still being cherished.

But the Air Force had to accept the budgetary realities and operational requirements as formulated by the Carter administration, resulting in a changing role of the bomber in the strategic triad. Was it in anticipation of a possible defeat by the cruise missile advocates that Dougherty wrote in the aforementioned March 1976 letter to Goldwater:

“A penetrating bomber can always be adapted to utilize and exploit any advantages of a stand-off air launched cruise missile, while still retaining the important advantage of not being limited to a standoff role.”

Within a year, at least in its rhetoric, the Air Force’s stance towards a stand-off mission for its bomber fleet changed completely. Experts concluded that there was a shift in operational emphasis in the Strategic Air Command’s nuclear bomber force toward increased reliance on stand-off aircraft carrying cruise missiles.79

In the late 70s the Air Force, on several occasions, suggested that the B-1 could be modified to serve as a cruise missile carrier, and that this option would produce a less vulnerable system than the modification of commercial aircraft, as the Carter administration suggested. The Air Force even supported the suggestion of stripping off the B-1’s penetration capacity to make the B-1 option more cost-effective.80

The Rockwell/SAC strategy to hook on to the successful cruise missile network was a success. In a Congressional Hearing three years after the start of the CMCA study, it was concluded that derivatives of existing commercial transports were too vulnerable and not cost-effective against severe threats. In his testimony, Lieutenant-General Kelly H Burke, Deputy Chief of Staff, Research, Development and Acquisition declared:

“Based upon the excellent base escape and hardening characteristics of the B-1 and its capability to carry as many as 30 ALCMs to an adequate range, we have initially focused the CMCA program on evaluating a B-1 derivative which we call the Strategic ALCM Launcher (SAL).”81

This episode shows how the dedicated network builders managed to keep the production-line for a new bomber open. Rockwell, in order to save its aerospace division, successfully hooked onto the more successful competing cruise-missile network. It became clear that Rockwell was willing to produce any bomber and did not really care about the technological features, if only it could be built at the B-1 assembly line in their plant. This again indicates that adaptations in the technological artefact are most easily implemented when there is a relatively small and therefore flexible network.

The Air Force only reluctantly followed, because SAC still favoured the penetrating bomber mission over stand-off systems, but they were aware that not anticipating on cruise missile carriage meant anticipating on nothing at all. Although officially the penetrating bomber no longer existed, the B-1 airframe, based on the requirements as formulated in 1969/1970, was only slightly altered to accommodate a cruise missile-carrying capacity.

On the other hand, widening its body to accommodate the cruise missile rotary launchers meant that the plane would have a reduced speed and fly at subsonic speeds. High speed, the original Air Force requirement by now was completely eliminated from the artefact. Nevertheless, because of its early design features, the concept of a long-range penetrating bomber remained dominant.

Phoenix rises

By late 1979, international events, such as the toppling of the Shah of Iran and the subsequent taking of 66 American hostages in the US embassy in Tehran, and the Soviet intervention in Afghanistan, caused the political climate to change in favour of increasing defense expenditures. Carter, seemed to be overwhelmed by the events in Iran and Afghanistan and was rapidly losing credit in Congress.

Carter’s conservative opponent in the coming elections, the former governor of California, Ronald Reagan, made Carter’s apparent indecisiveness and national security issues central themes of his campaign. Reagan assured the constituents that he would build a strong America. One of his promises was the acquisition of a new bomber: the B-1. Especially in California, where most of Rockwell’s production sites were located, Reagan’s campaign promises were very well received.

When the 1980 session of Congress unfolded, it became clear that an increasing number of its members shared the Air Force’s reservations about the B-52’s penetration capacity. The B-1 advocates in Congress — Battista, Dickinson and others — followed their own agenda and moved forward the B-1, thinly disguised as the so-called Strategic Weapon Launcher (SWL). On 14 May the House voted 297 to 119, approving $600 million for development and
initial production of the SWL.\textsuperscript{82} Carter, not being fooled, threatened the Democratic leaders in the Senate that he would veto the entire defense bill if it contained the bomber appropriation. The Senate approved an amendment from the Democratic senators Cranston and Glenn\textsuperscript{83} that called for the President to present plans for a new multi-role bomber by 15 February 1981, thus salvaging both the B-1 and Carter's prestige.

On the other hand, the amendment listed multiple missions, such as: for use in both conventional and nuclear weapons delivery missions; for use as a cruise missile carrier and as a penetrating bomber; and it asked for a first squadron ready for combat by 1987.\textsuperscript{84} These multiple requirements could only be met by the revised B-1. The Glenn/Cranston amendment resurrected the B-1: the new President would have $350 million and a deadline of 15 February 1981 to come up with plans for a new plane.\textsuperscript{85}

After the Soviet invasion of Afghanistan, the Air Force had started a drive to revive the B-1. The senior commanders concluded that the climate of public opinion was fruitful to talk about their demand for a new bomber to replace the 20-year old B-52. Hans Michael Mark, the Air Force Secretary, started a campaign to bring back the penetrating bomber.

But within the Strategic Air Command there was a discussion as to whether the B-1B would still be a viable penetrator by 1990, when confronted with an improved Soviet air defense. Voices could be heard, for instance of SAC commander Richard Ellis, saying that the B-1B should be by-passed to wait for the Advanced Technology Bomber\textsuperscript{86} (ATB) or 'Stealth'. SAC by now deviated from its former course and from its coalition partner Rockwell, because they were tempted by the promise of the ATB, whose existence had been exposed by President Carter, to counter the attacks on his defense posture during the election campaign.

ATB as a weapon system was initiated during the Carter administration and the program was still in the early stages of development. The research was coordinated at DARPA, and until this point was surrounded by secrecy. ATB held the promise for a new strategic bomber with a high payload and an even better penetration capacity than the B-1 could give.

SAC now favoured vigorous ATB (Stealth) development, because of its promise of unrestricted penetration capacity, providing all the flexibility and survivability a bomber could have. ATB deployment also meant that a stand-off capability would not any longer be considered the main task of the strategic bomber force, an important factor for SAC, because:

"[SAC] wanted to ensure that the traditional penetration mission would survive and not be superseded by stand-off cruise missile operations."\textsuperscript{87}

**Political symbols**

But the ATB was still in the early stages of development. Awareness that the political climate for a production decision was favourable at this very moment, forced the Air Force and the SAC generals to reach a consensus on B-1 and ATB. The Air Force, after having been robbed of one of its favourite toys three years earlier, now, because of the existing political rivalry, saw the opportunity to get both bombers. As Kozt described the situation:\textsuperscript{88}

"The B-1 was backed by Republicans, the House of Representatives, and Rockwell. The Stealth was supported by Democrats, the Senate and Northrop. Each bomber had become a political symbol."

The Air Force, merely for budgetary and political reasons, requested 100 B-1Bs and 132 Stealths. The advocates of the 'Stealth-only' option within SAC were silenced by both the Air Force Secretary Hans Michael Mark and Secretary of Defense Caspar Weinberger.

The Air Force in the first place asked for 100 B-1Bs, whose mission would be to penetrate the heaviest defenses and fly deep into the Soviet Union, armed with 40 to 60 tons payload of nuclear missiles and bombs. The B-1Bs would be supported by modernized B-52s firing cruise missiles from the enemy's borders.

When the ATBs were ready for production by 1990, they would take over the penetrating role and the B-1Bs would become cruise-missile carriers. Salesmanship prevailed and, by the end of 1981, the Air Force was explaining how both planes would be used together as penetrators, creating a synergistic effect.\textsuperscript{89} The technological adaptability of the B-1 airframe to variable missions proved to be an important factor in the survival of the B-1 bomber, because the B-1B appeared to be a very versatile strategic system in terms of cruise missile carriage.

After coming into office in 1981, the Reagan administration decided to make the B-1B one of the centrepieces of its strategic modernization program. It awarded the Air Force's requests, when on 3 October, Reagan announced his strategic modernization program, according to which the USA would build 100 B-1B bombers, to be followed by 132 Stealth bombers.

The most important changes to the B-1 that had been flight tested were:

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**Assessments and the B-1 bomber network**

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Salesmanship prevailed and, by the end of 1981, the Air Force was explaining how both the B1-B and the ATB would be used together as penetrators, creating a synergistic effect.
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- 82,000 pounds added to the design cross weight, that now rose to 477,000 pounds;
- the redesigning to facilitate stealth aerodynamics and materials, lowering its radar cross section by a factor of 10;
- new offensive and defensive avionics systems.

Building the B-1B was a pragmatic choice: the B-1 was a program that could be started up immediately, and Congressional support was self-evident, because the B-1 was the only option that could meet the 1987 limit.

This episode shows a rapidly expanding network, with actors effectively exploiting the changing political atmosphere. The weakening opposition (Carter) was outmanoeuvred by B-1 advocates in Congress. Rockwell was ready to start production at any time and effectively lobbied the Republican candidate Ronald Reagan.

The Air Force smelled bombers in the air and started a drive for new penetrating bombers: the B-1B for short-term deployment and the ATB as a future option, to replace the B-1B as primary penetrator in the 1990s. Within the Air Force an interesting clash took place. Some people within SAC were tempted by the prospects of future ATB deployment. The Stealth would undoubtedly be a much more effective penetrator than the B-1 or even the B-1B. The Stealth coincided perfectly with SAC’s traditional doctrinal ideas about its penetrating bombardment mission, as described in the paragraph ‘Indispensable system’ (page 242). Because political tides never last long, a procurement decision had to be forged now (or never), according to Air Force and Pentagon officials, and SAC was pressed to march along.

The resurrection of the B-1 as a penetrating bomber with some Stealth characteristics, once again shows the flexibility of the technology. Rockwell anticipated the new requirements and emerging technological options. The new design could be successfully presented as a much better penetrator than the original B-1. The B-1B’s versatility in terms of cruise missile carriage now was being used as an argument to overcome doubts about its future penetration capacity in comparison to the expected ATB development.

These factors can be coupled to groups of actors involved in the B-1 network. Participation in other, different networks as well, allows these actors to introduce new themes, deriving from other fora, into the network. In other words, it is important to be aware that actors in the network under study (B-1 in our case) often participate in other networks too. In order to successfully enrol them, actors can and do try to anticipate the guiding principles that play a role in other networks, such as by changing the requirements or by changing the artefact itself.

The dynamics of the network building is reflected in the artefact that is being developed. The dedicated network builders, SAC and Rockwell, time and again changed the requirement and/or the technology to satisfy the needs and wishes of other actors, such as the Secretary of Defense or the US Congress. Especially at times when the B-1 network lacked sufficient support and new groups had to be enrolled, the bomber was adapted in such a way as to accommodate the wishes of these groups.

In fact the original requirements for the B-70 and AMSA, set by the USAF, were very different from the qualities and capabilities that finally gave shape to the B-1B. At times it seemed that building a bomber — any bomber — to keep the B-1 network alive became more important to Rockwell and the Air Force, than its operational characteristics as formulated in the initial requirement. This adaptation of the B-1 network to other groups of actors was in fact the most important mechanism in re-directing the research and development process to keep the fledgling network alive.

Networks and interactions

At the beginning we stated that a network approach to the analysis of the weapon innovation process would allow a more flexible and more dynamic approach than do the traditional frameworks of analysis. The description of the development of the B-1 in terms of expansion and shrinkage of the network indeed allows a dynamic picture of the innovation process. The network approach allows us to take into account inter- and intra-organizational aspects of defense policy-making, as well as outside technological developments and international political events.

Technology as first aid kit

A critical episode in the life of the B-1 bomber has been sketched, by concentrating on the four principal actors in the B-1 network — the aerospace company Rockwell International, the USAF’s Strategic Air Command, the US Congress and the Executive Branch. By 1977, Rockwell and SAC, were looking for an opportunity to move the B-1 bomber into full-scale production. US-USSR détente, development problems, the growing criticism of the program, inside as well as outside the US Congress, and the intrusion of the cruise missile into the world of strategic delivery systems, almost rendered the new penetrating bomber extinct.

The dedicated actors in the B-1 network tried to ward off the attack by adapting their weapon system to the new (social and technical) circumstances: they tried to hook on to the developing and, by then, becoming dominant cruise missile carrier network. They adapted their penetrating bomber to the new technological environment, changing it into a cruise missile launching platform. Even the traditionally conservative SAC, for the sake of the cause, changed its rhetoric and (at least officially) shifted its vocational emphasis to stand-off missions.
Requirement changes were reflected in technical changes in the B1-B: these in turn caused severe alterations in its operational characteristics so that the original plane was hardly recognizable.

The actors in the B-1 network believed in the ultimate success of this strategy and invested heavily, both in money and people, to make it work. External events, Afghanistan, Iran and the new Reagan administration, provided new chances for the B-1 network builders. They profited from the changing circumstances and the new political climate that favored defense spending. The B-1 re-emerged as a penetrating bomber and was finally pushed into full-scale production.

Requirement changes, such as the accommodation of cruise missiles, caused by outside technological innovations, changing external political circumstances and changes in the network structure, were reflected in technical changes in the artefact. The adaptation of the artefact to the new requirements in turn caused severe changes in its operational characteristics.

The B-1 originally was designed to be a supersonic, long-distance, high-altitude aircraft with a low-level high-subsonic penetration capacity. In the end it became a much slower and heavier aircraft (for the sake of potential future accommodation of cruise missiles), flying at reduced heights with a slightly reduced range, but with a very good, high-subsonic, low-level penetration capacity.

The multi-role mission B-1, in the end, thanks to the incorporation of new 'stealthy' technologies, even became better suited for low-level penetration than originally expected or intended. Although the B-2 Advanced Technology Bomber (Stealth) may take over the B-1B’s penetration role, the cruise missile carrying capacity is expected to stretch the B-1B’s lifespan until far in the next century as an irreplaceable part of the strategic triad.

Weapon innovation revisited

In the introduction we argued that new weapon developments may undermine existing arms control treaties and that the introduction of certain types of weapons can have a destabilizing effect. We also touched on the perceived lack of instruments for steering the weapon innovation process to overcome these problems and suggested that clues to this problem might be developed by using a network approach. The case study of the development of the B-1 rendered insight into the crooked course of a specific case but can also provide insight in the weapon innovation process in general.

In studying the dynamics of weapon innovation it is important not to focus merely on the technology involved, but also to take notice of the shaping of the social dimensions of the surrounding network. The B-1 case showed that a specific pattern of social relations, was, time and again, a very important factor in directing the subsequent course of the technological innovation. Anticipation of the perceived wishes of other groups of actors, used in the interaction between the potential network actors, to a large extent directed the technology under development.

Especially in periods when the B-1 network was relatively small and the dedicated network builders were fighting for survival, adaptations in the technology were easily made. The network builders tried to enrol new groups of actors by adapting the artefact to a certain extent to the wishes of those still outside the network.

Enrolling new actors in the network introduced new themes, originating from the underlying networks in which the new actors participated, into the interaction within the B-1 network. These new themes subsequently co-determined the further course of technological development. Once groups of actors were committed to the network, the technological features of the artefact under development stabilized, they became more entrenched and changing them became less easy.

This observation indicates that there are periods of major change and periods of relative stability of the technological characteristics in a weapon innovation process. In order to exercise a more effective guidance of military R&D than currently exists, it is worthwhile focusing on those stages of weapon innovation in which changes in the artefact occur most frequently. From the study of the B-1 case we infer that these stages are often accompanied by the following social phenomena:

- Major changes in the technology occur in the early phases of the R&D process, when the numbers of actors supporting the technology is still relatively small, when the initial requirements have to be formulated and consensus between the actors has to be reached.
- Changes in the technological development course are more easily made when there are only a few network actors involved. This may be the case when the network is under great stress and becomes eroded. This leaves the dedicated network actors with the task of enrolling new groups.
- The enrollment of new groups of actors can cause changes in the artefact, because the dedicated network builders, in order to expand their network, have to anticipate (possibly deviating) requirements of the new actors expressed in the interaction.

This implies that the technological characteristics of a weapon system become largely fixed in a period preceding procurement and deployment decisions.
Focusing arms control efforts on the latter phase then implies that certain characteristics, that may be undesirable from the perspective of arms control, are nonetheless hard to change.

Our case study showed that even explicit decisions not to deploy the bomber did not imply a standstill of technological development. As a result the technological characteristics of the bomber were determined in a network where arms control impact considerations played no role whatsoever.

In the light of controlling/guiding weapon development this observation has important implications. At the beginning we suggested that, currently, existing agencies, potentially involved in arms control assessments, lacked influence, both because of their organizational setting and because of their focus on systems that are being developed or are already in the inventory.

The B-1 case corroborates this: it shows how, on the one hand, the technological course is set out in the early phase of R&D, and, on the other, how the artefact gets its definite shape in the interactions within the growing network supporting the technology. Therefore, military R&D can only be effectively guided when arms control assessments are taken into account in the early phases of the R&D process, with an agency actively partaking in an institutionalized manner in the decision-making process throughout the research, development and procurement cycle.

The B-1 case shows that major changes in the technology are possible only when the surrounding socio-technical network is relatively small. A small network will be more easily influenced by 'external' actors hooking on to the network. For guiding the weapon research and development, one should concentrate on those periods, in which small networks shape the technology. Focusing on procurement and deployment, as is current practice, in many cases will be too late.

Notes and references


5. The bomber RD&P program faced several halts and restarts. The sympathy of the US Presidents, for example, changed many times: Eisenhower started the B-70 R&D program in 1957, cancelled it in 1959 and restarted it in 1961 during the election campaign. Kennedy although "wholeheartedly endorsing" the 570 program during the election campaign, cancelled it two weeks after coming into office. Nixon and Ford both endorsed bomber development (the B-1) and Carter coming next into office cut it back into an extended testing program. Reagan in his turn endorsed bomber (B-18) production. Rockwell International is the result of a merger between North American Aviation and Rockwell Standard in 1967. The new company got the name North American Rockwell. In 1973 this name was changed to Rockwell International.


7. Assessments and the B-1 bomber network


9. Fiscal Year 1984 Arms Control Impact Statements, statements submitted to the Congress by the President pursuant to Section 36 of the Arms Control and Disarmament Act (April 1983), especially pages 98-100.


14. These actors can then be seen as point-representations of underlying networks. In this respect we follow Latour/Callon’s actor-network approach. The main difference is that we do not consider non-human entities to be nodes in our networks.

15. See for this phenomenon also: Elzen (1988), reference 1, especially pages 422-425.


17. The bomber RD&P program faced several halts and restarts. The sympathy of the US Presidents, for example, changed many times: Eisenhower started the B-70 R&D program in 1957, cancelled it in 1959 and restarted it in 1961 during the election campaign. Kennedy although "wholeheartedly endorsing" the B-70 program during the election campaign, cancelled it two weeks after coming into office. Nixon and Ford both endorsed bomber development (the B-1) and Carter coming next into office cut it back into an extended testing program. Reagan in his turn endorsed bomber (B-18) production.

18. Rockwell International is the result of a merger between North American Aviation and Rockwell Standard in 1967. The new company got the name North American Rockwell. In 1973 this name was changed to Rockwell International.


20. ACDA, having to report about the arms control aspects of strategic delivery systems in their annual reports, had a legitimating stance: OTA was never asked to conduct an analysis on strategic delivery systems. On the other hand, assessments and analyses, mainly focusing on procurement choices and management problems were produced in large numbers by the USAF, the Department of Defense Office of Systems Analyses, the Congressional Budget Office, the General Accounting Office, Rockwell, outside advisory organizations, universities and public policy groups.


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24. Additional lift: the compressed air of the shock wave is directed under its wings in such a way that it gives the aircraft additional lift, resulting in improved range.


27. Rockwell's subcontracting policy resulted in a network of over 5000 companies all over the country, having a share in the B-1 production work. The most important subcontractors involved were: General Dynamics, Boeing (offensive avionics), AIL (defensive avionics), AVCO (wings). Source: Aviation Week & Space Technology, 1 August 1983; Kotz (1988), see reference 24, pages 256-260.

28. Such strategies for gaining support in Congress are very common in the USA. See eg Mary Kaldor, "The armament process", chapters 7 to 9 in: Donald Mackenzie and Judy Wajcman (editors), The Social Shaping of Technology (Open University Press, Milton Keynes, Philadelphia, 1988) pages 263-269.

29. For a further elaboration of this concept see Elzen (1988), see reference 1, chapter 7, especially pages 418-419.


31. The B-70 and B-1 are special cases... in the sense that there is a whole integrated Strategic Air Command and that this is their only weapon." Gansler, interview 13 December 1969. See also: Mary Kaldor (1985), see reference 26, page 256; "[armed forces] remain functionally organized around the weapon system... The functional autonomy of individual services or military units is achieved through independent strategies associated with particular weapon systems. This would explain why strategic bombing is so central to US Air Force...


36. Norman Polmar (editor), Strategic Air Command, People, Aircraft, Missiles, chronology compiled by the Office of the Historian of the Strategic Air Command under the direction of John T Bohn, Patrick Stephens (Cambridge, 1979) pages 173-175.

37. Compression lift: the compressed air of the shock wave is directed under its wings in such a way that it gives the aircraft additional lift, resulting in improved range.

38. Main competitors in this design competition were Boeing from Seattle and North American Aviation. See Robert C. Seaman, former Secretary of the Air Force, interview 16 November 1989.


40. On 4 October 1957 the Russians successfully orbited their Sputnik. In the USA this event provoked an avalanche of criticism of the Eisenhower administration and created an atmosphere supportive to large military expenditures. The so-called 'missile-gap' was exploited by the USAF putting that in the short run (ICBM's still being experimental), only bombers could fill this gap in delivery systems.

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gogy, 10 May 1976, page 45.
74. See eg: Jeffrey M Lenorovitz, "B-1 proposed as core aircraft", Aviation Week & Space Technology, 17 September 1979.
75. Sources: Eugene Kozicharow, "B-1 for cruise missiles urged", Aviation Week & Space Technology, 19 September 1977, page 14; Donald E Fink, "Rockwell seeks funding to complete two B-1s, Aviation Week & Space Technology, 26 September 1977.
78. Kotz (1988), see reference 24, pages 187-188. "Chairman Ichord and his subcommittee refused to approve funds to study the feasibility of converting a wide-body transport plane for use as a cruise carrier." and "Kelly Burke, [...] the Air Force deputy chief of staff for research and development... pitted a modified B-1 against the designs for a huge new super-transporter called C-X.
83. Glenn and Cranston were both Democrats running for re-election and their home states (Ohio and California) contained more B-1 jobs than any others in the USA. Source: Kotz (1988), see reference 24.
85. Clarence A Robinson, jr, "Multipurpose bomber advances, authorization approved by conference using language that is careful to avoid linking project with B-1", Aviation Week & Space Technology 4 August 1980, page 10.
86. ATB or Advanced Technology Bomber, nowadays known as B-2 'Stealth' bomber.
90. The importance of taking into account underlying networks rather than individual actors is elaborated in a previous study: Elzen, Ensink and Smit (June 1990), see reference 12, pages 171-193.

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