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**AMERICAN TECHNOSTRATEGY
AND THE NUCLEAR ARMS RACE:
EVALUATING THE EVANGELISTA MODEL**

by

DONALD ALEXANDER NEILL, B.A.

A thesis submitted to
the Faculty of Graduate Studies and Research
in partial fulfilment of
the requirements for the degree of

Master of Arts

The Norman Paterson School of International Affairs

Carleton University

Ottawa, Ontario

13 December, 1990

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The undersigned hereby recommend to the Faculty of Graduate Studies and Research acceptance of this thesis, submitted by Donald Alexander Neill, in partial fulfilment of the requirements for the degree of Master of Arts.

Christopher J. Maule, Director
The Norman Paterson School
of International Affairs

Professor F. Hampson, Supervisor

Carleton University

ABSTRACT

Four decades of superpower competition in the field of strategic weaponry have left arms control analysts and negotiators faced with a daunting task. In order to dismantle a given device with a minimum of difficulty and extraneous damage, it is necessary to understand its operation. The complexity of the American armaments acquisition dynamic is such that the process does not lend itself to facile analysis; expensive, time-consuming, and prodigal of the resources of the United States, it demands restructuring. Matthew Evangelista has proposed a model explaining the nature of the American innovation-deployment link, and has tested it against the case of the development, acquisition, and deployment of tactical nuclear weapons. The model would appear at first glance to be applicable to the strategic arms acquisition process as well. This paper tests that applicability against the cases of the American development and deployment of both MIRV and ALCM technology in hopes of providing a useful schematic of the American strategic armaments dynamic.

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An undertaking of this scope and its termination within a severely restricted time period can be a daunting task in the absence of competent assistance and constant academic support. I would like to thank my Supervisor, Professor Fen Oler Hampson, for his able instruction throughout the academic year, and the provocative influence of his work in the field of defence procurement. I would also like to thank Professor Harold Von Riekhoff for his helpful suggestions as to directions of research and the refinement of my approach to the questions posed by my topic. Finally, I would like to offer my heartfelt thanks to my parents and brother, Allister, Sharon, and Michael Neill, for their unrelenting support and assistance over the months; and most especially to my fiancée, Linda Olsen, in fond memory of her fierce (but loving) encouragement throughout my "tour of duty" at the Norman Paterson School of International Affairs.

This paper is dedicated to the officers and men of the Royal Regiment of Canadian Artillery, to which brotherhood I now happily return.

Donald Alexander Neill
13 December 1990

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and the fourth offers a discussion of the conclusions drawn from the study and their implications for the future of American nuclear arms acquisitions in a post-dualist world.

It has been argued that the use of case studies in the illustration of the applicability of any given theory perforce violates the principle of the "generalizability" of an hypothesis. A case-oriented approach need not necessarily sacrifice methodological rigour in favour of issue relevance,¹⁰ provided that sufficient attention is accorded any extra-theoretical elements which may have had a bearing on the outcome of the discrete events under scrutiny. The following study, one hopes, while necessarily case-specific, has, as Evangelista suggested in his own work, been structured and focused in such a way as to support the "generalizability" of his theory.

The process of developing, deploying, and maintaining a major weapons system is a lengthy and monstrously expensive one. Alexander Kossiakoff suggests that a better understanding of the arms acquisition dynamic might lead to a less prodigal expenditure of both time and money:

A major weapons or communication system for the U.S. military services will take five to ten years for full development, will be in production for perhaps a decade, will have a useful life of 2-3 decades, and may cost \$30 billion to develop and produce, and require a comparable expenditure for its lifetime operation and maintenance. Clearly it becomes of the utmost importance to choose well and design carefully.¹¹

Evangelista's theory is both elegant and compelling, and offers prima facie a simplified means of dealing with an exceptionally complex problem. The verification of his approach would provide arms control

INTRODUCTION

The most historically significant technological innovation of the present century was without question the atomic bomb. Nuclear weapons have dominated international relations and the global power structure since their development and initial use at the close of the Second World War - and unless a revolutionary series of scientific achievements renders them obsolete at some point in the near future, they will remain the principal measure of statehood and influence for decades to come. While the nuclear arms race through the conscientious efforts of the superpowers seems at present to be decelerating, the efficacy of such weapons as tools of intimidation and, ultimately, mass destruction will not be obviated by mere writ. Remaining arsenals will continue to undergo modernization and upgrading, such improvements necessitated by the requirement for a stable deterrent balance at lower overall force ceilings. The process of weapons innovation will go on.

Significant technological innovations in the field of nuclear weaponry have led to major and irreversible alterations in how the superpowers approach the grim spectre of nuclear war. Many of these were qualitative, such as the miniaturization of nuclear warheads which permitted the deployment of tactical atomic weapons, or the progressive increase in strategic bomber ranges and payloads; others were truly innovative, leading to increases in overall destructive power, like the fusion or thermonuclear bomb; improvements in weapon-for-launcher effect,

such as the development of the Multiple Independently-targetable Re-entry Vehicle (MIRV); or the creation of an entirely new class of weapons, such as the fielding of the first Inter-Continental Ballistic Missiles (ICBM). These and a host of other technical accomplishments have combined to bring the nuclear arms race to its present pitch. Given past experience and the continuity of scientific research and development, it would be irrational to assume that future developments will not lead to new capabilities or new varieties of weapons systems.¹

Numerous writers have offered a variety of comprehensive assessments of the effects of technological innovation on the arms race. Their suggestions vary from complete dependence upon extra-state or international factors, in which national technological developments play a limited or almost non-existent role, to positing a "technological imperative" all but wholly responsible for driving the arms race in an upward spiral of aggregate destructive power.² Further opinions are to be found between these extremes. The aim in attempting to define a set pattern for the innovation-deployment phenomenon is relatively consistent, however; if a tested and reliable "flow chart" may be drawn up to describe what has been referred to as the "great power armaments dynamic", then it will be possible to derive an understanding of the process which may lead to the development of effective checks on the nuclear arms race. It is far easier to interrupt the operation of a machine without causing serious upset or damage if one has a trustworthy schematic detailing its construction and operation.

Among the variety of scholars having given thought to this problem, Matthew Evangelista has proposed something of a centralist model

explaining the superpowers' respective armaments dynamics. In his Innovation and the Arms Race, he delineates certain elements drawn from organization theory which control the innovative processes in any national research and development programme, and has identified a variety of individual stages in the American innovation-deployment cycle. The elements which determine the effectiveness of national technological innovation are fivefold: the centralization of the systemic effort, the complexity of the organization, the extent to which the operation of the same is formalized, the "interconnectedness" of the organization, and the amount of "slack" or operational laxity within the organization.³ The degree of applicability of each of these elements to a given national research and development programme will determine the ability of that programme to engender and exploit new ideas. As an example, Evangelista asserts that American innovative or research organizations may be characterized by a low degree of formalization, which enables individual research to proceed without excessive systemic hampering, while the reverse is true for research bodies within the Soviet Union. Each of the remaining elements is dealt with in a similar fashion.

Evangelista's stages of operation in the American research and development process form the basis for his innovation-deployment theory.⁴ Each innovation, he asserts, comes into existence via the discovery of a new technical possibility, for which scientists advocate a military application; this stage is termed the "technocratic initiative". Scientists and associated military personnel then undertake a series of "consensus-building" efforts aimed at generating interest in the new technology within the scientific community. "Promotion" by industrial

entrepreneurs of the new technology along with its attendant military applications thence occurs in a variety of places: the armed services, Congress, and the Executive levels of the national government. Fourthly, a series of "open windows" or external threats are exploited as opportunities to justify the acquisition of the new system; and finally, Pentagon and other officials provide "high-level endorsement" of the new technology, and obtain appropriations for the mass production of the new system.⁵ This process is unique to the American armaments dynamic; by virtue of a radically different governmental system and organizational approach to scientific research and innovation, the corresponding Soviet dynamic would perforce be different.⁶

Although Evangelista has chosen in his work to concentrate upon the respective American and Soviet acquisition of tactical or battlefield nuclear weapons, it would appear at first glance that his approach is adaptable to the strategic weapons acquisition process; while state-specific, the dynamic outlined in the five stages does not contain any discernible characteristic which would tend to restrict its applicability to any particular class of weapon.⁷ His comparative analysis of the individual American and Soviet approaches to the exploitation of scientific innovation lends itself readily to application to other systems. However, our predominant interest herein is more to determine the utility of his or any other approach in understanding the American armaments acquisition dynamic; its Soviet counterpart, while interesting, is not to be an object of study except insofar as it tends to influence the American process.

The aim of this paper, then, is to evaluate the utility of

Evangelista's model as a tool for understanding the American innovation-deployment dynamic, in hopes of verifying for strategic weaponry a systemic definition which he has tested only against the case of tactical arms. Such a model of proven applicability would be invaluable in arms control analysis, and would permit the deceleration or interruption of the American armaments acquisition process at any of a variety of established control points. In order to accomplish this aim, the theory will be tested against two individual case studies in strategic arms acquisitions, each of which represents what Evangelista has termed a "significant innovation"⁶ in armaments technology: the development and decision to deploy the MIRV and, later, the Air-Launched Cruise Missile (ALCM).

The concept of a "significant innovation" (as discussed in the previous footnote) remains somewhat difficult to pinpoint. We shall adopt Knorr and Morgenstern's definition of the "newness" of a system:

When we talk of a new system, we exclude the improvement, no matter how substantial, of an established one and refer instead to a system based on a radically new idea, representing a discrete forward step. Thus the increase in speed, firepower, and range of tanks and airplanes is a highly desirable development of the capabilities of these weapons. But the associated extensions of their uses occur within an established pattern which changes only gradually and the defenses against these weapons require no basically new ideas or principles.⁷

This paper has been structured so as to address the theory verification issue in relatively discrete chapters. The first of these deals with the theoretical background underlying Evangelista's work. The second and third chapters deal respectively with the cases under scrutiny,

and the fourth offers a discussion of the conclusions drawn from the study and their implications for the future of American nuclear arms acquisitions in a post-dualist world.

It has been argued that the use of case studies in the illustration of the applicability of any given theory perforce violates the principle of the "generalizability" of an hypothesis. A case-oriented approach need not necessarily sacrifice methodological rigour in favour of issue relevance,¹⁰ provided that sufficient attention is accorded any extra-theoretical elements which may have had a bearing on the outcome of the discrete events under scrutiny. The following study, one hopes, while necessarily case-specific, has, as Evangelista suggested in his own work, been structured and focused in such a way as to support the "generalizability" of his theory.

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Evangelista's theory is both elegant and compelling, and offers prima facie a simplified means of dealing with an exceptionally complex problem. The verification of his approach would provide arms control

them to fit existing production designs and capabilities. The ultimate appearance and qualities of a finished product are often the results of an intimate collaboration between industry and the military; Hampson notes that industrial officials often take a part in the drafting of the "Mission Element Need Statement" justifying a new weapons system,¹⁶ so as to tailor the requirements to their capabilities. While this type of activity may seem to result in a somewhat "contrived" or fabricated justification for the acquisition of a new system, it also shortens the process by preventing (to a certain extent) the military from making demands which industrial technology is incapable of meeting. "The area of corporate and independent research and development (IR&D)...is one of the very best potential sources of new research ideas".¹⁷

Industrial actors do not implicate themselves in the innovation process through altruism; as do all actors, industry has its own particular organizational and bureaucratic interests. New systems contracts represent a means of claiming resources and a certain degree of power and influence over future weapons decisions (to say nothing of the immediate benefits of, for instance, obtaining a contract to produce more than a hundred B-2 "Stealth" bombers at \$550 million per unit).¹⁸ Government contracts are the lifeblood of the defence industrial community; it would be naive to expect industrial actors to distance themselves from the acquisition process until the evaluation or production stages.

1.1.1 The Origins of Innovation

The evolution of a given technology in the modern scientific

CHAPTER ONE:
EXPLAINING AMERICAN STRATEGIC ARMS ACQUISITION

More than four decades have passed since the Second World War was terminated by the American employment of the first nuclear weapons against Japan in what has been variously described as an experiment in curiosity, a demonstration of American military might to the Soviet Union, and a last-ditch effort to avoid the expense of a full-scale invasion. Regardless of Trumann's internal rationale for ordering the atomic bombings of Hiroshima and Nagasaki, the fact was made ineluctably clear to the world at large that the exploitation of nuclear energy for military purposes had added a new and terrifying dimension to traditional notions of warfare. Destruction of property and human life on a scale heretofore unprecedented was within the grasp of practically any state, at minimal cost and without a tremendous expenditure of resources. Soviet scientists lost no time in following the path set down by their American, British, and Canadian counterparts, and within four years had achieved what Trumann later called "the Russian bomb". In the forty years since, three other nations have built impressive nuclear stockpiles, a fourth has tested a "peaceful nuclear device", two more are suspected of possessing nuclear weapons, and nearly half-a-dozen are believed to be near-capable of constructing them.¹ The contemporary measure of great power status, nuclear weapons possession is the double-edged sword much sought after by influence-hungry nations. This quest for influence has engendered

superpower competition in the arena of nuclear arms development and acquisition, a race best envisioned as a waxing spiral of overall capabilities and aggregate destructive potential.

The American contribution to this trend has taken the shape of two generations' worth of strategic weapons system acquisitions. The acquisition process from the research to the final deployment stage displays, as mentioned in the introduction to this paper, two characteristics of prime importance: it is exceptionally complex and exceptionally expensive. The aim of this chapter is to examine this process in some detail, with an eye towards discerning the critical or control points of its inner operation; that is to say, those points at which the application of appropriate pressure might elicit change for the better.² The first section will discuss the model proposed by Matthew Evangelista explaining the acquisition process and upon which the present study is based, illustrating both its strengths and its foibles. The second outlines the approach which the author intends to take in evaluating Evangelista's model against the aforementioned pair of test cases.

1. The Evangelista Model Illuminated

Students of the American armaments acquisition process tend in their criticism to draw a sharp distinction between two complementary (indeed, parallel) levels of operation. In the absence of appropriate nomenclature, we shall refer to the "official" level as the "first track" process, and the "unofficial" level as the "second track" process. The official level of operations for the armaments acquisition process tends

to follow a certain series of documented and legally obligatory steps, notably those outlined by Hampson in Unguided Missiles, and offered in the form of a somewhat less complex flow-chart by Daniel Kaufman (see Fig. 2). Progress along the "first track" of the acquisition process involves the officialdom of government: the justification for a new major system, the exploration of a new concept, the demonstration and validation of a novel technology, the full-scale development of the new system, and its ultimate production and deployment. The first track delineates what "should" happen during the procurement process; but not all operations which impact upon the process occur in full view. The "second track" subsumes those activities the carrying out of which, "behind the scenes" as it were, is crucial to the success of a given project.

Figure 1

The defense acquisition process (Kaufman)

Source: Adapted from Daniel Kaufman, "The Defense Technology Community: Players and roles", in Asa Clark and J.F. Lilley, Defense Technology, (New York: Praeger, 1989), p.184.

Matthew Evangelista has in his Innovation and the Arms Race proposed a second track solution to the nuclear armaments acquisition process. He maintains that there are five discrete stages of activity which occur "behind the scenes" during the procurement process, and that each individual operation must be concluded in the requisite sequence in order to ensure the success of the project as a whole. None of these stages would appear in the procedure manuals for systems acquisition, and yet without their positive impact, any major weapons project must fail. These stages, in chronological order of operation, are the Technocratic Initiative, Consensus Building, Promotion, Open Windows, and High-Level Endorsement (see Fig. 3).

The "Technocratic Initiative" stage of Evangelista's argument is based upon the tendency within the American scientific community towards a certain degree of operational looseness within pure research organizations (see section 1.1.1 concerning the origins of innovation). This looseness encourages the uninterrupted flow of new ideas and concepts from the lower to the upper echelons of the organization (as opposed to a bureaucratically enshrined stifling of individual initiative at the lower levels, such as appears to be the case, according to Evangelista, in the Soviet Union).³ Thus, scientists engaged in pure research have the opportunity to present their ideas unhindered, and this freedom of action lends extra impetus to the technocratic initiative: the presentation of novel technological developments, often already conceptualized as weapons systems.⁴

Following the presentation of a new development, scientists within both the pure and applied research communities -- and in conjunction with

military associates -- begin a process of "consensus building" in order to generate interest in the new technology throughout the military and

Figure 2

Second Track Stages in the American process of weapons innovation (Evangelista)

1. TECHNOCRATIC INITIATIVE

Discovery of new technical possibilities; scientists advocate military applications.

2. CONSENSUS BUILDING

Scientists and military associates generate interest in new technology within military-technical community.

3. PROMOTION

Scientific, military, and industrial "entrepreneurs" promote new weapon proposals within military services, congress, and executive.

4. OPEN WINDOWS

External threats serve as windows of opportunity for military to push a new weapon into production.

5. HIGH-LEVEL ENDORSEMENT

Pentagon officials gain congressional support for mass production of a new weapon, justified with more specific reference to an external threat.

Source: Adapted from Matthew Evangelista, Innovation and the Arms Race, (London: Cornell University Press, 1988), p. 52.

technical communities.⁶ The principal aim at this stage is to build up a sizable constituency supporting the new concept, so as to be able to present a relatively united front in favour of the idea when it is subsequently presented at higher levels.

Once a firm constituency backing the new idea has been acquired, a process of "promotion" begins on a variety of wider fronts. The concept is presented before larger audiences at considerably higher levels by scientists, military personnel, and industrial representatives interested in obtaining "a piece of the action" should the project eventually be approved for full-scale development.⁶ The process may go as far as the senior echelons of the military services (that is to say, the Pentagon), the Congress, and the Executive level of government. This type of upper-level lobbying is intended to form as wide a base of support favouring the new system as is possible.

Having gained the attention of the Congress and the senior levels of the military services, promoters in all spheres will attempt to take advantage of "open windows" in the form of external threats in order to justify the development, acquisition, and deployment of their proposed system.⁷ These threats may take a number of different forms, but generally tend to devolve around a perceived disadvantage vis-a-vis the military forces of the Soviet Union. Threats of this nature were more than evident in the creation of the so-called "missile gap" in the late 1950s and early 1960s. Evangelista also notes that American military prestige and the need to be first in all things scientific is often invoked at this stage.

Once justified, the system requires only "high-level endorsement" in order to proceed to mass-production and deployment. Pentagon officials lobby in the Congress in order to obtain adequate funding and the "green light" for procurement of the system. At this stage, a certain amount of additional justification is required, often with reference to a more

specific threat.⁸ Evangelista comments that it is uncommon at this stage for the stated threat to even resemble that which the system had originally been intended to counter.

Evangelista notes that there is a fluctuation of systemic dependence throughout the course of this process between internal and external factors. The early stages, he states, are characterized by such activities as professional collaboration within scientific and military organizations, inter-organizational support-mongering, the melding of ideas between groups, and a remarkable amount of collusion between normally disinterested groups in the interest of achieving a common goal. The middle stages, on the other hand, depend for their success on the rationalization of the project by quoting external factors, such as military or technological threats, or by waving the banner of American technological superiority with respect to a foreign state. However, in the terminal stages of the process, the emphasis swings back to internal political and financial factors, where questions of cost-effectiveness, the utility of the system as a potential bargaining chip, and similar considerations are deemed to be of greater import.⁹ This fluctuation will be discussed to a greater extent in the upcoming sections.

These stages form the basis of Evangelista's theory concerning the operation of the critical "second track" of the arms acquisition process. The first track is only paperwork and "button sorting"; the success of its unofficial counterpart is what will determine the ultimate success or failure of a given weapons system programme. The following subsections will examine each of these stages in greater depth.

1.1 "Technocratic Initiative"

What, in fact, is innovation? Having established in the introduction a definition of the term "significant innovation", there remains to determine a definition of the root term as the technocratic initiative is based in scientific innovation and little else. Again we must turn to Knorr and Morgenstern for an acceptable answer.

Knorr and Morgenstern distinguish between "innovation" and "invention" by employing what they call "the economist's definition". An inventor, in their view, is one who discovers or creates a new scientific concept or device; the innovator, on the other hand, "decides whether it is a "useful" idea, and organizes its development and application".¹⁰ One should be careful to avoid taking their definition too far within the context of "development and application"; the innovator is not at this point responsible for activities beyond the scope of the initial stage. His task is to prepare a hitherto isolated idea for acceptance by less technically oriented people by placing it in the context of an applicable technological concept. For instance, while Berthold Schwartz is said to be responsible for the Western invention of gunpowder, he did not create the first pots-de-feu or firearms;¹¹ others have been credited with that innovation. Schwartz was the inventor; the military application of gunpowder was discovered and exploited by someone else. It is not unacceptable, of course, for an individual to be both innovator and inventor; Knorr and Morgenstern merely note that this need not necessarily be the case.

Technological innovation in the absence of the other four

aforementioned factors is insufficient to engender the development of a new weapons system; it provides only the spark. Without structured management of the research and design process, as well as a myriad of other seemingly unrelated considerations, any novel concept or device will remain idle. Hampson notes in Unguided Missiles that "Technological innovation is a...necessary but not sufficient condition for new weapons development";¹² any new system must be designed for a particular role in order to meet a specified threat. In addition, bureaucratic rigidity within the services for which the weapon is designed demand that any new system conform to the existing military structure, and that it enhance rather than eliminate traditional roles in favour of a new organization.¹³

Ideally, a technological innovation leading to the production of a new weapons system should be the offspring of the willing union of technology and military needs and interests. Noel Gaylor argues that, "In a logical world, the initiation of a military development follows from the confluence of a military need and a technical opportunity".¹⁴ Unfortunately, reality does not often evince logic, and one must rely instead upon the influence of other actors on the innovative process.

The impact of industry upon technological innovation should not be underestimated. The industrial community has a great deal to gain by investing in new developments, most notably by obtaining multi-billion-dollar government weapons contracts. Industry contributes heavily to the development of new ideas and concepts, both through the application of their own funds and via the Independent Research and Development Programme (IR&D) sponsored by the federal government.¹⁵ Industry also plays an important role in the conceptualization of new developments by shaping

them to fit existing production designs and capabilities. The ultimate appearance and qualities of a finished product are often the results of an intimate collaboration between industry and the military; Hampson notes that industrial officials often take a part in the drafting of the "Mission Element Need Statement" justifying a new weapons system,¹⁶ so as to tailor the requirements to their capabilities. While this type of activity may seem to result in a somewhat "contrived" or fabricated justification for the acquisition of a new system, it also shortens the process by preventing (to a certain extent) the military from making demands which industrial technology is incapable of meeting. "The area of corporate and independent research and development (IR&D)...is one of the very best potential sources of new research ideas".¹⁷

Industrial actors do not implicate themselves in the innovation process through altruism; as do all actors, industry has its own particular organizational and bureaucratic interests. New systems contracts represent a means of claiming resources and a certain degree of power and influence over future weapons decisions (to say nothing of the immediate benefits of, for instance, obtaining a contract to produce more than a hundred B-2 "Stealth" bombers at \$550 million per unit).¹⁸ Government contracts are the lifeblood of the defence industrial community; it would be naive to expect industrial actors to distance themselves from the acquisition process until the evaluation or production stages.

1.1.1 The Origins of Innovation

The evolution of a given technology in the modern scientific

environment is generally a complex and circuitous affair. Significant advances result from the scientific application of the fruits of theory-driven research, much of which is based so deeply in complex mathematical or physical principles that researchers are doubtful as to whether their concepts are even applicable to the "real" world. Developments stemming from theoretical research of this nature led to such innovations as the atomic bomb, the laser, and the silicon microprocessor. More often than not an innovative idea is the chance offspring of the combination of a variety of unrelated technologies, combined in such a way as to present a novel system of unprecedented design and utility. Evangelista holds that in today's highly complex scientific environment, this sort of innovation is becoming the rule rather than the exception.¹⁹

Evangelista's technocratic initiative concerns technological opportunities more than it does the deliberate development of a desired weapons system. The exploitation of a possibility leads ultimately to a novel development and a deployable system. He is of the opinion (echoed by Marek Thee, albeit more strongly) that systems acquisition and deployment is more the result of opportunities in applicable military technologies than of the reasoned response by the military or government to a perceived security threat. Knorr and Morgenstern concur:

Indeed, it seems fair to ask whether U.S. weaponry (and hence military capabilities and doctrine) is not too much the result of new scientific progress and technological opportunities, and reflects to too small an extent anticipated security needs that might be derived from an imaginative identification of various future contingencies.²⁰

This tendency is reflected in the growing inability of both the military

and government to formulate coherent policy other than in a post facto manner, once the weapons systems made possible by technology are in their grasp. One wonders whether the strategic policymaking process is not almost entirely driven by technological capability rather than strategic "necessity".

This debate raises further questions concerning the origins of technology, which Evangelista has chosen to answer via the application of certain elements of organization theory to the American scientific community. As discussed in the preamble to this chapter, Evangelista holds that there are certain organizational characteristics peculiar to American research and development groups which empower those groups to conduct research and produce useful results at a rate superior to that found elsewhere. These characteristics, he argues, are the strength of the American technical community (see Fig. 4).

The five characteristics which he addresses are derived from E. Rogers' treatment of the effects of organizational structuralism on the dissemination of information in his Diffusion of Innovations. The critical elements of the research organization, Evangelista argues, are its centralization, complexity, formalization, interconnectedness, and organizational slack. Centralization refers to the extent to which the organization is structured in an echelon formation following a military-style "chain of command" or pyramid of responsibility. Complexity is "the degree to which an organization's members possess a relatively high level of knowledge and expertise, usually measured by the members' range of occupational specialties and their degree of professionalism expressed by formal training".²¹ Formalization is the amount of "red tape", paperwork,

and bureaucracy required by the organization's infrastructure.

Figure. 3

Organizational characteristics related to / controlling innovation

Characteristic	Effect on Innovativeness	Relative degree found in organization of American military R&D
Centralization	Inhibits	Low
Complexity	Encourages	High
Formalization	Inhibits	Low
Interconnectedness	Encourages	High
Organizational Slack	Encourages	High

Source: Adapted from Evangelista, Innovation and the Arms Race, (London: Cornell University Press, 1988), p. 29; also E. Rogers, Diffusion of Innovations, (New York: Free Press, 1983), pp. 359-61.

Interconnectedness refers to the extent of the informal communications network (can anyone talk to anyone else whenever necessary?); and organizational slack determines the degree to which "uncommitted resources are available to an organization",²² a measure of the ease with which the routine order may be circumvented in the interest of increased efficiency.

Evangelista argues that the degree to which these characteristics are exhibited in the American scientific research community tends to encourage creativity and innovation. Low centralization permits flexibility of operation; high complexity leads to the widespread availability of expertise and specialized knowledge for the solution of problems; low formalization removes bureaucratic inhibitors to scientific research (and, generally, makes life a little less frustrating for researchers); a high level of interconnectedness permits extra-structural

contact between personnel, raising the availability level of expertise; and a high level of organizational slack encourages low-level innovators to accept high risks in research and development in order to achieve high gains.

The exhibition by research and development groups of these characteristics is, Evangelista argues, the basis for a more successful American scientific productivity quotient. The following section discusses more specific characteristics of research and development bodies, focusing on their specialized contributions to the process of technological innovation.

1.1.2 The Politics of R&D

Research and development efforts are without question the co-progenitors of all technological innovation contributing to the growth of the American military arsenal. Scientific curiosity supported by extensive funding (whether private, industrial, or federal in nature) leads through theorization and experimentation to the development and validation of principles underlying the design and production of new weapons systems. Research and development organizations through their monopoly on scientific discovery wield a powerful influence in the determination of America's military capabilities, and even of the direction of America's strategic policies. Kosta Tsipis states that

Weapon systems, even major ones, are rarely deployed as the end-result of a categorical decision to create them made at some level of the political, or even military, leadership of the country. Rather, weapon systems more or less emerge from an ongoing R and D process that often develops entire new technologies rather than specific pieces of hardware, and that

is guided in an overall way by technological leaders who are very much aware of, and strongly share in, the general perceptions of the international situation.²³

Such leaders, if correctly attuned to the global strategic situation, are perhaps capable of ensuring that the course of research does not drift too far from the mainstream of military requirements; if such is indeed the case, it would perhaps be less distressing to accept the possibility that, as both Thee and Evangelista suggest, technological opportunities determine policy rather than the inverse.

Research and development within the United States has grown considerably over the past decade, and nowhere has it expanded as rapidly as in the defence technology and military research fields. Franklin Long notes that "the (U.S. defence) R&D budget has grown at a considerably faster rate than the total budget for the military",²⁴ a sound indication of the increasingly important role played by technology in ensuring American supremacy within the arms race. Even outside the context of the military, funding for armaments R&D is growing at a startling pace: Thee notes that military research and development accounts for one-third of all money spent on R&D within the United States, and that this quantity represents a staggering sixty percent of all federal spending on research and development.²⁵

This is not a surprising revelation if one holds, as Thee does, that "Military research and development is the forge and engine of the armaments dynamic".²⁶ Without the contribution of technological innovation, the armaments acquisition process would come to an abrupt halt. Furthermore, were the technological innovation stemming from R&D

a passive force, no arms race would exist. Thomas Glennan in his review of American military R&D policies has determined that military research and development is essentially driven by two parallel elements: the requirements-pull factor, and the technology-push factor.²⁷ These factors may be differentiated by the origin point of their respective motivating forces. The "requirements-pull" factor is what Glennan has labelled a "top-driven" element, so called because military requirements are determined by bureaucrats and military officials. On the other hand, the "technology-push" factor may be termed "bottom-driven", as technological innovation stems from the efforts of research and development organizations. Needs flow from the top; possibilities, from the bottom.²⁸ Research and development, then, is a critical driving force in -- rather than a passive contributor to -- the innovation process.

Others would argue -- Marek Thee among them -- that beyond playing merely a driving role in the armaments dynamic, research and development (and the resulting technological innovation) is for all intents and purposes in the "driver's seat". The development of a new technology or principle often seems unstoppable: Thee contends that "whenever military research and development has proved the technological feasibility of new weapons, there has been no force to halt their acquisition and deployment".²⁹ Certainly one of the aims of research and development is to maximize the employment of any new principles developed; Thee fails to emphasize sufficiently the role of other organized entities in the manifestation of "technological push".

One characteristic of military research and development which is worthy of note is that researchers tend to seek continual amelioration of

all facets of a given technology or combination of technologies. "Military R&D works on the whole gamut of qualitative improvements -- explosive power, speed, range, precision, guidance, automation, versatility, and manoeuvrability -- racing for a capability mix unprecedented in history".³⁰ In short, the goal of military R&D is to achieve an overall increase in capabilities; that is to say, in the Aggregate Destructive Power of the American strategic arsenal. It is this tendency which contributes to the upward-trending spiral characterizing the superpower arms race.

Military research and development is not a risk-free undertaking; a great deal of uncertainty pervades any such venture. Among the uncertainties which tend to dominate the R&D environment, Glennan notes the future role of military forces; the future effectiveness of a given type of force; the alternatives to achieving one's set objectives (and whether these alternatives are more or less viable than one's own); and the possibility of unforeseen developments overtaking and obviating one's research efforts.³¹ Examples of these would be, for instance, the uncertainty regarding the role of the heavy armoured division in a world characterized by shrinking European tensions and a growing need for a trans-oceanic power-projection capability; concerns over the effectiveness of capital ships (battleships, supercarriers) given recent developments in high-technology anti-ship cruise missiles; or the developmental flurries that pushed ICBM projects along at a fabulous rate in the early 1960s, rendering the problem-plagued Snark cruise missile and its cousins prematurely obsolete. Research and development, even given a comfortable cushion of government funding to fall back on, is a venture fraught with

risk. If the potential for gain is enormous, the possibility of loss is equally so.

Perhaps the most apt description of the role of military research and development in the innovation process is offered by Marek Thee:

Military R and D evinces specific traits which inherently tend to kindle the arms race, making it intense and vicious. Fundamentally, R and D visualizes the research process as an endless continuum with no end-solution to any particular problem. Applied to military R and D, this necessitates, as a matter of expediency and scientific pressure, constantly seeking improvement on any achievement in weapon development. Scientific curiosity is compounded by material favour and professional ambition combining into an irresistible drive for higher and higher levels of arms utility and efficiency. The focus of this exertion is not quantity, but superior quality.⁸²

1.2 "Consensus-Building"

Following the technocratic initiative stage, proponents of a new weapons system concept undertake a process of "consensus-building" -- the second element of the "second track" armaments acquisition process. The aim of consensus-building is to construct as wide a base of support as possible for the emerging innovation. This "rallying 'round the research", as it were, involves the collusion of scientists, industrial officials, military personnel, and a wide range of political personalities within research organizations, the services, the Department of Defence, and the Pentagon.⁸³ If the system's proponents are able to generate sufficient interest within these groups and among these individuals, their system will gain the momentum necessary to obtain the funding and Congressional support required for advancement to further stages of the developmental process.

Far from an optional exercise, consensus-building (like the other elements characterizing the second track sequence of events) is a condition necessary to the procurement process. Technology, while a powerful motivator, is not by itself "an autonomous force...If an idea for a new weapon is to attract political support and funding, it must have promoters."³⁴ From its inception, the idea must be brought to the attention of all who might potentially have an interest in its ultimate development as a weapons system. None would be better suited to this task than those most intimately involved in the research process. Evangelista notes that the initial promoters of any novel technological concept are often those research scientists who originally brought the idea to light.³⁵

The strategic aim of those involved in the consensus-building exercise is to forge agreement among and within what Evangelista terms "the chief power centers" of the weapons system acquisition elite: the Air Force, the Navy, the Office of the Secretary of Defence, the Directorate of Defence Research and Engineering (DDR&E), the group of aerospace contractors (Lockheed, Boeing, General Dynamics, and the like), and the weapons laboratories of the Atomic Energy Commission.³⁶ One might add a few additional important bodies, for instance the Department of Energy (responsible for the design and testing of nuclear warheads), and certain of the more influential systems engineering and electronics contractors. With the creation of a base of support for the new system amongst those organizations and groups most likely to benefit from its development and production, the project will begin to take on something of a life of its own.

Consensus-building is to a certain extent a tactical exercise as well. In the early stages of a conceptual project, promoters tend to use a low-key, relatively quiet approach to inter-group lobbying, so as to make advances and gain as much support as possible without being noticed by larger organizations (specifically Congressional committees, the service Departments, and government agencies); in the later stages, once the idea has gained sufficient backing and a certain amount of momentum, promotion takes on a louder note, the aim being to attract high-level backing in order to ensure the necessary heavy funding.³⁷ The fledgling innovation is protected and nurtured in its infancy; but once having achieved sufficient growth, it is thrown out of the "nest" to fly or fall on its own.

The consensus-building process, unlike other elements of the second track, is not a discrete, one-time affair; rather, it is an ongoing effort by interested promoters intent on securing as wide a base of support as possible for their project. Michael Armacost states that "securing the requisite program approvals for a major technological innovation entails consensus-building efforts of ever-widening scope";³⁸ Evangelista offers the example of Admiral Rickover's pet nuclear submarine project, in which the Admiral advocated and incorporated "technical designs favoured by others if he thought they could be useful for his project as well" in the interest of gaining the support of as many industrial and technical groups as possible.³⁹ It is somewhat doubtful whether this type of activity would lead to an optimum systems design, but it is nonetheless indicative of the lengths to which interested promoters are prepared to go in order to secure support for their projects.

One further point raised by Evangelista is the sequential nature of decision-consensus formation found in the United States. US promoters attempt to form a broad base of support in order to influence the taking of a decision by those in power. Soviet practice, on the other hand, is to formulate a decision and thereafter attempt to rally support in favour thereof.⁴⁰ Evangelista surmises that this tendency is characteristic of each nation's individual innovative process (top- as opposed to bottom-driven). One wonders which system would, in the short and long terms, be more effective.

One unavoidable facet of the consensus-building process is that, in gaining the support of a wide range of developers, research groups, services, and other interested parties, the complexity of the proposed system begins to skyrocket.⁴¹ In order to interest as many parties as possible in the project, design features are incorporated into the proposed system which, while pleasing to potential producers and/or buyers, may be inherently inimical to each other. Such was the case with the AIM-7 Sparrow missile; in an attempt to design an anti-aircraft system operable from aircraft, ships, and land-based launchers, the development and perfection of the system was delayed by several years. Overtaken by the simpler (and considerably less sophisticated) AIM-9 Sidewinder missile, the Sparrow continued to be plagued by operational difficulties until the programme was split into separate paths for each operational element. Similar problems were encountered during the early years of the cruise missile programme, until the development efforts were reallocated, Boeing being assigned responsibility for the ALCM (AGM-86B), and General Dynamics for the SLCM and GLCM (Tomahawk).

Excessive complexity results from two factors: an inability to limit the technical options favoured by each interested party, and the fact that promoters tend to incorporate all suggested design features in an attempt to please everybody.⁴² Thomas McNauer suggests that "sophistication may be the by-product of intense intra-service bargaining and consensus-building".⁴³ It is not unlikely that industry views excessive systems sophistication as an opportunity to both charge more per unit manufactured, and make additional money from the extra time spent attempting to "iron out the bugs" in an overly complex system.

1.2.1 Contractors and the Defence Industry

The influence of contractors and the various groups within the American defence industry must not be underestimated. Defence contractors represent a considerable portion of the industrial capacity of the United States, as well as a healthy percentage of the working force. Decisions which adversely affect the defence industry can be politically significant; politicians with foresight avoid antagonizing such a large and powerful constituency possessed of considerable political clout, as President Carter learned to his sorrow following the decision to cancel the B-1 bomber. The interests of the defence industry are not only inseparable from the government weapons system acquisition process, they are mutually reinforcing.⁴⁴

Defence contractors possess two assets critical to the systems acquisition process: capital and talent. Money and people, perhaps the most valuable currencies in today's production-oriented world, are power, and the defence industry controls vast amounts of each. Investment in

material capital (such as specialized production equipment) is likewise an expensive proposition; it would be unreasonable therefore to expect a contractor's interest in a project to cease with the delivery of the last production model. Repair and replacement contracts, additional units, and follow-on programmes are all eagerly sought after. It must be remembered that while the defence industry employs large numbers of political and strategic analysts, it does not operate entirely in the interest of national security, but rather in that of the proverbial "number 1".⁴⁵

If influence is power, then defence contractors represent one of the more powerful elements in the entire acquisition process. Hampson maintains, for instance, that "contractors are in the enviable position of being able to shape service preferences and to press the services to buy the latest technology and hardware".⁴⁶ By influencing arms acquisitions, the defence industry -- if one holds with Marek Thee that capability molds policy -- then has a hand in directing national security strategy. This is influence and power, in spades. Even at the consensus-building stage, industry is able to subtly direct the concept formulation process, by indicating what is and is not technically feasible, and what would or would not be overly expensive to achieve. Although specific systems are not commonly discussed at this stage, the role of industry as discussants in the process allows them a certain amount of leverage in directing the formulation of the concept.⁴⁷

1.3 "Promotion"

Having built a strong base of support throughout the lower echelons of the influential organizations and groups implicated in the development

of a new weapons system, proponents of the innovation proceed to the third stage specified by Evangelista's second track: that of higher level promotion. In this third stage, "scientists and their military and industrial associates in the R&D community promote the new weapons proposal within the military services, the Congress, and the Executive, until it gains influential supporters".⁴⁸ One may differentiate between the second and third stages by considering the eventual impact of the third: if a weapons system concept is promoted in Congress, one result will be a series of investigations in industry, research, and military venues in order to determine whether the system is both possible and desirable. If a strong base of support was built during the "consensus-building" stage, the answer from below will be "yes, the system is both feasible and necessary". Without this positive response, the system will likely fail at the promotion stage.

Promotion is also characterized (to a certain extent) by something of a "parting of the ways" by the systems proponents. The process of lobbying in the various services requires the proponents to split their efforts and employ different approaches with respect to different potentially interested parties. The Army must be convinced that the new system is good for the Army (or at least, not bad);⁴⁹ the Navy, that the system is good for the Navy; and the Air Force, that they will benefit from its procurement as well. Congress must be convinced that national security goals can only be met by procuring the new system, and that it will not be prohibitively expensive; and the Executive must be convinced that the acquisition project is politically desirable (and, contrariwise, that to not acquire the system would be politically damaging).

Evangelista notes that the eventual goals of the individual promoters may come into conflict;⁵⁰ such are the fortunes of economic war.

Different groups and institutions are motivated by different things; lobbyists must take this homily into account at the promotion stage. The military services want more and better weapons, whereas civilian bodies tend to be preoccupied with economic considerations and political motives.⁵¹ Government agencies tend to be concerned with monetary issues and with threats to national security; at the upper levels (to wit, Congress and the Executive), Evangelista notes that promoters often find it necessary to appeal to security sensibilities by raising threats (see section 1.4, "Open Windows"). However, it is usually not necessary at this stage to appeal to external factors; promotion of the new system is often based on the internal merits of the programme (job creation, political benefits, service requirements, and the like). Congress is particularly vulnerable to suggestions dealing with the goodwill of the electorate; "The widespread belief that the development of new weapons creates opportunities for employment has apparently been particularly influential in gaining Congressional support for military innovations."⁵²

Once past the consensus-building and promotion stages, development programmes tend to gather a considerable amount of momentum. Beyond the efforts of the original promoters,

the companies themselves often take the initiative. Once a major weapons system exists, momentum is created within the company, the Department of Defence, and Congress to buy it, particularly since the government has already heavily invested in the company research and development.⁵³

Programmes having built up this kind of momentum become inherently tenacious; by the time a considerable amount of money has been expended developing a particular idea, politicians and industrial officials alike are loathe to cancel it -- even if it is a demonstrable failure. Hampson draws a line between the early stages of a programme, where it is still vulnerable to cancellation, and its later stages, where it takes on a juggernaut-like quality and becomes essentially invulnerable:

In the early stages of research and development, a program enjoying strong bureaucratic and political support will obtain enough seed money -- which can run into the hundreds of millions of dollars...to move ahead.

But,

Major weapons programs enjoying strong political backing are rarely cancelled and usually obtain sufficient funding to remain viable. Like giant octopuses, they survive even if they lose some tentacles.⁵⁴

Also like octopuses, programmes in which government and industrial organizations have invested heavily tend to be able to acquire additional funding to the point where an essentially useless system -- such as the DIVAD (Divisional Air Defence) weapons system -- is acquired and all but deployed simply because it is too expensive not to do so (and too embarrassing to explain such unforgivable prodigality to Congress).

1.4 "Open Windows"

One of the more challenging requirements of the second track complement to the systems acquisition process is the production of a rationale defending the procurement of a new system. Without a

sufficiently convincing justification, the upper echelons involved in acquisitions decisionmaking are unlikely to approve the research and testing of a novel technological innovation, much less appropriate the vast sums necessary to support the project. The "open windows" stage of the acquisition process is intended to provide this justification by appealing to the strategic fears of the decisionmakers.⁵⁵ It is at this stage that the acquisition of a new system is rationalized on the basis of an external threat which said system is intended to overcome. Perhaps one of the best possible examples in recent memory was the effect of the launch of Sputnik by the USSR in 1957 upon the American ICBM programme. Having ignored a successful Soviet ICBM test launch several months earlier, the demonstration of a sub-orbital payload capability was hyperbolized by missile proponents into a serious strategic threat which was, in fact, largely a straw figure. As General Andrew Goodpastei reports,

The whole story of the bomber gap, the whole story of the missile gap, this was largely fed by...the arms manufacturers, the military services, and the politicians who saw this as something they could exploit and on which they...could receive the support of the armed services and of the arms manufacturers.⁵⁶

East-West military and political competition is undoubtedly one of the driving forces behind the respective armaments dynamics of the superpowers. The rivalry is derived from "conscious and well-ordered...notions concerning the international state system and the appropriate place of each great power in that system".⁵⁷ Competition in all arenas of international affairs leads to innate reliance upon the

relative strengths of the superpowers' respective military industries: the United States depends for the most part on technological innovativeness to attain and maintain military supremacy, while the Soviet Union employs central organization and mass labour mobilization to produce enormous quantities of less technically sophisticated weapons. While technological advance tends to drive this process onward, its essential inspiration is drawn from the mutually perceived threat of superpower military competition.

It is interesting to note that justification for a given development is not usually offered in the earlier stages of the second track process. Technological innovations supporting a budding weapons system may initially be presented as simple oddities rather than as future pillars of national security; it is only in the latter stages where large monetary appropriations and political advantage are at stake, that a system must be justified on the basis of military requirements or external threats.⁵⁸ Without this justification, the project will be passed over in funding allocations. External threats and national security needs are the coin of both the Congress and the Executive.

Paradoxically, the existence of a national security threat (or other external factors, such as inherent superpower competition for "first-place" status in matters military) is not capable of engendering a weapons procurement programme, but only of hastening one already "in the works".⁵⁹ To suggest otherwise would be to subscribe to the notion of the existence of an action-reaction phenomenon between security matters and the defence industry. This, according to Evangelista, is demonstrably not the case. External factors may speed up the process; they will not initiate it. The

initiation of a weapons system acquisition may only be accomplished by the emergence of a technological innovation.⁶⁰

The importance of a perceived threat is paramount to the promoters and proponents of a given weapons system. If necessary, a threat will be fabricated in order to justify the new concept; Goodpaster suggests that this was precisely the case in his aforementioned commentary on the bomber and missile gaps. The threat need only be credible in order to generate the appropriate response from American decision makers; it need not be real. Harvey Brooks records that

Experience has taught the military technical community that it is much easier to sell interesting research if it can be pushed as a fully conceptualized weapons system meeting a well-defined military requirement based on a well-established threat from a postulated opponent. In practice, both the threat and the requirement may have been invented to provide a rationale for a development program started for other reasons.⁶¹

1.5 "High-Level Endorsement"

The final stage of the second track acquisition process involves gaining the approval of the highest levels of the American procurement decisionmaking elements. Obtaining the "okay" of the President, the Executive, and Congress is a mandatory final step in the development of any new system. The President can veto a proposal; the Congress can deny it funding. This dual control over permission and purse-strings is a powerful force which must be overcome by the proponents of the innovation.

Although they wield a great deal of power with respect to the "yea or nay" of weapons system procurement, the upper decisionmaking echelons

have relatively little influence when it comes to determining the shape or role of the system itself. Kosta Tsipis says of the "Higher-Level" that

Where the defense imperatives, or the prevalent strategic doctrine, and therefore the central decision-making role of the political and military leadership enter is in choosing which of the many systems...will be funded, at what level, and when along their development cycle.⁶²

The higher leadership will not determine how the weapons are designed; that is the province of industry and the military. Nor, for the most part, will they determine how the weapons are deployed and used; that is the sole province of the military. Outside of general policy strictures, deployment and infrastructure are beyond the mandate of the higher levels of officialdom.

The aim of high-level endorsement, then, is the seeking by promoters of support amongst the public, and, as stated, within Congress and the Executive. This stage of the process is generally carried out under the closer scrutiny of Congress, public interest groups, certain lobbies (arms control, disarmament, Greenpeace, and the like), and consumer interest "watchdogs". More justification of the system with reference to crucial security threats is required; but, paradoxically, because a strong backing has already been created to support the procurement of the system, such threats need only be general in nature, and, as Evangelista intimates, need not "have much grounding in reality".⁶³

Even the rationales for acquisition and deployment can, at the higher levels, be wildly varied. One such example of this trend is the

aforementioned psychological commitment to the maintenance of US strategic superiority over the Soviet Union; Desmond Ball suggests that this widely-held value was in part responsible for the rapidity with which the United States expanded its ICBM force in the era of the "missile gap". Psychological fears are, if anything, more easily played upon than verifiable threats; the promoter need only be aware of which "buttons" to push.

The role of the President himself as a target of high-level endorsement is somewhat nebulous. The power of the President in formulating policy with regards to individual weapons systems is somewhat restricted. As a general rule, states Mclean, he decides only what "has not or cannot be decided at a lower level".⁸⁴ Quite often the President does not even see a developed concept unless he asks for information concerning it; and, failing that, it might only be brought to his attention when the appropriation is brought before Congress. In short, by the time the President's approval is required, nearly all decisions concerning the system have already been made.⁸⁵

This is not to say that the President is powerless with regards to new weapons deployments, however; as Jimmy Carter proved in the case of the B-1 bomber, the President's most powerful tool is a simple "yes" or "no". However, as previously discussed, the President must be wary of rejecting a given weapons system; the defence industry is a powerful constituency supporting millions of voters. Political and military officials quite often put their reputations (if not their careers) on the line in support of a weapons system. Once past the earliest development and testing stages, the cancellation of a weapons system carries with it

enormous political costs.⁶⁶ Doing so is a risky venture for the President; as Mclean states, "Expending political credits on a weapon decision will mean fewer credits for future battles, as President Carter learned after his B-1 bomber decision".⁶⁷ The B-1 bomber, by dint of unrelenting support from interested parties, survived the decision; Jimmy Carter, lacking such support, did not.

1.5.1 The Policy-Role Disjunction

Any discussion of the superpower armaments dynamic -- and particularly of the convoluted and confusing American arms acquisition process -- leaves one somewhat in doubt of whether national strategic policies play anything of a role therein. Do nuclear strategic thinkers have any voice in deciding, on the basis of security needs and the state of nuclear strategic thought, what the nation's needs are and how best they might be answered? The response to this question, offered equally and resoundingly by all principle authors under discussion in this paper, is an unmodified "no".

The former Scientific Adviser to the British Government, Lord Zuckerman, once stated: "During the twenty years or so that I myself was professionally involved in these matters (i.e. nuclear strategic planning), weapons came first and rationalizations and policies followed".⁶⁸ The same holds true for all world powers possessing nuclear weapons: policy follows capability. Massive Retaliation was impossible without the bomb; flexible response without the range of options offered by a bomber/ICBM capability; counterforce without the MIRV and accurate targeting systems; and countervailing without an unprecedentedly varied

strategic force permitting an wide variety of options. "In American nuclear history...strategic force planning decisions have been isolated and insulated from declaratory policies and employment doctrine";⁶⁹ only a fool would contemplate a given policy approach without an extant weapons systems to back it up.

Many have argued that the apparent failure of the SDI programme was rooted in the inversion by President Reagan of the normal order of innovation-capability-policy. Defence research scientists, confident in the possibilities demonstrated by new developments in directed energy and kinetic-kill technology, reported the potential for a strategic defence system; politicians took a fledgling idea and hyperbolized it for political purposes, forcing the scientific community to, in effect, show a "busted flush". SDI is an excellent counter-example of the normal process of weapons system innovation (and, indeed, of the perils of an entirely "top-down" process of innovation).

Politics and technology, especially in the defence research community, are at best uneasy bedfellows. Instinct and conventional wisdom state that policy should precede expenditures and acquisitions; technological fact dictates otherwise. This disjunction causes a certain amount of tension within the scientific-political communities, tension which manifests itself in the clumsiness with which innovation is handled. Zuckerman criticizes the handling of policy during the American tactical nuclear weapons acquisition programme:

At the time there was no military operational requirement...First came the weapons; then they had to be fitted into a presumed tactical doctrine, which in turn had to be fitted into an illusory strategy, usually elaborated by armchair warriors.⁷⁰

In the case of tactical nuclear weapons, the capability was made available and a strategy and policy were drawn up around it in order to justify their acquisition and deployment en masse. The new capability rendered flexible response and forward defence on the European battlefield more a reality and less an unfulfillable commitment.

There exists some suspicion amongst numerous authors that military technology is by its progressive nature becoming to a certain extent dominant over the policy process. Thee states that new systems like the MIRV and strategic cruise missiles (SCMs) burst onto the strategic armaments scene like "heroes in search of a mission" -- which is to say, the weapons come first and the doctrines follow.

Decision-makers and bureaucratic politicians are increasingly deprived of the ability to control military technology, being relegated rather to administering its yields, with their elbowroom for intervention becoming more and more restricted...Thus, parallel to the thrust of military technology we may observe a rising curve of predominance of military technology over the political process.⁷¹

Technological momentum may indeed be overwhelming the role of policymakers in the American defence community; such appears to have been the case many times over in the past, and the trend shows no signs of weakening at any time in the future. The fruits of technology, presented to the defence community in the form of potential weapons systems, determine the direction of national strategy, and it would be well for American strategists and defence policymakers to adjust to this fact. Capabilities determine strategy; the inverse is nothing more than a recipe for confusion and wasted effort. In Marek Thee's assessment of the

American armaments acquisition process, military technological innovations play the more important role: "Once the weapons are at hand and one needs to frame uses for the military stockpile, doctrinal rationalisations for military requirements can always conveniently be pieced together".⁷² Adapting the policy process to the obvious would save considerable time, effort, and money.

2. Approaching the Problem

The technological arms race between the superpowers has been under way essentially since the close of the Second World War. Competition in matters military has provided one of the less destructive substitutes for direct superpower conflict, permitting the US and USSR to expend tremendous amounts of time, energy, and capital in an ongoing attempt to outdo each other, while at the same time avoiding the attendant damage which usually accompanies open or "hot" warfare. The advent of the atomic bomb rendered direct superpower conflict unthinkable; simultaneously, it moved the unspoken struggle onto a less deadly but no less contentious battlefield.

"Less deadly", that is to say, only so long as the contents of the superpowers' respective strategic arsenals sit idle. The world has wavered on the brink of global nuclear war on few occasions each of which being, one might argue, one occasion too many. Contemporary thinkers applaud the Presidential incumbents' shared desire to rid the world of a healthy proportion of these weapons; and yet, if past experience with strategic arms control efforts is any indication of the level of success we can reasonably expect, their efforts may be undone in the future by a

combination of exempted technologies, new innovations, and overlooked evolutionary possibilities.

The topics discussed in the first section of this chapter raise a plethora of questions about the problem of determining the nature of the operating mechanisms underlying the American strategic weapons systems acquisition process. What, if any, is the definitive driving force? Are there identifiable control points within the process? Who, if anyone, exerts a controlling influence over the process? Is uncontrolled technological innovation in part responsible for the arms race -- and, if so, can it be used as a lever to decelerate the race? Does Evangelista's sequence of second track stages offer an accurate schematic of the "second track" American weapons system procurement process? Why look for solutions in the armaments dynamic at all?

The last question holds the greatest import, and is the focus of this section. Why look to the armaments acquisition cycle for answers? The answer is a relatively simple one. We have already established that the global arms race is characterized by an upward-trending progression in the aggregate destructive power of weapons systems. Aggregate destructive power by definition increases only under two circumstances: first, when a state decides to deploy greater numbers of an existing system without undertaking to deactivate any previously deployed systems (or while concurrently deactivating a similar or lesser number of inferior systems); and second, when technological advances render possible the deployment of an advanced system whose destructive capacity results in a net gain in ADP even in the face of the withdrawal of an existing system. The latter condition has characterized the deployment of every new

American strategic weapons system since the Second World War.

The second track armaments acquisition dynamic offered as a solution by Matthew Evangelista depends upon significant technological innovation as a starting point for a systems development programme leading ultimately to the deployment of a new system. If Evangelista's arguments hold true, it may be possible to apply his conclusions to the American strategic arms acquisition process, offering a model for comprehension and, perhaps, locating critical or control points within the armaments dynamic in hopes of rendering the process more efficient and less wasteful, toning down the arms race by alleviating the drive to create, and facilitating the arms control process by decelerating one of its principal driving forces.

There is one difficulty inherent in this particular study: Evangelista in his work, while offering numerous examples drawn from armaments acquisition cases (both strategic and not so), has chosen to concentrate specifically upon the case of the American (balanced in Innovation and the Arms Race against the Soviet) acquisition of tactical nuclear weapons. Evangelista's theory may not hold true as a model for the strategic armaments acquisition process (while strategic systems are nuclear as well, the role is inherently more important for this discussion than the nature of the weapon itself). He maintains that it should; the author suggests that it may. The aim of this study is to test his model against a pair of temporally and technologically unrelated cases in the history of American strategic arms acquisitions in order to determine its utility as a prescriptive tool.

Evangelista's approach to the problem is designed along the lines of an in-depth case analysis. Eschewing traditional scientific method,

he has postulated on the basis of examples and background evidence the five second track stages described in the first section of this chapter. From a strong theoretical background presented in his first two chapters, Evangelista examines the tactical nuclear weapons acquisition programmes from both the Soviet and American paradigms, terminating the study with a number of conclusions as to the nature of the respective procurement cycles. The present study will follow a similar course of action. Based on the information presented above, two case studies will be evaluated against Evangelist's sequence of events in order to determine whether they display the characteristics he has observed. Each case study will consist of an analysis of the procurement process for that particular system with respect to Evangelista's second track model (we shall assume, on the basis that both systems have been deployed for some years now, that the first track or official aspect of the process was followed more or less to the letter). A third section will discuss a variety of elements peculiar to that particular system not incorporated under Evangelista's theories, and a final summary will determine the applicability of his model to the individual case in question.

The case study method itself tends to meet with some resistance in certain quarters of the social scientific world on the basis that any theory "proven" thereby is not by definition "generalizable". There is some truth to this argument; in mathematical terms, a formula derived by the integration of a given number of points will define a line passing through those points. However, if one has not taken into account all extant or possible points, one cannot derive the true equation of the line. By the same reasoning, one cannot by analyzing one or two case

studies derive a precise answer explaining behaviour for dozens of other cases. However, social science studies are less interested in absolute explanations than in explaining trends, and case study analysis is admirably suited to determining, describing, and explaining trends in behaviour. Further, Evangelista notes that arms race analysts often must rely solely on case studies for their information, as the arms race -- when considered from the viewpoint of a continuing sequence of discrete weapons system deployments -- consists of little other than individual cases of system deployment. Evangelista has found no difficulty in constructing a general set of postulates about two sides of the armaments dynamic from a single case study;⁷⁸ the author feels that there should be no impediment in this study to generalizing about one side of the dynamic from a study of two cases. The determination of utility or inutility will be relatively simple; like Evangelista, the author intends to construct a boolean comparison whereby the success of an acquisition programme (represented by "A"), is subject to dependency upon the successful completion of all five of Evangelista's second track stages (represented by "B"). Thus, the study of each case will render one of two results:

- 1) if A AND B, then his theory is valid for that case; or,
- 2) if A AND NOT(B), then his theory is invalid for that case.

The reader will note that no provision is made for cases evidencing NOT(A) behaviour. As the cases in question (in order to be considered cases of weapons system acquisition) were both successful, no instances of NOT(A) behaviour will be addressed at this time. Future studies might address

the problem of NOT(A) behaviour by analyzing failed acquisition programmes in light of their respective adherence to the pattern of Evangelista's model.

As mentioned in the introduction, the cases under discussion will be those of the development, acquisition, production, and deployment of the MIRV and the ALCM. These cases represent successful arms acquisition programmes, each of which was plagued by certain difficulties along the path from innovation to deployment. Each represented a revolutionary addition to the US strategic arsenal and a significant contribution to US nuclear power; and each added considerably to the aggregate destructive potential of the global nuclear stockpile. By testing its precepts against these discrete cases, it should be possible to determine the utility of Evangelista's model both as a descriptive tool for the American strategic armaments acquisition process, and as a prescriptive tool for the reparation and deceleration thereof in the interest of removing one of the principal motors of the arms race and increasing global security.

CHAPTER TWO: ACQUIRING THE MIRV

The aim of this chapter is to examine against Evangelista's five criteria the development, acquisition, and deployment processes that led to the intrusion of MIRVs into nearly every element of America's strategic forces. In order to do so, this chapter has been divided into three individual sections. The first will discuss the systems acquisition process in the context of the theories explained in the preceding chapter. The second will address the question of additional contending elements in the process -- to wit, service influence, programme momentum, informal channels of communication, and high-level interference -- and the third will offer a summary of the relevant findings and a synthesis of the arguments presented.

The introduction of MIRV into the American strategic arsenal followed neither a smooth road nor a rocky one. Although institutional interests were often at odds with those of policymakers or the scientific community, a concentrated campaign of inter-organizational bargaining resulted in the eventual deployment of several efficient and cost-effective systems. The following sections will examine that process in some depth with an eye towards verifying Evangelista's assertions.

Concerning Multiple Warhead Missiles

The development and deployment of MIRVed ballistic missiles, both sea- and land-based, during the 1960s represented the most significant

alteration in the American strategic force posture since the advent of the atomic bomb.¹ The combination of a variety of minor technical innovations rather than a single breakthrough, MIRV multiplied the number of nuclear warheads available to the American strategic arsenal, thereby offering policymakers a wider range of options for striking more (and more diverse) targets. There was no initial mission requirement for MIRV; as will be discussed further along, the concept arose independent of a role as the result of evolutionary developments in a variety of fields, some only remotely related to ballistic missile research.² The need for MIRV as a crucial element of America's strategic forces only became apparent once its capabilities had been evaluated and understood.

The "egg-chicken" debate over the pulling/pushing roles of strategic technologies was particularly prevalent in the case of MIRV development. The concept of multiple warhead missiles predated the generation of a counterforce targeting doctrine by the American strategic community. McNamara's announcement of a "no-cities" policy, as discussed in the first chapter, was in effect little more than a sop to the moral sensibilities of those in the policy- and decision-making communities unhappy with contemplating and planning the deliberate massacre of Soviet civilians in the event of a "showdown"; the American strategic arsenal contained at the time no means of supporting any other doctrine. In the early 1960s, American capabilities demanded either "massive retaliation" to an enemy provocation, or no retaliation at all.

Tammen suggests that one of the forces which sparked further interest in developing an increased targeting capability was the U-2 reconnaissance overflight programme which took place during the late 1950s

and early 1960s.^a The photographic equipment carried by the U-2 enabled the intelligence community to produce exceptionally accurate images of possible targets: command elements, military facilities, air bases, radar sites, and missile silos. Further, the use of inertial reckoning equipment in conjunction with the photographic capability of the aircraft led to the production of highly accurate maps offering sufficiently precise geographic reference data for the programming of existing ICBM guidance computers. Given the exact location of both the missile launch and target sites, a counterforce capability was only as far away as an accurate missile guidance system.

Another result of the U-2 overflights was the observation and recording of enormous numbers of potential targets. Expanding target lists rapidly outgrew the capacity of the American strategic arsenal, leaving policymakers the unpleasant choice of either ignoring a large number of precisely-located and intrinsically valuable targets, or of undertaking to expand the American missile and bomber fleets by an order of magnitude. The first option was strategically unsound, the second prohibitively expensive.

Concurrent scientific research into varied fields resulted in the development of the MRV (Multiple Reentry Vehicles) concept. This idea envisaged the deployment of several nuclear warheads atop a single launcher. The warheads would be released at some point along the post-boost phase, to continue their own ballistic trajectories and impact in a predetermined pattern around the target (along the lines of a shotgun pellet spread). While this idea failed to answer the need for increased numbers of separately-targetable warheads, it represented a critical

development in the chain of events which led from single-warhead launchers to modern MIRVed ballistic missiles.

From a mission standpoint, MIRV is the evolutionary successor to the MRV concept conceived in the late 1950s.⁴ The latter had yet to reach the proposal stage when further developments in guidance, propulsion, and multiple-launch technologies rendered possible the individual release and targeting of multiple warheads from a single launcher. This possibility delighted planners, as it promised to resolve a host of troublesome issues, including the potential threat of a Soviet ABM deployment and the aforementioned burgeoning target lists. Furthermore, MIRV capability would lend strategic credibility to McNamara's developing counterforce doctrine, as it became apparent that increased fractionation and improvements in accuracy would enable the precise targeting of individual command posts and even missile silos. The MIRV concept gave counterforce the material backing it sorely lacked.⁵

Skepticism about MIRV capabilities abounded in the early years. Would individual post-boost targeting systems be sufficiently accurate to ensure a near-direct hit? Would a smaller warhead pack a large enough "punch" to destroy a hardened bunker or silo? Would not a MIRVed missile force be increasingly vulnerable to a pre-emptive enemy attack? All of these arguments were dealt with in stride by the system's proponents, and will be discussed in turn in the following section. The outcome of the MIRV debate was that the concept lent American strategic forces a capability that only the prodigal would be willing to set aside unconsidered. MIRV, while expensive on an individual basis, was in the long run comparatively cheap. A MIRV force with sufficient accuracy would

be able to provide target coverage that would otherwise require the expansion of existing forces manyfold, a financially impossible objective. MIRV answered both the counterforce and countervalue concerns of all involved.

Initial evaluations of the MIRV concept promised a weapons system of unprecedented potency. Additional improvements in targeting computers and precision guidance increased the flexibility of the system and offered the President a considerably wider choice of options, the ultimate aim of McNamara and the 1962 SIOP. By the time the MIRVed Minuteman III reached the deployment stage, the Strategic Air Command was able to offer the President the ability to attack any fixed target in the Soviet Union with relative certainty of destruction.⁶ Counterforce was rendered an operational doctrine rather than a nebulous ideal.

Countervalue capabilities also waxed enormously with the introduction of MIRV. The role of ensuring the validity of the "assured destruction" concept fell to the submarine-based ballistic missiles of the Navy (see Section 2.2.1 on the Armed Services), which happily endorsed the addition of MIRVed payloads to their arsenal. In many ways, MIRV served countervalue capabilities to a greater extent than it did counterforce. The ability to strike a city with a nuclear weapon is what matters in the assured destruction scenario; the size of the weapon itself is of little consequence.⁷ The Navy accepted the fourteen-warhead-per-launcher capability offered by the modified Poseidon MIRV with predictable grace.

Freedman has stated that the MIRV debate was characterized by this question of justification:

Although ensuring that a greater diversity of targets would be available for attack, it was not expected originally that MIRVs would render hardened targets, particularly the protected missile silos of the Soviet Union, vulnerable. They were approved as a means of degrading ABM systems and removing the necessity for further increases in launch vehicles.⁶

The justification debate will be discussed further in the following sections.

1. The Evangelista Model Applied

Any prima facie analysis of the MIRV development and acquisition process raises immediate questions as to the effect of unofficial influences on the strategic armaments cycle. MIRV arose without a requirement, succeeded due to behind-the-scenes "pulling and hauling", and went into deployment for a number of reasons, none of which were related to the rationales which were proposed to justify the system. Clearly, the first-track explanation does not suffice to explain the acquisition of MIRV technology.

Evangelista's theories regarding weapons system procurement offer a more revealing explanation of exactly what went on throughout the MIRV development and acquisition process. The following section will examine that process in light of Evangelista's five criteria with an eye towards validating his second-track explanation for the process under scrutiny.

1.1 Was There "a Technocratic Initiative"?

Dr. John Foster, Director of Defence Research and Engineering in the heyday of MIRV development and deployment hailed the invention of the Post-Boost Control System (or "space bus", as he called it) as a major

breakthrough in missile technology.⁹ In fact, experience and evidence indicate otherwise. The development of the MIRV concept itself, as discussed previously, was more the offspring of the intelligent combination of extant or near-extant technologies for a new purpose. The process of innovation that led to MIRV was less the result of individual genius or scientific brilliance than widespread technological competence and careful consideration. Tammen suggests that Foster may have exaggerated the situation somewhat:

The MIRV concept was not a radical departure or a quantum leap in weapons development. Neither was it a nationally committed goal with enormous funding and organization, such as the Manhattan Project. In fact, MIRV was a logical offshoot from a broad technological base accumulated in the penetration aid and space programs. It is a classic example of technology shaping a strategic decision. Existing technology was the forcing rather than the constraining element of MIRV.¹⁰

MIRV developments grew out of multi-field cooperation in the scientific community. It was what has come to be known as a "sweet" problem; a difficult challenge for scientists and engineers, but one within the grasp of modern technological capabilities. Developing such a concept would prove sufficiently difficult to stimulate the interest of the research community,¹¹ but not so daunting that success would be possible only in a time-frame of decades rather than years.¹² There was, in effect, little doubt amongst scientists and engineers that MIRV was "do-able".

The drive to include the latest technical gadgetry in emerging weapons systems seems to have been universal. In the case of MIRV, designers and innovators appear to have felt constrained to include the most advanced technologies possible in the field concerned.¹³

Developments in computer guidance, propulsion systems, and other elements of the design concept were added as the project evolved. MIRV, "invented" simultaneously by diverse groups within the defence research community (and several outside it) continued to be "invented" as the research process advanced.

The technical origins of MIRV were basically fourfold. The design concept required inter alia a reentry vehicle (the warhead), guidance and propulsion systems, navigation propulsion systems, and a bus-separation capability. These technologies were supplied by a variety of "innovators"; the weapons laboratories of the AEC supplied the warheads, diverse defence contractors supplied the RV, guidance control, and "bus" elements, and space research (notably NASA) offered numerous critical developments resulting from their scientific endeavours: restartable and throttlable main engines, gas-operated vernier engines, multiple satellite separation capabilities, and improvements in guidance and accelerometer equipment.¹⁴ Penetration aids were added by the Advanced Ballistic Reentry Systems (ABRES) penaids programme, most notably ablative heat shielding and reductions in radar cross-section for the RVs. In addition, further developments in warhead design by the Department of Energy (specifically the Atomic Energy Commission at Lawrence Livermore Laboratories) led to decreases in payload weight and volume, improving the overall range of the missile itself.

The interaction of separate research companies in the development of MIRV is characteristic of modern weapons evolution. The complexity of contemporary systems is such that the secretive research and development of an entire strategic weapons system by a single company is virtually

impossible; the variety of components and technologies required is simply astronomical. Cooperation such as that demonstrated by individual research groups is an absolute necessity. Technological competition is not ruled out, however; those groups specializing in similar technologies vie with each other for the favour of government contractors and defence agencies. Technological advance rather than financial status is the coin of competition;¹⁵ new ideas and capabilities are the most salable commodities in the defence research market. Research organizations capable of adapting to new technologies will succeed where less mutable groups fail.

Adaptation to innovation in the case of MIRV was not as challenging as it might have been. The new technology demanded no significant changes in organization, as only qualitative improvements in individual technologies were involved. Existing structure, organization, and research policy were consistent with the new research, and in most cases retooling was hardly necessary.

The main thrust for technological innovation in the MIRV arena came from different scientific institutions, most notably the Ballistic Systems Division within the Air Force and the Special Projects Office within the Navy.¹⁶ Individual missile systems were handled by subdivisions of these bodies, but the MIRV research was dealt with directly. The principal impetus in favour of MIRV research and eventual deployment was generated by scientists within these groups. Once the possibility of a MIRV system became apparent, defence research organs within the DoD undertook to develop the technology at breakneck speed. The induction of technical ideas from civilian sources into military research laboratories fuelled

the process. Developing the technology was, as is usually the case with strategic (and in fact any) weapons systems, an exceptionally expensive proposition; defence researchers within the purview of the services were understandably best equipped to deal with the costs of investigation.

These research and development bodies lay at the heart of the MIRV concept. Once the idea had surfaced it would for a number of reasons have been difficult to put down, had anyone even been inclined to try. The first of these, as previously discussed, was its attractiveness to the scientific community; the second was the extent to which collusion of scientists within the defence community and their military counterparts led to the formation of an interest group backing MIRV research. The politicization of the R&D process within the research groups themselves led to its perpetuation.¹⁷ Thirdly, the fact that MIRV was seen as a series of qualitative improvements rather than a wholly new weapons system led to its being downplayed in higher-level discussions. Labelled as an improvement of existing missile systems -- rather than, as was actually the case, a new idea destined to irrevocably change the strategic balance -- MIRV researchers were able to continue their work undisturbed by restraint and cuts affecting other weapons systems. Greenwood suggests that the entire organizational structure of the Air Force existed at the time to exploit new technologies;¹⁸ it would be unreasonable to have expected as attractive an idea as MIRV to go undeveloped.

The initial stages of MIRV research were effectively rife with what Evangelista has termed "technological initiative". Civilian research groups brought the concept to the attention of their defence counterparts, who grasped the idea and, with the blessing of their military co-workers,

undertook to bring it to fruition. Greenwood states that the "initiative" went even further, as research and industrial groups fought to present military designers with irresistible technological choices:

Examples of industry initiative are easy to provide from the history of MIRV. The Thiokol Chemical Corporation was said to have advanced designs of a new Minuteman third stage as early as 1963. Autonetics and the Instrumentation Laboratory were reported to be continually suggesting to DDR&E and the services improved components for the Minuteman and Polaris guidance systems...General Electric continually pushed against the state of the art in reentry vehicles and in doing so worked very closely with aerospace and with the ABRES program. Engineers at Singer-General Precision, Kearfott Division, invented and then sold to DDR&E a greatly improved stellar inertial guidance concept for use on Poseidon.¹⁰

This type of behaviour on the part of industry is an excellent illustration of the extent of informal technological initiative by research and industrial groups resulting in the development among technical and military bodies of an interest in a new concept.

1.2 ..."Consensus-Building"?

It has already been stated that the MIRV concept in its earliest stages advanced at a relatively rapid pace, free to a great extent from organized or bureaucratic opposition. This was due in part to it being considered an improvement rather than an innovation at the policy level, a misconception which did nothing to detract from its novelty. The MIRV story was not entirely free from discord, however, and occasional pockets of resistance grew in response to some of the developments and adjustments required by the innovation. A certain amount of consensus-building was required both to get the MIRV project under way and to maintain its

momentum once started.

Greenwood asserts that the technological community supporting the MIRV idea was ideally suited to the kind of consensus-building process required to keep an arms project afloat. He holds that the research community involved in forwarding the concept was "quite circumscribed and (had) excellent modes of communication, (hence) there may have been some undiscovered and even unrealized cross-fertilization".²⁰ Interoperability between research bodies in engendering the concept likely continued throughout its early stages, in the interest of fostering its acceptance within industrial, military, and other interested groups.

Intergroup cooperation and interconnection did not exist only at the research level. Recipient organizations and policymaking groups were rife with internal and external chains of informal communication built and maintained for the purpose of mutual support. Individual personnel postings between inherently separate organizations led to an almost incestuous relationship between interested groups; in certain instances, key personnel were seconded from recipient services to research bodies and vice-versa in the interest of building strong backing and coherent support for a given innovation.²¹ Even the industrial sector was subject to this trend.

Industry, meanwhile, bolstered the MIRV concept in order to procure and protect its own contracts. Technical and industrial organizations were highly involved in driving the MIRV concept onward:

Pen-X reports of the Air Force Scientific Advisory Board Nuclear Panel and Guidance Control Panel, and the influence of the Livermore physicists all contributed to the growing momentum carrying the programme forward. The ongoing developmental work at Autonetics and General Electric, including some company-funded development, the collaboration

between the two and especially the strong influence exerted by Aerospace and STL over the direction of these efforts were major factors in establishing the feasibility of the MIRV concept.²²

The rapid acceptance of MIRV at the technical and policy levels obviated the need for spirited proponents. However, strong lobbying was required in the initial stages of the programme within certain of the Armed Services in order to convince the eventual recipients of the system of the benefits of (and the "need" for) MIRV procurement and deployment.

The military elements of the programme development process must pass through a variety of official channels. Within the separate services, these channels vary. Within the Air Force, the Ballistic Systems Division handles strategic systems acquisition; within the Navy, the Special Projects Office is tasked to do so. These organizations have different perceptions of their relative strategic roles (and, hence, material requirements), and this divergence of perceptions played a crucial part in the MIRV acquisition process.

A more elaborate schematic of the consensus-building process within the Air Force is offered by Greenwood:

Most new projects would begin with BSD at the level of the system project offices as a result of the interplay between their personnel and their industrial contacts. Sometimes a formal proposal would be put together and a briefing given at AFSC (Air Force Systems Command) headquarters. Other times a presentation would be made based only on a preliminary concept. Ideas would bounce back and forth for a while until a firm proposal was generated and a contracting team was on board. It would then be presented to the Air Staff for approval and the issuing of formal requirements.²³

This analysis suggests that the generation of systems concepts takes place on a tripartite basis, involving both industry and the technological innovators as well as the military bureaucracy. This type of behaviour might be termed "pre-emptive consensus-building", or the inclusion of interested parties in decisionmaking at all stages in order to prevent contention at a later date.

Consent within the services regarding weapons system research and production is actually required from only a very few organizations. Within the Air Force only Systems Command and BSD are concerned at the development stage; Strategic Air Command (SAC) is involved as the eventual recipient of the new system; and the Air Staff and civilian Secretariat represent the actual decisionmaking body. On the Navy side, only the Special Projects Office and the Navy Secretariat are actually involved in decisions regarding strategic weapons procurement (see Fig. 4 for a schematic of these organizations). Concentration of authority is a powerful tool in consensus-building, and the military organizations appear to be structured almost with this principle in mind.

Beyond contention over the size and yield of reentry vehicles, it is difficult to find any type of publicly available evidence suggesting Air Force opposition to MIRV. The reentry vehicles issue was sorely fought, however, and was resolved only when the Air Force was forced by circumstances to accept what, ironically, it ought by rights to have been overjoyed to receive.

The Air Force's major arguments against MIRV were fivefold:

1. The Air Force preferred large, rather than small, warheads;
2. Bombers were considered more accurate for delivery than missiles;

3. MIRV deployment might hurt the Air Force's case for a large bomber force;
4. The Air Force desired to maintain its perceived counterforce role; and,
5. Missiles tended to draw resource allocation away from aircraft.

These were legitimate concerns. Air Force strategy since the Second World War had advocated the use of penetrating strike bombers tasked with the massive nuclear bombardment of Soviet population centres. Huge weapons had been developed for this purpose; during the 1950s American gravity bomb arsenals contained weapons as large as 24 Mt. It was difficult to convince Air Force generals that they could do the same job with smaller warheads.²⁴ Their arguments in favour of bombers on the basis of accuracy were well-founded as well; in the early 1950s, the accuracy of a high-flying bomber equipped with a World War Two vintage bombsight exceeded that of contemporary ICBMs. Finally, the counterforce argument was equally legitimate; SACs ICBM fleet due to imprecision required megaton-range warheads to guarantee the destruction of hardened targets. Replacement of these weapons with smaller MIRVed warheads was expected to degrade an already limited counterforce capability. It was only when guidance technology had advanced to the point of minimal error that the Air Force accepted that a smaller bomb closer to the target might do the job as well as a larger one further back.

SAC, therefore, was understandably interested in the "front-end" or payload of the missile. It lobbied long and hard against reduction in warhead yield, offering considerable resistance to the Air Force MIRV project. Theoretically, DDR&E could simply have imposed its will on the Air Force; however, due to the service's influence on the policy process, "in practice the rest of the Air Force had to be brought along or bought

off".²⁵ The "buying off" was accomplished by McNamara's funding of the Mk17 heavy (single) warhead project as an optional warhead for both Minuteman and Poseidon missiles; however, DDR&E did not give up on promoting the desirability of the Mk12 MIRVed payload.

The warhead controversy with the Air Force is one of the best examples of institutional consensus-building available. The development process for both the MIRV and the Minuteman missiles naturally took a good deal of time, during which the accuracy and miniaturization improvements on the Mk12 system led to a more powerful (albeit still "small") warhead possessing considerably greater accuracy than initially suspected. DDR&E began to promote it to the Air Force on the grounds that, in a counterforce role, smaller warheads tended to cause less collateral damage than larger ones. In addition, McNamara commissioned the development of the Mk100 MIRVed payload, an offshoot of the Mk3 Poseidon MIRV, with very high fractionation, but with yields potentially as low as 50 kt. At roughly the same time, development on the Mk17 was curtailed as a cost-cutting measure. The Air Force, noting the writing on the wall (and appreciative of the fact that the more accurate Mk12 could in fact accomplish their mission) backed down and accepted the Mk12 in lieu of perhaps being forced to accept the Mk100. By 1965 the Air Force was solidly in favour of the MIRV, and McNamara's 1968 cancellation of the Mk17 was met with relief.

The Navy had no comparable problems with the MIRV concept. As previously explained, they saw the MIRV as a means of reinforcing their adopted countervalue role and rallied behind it from the outset. Little consensus-building of any kind was required; what did occur was easily

achieved due to a greater concentration of decisionmaking authority than was the case with the Air Force.²⁶ Target coverage and ABM penetration (both of which were inherent rather than developed characteristics of MIRV) rather than accuracy and yield were the key issues in the Navy systems selection process. The Navy itself was not overly concerned with the development of the front-end of their new missile, so long as it carried multiple warheads; thus the only consensus-building required took place between DDR&E and SPO on issues of mission requirements.²⁷

The limited number of organizations and individuals involved in the MIRV development process facilitated the consensus-building process considerably, and the non-controversial nature of the new weapon allowed it to evade undue higher-level notice. Only the Office of the Secretary of Defence, the Air Force, and the Navy were significantly involved in MIRV development (as well as a number of scientific groups and research organizations).²⁸ Thus, consensus-building for the most part was carried out inside the defence department between DDR&E and the two implicated services. The proximity of the organizations and the profusion of informal communication links connecting them rendered consensus-building a less arduous task than might otherwise have been the case.

1.3 ... "Promotion"?

As previously discussed, the MIRV concept apparently arose out of technological advance rather than operational need. If it can be considered to have had an initial strategic justification, one need only look as far as the requirement for increased target coverage. Given the choice between the dramatic expansion of a force of single warhead

missiles (a financially unlikely option) and the installation of MIRVs upon the existing missiles, the services -- and the OSD -- were all but unanimously in favour of multiple warheads. MIRV was originally justified on the basis of a cost-effective increase in target coverage.²⁰

The process of selling MIRV to the Armed Services, Congress, and the American electorate while not seriously opposed required a good deal of lobbying on the part of systems proponents, strategists, and scientific advocates. The principal targets, and the source of the only real opposition, were the services. The key divisions in the promotion effort were BSD in the Air Force, and SPO in the Navy; both of these departments were responsible for their respective missile programmes. Persuading these elements of the decision chain was, as the preceding sections might suggest, anything but difficult; the scientific and industrial communities had already convinced the military R&D groups of the utility of the new concept. Mclean suggests that the rapidity with which MIRV was accepted by both BSD and SPO may have been the result of close operational ties between the service organizations and defence contractors.²¹ Whatever the route, persuasion was effective and MIRV promotion met no significant resistance once the services had been convinced of its utility. Air Force support for MIRV devolved upon two conditions; its accuracy as a counterforce weapon had to be proved, and the impetus of a restricted ICBM force had to be applied. The Navy's attitude was less technical; the Secretariat wanted money for more ships, but as it was going to get Poseidon SLBMs in any event, why should they not be MIRVed? These conditions fulfilled, promotion of the MIRV within the services became a downhill battle.

Promotion of the MIRV concept within the electorate, Congress, and the Executive was similarly a pro-forma affair. MIRV proponents overcame the slight resistance (mostly of a budgetary rather than strategic nature) by invoking four bogeys, at least two of which were essentially straw figures. Threats of a huge Soviet missile force and a potential Soviet ABM system could be countered by MIRV⁹¹ capacity both as a counterforce weapon and an ABM penetrator. Other concerns were voiced as well, notably in Congress and in public statements, about the probability that the Soviet Union would eventually develop and deploy -- en masse -- MIRVed missiles. Either eventuality would pose serious strategic quandries for the United States, which might best be avoided by a "pre-emptive" deployment of MIRVed missiles.

It is interesting to note that the original justification for MIRV, increased target coverage, was subsumed in the frenzied debate over the need to counter a potential Soviet ABM system (this trend will be discussed further in the following section). Once American paranoia about Soviet anti-missile capabilities had reached a sufficient level, it became obvious that touting the MIRV as an ABM penetrator would lead to its almost immediate acceptance throughout the electorate, the Congress, and the Executive. The Soviets unwittingly aided MIRV promoters with this process by parading their new interceptor, the Galosh, during the May Day festivities of 1965, and by releasing film clips of successful RV interceptions by the new missile. Convinced that American strategic forces were about to be obviated by emerging Soviet technologies,⁹² the few remaining dissenting opinions shifted to the support of MIRV.

The new justification was forwarded in document as well as verbal

rhetoric form. In 1969 the Department of Defense released a fact sheet stating that the MIRV was a necessary response to advancing Soviet ABM capabilities, and that such possible activities as a sudden upgrade of the Tallinn air defence "Line" could render existing American missile fleets useless.³³ As late as 1971 the DOD continued to emphasize the ABM threat, stating that American MIRV deployments represented the only certain means of "assuring destruction" in the event of nuclear hostilities.

The use of the ABM threat was a convenient blind for the actual motivations of the system promoters. Consent to MIRV acquisition within the critical elements of the services and the OSD devolved upon cost-effectiveness and target coverage. The Navy received a more effective counterforce weapon and assurance of a continuing strategic nuclear role; the Air Force maintained its superior strategic position within the Services, and received in addition an increased counterforce capability (had either service been wholly interested in ABM penetration they would likely both have opted for the Mk100 with its plethora of smaller warheads). And the Office of the Secretary of Defence was able to simultaneously avoid enormous defence expenditures and upgrade American strategic forces in a cost-effective manner. Tammen suggests that the greatest selling point at the decisionmaking levels of the services and Congress was that MIRV was "a response to an immediate threat at the lowest alternative price".³⁴

At the higher levels of civilian authority promotion of the MIRV was virtually unnecessary: the Congress and the President, for reasons which will be addressed in the following section, had been in favour of it for some time. However, each body lent the programme its support for

different reasons. Promoters "sold" MIRV to the Congress as a systems upgrade rather than a novel weapons innovation; thus, it is likely that MIRV failed to receive the in-depth committee study that usually accompanies the development and impending procurement of any new weapons system. In addition MIRV, as discussed earlier, was developed somewhat on the "Q.T."; by the time the issue came before Congress for appropriations in 1965, promoters had had more than enough time to build a strong base of support throughout the political community. Nor did industry function as the only source of promotion; Mclean suggests that

To communicate to higher levels of the bureaucracy, the scientific advisors from RAND and the Lawrence Livermore Laboratory played an important role, using their positions on scientific advisory boards to various departments in the services and the DOD to present the case for MIRV.³⁸

Nor was promotion restricted to Congress. The 1964 presidential campaign had seen the incumbent Lyndon Johnson plagued by questions about strategic armaments; opponent Barry Goldwater charged that Johnson had during his term in office failed to expand America's strategic nuclear forces in the face of a growing Soviet "threat". The rapidly-maturing Poseidon project was presented to the President as a means of refurbishing his image as a man concerned with strategic security.³⁹ While essentially a redesigned upgrade of existing Polaris missiles deployed in refitted Polaris SSBNs, the MIRVed Poseidon was touted as a "new" weapons system developed, acquired, and deployed under the auspices of the President. This small distortion of the facts allowed Johnson to claim the political credit for having deployed a new strategic system at a relatively minor

cost.

The promoters of an embryonic weapons system rarely restrict themselves to logical strategic rationales for new armaments procurements. As seen above, the justifications employed may vary widely. All that is required is that the promotee believe that the new system will answer whichever threat or resolve whichever difficulty the promoter chooses to present. The judicious choice of threats and rationales will inevitably result, as they did in the case of MIRV, in nearly universal support for the fledgling system. The following subsection will discuss the presentation of threats in greater depth.

1.4 ..."Open Windows"?

The promotion of a new weapons system at the upper levels of the decisionmaking organs and within the public sector inevitably requires a convincing justification. Such developments are quite expensive, and Congressional financial allotments tend to be assigned on the basis of fiscal rather than strategic necessities. In order to ensure the universal acceptance of the system, its proponents must be able to balance it against a specific threat or threats. The "open windows" stage of the acquisition process involves the exploitation of extant (or fabrication of convincing) threats to rationalize the enormous expenditures required to develop and procure a new weapons system.

Tammen has suggested that "a simple technical problem gradually evolved into the MIRV concept, without any input from Soviet activities".³⁷ This statement is patently erroneous, especially in view of the intense discussion of the influence of Soviet ABM systems on MIRV

development conducted later in his work. Soviet activities (and especially the American perception and interpretation thereof) in fact provided the principal promotional impetus for MIRV. Originally conceived to answer three individual dilemmas -- increased targeting requirements, Tallinn Line/Soviet ABM buildups, and cost-effective force expansion -- MIRV came to be justified in the public and legislative domains as the solution to the problem of Soviet anti-missile capabilities.

In its early stages, as previously discussed, MIRV evolved and was accepted into the services on the basis of its utility in meeting the demands of ever-expanding target lists. ABM penetration, while discussed, was never expected to represent a serious threat to US strategic capabilities. However, it apparently became clear to systems promoters that the justification of MIRV as a force multiplier for the American nuclear arsenal might appear somewhat too provocative;³⁰ a less militant rationale was required. Soviet ABM testing and boasts about anti-missile capabilities provided that rationale.

As early as 1964, promotional emphasis appeared to shift from target coverage and cost-effectiveness to the need to penetrate destabilizing Soviet ABM deployments in order to ensure the continuity of the "assured destruction" deterrent. MIRV promoters were aided in this (all unwittingly) by the words and actions of the Soviets. In the late 1950s, Soviet Premier Nikita Krushchev spoke with the New York Times:

I can only tell you that at the same time we told our scientists and engineers to develop intercontinental rockets, we told another group to work out means to combat such rockets...(and) we remain very satisfied with the work of those who produced the means for combatting such rockets.³¹

Statements of this nature were later backed up by Soviet defence department speeches, publications, and capability assessments. In 1961, Soviet Defence Minister Marshal Malinovsky reported to the 22nd Party Congress that "The problem of destroying missiles in flight (had) been successfully solved."⁴⁰ Other spokesmen claimed that an anti-missile missile had already been built.

Actions matched words. In 1962 the first Soviet attempt at an ABM system, Griffon, was deployed briefly around Leningrad. Although it was later withdrawn, its appearance caused a great deal of alarm within the American defence community, as did Krushchev's statement of that summer when he declared that Soviet ABMs "could hit a fly in outer space".

Much of the American consternation over Soviet ABM systems was little more than fabricated "hype". While it is true that an operational anti-missile belt around Moscow might indeed have succeeded in destroying some (or even most) of the American warheads hypothetically targeted against that city, it would appear that the majority of American (and Soviet) thinkers neglected to apply the dynamics of terrorism to nuclear offence and defence: the defender must be successful at all times; the attacker need only be lucky once. The principal argument raised against SDI was equally prevalent in the Soviet ABM case; an anti-missile system which is only ninety-five percent effective need only be targeted on average with twenty warheads, as only one warhead need reach the target to accomplish the goal.

DDR&E Herbert York accepted this fact and attempted to explain it in a report in the mid-1960s, suggesting that any ABM system would be ineffective simply because it was inherently much easier to develop

offensive measures -- or penails -- than it was to create an impenetrable defence.⁴¹ His protestations did little to sway the mass of carefully-managed public opinion; the "hype" engendered sufficient worry over the looming Soviet ABM threat that MIRV was accepted at large solely on the basis of its penetration capabilities.⁴²

The promotion of the system on this basis was not restricted to industrial, scientific, or defence advocates. In 1963 President Kennedy made a public statement: "I don't think there's any doubt that they have an anti-missile system as we do. The problem, of course, however, is what you do with saturation".⁴³ This statement was clearly a "plug" for MIRV deployments. Other highly-placed officials assisted the threat-development process; McNamara announced the decision to procure the Poseidon C-3 in 1966, and

In the same announcement and with deliberate linkage, the Secretary cited "considerable evidence" that the Soviets were deploying an ABM system. McNamara reinforced his argument by claiming that the Soviet Union would have more ICBMs by mid-1968 than the 1965 intelligence estimate had predicted.⁴⁴

The added spur of Soviet ICBM superiority served to bolster public support of new strategic weapons acquisitions, the MIRV included.

Further efforts were made to justify the system on the basis of penetrability. DDR&E Foster argued to Congress in 1969 that MIRV development had been initially triggered by "uncertainty about the capability of the Tallinn system."⁴⁵ The Tallinn "Line", as it was called, was an air defence belt passing through the Estonian town of Tallinn. It employed the latest Soviet radar and surface-to-air missile

(SAM) technology. Defence estimates suggested that a rapid upgrade of this system to ABM capability might be feasible. Foster went further to assert that

It should be clearly understood that we are not reacting to the Moscow ABM alone. We have to hedge against the installation of a Galosh or improved ABM around a number of cities. That system employs a large number of interceptors which could be converted to an ABM capability in addition to their anti-aircraft role. The planned MIRV force is needed to maintain our deterrent posture in the absence of assurances that Tallinn has no ABM capabilities or is not being upgraded to have an ABM capability.⁴⁶

Ironically enough, Tallinn was more of a threat to American strategic capability than the crude and inefficient Galosh ABM system. While it would be an enormously challenging task to convert an anti-aircraft missile system to ABM capability (as the accelerations required are of an order of magnitude higher, and as the new missile would require a nuclear rather than conventional warhead), the Tallinn system as it stood, if fully deployed, would have posed a considerable threat to American strategic bombers. Oddly enough, the Air Force's aircraft, not its missiles, were threatened by the installation of the Tallinn Line.

Albert Wohlstetter in a briefing to Congress in 1969 attempted to set the record straight, arguing that

contrary to popular belief MIRVs are not a reaction to the ABM. MIRVs are a reaction to dispersed vulnerable target systems, and I know of at least two places in which the MIRV idea originated independently that had nothing whatsoever to do with ABM. It had to do with cases where a dispersed target system presented excessively tempting targets, if you could divide your payload.⁴⁷

Thee argues that records of the actual Congressional debates at the time suggest that Wohlstetter's statement accurately represents the true course of events in the MIRV case. York, of course, disagreed with the target-coverage argument, stating that while new justifications had arisen for MIRV, ABM penetration remained the original mission requirement.

Simple investigation of the comparative course of research and funding would have answered this dilemma; the arguments presented by Kennedy, McNamara, York, and others fail to convince when one considers that the MIRV concept arose some years before a Soviet ABM system had ever become a possibility -- and that, as well, official R&D had been commissioned at least a year before the Leningrad deployment.⁴⁵ Also, one must consider that MIRV deployments were accelerated and fractionation in new systems continued to grow following the signature of the US-Soviet ABM Treaty in 1972. Had MIRVs true aim been the penetration of ABM systems, they would have been rendered unnecessary by this agreement.⁴⁶

Counterforce capability was clearly the original justification for MIRV, employed widely at the "technological initiative" and "consensus-building" stages in order to gain the support of the military; however, ABM penetration -- a threat thoughtfully provided by the Soviets, expanded by promoters into a menacing "open window" -- and, to a lesser extent, cost-effectiveness, were employed as the principal threat-oriented justifications for MIRV in its later stages. Determination of MIRV deployments was entirely unrelated to assessments of Soviet ABM capabilities; McNamara arrived at his missile/warhead totals through an analysis of target opportunities, not anti-missile defences.⁴⁷ MIRV simply could not be rationalized to the public at large on the basis of

3) expedited the development and eventual acquisition of the MIRV.

Evangelista notes that any

research community is more likely to conceive of and propose innovative ideas to the extent that it is complex, diversified, decentralized, loosely coordinated, and tied together by an efficient communications network.⁸¹

The discussion in the previous section demonstrates that the American research and development organizations involved with the MIRV programme were indeed complex, diverse in nature and loosely coordinated. The extent of their relative formalization cannot be determined in the absence of an in-depth operations report; but the existence of a highly efficient informal system of communications has been posited, and will be addressed in a following subsection.

MIRV development and acquisition was aided considerably by the interconnectedness not only of research organizations, but of nearly every group and division -- civil, military, and governmental -- involved with the process. Greenwood suggests that informal linkages of this sort are characteristic of the collective US armaments interest,⁸² and that this has led to something of a "blurring of the distinction between the private and public sectors". The armaments production chain -- from innovation through production and deployment -- has resulted in the aggregation of supposedly independent organizations of diverse origins into a quasi-homogenous armaments complex linked together by the common goal of maintaining the continuity of arms innovation and production.⁸³ Evangelista's set of determinant organizational characteristics are even more prevalent in an entity of this nature.

would likely have been a sharp blow to the services' respective strategic programmes. However, cancellation was never an issue; Greenwood argues that the services wielded considerable high-level influence through DOD, and that while their individual leverage had been poorly organized due to technical squabbles in the early stages of the MIRV programme, once their interests coincided their combined support was all but immovable. No force, he argues was strong enough to counterbalance the united influence of the services once doctrinal and material commitment had been made.⁵² No significant attempts to block MIRV were undertaken.

Institutional pressures, as previously discussed, often drive upper-echelon individuals or groups towards certain decisions.⁵³ This tendency led President Johnson to release MIRV programme data earlier than would otherwise have been the case, in order to counter accusations of strategic laxity by his political opponents. Johnson's administration, they charged, by failing to procure any new strategic weapons systems was ignoring American security needs. There is some evidence to indicate that Johnson's support for the MIRVed Poseidon SLBM project (and the resultant rapidity with which it was, after a year's delay, suddenly restarted and deployed) resulted from his desire to avoid further political entanglements on the strategic arms front.⁵⁴

Endorsement of MIRV was achieved at different stages by employing different promotional "hooks"; the services accepted it for its target coverage capabilities, the public and Congress for its ABM penetrability, and the President as a political lever. The Bureau of the Budget (and Congress, to a certain extent) advocated MIRV as a strategic upgrade for its cost-effectiveness; MIRVing the Minuteman force would triple America's

ICBM capability without tripling defence expenditures thereupon. John Foster justified MIRV to a budgetary committee in 1970:

The MIRV capability is a low cost and efficient way to maintain our national policy of deterrence without increasing the number of our expensive missiles. The use of multiple warheads can provide effective penetration of Soviet ABM defense systems and less "overkill" through a more efficient use of booster payload.⁵⁵

The prospect of a major increase in offensive strategic power (and, therefore, a major increase in national security -- or so it was perceived) without a concomitant major increase in defence spending was grasped eagerly by Congress; the American electorate, it has been argued, tends to think well both of elected officials who offer increases in national security, and those who avoid overspending the taxpayers' money. MIRV offered the option of achieving both aims at once.

The influence of Congress on the MIRV development and acquisition process, Greenwood argues, was in all actuality rather minimal. As the programme was initially presented as an "improvement" and an "upgrade" of existing systems rather than an entirely new one, Congress was not involved in its development until the final acquisition stages. Even at this point, with entire systems being presented as "the Minuteman II with the Mk12 MIRVed warhead", or "the Minuteman III, an improved version of the Minuteman II", MIRV was not accorded the attention which its impact on strategic affairs merited. No serious controversy was attached to the new concept; hence, Congress paid it little attention.⁵⁶

When MIRV appropriations were finally brought to the attention of the Congress, the development was greeted favourably. Greenwood argues

that unlike the electorate, Congress-persons often tended at the time to advocate more and greater expenditures on defence;⁶⁷ and those who did not, supported MIRV as its acquisition allowed budgetary holds to be placed on other more expensive (and less cost-effective) projects. In addition, the generally low level of technical sophistication among Congress-persons led the House as a whole to follow the suggestions and judgement of the Armed Services Committee and the various subcommittees on Department of Defence appropriations.⁶⁸

Finally, high-level endorsement was often carried out by high-level supporters themselves -- which, as has been mentioned, MIRV never lacked. McNamara, for reasons already discussed, remained strongly behind the programme throughout its course, occasionally sacrificing less attractive systems in order to maintain the integrity of the MIRV development process. He used MIRV as something of a defence against accusations of advocating "unreasonably low" Minuteman force totals, his deliberate delaying of an American ABM deployment, and the cancellation of a variety of other programmes (including the B-70 bomber in the early 1960s).⁶⁹

High-level officials in general supported the MIRV development programme, and often exploited it for their own purposes. Greenwood notes that

To McNamara MIRV was not only a system to defeat the Soviet ABM, it was also one that could be used to reduce domestic political pressure for a comparable US deployment.⁷⁰

Other political officials, President Johnson included, linked their fortunes to the MIRV programme. With so many highly-placed individuals

advocating and supporting its progress throughout the course of its development, it is not surprising that MIRV never lacked strong high-level political support.

2. Contending Elements

The characteristics of the MIRV acquisition process discussed in the previous section outline a clear and relatively predictable schematic of the second-track stages through which a potential weapon must pass on the route from innovation to deployment. The presence of the systemic elements posited by Evangelista would tend to confirm the utility of his approach. No weapons programme exists in a vacuum, however; the developmental process which raised MIRV from technical obscurity to strategic preeminence exhibited several second-track characteristics not addressed by Evangelista's model. The aim of this section is to examine these characteristics in order to determine their impact on the MIRV acquisition process relative that of the second-track elements already discussed.

One characteristic which Evangelista has addressed, however, and which was displayed throughout the earlier stages of MIRV development, was the close working relationship found between the services and the scientific community, and within that latter community itself. Discussion was entertained in the previous chapter concerning the effect on the innovation process of certain structural and operational characteristics of research organizations: centralization, complexity, formalization, interconnectedness, and organizational slack. The relative levels of these characteristics inherent in American R&D groups (as shown in Fig.

3) expedited the development and eventual acquisition of the MIRV.

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MIRV development and acquisition was aided considerably by the interconnectedness not only of research organizations, but of nearly every group and division -- civil, military, and governmental -- involved with the process. Greenwood suggests that informal linkages of this sort are characteristic of the collective US armaments interest,⁸² and that this has led to something of a "blurring of the distinction between the private and public sectors". The armaments production chain -- from innovation through production and deployment -- has resulted in the aggregation of supposedly independent organizations of diverse origins into a quasi-homogenous armaments complex linked together by the common goal of maintaining the continuity of arms innovation and production.⁸³ Evangelista's set of determinant organizational characteristics are even more prevalent in an entity of this nature.

2.1 Service Influence

If military men have a fault, it lies perhaps in their overriding desire to fulfil their responsibilities, often to the exclusion of sensible behaviour. It is axiomatic within the American Armed Services that each Department therein is of the opinion that it is capable of ensuring the defence of the country more effectively than the others; it is also an exaggeration.⁸⁴ The development and procurement process which led to the inclusion of MIRV technology within the arsenals of the Air Force and the Navy demonstrated the extent to which complex cooperative behaviour may be undertaken between different services in the interest of obtaining a mutually beneficial goal; it also demonstrated that even in the presence of such cooperative behaviour, certain independent interests exist which will not be sacrificed in the interest of mutual gains, no matter how attractive.

The appearance of the MIRV concept was a godsend to the American strategic forces. Apart from the inevitable military tendency to argue for more and better weapons,⁸⁵ it offered a means of rapidly expanding at a reasonable cost what was perceived as an inferior American strategic capability. While it has been established that MIRV was more a combination of advanced technological capabilities than a novel innovation, it is equally obvious that the military did not see it in quite the same light:

There is little doubt that the military saw MIRV as a dramatic new weapon. One senior Air Force officer was quoted as saying "We are about to enter a new era in warfare".⁸⁶

A "sweet" technology, MIRV offered an increase of an order of magnitude in the overall effectiveness of American strategic capability, even to the point of enabling the operationalization of a new strategic targeting doctrine.⁶⁷ But the overriding issue, according to one time special assistant for national security affairs McGeorge Bundy, is that MIRV was most appealing to military men who measured their strategic preferences "more by what they could deliver than by what the Soviets might later possess".⁶⁸

The MIRV procurement process immediately sparked inter-service rivalry over exploitation of the new technology, especially concerning the determination of evolving counterforce roles. However, as Hampson has suggested, it would be erroneous to ascribe only antagonistic behaviour to the two services involved; their interaction might be better described by his "cooperative-competitive" model. In the early stages of MIRV development, though, the incidence of the latter element outweighed that of the former. Strategic "turf battles" over roles in the deterrent balance became commonplace, as each service attempted to produce its own rationale for acquiring MIRV, the more prominent elements of which were the inability of that service to ensure American security without MIRV, and the performance with MIRV of a role which the rival service was incapable of fulfilling.⁶⁹ This type of behaviour was moderated by cooperation in the latter stages of the process, as inter-service bargaining established a division of operational roles between the Air Force and the Navy.

The Air Force resisted MIRV development and acquisition in the early stages almost as a matter of habit. Research into penetration aids

carried out in the late 1950s was viewed disparagingly by the Air Force - partially out of an institutional contempt for ballistic missiles, and partly out of the (very real) fear that an effective ICBM system might render the manned bomber force obsolete. As one author has commented, Air Force personnel, while interested in ever-increasing destructive potentials, would rather be flying planes than squatting in missile silos.

Air Force resistance to MIRV was based on four objections:

1. The early warheads were too small;
2. The early systems were too inaccurate;
3. MIRV would damage the case for more Minuteman missiles; and,
4. More effective ICBMs would obviate manned bombers.

Fortunately for MIRV proponents, these objections were rather easily overcome during the second-track "consensus-building" stage of the acquisition process. Improvements at Livermore Laboratories in warhead technology led to more powerful small RVs, while the miniaturization of computer components and advances in guidance technology solved the accuracy problem. McNamara's limitation of the total ICBM force put MIRV in a more favourable light as the only means of increasing the destructive power of a numerically limited missile force. Finally, the manned bomber issue remained something of a sore point; but as some thirty years have passed since the advent of the MIRV concept and manned bombers have yet to be eliminated from the American arsenal, one must assume that Air Force pressure was sufficient to preserve this arm of the strategic triad.⁷⁰

Nonetheless, the cancellation of the B-70 strategic bomber in the early 1960s presaged the deemphasization of penetrating aircraft in favour of shortening the perceived Soviet lead in ballistic missiles. Acceptance

of the MIRV was the most expedient way to exploit the "writing on the wall" concerning missile forces. Programme initiative within the Air Force was handled by BSD, a group concerned more with organizational continuity than strategic necessity. The continued existence of BSD depended entirely upon the creation and provision to the Air Force of new missile systems and components;⁷¹ in the absence of an increase in missile systems acquisitions, MIRV remained the only means of ensuring the future of then Division.

Between the Air Force and the Navy lay a wide gulf in organization, attitudes, and strategic roles. Where BSD held responsibility within the Air Force for the development of MIRVed "front-ends" for ICBMs, naval ballistic missile systems were the concern of the SPO. The organizational characteristics displayed by these groups led to considerable differences in the response of the services to MIRV:

Much greater organizational complexity and diversity of both task structure and incentive system existed within the Air Force technical community consisting of BSD and its supporting contractors than within the comparable Navy community centred around (SPO). BSD relied more heavily on outside consultants, had a looser and less centralized management structure, was less concerned with efficiency and pursued more projects simultaneously than (SPO).⁷²

Despite the greater efficiency of the Air Force development organization, the programmes proceeded at relatively equivalent rates.

In contrast to the Air Force, the Navy was not conceptually dedicated to a tradition of large warheads and "bigger bangs"; weapons such as the Air Force 24 Mt gravity bomb had never been available to the Navy. Also, while naval air support had been decisive in the naval

battles of the Second World War, the Navy had never developed a tradition of strategic bombing aimed at the reduction of enemy war-making capacity and national will. The smaller warheads necessitated by a MIRVed SLBM system did not cause doctrinal problems; the Navy seemed to have a relatively firm grasp of the fact that while a "small" nuclear explosion in a city is not as destructive as a "large" nuclear explosion, it is still -- by definition -- a nuclear explosion, and the terms "small" and "large" are relative. Even the 50 kt warhead planned for the Mk100 RV would have been three times as powerful as that which devastated Hiroshima, causing in excess of 150,000 casualties. As the critical supporting element of a countervalue targeting policy, the smaller warheads were perfectly acceptable to the Navy.

In fact, where the choice of warheads was concerned, the Navy had never favoured the Mk17 preferred by its strategic "rival", considering it an exclusively Air Force weapon supportive of a counterforce strategy.⁷³ The Navy had originally favoured a counterforce role of their own, an approach which elicited considerable resistance from the Air Force who saw this move as an infringement upon their prerogatives. In the final analysis, the Navy agreed to accept a countervalue "assured destruction" role based on the invulnerability of their strategic forces in exchange for Air Force support in the procurement of MIRV for both services.⁷⁴ Thereafter the Navy fought for the Mk3 with its 14 small warheads,⁷⁵ while the Air Force -- having given up on the Mk17 -- settled for the Mk12 payload with its three less powerful RVs. The Navy obtained a strategic role of some significance, while the Air Force maintained its dominant counterforce role.

In the upper echelons of military decisionmaking, attitudes toward MIRV underwent a profound sea-change over the years between innovation and procurement. Mclean suggests that the Joint Chiefs of Staff had in the early 1960s considered MIRV a possibly useful bargaining chip in a potential US-Soviet arms control negotiation process; however, by the time such a process had actually got underway in 1968, the strategic value of MIRV was such that the JCS refused to allow it to be put on the bargaining table.⁷⁶ It is likely that even had the talks not been interrupted by the Prague Spring and its concomitant political consequences, MIRV development and deployment would have gone on. JCS rationale for the continuation of development and deployment lay generally along the lines of a desire to bargain later from a position of strength; but the diffusion of MIRV throughout the American strategic forces rendered any such inclusion highly unlikely.

Arguments and policies would in a rational world be framed to support a given strategic doctrine; in a more realistic sense, they are designed "primarily to further the objectives of the individual or organization that makes them".⁷⁷ Greenwood suggests that all parties involved with the MIRV, while advocating its acquisition for entirely different reasons, saw the new concept as the solution to their own problems: BSD to prop up a failing industry, the Air Force to support a counterforce role, the Navy to acquire a strategic role, and the scientific, industrial, and political groups for the standard reasons: furthering research efforts, acquiring investment capital, and attaining political advantage. The military, however, played a dominant role in the process and eventually became intent upon the acquisition of MIRV. This

drive towards the acquisition of a single system transcended all other considerations, including strategic justification.

Most of the time each branch of the military finds something interesting in the R&D of a new technology. This was the case in the story of the MIRV. It didn't matter what happened with the Soviets...had they not deployed an ABM or stopped their ICBM buildup, the US would probably still have developed and deployed MIRVs.^{7a}

Whether development and deployment would have continued in the absence of any sort of Soviet-engendered threat is moot; however, it is unlikely, lacking an "open window" for the justification of the MIRV, that the programme would have enjoyed as much high-level support or gone as far - and as rapidly -- as it did.

2.2 Programme Momentum

A variety of authors -- Ralph Lapp, Herbert York, and Marek Thee among them -- have suggested that armaments acquisition processes are for the most part driven by a "technological determinism" originating in the development of a novel technological innovation and resulting in the inevitable exploitation of that new technology for military purposes. Strategic weapons programmes tend through the influence of interested organizations to build up their own momentum, resulting in a combined technological-programmatic momentum which is exceptionally difficult to combat. Charles David explains that

There is a kind of mad momentum intrinsic to the development of all new nuclear weaponry. If a weapon works -- and works well -- there is a strong pressure from many directions to

procure and deploy the weapons out of all proportion of (sic) the level required.⁷⁹

The suggestion presented in the preceding section that the development and deployment of MIRV might well have continued even in the absence of a Soviet threat is not an idle one. While it has been established that the "open windows" stage -- specifically the Soviet ABM challenge -- was a crucial impetus to MIRV development, it is entirely possible that the new system might have been procured and operationalized regardless of the existence of a threat. MIRV did not, in fact, require Congressional approval except insofar as it was a component of a larger weapons system (Minuteman or Poseidon); subcomponents do not "come up" for debate.⁸⁰ Technological determinism played a central role in the MIRV acquisition process.

Evidence presented in the preceding section would seem to indicate a reversal of the normal relationship between technology and policy at a number of stages in the MIRV development and deployment process. MIRV evolved, as has been said, in the absence of a strategic requirement, more as a technological curiosity than an operational necessity. The programme grew in scope and cost, and eventually had to be strategically justified; given the comparative wealth of "provocative" Soviet developments and deployments (such the postulated ABM screens, the increasing numbers of viable targets, and the like), such justification was not an overly challenging task. Tammen argues that

There never was an official paper requirement which led to MIRV development. Instead, MIRV development created self-generating requirements which justified the continuation of the program. The threat, as an external influence, was used

MIRV was typical of those innovations which might be labelled "insidious", in that while the concept was ultimately to become an integral part of American strategic nuclear forces, it was initially considered only a relatively unimportant addition to the arsenal -- a technological curiosity and nothing more. That perception changed over time, of course, and MIRV has been acknowledged as one of the single greatest influences on the American strategic posture since the Second World War. In its formative years, however, it was anything but a major issue; when the concept was first brought to the attention of the upper echelons of the American government, it was considered and approved with a minimum of fanfare, and entered operational service "not with a bang, but a whimper". MIRV lacked controversy; and therefore the Congress, which often thrives on the political fallout of debates over controversial weapons systems, took comparatively little interest in either retarding or expediting its progress.**

Part of the reason for MIRVs evasion of high-level interference was the fact that, due to its being perceived more as a qualitative improvement than a quantum leap, the bureaucratic power centres involved in the decision process were located at a much lower level. Congress and the Executive worry about entire systems; for instance, approval of Poseidon as a new SLBM was required. Beyond a basic discussion of operational needs and the capabilities of the missile, its components were generally not open to discussion. The MIRVed front-end was discussed as a missile component, rather than as a catastrophically new development; thus, responsibility for its acquisition was mandated to a lesser body than Congress or the Executive.

spontaneously, responsively as a justification. The threat changed, but no modification occurred in the MIRV program.⁶¹

This would suggest either that the MIRV programme was independent of strategic requirements, or that it fulfilled changing mission needs equally well. Both of these answers are equally viable.

Programmatic momentum went beyond even the development effort and affected the final decisionmaking processes -- not a surprising result, as programmes tend to wax in momentum over time. Herbert York, one-time DDR&E, states that

during the development phase, the MIRV program was almost entirely technologically determined in the sense that the key decisions were made by technologists who were either attempting to solve problems posed by nature, or responding to their perceptions of the technological challenges posed by the Soviet missile and space programmes.⁶²

This trend towards retroactive decisionmaking at lower levels continued throughout the development and procurement process: scientists determined what the military could have, the military determined what shape the eventual strategy would take, and the policymakers -- McNamara and his advisers -- determined by their own actions in shaping the MIRV programme the progress of the acquisition and deployment efforts (see subsection 2.2.4).

York even goes so far as to state that the final decision to deploy MIRVs was predetermined by the decision to develop them.⁶³ The very act of instigating the development of a new weapons-applicable technological concept ensures the eventual exploitation of that concept as a weapons-capable system, destined for inclusion in the American arsenal. Greenwood

argues that despite the deterministic nature of this statement, McNamara was in a position to slow or halt the MIRV procurement process, had he so desired, but would have been faced with enormous opposition in so doing:⁶⁴ Congress was by the onset of the procurement stage overwhelmingly in favour of MIRV deployment, and the services would have been incensed at the loss of their new toy. Finally, the simple fact that, at the time and in view of the contemporary Soviet force posture, MIRV deployment was a strategically sound decision, which fact alone would have mitigated against any attempt at cancellation. The momentum engendered by MIRV innovation in 1962 saw the concept through to its operationalization in 1970.

2.3 Informal Channels of Communication

Of the organizational characteristics discussed in the previous chapter (see Fig. 3), perhaps the most influential was the unprecedented extent of the informal channels of communication linking the actors involved in the MIRV acquisition process. A high level of interconnectedness is, according to Evangelista, conducive to increasing and improving the output of innovative organizations; it is similarly critical to the efficient operation of the armaments acquisition process. Informal channels of communication between scientific groups, industry, the military, and the bureaucracy facilitated the process immeasurably.

One of the earliest symptoms of high interconnectedness appeared at the innovation stage of MIRV development. The fact that several companies "invented" the MIRV concept simultaneously would seem to indicate the existence of efficient and well-worn channels of communication between

Relationship Key

FORMAL INFORMAL ADVISORY CONTRACT MILITARY
 _____ - - - - - = = = = =

Figure 4

Informal channels of communication during MIRV development

Source: Adapted from Ted Greenwood, Making the MIRV, (Cambridge, Mass.: Ballinger Publishing, 1975), p. 17.

diverse elements of the scientific community; Mclean notes that four companies -- Aerospace Corporation, Autonetics and Rocketdyne, the Space Technology Laboratories, and the Lockheed Missile and Space Company -- approached the military services at roughly the same time, each prepared to offer their own version of the MIRV concept.⁸⁸ This sort of phenomenon -- especially involving groups usually found in competition -- shows that a good deal of scientific cross-fertilization likely took place in the preceding years. Technical communication between researchers has always been a prerogative of scientists, often unfortunately restricted by industrial security concerns; that these concerns were overridden by the informal communications network indicates the level of commitment of researchers to a mutual exchange of ideas and advances.

Links between the DDR&E and the services were likewise very strong.⁸⁹ As the eventual recipients of any potential strategic weapons system, the services require a certain degree of input into its development and design in order to ensure compatibility with existing systems, operational reliability in a field environment, and adequate ergonomics. Consultation between DDR&E and the services was in the case of MIRV also required in order to allow the implementation of such changes as were required by those services in order to ensure their (informal, but very necessary) ratification of the new system. The posting of serving officers within the otherwise civilian defence research groups was not an uncommon practice. Similarly, civilian consultants were often attached to service Systems Commands in order to ensure a constant exchange of ideas, scientific possibilities, and technical limitations. In fact, Greenwood argues that rather than relying solely upon the

military to draft mission need statements, inter-organizational collusion was the rule:

Although hardware requirements are formally provided by the government contracting agent, they are frequently written by, or coordinated with, the firm that will eventually be contracted to do the work.⁸⁷

The extent of informal communications channels is demonstrated by the table of organization representing implicated groups within the DOD (see Fig. 4).

In addition to service-DDR&E linkages, the secondment of personnel between organizations as a sort of "interchange insurance" intended to promote the free exchange of information was undertaken at higher levels of the decisionmaking echelons. Personnel from DDR&E were often upon retirement from the defence research group taken on by industry in a consulting role, both for their expertise and as a means of preparing that industry for the future goals of the armed services.⁸⁸ This type of behaviour forged permanent bonds of friendship and personal acquaintance between organizations in addition to the more formalized (but still less than official) links obtained by the transferral of active personnel. Greenwood argues that these close personal relationships were a keystone of the external, informal communications channels, and notes that former DDR&E Harold Brown (once Director of Livermore Laboratories)⁸⁹ maintained while in office informal communications links through old acquaintances within BSD and the services that were "totally outside the normal bureaucratic channels".⁹⁰ The strict legality of such communications links may be questioned, as they offer much opportunity for the abuse of

one's authority. However, their positive effect -- in terms of the expedition of the acquisition process -- cannot be denied.

Greenwood offers a typical scenario detailing the extent of the informal communications channels between otherwise unconnected (except, perhaps, for official channels) organizations:

On occasion BSD would bypass AFSC headquarters and go directly to the Air Staff with a proposal. If an alliance could be built with the Air Staff from the beginning, approval in AFSC was easier to obtain. Even more useful were the direct contacts at the working level between personnel in BSD and those in DDR&E. Since the technical competence of BSD was much higher than at AFSC headquarters or on the Air Staff, DDR&E tended to work directly with BSD. Briefings were regularly made at DDR&E and personnel from that office visited BSD frequently. Through these indirect channels BSD commonly reported its own preferences to DDR&E, even when these did not correspond to an official Air Force position. Since DDR&E had effective authority over the development budget of the services, agreements worked out between it and BSD were very difficult to overrule.⁹¹

It is easy to see how linkages of this sort would expedite the systems development and procurement process, most notably at the "technocratic initiative" and the "consensus-building" stages. The rapidity with which the MIRV moved from the development to the deployment stage -- and the relative insignificance of the opposition it encountered along the way -- is characteristic of strong informal connections between defence organizations.

2.4 High-Level Interference (or Lack Thereof)

MIRV was typical of those innovations which might be labelled "insidious", in that while the concept was ultimately to become an integral part of American strategic nuclear forces, it was initially considered only a relatively unimportant addition to the arsenal -- a technological curiosity and nothing more. That perception changed over time, of course, and MIRV has been acknowledged as one of the single greatest influences on the American strategic posture since the Second World War. In its formative years, however, it was anything but a major issue; when the concept was first brought to the attention of the upper echelons of the American government, it was considered and approved with a minimum of fanfare, and entered operational service "not with a bang, but a whimper". MIRV lacked controversy; and therefore the Congress, which often thrives on the political fallout of debates over controversial weapons systems, took comparatively little interest in either retarding or expediting its progress.⁹²

Part of the reason for MIRVs evasion of high-level interference was the fact that, due to its being perceived more as a qualitative improvement than a quantum leap, the bureaucratic power centres involved in the decision process were located at a much lower level. Congress and the Executive worry about entire systems; for instance, approval of Poseidon as a new SLBM was required. Beyond a basic discussion of operational needs and the capabilities of the missile, its components were generally not open to discussion. The MIRVed front-end was discussed as a missile component, rather than as a catastrophically new development; thus, responsibility for its acquisition was mandated to a lesser body than Congress or the Executive.

The real center of decision-making for the Polaris system and the Poseidon missile was in DDR&E and in the development organization, the Special Projects Office (SPO). They shared a technical orientation and expertise, as well as budgetary authority.⁹³

The decision process on the Navy side of the procurement process was expedited by other characteristics peculiar to the Special Projects Office. Mention has already been made of the BSD's greater tendency to display a more favourable level of Evangelista's organizational characteristics, which tended to hasten the developmental process, while its naval equivalent, the SPO, was more tightly controlled. Greenwood argues that tighter control of the decisionmaking organs within SPO worked in favour of rapid decisionmaking,⁹⁴ in general removing some of the more time-consuming elements which inhibited rapid decisionmaking in BSD.

More time was saved by the autonomous option-selection habits of the technical and military groups involved; while all elements of the system were eventually to be subject to OSD approval, research and development groups, as well as the military personnel involved, occasionally selected certain alternatives regarding design features of the respective systems and eliminated others. This procedure had the two-fold effect of hastening the development process by cutting down on decision time (by refusing to pass every minor decision to a higher person in the chain), and by trimming alternatives when the system finally went before a higher-level board. In the first chapter the role of the President was discussed, revealing that his sole official input occurs at the terminal stage of the procurement process, where he is required to make only those

decisions which "were not, or could not" be made at lower levels; by limiting the options available at the Presidential stage, the executive decisionmaking process is expedited, and upper-level resistance is reduced.

MIRV was also relatively unique in that it failed to attract public debate or discussion concerning its effect on either US strategy or global security before it was actually in production (and was thus brought to the attention of the Arms Control and Disarmament Association). Tammen argues that Congress paid so little attention to MIRV that it avoided entirely an overt role in the decisionmaking process at all;⁹⁰ MIRV simply "slipped by them".

Even at the aforementioned Presidential level, personalities and personal preference tended to expedite the MIRV acquisition process; Greenwood argues that both President Kennedy and his successor allowed McNamara to manage the affairs of his office almost exclusive of Presidential interference.⁹¹ He notes that both Presidents likewise allowed the Defence Secretary considerable leeway in the determination of his own budgetary requirements, which tended to exclude the Bureau of the Budget from the decisionmaking process as well. Congressional inactivity and Presidential preference streamlined upper-level involvement in the MIRV programme considerably. Only Secretary of the Navy Nitze played any sort of a role at all in the selection of Poseidon as the chief strategic naval weapons system; and, Greenwood notes, Nitze's role was limited to decisions on major issues -- which did not include the front-end of the missile -- and informal discussions resulting "from his close relationship with Secretary McNamara".⁹² Nitze's role -- like those of so many other

top-level officials theoretically involved in the decisionmaking process - was effectively usurped by the lower-level technocrats, industrial, and military personnel more intimately involved with the project. While this exclusion may in fact have hastened the development and acquisition of MIRV, the taking of such liberties with an otherwise rigidly-controlled process is not necessarily a good thing.

3. Summary

The development, procurement, and eventual deployment of MIRV as a decisive element of the American strategic deterrent provides a convincing example of Evangelista's second-track armaments acquisition process. Each of the requisite five elements were present in the process in an easily identifiable form. The MIRV concept, while not precisely an entirely novel innovation, was pieced together and proposed as a weapons system by the scientific community; its possibilities were circulated throughout the scientific, military, and industrial communities by interested groups; its virtues as a weapons system were presented before the upper echelons of industry, the Pentagon, and Congress; its acquisition and deployment was justified in the face of perceived Soviet threats; and the approval of the Congress, the Executive, and the President was obtained with comparatively little fuss. If there is anything at all striking about the MIRV system, it is the lack of opposition which it experienced, and the relative ease with which it came into operation.

The development and acquisition of the MIRV was expedited in different organizations for various reasons. Organizational characteristics favoured the rapid advance of the programme within the Air

Force's BSD, while relative systemic centralization tended to slow its progress in the Navy's SPO. However, a rapid advance in the Air Force was impeded by initial institutional resistance (resulting from protectivism vis-a-vis its traditional manned-bomber and emerging counterforce roles), while its immediate acceptance by the Navy allowed the programme to proceed apace. High-level opposition, in comparison, was non-existent, in part because those who considered it a critical development were for the most part in favour of its procurement, while those who considered it a minor qualitative improvement tended in general to ignore it. The strategic impact of a large MIRVed US strategic force was never fully evaluated during the acquisition process.

Certain authors consider the MIRV a prime example of the driving effect of a "technological determinism" on the armaments procurement process; others have labelled it a demonstration of bureaucratic indifference to the strategic implications of major weapons system production and procurement. All agree, however, that the MIRV development and procurement process demonstrated the utility of strong informal inter-organizational connections -- as discussed in subsection 2.2.3 -- in expediting the procurement process. In short, MIRV was a cost-effective means of increasing American strategic power; strategically sound in that it answered the three-fold problem of target coverage, ABM penetration, and limitations on launchers; politically acceptable, in that it allowed a move from countervalue to counterforce targeting; and technically secure, in that -- unlike the abortive Snark and Navaho cruise missile projects -- it was unlikely to be rendered obsolete for some time to come. In fact, its sole weak point (raised during the SALT I negotiations) was

the possibility that it might -- if deployed in mass quantities by both superpowers -- lead to a disruption of the strategic balance. With the exception of the latter point, all arguments, whether strategic, financial, political, or technological, tended to support the development and acquisition of the MIRV. In view of its positive qualities, the availability of useful Soviet threats, and the plethora of benefits (political, fiscal, and otherwise) to be gained by proceeding with the programme, failure to deploy the MIRV once development had been completed would have been somewhat surprising.

CHAPTER THREE: ACQUIRING THE ALCM

In 1983, a United States Air Force Snark cruise missile was found in the Brazilian jungle, having crashed during a 1958 flight test. The missile had strayed more than a thousand nautical miles from its intended course. Incidents of this nature had prompted the military services to treat the cruise missile concept in its early stages with a certain amount of skepticism; the delivery of nuclear warheads could be accomplished more quickly, more accurately, and more reliably through the use of manned bombers or ICBMs. Also in 1983, a conventionally-armed US Navy Tomahawk SLCM flew six hundred nautical miles from its submarine launcher to destroy a warehouse-sized target some four hundred miles inland. Contemporary military skepticism concerning the utility of the cruise missile has all but vanished.

The evolution of cruise missile technology since the first operational exhibition of such weaponry during the First World War has been enormous. It has been suggested that in contrast to the spectrum of difficulties which contributed to the late-1950s de-emphasization of the cruise concept in favour of ballistic missiles, long-range cruise weapons today offer the simplest and most effective means of nuclear weapons delivery, while avoiding many of the more disagreeable traits characteristic of other systems (such as the destabilizing effect of the MIRV).¹ The missiles are small and slow-moving, thus rendering them difficult to detect, and may be carried in large numbers by a variety of

different vehicles, among them bombers, surface vessels, and submarines. Their warheads are compact and light, allowing for increased fuel capacity, but are coupled with a guidance system of sufficient accuracy to afford a hard-target kill capability. Finally, the relative tardiness of delivery -- and the recall capacity of the carriers -- render the cruise missile a stabilizing addition to the American strategic deterrent. Paraphrasing Ted Greenwood's sentiments regarding the MIRV, it would appear that the cruise missile is indeed a technology whose time has come.

The following chapter examines the development and acquisition of the air-launched cruise missile (ALCM) in the context of Evangelista's five characteristics. The first section will examine the applicability of each of Evangelista's characteristics to the ALCM case. The second will discuss in greater depth the effect of service interference (both positive and negative) on the ALCM acquisition programme, and the third will summarize the results obtained.

1. The Evangelista Model Applied

One of the precepts of the "technological determinism" paradigm is the inevitability of exploitation attached to the appearance of any new technical concept. While this type of activity should be characteristic of any profit-oriented organization (such as a large business), it would be unrealistic to expect it to manifest itself in every strategic arms acquisition case -- unless technology were a base element contributing to national security (or result from the aforementioned irresistible drive). However, the unavoidable exploitation of new technologies does tend to occur in major arms development programmes, often seemingly

without invitation or previous planning. Such was the case with the ALCM; originally conceptualized as a decoy penaid and armed almost on a whim, it evolved into an entirely new weapons system destined to have a major impact on the global nuclear force balance -- the strategic cruise missile. Regardless of the existence of a "technological determinism", American technological advances unarguably enable and exacerbate the arms race.²

Like the MIRV, the development of the ALCM was made possible by the fortuitous combination of a wide variety of newly-developed technologies, most notably: the micro-miniaturization of a complex guidance package; the coupling of inertial with terminal guidance; the use of TERCOM guidance; the development of highly efficient turbofan engines; and the miniaturization of potent nuclear warheads.³ While neither the cruise concept nor the individual technologies enabling its resurgence were entirely new, their amalgamation resulted in the deployment of a significantly novel weapons system. The aim of this section is to determine whether the development and acquisition of that system adheres to Evangelista's criteria.

1.1 Was There "a Technocratic Initiative"?

The cruise missile concept did not materialize out of "thin air". Unlike the MIRV, cruise missiles had a firm grounding in historical usage dating back to the Second World War, as well as a background of intensive research and development during the 1950s. Cruise missiles were a tried and tested idea, and had been judged inadequate as a means of meeting America's defence requirements -- until new technologies emerged. The

technocratic initiative which led to the development, production, and procurement of the ALCM was to have an all but devastating impact upon American strategic policy; indeed, Phillips suggests, the growth of cruise missile technology and its subsequent exploitation enabled the evolution of the ALCM from a standard penetration aid to a system capable of replacing the manned penetrating bomber.⁴

The development of the necessary technologies was virtually simultaneous. Diverse research groups and industrial organizations, upon receiving word of the impending development of an armed replacement for the Quail, dissected the extant system in an effort to improve thereupon. Too large? Make the missile smaller. Too short-ranged? Improve the engine and its fuel efficiency. Payload too heavy? Develop a smaller nuclear warhead. Missile inaccuracy a problem? Improve existing inertial guidance, and invent a novel terminal guidance system. The result of the combination of these technologies little resembled the original product. "The simultaneous development of the parsimonious turbofan engine, microelectronics and high yield-to-weight ratio nuclear warheads have coalesced into a potentially cost-effective...weapons system".⁵ The new developments went beyond incremental refurbishment, upgrade, or even improvement upon an existing system; individual improvements brought forward by research groups resulted in a radically new concept. Had each technical "improvement" been applied separately, the result would have been merely a longer-range (but large, inaccurate, and unarmed) Quail; or a small (short-range, inaccurate, unarmed) Quail; or any of a plethora of combinations of extant technologies with a single improvement. The development of the four critical technologies, however, permitted the

augmentation of all of the critical characteristics of the weapon system: size, range, yield, and accuracy. The ALCM was the result of the right capabilities being assembled in the same place, at the right time.

What transformed a neglected missile into an important part of United States defense programmes was a collection of rather uncoordinated technological innovations rather than a deliberate effort to develop a particular weapon for particular military missions.⁶

ALCM was if anything even further removed from the "official" or first-track sequence of events than had been the MIRV. Initial statements of requirement for a Quail replacement envisioned the development of a new, improved, and more capable decoy -- armed, perhaps, but still essentially a decoy. What was eventually purchased was a weapons system designed to avoid rather than attract radar attention, whose aim was the direct attack of deep targets, and whose side-benefits, rather than aiding bomber penetration (as had been the original intention), included the elimination of the need for bombers to penetrate at all. The military services, due to the technological zeal of research and development organizations, received considerably more than they had bargained for.

Betts suggests that the uncoordinated and "synthetic" developmental efforts of scientific organizations was the principal impetus underlying the development of the ALCM in its ultimate form; Huisken supports this statement by attesting to the absolute lack of any mission need statement for a cruise-missile-type weapons system at the time of programme initiation in 1973. "Only after the SCMs (strategic cruise missiles) were in an advanced stage of development and production did their employment

become fully integrated into strategic planning".⁷ In fact, due to the unexpected range of capabilities of the final product, no role was even envisioned for the ALCM until the B-1 penetrating bomber programme was cancelled in 1977. Lacking a new penetrator, the standoff role became more attractive -- especially to the Air Force, who faced the prospect of piloting the venerable B-52 through increasingly effective Soviet air defences.

It has been argued that technological momentum usurped the normal course of events and controlled the development process which produced the ALCM. Certain evidence supports this case; the fact that operational requirements were insufficiently rigid to constrain the addition of unnecessary (and in the case of the Air Force, undesirable) capabilities to the cruise missile points to the dominant role played by innovators within that process. Thee argues that, in the case of the ALCM, the development programme operated entirely independent of the US strategic policymaking process;⁸ Phillips raises the issue, discussed in previous chapters, of the irresistible attraction of a "sweet" idea whose technological feasibility developed into political necessity. The ALCM is certainly an example of one such.

The technocratic initiative which led to the eventual development of a weapon exceeding all desired capabilities easily demonstrates the powerful force exerted upon the acquisition process by research organizations. The fact that the programme could proceed as far and as rapidly as it did in the absence of any operational requirement (or even the conceptualization of a potential role) proves that

technologies like the cruise missile are translated into development programs and end up as major weapon systems without any prior clear definition of need for such weapons, or even a clear perception of the mission that such weapons could perform.⁹

1.2 ... "Consensus-Building"?

The process of support-mongering which took place throughout the ALCM development and acquisition process was critical to the success of the programme. The main goal of the industrial groups was to include as many (and as wide a variety of) technological innovations and incremental improvements in the design scheme as was physically possible; countering this was the Air Force's desire to avoid the acquisition of anything even remotely resembling a stand-off weapons system (see section 3.2). Hovering anxiously over this antagonistic relationship was the political authority, including the Congress and whichever Administration and President happened to be in office at the time. Supposedly non-partisan throughout the course of the acquisition programme, high-level political authority played a critical hand in its evolution, most notably when President Carter cancelled the B-1 bomber, all but forcing the ALCM down the collective throats of the Air Force. In effect, all three interested groups -- industry, the Air Force, and the political echelons -- played an integral role at the consensus-building stage of the acquisition process.

Much of the civilian-sector pressure in favour of the ALCM was the result of corporate rivalry over the choice fruits of the development programmes.¹⁰ Boeing and General Dynamics vied for the principal contract allocations; lesser companies, such as Litton Systems (a Canadian group

responsible for the inertial guidance system), fought for component contracts. In an attempt each to outdo the other, research groups proposed increasingly complex concepts and capabilities, resulting in considerable rallying of favourable opinion within industry; in fierce inter-group competition, but firmly in support of the ALCM. Rosenblum suggests that industrial groups engaged in a spiralling competition of improvements to the existing design, to the point where the continual objections of the Air Force were entirely over-ridden.¹¹

No expense was spared by industry in getting the military "on side". Boeing pushed a variety of concepts which it hoped would be more palatable to an Air Force firmly wedded to the idea of penetrating bombers, among them a shorter-range tactical version of the ALCM.¹² Similarly, Boeing intentionally geared its design concept to B-52 specifications, determining the size, shape, and handling characteristics of the new missile in advance, in a rather transparent effort to avoid infringing upon the penetration role of the new B-1 bomber under development by Rockwell. The consensus-building tactics of the industrial sector may be summed up in a statement made by a member of a DDR&E research team:

The trick in any innovation is to balance the demands of the innovators with the political reality. We always took care to list modifications as "refurbishments" rather than as "upgrades". We kept everything as incremental as possible. It's a lot less threatening that way.¹³

Keeping a low profile on the innovative front aided industry significantly in adding features to the embryonic ALCM which the Air Force, favouring a less capable missile, would have preferred to forego.

Once military hostility vis-a-vis the ALCM became apparent, the entire concept of a long-range cruise missile was presented as a complement to -- rather than a replacement for -- the manned penetrating bomber.¹⁴ The increase in missile length necessitated by the longer-range characteristics of the ALCM-B resulted in their being too large to be carried in the internal bays of the proposed B-1 bomber; a compromise suggested to the Air Force envisioned the use of the B-52 as a stand-off cruise missile carrier intended to strike against air defence radars and command sites, while the B-1 would penetrate behind the barrage of cruise missiles and attack hardened targets in depth. In order to convince the Air Force that the ALCM would not pose a threat to their cherished strategic bombardment role,

it (was) argued that cruise missiles and bombers carrying nuclear-armed short-range attack missiles (SRAMs) would perform complementary roles, bombers being less vulnerable to low altitude surface-to-air missiles (SAMs) (terminal defences) and cruise missiles being less vulnerable to defences designed against aircraft.¹⁵

Of course, one might argue that the ultimate consensus-building effort undertaken with respect to military sensibilities was the overnight cancellation of the B-1 bomber programme by President Carter in 1977. Resistance to the ALCM all but vanished as the Air Force attempted to make the best of a bad situation.

Consensus-building on the ALCM issue within the higher political echelons of the American government was a more subdued and less frantic exercise. The Executive and the President (from Nixon to Reagan, without exception) were wholeheartedly in favour of the cruise missile as both an

effective addition to the American strategic deterrent and an impressive demonstration of American technological superiority.¹⁰ The Pentagon saw the cruise missile as a means of circumventing the strictures of the SALT I agreement; the OSD concurred, viewing the fledgling technology as a means of expanding arsenals and catering to service demands without stepping across the bounds of the new agreement. Both groups considered the cruise missile in all its forms -- as Rosenblum would have it -- virtually "SALT-free". In short, consensus-building on the ALCM issue was both necessary and rampant at all levels of interaction, especially those involving the Air Force as the sole resisting element.

1.3 ... "Promotion"?

Major weapons systems often seem to be presented to the services, the political authority, and the taxpayer in somewhat illusory forms. In the case of the ALCM (and, to a certain extent, the MIRV) this lack of a solid basis for promotion was primarily the result of a dearth of strategic justification for the acquisition of the new system. Not only had American policymakers failed to develop a utilization theory based on cruise missile capabilities; neither the Air Force, the Pentagon, nor the Executive had much of an idea as to what, precisely, they were acquiring (nor what its capabilities would be). Incremental reports from research and development organizations indicated only that the new weapon would be, essentially, a long-range, more accurate Quail with a nuclear warhead. Promotional efforts in favour of ALCM acquisition and mass production relied on projections and assumptions about the ALCM rather than rational doctrine and the results of operational testing.

The destabilization argument which had grown up around MIRV in the early 1970s (its deployment coincided with the inauguration of the ALCM programme) was dealt with by arguing that on the basis of speed of delivery alone the cruise missile could not be considered a first-strike weapon.¹⁷ CMCA's offered instead the reaffirmation of an American second-strike capability by improving the penetration and striking power of the airborne arm of the Strategic Air Command. Opponents of the concept argued, however, that despite the relative slowness of the missile's launch-to-target time, its small size (and, hence, undetectability) and the hard-target kill capability permitted by extreme accuracy more than qualified the ALCM as a first-strike weapon. In the absence of any clear deployment or utilization doctrine, proponents from the civil, military, and Executive levels were unable to refute this charge convincingly.

The strongest proponents of the ALCM were the civilian defence planning organizations within the Pentagon.¹⁸ As an emerging "sweet" technology, the ALCM offered a wide range of advantages over traditional Air Force second-strike roles: it was cheaper and more survivable than manned bombers, it demonstrated American technical capabilities, and it offered the possibility of trimming budgets while still appearing to increase strategic force sizes. Industrial organizations (especially those benefitting directly from the development and procurement programmes) saw endless opportunity for research funding and technological exploitation in the loosely-structured and under-controlled requirements package. The Pentagon, the Executive, and the President viewed the system as a cost-effective means of increasing American strategic superiority in a vein presently beyond Soviet technological capabilities; and, in the

event that further arms control efforts were undertaken between the superpowers, the ALCM -- developed and deployed -- might serve as an effective bargaining chip. Nearly all parties involved were wholly in favour of the ALCM procurement.

Much of the promotion during the course of the ALCM acquisition programme was directed at convincing the Air Force that cruise missiles were, in fact, a "good thing". The technical, industrial, and political communities went out of their way to bring the Air Force "on side" and gain, if not their approval, at least their consent. Industrial groups endeavoured to present the cruise missile as a less threatening system, in the case of Boeing going so far as to propose the development of a short-range "tactical" cruise missile. Developers argued that conventionally-armed cruise missiles would be more useful in land-based tactical roles than conventionally-armed ballistic missiles, and industrial agents (most notably General Dynamics in the development of the Tomahawk) pushed hard for the simultaneous development of conventional warheads for the "cruise".¹⁹ The scientific community argued in favour of the ALCM on the basis of its inherent technical superiority over the "vacuum-tube" technology of the B-52, which would render the missile a more effective penetrator than the aging bomber.²⁰

The Pentagon and the President were more cautious in dealing with the fears and prejudices of the Air Force. Cognizant of the consequences of offering a threat to the penetrating bomber role, the Pentagon pushed the cruise missile as a means of preserving and extending the role of air-breathing platforms. It argued -- and quite correctly -- that the ALCM would ensure the continued utility of the manned bomber as an arm of the

US nuclear deterrent. The penetration question was resolved by labelling the ALCM as a sophisticated penaidd designed to neutralize early warning radars, interceptor bases, SAM, and C3 centres.²¹ As long as the Air Force could be convinced that the ALCM assisted rather than obviated the penetrating bombardment role, its compliance (if not its enthusiastic support) could be ensured.

Higher-level decisionmakers in the Congress and the Executive were charmed by the cost-effectiveness of the cruise missile. Here was a weapon capable of pinpoint nuclear delivery, which could be procured for a mere one million dollars per unit, and whose deployment would not put expensive bombers (and airmen) at risk. Cost was a major factor in the ALCMs favour.²² While the carriers might continue to be considered vulnerable to enemy attack (at least on the ground), the high number of independent weapons carried by each offset that vulnerability.²³

Cost effectiveness of delivery systems and individual weapons remains a factor of some concern. While it is generally true that the ADP of individual weapons systems has increased with time, it is an undeniable fact that the cost of individual weapon systems increases at a rate well beyond inflationary estimates. Ideally, technological advances would offset this higher unit cost by increasing performance, but this is not always the case. The B-52H bomber, following thirty-five years of upgrades, costs approximately 36-40 million dollars; the B-1B, approximately 200 million; and the new B-2 "Stealth" bomber, about 520 million.²⁴ In a penetrating role, these aircraft are placed at extreme risk; in a standoff role, only the one million dollar ALCM is endangered. The cost-effectiveness argument at the decisionmaking levels was

overwhelmingly in favour of the ALCM.

Finally, in support of the cost-effectiveness argument were the low operations and maintenance (O&M) costs of the cruise missile. Simple to construct, devoid of complex safety or life-support features, and designed for one-shot performance rather than durability, the ALCM could be stored and ignored with only periodic pre-loading maintenance.²⁵ Common practice today is to shelve the missile fully fuelled; its viscous aviation propellant, unlike the more complex compressed liquid fuels required by older rockets and the manoeuvring systems of MIRV buses, is relatively unreactive and non-corrosive. The cruise missile, belying its effectiveness and flexibility, is hardly more difficult to maintain than a standard nuclear gravity bomb. Its simplicity and cost-effectiveness were strong arguments in the presentation of the ALCM programme to higher-level decisionmakers.

1.4 ... "Open Windows"?

Despite that fact that the cruise missile development and acquisition programme was inaugurated in 1973, the ALCM waited nearly five years for justification on a strategic basis. The lack of a procurement rationale was due in part to the adamant refusal of the Air Force to have anything to do with a standoff weapon; disregarding the expected capabilities of the cruise missile, Air Force planners continued to allocate it as an armed decoy, or at best as a close-in defence suppression weapon. The difficulty in finding or developing a doctrine to fit the ALCM might also be explained by the continual process of improvement which led to its evolution from a mere decoy to a highly-

accurate, long-range attack missile. Technological advances were added willy-nilly to the system throughout the developmental stages, forcing designers to continually alter their estimates of its performance envelope. Fluidity of capabilities likely frustrated Defence Department planners.

A coherent (if somewhat vague) rationale defending the acquisition and deployment of the ALCM eventually emerged in 1977: the new cruise missile would serve as a "hedge against the development of effective threats to pre-launch survivability of land-based forces, to in-flight vulnerability of ballistic missiles, and to bomber survivability".²⁶ In short, the role of the ALCM was to enforce American second-strike capability by enhancing the launch-on-warning policies of the Air Force's bomber element, while offering both improved penetration of Soviet air defences and a recall option.

In the wake of MIRV deployment, the effectiveness of Soviet air defences continued to plague American military policymakers. While trepidation concerning the ABM-upgrade capability had waned considerably by 1977, the system remained without doubt a highly-concentrated air defence line. The Pentagon and the Air Force were concerned that effective air defences might seriously degrade the mission performance of penetrating bombers, a problem which the Air Force hoped to solve by improving bomber-carried penetration aids. The Pentagon, for its part, preferred to solve the problem by keeping the bombers away from Soviet airspace entirely. While the Joint Strategic Bomber Study (JSBS) does not form an integral part of this study, one of its conclusions is particularly relevant: the JSBS predicted (somewhat erroneously) that, by

1985, Soviet air defences would have reached an unprecedented level of lethality.²⁷ Both the Pentagon and the Air Force interpreted this prediction as supporting their own particular paradigms.

Although the JSBS has been accused of considerable pro-Air Force bias (and "cooking" its results), its admonitions were taken to heart by many throughout the defence community. Whether "highly lethal" or merely efficient, the fact remains that Soviet air defences would inevitably degrade the performance of penetrating bombers. Malcolm Currie (Foster's successor at DDR&E) viewed the ALCM as a means of avoiding the penetration problem entirely.²⁸ Zbigniew Brzezinski, President Carter's National Security Adviser, for his part expressed the issue eloquently: were he responsible for the defence of Soviet airspace, he would rather face 100 ultra-modern B-1 bombers than 5000 cruise missiles.²⁹ The penetration argument was one of the principle threats employed at the "open windows" stage of the procurement process. Whether it was in fact a serious threat or a minimal one is open to conjecture; the capabilities of Soviet air defences have never been tested.³⁰

The second "open window" allowing justification of the ALCM procurement lay in the realm of strategic arms control. The 1970s were overshadowed by American-Soviet arms control efforts, a process which, while praiseworthy, tended to colour strategic policymaking on both sides of the Iron Curtain. Memory of failed attempts to stop the deployment of the MIRV by a mutual ban during the SALT I negotiations prompted higher-level policymakers to view the procurement of the ALCM as an inexpensive means of acquiring an extremely useful bargaining chip. Defence Secretary Melvin Laird suggested in 1972 that the development of the ALCM would put

the United States in a stronger position at the bargaining table, and might be used as a "cheap" tradeoff against a Soviet ban on mobile land-based missiles.³¹ Rosenblum goes further to suggest that the threefold justification for ALCM on the arms control front was that it was comparatively cheap, it might be exchanged against a more threatening Soviet system (such as the SS-19), and that, finally, it would serve as something of an apology to the Armed Services for the limitations imposed by SALT I.³² Congress subscribed to the "bargaining chip" rationale in the early years, and lent its support readily to the ALCM on the basis of its inexpensiveness and its proposed second-strike role.³³ Arms control leverage seemed a benign and all-around acceptable rationale for the ALCM.

1.5 ... "High-Level Endorsement"?

Of the diverse elements which alternately enabled and influenced the ALCM development and acquisition programme, none was to have as great an effect on its overall progress as the actions of high-level operators. Art and Ockenden maintain that at every critical stage in the evolution of the air-launched cruise missile, high-level support was necessary either to initiate the process or to sustain it.³⁴ Motivations were as varied as the actors; diverse organizations and individuals saw the ALCM, as previously mentioned, as a SALT II bargaining chip, a means of reinforcing the extended deterrence policy in the eyes of NATO allies, a reinforcement of US strategic superiority, and a sop to military demands for new weapons systems at an acceptable cost. While rationales and viewpoints differed, high-level policy- and decisionmakers were essentially unanimous in their support for the ALCM.

Support within the defence bureaucracy for the concept of a strategic cruise missile was initially confined to the small group of "technically oriented civilians" within the OSD.³⁵ The technocratic initiative apparently pervaded even the upper levels of the defence establishment, creating support on a wider front than had initially been expected; by the time the OSD was approached with the cruise missile proposal, the defence research establishment had long been one of its stronger backers. The civilian DDR&E (Malcolm Currie by 1975) was very much in favour of the system as early as its inception, and employed his not inconsiderable influence to expedite the testing and development process, noting -- even in advance of any type of threat assessment -- that the cruise missile would be an effective counter against interceptor aircraft.³⁶ The upper echelons of the defence research community argued strongly in favour of the ALCM practically from "day one", noting that it offered the dual advantage of being both relatively cheap to deploy, and inordinately expensive to defend against; John Foster (the retired DDR&E who had overseen the various MIRV programmes) stated that cruise missiles had the potential to add more "deterrent per dollar" than any other programme under consideration at the time.³⁷

As expected, the Office of the Secretary of Defence was intimately involved with the ALCM programme. Echoing Foster's statement, Secretary of Defence Harold Brown argued that a critical point in the favour of the ALCM was its "upgradeability";³⁸ due to its modular construction and the ongoing nature of systemic improvements, the cruise missile could be upgraded much more quickly and cheaply than Soviet air defences. Like the MIRV, the ALCM represented a technology the exploitation of which was

child's play in comparison to the difficulty of neutralizing it from the target end. In order to facilitate the development process, Brown went so far as to implicate himself directly in the affairs of the individual research organizations, ordering the standardization or "commonality" of certain of the components being developed concurrently by Boeing and General Dynamics for their different missile programmes.³⁹ Propulsion and guidance systems were to be 85% common between the two missiles in order to avoid duplication of effort. The willingness of Brown to take a direct hand in the affairs of industry indicates the extent of his support for the programme.

Congress and the various presidents whose terms in office coincided with the ALCM programme collaborated in order to ensure its acceptance by the military services. The inauguration of the cruise missile programme was a response by Nixon to the demands of Senate hawks and the Joint Chiefs of Staff in the early 1970s for compensation for the sacrifices of SALT I; Rosenblum suggests that the cruise missile may have been a Nixon payoff to the Pentagon.⁴⁰ The initial lack of enthusiasm evidenced by the Air Force toward the cruise missile was dealt with effectively by the Ford Administration, which developed a conceptual picture of the cruise missile as a means of extending the operational utility of the aging B-52 as a complement to the B-1.⁴¹ The Carter administration solved the problem of Air Force recalcitrance in a single unintentional stroke; the loss of the B-1 left the Strategic Air Command with Hobson's choice. It accepted the ALCM as the best of a bad deal. Finally, President Reagan's reinstatement of the B-1 as a penetrating bomber with the B-52 as a standoff CMCA allowed the Air Force to, as it were, "have its cake and eat it, too".

Once the B-1B had been installed in the penetrating role, the Air Force happily accepted the cruise missile as a potent and doctrinally non-threatening addition to its arsenal.

As was the case with MIRV, the Congress played something of a minor role in the ALCM drama.⁴² Although it was involved to a certain extent at the appropriations stage, it appears that once again the exact nature of the weapons system under consideration was somehow missed. Whether Congress was unaware of the importance of the ALCM (it having been presented as little more than a long-range, armed decoy) or was aware and entirely in favour of it, neither it nor the Senate did anything significant to either help or hinder the development programme. Hampson states that "Congress played a passive role in the development of the air-launched cruise missile. It supported the proddings of successive administrations to get the Air Force to take the cruise missile more seriously".⁴³ In addition to the considerable edge which the ALCM afforded American second-strike capability, cruise missiles were considered important as a reinforcement of the NATO extended deterrence and deep-strike roles.⁴⁴ Flexible response depended (and continues to depend) upon a western capability to strike any target at any time, with any amount of force. This role had been somewhat weak due to a NATO inability to reach targets in strategic depth in the event of a Soviet conventional strike into Western Europe. The development of the ALCM (and its companion systems, the SLCM and GLCM) promised a dual conventional/nuclear deep-strike capability, covering in the case of various systems from the Atlantic to Moscow (SLCM), from Germany to the Urals (GLCM), or anywhere at all in the continental Soviet Union (ALCM). NATO-oriented defence

planners in the Pentagon appreciated the potential of the ALCM and unhesitatingly advocated its acquisition.

The cruise missile would not have proceeded as fast and as far, if indeed at all, had it not been for the intervention and support of high-level political figures in the Pentagon, the White House, and the US Department of State.⁴⁰

Most authors agree that in the absence of strong high-level support, the ALCM might never have come into being. Air Force resistance to the system (examined in the following section) was vehement, and only the continued advocacy of Congress, industry, and a long line of presidents served to overcome the objections and see the cruise missile through to the deployment stage. Why did the US government insist upon continuing with the ALCM programme when the Air Force had demonstrated unequivocally that it did not want them? According to Art and Ockenden, "The answer, quite simply, is that the politicians did, and their preferences prevailed."⁴¹

2. Air Force Resistance

Questions concerning the relevance of Evangelista's criteria and their individual importance to the evolution of the air-launched cruise missile programme aside, the most important factor remaining to the comprehension of the second-track process which eventually led to the deployment of the ALCM is the extent to which Air Force resistance to and interference with ALCM development shaped the outcome of the programme. Unlike the vast majority of other novel weapons systems, resistance to which originates "externally" (within non-governmental organizations,

civilian interest groups or lobbies, and the like).⁴⁷ the principal conflict with respect to the ALCM development and procurement plans devolved upon the hesitancy of the intended recipient of the system to accept it.

The reasons underlying the reluctance of the Air Force to embrace the ALCM were myriad; certain of these have been discussed at some length in previous chapters. It is sufficient to recall that technological advances resulting in a cruise missile of unexpected capabilities threatened to change most of that service's "traditional" strategic roles: a self-guiding and accurate weapon could obviate the need for a penetrating bomber, and its hard-target kill capability could replace the counterforce role previously secured by land-based ICBMs.⁴⁸ The Air Force could easily be reduced to a small fleet of converted Boeing 747s, flying occasional patrols no closer than 1000 km to Soviet airspace. A certain amount of unease was inevitable as the possibilities offered by a long-range cruise missile became apparent.

Within the upper echelons of the Air Force, high-level opposition to the cruise missile developed almost as soon as the standoff capability emerged. The resistance was directed not so much at cruise missiles as such, but instead toward long-range cruise missiles. The Air Force had long employed shorter-ranged cruise missiles (such as the Hound Dog) as highly-efficient defence suppression weapons; only their excessive size had prohibited multiple deployments per bomber. The Air Force was greatly appreciative of the SRAM (essentially a fast cruise missile with a 100 km range), as its smaller dimensions permitted several to be carried by a single B-52. However, SRAM -- like the Hound Dog -- due to its limited

range required that the carrier aircraft penetrate Soviet airspace in order to reach deeper targets.

The SCAD proposal appeared innocuous enough in its early stages; as a replacement for the Quail, the only significant change seemed to be the arming of the new "decoy" with a nuclear warhead in order to force clever air defence specialists capable of distinguishing bombers from decoys to engage all observed targets. The incorporation of a highly efficient engine and a commensurately accurate guidance system changed the nature of the SCAD, however; the OSD, recognizing its emerging capabilities, pressured the Air Force to write the new weapon into its doctrine as a standoff system -- a device whose principal utility would be as a weapon rather than a decoy.⁴⁹

A bomber that is not required to penetrate enemy airspace in order to deliver its payload is not a bomber any more than a troop train is an armoured personnel carrier. Were the CMCA of the future required only to approach the enemy coastline to within 1000 kilometres, defensive electronics, high speed, low radar cross-signature, and a host of other penetration-aiding systems or capabilities could safely be eliminated. In fact, the job could be done by a modified passenger aircraft.⁵⁰ Also, enforced research and development on the cruise missile would cost a great deal of hard capital, which the Air Force felt might be better spent on less doctrinally threatening projects. Art and Ockenden state that "without exception, the military services did not want cruise missiles if they threatened their respective dominant missions or ate into their scarce funds".⁵¹

The Air Force raised innumerable points against the long-range

cruise missile concept. Cruise missiles, it argued, would be as vulnerable as manned bombers to enemy air defence systems, and would lack the flexibility of a human at the controls. Any subsonic system would be threatened by new developments in Soviet SAM technology; the SCAD, as a decoy, might be useful in drawing the fire of air defence forces, but its intentional use as a strike weapon, in view of the AD threat, would be foolhardy.⁵² The Air Force went to great lengths to oversee the development of SCAD (and, later, of ALCM) in hopes of preventing its evolution into an effective standoff system, a battle against the technocratic forces supporting the research and development effort which the military was doomed to lose. Nonetheless, the Air Force maintained the effort in hopes of defending their traditional role:

The Air Force...responded by monitoring and managing the program's development as closely as possible in order to ensure that the decoy did not become a full-fledged standoff weapon. The Air Force Systems Command took the unprecedented step of acting as a subsystems integrator, a role normally reserved for the prime contractor...Such close monitoring ensured that the decoy...would remain an augmentation of, rather than a replacement for, the penetrating bomber.⁵³

The previously-mentioned Joint Strategic Bomber Study (JSBS) was a bureaucratic attempt by the Air Force to discredit the cruise missile as an effective strategic nuclear delivery system. Labelled the "Joint Strategic B.S." by other branches of the services, the Study manipulated the results of a series of systems comparisons in order to defend the penetrating bomber role, in particular the development and acquisition of the emerging B-1. The longer-range version of the ALCM, the ALCM-B (AGM-86B), was judged too long to be fitted to the internal launcher on the B-

1B; thus, the ALCM-A would be required for this aircraft (its 700 km range requiring the bomber to penetrate in order to reach most targets).⁵⁴ As demonstrated by American science on countless previous occasions, technical difficulties of this nature are easily overcome; the deeper motivation for the conclusions drawn was the frantic scramble to preserve the role of the penetrating bomber.

Other arguments of equal validity⁵⁵ were raised during the course of the development programme. The Air Force maintained that cruise missile-armed aircraft in a standoff role would be unable to reach crucial targets in wartime, and that cruise missiles would be unable to penetrate sites defended by SAMs.⁵⁶ All the while, the rising cost of the B-1 programme put additional pressure on the Air Force; it began to argue that there was no need at all for SCAD or any similar device, as the use of a decoy would have only marginally improved the penetration of the highly-evolved B-1.⁵⁷ The Air Force even suggested a mixed force of B-52 and B-1 aircraft (in order to cut back the purchase cost of the originally-scheduled 250+ aircraft), stating that the B-52 was "not about to fall apart", and that a mixed force would be capable of serving well into the 1990s.⁵⁸

In the end, the Air Force won a small victory by capitulating; the B-1B force (considerably reduced in numbers) revived by President Reagan was armed with SRAMs and assigned the role of a penetrating bomber, while 194 modified B-52G and H aircraft were designated as standoff cruise missile carriers.⁵⁹ The B-52/ALCM combination was nothing if not cost-effective, and the cruise missiles would at least be useful against "soft" targets within at most 2000 kilometres of the coastline;⁶⁰ the B-1B would

be assigned to strike those strategic targets (missile silos, mobile missiles, command centres, and the like) located further inland.

Battles between the OSD and the Air Force were often invisible, and tended to include unexpected participants with their own particular motivations. Melvin Laird, for instance, in an attempt to use inter-service rivalry to his advantage, pushed hard for the development of the SLCM for the Navy, hoping that the Air Force, in a fit of technological jealousy, would come to favour the ALCM.⁶¹ The individual who most made his impact felt upon the service-OSD quarrel, however, was Henry Kissinger, who, in 1973, "sold" the Air Force the cruise missile, partly as a payoff for SALT I, and partly in anticipation of SALT II -- and found, when SALT II had finally come into being, that he couldn't "buy" them back again.⁶² In the interim, the Air Force had come to appreciate the flexibility of the new weapons, and -- shaken by the cancellation of their new strategic bomber -- was unwilling to give them up.

The Air Force blocked the cruise missile programme to the best of its ability because a standoff weapon system would threaten the traditional role of penetrating strategic bombardment developed during the Second World War. In the end, the ALCM was accepted only as an adjunct to, not a replacement for, the manned bomber.⁶³ The resistance offered was considerable, but its ultimate failure was inevitable given the fact that decisionmaking power lay in the hands of unsympathetic authorities.⁶⁴ Art and Ockenden summarize the Air-Force/ALCM struggle:

In retrospect, the ALCM-B was so long delayed because of the threat presented to the Air Force's preferred mission of penetrating strategic bombardment. Indeed, so highly did the Air Force value its doctrine and the penetrator that it took

the combined efforts of many in Congress, the Department of Defense, and the White House to force adoption of a long-range standoff cruise missile.⁸⁸

Given the strength of the combined influence of these organizations, including that of the incumbent President, it is surprising that a single service was capable of mustering any resistance at all, let alone the staunch rearguard action fought thereby for the better part of a decade.

3. Summary

The evolution of the cruise missile, while in fact spanning some six decades since the testing of the "bug" during the First World War, accelerated significantly during the 1970s. Previously-designed cruise-concept systems such as the Snark and Navaho were plagued by operational difficulties stemming from technological limitations, difficulties which for the most part have been solved by modern science. Once dismissed as inefficient and passed over in favour of ballistic missiles, the cruise missile in all its various forms has returned with a vengeance.

It has been argued that the development of the modern long-range (or strategic) cruise missile was engendered by the mere existence of the applicable technologies; Ronald Huisken echoes Ted Greenwood's statement of a decade earlier concerning the MIRV: "The strategic cruise missile in 1972 was a weapon whose time had come".⁸⁹ Technological determinists argue that the capability to create a significantly new weapons system inevitably spawns the political necessity to do so; given the extent to which political sponsorship was crucial to the success of the ALCM programme, it may be said that the cruise missile case supports this

paradigm admirably. Yet to espouse only this explanation would be to ignore the impact of other critical variables which affected the process.

The foregoing analysis clearly demonstrates that Evangelista's five criteria were met within the context of the ALCM development and acquisition programme. Each of the postulated stages was attained by the proponents of the system to a different degree depending upon the nature of the obstacles to be overcome. A variety of conflicting perspectives shaped the outcome of the programme, among them those characteristic of the three principal actors. The military, specifically the Air Force, viewed the cruise missile as a threat to the penetrating bomber, as well as (albeit to a lesser extent) an unwarranted and prodigal expenditure of scarce R&D funds. The scientific community (both in the civilian and military spheres) saw the ALCM as an opportunity to exploit a whole spectrum of emerging technologies, thereby demonstrating the extent of American technical wizardry; and the political animals, most notably the OSD and the White House, viewed the missile as both a potential bargaining chip to be traded away in future arms limitation talks and a political "plum" to be exploited at every opportunity.⁶⁷

Evidence suggests that in the case of the ALCM, the relative importance of each of Evangelista's five individual stages varied considerably; for instance, political pressure was more important to the success of the development programme than promotional efforts had been. This anomaly will be discussed at greater length in the concluding discussion.

In the final analysis, the Air Force accepted the air-launched cruise missile only because President Carter ordered it to do so, and not

without considerable reservations. It is not unthinkable to suggest that resistance might have been stronger still had President Reagan not reinstated the B-1 bomber programme (albeit with a slightly reduced final production run) as a sop to Air Force demands. It has been suggested that the success of the cruise missile programme despite service interference was in part the result of fortuitous timing;⁶⁶ had the Air Force already been committed to a new bomber when the SCAD project was inaugurated, its refusal to accept the new missile might have been more successful. Hindsight is an unreliable servant at best; the fact remains that whatever the nature of its initial sentiments regarding the cruise missile, the Air Force gained a potent, cost-effective, and stabilizing weapon in the ALCM -- one which, today, it would likely fight to retain.

CHAPTER FOUR

CONCLUDING OBSERVATIONS

The preceding two chapters discussed the processes of development and acquisition which led to the addition of the MIRVed warhead and the ALCM to the American strategic arsenal. The majority of these discussions have been aimed at determining the extent to which the model proposed by Matthew Evangelista is capable of serving as a tool for conducting an analytical post-mortem of these processes. At first glance, it would appear that the five-stage schematic suggested in his Innovation and the Arms Race is suitable for providing a framework for the examination of American strategic nuclear arms acquisition programmes. However, a more in-depth study of these cases suggests that the Evangelista Model, while certainly helpful in "roughing out" the approximate shape of the separate chains of events which led to the eventual deployment of both the MIRV and the ALCM, overlooks or downplays a number of factors which appear to have been critical to the success of the programmes in question.

The aim of this chapter is, via a comparison of the critical or turning points of the cases, to question the effectiveness of Evangelista's Model as an analytical tool, and to suggest means by which it might be improved or upgraded so as to increase its utility in the examination and explanation of cases of strategic arms acquisition. In order to do so, this discussion will be carried out in two parts. The first section will offer a comparison of the cases in terms both of Evangelista's criteria and those elements of the acquisition process which

he has failed to take into account. The second will discuss the utility of Evangelista's arguments in the context of a changing time-frame, including the shortcomings of his theory with respect to the world of strategic arms acquisitions and the means by which the theory might be improved.

1. A Tale of Two Cases

The addition of the MIRV and, later, the ALCM to the American strategic arsenal represented two in a series of significant technological innovations which augmented in no small fashion the aggregate destructive power thereof. Recalling the definition of "significant innovation" offered in the introduction to this paper, it is obvious that other important weapons systems based on a telling departure from the material norm surrounded each of these developments: the atomic bomb, the jet bomber, the thermonuclear bomb, the tactical nuclear weapon, the ICBM, the SSBN and its weapons, the SLCM, and the Stealth Bomber, to name only a few. While each of these may certainly be said to have been of "strategic significance", in purely military terms one stands apart from its fellows. The tactical nuclear weapon -- the focus of Evangelista's own case study -- while unarguably representing something of a revolution in land warfare, is not a strategic weapons system by any of the accepted definitions. In fact, one might argue that it is merely an extension of extant systems, such as large conventional bombs, chemical weapons, and short-range ballistic missiles. When calculating the influence of state against state in terms of the "beans" of strategic weaponry, tactical nuclear weapons are usually left out of the picture; their role is on the battlefield, as

a means of boosting the destructive power of a conventional army. In the game of superpower diplomacy (with the possible exception of recent arms control efforts) they are invariably left out of consideration.

One might question, then, Evangelista's choice of the development and acquisition of tactical nuclear weapons as an appropriate single case study upon which to base a theory of arms acquisitions. Too powerful to be considered a truly usable conventional weapon, and insufficiently potent to be counted within the strategic arsenal, tactical nuclear weapons are a maverick in the pantheon of armaments. As neither conventional nor truly strategic weapons, the processes which led to their development and eventual deployment may contain certain psychological and political elements unique to these weapons and these alone.

Both the MIRV and the ALCM, however, are unquestionably representative of the strategic class of weapons systems. The influence and operation of Evangelista's five criteria were readily observable throughout these cases. Following a discussion of the appearance of these five essential elements within both the MIRV and ALCM development programmes, we shall examine the influence of five factors which Evangelista has variously downplayed or ignored, but which -- in the author's opinion -- exerted a considerable influence on their respective progress.

The first stage, that of the "Technocratic Initiative", is of course of great importance to the development of any weapons system regardless of type. Characterized in the United States by its "bottom-up" nature (the origin of this moniker is discussed in the first chapter), the actions of defence industry scientists and those involved in other forms

of technological research in bringing novel developments to the attention of interested parties were indispensable. In the case of both the MIRV and the ALCM, the significant innovations involved were the result of separate aggregations of extant and emerging technologies into a novel whole of unprecedented capabilities. The process of aggregation was in each case characterized by considerable collusion between research organizations; in fact, cross-fertilization of this nature resulted in the case of the MIRV in the presentation by four separate research groups within the space of a few weeks of four entirely diverse multiple warhead launch proposals.

Technological innovation is the fulcrum upon which rests the lever of the Evangelista Model. The nature of the MIRV and ALCM developments (by the aggregation of extant technologies) in no way detracts from either the novelty or the significance of the innovation. The tactical nuclear weapon was the result of improvements in warhead miniaturization capabilities; further developments along this line were part of the process of development for both MIRV and ALCM. That additional refinements in other areas were required to complete the programmes merely added to their relative complexity rather than detracting from their technological "originality" (if such a thing can be said to exist). Contemporary technological innovations are more often the result of a multitude of parallel refinements rather than a single novel development. In both cases, one might assert that change in weapons technology is incremental due to the apparent unwillingness of the military mind-set to accept systems requiring radical alterations to existing structure or doctrine. It might therefore be argued that MIRV and ALCM represent more

appropriate test cases in a modern context than did the tactical nuclear weapon.

Evangelista throughout his study maintains that the respective armaments acquisition processes of the United States and the Soviet Union display an overwhelmingly divisive characteristic: that within the acquisition structures of the former innovation tends to be driven by independent scientific research (thus resulting in a "bottom-up" flow of possibilities and concepts), as opposed to the process evinced by the latter, wherein ideas and research directions engendered by policymakers are forced upon the scientific community (a "top-down" dynamic). This theory was discussed at greater length in the first chapter of this paper and has by examination of the cases been proven somewhat erroneous. The division is hardly iron-clad; weapons system innovation within the United States is far more "top-driven" than Evangelista would care to admit. The ALCM provides a sterling example of the remolding of a proposed system by actors in positions of influence; what began as a decoy and grew via technological advance into a standoff weapon of vast potential was forced back into the mold of a decoy by a series of inventive restrictions and prohibitions (such as the size and shape of the weapons bay on the B-1 bomber) imposed by the Air Force for its own ends. In effect, although the technical potential of the new system originated within the scientific community, its eventual shape upon deployment was dictated almost entirely by the upper echelons of the military hierarchy. This example would appear to suggest a dual dynamic consisting of a "bottom-up" flow of ideas and possibilities and a "top-down" flow of requirements and specifications, each contributing to the overall outcome of an given

project. The bi-directional nature of the US innovative process is ignored in Evangelista's study.¹

The process of consensus-building which is assumed to take place as the second stage of the Evangelista Model is not so easily characterized. Evangelista notes that this element requires the conscious efforts of research and development personnel to interest a wide variety of non-scientific groups in the potentialities of the new development: defence contractors, the military, and certain political groups and personalities which might benefit from the development and production of the proposed system. Naturally, such activity of necessity takes place "behind the scenes" rather than in documented meetings and interviews. However, sufficient evidence exists in the case of both the MIRV and the ALCM that a certain amount of unofficial lobbying was undertaken in support of each of the weapons systems.

Consensus-building in favour of the MIRV was an essentially uni-directional process aimed at securing the support of the armed services, the only balky player involved. Research groups, the defence industry, and minor political players were all for their own reasons firmly behind the idea; only the contentious nature of the Air Force-Navy relationship offered any resistance to the idea, and this only in the later stages of the developmental process. During the ALCM development, however, a considerable amount of resistance was offered by the Air Force to the acquisition process; feathers ruffled by the gradually fading role of the penetrating bomber were only eventually smoothed over by firm promises to continue the production of new bombers, and to relegate the cruise missile to the role of an armed decoy rather than a replacement for the manned

bomber. It must be noted, however, that in neither case was a tremendous amount of consensus-building effort required, as both weapons systems were greatly desired by nearly all actors involved. There is no question of any one actor or group (save in theory the President) possessing a unique veto power over any proposed weapons system; however, certain actors (such, as demonstrated by the cases, as the Air Force and Congress) are capable of raising nearly insurmountable obstacles in its path. While these obstacles may not entirely foil the acquisition process for the system in question they may certainly delay its progress considerably, and may result in changes or modifications to the programme to such an extent that the eventual system little resembles the original design. Thus, effective consensus-building predating the presentation of the concept to higher-level decisionmakers and the public is an unavoidable necessity.

Promotion of the respective systems presented as little difficulty as did the consensus-building process. Standing firm upon a broad base of support amongst the services, the defence industry, and the research groups, more experienced promoters took it upon themselves to convince the Congress, the Executive, and the Public of the desirability of the weapons system in question. In each case, these promoters met with the solid approval of the President and the Executive, and the complete inattention (with respect to the MIRV) and relative indifference (concerning the ALCM) of the Congress. Promoters play upon the perceived strategic concerns of their targets, raising whichever spectre seems to excite the greatest amount of worry, thus ensuring support for the system. In the case of the MIRV the principal bugaboo was the (grossly exaggerated) sophistication of Soviet ABM systems, and in that of the ALCM, the need to increase the

striking power of American strategic bombers in the face of overwhelming Soviet air defences -- yet another hyperbole.

In other arenas, most notably that of Congress, the importance of a given weapons system is often played down. During the MIRV development, Congress paid the programme little heed as it was presented as an evolutionary rather than a revolutionary technological development aimed at improving an existing system. Later on, having perhaps "learned their lesson" from the MIRV experience, Congress dealt more intimately with the cruise missile development programmes -- but, due to the great extent of support for the ALCM and its attractive cost-effectiveness, the result was essentially the same. The cost-effectiveness argument often tends to win over current administrations as well; Johnson saw the MIRV as a means of expanding enormously American strategic power at a relatively minor cost, while Carter viewed the ALCM as a cheap alternative to the increasingly expensive B-1 bomber project. Promotion of a developing weapons system is something of an art; it consists primarily of knowing which "carrot" to dangle before a particular target.

The "open windows" element of Evangelista's argument consists of matching a proposed weapons system to an existing, postulated, or invented threat. Both Evangelista and Thee note that more often than not the threat against which the system is initially proposed resembles very little that by which its acquisition is finally justified. Both the MIRV and the ALCM offer excellent example of this tendency; originally intended to meet the requirements of a rapidly expanding target list, the MIRV was in the final analysis justified on the basis of its ABM penetration-by-saturation capability (thus shifting the emphasis of its existence from

offensive to defensive targeting). Similarly, the justification for the ALCM shifted a number of times during its development; originally conceived as an armed decoy intended to shift the weight of Soviet air defence power away from penetrating bomber fleets, its technological potential rendered it capable of replacing the manned penetrating bomber entirely. In response to the dissatisfaction of the Air Force with the proposed elimination of this role, the ALCM was eventually deployed as a system designed to augment penetrating bomber capacity and extend the useful life of the venerable B-52. Taking advantage of "open windows" (or creating them extemporaneously) is of critical importance to the weapons system development process. Each single project is hideously expensive, and unless promoters and politicians are able to justify it on the basis of a dire threat to national security, a programme will inevitably fail for lack of support within both public and political circles.

The final stage of the Evangelista Model requires the assurance of "high-level endorsement" of the proposed weapons system. Congress controls the flow of funding, the Pentagon (as the eventual recipient) requires a hand in shaping the development, and the President is theoretically capable of vetoing the production of a system which he and his advisors deem unnecessary. The approval of each of these groups (in addition to others, such as the State and Defence Departments) is fundamental to the success of any weapons system development programme.

Garnering endorsement from high-level actors is a convoluted process. For example, even if it is assumed that Congress will be behind a given programme from the "promotion" stage, one must remember that while a single programme may take ten years moving between the research and

deployment stages. Congressional actors may rotate every two years (although incumbents are frequently re-elected). The same holds true for presidents and presidential administrations; ensuring the support of these groups and individuals is an ongoing rather than a "one-shot" exercise. The B-1, inaugurated by Nixon and fostered by Ford, was cancelled by Carter and later reinstated by Reagan. Political shifts of this nature can wreak havoc with the progress of a given programme. Similarly, while one might assume the Pentagon to be overjoyed with the acquisition of any new weapons system, such is not always the case; the Air Force successfully resisted and interfered with the development of the ALCM for the greater part of a decade, until the system was eventually forced upon them by President Carter. Thus, high-level support is not always ensured, regardless of the apparent desirability of a given weapons system.

The five criteria proposed by Evangelista and outlined above with respect to the two case studies presented herein appear to be necessary to the successful development and acquisition of a strategic nuclear weapons system. However, qualitative differences between these cases and that of the acquisition of tactical nuclear weapons offered by Evangelista, as well as vagaries between the strategic cases themselves suggest that other modifying elements may have a crucial impact upon the progression of such cases. In addition to the five stages of the Evangelista Model, the five factors outlined below must be taken into consideration, as each had a significant impact upon the development of the weapons systems in question.

The existence of a "technological momentum" has been a sore point amongst arms race analysts for the past three decades. Technological

determinists would argue that the development and procurement of a given weapons system is inevitable once the system itself becomes technically feasible; they cite as their evidence the fact that no weapon whose feasibility has been proven has been passed over for deployment. While this statement is something of an hyperbole, it remains true that for the lion's share of weapons systems proposed over the decades very little of consequence has been left undeveloped. The attractiveness of new technologies is a powerful motivator for the leaders of a nation which since the Second World War has relied upon qualitative superiority to maintain its strategic lead.

The development of both the MIRV and the ALCM bear the marks of this trend, albeit each to a different extent. The MIRV was developed, tested, produced, and deployed in an environment startlingly devoid of dissenting voices. Scientific research groups in their proposals (as well as industry and the military, as the eventual recipients of contracts and weapons) seem to have assumed that the MIRV would be approved as a matter of course. The idea faced no significant opposition until the eighth year of its existence, during the SALT I negotiations; hindsight on a broad scale reveals a system which, once its minor faults were ironed out and a role found for each of its configurations, proceeded from development to deployment with juggernaut-like certainty, essentially unopposed.

A similar atmosphere of determinism was fostered by the variety of technocrats charged with the development of the ALCM project. Convinced of its utility and range of capabilities, as well as enamoured of a weapons system superior to anything possessed by the Soviet Union, individuals so empowered usurped many of the decisions supposedly within

the bailiwick of higher-level decisionmakers, effectively forcing the development of the ALCM against the directions suggested by the Air Force, the eventual recipient. Not satisfied with creating a short-range armed decoy, research and development organizations produced a weapon capable of long-distance, low-level flight, and possessing accuracy sufficient for counterforce operations. The maximum potential of the system was exploited -- quite against the desires of the Pentagon. The development of the ALCM, by virtue of its unique range of possibilities, was taken much further than had been intended. In both of these cases, technological momentum was, if not a deciding factor, at least a contributing one.

A second element of importance within the cases under scrutiny is the extent to which service involvement helped or hindered the development and acquisition processes. "Inter-service rivalry" is a tired cliché; as Hampson has pointed out, interactions between the services in matters of weapons procurement are more often characterized by a complex form of cooperative behaviour in which concessions are exchanged in the interest of achieving greater gains for one's own branch. In the case of the MIRV, initial Air Force resistance to the system was based upon a threefold concern: that the MIRV would obviate the manned bomber, that fractionation of missile warheads would eliminate the need for increased numbers of launchers, and that the Navy would become capable of assuming a portion of the Air Force's coveted counterforce role. Executive direction nullified the first two objections (in the form of the cancellation of the XB-70 bomber and the limitation of total launcher numbers -- see Chapter Two). Proponents of the inter-service rivalry paradigm would assume that

the remaining sore point would lead to unresolvable difficulties between Navy and Air Force; on the contrary, voluntary selection of different warheads by the individual services assured the Navy of a solid and invaluable countervalue role, while reassuring the Air Force that the counterforce mission (by elimination of capabilities) remained its sole prerogative. The MIRV incident effectively debunks the "inter-service rivalry" myth, while at the same time emphasizing the importance of service interactions in resolving system acquisition conundrums.

In the case of the ALCM, the Air Force as the sole recipient demonstrated the extent of its influence by retarding and interfering with the development and production programme of the new cruise missile. Hoping that the new SCAD would provide a decoy to assist bomber penetration, the Air Force unwittingly found itself faced with a weapon capable of rendering the penetrating bomber obsolete. Cheap, practical, and relatively undetectable, the ALCM threatened to obviate the long-range bomber entirely. Air Force efforts to keep the cruise missile from developing into a threatening system (by insisting upon a shorter missile to fit bomb bays, therefore a shorter range; and by going so far as to offer to give up expensive penaid equipment planned for the B-1, so as to reduce bomber costs) failed due to governmental pressure; the weapon was only reluctantly accepted after the application by President Carter of the draconian measure of cancelling the B-1 bomber. Faced with a choice between the cruise missile and nothing, the Air Force took the cruise missile. The example of the ALCM demonstrates the power of a single service as recipient when it is displeased with a developing system. Once again, this power was insufficient to stop deployment; but it was

significant in terms of the effect of Air Force influence upon the development of the system itself. These two cases indicate that inter-service interactions are characterized by cooperation under pressure, and that their influence had best be carefully considered in any weapons development programme.

Of less critical importance but still a crucial element of the procurement process is the significance of political support for an emerging weapons system. As previously discussed, a number of groups (most notably the Executive, the Pentagon, and the Congress) have the power to "make or break" a given programme. Each of these groups must be properly propitiated in order to ensure their support. Cooperation -- or at least a mutual non-interference pact -- between these groups may in fact be crucial to the survival of an emerging weapons system. Evangelista comments upon this necessity to a certain extent in his section on "high-level endorsement", but fails to give it the attention it merits. It has been said that individuals, not groups, hold the reins of government; such was demonstrably the case with both weapons systems under discussion. The MIRV was fostered and nursed through infancy by Robert McNamara on the orders of President Kennedy and later, its firm advocate, President Johnson. The ALCM was entirely thrust upon the Air Force by the action of one man, President Carter. That the powers of decision devolve so completely upon the credence of individuals speaks out loudly for the importance of concentrated high-level influence. Evangelista's model does not give this crucial element the recognition it deserves.²

Another element accorded less than adequate notice is the effect

upon the development and acquisition process of widespread and complex informal communications linkages within and between important organizations. Ted Greenwood has documented the chain of informal working and service relationships between actors within the Department of Defence during the MIRV development; and similar linkages exist in abundance throughout defence and defence-related organizations. Cross-fertilization of technological concepts between research organizations is one such example; inter-organizational collusion between, for instance, the services and the defence industries which resulted in a good deal of the MIRV systems developments is another. Enforced inter-organizational cooperation is yet a third example of this element, observed when DDR&E demanded a high ratio of commonality in propulsion and guidance components between the ALCM and SLCM. Finally, the links forged when individuals are transferred between organizations create lines of informal communication which may be capitalized upon during subsequent development programmes; the practice of appointing the DDR&E from the ranks of Livermore ex-directors is an excellent example of this, as is the tendency to assign service personnel as consultants to developers and the defence industry.

One factor which is seldom considered to be an influential force in the development and acquisition of strategic nuclear weapons systems is the arms control lobby. Insignificant in the early sixties, groups such as ACDA made themselves felt during the SALT I negotiations, raising questions as to the strategic advisability of suddenly multiplying the striking power of the American missile force. Arms control concerns grew in influence over the decade separating the MIRV and ALCM development programmes, and the cruise missile was (and continues to be) met with a

considerable amount of concern. Would it not qualify as a first strike weapon? Does the average voter want such things in his back yards? While arms control was not a major concern during the development in the United States of tactical nuclear weapons, its importance has since expanded manifold; today, systems designers and developers would do well to treat the arms control lobby with considerable caution, especially in view of the retreating nature of global superpower tensions.

The last and perhaps most important of elements to be considered is the effect of "era", or temporal location, on the development and acquisition of a single system. Evangelista chose one case study located temporally in the mid-1950s, and in 1988 forged from it a theory describing the nature of arms acquisitions. This is not sound procedure; first, because a single case study may not be positively generalized to include anything other than itself, and second, because a great deal has changed over the last thirty-five years. This lack of temporal generalizability requires one of two responses: either the Evangelista Model may only be applied to arms acquisition projects undertaken in the mid-1950s, or additional verifying data must be examined in order to provide modifications for different points along the time axis. The latter has, in effect, been the aim of this paper. The final section will examine Evangelista's theory in terms of the deficiencies discussed above, in the interest of offering certain modifications which would enable one to adapt his Model to any American strategic arms procurement programme, regardless of the era in which it might occur.

2. The Evangelista Model Adapted

Within the context of a discrete period of time, Evangelista's model is an adequate tool for the examination of the critical elements and turning points of a strategic arms acquisition process; however, as discussed in the preceding section, it tends to ignore certain influential factors the impact of which upon the development and procurement process is sufficient to warrant their inclusion in any such examination. Of the five non-Evangelistan elements outlined above, four are of crucial import. It has been demonstrated that the effect of "technological momentum" if it can be said to exist at all acts as a constant in that it all but invariably drives arms development processes forward; thus, it may safely be eliminated from our discussion as it seems to act upon all processes in a constant fashion. However, the remaining four criteria must be brought into consideration: the effects of service interests, informal channels of communication, and the arms control lobbies are too influential to dismiss out of hand; and the consideration of external political factors -- primarily the superpower relationship, but including such things as alliance concerns, economic partnerships, and regional interests -- which change with time must not be overlooked.

It would be fair to state that as it stands the Evangelista Model is a limited but accurate descriptive tool with respect to strategic arms acquisition processes. Of the four additional criteria mentioned above, the former three may be included not as separate stages (as they tend to operate throughout the process without dependence upon a particular discrete instant) but as pervasive necessary processes which transcend discrete stage-by-stage analysis. Service cooperation and interference

operated, respectively, throughout the MIRV and ALCM cases from start to finish: its effect upon the separate processes was marked and continual. Similarly, the advantageous effects of strong informal links of communications between organizations otherwise officially unconnected expedited the MIRV development process throughout its 12-year history. Also, in the case of the ALCM, arms control lobbies both within Congress and the electorate at large paid close attention to the progress of the system, becoming more powerful near its conclusion; and arms control concerns, more important today than ever before, will in the future assume even a greater role in overseeing and reacting to strategic weapons developments. These factors play an encompassing role transcending the individual stages (or perhaps within and throughout them); their effects are manifest at all times.

Nor are these three factors static and unchanging. Service cooperation waxed with the progress of the MIRV project, reaching its zenith at the procurement stage when strategic roles were parcelled out between the Air Force and the Navy. In a different sense, Air Force resistance waned and waxed and waned again during the ALCM programme, as the missile went through the various stages of SCAD, long-range cruise missile, and finally the sole consolation for the cancelled B-1 bomber. Informal links of communication are reinforced by long association and comfortable working relationships, while in opposition to a weapons programme the arms control lobbies gain strength and momentum. The effects of these variables fluctuate unpredictably, and must therefore be treated as mutable.

Finally, the fourth factor which demands attention is that of

temporal location. Arms acquisition programmes do not take place in an historical vacuum; external or international events, attitudes, and conditions have an enormous impact upon any development and procurement process, most notably during the "open windows" stage described by Evangelista. Threat assessments are of necessity tailored to a specific time-frame; the justification upon which a given system is based may no longer be valid by the time that system is deployed. It would be unreasonable to expect Congress or the electorate to support, for example, an ABM system which predated inter-continental ballistic missiles, or a MIRVed missile payload programme in the absence of Soviet ABMs or a lengthy, diversified target list. In addition to these considerations, change in international tensions must be taken into account. Justifications -- such as the "maintenance of strategic superiority" -- which may have seemed appropriate in 1960 would appear to the public of the era unnecessary in 1970, provocative in 1980, and downright silly in 1990. The changing superpower relationship -- another dynamic process -- will continue to be a significant element in any future arms acquisition programmes. Does threat assessment in fact play as important a role in the process as Evangelista implies? The cases indicate that even in the absence of a predicted threat (Soviet ICBM or ABM superiority, for example), the deployment of counteractive weapons systems goes on unchecked. Perhaps the evolving strategic environment has less of an impact upon the armaments acquisitions process than Evangelista suggests. The continuation or abandonment of systems presently "in the works" will, given the new climate of US-Soviet relations, likely answer this question.

Thus, we are left with a slightly modified version of the

Evangelista Model consisting of his five stages, essentially untouched; augmented by an analysis of trends in service interaction, informal links of communication, and attitudes towards arms control; and the whole surmounted and surrounded by a careful consideration of the "era" in which the acquisition process takes place. By applying this adjusted model to other strategic arms acquisition projects, it should be possible to verify its utility as a prescriptive tool rather than a merely descriptive one. Thus far, it has proven to hold essentially true for two cases; perhaps it will also prove useful in examining and evaluating those which remain.

Despite the conclusive nature of these statements, the adjusted model presented here is far from an authoritative statement of the process by which the United States develops, acquires, and deploys strategic weapons systems. This paper is only a beginning; as the author has tested and evaluated the Evangelista Model in order to create an adjusted version, so too must others test this adjusted version against cases both similar and diverse (particularly against cases of procurement failure) in order to determine in turn its utility. However, it would appear that the adapted Evangelista Model may offer a useful means of examining and dissecting the American strategic arms acquisition process, in hopes of improving its efficiency in terms of cost, strategic planning, and effort expended in scientific research. Perhaps it may eventually serve as a means of reducing and even dismantling the larger and more wasteful elements of the armaments dynamic, whose only visible achievement beyond the maintenance of an uneasy peace is the conversion of national resources into ever more destructive -- and ever more costly -- instruments of cataclysmic warfare.

NOTES

Introduction

1. In order to ensure continuity throughout the paper, we shall employ the definition of "weapons system" offered by Knorr and Morgenstern: "The concept of a 'weapons system'...(should not) be limited to mere hardware, as is still often done, but should be understood to comprise a man-machine system, frequently of great complexity. Indeed, it should even be extended to new strategic, tactical, and logistical concepts of which new hardware is an integral part, or with which hardware is closely associated". Klaus Knorr and Oskar Morgenstern, "Science and Defense", (Princeton: Center of International Studies, 1965), p. 11. While this document is somewhat dated, the definition itself remains valid.

2. "Aggregate Destructive Power" is a term created by the author to define the cumulative effectiveness of a weapons system in terms of its range, speed and accuracy of delivery, warhead precision, readiness, operational reliability, fractionation, explosive yield, survivability, and a variety of other factors. While the overall EMT of the American strategic nuclear arsenal has decreased by half since the early 1960s, its aggregate destructive power, based inter alia on the aforementioned factors, has actually increased dramatically.

3. Matthew Evangelista, Innovation and the Arms Race, (London: Cornell University Press, 1988), p. 29, Table 2.

4. The arms acquisition process follows two separate "tracks"; that of those actions officially or legally required in order to further the process, and that of those which are unofficial or "behind-the-scenes". Evangelista's theory models the "second track".

5. Evangelista, Innovation and the Arms Race, pp. 52-53. For a more general treatment of this process, see James Kurth, "A Widening Gyre: The Logic of American Weapons Procurement", (Public Policy #19 - Summer 1971).

6. The respective Soviet armament dynamic is presented in the same chart as its American counterpart. Evangelista notes that the two systems may be differentiated between on the basis of the origin of innovative thought; US scientists tend to bring novel ideas to the attention of their superiors, resulting in a "bottom-up" flow of creativity, while Soviet scientists tend to confine themselves to research directions suggested by their supervisors -- in effect, a "top-down" stream of originality (see Evangelista, Innovation and the Arms Race, p. 27).

7. Evangelista, Innovation and the Arms Race, pp. 53-68.

8. Evangelista has chosen to define "technological innovation" as follows: "Technological innovation in weaponry is defined here as the development of a new military technology that leads to significant changes - for example, in the realm of strategy, in the organization of military forces, or in the distribution of resources among services. The term does not refer to the incremental improvements in the characteristics of weapons that arguably constitute the main activity of military research and development" (Evangelista, Innovation and the Arms Race, p. 51). This definition, which is essentially equivalent to that proposed by Knorr and Morgenstern in the subsequent paragraph, is derived from that offered by Milton Leitenberg in "The Dynamics of Military Technology Today" (International Social Science Journal 25 #3 - 1973).

9. Knorr and Morgenstern, "Science and Defense", p. 12.

10. Evangelista, Innovation and the Arms Race, p. 51.

11. Quoted in Franklin A. Long and Judith Reppy, eds., The Genesis of New Weapons: Decisionmaking for Military R&D, (New York: Pergamon Press, 1980), pp. 83-84.

Chapter One: Explaining American Strategic Arms Acquisition

1. The three additional nuclear powers are, in the order of nuclear acquisition, Great Britain (1952), France (1960), and The Peoples Republic of China (1964). India carried out a "peaceful nuclear explosion" in May of 1974, confirming its nuclear capability. The American intelligence community has indicated that it strongly suspects both Israel and South Africa of possessing nuclear weapons. A US survey satellite recorded in September of 1979 a high-intensity luminous flash in the South Atlantic; a nuclear test by one of these states was postulated. A number of other states, among them Brazil, Argentina, Iraq, and Libya have been adjudged by a variety of authorities technologically capable of constructing at the very least crude fission weapons.

2. Yet another slippery concept. Let us, in the absence of a purposeful discussion on the nature of "change for the better" (which will be reserved for chapter four) assume that the American strategic arms acquisition process might be improved by increasing efficiency, reducing political entanglements, cutting costs, and eliminating useless or unwanted systems early in the acquisition process.

3. Evangelista, Innovation and the Arms Race, pp. 69-70.

4. Ibid., pp. 53-55.

5. Ibid., pp. 55-58.

6. Ibid., pp. 59-63.
7. Ibid., pp. 63-66.
8. Ibid., pp. 66-68.
9. Ibid., p. 228. The question at hand, of course, is whether this fluctuation of emphasis is applicable to the case studies under scrutiny as well.
10. Knorr and Morgenstern, "Science and Defense", p. 13.
11. Not surprisingly, as he was reported to have been killed in the course of experimenting with the newfound technological capability.
12. Fen Osler Hampson, Unguided Missiles: How American Buys its Weapons, (New York: W.W. Norton and Company, 1989), p. 290.
13. The problems engendered by bureaucratic politics and service rigidity will be addressed more fully in later chapters.
14. Noel Gaylor in Long and Reppy, The Genesis of New Weapons, p. 34.
15. Alexander Kossiakoff, "Conception of New Defense Systems and the Role of Government R&D Centers", in Long and Reppy, The Genesis of New Weapons, p. 66.
16. Hampson, Unguided Missiles, p. 7.
17. Long and Reppy, The Genesis of New Weapons, p. 53.
18. Franklin Long and Judith Reppy, "The Decision Process for U.S. Military R&D", in Kosta Tsipis and Penny Janeway, Review of U.S. Military Research and Development 1984, (Washington D.C.: Pergamon-Brassey's, 1984), p. 18.
19. Evangelista, Innovation and the Arms Race, p. 68.
20. Knorr and Morgenstern, "Science and Defense", p. 37.
21. Evangelista, Innovation and the Arms Race, p. 33.
22. Ibid., p. 45.
23. Quoted in Marek Thee, Military Technology, Military Strategy, and the Arms Race, (London: Croom Helm, 1986), p. 32.
24. Long and Reppy, "The Decision Process for US Military R&D", in Tsipis and Janeway, Review of U.S. Military Research and Development 1984, p. 4.

25. Thee, Military Technology, p. 105.
26. Ibid., p. 103.
27. Thomas Glennan, "Policies for Military Research and Development", (The RAND Corporation, 1966), pp. 27-29.
28. One might note that the harmonious convergence of these two streams would ideally occur in Noel Gaylor's "logical world" (q.v.).
29. Thee, Military Technology, p. 127. He goes on to add that such was true for both the MIRV and the ALCM,
30. Ibid., p. 106. Note the definition of "Aggregate Destructive Power" presented in the introduction to this paper.
31. Glennan, "Policies for Military Research and Development", pp. 13-15.
32. Thee, Military Technology, p. 105.
33. Evangelista, Innovation and the Arms Race, p. 56.
34. Ibid., p. 56.
35. Ibid., p. 56.
36. Ibid., p. 59.
37. Ibid., p. 59.
38. Quoted in *ibid.*, pp. 57-58.
39. Ibid., p. 58.
40. Ibid., p. 57.
41. Ibid., p. 57.
42. Ibid., p. 57.
43. Quoted in *ibid.*, p. 57.
44. Long and Reppy, The Genesis of New Weapons, p. 39.
45. Daniel Kaufman, "The Defense Technology Community: Players and Roles", in Asa Clark and J.F. Lilley, Defense Technology, (New York: Praeger, 1989), p. 191.
46. Hampson, Unguided Missiles, p. 11.
47. Ibid., p. 11.

48. Evangelista, Innovation and the Arms Race, p. 59.
49. Which is to say, the new system does not threaten any particular service's existing systems or traditional roles or prerogatives.
50. Ibid., p. 59.
51. Thee, Military Technology, p. 120.
52. Evangelista, Innovation and the Arms Race, p. 60. See also Miroslav Nincic, The Arms Race: The Political Economy of Military Growth, (New York, 1982), chapters 2-5.
53. Quoted in Hampson, Unguided Missiles, p. 7.
54. Ibid., p. 281.
55. James Kurth, "A Widening Gyre: The Logic of American Weapons Procurement", (Public Policy #19 - Summer 1971), p. 37.
56. Evangelista, Innovation and the Arms Race, p. 65.
57. Jonathon Stein, From the H-Bomb to Star Wars, (Toronto: Lexington Books, 1984), p. 49.
58. Evangelista, Innovation and the Arms Race, p. 68.
59. Ibid., p. 65.
60. There are a variety of reasons underlying the inability of national security problems to initiate systems procurement programmes. The most important is that the procurement process is simply too slow; any system conceived to meet a specific threat would be decades late in coming into service. Imagine, for instance, a procurement programme begun "from scratch" (at the concept formulation stage), intended to produce an ICBM force for the United States -- but initiated only upon Congress' being informed of the existence of a soi-disant "missile gap". The first American missile would likely have entered operational status some time in the early 1970s, according the Soviets an unbreakable lead.
- The second reason relates to the rationales underlying given systems. These change with time, and rarely 's any system, in the final analysis, deployed to meet the threat it was originally intended to counter. For example, the MIRV warhead system was initially envisioned as a means of increasing American coverage of Soviet targets without incurring the expense of thousands of additional launchers and silos or submarines; however, it was justified for deployment on the basis of its (postulated) ABM penetration capability. In short, while external threats may add momentum to a given weapons programme, they are incapable of generating one in the absence of the aforementioned accompanying factors.
61. Quoted in Evangelista, Innovation and the Arms Race, p. 13.

62. Quoted in Thee, Military Technology, p. 32.

63. Ibid., p. 67.

64. Scilla Mclean, ed., How Nuclear Weapons Decisions Are Made, (New York: St. Martin's Press, 1986), p. 62.

65. Ibid., p. 62.

66. Ibid., pp. 62-63. One might liken the acquisition process to a train engine. Starting out in the marshalling yard, the lone engine and its caboose move slowly. Given time and the additional of several cars, the train will gather both speed and momentum (a function of speed and mass). The analogy extends to the systems acquisition process, where the engine represents the system itself, and the cars those soldiers, politicians, and technocrats which may have attached their influence to its success. Halting a well-supported systems acquisition process in full swing is a difficult -- and potentially as disruptive -- as stopping a heavily-laden train.

67. Ibid., pp. 62-63.

68. Quoted in Thee, Military Technology, p. 44.

69. Robert Haffa, Planning US Forces, (Washington D.C.: National Defense University Press, 1988), p. 13.

70. Quoted in Thee, Military Technology, p. 45.

71. Ibid., p. 37.

72. Ibid., p. 47.

73. Evangelista, Innovation and the Arms Race, p. 51.

Chapter Two: Acquiring the MIRV

1. McGeorge Bundy, Danger and Survival: Choices About the Bomb in the First Fifty Years, (New York: Vintage Books, 1989), p. 544; see also Ted Greenwood, Making the MIRV, p. xiii.

2. Mclean, How Nuclear Weapons Decisions are Made, pp. 78-79.

3. Ronald Tammen, MIRV and the Arms Race: an Interpretation of Defense Strategy, (New York: Praeger Publishers, 1983), p. 37.

4. Greenwood, Making the MIRV, p. 27.

5. Thee, Military Technology, p. 48.

6. Lawrence Freedman, The Evolution of Nuclear Strategy. (London: The MacMillan Press, 1983), p. 353.

7. It matters little whether one strikes a city with a warhead of 100 kilotons, or one of 2 megatons; the sole difference (collateral damage aside) lies in the killing of, respectively, 50 percent or 90 percent of the populace. Either blast is sufficient to destroy any city in the world today, as well as rendering it uninhabitable for quite some time. It has been said that the difference will lie only in the depth of the rubble.

8. Ibid., p. 352.

9. Tammen, MIRV and the Arms Race, p. 78.

10. Ibid., p. 81.

11. Greenwood, Making the MIRV, p. 3.

12. The author considers the American SDI project one such.

13. Ibid., p. 20.

14. Tammen, MIRV and the Arms Race, p. 91.

15. Greenwood, Making the MIRV, p. 13.

16. After 1967, BSD came to be known as the Space and Missile Systems Organization.

17. Thee, Military Technology, pp. 31-32.

18. Greenwood, Making the MIRV, p. 19.

19. Ibid., p. 35.

20. Ibid., p. 29.

21. Ibid., pp. 16-17.

22. Ibid., p. 47.

23. Ibid., p. 20.

24. Despite the fact that most of them had never experienced an atomic explosion of any size, and that all failed to accept that a city destroyed by a 100 kt bomb is just as poorly off as one destroyed by a 20 Mt bomb. The term "Destroyed" is, after all, an absolute -- not a relative.

25. Ibid., p. 37.

26. Ibid., p. 22.
27. Ibid., p. 37.
28. Ibid., p. 16.
29. Tammen, MIRV and the Arms Race, p. 99.
30. Mclean, How Nuclear Weapons Decisions are Made, p. 79.
31. Evangelista, Innovation and the Arms Race, p. 63.
32. And an ABM deployment which, apparently, strategists expected to spring into being practically overnight.
33. Tammen, MIRV and the Arms Race, p. 104.
34. Ibid., p. 106.
35. Mclean, How Nuclear Weapons Decisions are Made, p. 79.
36. Greenwood, Making the MIRV, p. 75.
37. Tammen, MIRV and the Arms Race, p. 94.
38. American political animals seem almost pathologically concerned with the maintenance of the "moral high ground" over their Soviet counterparts.
39. Quoted in *ibid.*, pp. 71-72.
40. Ibid., p. 72.
41. Ibid., p. 73.
42. Mclean, How Nuclear Weapons Decisions are Made, p. 81.
43. Tammen, MIRV and the Arms Race, p. 73.
44. Ibid., p. 77.
45. Ibid., p. 103.
46. Ibid., p. 103.
47. Ibid., p. 98.
48. Thee, Military Technology, p. 31.
49. Penetration of the defended single city and ICBM-field sites permitted under the Treaty would not have been by any stretch of the imagination a daunting task; both superpowers possess sufficient numbers

of strategic warheads to saturate the two potentially protected targets hundreds of times over.

50. Evangelista, Innovation and the Arms Race, p. 66.

51. One might speculate that Johnson, by advocating deployments "in response to Soviet activities" was successful, where Goldwater, advocating deployments for the sole sake of increasing American strategic supremacy, was not. This is a clear illustration of the power of the "moral high ground".

52. Greenwood, Making the MIRV, p. 127.

53. Charles-Philippe David, Debating Counterforce: A Conventional Approach in a Nuclear Age, (Boulder, CO.: Westview Press, 1987), p. 153.

54. Tammen, MIRV and the Arms Race, pp. 78-79.

55. Quoted in *ibid.*, p. 106.

56. Greenwood, Making the MIRV, p. 15.

57. *Ibid.*, p. 15. This may have been a holdover from the right-wing McCarthyist era, when anyone not advocating massive defence expenditures was likely to be labelled a Communist sympathizer.

58. *Ibid.*, p. 107.

59. *Ibid.*, p. 73.

60. *Ibid.*, p. 77.

61. Evangelista, Innovation and the Arms Race, p. 56.

62. Greenwood, Making the MIRV, p. 47.

63. The "military-industrial-technological-bureaucratic" complex of Marek Thee's creation might well serve as an appropriate term for this unwieldy entity.

64. Each service often appears to feel itself capable of defending the nation without the assistance of the other two.

65. David, Debating Counterforce, p. 153. He cautions the reader that the "destructive avarice" displayed by military men is motivated more by an honest desire to serve the interests of the country to the best of their ability than by self-serving or bureaucratic motivations. Unfortunately, he adds (quoting Kanter), the quest for new systems is often undertaken at the expense of other actors and their material requirements.

66. Tammen, MIRV and the Arms Race, p. 78.

67. The aforementioned counterforce policy.

68. Bundy, Danger and Survival, p. 551.

69. Evangelista, Innovation and the Arms Race, pp. 63-64.

70. Improvements in detection, interception, terminal defence, and air defence technologies over the past thirty years have very likely rendered the manned bomber, if not obsolete, then at least a highly risky proposition. Nonetheless, enormously costly programmes perpetuate antiquated traditions; with the exception of America's supercarriers, the B-2 "Stealth" bomber is the worst case of "all-the-eggs-in-one-basket" ever created by the American technical community. One might speculate (and Hampson insists) that successive administrations have feared the potential backlash of attempting to take penetrating aircraft away from the Air Force.

71. Greenwood, Making the MIRV, p. 19.

72. Ibid., p. 36.

73. Tammen, MIRV and the Arms Race, p. 89.

74. Greenwood, Making the MIRV, pp. 54-55.

75. This demonstrates an effort on the part of the Navy to counterbalance by large numbers of RVs the strategically dominant role of the Air Force. Ironically, the US SSBN force seems today to represent the most stabilizing and effective element of the American strategic triad.

76. Mclean, How Nuclear Weapons Decisions are Made, p. 82.

77. Greenwood, Making the MIRV, p. 79.

78. David, Debating Counterforce, p. 153.

79. Ibid., p. 155.

80. Mclean, How Nuclear Weapons Decisions are Made, pp. 81-82.

81. Tammen, MIRV and the Arms Race, p. 107.

82. Quoted in Thee, Military Technology, p. 30.

83. Quoted in Greenwood, Making the MIRV, p. 49.

84. Ibid., p. 49.

85. Mclean, How Nuclear Weapons Decisions are Made, p. 78.

86. Greenwood, Making the MIRV, p. 26.

87. Ibid., p. 47.

88. Ibid., p. 26.

89. Greenwood also notes that since 1958 (until at least 1975) the position of DDR&E was awarded to an ex-Director of Livermore Laboratories - the official sanction, one might suggest, of the maintenance of strong informal communication links between essentially unrelated organizations in order to facilitate the research process.

90. Ibid., p. 22.

91. Ibid., p. 21.

92. Greenwood, Making the MIRV, p. 16.

93. Ibid., p. 23.

94. Ibid., p. 24.

95. Tammen, MIRV and the Arms Race, p. 79.

96. Greenwood, Making the MIRV, p. 16.

97. Ibid., p. 23.

Chapter Three: Acquiring the ALCM

1. Phillip J. Gaddes, "The Cruise Missile Era Dawns", Interavia, (September 1982), p. 1.

2. The general trend would seem to indicate that Soviet developments are made in response to an American innovation, while American developmental responses occur with respect to the massive production and deployment of a Soviet system. In the vulgar brevity espoused by conventional wisdom, the United States relies upon quality production for strategic superiority, while the Soviet Union attempts to achieve quantity (perhaps in an echo of Stalin's "Quantity has a quality all its own").

3. Thee, Military Technology, p. 34.

4. Sheena Phillips, "Cruise Missiles", in Kosta Tsipis and Sheena Phillips, Annual Review of Military Research and Development 1982, (New York: Praeger, 1983), p. 163.

5. Ibid., p. 170.

6. Simon Rosenblum, Misguided Missiles: Canada, the Cruise, and Star

Wars, (Toronto: James Lorimer and Company, 1985), p. 26.

7. Thee, Military Technology, p. 35.

8. Ibid., p. 34.

9. Rosenblum, Misguided Missiles, p. 35.

10. Ibid., p. 40.

11. After all, it is difficult for a military service to offer credible objections to an increase in the operational capabilities of a new weapons system.

12. Gaddes, "The Cruise Missile Era Dawns", p. 3.

13. Robert J. Art and Stephen E. Ockenden, "The Domestic Politics of Cruise Missile Development", in Richard K. Betts, ed., Cruise Missiles: Technology, Strategy, and Politics, (Washington D.C.: The Brookings Institution, 1981), p. 366.

14. Charles A. Sorrels, US Cruise Missile Programs, (USA: McGraw-Hill, 1983), p. 21.

15. Phillips, "Cruise Missiles", p. 163.

16. Sorrels, US Cruise Missile Programs, p. 6.

17. Rose E. Gottemoell, "Land-Attack Cruise Missiles", Adelphi Paper no. 226, (London: The International Institute for Strategic Studies, 1987), p. 3.

18. Rosenblum, Misguided Missiles, p. 35.

19. Gottemoell, "Land-Attack Cruise Missiles", pp. 15-17.

20. George J. Seiler, Strategic Nuclear Force Requirements and Issues, (Alabama: Air University Press, 1983), p. 137.

21. Gottemoell, "Land-Attack Cruise Missiles", p. 14.

22. Seiler, Strategic Nuclear Force Requirements and Issues, p. 137.

23. It might be argued that high fractionation puts the carrier vehicle at greater risk by making it a choicer target for neutralization. The cost-effectiveness argument presented by Gottemoell ignores this point, suggesting only that carrier vehicle vulnerability may be offset by the higher weapon numbers allowed by a lower unit cost (see Gaddes, "The Cruise Missile Era Dawns", p. 1).

24. While neither the B-1 nor the B-2 had yet come to light, strategic planners were able to read the fiscal writing on the wall.

25. Seiler, Strategic Nuclear Force Requirements and Issues, pp. 137-138.

26. Ron Huiskens, "The History of Modern Cruise Missile Programs", in Richard K. Betts, ed., Cruise Missiles: Technology, Strategy, and Politics, (Washington D.C.: The Brookings Institution, 1981), p. 88.

27. Ibid., p. 95.

28. Ibid., p. 89.

29. Rosenblum, Misguided Missiles, p. 41.

30. That is to say, Soviet air defences have never been tested extensively by manned penetrating American bombers. Neither Korean Air Lines flight 007 nor the Cessna piloted by Mathias Rust may be considered an accurate test of Soviet air defence reliability.

31. Ibid., p. 29.

32. This last point, while obviously cynical, is not off base. SALT I restricted the development and deployment of more than a single new ballistic missile, ICBMs being at the time the mainstay of both American and Soviet strategic power. Obviously, Laird felt that the services required appeasement in order to ensure their support in future arms control efforts.

33. Art and Ockenden, "The Domestic Politics of Cruise Missile Development", p. 411.

34. Ibid., p. 361.

35. Thee, Military Technology, pp. 33-34.

36. Sorrels, US Cruise Missile Programs, p. 19.

37. Rosenblum, Misguided Missiles, p. 30.

38. Huiskens, "The History of Modern Cruise Missile Programs", pp. 95-96.

39. Gaddes, "The Cruise Missile Era Dawns", pp. 1-2.

40. Rosenblum, Misguided Missiles, p. 27.

41. It would appear in retrospect that the B-52/cruise combination was an attempt to avoid the purchase of excessive numbers of the increasingly expensive B-1. Once the concept of a standoff bomber had been arrived at, it became rapidly apparent that penetrating bombers of necessity courted risks which -- in view of the new capabilities offered by the cruise missile -- were essentially unnecessary.

Rosenblum adds that Secretary of State Henry Kissinger provided an invaluable impetus to the ALCM programme in his search for a SALT II bargaining chip: "The cruise missile program might have foundered had it not been for SoS Henry Kissinger, who was looking for 'marginal' systems that could be bargained away. Kissinger in particular saw the air-launched cruise missile as a bargaining chip to trade away if the Soviet Union would agree not to produce mobile land-based missiles" (Rosenblum, Misguided Missiles, p. 29).

42. Art and Ockenden, "The Domestic Politics of Cruise Missile Development", p. 362.

43. Hampson, Unguided Missiles, p. 197.

44. Gottemoell, "Land-Attack Cruise Missiles", p. 16.

45. Art and Ockenden, "The Domestic Politics of Cruise Missile Development", p. 360.

46. Ibid., p. 413.

47. Huiskens, "The History of Modern Cruise Missile Programs", p. 91.

48. Gottemoell, "Land-Attack Cruise Missiles", p. 5.

49. Hampson, Unguided Missiles, p. 184.

50. The use of a military conversion of the Boeing-747 "Jumbo" jet liner as a "soft" cruise missile carrier aircraft (CMCA) was examined by the JSBS and found to be risky due to excessive concentration of striking power in a single aircraft or group of aircraft (see note #22 above).

51. Ibid., p. 182.

52. Huiskens, "The History of Modern Cruise Missile Programs", p. 87.

53. Hampson, Unguided Missiles, p. 184. See also Art and Ockenden, "The Domestic Politics of Cruise Missile Development".

54. Sorrels, US Cruise Missile Programs, p. 20.

55. That is to say, logically baseless; zero equals zero.

56. Hampson, Unguided Missiles, p. 190.

57. Ibid., p. 186. Hampson also notes that, in an effort to cut the costs of the B-1 project and rescue it from oblivion, the Air Force was prepared to eliminate from the new bomber the sophisticated ECM equipment which would have made enemy airspace penetration possible. Without such equipment, the B-1 would have been a less effective penetrator than the B-52. Such a willingness to throw out with the bathwater not only the baby but the bathtub as well is a clear indication

of the extent of the Air Force's panic in this matter.

58. Ibid., p. 186.

59. Art and Ockenden, "The Domestic Politics of Cruise Missile Development", p. 373.

60. A careful study of the geography of the Soviet Union shows that approximately 90% of Soviet land area is within 2000 kilometres of a coastline. Cruise missile coverage, given a world-wide forward basing system, can be exceptionally extensive.

61. Ibid., p. 368.

62. Rosenblum, Misguided Missiles, p. 36.

63. Hampson, Unguided Missiles, pp. 289-290.

64. See Hampson, Unguided Missiles, pp. 196-198 for a further discussion of this dilemma.

65. Art and Ockenden, "The Domestic Politics of Cruise Missile Development", p. 379.

66. Quoted in Thee, Military Technology, p. 33.

67. Art and Ockenden, "The Domestic Politics of Cruise Missile Development", p. 360.

68. Gaddes, "The Cruise Missile Era Dawns", p. 1.

Chapter Four: Concluding Observations

1. The bi-directional nature of the American armaments acquisition process is to a certain extent implicit in Evangelista's Model. The fact that higher-level decisionmakers play such a significant role in the "promotion" and "higher-level endorsement" stages of the process indicates a degree of influence over the process itself. As stated, the Air Force made use of this influence to alter the shape of the final product of the development process; other higher-level actors are capable of the same.

2. Hampson refers informally to such individuals as "champions" and "detractors" depending respectively upon whether that individual supports or opposes the development of the system in question.

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- Fen Osler Hampson, Unguided Missiles: How America Buys its Weapons, (New York: W.W. Norton and Company, 1989), pp. 349-52.

ABM: Anti-Ballistic Missile

ACDA: The Arms Control and Disarmament Association

ADP: Aggregate Destructive Power

AEC: Atomic Energy Commission

ALCM: Air-Launched Cruise Missile

ASM: Air-Surface Missile

Ballistic Missile: A missile propelled upward by a rocket motor, which is returned to earth by gravity.

BMD: Ballistic Missile Defence

C3I: See-Cubed-Eye, or Command, Control, Communications, and Intelligence (the human elements of the nuclear operations control chain).

CEP: Circular Error Probable (the radius within which 50% of warheads will impact if aimed at the same target - a measure of missile accuracy).

Conventional: The term applied to any element of a state's military potential exclusive of nuclear, chemical, or biological capabilities.

Counterforce: Operations in which the opponent's military potential is

targeted.

Countervalue: Operations in which the opponent's population and industrial centres are targeted.

Cruise Missile: An air-breathing weapon delivery vehicle kept in flight by wings and a jet engine.

DDR&E: Directorate (Director) of Defence Research and Engineering

Dual-Capable Systems: Weapons systems capable of carrying and/or launching either conventional or nuclear warheads.

DOD: Department of Defense (United States of America)

DOE: Department of Energy (United States of America)

EMT: Equivalent Megatonnage (a measure of the yield of one or more nuclear weapons, adjusted to allow for a variety of limiting effects).

ESECS: European Security Study

FBM: Fleet Ballistic Missile (that missile carried by an SSBN).

First Strike: A pre-emptive attack intended to eliminate an opponent's strategic offensive systems (including perhaps his C3I potential). Such a capability is dependent upon high speed, flexibility, reliability, and accuracy of one's strategic forces.

First Use: The initial employment of nuclear weapons in a conflict.

FOBS: Fractional Orbital Bombardment System (a depressed-trajectory delivery system allowing reduced time for radar detection).

Galoche (Galosh): The Soviet ABM system deployed around Moscow.

GLCM: Ground-Launched Cruise Missile (Eliminated by the Intermediate-Range Nuclear Forces Accord of December 1987).

Hard Target: A defended (by BMD) or hardened (rendered physically tougher) site - usually command centres, missile silos, and the like.

ICBM: Inter-Continental Ballistic Missile (range 5500+ kilometres).

IRBM: Intermediate-Range Ballistic Missile (range 1500-3000 kilometres).

JCS: Joint Chiefs of Staff (United States of America)

Kiloton (kt): The nuclear explosive equivalent of 1,000 tons of TNT (tri-nitro toluene).

MAD: Mutual Assured Destruction - the recognition that a global nuclear

conflict would inevitably result in totally unacceptable damage to both parties. This is a concept of reciprocal deterrence depending upon the ability of both sides to retain a decisive retaliatory force even after having absorbed a first strike.

MARV: Manoeuvrable Re-entry Vehicle (providing improved accuracy and avoidance of terminal ABM defences).

Massive Retaliation (MR): The act of inflicting a crushing nuclear attack upon an opponent in response to any aggressive act serious enough to warrant such action.

Megaton (Mt): The nuclear explosive equivalent of 1,000,000 tons of TNT (tri-nitro toluene).

MIRV: Multiple Independently-targetable Re-entry Vehicles (numerous warheads per launcher, arranged on a 'bus', each of which may be directed toward a different target).

MRBM: Medium-Range Ballistic Missile (range 600-1500 kilometres)

NASA: National Aeronautics and Space Administration

NATO: The North Atlantic Treaty Organization

NSC: National Security Council (United States of America)

(S)NDV: (Strategic) Nuclear Delivery Vehicle (land or sea-based missiles, and nuclear-capable aircraft rather than air-delivered weapons themselves).

NORAD: North American Air Defence Command

OSD: Office of the Secretary of Defence

OTH Radar: Over-The-Horizon radar (used to detect missiles and aircraft not in line-of-sight).

OTH-B Radar: As above, but making use of atmospheric scattering to increase detection range.

Overkill: Destructive capacity well in excess of what would be logically required to attain specific security objectives.

Parity (Essential): A condition in which opposing forces are roughly equivalent in overall effectiveness. Essential Parity, or Essential Equivalence, is a statement that while differences in force structures and individual system effectiveness may exist, the capacities of the two opposing sides are more-or-less comparable.

R&D / R and D: Research and Development

SAC: Strategic Air Command (United States of America)

Second Strike: Generally is used to describe a retaliatory operation undertaken after an opponent has launched a first strike (q.v.). Such a capability is dependent more upon the survivability of one's strategic arsenal than accuracy or speed of delivery.

SDI: Strategic Defence Initiative

SLBM: Submarine-Launched Ballistic Missile

SLCM: Sea-Launched Cruise Missile

Soft Target: An unprotected or unhardened site, such as an industrial area, a city, or an undefended missile base or operations centre.

SOS: Secretary of State

SRAM: Short-Range Attack Missile (an air-delivered nuclear missile designed to penetrate terminal bomber defences).

SSBN: A nuclear-propelled submarine capable of launching SLBMs (and possibly SLCMs).

Throw-weight: The total mass of the combined payload (warheads, decoys, and bus) which a given missile can carry - generally expressed in tonnes.

Triad: Refers to the three 'legs' of the US strategic nuclear forces - air-breathing (manned bombers), land-based (ICBMs), and sea-based (SSBNs).

Yield: The energy released by a nuclear explosion, expressed in either kilotons or megatons.

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