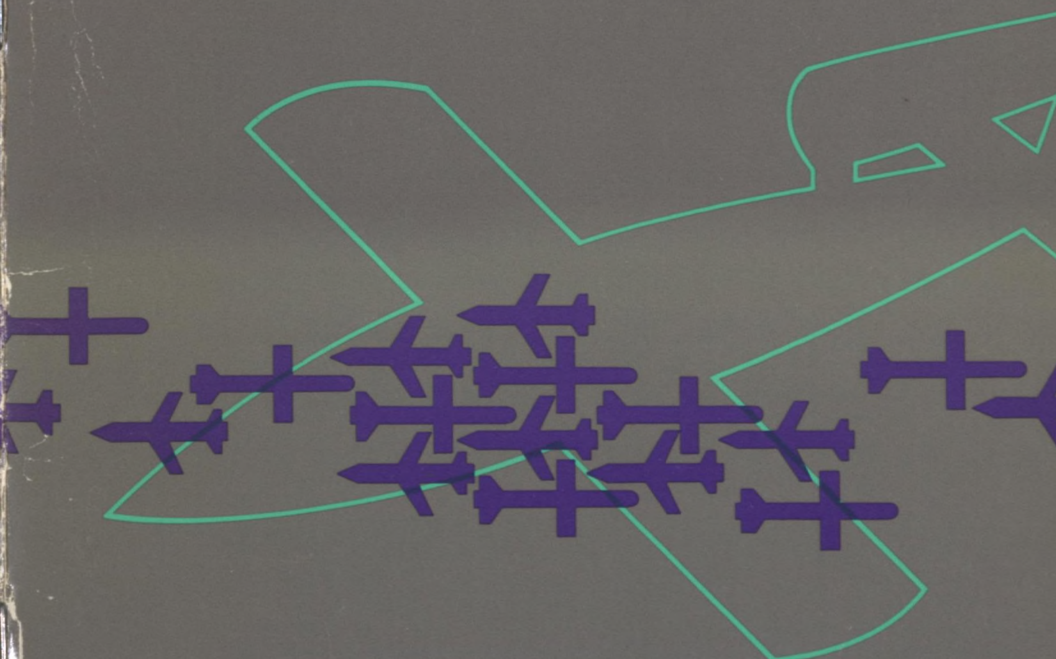
doc
CA1
EA365
88V04
ENG

External Affairs Canada
Affaires extérieures Canada

CRUISE MISSILES

Background, Technology and Verification



Verification Brochure No. 4

Extract from the INF Treaty Elimination Protocol

For the BGM-109G:

Missile:

(a) missile airframe shall be cut longitudinally into two pieces;

(b) wings and tail section shall be severed from missile airframe at locations that are not assembly joints; and

(c) front section, minus nuclear warhead device and guidance elements, shall be crushed or flattened.

Launch Canister:

launch canister shall be crushed, flattened, cut into two pieces of approximately equal size or destroyed by explosion.

Launcher:

(a) erector-launcher mechanism shall be removed from launcher chassis;

(b) all components of erector-launcher mechanism shall be cut at locations that a assembly joints into two pieces of approximately equal size;

(c) missile launch support equipment, including external instrumentation shall be removed from launcher chassis; and

(d) launcher chassis shall be cut at a location that is not an asse pieces of approximately equal size.

For the SSC-X-4:

Missile:

(a) missile airframe shall be cut longitudin

(b) wings and tail section shall be sev not assembly joints; and

(c) front section, minus nucl or flattened.

Launch Canister:

launch cani equal si

Launcher:

(a)

The air-launched cruise missile with its long flight time and its relatively slow recallable carrier is currently among the most stabilizing elements of nuclear deterrent forces. However, we believe that it too should be subject to arms control restraints.

The Right Honourable
Joe Clark,
Secretary of State
for External Affairs,
Speaking in the House
of Commons,
6 March 1987

43-251-006

b2215895(E)

43V04

CRUISE MISSILES

Background, Technology and Verification

Dept. of External Affairs
Min. des Affaires extérieures

OCT 22 1992

RETURN TO DEPARTMENTAL LIBRARY
RETOURNER A LA BIBLIOTHEQUE DU MINISTERE

The graphic on the upper part of the cover page represents the ongoing dialogue on arms control and disarmament issues in Canada and between Canadians and the world community.

On peut se procurer une version française de cette étude en écrivant à l'adresse suivante :

Direction du contrôle des
armements et du
désarmement
Ministère des Affaires
extérieures
Tour A
125, promenade Sussex
Ottawa (Ontario)
Canada
K1A 0G2

Department of External
Affairs
ISBN 0-662-16503-9
ISSN 0830-923X

Table of Contents

Figures

Introduction

Introduction

Cruise missiles have been of particular interest to Canadians. Initially, this interest was stimulated by a degree of controversy surrounding the Canadian government's decision to permit flight testing of the air-launched cruise missile on a co-operative basis with the United States. The Canadian government's decision was made as an effective method of contributing to collective security within the framework of the North Atlantic Treaty Organization. It followed from a long standing policy of providing Arctic testing for a variety of allied weapons systems.

More recent interest in cruise missiles follows from the fact that controls on ground-launched cruise missiles, which have a degree of commonality with some air-launched systems, form a key element of the INF Treaty signed in Washington on 8 December 1987. The INF Treaty is the first significant disarmament agreement dealing with nuclear systems. NATO's determination to deploy, if necessary, a limited number of ground-launched cruise missiles and Pershing II ballistic missiles played a significant role in successfully negotiating the INF Treaty.

An additional cause of interest relates to the control of sea-launched cruise missiles. This subject is an important matter of discussion between the United States and the Soviet Union in the context of deep cuts in their overall nuclear arsenals.

In order to describe the basic role of cruise missiles today, this brochure begins with a brief discussion of their construction and capabilities as well as the history of their development. It is critical to realize, in this context, that the modern strategic air-launched cruise missile evolved in order to prevent the relatively slow-flying and recallable manned bomber forces from becoming obsolete. These bomber forces were in danger of being replaced by highly accurate and swift ballistic missiles, which entailed significant risks for strategic stability.

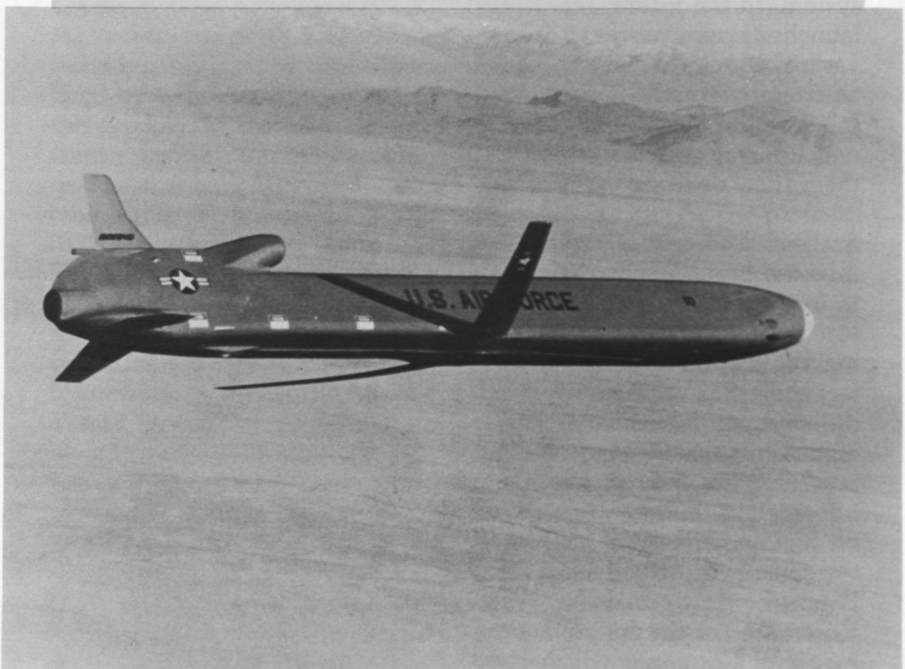
The brochure also examines existing arms control agreements pertaining to cruise missiles, paying particular attention to the issue of how they are verified.

Simply put, past arms control agreements show that air-launched cruise missiles have been verified by their carriers (i.e., bombers) and ground-launched cruise missiles by focussing inspections and monitoring devices on their extensive cruise missile support system. In the future, sea-launched cruise missiles may be verified by a combination of co-operative methods such as, for example, restrictions on which naval vessels can carry them (i.e., dedicated platforms).

Successful control of cruise missiles, besides being valuable in its own right, will inevitably teach important lessons respecting verification and other matters for future arms control and disarmament agreements. The material in this brochure is presented not only to provide information on an issue of interest to Canadians, but also in the same spirit as the June 1986 Report of the Special Joint Committee of the Senate and House of Commons which states:

> *We believe that it is necessary to enhance strategic stability by pursuing arms control and that the best path forward is one that includes mutual agreements, balanced and deep reductions, and adequate means of verification.*

Figure 1 Cruise Missile in Free Flight



Courtesy of the U.S. Government

Background

Chapter 1

Background

The last 100 years have seen a revolution in the science and technology of weapons. Perhaps the greatest overall change has been created by the development of nuclear weapons and their delivery systems. Since the Second World War, ballistic missiles and bombers carrying nuclear weapons have played the leading role in shaping the military strategic relationship between the superpowers, with profound effects on international relations in general.

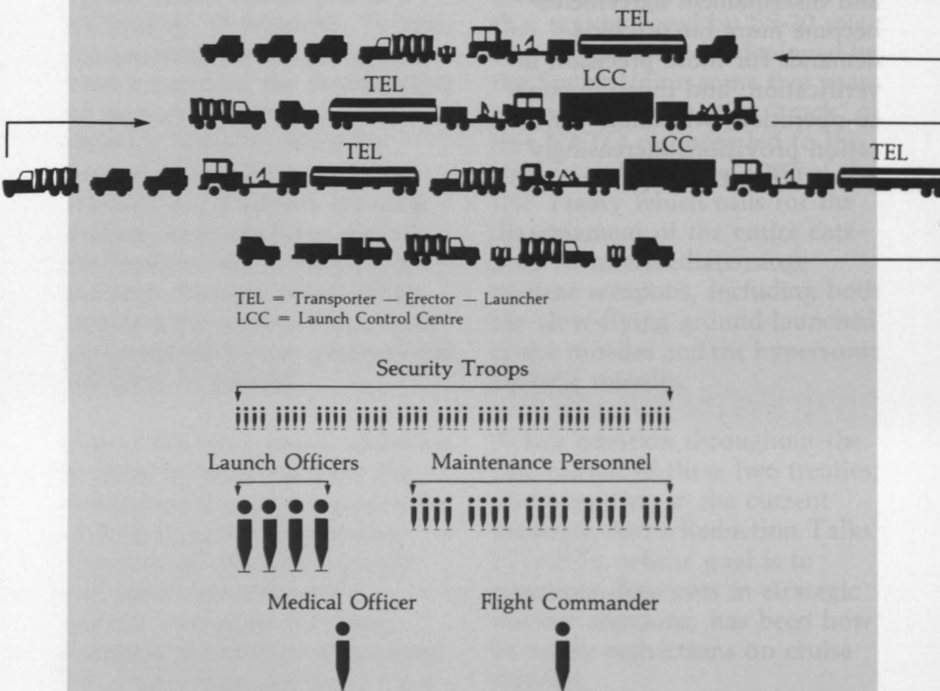
One of the most recent additions to these systems has been the development of a new generation of long-range cruise missiles. These small, pilotless aircraft can carry conventional or nuclear warheads over long distances and with great accuracy. They have been deployed on a wide range of launch platforms to fulfill a variety of missions. Air- and ground-launched cruise missiles have also been subject to arms control agreements.

Initially, air-launched cruise missiles, deployed to enhance the effectiveness and extend the life of manned bombers, were limited under the SALT II Treaty. Ground-launched cruise missiles were deployed by the United States in Europe starting in 1983 as part of NATO's "two-track" response to the threat to that region posed by SS-20 missiles which had been deployed by the Soviet Union some five years earlier. The negotiating "track" of this NATO response led to the signing in December 1987 of the INF Treaty which calls for the disarmament of the entire category of intermediate-range nuclear weapons, including both the slow-flying ground-launched cruise missiles and the hypersonic ballistic missiles.

A key question throughout the negotiation of these two treaties, and persisting in the current Strategic Arms Reduction Talks (START), whose goal is to negotiate deep cuts in strategic nuclear weapons, has been how to verify restrictions on cruise missiles.

Verification responds to the need to check independently the information provided by other governments and to ascertain that they are, in fact, complying with the rules by which they have agreed to abide. The verification provisions of the recent INF Treaty are far more complex, and require more co-operation between the U.S.A. and the U.S.S.R., than did those of the SALT II Treaty or any of its predecessors. As arms control and disarmament agreements become more far-reaching, demands for more precision in verification, and thus for more co-operation, will make verification provisions increasingly more difficult to negotiate.

Figure 2 Ground-Launch Cruise Missile "Flight" Organization



Courtesy of the U.S. Government

What is a Cruise Missile?

Chapter 2

What is a Cruise Missile?

Definition

Although some missiles can readily be recognized as "cruise missiles," it is not easy to reach a consensus on a precise definition. The only internationally agreed definition was negotiated by the United States and the Soviet Union in their Strategic Arms Limitation Talks (SALT II). The SALT II Treaty defines cruise missiles to be:

> *...unmanned, self-propelled, guided, weapon-delivery vehicles, which sustain flight through the use of aerodynamic lift over most of their flight path.*

This very broad definition encompasses a large variety of missiles, since it does not specify whether they are powered by rockets or by turbine engines, whether they can fly long or short distances, whether they carry nuclear or conventional explosives, whether they are self-guided or controlled remotely and so on. Within the SALT II Treaty, it is made clear that cruise missiles with ranges exceeding 600 km are considered part of a "strategic" system when carried by long-range bombers. For this reason, only air-launched cruise missiles fall within the scope of the Treaty itself.

There are many designs of air-launched cruise missiles (ALCMs) in use today, though only two of these are constrained by the SALT II Treaty (see Figure 3). Furthermore, many nations have the capability to produce shorter-range cruise missiles.

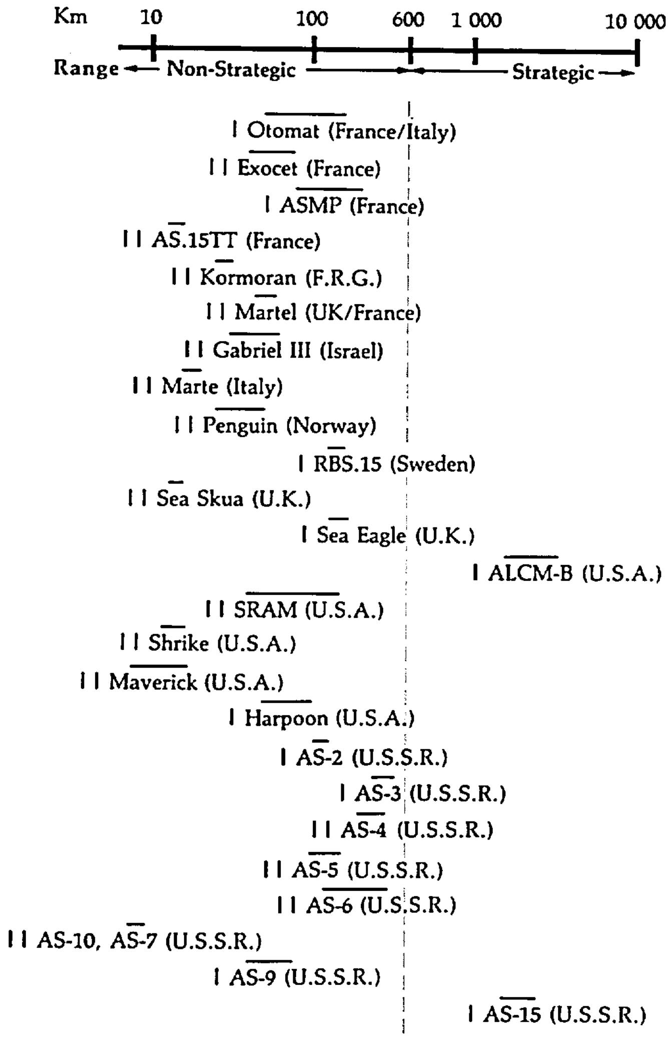
One way to focus the discussion is to eliminate consideration of rocket-powered cruise missiles, and concentrate exclusively on systems with turbine engines. Rocket-powered missiles tend to have short ranges, and so are not, in general, part of "strategic" weapon systems. Missiles powered by turbine engines, on the other hand, tend to be used not only as relatively short-range missiles, but also as long-range "strategic" missiles. Similar trends hold true for current sea-launched cruise missiles (SLCMs). The following discussion will focus on these longer-range, turbine engine powered or "air-breathing," cruise missiles.

Cruise Missile Design

According to the modified definition above, for our purposes, a cruise missile is essentially a pilotless aircraft. It is composed of:

- the airframe and its control system;
- an air-breathing engine;

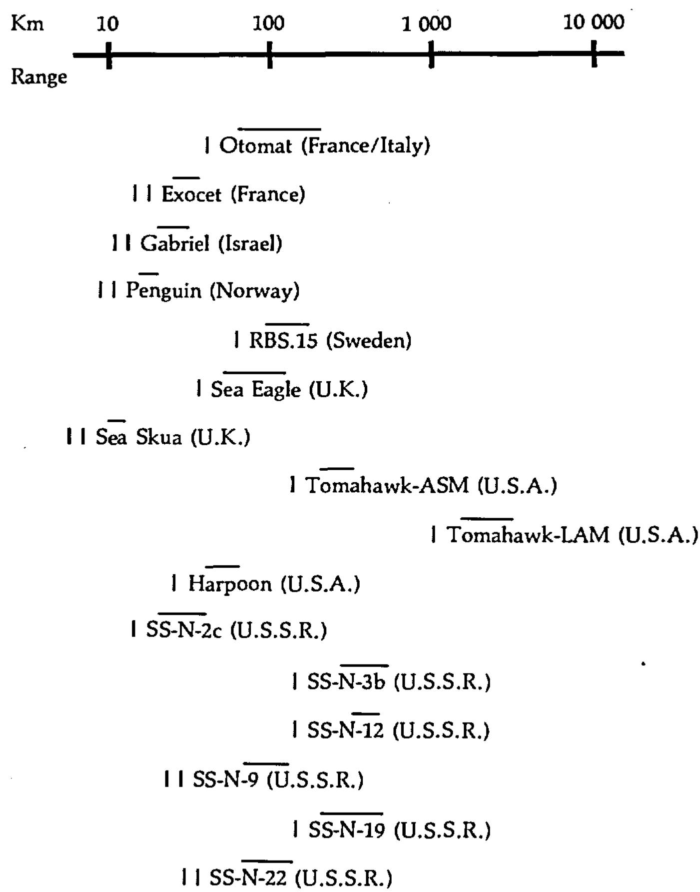
Figure 3 Current Air-Launched Cruise Missiles (According to *Jane's Weapons Systems* 1987–1988)*



I I = Rocket Powered I = Air Breathing ——— = Range

**Some missiles excluded due to insufficient data*

Figure 4 Current Sea-Launched Cruise Missiles
(According to *Jane's Weapons Systems*, 1987–1988)*



I I = Rocket Powered I = Air Breathing ——— = Range

**Some missiles excluded due to insufficient data.*

- fuel;
- a guidance and navigation system;
- a warhead; and
- rocket boost motor.

The Support System
Any cruise missile must have a support system to be effective. This system must:

- keep the missile safe in storage until needed;
- make sure the missile and its launcher work, and perform maintenance when necessary;
- transport it to an appropriate launch point when required;
- tell it where its target is and how to fly there; and
- launch it on command from the proper authority.

These requirements mean that the support system for any single missile is quite large. For this reason, missiles are usually organized into groups to make the support system more efficient.

Up to now, not much has been generally known about the Soviet method of supporting cruise missiles, since the U.S.S.R. has not published such information. Therefore the general public, analysts and critics have tended to focus on the U.S.A.'s cruise missile programs because of the availability of information from the United States government.

The United States organized its ground-launched cruise missiles (GLCMs) in Europe into "flights" of 16 missiles. A "flight" consisted of the following:

- two launch control centres (LCCs);
- four transporter-erector-launchers (TELs) (each carrying four *Gryphon* cruise missiles);
- sixteen support trucks; and
- the following personnel:
  - — 1 flight commander
  - — 4 launch officers
  - — 19 maintenance personnel
  - — 44 security troops
  - — 1 medical officer

The six critical vehicles — the two launch control centres and the four transporter-erector-launchers — are all massive 36 tonne tractor-trailers. The entire "flight" is housed in reinforced shelters. Only in case of war, or during practice dispersals, would a flight emerge from its shelters and disperse from its home base.

For cruise missiles launched from aircraft, ships, or submarines, the support system is analogous in size and complexity (though, of course, the specifics will vary).

Figure 5 Cruise Missile Schematic

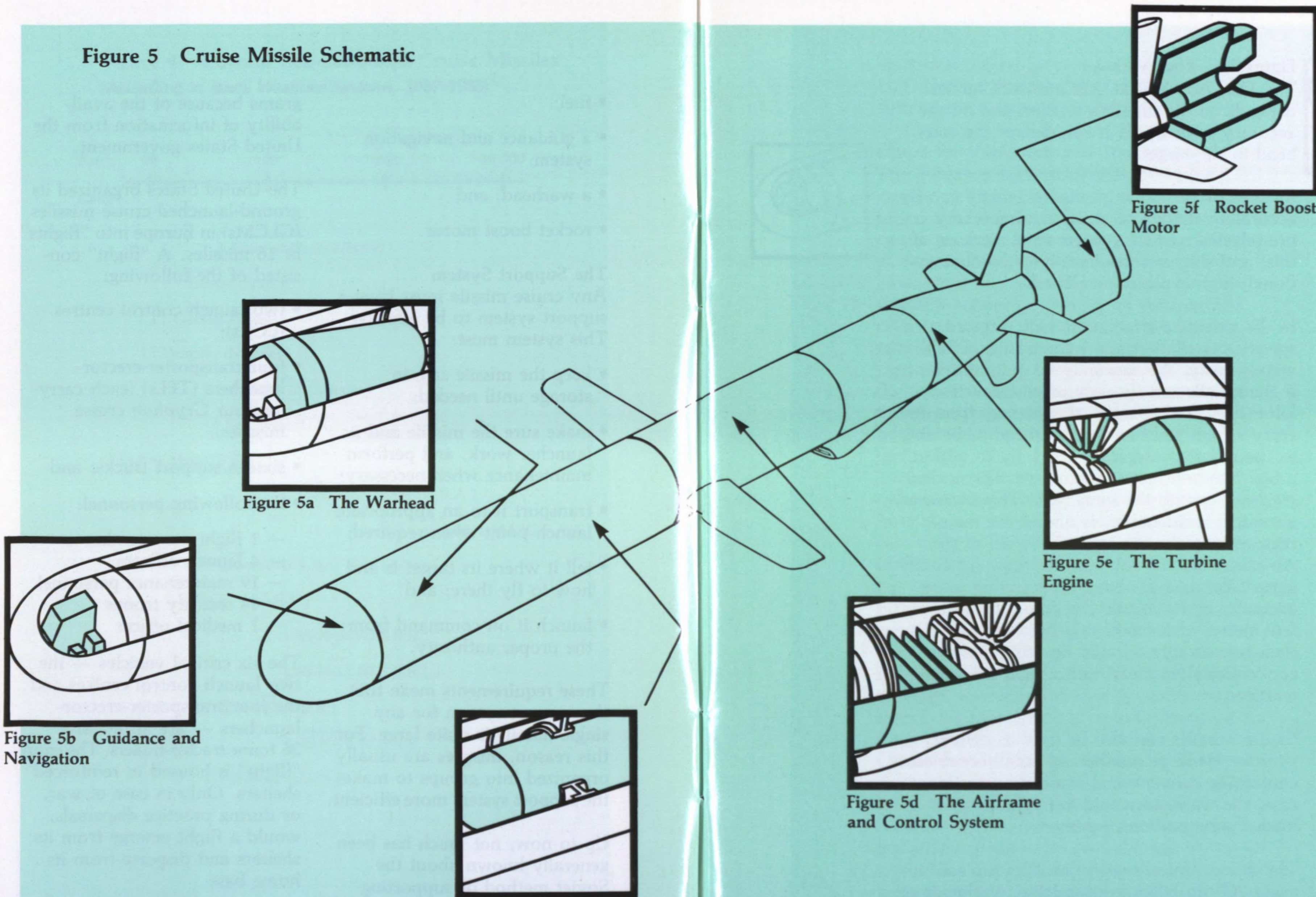


Figure 5a The Warhead

Figure 5b Guidance and Navigation

Figure 5c Fuel

Figure 5d The Airframe and Control System

Figure 5e The Turbine Engine

Figure 5f Rocket Boost Motor

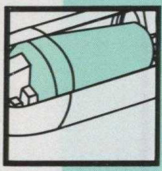


Figure 5a The Warhead

The kind of warhead that a missile carries depends on the missile's mission and on the accuracy with which it can deliver the warhead to the target.

In the case of anti-ship missiles, many can fly accurately enough to strike at almost any pre-selected part of a target ship. Because of this, anti-ship missiles usually carry conventional, high explosive warheads.

In the case of a strategic missile targeted at a specific installation many thousands of kilometres away, the case may be quite different. If the missile can fly only to within a few kilometres of the target, then it may have to carry a high-yield nuclear warhead to be able to destroy that target. If it can fly to within a few hundred metres, then a smaller nuclear warhead can do the same task. This increased accuracy, incidentally, is one of the major reasons why the net explosive yield of the American arsenal has been decreasing steadily since 1960: missiles have been getting more accurate. If the missile can come within a few metres of a small, unprotected target, then conceivably it could be fitted with a conventional warhead rather than a nuclear warhead.

Cruise missiles can also be used as delivery vehicles for large numbers of small bomblets containing conventional explosives. In this case, the warhead would be replaced by a loaded submunition dispenser.

The Soviet Union's cruise missiles are said to carry 200- to 800-kiloton nuclear warheads or 1- or 2-tonne conventional high explosive warheads, depending on the application. By contrast, American missiles carry 10- to 200-kiloton nuclear warheads or 450 kg (1 000-pound) conventional high explosive warheads, depending on the application. The U.S. Navy has indicated it will also acquire submunition-dispensing warheads.

Figure 5b Guidance and Navigation
The guidance systems of modern cruise missiles comprise two main parts. One part senses the forces acting on the missile and calculates from these its speed and position. If, for example, the missile is flying with a cross-wind pushing it to one side, then the missile's accelerometers try to measure the extent to which this cross-wind is altering the missile's flight path. The missile's computer then attempts to correct this error. However, the accelerometers and gyroscopes inside the missile are not perfectly accurate. After an hour of flight, even using the most modern technology, the missile could wander almost a kilometre off course. One way of correcting this error is for the missile to be able somehow to "see" where it really is, and to correct its position. Although it flies for only about 15 minutes, an anti-ship cruise missile has to find a moving ship which could change position by many kilometres while the cruise missile is on its way. Anti-ship cruise missiles are therefore equipped with a terminal homing sensor. As it approaches the vicinity of the ship, a missile can use the sensor to search for its target and then to home on it.

Cruise missiles that navigate long distances over land may also be equipped with some form of radar. They do not use this radar to look for their target, however. They use it instead to measure the undulations of the terrain underneath them as they fly along. The missiles then compare the variations in land height against those stored in memory for that region, and on that basis try to determine exactly where they are and in what direction they are flying. Obviously, such a system cannot work well over water or over large featureless plains. In these areas, the missile must rely on its own internal gyroscopes and accelerometers.

A further problem is obtaining the map of the area to be overflown by the missile, and programming the data into the missile's memory. The easiest way to get such data is from satellite maps, since satellites can pass over any region in the world at regular intervals. However, mapping all the required area for the many approach routes to the many possible strategic targets takes much effort. This information must also be updated periodically to account for any seasonal, geological, or man-made changes.

In addition to using radar, and to improve accuracy, the newest American cruise missiles are said to incorporate an optical system. In effect, the missile electronically photographs the ground underneath and compares the photograph to others in its memory of the same area. Modern Soviet cruise missiles are likely to use similar guidance techniques.

Finally, in the future cruise missiles may be able to use space-based navigation beacons to monitor their position continuously. This, in combination with the missile's own gyroscopes and accelerometers, could provide the ultimate level of navigation accuracy.

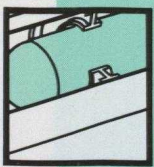


Figure 5c Fuel
Modern cruise missiles use high-energy fuels, rather than standard aviation fuels. This makes the missile more compact and lighter. Many American cruise missiles are stored fully fuelled.

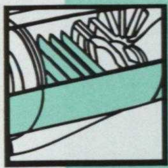


Figure 5d The Airframe and Control System

The advent of compact nuclear warheads, micro-electronics, high-energy fuels and efficient turbine engines has allowed the weight of the cruise missile to decrease over time. For example, the American *Snark* of the late 1950s weighed in excess of 13 000 kg, and had a 3 200 kg rocket booster, whereas the ground-launched *Gryphon* of the early 1980s weighed approximately 1 200 kg, with a 300 kg rocket booster. The new generation of long-range Soviet cruise missiles (AS-15 air-launched, SSC-X-4 ground-launched, and SS-NX-21 sea-launched variants) are said to have followed a similar evolution. As a result, modern cruise missiles are relatively small, measuring approximately 50 cm in diameter, and just over 6 m in length. At the same time, the Soviet Union still has in service the older rocket-powered supersonic AS-4 air-launched cruise missile, which is as large as a modern jet fighter. It is also reported that the next generation of long-range Soviet cruise missiles, the SS-NX-24, and a ground-launched variant may be supersonic over long ranges, and therefore may be quite large.

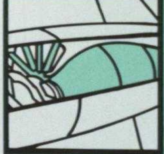


Figure 5e The Turbine Engine

A cruise missile engine is designed primarily to be inexpensive and efficient for its weight. Whereas normal aircraft engines must be extremely safe, durable and easy to maintain, this is not the case with a modern cruise missile engine. After all, such a missile may spend no more than three or four hours in the air on its own power. (Air-launched cruise missiles are carried for several hours by their B-52 or TU-95 carriers before release, of course.) Shorter-range anti-ship cruise missiles can fly their mission in about 15 minutes or less. As a result, very high engine performance can be achieved at costs far below those of conventional aircraft engines.

For supersonic missiles, ramjet engines can be employed. These use the speed of the missile itself to compress the air coming into the engine, generating extremely high thrust. Supersonic flight, however, requires very large amounts of fuel, so long-range cruise missiles tend to fly at subsonic speeds similar to those of commercial airliners, and use turbojet or turbofan engines.

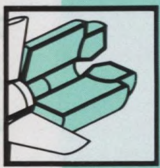


Figure 5f Rocket Boost Motor
In order to be able to take off in a very short distance, some cruise missiles are equipped with a secondary rocket boost motor which accelerates them quickly to flying speed. Once the missile has reached a velocity capable of sustaining flight, the rocket booster falls off, having accomplished its mission.

History of the Cruise Missile

Chapter 3

History of the Cruise Missile

Cruise missiles are by no means a new development: their history goes as far back as the Second World War. The following short overview of this history sets the stage for the discussion of measures to control these missiles, and in particular, of the verification of such measures.

World War II

The first widely used cruise missile was the V-1 "Buzzbomb," which was deployed operationally in the summer of 1944. Some 20 000 of these unmanned, low-flying, self-guided, small aircraft were launched in the latter stages of World War II, including 1 600 air-launched from HE-111 aircraft. Their military effectiveness, however, was limited; after a flight of 250 km, the V-1 could only be expected to land within 13 km of its target. They were largely used, therefore, as "terror" or "revenge" weapons against large population centres. To defend against these cruise missiles the Allies intercepted them in flight, attacked their launch installations; and, eventually, attacked also their manufacturing and assembly plants.

The key characteristics of cruise missiles were, therefore, established by the mid-1940s: accuracy, range, speed, vulnerability and launcher size. Development of nuclear technology added the missile warhead as the final, and most important, characteristic.

Post-War Development

After the War, work continued both in the Soviet Union and in the United States on advanced cruise missiles based on jet fighter airframes. Two distinct missions were envisioned for cruise missiles:

- the strategic mission: to fly long distances and deliver nuclear weapons to strategic targets (population centres, command and control centres, large military facilities, etc.,);
- the tactical mission: to fly relatively shorter distances to destroy military targets on the battlefield or at sea.

These two missions led initially to the development of two quite different kinds of missiles. The evolution of technology eventually permitted both these missions to be accomplished by outwardly very similar missiles. This evolution, as will be described later, has led to one of the chief difficulties in verifying a limitation on some of the "strategic" nuclear-tipped, long-range cruise missiles deployed today: how to limit these strategic weapons without also involving conventionally armed tactical cruise missiles.

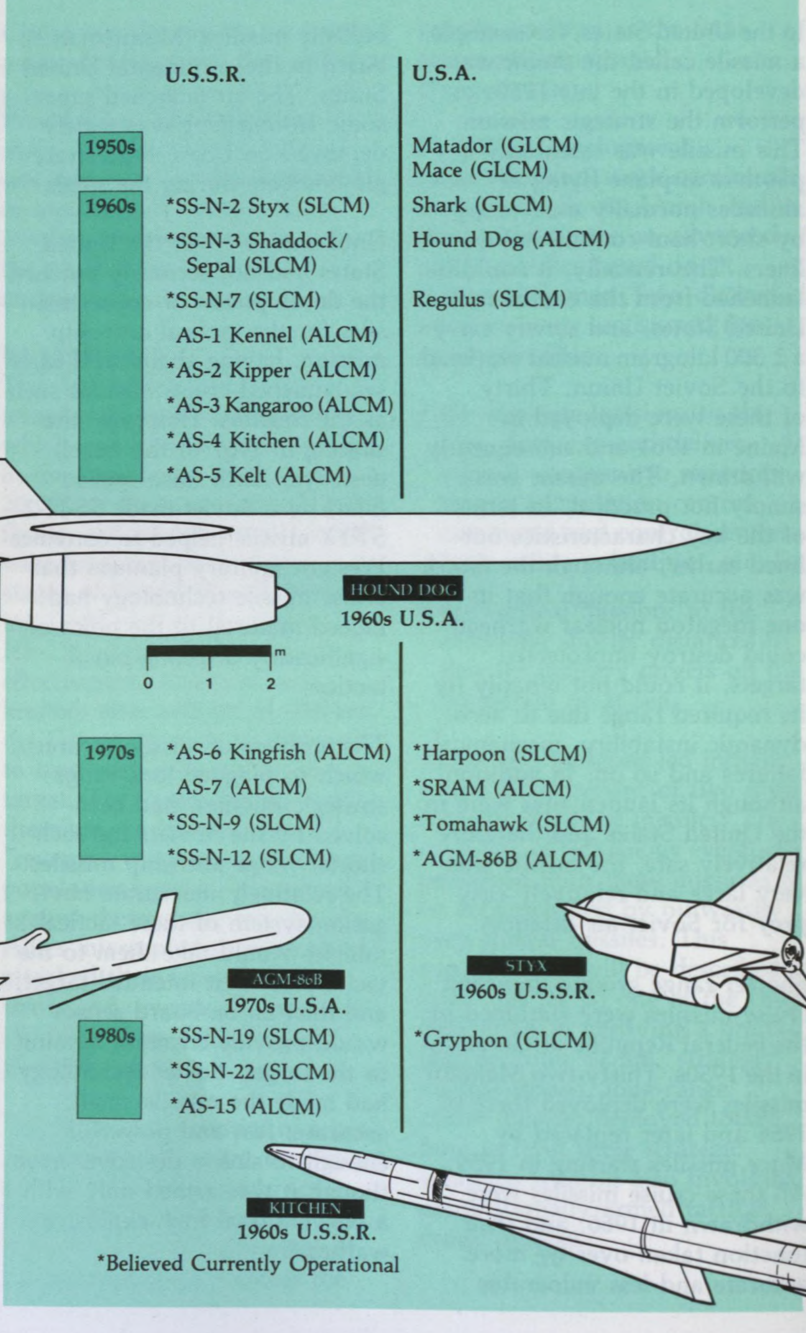
In the United States, for example, a missile called the *Snark* was developed in the late 1950s to perform the strategic mission. This missile was essentially a pilotless airplane flying at altitudes normally used today by short-haul commercial airliners. Theoretically, it could be launched from the continental United States, and slowly carry a 2 300 kilogram nuclear warhead to the Soviet Union. Thirty of these were deployed in Maine in 1961 and subsequently withdrawn. The missile was simply not practical. In terms of the key characteristics outlined earlier, although the *Snark* was accurate enough that its one megaton nuclear warhead could destroy unprotected targets, it could not reliably fly its required range due to aerodynamic instability, mechanical failures and so on. In addition, although its launch sites were in the United States and therefore relatively safe, the missile was very large and relatively easy prey for Soviet air defences.

Shorter-range ground-launched cruise missiles were stationed in the Federal Republic of Germany in the 1950s. Thirty-two *Matador* missiles were deployed there in 1954 and later replaced by *Mace* missiles starting in 1959. All these cruise missiles were withdrawn in 1966, and their function taken over by more accurate and less vulnerable ballistic missiles (Minuteman I), based in the continental United States. The air-launched supersonic *Hound Dog* was widely deployed on USAF B-52 strategic bombers during the 1960s.

Until almost 1970, the United States had not seriously pursued the development of cruise missiles for the tactical anti-ship mission, having abandoned early sea-launched cruise missiles such as the *Regulus*. However, the sinking in 1967 of the Israeli destroyer *Elath* (also spelled *Eilat*) by a Soviet-made SS-N-2 *STYX* missile helped to convince Western military planners that cruise missile technology had indeed matured to the point of significantly affecting naval tactics.

The problem of missile accuracy, which so plagued long-range strategic missiles, had been solved by the Soviets for such shorter range anti-ship missiles. The relatively inaccurate navigation system of these tactical missiles would take them to the vicinity of their intended target, and then an on-board sensor would provide terminal homing to the target. Soviet technology had made the missile small, accurate, fast and powerful enough to sink a destroyer even though it was armed only with a conventional high-explosive warhead.

Figure 6 Soviet and American Cruise Missiles



A number of anti-ship cruise missiles were developed with ranges of tens to hundreds of kilometres first by the Soviet Union in the 1960s, and then also by the United States in the 1970s. At this time, it was not practical to develop cruise missiles with longer ranges because, among other things, there was no way to detect ships at longer ranges.

While the development of terminal homing systems to guide cruise missiles to their targets made anti-ship missiles more practical, it did not do so for strategic missiles, whose targets were land-based. Figure 9 illustrates the reason for this. It shows an image of a harbour as seen by airborne radar. The ships in the harbour stand out very clearly against the water. However, land presents a large amount of "clutter" from which it is extremely difficult to isolate specific targets.

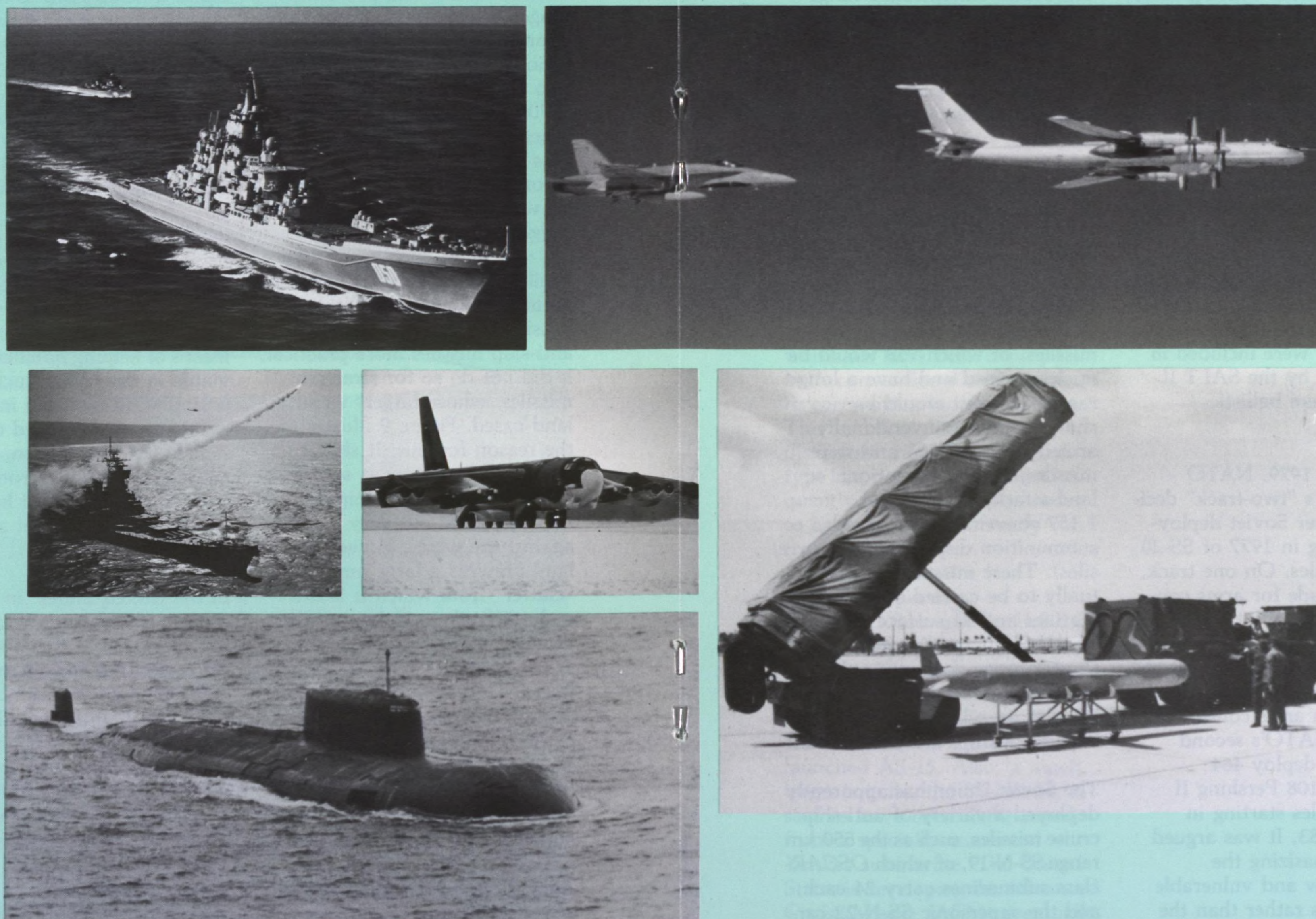
Recent Developments

From a technical perspective, modern land-attack cruise missiles were made *possible* through the development of a variety of guidance systems that allowed a pilotless aircraft to navigate over land by itself. They were made *practical* by advances in small, efficient turbofan and turbojet engines and high-energy fuels. As well, the development of small nuclear warheads means that modern cruise missiles need to carry much less weight (approximately 120 kg) than did the *Snark* (approximately 2 300 kg) in 1961.

From an *operational* side, air-launched cruise missiles may initially have been used by the Soviet Union as a means of extending the operating range of its bombers. However, as air defence technology improved and became more effective against strategic bombers, cruise missiles became an essential means of helping bombers remain viable in delivering nuclear weapons. In fact, the initial American air-launched cruise missile (ALCM) design, the AGM-86A, evolved from designs of decoys intended to help B-52s penetrate Soviet air defence.

In the United States, in 1977, testimony before the Committee on International Relations indicated that the American ALCM "precludes the necessity to substitute ballistic missiles — with their first-strike capability — for the bomber leg of the Triad." To maintain the effectiveness of bombers against the improved Soviet air defence then coming into place, the bombers would have to be either radically improved, replaced by ballistic missiles, or equipped with cruise missiles. In 1977, President Carter chose the

Figure 7 Examples of Cruise Missile Carriers



Courtesy of Canadian Armed Forces

Photos courtesy of U.S. Government except as indicated.

cruise missile as the primary armament for the existing US bomber force of B-52s.

The Soviet bomber force was modernized, probably for similar reasons, with the deployment of the AS-15 cruise missile on newly manufactured BEAR H bombers. This modernization was a balanced one between the superpowers, since air-launched cruise missiles (both the AS-15 and the AGM-86A, and later, the AGM-86B) were considered part of their strategic weapons systems, and were included in the limits set by the SALT II Treaty, as were ballistic missiles.

In December 1979, NATO announced it's "two-track" decision to counter Soviet deployments starting in 1977 of SS-20 ballistic missiles. On one track, a call was made for arms control negotiations with the U.S.S.R. to restore the balance of intermediate-range nuclear forces at the lowest possible levels. In the absence of an arms control agreement, NATO's second track was to deploy 464 GLCMs and 108 Pershing II ballistic missiles starting in December 1983. It was argued that, in emphasizing the relatively slow and vulnerable cruise missiles rather than the highly effective and fast ballistic missiles in such a counter-deployment, a positive signal would be sent to the U.S.S.R. The recent Intermediate-range Nuclear Force Treaty (INF Treaty) to eliminate these GLCMs demonstrates that agreement on disarmament is possible for at least one category of cruise missiles.

Sea-launched cruise missiles (SLCMs) have also been deployed on ships and submarines, but these are not governed by any arms control agreement. The U.S. Navy has announced plans to procure 3 994 *Tomahawk* missiles, of which 758 would be nuclear-armed and have a long range. The rest would be shorter-range, conventionally armed variants (593 anti-ship missiles, 1 486 conventional land-attack missiles, and 1 157 conventionally armed submunition dispensing missiles). These missiles are eventually to be carried by 107 submarines and 91 surface craft. The U.S. Navy also deploys shorter-range conventionally armed *Harpoon* anti-ship cruise missiles on a large number of its surface ships and submarines.

The Soviet Union has apparently deployed a variety of anti-ship cruise missiles, such as the 550 km range SS-N-19, of which *OSCAR*-class submarines carry 24 each, and the supersonic SS-N-22 carried by new *SOVREMENNYY*-class guided missile destroyers. Altogether, the Soviet Union is said to have deployed SLCMs of different designs on over 100 surface ships and submarines.

In the case of air- and ground-launched cruise missiles, only nuclear warheads were deployed. Also, these missiles were intended for single-purpose roles — ALCMs to upgrade bombers, and GLCMs as part of the response to the deployment of Soviet SS-20 ballistic missiles. In contrast, on ships and submarines, various types of warheads have been deployed, both conventional and nuclear, to carry out a variety of roles. This makes it difficult to distinguish how many of each type are present, and consequently, makes it much harder to agree on ways to verify controls on SLCMs.

Future Prospects

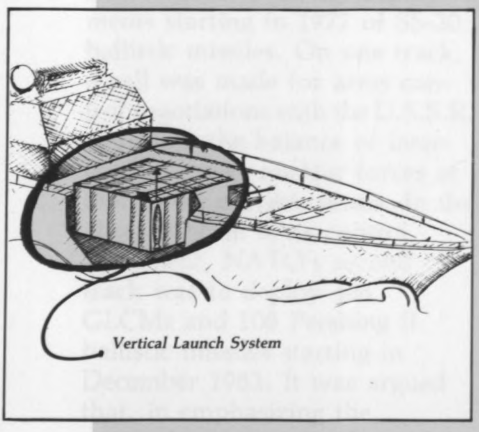
Both the U.S.A. and the U.S.S.R. have advanced cruise missile developments under way. The Soviet Union is developing the SS-NX-21, a *Tomahawk*-like sea-launched variant of the air-launched AS-15. Also, a much larger missile, the SS-NX-24, is said to have been flight tested from a specially converted *Yankee* submarine. The United States is developing the Advanced Cruise Missile (ACM) eventually to replace the currently operational AGM-86B air-launched cruise missile. The new missile is reported to be equipped with radar-evading "stealth" technology, have longer range and be capable of bursts of high speed to penetrate air defences.

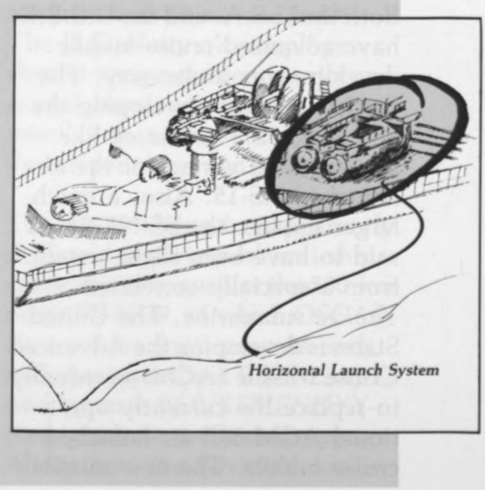
This, then, sets the stage for discussion of current negotiations to reduce the cruise missile components of strategic arms. History has shown that arms control and disarmament for air- and ground-launched cruise missiles is possible. Sea-launched cruise missiles present new challenges.

Figure 8 Launch Systems for Sea-Launched Cruise Missiles (SLCMs) on Surface Vessels

Initially, SLCMs were launched from relatively distinct canisters at a shallow upward angle roughly towards their intended targets as illustrated below.

More recently, missiles have been adapted for vertical launch. They then pitch over automatically in the direction of their target and fly towards it. The vertical launch systems on ships are much harder to see and characterize than the previous horizontal launch systems. Furthermore, vertical launch tubes are designed to be loaded with a variety of weapons, including both long-range and short-range cruise missiles as well as short-range anti-submarine weapons and anti-aircraft missiles. It therefore becomes very difficult, if not impossible, to tell by using long-range sensors alone how many cruise missiles are on board.





Strategic and Arms Control Aspects

Chapter 4

Strategic and Arms Control Aspects

Although cruise missiles constitute a single class of weapons, for the purpose of arms control and disarmament negotiations, they have been split into different groups depending on whether they are ground-, air-, or sea-launched.

Air-launched cruise missiles, because they form part of the strategic system designed to deter nuclear war, have been addressed in strategic arms limitation and reduction talks (SALT and START). The number of allowed ALCMs is negotiated to maintain an overall balance between the U.S.A. and U.S.S.R. and between the different kinds of strategic weapons — bombers and ALCM carriers, land-based ballistic missiles, and sea-based ballistic missiles on submarines — on each side. As Figure 10 shows these three types of nuclear systems form a "strategic triad" which, if well balanced, can provide a high degree of confidence that surprise attacks, or "first strikes," cannot succeed.

Removing only one "leg" of the "triad" would eliminate some nuclear weapons, but it would leave the rest of the weapons deployed in a less stable way. Thus the SALT II Treaty (see Figure 11) and the ongoing Strategic Arms Reduction Talks (START) deal with the entire category of strategic weapons simultaneously.

The major treaty controlling air-launched cruise missiles, the Treaty Between the U.S.A. and the U.S.S.R. on the Limitation of Strategic Offensive Arms (the SALT II Treaty) was signed by the U.S.A. and U.S.S.R. in Vienna on 18 June 1979. Although it was never ratified, and therefore did not come into force, both superpowers agreed to abide by its terms. The Treaty was to remain in force "through 31 December 1985, unless replaced earlier by an agreement further limiting strategic offensive arms."

In early 1985, after a 15-month hiatus, the U.S.A. and U.S.S.R. resumed their Strategic Arms Reduction Talks (START), the goal of which is to reduce dramatically the number of strategic offensive arms. Control of air-launched cruise missiles is therefore part of those strategic arms talks.

Ground-launched cruise missiles (GLCMs), on the other hand, were developed by the U.S.A. for deployment in Europe — not as intercontinental-range weapons as ALCMs are when carried by bombers — but as intermediate-range weapons. NATO's two-track approach (see Chapter 2) culminated on 8 December 1987 with the signing of the Intermediate-range Nuclear Force (INF) Treaty which provides for the elimination of all INF weapons (see Figure 12). On

1 July 1988, on-site inspections to verify the baseline data were initiated by the United States and the Soviet Union. The disarmament process is expected to take three years.

As part of the initial data exchanged with the signing of the Treaty, it was revealed that the Soviet Union had also produced 84 GLCMs for deployment in Europe.

Finally, sea-launched cruise missiles (SLCMs) have evolved from tactical sea-skimming anti-ship weapons. Now having longer ranges and an ability to navigate over land, these missiles have created a new long-range land attack capability for ships and submarines. The SALT II Treaty considered only air-launched cruise missiles (ALCMs). SLCMs were covered by the SALT II Protocol to SLCMs and GLCMs. The Protocol, however, involved only an agreement "not to deploy cruise missiles capable of a range in excess of 600 kilometers on sea-based launchers or land-based launchers" through 31 December 1981. Once that Protocol expired, the parties to the Treaty were free to deploy SLCMs, GLCMs and mobile ICBMs. The United States went on to deploy SLCMs (*Tomahawk*) and GLCMs (*Gryphon*), and the Soviet Union to produce GLCMs (SSC-X-4) and possibly SLCMs (SS-NX-21) and to deploy mobile ICBMs (SS-25).

As currently envisioned, nuclear-tipped SLCMs will likely form only a small percentage of the overall arsenals of the U.S.A. and U.S.S.R. They do not as yet constitute a significant factor in the nuclear balance, and relatively few are currently deployed. However, many analysts feel that if deep cuts in land- and sea-based ballistic missiles (ICBMs and SLBMs) are agreed to while nuclear SLCMs are left unconstrained by arms control agreements, then SLCMs may emerge in the future as a much more significant strategic system.

Thus, limits on nuclear-tipped SLCMs have been considered as part of the overall strategic arms reduction package. However, in this latter category of cruise missile, verification of any long-term agreement is particularly difficult.

Figure 9 Radar Image of a Harbour

Courtesy of MacDonald Dettwiler and Associates Ltd.

Verification

Chapter 5

Verification

General

Verification has been defined in many ways. The definition most applicable to a general discussion defines it as:

> *...the establishment of truth or correctness of, by examination or demonstration.*

Two key elements of this definition are *examination* and *demonstration*. The first of these does not necessarily require co-operation by the treaty parties. The other element, *demonstration*, requires co-operation. The more co-operation that exists between signatory parties, the easier it is to verify treaty provisions. Of course, there are limits to the amount of co-operation one can expect in the verification of an arms control treaty.

If, under complete co-operation, free-roaming inspectors were present on every military installation, with every deployed military unit, on every ship, and in every submarine, there would be no question as to whether an agreement was verifiable. If such a degree of trust existed between nations, though, there might be no need for any armaments or arms control measures either. One example wherein such general on-site inspections have been agreed to internationally, the 1959 Antarctic Treaty, provides for complete freedom of access by the parties to each other's installations, at any time, in any part of Antarctica.

The Antarctic is, however, an exceptional situation. Most arms control treaties operate in an environment where complete trust does not exist, and seek to provide nations with equivalent security while reducing reliance on weapons. Verification is the way that countries ascertain whether or not other parties to agreements are complying with their obligations. This process operates under some restrictions as to what can be seen, when, how often and in what detail. In as much as it leads to a guaranteed access to sensitive information, verification involves some loss of sovereignty for the participating nations.

It is, therefore, only with great difficulty that nations finally agree on how much of their national sovereignty they are prepared to give up (for example, by allowing foreign inspectors access to sensitive information) in exchange for the benefits that an arms control agreement brings. What is given up in terms of national sovereignty, however, is compensated for by increased national security. The judgement of whether the verification provisions are either excessive or insufficient depends heavily on the perception of the value of the treaty and the risk posed by a violation.

Figure 10 Features of the U.S. Strategic Triad

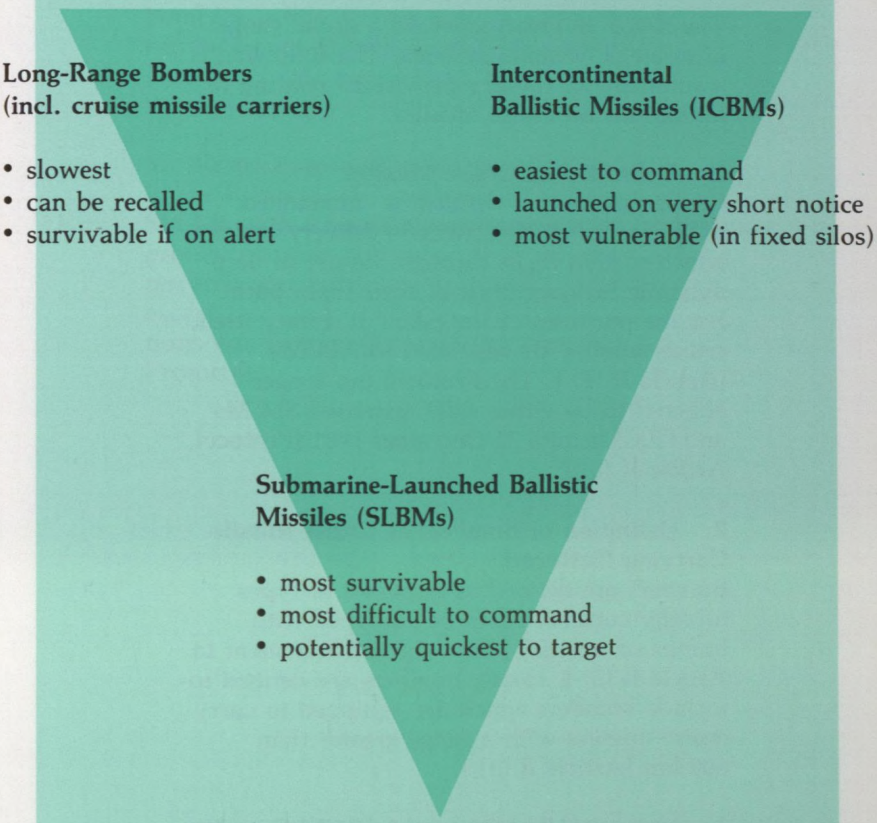


Figure 11 The SALT II Treaty: Key Cruise Missile-Related Limitation Provisions

The SALT II Treaty covered a broad range of strategic weapon systems. The following is a summary of the key provisions relating to limitations on cruise missiles.

1. Definition of Cruise Missiles
Cruise missiles are defined as "unmanned, self-propelled, guided, weapon-delivery vehicles, which sustain flight through the use of aerodynamic lift over most of their flight path." For the purposes of the SALT II Treaty itself, cruise missiles are restricted to ALCMs [Article II (8)]. The Protocol (no longer adhered to by either side) restricted SLCMs and GLCMs until 31 December 1981 [Protocol, Article II (3)].

2. Definition of Bombers as Cruise Missile-Carrying Platforms
Bombers are defined as airplanes of types initially constructed to be equipped with bombs or missiles [First Agreed Statement to Article II (3)]. Heavy bombers are defined to include bombers which are equipped to carry cruise missiles with a range greater than 600 km [Article II (3)].

3. Numerical Restrictions on ALCM-Carrying Bombers
Heavy bombers are included under the ceiling of 1 320 Multiple Independently Targeted Vehicle (MIRV) launchers, such that 120 heavy bombers with cruise missiles are permitted if the maximum permitted number of MIRVed ballistic missiles (1 200) are deployed [Article V].

4. Numerical Restriction on ALCMs
The maximum number of ALCMs for each party's heavy bomber force is limited to the product of 28 and the number of heavy bombers, while current heavy bomber types can be equipped with 20 ALCMs each [Article IV (14) and Second Agreed Statement thereto].

5. Restrictions on SLCMs and GLCMs
In the Protocol, deployment of GLCMs and SLCMs with a range in excess of 600 km was prohibited until 1981 without restricting research and development on these weapons, except that flight testing of MIRVed variations was banned [Article I and II of the Protocol].

Verification can be carried out using a variety of methods including on-site inspections, control-post monitoring, in-situ sensing, and airborne and space-borne remote sensing. These methods require various levels of co-operation from the "verified" party.

If there is no co-operation between the parties, then only long-range verification methods can be used. These include the use of space-based sensors, airborne sensors and electronic listening devices all operating from outside the territory of the country being monitored. These methods, and others like them, comprise what are generally called "national technical means," or NTM. NTM are used by a nation unilaterally.

One of the most basic ways that verification can be facilitated is through an agreement that there will be no interference with NTM, and that no unusual measures will be taken to hide activities related to arms control agreements. Provisions to this effect have been agreed to in all the major arms control and disarmament agreements between the superpowers. In such verification schemes, neither party forfeits any sensitive information that was not already largely available through the other party's NTM.

ALCMs

When an arms control agreement deals with armaments not visible through long-range observation, more co-operation is needed. For example, in the case of air-launched cruise missiles (ALCMs), some mechanisms had to be found by which ALCM-carrying bombers could be distinguished from other bombers, and by which the number of missiles per bomber could be counted.

One way to achieve the former is to make ALCM-carrying bombers different in outward appearance from other bombers. Preferably, the distinguishing features should be related to the cruise missiles themselves, so that a bomber lacking these features is not able to carry cruise missiles. In the SALT II Treaty, these are called Functionally Related Observable Differences (FRODs), and are used to help count ALCM carriers. FRODs "shall be verifiable by national technical means. To this end, Parties may take, as appropriate, co-operative measures contributing to the effectiveness of verification by national technical means." (SALT II, First Common Understanding to Paragraph 3 of Article II of the Treaty). Other means of distinguishing between different types of arms used in SALT II are

Figure 12 The INF Treaty: Key Cruise Missile-Related Disarmament Provisions

Article II — Definitions

"2. The term 'cruise missile' means an unmanned, self-propelled vehicle that sustains flight through the use of aerodynamic lift over most of its flight path. The term 'ground-launched cruise missile (GLCM)' means a ground-launched cruise missile that is a weapon-delivery vehicle."

"4. The term 'GLCM launcher' means a fixed launcher or a mobile land-based transporter-erector-launcher mechanism for launching a GLCM."

"5. The term 'intermediate-range missile' means a ground-launched ballistic missile (GLBM) or a GLCM having a range capability in excess of 1 000 kilometers but not in excess of 5 500 kilometers."

"6. The term 'shorter-range missile' means a GLBM or a GLCM having a range capability equal to or in excess of 500 kilometers but not in excess of 1 000 kilometers."

Article IV — Elimination Provisions

1. "Each party shall eliminate all its intermediate-range missiles and launchers of such missiles, and all support structures and support equipment of the categories listed in the Memorandum of Understanding associated with such missiles and launchers, so that no later than three years after entry into force of this Treaty and thereafter no such missiles, launchers, support structures or support equipment shall be possessed by either Party."

2. A two-phase approach is specified. After the first phase, which lasts no more than 29 months, neither party will have more intermediate-range missiles deployed than "the number of such missiles considered by the Parties to carry 180 warheads." Restrictions are also placed on the number of non-deployed missiles, deployed and non-deployed missile launchers, and the relative proportion of deployed and non-deployed GLBMs.

By the end of the second phase, "that is, no later than three years after entry into force of this Treaty, all intermediate-range missiles of each Party, launchers of such missiles and all support structures and support equipment of the categories listed in the Memorandum of Understanding associated with such missiles and launchers, shall be eliminated."

Article VI — Non-Production Provisions
1. "Upon entry into force of this Treaty and thereafter, neither Party shall:

(a) produce or flight-test any intermediate-range missiles or produce any stages of such missiles or launchers of such missiles; or

(b) produce, flight-test or launch any shorter-range missiles or produce any stages of such missiles or any launchers of such missiles."

Figure 13 Verification Methods

On-Site Inspection

On-site inspection involves physical access to the objects and facilities subject to control under the terms of an agreement. Under *general on-site inspection,* access is unrestricted. This is in contrast with *selective on-site inspection* during which, typically, inspectors are permitted entry only for the limited purpose of monitoring compliance with agreements concerning specific weapons systems and facilities. Access might be allowed only at particular geographic locations. Limitations could also be placed on the duration of the inspection, on the activities which inspectors may undertake at the place of inspection and on the information which they may acquire there. *Challenge on-site inspection* is a derivative of the above, in which one party requests on short notice that another party allow an on-site inspection of a particular activity or facility, in order to verify that this activity or facility falls within the bounds of the agreed treaty constraints. Much of the debate about challenge inspections has focused on whether such requests should trigger mandatory inspections or be subject to a right of refusal by the challenged party; the time-frame that inspectors should be allowed on site; the advanced notice required; and whether sites subject to inspections should be specified in advance in some way, or permitted "anywhere" upon request.

Control Post Monitoring

This general category includes several variations whose common element is a permanent presence of inspectors in the controlled area. *Portal monitoring,* as in the INF Treaty verification package, can be used to monitor what goes in and what comes out of a factory. The inspection team does not have to enter the factory to do this. It simply needs to set up a secure fence around the factory, and ensure that all vehicles and personnel enter and exit the factory through a *portal*, or gate, that is watched by inspectors. A variant of this concept is an *entry/exit point*. This is a point through which all vehicles or ships covered by an agreement must pass when they transit through a controlled region. Such a method allows a group of inspectors to count or inspect vehicles or ships without the inspectors having to move freely (as might be the case in a *general on-site inspection* scheme). An *observer/liaison mission* can be used when the controlled point is actually an area. In this case, inspectors are allowed access to any part of a specified, controlled area.

In-Situ Sensing

In some cases, when it is either undesirable or impractical to station inspectors at specific sites, *sensors* can be installed *insitu*, that is, at the site, to monitor activities there. Sensors such as tamper-indicating cameras and motion detectors can be used to monitor warehouses and stockpiles, for example. This form of sensing can be extended through the use of tags. For example, tagged missiles could be tracked by remote instruments without the need for the presence of inspectors.

Airborne and Space-Based Remote Sensing

Because satellites can pass over any part of the globe regularly, they are good platforms for cameras and other imaging sensors. The overhead imagery thus obtained can provide a great deal of information regarding the disposition of troops and weapons. Furthermore, satellites can be operated unilaterally by any country. Aircraft, on the other hand, can usually only be used to gather overhead imagery if permission is granted by the party to be inspected. Because neither airborne nor space-based remote sensing can be used to see into vehicles, buildings, or underground, various co-operative measures have been agreed to in the past by the U.S.A. and U.S.S.R. to enhance their verification effectiveness.

Externally Observable Differences (EODs) and Externally Observable Design Features (EODFs). Of course, observable differences do not necessarily show how many cruise missiles are on board an aircraft.

There are other key characteristics which cannot be determined through observable differences. Some of these are: missile range, launcher reload capacity and missile type. These characteristics can, however, often be deduced from data observed using NTM during missile and aircraft testing. In order to prevent a party from claiming that deployed systems are not as capable as those systems that were tested, a powerful principle, which could be called the *associative* principle, is used in SALT II.

This principle simply establishes the presumption that the performance of all deployed systems is at least equivalent to that of the tested system observed by NTM. In other words, if one airplane is seen to launch an ALCM, then all airplanes of that type are assumed to be ALCM launchers. Or, as is stated implicitly in SALT II, if a cruise missile has been flight tested to a range in excess of 600 km, "all cruise missiles of that type shall be considered to be cruise missiles capable of a range in excess of 600 kilometers" (SALT II, First Agreed Statement and First Common Understanding to Paragraph 8 of Article II of the Treaty). These tests of cruise missiles and their carriers are generally observed by NTM. Agreements also have been reached to make this observation easier through co-operative measures such as not encrypting the data sent by the missile to the engineers on the ground testing it. In this way, ALCM-carrying bombers can be distinguished, and the number of missiles they carry can be verified for the purposes of an arms control treaty.

In summary, under SALT II, ALCMs were constrained indirectly through limits placed on the aircraft that could carry them. Verification of ALCMs was undertaken by a combination of NTM and co-operative measures. Essentially, it was agreed to deploy ALCMs only on designated types of bombers. These types were distinguished by externally observable differences (EODs) in the case of certain specified heavy bombers, and functionally related observable differences (FRODs) in the case of other types of bombers (SALT II, Fourth Agreed Statement to Paragraph 3 of Article II of the Treaty). These differences were observable using NTM. Since all long-range ALCMs were considered to be nuclear-tipped, no further co-operative verification measures were required to distinguish them from conventionally armed ALCMs.

Unless the pattern of deployment and military mission of ALCMs changes, it is likely that future ALCM arms control agreements will contain verification provisions similar to those developed and implemented in SALT II.

GLCMs

Yet more intrusive levels of verification involve some form of physical presence by the verifying party at the site of the activity to be verified. A variety of ways have been suggested as to how to focus such methods on the collection of treaty-related verification data necessary to monitor compliance, and away from the collection of unrelated data (e.g., which might have military uses) such as might be available through general on-site inspection.

Some of these inspection methodologies are: control-post monitoring, challenge on-site inspection and selective on-site inspection. Control-post monitoring can include such devices as entry/exit points, observer/liaison missions and portal monitoring, as described in Figure 13. Several of these inspection methodologies were applied to the verification of intermediate-range nuclear ground-launched cruise missiles (GLCMs).

The only arms control treaty controlling (and eliminating) GLCMs is the Treaty Between the United States of America and the Union of Soviet Socialist Republics on the Elimination of Their Intermediate-Range and Shorter-Range Missiles (the INF Treaty) signed in December 1987. The verification provisions of this Treaty are much more complex and demand much more co-operation than did those of SALT II.

In particular, provisions are made for the periodic presence of inspectors at missile operating bases and missile support facilities, and a permanent presence of inspectors during elimination operations. Portal monitoring of one ground-launched *ballistic* missile production facility in each country is also allowed. However, inspections of *cruise* missile production facilities are not allowed in any form.

As under SALT II, provisions are also included to enhance the operation of NTM through agreement:

- not to interfere with NTM; and

- not to use unusual concealment measures to impede verification.

In addition, there was agreement on co-operative measures upon request such as:

- to open the roofs of all fixed structures for launchers located at a base; and
- to display missiles on launchers in the open without using any concealment measures.

The latter co-operative measures relate to road-mobile *ballistic* missiles and not *cruise* missiles. As with ALCMs under SALT II, all intermediate-range GLCMs, whether nuclear or conventionally armed, fall within the scope of the INF Treaty. It is not necessary to agree on provisions to verify the type of warhead on any remaining missiles simply because there are to be no remaining missiles. Verifying a complete ban is generally easier than verifying restrictions on numbers because detection of a single illicit missile would signal a violation.

INF Treaty verification provisions call for greater co-operation in the verification of the destruction of missile systems than in the verification of missile systems that will continue to have an operational military role. This is illustrated in Figure 16. Elimination activities at missile destruction facilities can be monitored continuously. These activities and facilities have, however, no operational military role. Operational missile bases themselves are subject to challenge on-site inspection, with an agreed annual quota for each party. These inspections are potentially thorough, but since they may not exceed 36 hours (including a possible 8-hour extension), they do not provide a view of the operational activities of the military base. They merely guarantee that inspectors can take an inventory of the amount of Treaty-controlled equipment and facilities. In any case, these items are due for elimination within three years of Treaty ratification. They are therefore not as militarily sensitive as other systems which fall outside the scope of the Treaty.

When it comes to inspection of other systems which have a resemblance to Treaty-controlled armaments and facilities, but which are not controlled by the INF Treaty, only national technical means with limited co-operative procedures can be used. In the case of long-range ballistic missiles, the co-operative measure indicated above is introduced to facilitate the operation of NTM, since it is already known that a potential difficulty exists. (A stage of the long-range SS-25 ballistic missile is said to be outwardly similar to a stage of the intermediate-range SS-20 missile.) However,

Figure 14 Use of Observable Differences in SALT II

Functionally Related Observable Differences (FRODs)
These are defined as differences in the observable features of airplanes which indicate whether or not they can perform a certain defined mission. For example, FRODs are used to distinguish:

(a) heavy bombers from other bombers;

(b) ALCM-equipped bombers from other bombers; and

(c) Air-to-Surface Ballistic Missile (ASBM) equipped bombers from other bombers.

This definition appears in the First Common Understanding to Paragraph 3 of Article II of the Treaty, which goes on to say that FRODs "shall be verifiable by national technical means. To this end, Parties may take, as appropriate, co-operative measures contributing to the effectiveness of verification by national technical means."

Because they are related to the *function* of an airplane, FRODs are a more effective verification measure than externally observable differences.

Externally Observable Differences (EODs)
These are observable differences that do not necessarily relate to the function of an airplane. For example, airplane markings could serve as EODs. For this reason, EODs are not as effective a verification measure as FRODs. In the Treaty, they are used to distinguish between various types of heavy bombers. In particular, heavy bombers not equipped with ALCMs will be considered as such, "on the basis of

externally observable differences" [Fourth Agreed Statement to Paragraph of Article II].

Heavy bombers of all kinds are limited under the Treaty, so that distinguishing between different types is not as important as distinguishing between airplanes covered by the Treaty from those not covered by Treaty.

Externally Observable Design Features (EODFs)
These are the design features that differentiate weapon systems covered by the Treaty from those that are not. According to the Treaty, if one cruise missile is tested to a range in excess of 600 km, then all cruise missiles *of that type* are considered to have the same capability. EODFs are required to differentiate cruise missiles with capabilities other than those of the tested missile. Therefore, if a short-range missile is designed to look the same from the outside as a long-range missile, according to SALT II, they are both considered to be long-range missiles. For example, in the SALT II Treaty, EODFs are used to differentiate, among others:

(a) short-range cruise missiles from long-range cruise missiles [Second Common Understanding to Paragraph 8 of Article II]; and

(b) non-weapon cruise missiles (such as decoys, drones, or reconnaissance vehicles) from nuclear-armed ALCMs [Third Common Understanding to Paragraph 8 of Article II].

Figure 15 SALT II Treaty Verification Methodology

	NTM**	NTM** + physical co-operation e.g., FRODs, EODs
All Bombers		X
All ALCMs		X
All ASBMs*		X
ICBMs	X	
All Missile Tests	X	

*ASBM — Air-to-Surface Ballistic Missiles

**NTM — National technical means supplemented by agreed non-interference and non-concealment measures, as well as regular meetings of Standing Consultative Commission.

Figure 16 INF Treaty Verification Methodology

	On-Site Inspections (OSI)			NTM* + physical co-operation	NTM* only
	Permanent OSI	Portal Monitoring	Quota Challenge OSI		
All Destruction Operations	X				X
GLBM Assembly Facilities		X			X
All Missiles			X		X
All Launchers			X		X
All Declared Bases			X		X
All Declared Support Facilities			X		X
Other GLCM Systems**				X	X
Other GLCM Systems***					X
GLBM Assembly Facilities					X
Undeclared Facilities					X

* Also includes consultation between the parties in the Special Verification Commission, and non-interference and non-concealment measures.

** Refers to road-mobile ground-launched ballistic missiles (GLBMs) with a range exceeding 5 500 km and hence not included in the INF Treaty.

*** Refers to any GLCM system not included in the INF Treaty.

should either side deploy, for example, short-range ground-launched cruise missiles, this could be verified only by NTM. Such issues could presumably be discussed by the Special Verification Commission, in which further co-operative measures could be negotiated.

The potential "spill-over" of information-gathering from Treaty-covered systems to those not covered by the Treaty is thus minimized. This requirement to minimize such "collateral" information gathering also makes verification of sea-launched cruise missiles extremely difficult, as discussed below.

SLCMs

Although no treaty is in place today to constrain SLCMs, there are indications that some constraints on them may be included as part of the strategic arms limitation and reduction process.

Verification of controls on SLCMs is generally considered to be difficult, however. Several factors combine to make this so:

1. Range: Long-range (strategic) and short-range (tactical and anti-ship) SLCMs look similar from the outside; if only one of these types is constrained by treaty, then a way must be found to tell them apart. In the case of ALCMs, only long-range versions of the American AGM-86B and Soviet AS-15 have been deployed. Other, short-range ALCMs are distinguishable on the basis of externally observable design features. GLCMs under the INF Treaty are being eliminated along with their launch platforms and support systems unless such platforms and systems are clearly distinguishable on the basis of externally observable design features, and therefore determined to be outside the INF category. SLCMs, however, are being deployed in both short-range anti-ship and long-range nuclear versions.

2. Warhead: SLCMs can be equipped with either conventional or nuclear warheads without this being outwardly evident, posing again the problem of distinguishing between two types. So far, ALCMs and GLCMs have only been deployed with nuclear warheads and thus do not pose this problem. On the other hand, the vast majority of planned SLCMs are to be equipped with conventional warheads. The large number of these outwardly similar non-nuclear cruise missiles could make detecting and counting nuclear-tipped missiles much more difficult.

In addition, several nuclear weapons states have a long-held policy of "neither confirming nor denying" the presence of nuclear weapons on board specific ships in their navies. Any verification scheme that would associate a specific number of nuclear weapons with any particular ship or class of ships would have to be reconciled with this policy. This means that counting rules analogous to those used for verifying ALCMs (i.e., each current B-52 or Tu-95 is assumed to carry 20 ALCMs) cannot automatically be applied to verifying SLCMs. Similarly, having certain types of naval vessels dedicated to carrying nuclear-armed cruise missiles could prove problematical.

3. Launchers: SLCMs are being deployed in vertical as well as horizontal launchers by both the U.S.S.R. and the U.S.A. Since the vertical launchers are recessed into the ship, and, in practice, loaded with a variety of munitions other than just cruise missiles, it is difficult to count the number of cruise missiles on each ship just by counting the number of vertical launch tubes. Horizontal launchers tend to be single-purpose in that different types of missiles are generally launched from different types of launchers, though in principle, they too could present the same problem. These considerations mean that some form of inspection of ships is likely to be necessary to establish the number of SLCMs present. This, of course, would demand an unprecedented degree of co-operation in the verification process.

4. Convertability: SLCMs are designed to be easily reconfigured. In principle, a short-range anti-ship SLCM can be modified into a long-range nuclear SLCM on board a ship at sea. This means that a verification system should provide a way to detect any SLCMs that had been upgraded in violation of the treaty to carry nuclear warheads.

The only way to verify that SLCM treaty provisions are being observed may well be through physical inspection of ships. Indeed, in testimony before the U.S. House Committee on Armed Services in February 1985, Navy Secretary Lehman said that "the Navy stands ready to accept whatever intrusive means of arms control inspection, including allowing Soviet inspection teams aboard our ships, negotiated by our national negotiators." Further clarifications suggested that these inspections would not extend to vessels at sea, or in foreign ports, however.

The case of SLCM verification illustrates the problem of collateral information gathering. If on-site inspection were to be allowed of ships and submarines at sea, then it is quite possible that the process of verification could compromise the military effectiveness of the vessels involved. For example, just giving away the position of a submarine may be detrimental to its operations.

Perhaps the techniques used in the past to limit collateral information loss in SALT II and INF Treaty verification operations can be applied again to the problem of SLCM verification. Also being discussed are techniques such as tamper-proof missile tagging or sealing, dock-side or ship-borne monitoring systems, and new esoteric technologies. Some of these might provide new verification alternatives.

Ultimately, as noted earlier, the judgement of whether "too much" information is given away in return for the benefits provided by the treaty is a political one, and can only be judged by the parties involved in the negotiation. Verification measures can therefore only be negotiated hand-in-hand with the provisions of the treaty they verify.

Conclusion

Conclusion

Cruise missiles have been deployed in a variety of roles in their over 40-year history. Their emergence in the 1970s as bomber-enhancing strategic weapons led to the inclusion of air-launched cruise missiles in the 1979 Strategic Arms Limitation Treaty. Intermediate-range ground-launched cruise missiles, deployed in Europe as part of NATO's two-track decision, are to be eliminated under the disarmament provisions of the INF Treaty signed on 8 December 1987 by the U.S.A. and the U.S.S.R.

Sea-launched cruise missiles are, as yet, not subject to treaty limitation. The verification of SLCM limitations is generally seen to be particularly difficult. In the case of air-launched cruise missiles, bombers, which are relatively easy to count and which cannot carry extremely large numbers of missiles, can serve as a unit of account for the purpose of verification. In the case of ground-launched cruise missiles, a complete ban on them and their large support infrastructure has also been agreed to be verifiable.

Ships, however, have a far larger carrying capacity than aircraft, and the number of cruise missile-equipped ships can be relatively large. Submarines, the other SLCM launch platform, are designed to be undetectable when operating. The approach taken for the limitation of air-launched cruise missiles in SALT II is therefore much more difficult to apply in the case of sea-launched cruise missiles. An outright ban on nuclear SLCMs, though easier to monitor than a limit on numbers deployed, would also be difficult to verify. The continuing presence of similar shipborne missiles such as long-range conventionally armed SLCMs and shorter-range anti-ship SLCMs would introduce the problem of trying to determine whether any of them are fitted or could easily be fitted with nuclear warheads.

The SALT II and INF Treaties, however, do demonstrate that increasingly comprehensive and co-operative verification measures can be negotiated to facilitate meaningful arms control agreements. A few years prior to the signing of the INF Treaty, it would have been difficult to predict the far-reaching verification provisions that were eventually agreed upon. If a treaty to limit or to eliminate nuclear-armed sea-launched cruise missiles were eventually to be finalized, then the associated verification measures could well represent another step forward in the arms control process.

Figure 17 Procedure for Elimination Under the INF Treaty

This figure illustrates several of the procedures for destruction of cruise and ballistic missiles under the provisions of the INF Treaty.

Photos courtesy of the U.S. Government

A: Cruise Missiles

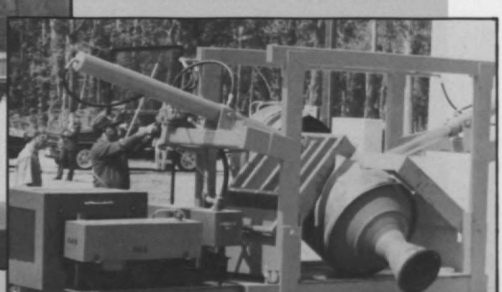
Airframes "shall be cut longitudinally into two pieces."

B: Ballistic Missiles

"Eliminate by means of launching . . ."

Four photos courtesy of the U.S.S.R. Government

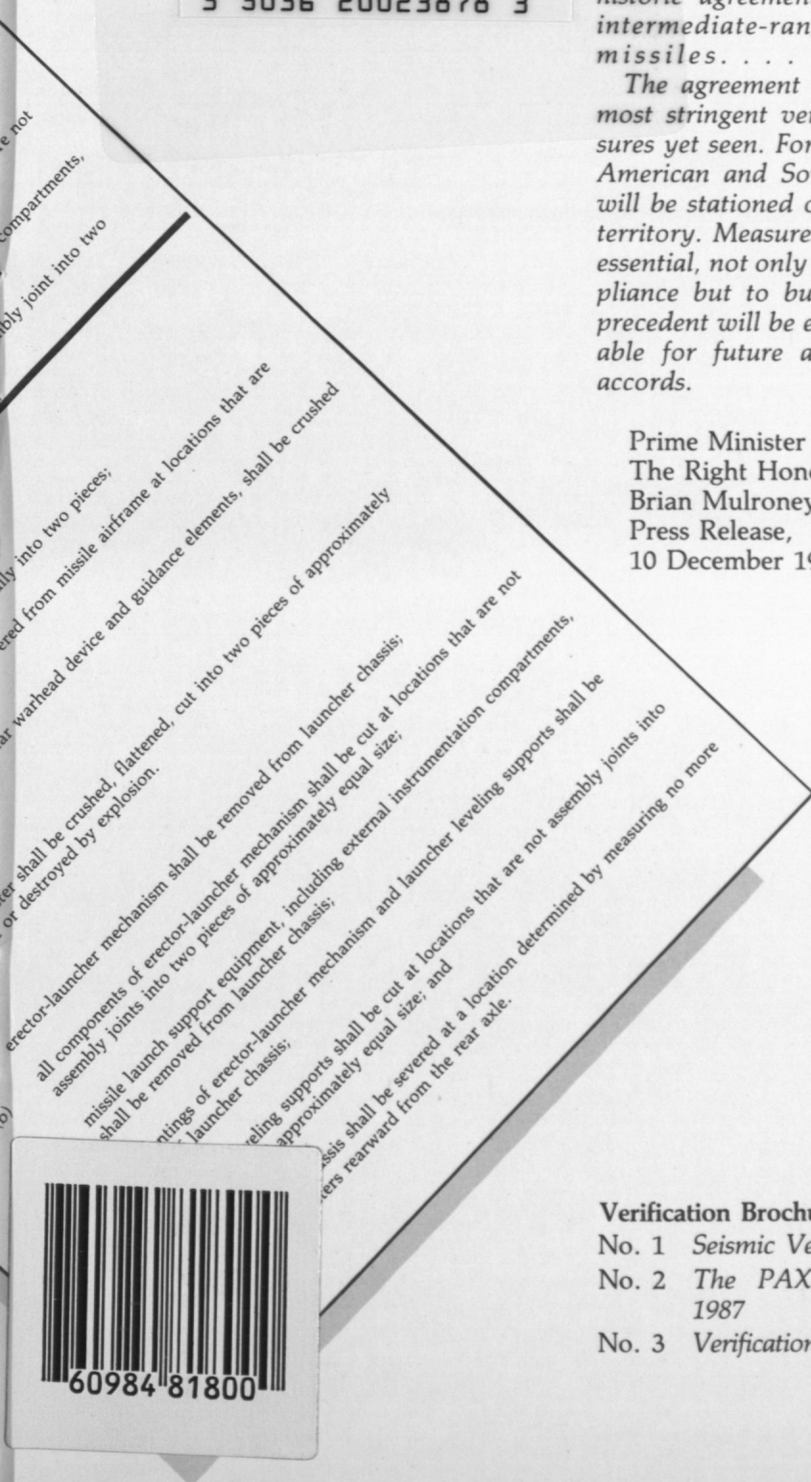
"By explosive demolition . . ."



Elements "not destroyed in this process shall be burned, crushed, flattened . . ."

Two photos courtesy of the U.S. Government

LIBRARY E A/BIBLIOTHEQUE A E
3 5036 20023878 3



On Tuesday, December 8, President Reagan and General Secretary Gorbachev signed an historic agreement to eliminate intermediate-range nuclear missiles. . . .

The agreement introduces the most stringent verification measures yet seen. For the first time, American and Soviet inspectors will be stationed on each other's territory. Measures like these are essential, not only to ensure compliance but to build trust. This precedent will be extremely valuable for future arms reduction accords.

Prime Minister
The Right Honourable
Brian Mulroney,
Press Release,
10 December 1987

Verification Brochures

No. 1 *Seismic Verification, 1986*
No. 2 *The PAXSAT Concept, 1987*
No. 3 *Verification Research, 1987*

60984 81800

Canada