FTD-ID(RS)T-0127-90

FOREIGN TECHNOLOGY DIVISION

CONMILIT
(SELECTED ARTICLES)

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HUMAN TRANSLATION

FTD-ID(RS)T-0127-90 20 August 1990

MICROFICHE NR: FTD-90-C-000857

CONMILIT (SELECTED ARTICLES)

English pages: 18

Source: CONMILIT, Vol. 13, Nr. 4(151), Jul, 1990, pp. 8-9; 34; 62-64; 79; 82-83

Country of origin: China
Translated by: Leo Kanner Associates
F33657-88-D-2188
Requester: FTD/SDAWS/Jerry Peters

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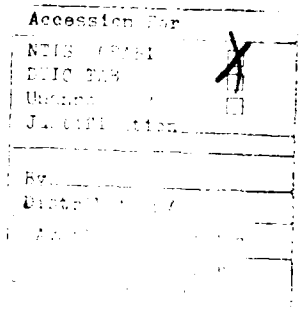
TABLE OF CONTENTS



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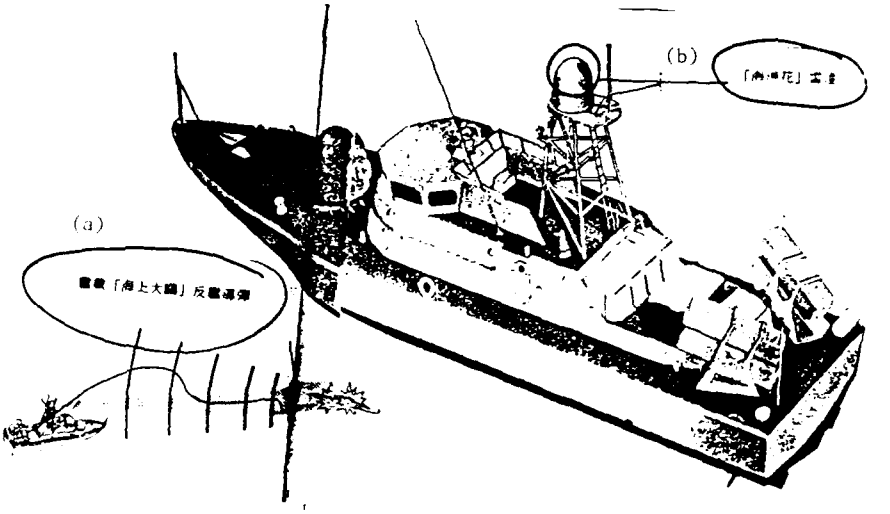


Key: (a) The Sea Skua anti-radar guided missile mounted on a ship; (b) Seaspray radar

The vertically-launched Seawolf guided missile blasts off. In trials it hit the Exocet anti-radar guided missile.

AN OVERVIEW OF ANTI-RADAR GUIDED MISSILES

Ding Ye

Outstanding Combat Performance

The Vietnam War opened the curtain on the implementation of electronic warfare using anti-radar guided missiles. A new model of special note was the Wild Weasel electronic combat aircraft that used Shrike anti-radar guided missiles to destroy radar installations. Deployment of the Shrike anti-radar guided missile and other electronic weapons effected a decrease in American losses compared with the number of guided missiles launched by the Vietnamese. American statistics show that one American aircraft was shot down for every ten ground-to-air guided missiles, but by the end of 1966, with the deployment of anti-radar guided missiles, only one American airplane was downed for every seventy guided missiles launched.

Besides the Shrike and Standard anti-radar guided missiles used heavily during the Vietnam War, anti-radar guided missiles were also used in the Mideastern Wars, in the war between England and Argentina in the Falkland Islands, in the war between Iran and Iraq, and in the American attack on Libya. All of these conflicts saw the extensive use of anti-radar guided missiles, which posed a great threat to the radar of land-based air defense systems. In the fourth Mideastern War, Egypt and Israel both used anti-radar guided missiles to attack the enemy's radar stations. Israel used the Shrike to attack the radar of Egypt's Soviet-made SA-2, SA-3 guided missile systems with a high ratio of successful strikes. In the 1982 war between Great Britain and Argentina in the Falkland Islands, Great Britain's Vulcan bombers were equipped with the newly-purchased Shrike guided missiles. Even though the pilots were very inexperienced in the use of this type of guided missile, they still managed to obtain noteworthy results in combat. The first few Shrike guided missiles launched wreaked havoc on Argentina's air defense radar antennae and put great psychological pressure on the radar operators. When the Vulcan aircraft were still at a distance of approximately 160 kilometers from the radar stations, the operators turned off the radar.

Even more impressive combat results occurred in the 1982 conflict between Israel and Syria in the Bekaa Valley. The Syrian army installed 20 SA-2, SA-3, and SA-6 guided missile bases in Bekaa Valley. In order to eliminate this threat, the Israeli army first launched small unmanned craft in order to deceive the radar's actuation mechanism, and then deployed the large F-4 model Phantom bomber and F-4G Wild Weasel aircraft using rapid strike bombs and anti-radar guided missiles (with long-range radar Shrike guided missiles were launched at a range of approximately 35 kilometers). It took only six minutes to destroy 19 guided missile bases - an outstanding combat performance.

In the war between Iran and Iraq, the Iraqi air force used Mirage F and IEQ specialized electronic combat aircraft to launch the French-made ARMAT anti-radar guided missiles against Iran's Hawk air defense radar, with fine results of seven strikes out of eight launchings.

In the American attack on Libya in 1986, the United States used for the first time the AGM-88A high-speed anti-radar guided missile. The F/A-18 Hornet and A-7E Corsair attack aircraft efficiently suppressed the Libyan air defense system by launching approximately 30 of these high-powered guided missiles at Libya's surveillance radar, target indicator radar, and heat-sensitive radar at a range of approximately 90 miles above the sea.

So far, the most recently used anti-radar guided missile has been the AS37 Martel anti-radar guided missile that the French air force deployed in the north of Chad. Two Jaguar attack aircraft launched the AS37 Martel anti-radar guided missiles from very long range against the surveillance radar at the Libyan-occupied Ouaden-Toumou Airport.

The wartime examples described above illustrate that in electronic combat, anti-radar guided missiles are definitely an optimal tool for suppressing the enemy's air defense systems. They not only can destroy the enemy's radar equipment and kill the radar operators, but can also suppress the effectiveness of radar in combat, by affecting ground-based radar readings of aerial situations and also affecting the efficacy of air defense ordnance. For these reasons, deployment of anti-radar guided missiles is a useful

technique of electronic warfare, which has commanded the respect of all nations.

Competitive Development

For the past 20 years, the United States, the Soviet Union, England, and France have been competing equally in the development of guided missiles. According to rough estimates, more than 20 types have been developed abroad.

The United States' Line of HARM Anti-Radar Guided Missiles

Continuing along the lines of the Shrike and Standard anti-radar guided missiles, the United States has developed a third generation of anti-radar guided missiles, the HARM, which is also well-regarded as a close-range anti-radar guided missile. It exemplifies the development of both anti-radar guided missiles and low-cost, unmanned anti-radar craft.

(1) The AGM-88 HARM anti-radar guided missile

Beginning in 1972, the United States spent ten years to develop the third generation of anti-radar guided missiles, the AGM-88 high-velocity anti-radar guided missile. In 1983 the United States equipped her forces with it, and in 1986 used it in combat for the first time in the strike against Libya.

The HARM missile is 4.17 meters long, with a bore of 0.25 meters, a fin-to-fin span of 1.13 meters, a weight of 360 kilograms, a velocity of 2.5 - 3.6 Mach, and a launch range of 25~96 kilometers. It has three modes for combat use: defensive, offensive, and pre-programmed. After a guided missile is launched, its course can be turned 180 degrees to strike a target behind the carrier craft. Carrier aircraft include the A-6E, the A-7E, the F-4G, the F/A-18, the EF-111A, the EA-6B, etc.

The HARM displays many technological breakthroughs in comparison with the Shrike and Standard anti-radar guided missiles. Among the most important new technologies used is a new passive broadband radar guidance head, covering a frequency range of 0.8 to twenty thousand megahertz. The rapid-connecting, inert apparatus contributes to more unified control of the passive radar search. It has also improved the ability to "lock in" on the target

radar and to jam it. Moreover, the smokeless fuse mechanism greatly reduces ultra-violet microwave signals; it represents the latest microwave technology and signal management technology. The duty end of the guided missile is packed with pre-crushed shrapnel and uses a radio contact fuse that also has tracking control functions. Because of this, the American military can use one HARM guided missile in place of nine Shrikes or five Standards.

HARM's improved model AGM-88B is equipped with a low-cost guidance head, and also is capable of striking a radiating target in mid-air. Mass production commenced in 1989. Furthermore, the controls of the AGM-88B use an electronic erasable programmable read only memory E²PROM in place of the flight-directing read only memory PROM, in order to respond quickly to new threats.

To date, Texas Instruments has produced approximately 1,500 HARM guided missiles, and has also confirmed advance orders for 2,500 additional units. The United States military also wants to purchase 17,000 units: 8,000 for the Navy and 9,000 for the Air Force. The Federal Republic of Germany has ordered 944, and Spain has placed an order for 80 units. Exports to other countries have occurred as well.

(2) The AGM-122 Sidearm uses the AIM-9C Sidewinder's air-to-air guided missile radar search head and guidance system as the base for research and development of a type of modified close-range, high velocity air-to-ground guided missile. At present this is still in its trial stage and being produced in small numbers.

The Sidearm missile is 2.19 meters long, with a fin-to-fin span of 0.64 meters , a bore of 0.127 meters, and a weight of 113 kilograms. Because Motorola completed the official trial production totalling nearly 1,000 units, their product was specially selected as a type of rapid-launch weapon for the heat-sensitive radar of the Warsaw Pact air defense systems. It has already been used on a trial basis by aviation personnel of the United States Navy and Marine Corps, in preparation for its installation on the AV-8B naval fighter craft and on the A-4 and AH-1 helicopters, as well as on the OV-10D

lightweight, two-seat surveillance craft.

At this time the supply department of the United States Navy plans to mass produce 4,000 - 5,000 improved Sidearm guided missiles. With the improvements, the missile will have a longer range, and the frequency range covered by the target-seeking head will be broader, thus greatly increasing the combat efficacy of the Sidearm anti-radar guided missile.

(3) The SRARM close-range defensive anti-radar guided missile originated from a joint project of British Aerospace and Ford, intended specifically to deal with high speed strikes against heat-controlled radar by surface-based air defense systems. The purpose was to improve the tactical strike advantage, sudden defense capability, and survival capability in front-line combat support positions, or in raids at the enemy's rear.

It is estimated that the SRARM will be placed in service by NATO forces in the mid 1990s, and will satisfy the following military technical standards: a launch distance of 10 kilometers, an error radius of 0.5 - 1 meter, high performance radio induction equipment, and shrapnel in the duty section. Moreover, the missile's volume is small and does not occupy much space in the carrier berth for major weapons systems. It can strike at fighter aircraft equipped with radar-guided air-to-air guided missiles that have semi-active target seeking capability.

(4) The dual mode AGM-65D Maverick anti-radar guided missile

Hughes Aircraft Corporation in the United States has built three unites of the Maverick anti-radar guided missile equipped with a dual mode passive radar/television target seeking head. It was designed especially to strike at radar control towers. The special characteristic of this guided missile is that even after enemy radar has locked in on the aircraft, it can still be used in a preventive function.

When the Maverick anti-radar guided missile with dual mode target seeking head was test launched from F-4 Phantom aircraft, in the first trial the anti-radar component in the target seeking head gauged the course of a radiating target. Later, in the second stage of trials, the missile automatically switched to the television target seeking head modality.

(5) The AGM-136A Tacit Rainbow unmanned anti-radar aircraft is a low-co unmanned, programmable anti-radar aircraft with air-to-ground and air-to-air dual function, developed jointly by the United States Navy and Air Force. It is used to strike at radar installations and at interfering aircraft. The combat model is a typical model of an unmanned harassment aircraft. Upon reaching the area of a target, the Tacit Rainbow assumes an unfixed patrol mode, awaiting the opportunity to strike. When it senses enemy radar it commences attack. If the enemy radar locks in on the plane during the strike phase, the aircraft flies higher, resuming patrol above the radar, and awaiting the opportunity to attack again.

The Tacit Rainbow is 2.54 meters long, with a fin-to-fin span of 1.05 meters, and a caliber of approximately .65. It is equipped with a programmable broadband frequency target seeking device, which can match most combat aircraft.

The Soviet Union's Line of Anti-Radar Guided Missiles

(1) The AS-5 Kelt air-to-ground guided missile is carried by the Tu-16 Badger Model G aircraft. This type of guided missile has a speed of 0.9 Mach at altitudes near the earth, and a speed of 1.2 Mach at an altitude of 9,144 meters. This missile is controlled by automatic pilot with semi-active or passive radar target finder. Its launch range is 185 kilometers, and its level of technology is comparable to the American Shrike.

(2) The AS-9 air-to-ground anti-radar guided missile is carried on the Su-17, Su-24, MiG-23, and MiG-27 aircraft. It uses a passive radar target finder. Its maximum launch range is 92 - 110 kilometers, its top speed is 0.8 Mach, and in 1975 it was distributed to the military forces for use.

(3) The AS-11 air-to-ground anti-radar guided missile is carried on the MiG-25 Foxbat F aircraft. Its specialized function is to suppress enemy air defense systems. It can strike NATO air defense guided missiles and radar installations from a considerable distance.

(4) The AS-12 air-to-ground anti-radar guided missile is carried on the

Su-17, Su-24, Tu-26, and Tu-27 aircraft. Its top speed is Mach 3, and its maximum launch range is approximately 40 - 90 kilometers. In 1984 it was distributed to the military forces.

Great Britain's ALARM and ASP Anti-Radar Guided Missiles

(1) The ALARM air-launched anti-radar guided missile was developed by the Aeronautical Weapons Division of British Aerospace Company for the British Royal Air Force. Its principal use is in aiding the self-defense of tactical strike aircraft and sudden defense aircraft. Because this missile is only four meters long, with a fin-to-fin spanof 0.75 meters, and a weight of 280 kilograms, all combat aircraft can load it.

The ALARM anti-radar guided missile has many original features. Its missile head is supplied with highly explosive gases and shrapnel and uses a light-triggered fixed-time contact fuse. The radar target-seeking head covers the E-J frequency range used by television and fire-control radar, and can be reprogrammed according to the specifications of the enemy radar. Before launching, the ground crew use a portable programming device, which rapidly uses information such as the target's level of priority, the strike surface of the guided missile, etc. to make the guided missile function according to the instructions from the ground. In flight, the pilot can change these instructions according to the combat situation.

The ALARM has two types of strike surfaces to choose from: direct entry and indirect entry. The former can allow the missile's maximum firing distance to reach 70 kilometers. The latter allows the guided missile to dive-bomb its target vertically, thus ensuring that the missile head will carry its maximum destructive force. Regardless of the type of surface selected, when the enemy radar signals momentarily disappear, the guided missile remains suspended in the air for a few minutes while continuing to search, until it picks up reference signals that it can use for orientation. It then drops a parachute, searching for the direction of the target, and flies in to strike.

The British Royal Air Force has already ordered 900 ALARM anti-radar

guided missiles, first to use on the Tornado fighter aircraft and then on the Jaguar, Harrier and Pirate fighters.

(2) The ASP defensive guided missile was developed by several British companies in response to recent suggestions from the military. It is a speed-launched anti-radar guided missile with rapid response capability. Its main function is to strike ground-based radar targets. Besides this, however, its ability to strike radiating targets in mid-air is being improved.

The French AS37 Martel, ARMAT, and STAR Anti-Radar Guided Missiles

(1) The AS37 Martel anti-radar guided missile is part of the British and French line of Martel anti-radar launches. It is 4.14 meters long, with a span of 1.12 meters, a bore of 0.4 meters, and a weight of 535 kilograms. It is loaded on the French Air Force's Jaguar and Mirage III E fighters and on the Navy's Atlantic shore patrol aircraft. The Jaguar and Buccaneer fighters of the British Royal Navy, as well as its Nimrod electronic fighter, are all equipped with this type of guided missile.

This type of anti-radar guided missile can be launched from any altitude. Its maximum firing distance is 100 kilometers. In the initial stage of attack, the AD37 passive radar target seeking head, directed by the navigation equipment, orientation apparatus, and electronic combat equipment, allows the carrier craft to maintain the most favorable course for launching. When the passive radar target seeking head (the AD37) determines the source of the enemy radar emissions, the AS37B Martel anti-radar guided missile needs no further assistance from the carrier after it is fired.

(2) The ARMAT is a long-range air-to-ground (naval) anti-radar guided missile based on the AS37 Martel and developed by the Martel Company in France. In the fall of 1983, France's Mirage 2000 aircraft were furnished with these missiles. Additionally, Iraq's Mirage F 1EQ bomber is equipped with these missiles.

By way of comparison with the AS37, the ARMAT is equipped with a solid state broadband passive radar target seeking head, which can handle the

target radar's frequency jumps, scintillations, and other types of interference. The guided missile is also equipped with an inert navigational system, which improves the intermediate stage controllability and the defense capability against radar lock in in the final stage. Its quality is comparable to that of the American HARM. The missile's duty section weight 160 kilograms, and it is equipped with both a radio fuse and a contact fuse. Its firing distance is 40 - 120 kilometers.

(3) The STAR supersonic anti-radar guided missile has replaced the heavyweight AS37 Martel and the ARMAT. The Martel Company is now in the process of developing a line of lightweight STAR anti-radar guided missiles. This missile's maximum Mach is 2-3, it weights approximately 220 kilograms, and it is equipped with an interference-resistant passive radar target seeking head. Its maximum firing distance is 150 kilometers. It is set into motion by a shock actuation device. It is predicted that the Super Etendard fighter may be selected as the carrier: four STAR anti-radar guided missiles can be mounted under the wings of this aircraft.

DEVELOPMENT TRENDS

(1) Expansion of the Frequency Range Covered by Guidance Heads

At present, the various nations are all working on developing broadband guidance heads, such as the United States' HARM and Great Britain's ALARM. With a single guidance head, these can distinguish frequencies in the range of 0.8 - 20 megahertz and 2 - 20 megahertz.In the future we can expect expansion of the range to 0.1 - 40 megahertz;

(2) Use of Composite Control and Guidance to Improve Ability to Counter Lock-in and Increase Precision in Striking Target

The new generation of anti-radar guided missiles, such as HARM and ALARM, uses rapid connection inert guidance in tandem with passive radar target seeking to form composite control and guidance. The next step of development will be composite control using a combination of passive radar search with television or infrared, as exemplified by the Maverick. Composite control and guidance will vastly improve the ability to counter lock-in and

will increase the precision in striking target.

(3) Multi-Purpose Missiles to Handle Different Threatening Targets

From now on, anti-radar guided missiles will be used not only for air-to-ground, but also for air-to-air tactics. The SRARM and ASP, currently being developed, can attack not only radiation-emitting targets on the ground, but also in the air;

(4) Use of new microwave technology and digital signal processing technology can improve the guidance head's ability to store, analyze, recognize, and remember signals. The guidance and control of guided missiles is being completely digitalized, which could result in improved reaction time, lighter weight, and smaller volume in guided missiles;

(5) Improvement of Flight Velocity and Sudden Defense Capability in Guided Missiles

When a missile's flight velocity is high, this can increase the surprise element of the attack, and also improve the survival capabilities of the guided missile and its carrier. The velocity of high-speed anti-radar guided missiles such as the HARM is already above Mach 3, and this missile's launch distance is 10 kilometers. This type of guided missile can strike radar targets at a range of 20 kilometers within 20 seconds;

(6) Development of Small, Close-Range Anti-Radar Guided Missiles

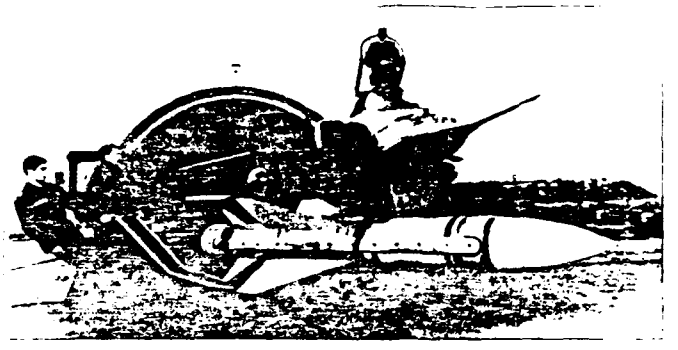
In order to deal with the proliferation of mobile, close-range air defense weapons of the modern battlefield, development of self-defensive close-range anti-radar guided missiles is under way. Examples are the United States Navy's Sidearm, the SRARM produced cooperatively by the United States and Great Britain, and the ASP brought forth by Great Britain. These types of anti-radar guided missiles are small and lightweight. Their responses are rapid, and they do not interfere with the main ordnance loads on the carrier;

(7) Reducing costs and developing low-cost, unmanned anti-radar craft is

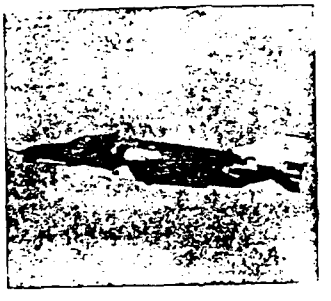
the same as with any other weapons system; if the cost is high, it is impossible to supply the military forces with large quantities. For this reason, the United States proposed research and development of the AGM-88B HARM with low-cost guidance head and the low-cost Tacit Rainbow unmanned anti-radar craft.

CONCLUSION

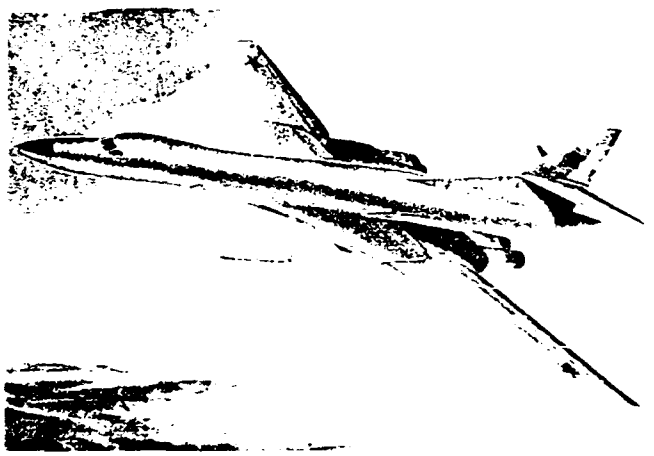
Anti-radar guided missiles provide a means in modern electronic warfare for reconnaissance, navigation, and destruction all provided by a single device. On many occasions their use has obtained fine results in wartime, by posing a major threat to air defense systems. It is projected that by the end of the 1990s, anti-radar guided missiles and unmanned anti-radar craft will constitute the major component of most nations' defensive strength. The development of anti-radar weapons, however, will be followed by a corresponding development of devices to counter them. This struggle between radar and anti-radar weapons will without doubt continue.



The French ARMAT anti-radar guided missile.



The HARM AGM-88A high velocity anti-radar guided missile carried by the United States Air Force's F-4G fighter.



The Soviet Union's Pirate Flag supersonic bomber carries the AS-15 reconnaissance guided missile with nuclear head, to perform both reconnaissance and nuclear strike functions.

NATO'S NEW NUCLEAR POLICIES

Suo Kaiming

In response to threats by the Conventions Section of the Warsaw Pact, the North Atlantic Treaty Organization since 1983 has been reducing its outdated land-based and air-launched close-range nuclear weapons, and has devised ways to modernize the rest. After the Intermediate-Range Nuclear Forces Treaty was signed, because mid-range nuclear weapons posing a threat to the Warsaw Pact had to be completely eliminated, the matter of modernizing close-range nuclear weapons became even more urgent. At present NATO's modernization of close-range nuclear weapons consists of four measures:

Number one, development of the FOL guided missile as a successor to the Lance, with an even larger firing range. The tactical guided missile systems of the United States Army is the main slot for which the FOL is designated. At this point it is being tested in accordance with the formalities of the Conventions, since in earlier meetings proscriptions were stipulated against developing these guided missiles as nuclear warheads. Research into this missile's designation as a nuclear weapon will begin soon.

Number two, plans to equip the F-111 bomber with SMAM II close-range attack missiles in 1993. The SMAM II missile and the B 83 gravity bomb are the standard nuclear weapons for the United States' B-1 and B-52 bombers. Ample evidence exists, however, to believe that the SRAM II misssile will be used on tactical bombers like the F-111 and the F-15E. Because of this, the Air Force's Office of Strategic Command is going to convert the F-111, which is the only carrier of the SRAM AGM-69, to F-111G for the use of the Air Force Office of Strategic Command.This renovated aircraft will be able to carry the SRAM II AGM-31 missile (which effects a nuclear strike outside the air defense zone) within its hull. It is believed that more than 50 F-111G tactical bombers will be deployed in Great Britain.

Number three, increasing the quantity of NATO's nuclear armaments and renovating them. The United States has already developed the W 79 and W 82 nu-

clear warheads, and has contributed a portion toward development of the W-79.

Number four, exerting pressure on the governments of NATO countries to agree to deploy mid-range nuclear bombs. At present, weapons of this type are still being stockpiled only in the United States.

No opinion has been reached within the NATO group, however, about the question of modernizing close-range nuclear weapons.

The United States and Great Britain have already expressed to NATO officials a strong support for the modernization of close-range nuclear weapons. They also insist that this type of weapon constitutes the most reliable component of NATO's deterrent force against the possibility of invasion by Warsaw Pact countries.

The other NATO countries, however, hold different viewpoints. In West Germany opposition to the suggestion of modernization continues to grow. Opponents within government circles maintain that because these weapons have a limited firing range, their use will necessarily occur within West Germany itself - a situation that the West German citizenry cannot accept. West Germany plans to hold its national election in 1990, and the strength of opposition to close-range nuclear weapons will become even greater. The Minister of Foreign Affairs, following the line of his Free Democratic Party, has maintained that it is still too early to make a decision about modernization of the weapons. West German leaders believe the decision should be deferred until after 1990, while emphasizing the possibility of negotiating a reduction of these weapons with the Warsaw Pact. This problem is also giving rise to much upheaval and debate within Kohl's majority Christian Democratic Party. In January the Chancellor reached a compromise and announced that the decision on the matter to be proposed by NATO this year would be accepted. There has been no indication, however, of what kind of decision this will be or when it will be offered.

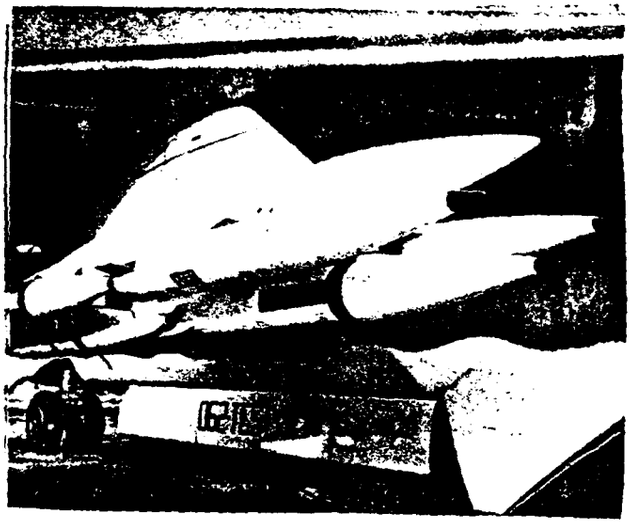
At NATO's last small group conference for nuclear planning, Belgium expressed a stance similar to West Germany's. The majority of NATO's European constituents tacitly support West Germany's policy. The Dutch leaders have

repeatedly called for reduction of NATO's nuclear arsenal. Turkey, however, has not yet decided whether or not to accept close-range nuclear weapons. Greece, Spain, Denmark, and Norway all have anti-nuclear policies.

In attempting to bring the NATO constituents' standpoints into harmony, the United States has been promoting a plan for modernization of close-range nuclear weapons. In February of this year,the Bush administration sent secretary of State James Baker to engage in dialogue with the 14 NATO countries, with special emphasis on persuading West Germany to change its stance. Although Baker stated that the United States did not wish to see NATO eliminate nuclear weapons, West Germany's dissent proved intractable. The question of modernizing NATO's close-range nuclear weapons has still not been resolved.

Focusing on the question of NATO's existence, Soviet foreign minister Shevardnadze and a delegate for armaments-control negotiations, Karpov, brought forth a definitive plan for the Soviet Union to eliminate a portion of its tactical nuclear weapons. On February 28 Karpov brought forth a concrete proposal that the Soviet Union prepare to reduce its close-range nuclear weapons from 1,600 to 88, which is the number currently held in the West. The Soviet Union also expressed willingness to negotiate with NATO the complete elimination of this type of weapon. Such proposals by the Soviet Union, of course, only added fuel to the fire as far as the debate among NATO constituents regarding close-range nuclear weapons was concerned.

In response to this state of affairs, NATO has not only resumed deliberation about its nuclear battlefield, but has also had to consider how to reduce close-range nuclear weapons bilaterally with the Soviet Union.



The American B-52 strategic bomber carries SRAM nuclear warheads. It may be assigned to the Air Force Office of Strategic Command.

The F-111 bomber of the United States Air Force Office of Strategic Command.

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