New Technology for NATO: Implementing Follow-On Forces Attack

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Foreword

The North Atlantic Treaty Organization (NATO) has been wrestling with a fundamental dilemma: how, within the confines of a strategy constrained by politics and geography, to maintain deterrence against the numerically superior and increasingly technically sophisticated forces of the Warsaw Pact. Nuclear weapons underpin NATO's deterrent, but Alliance military planners are uncomfortable with the prospect of a conventional defense that could be overwhelmed so rapidly as to require early resort to nuclear weapons. Under the leadership of the Supreme Allied Commander, Europe (SACEUR), General Bernard W. Rogers, NATO has sought to remedy this situation by exploiting a broad range of emerging technologies to enable it to effectively attack the follow-on forces of a Warsaw Pact offensive—those ground forces that would extend and support the successes of the initial attackers against NATO's defenders—and thus help even the odds on those fronts where armies are actually engaged.

The adoption of the Follow-On Forces Attack (FOFA) concept has raised a number of serious, complicated, and interrelated issues for the United States and the other members of NATO. The range of issues is broad—encompassing political, military, and technological questions—although no single issue is dramatic enough to garner headlines in any but the most specialized press. To help them make decisions on this matter, the House Committees on Foreign Affairs and Armed Services, with the support of the Senate Armed Services Committee, asked OTA to help bring some insight to this array of problems, so that the United States can more clearly understand and effectively support agreed NATO policy. This is the second report of that study effort. Complementary material can be found in an earlier report "Technologies for NATO's Follow-On Forces Attack Concept, " published in July 1986.

Because technology, military concept development, and political thinking have all been evolving, the preparation of this report has been much like boarding a moving train. The information in it is current as of February 1987. It begins from the premise that NATO has officially adopted FOFA, and the United States has supported that decision. Although some still question the wisdom of adopting FOFA, the current debate is really over how best to implement that decision. The report briefly reviews what FOFA is and how it fits into NATO strategy, but is primarily concerned with the outstanding technical issues, how our Allies view FOFA, how the Soviets might respond to it, and how the various technical developments might be brought together into "packages" of systems to support specific operational concepts.

OTA gratefully acknowledges the help and cooperation of the United States Army and Air Force, the Departments of Defense and State, NATO civilian and military staffs, the governments and Parliaments of our European Allies, companies, and numerous individuals who assisted the research and writing of this report.

John H. Gibbons

JOHN H. GIBBONS
Director

Preface

Volume II of this report consists of classified appendices that elaborate on some of the material contained in this volume. It may be requested by writing to:

Congress of the United States
Office of Technology Assessment
International Security and Commerce Program
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providing full name and social security number and the agency or office that can certify a SECRET security clearance and U.S. citizenship. For Congressional requests a need-to-know must be certified by a member of Congress. For other requests, need to know must be briefly explained.

The reader should be aware that the OTA staff did not have access to so-called "black" programs that may be relevant. It is unknown whether the results of such highly classified research could alter some of the technical discussions contained in this report. Interested members of Congress are referred to the Department of Defense for further information.

OTA Project Staff for New Technology for NATO: Implementing Follow-On Forces Attack

Lionel S. Johns, *Assistant Director, OTA*
Energy, Materials, and International Security Division

Peter Sharfman, *International Security and Commerce Program Manager*

Alan Shaw, ***Project Director***

Stephen Budiansky[1]

Michael Callaham

Allen Greenberg[2]

Peter Lert

Nancy Lubin

Administrative Staff

Jannie Coles   Cecile Parker   Jackie Robinson

---

[1]OTA Fellow,
[2]On detail from U.S. Department of State

Advisory Panel for New Technology for NATO: Implementing Follow-On Forces Attack

Jan M. Lodal, *Chair*
President, INTELUS

George S. Blanchard
General, USA (retired)

Joseph V. Braddock
Senior Vice President
The BDM Corp.

P. Robert Calaway
President
Resource Management International, Inc.

Seymour J. Deitchman
Vice President, Programs
Institute for Defense Analyses

Victor L. Donnell
Colonel, USA (retired)
Lockheed Missile & Space Co., Inc.

Christopher Donnelly
Director
Soviet Studies Research Centre
Royal Military Academy Sandhurst

Patrick J. Garvey
Colonel, USMCR
Post Commander, Camp Smith
New York State Division of Military and Naval Affairs

Andrew Goodpaster
General, USA (retired)

Fred Haynes
Vice President for Planning and Analysis
LTV Aerospace & Defense Co.

Glenn Kent
Lt. General, USAF (retired)
Rand Corp.

Ambassador Robert Komer
Senior Consultant
Rand Corp.

Walter B. LaBerge
Vice President
Corporate Development
Lockheed Corp.

John Pauly
General, USAF (retired)
Chief Executive Officer
Systems Control Technology

William J. Perry
CEO
H&Q Technology Partners, Inc.

Stanley Resor
Attorney
Debevoise & Plimpton

Stuart Starr
Director of Planning
The MITRE Corp.

Dorm Starry
Exec Vice President
Ford Aerospace & Communications Corp.

Harry Train, II
President
Strategic Research and Management Services, Inc.

John R. Transue
Technical Consultant
Falls Church, VA

Ralph Wetzl
Director of Systems Development
The BDM Corp.

Ennis Whitehead, Jr.
Major General, USA (retired)
Vice President for Analysis and Evaluation
Burdeshaw Associates

NOTE: OTA appreciates and is grateful for the valuable assistance and thoughtful critiques provided by the advisory panel members. The panel does not, however, necessarily approve, disapprove, or endorse this report. OTA assumes full responsibility for the report and the accuracy of its contents.

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Chapter 1
Principal Findings

The North Atlantic Treaty Organization (NATO) has adopted its Follow-On Forces Attack (FOFA) concept as part of its program to counter a growing Warsaw Pact conventional threat, and thus to avoid either an early resort to nuclear weapons or even a collapse so rapid as to preclude escalation to nuclear weapons. But the adoption of the concept has itself raised issues that will have to be addressed.

The general issues are:

- the role of FOFA within NATO strategy,
- how FOFA could be done,
- what is needed to make FOFA practical,
- what the Soviets might do to make it impractical,
- whether the supporting systems can be made to work well enough to justify the cost,
- how they will be paid for, and
- how to avoid political problems that could weaken the Alliance.

In addition, Congress is faced with specific FOFA-related funding issues, particularly: the Joint Surveillance/Target Attack Radar System (Joint STARS), a possible successor to the recently cut back Precision Location Strike System (PLSS), remotely piloted vehicles, advanced submunitions, and the issue of how to handle related armaments cooperation with our NATO Allies.

NATO currently has some quite limited capability to implement this concept, but faces three major shortcomings: adequate resources for reconnaissance, surveillance, and target acquisition; capable munitions in sufficient quantities as well as the weapons to distribute those munitions; and total systems—from surveillance to target destruction–that can respond rapidly, flexibly, and effectively across large areas. There are systems under development that could alleviate each of these shortcomings. However, it will be necessary to procure them in complete packages of systems that work together to provide the required capabilities, and buy enough of each to make a difference.

FOFA is a mission concept, not a specific weapons system. In general terms, it is the use of various conventionally armed long-range weapons to attack Warsaw Pact ground forces that have not yet engaged NATO defenders. From the Air Force's perspective it is interdiction; to the Army it is Deep Battle. The basic objective is to delay, disrupt, and destroy these follow-on forces so that NATO's defenses can hold as far forward as possible. Although applicable throughout NATO Europe, it is primarily focused on the Central Region, where West Germany borders East Germany and Czechoslovakia. When first proposed by NATO's Supreme Allied Commander, Europe (SACEUR), it was envisioned that attacks would take place from just beyond the engaged troops to hundreds of kilometers into enemy territory. SACEUR also suggested that implementing FOFA would require an increase in national defense budgets beyond the 3 percent real growth to which the nations had at that time committed themselves. Consensus has been building for several years; clearly, although very deep attack may remain an attractive long-term goal, current interest is focusing primarily on shorter ranges. Rather than committing themselves to additional funding, the member nations are primarily redirecting existing conventional force modernization programs to support the concept, as well as the applications for which they were otherwise intended. This includes the United States, which has many more FOFA-related efforts underway than the others.

The controversy that surrounded the adoption of the concept arose in part because it fit neatly with systems under development in the United States which had no European counterparts. Europeans saw this as requiring them to spend large amounts of money on American systems. This controversy has diminished as the concept has been further developed to define much of what the Europeans are producing as FOFA systems, and as cooperative arrangements for developing and producing other systems have been worked out.

Most of the systems needed for an effective FOFA capability either exist or are in various stages—mostly the later stages—of development. There are still important engineering problems to be solved, and important pieces may yet fail to materialize. But by and large the issue is not one of starting new programs to fulfill identified needs, but rather one of keeping the necessary programs alive both technically and financially. However, when these programs move from development to procurement, the budget requests will almost certainly increase, and Congress will face the question of how to finance them. Choices will have to be made among programs that are relevant for FOFA, and probably between FOFA and other areas as well.

HOW DOES FOFA CONTRIBUTE TO NATO'S DEFENSE POSTURE?

FOFA is one of a handful of key mission concepts for NATO's conventional forces, all of which are considered vital to a successful defense. It must be viewed not in isolation, but rather within the context of all the others, such as fighting the close battle against Warsaw Pact ground forces, establishing and maintaining control of the air, and safeguarding rear areas. For example, successfully attacking follow-on forces could improve the outcome of the close battle, and control of the air would facilitate attacking follow-on forces.

Many of the systems being considered to support FOFA would not be limited to that role, but would have applications to other mission concepts. Many of the U.S. systems would also have roles beyond NATO Europe. Furthermore, some surveillance systems that might be used to find and target follow-on forces could also aid in detection and assessment of Warsaw Pact activities prior to a conflict.

FOFA was conceived as a way to exploit technology to counter two fundamental aspects of Soviet strategy: their use of follow-on forces; and their ability to use a strategically mobile offense against a much less mobile defense. Soviet doctrine suggests that a Warsaw Pact offensive would probably include a substantial number of follow-on ground forces, i.e., ground forces not involved in the initial assault. These would either be moving forward to join or exploit the attack, or preparing to do so. By attacking these follow-on forces, NATO would hope to decrease their ability to affect the war; and by "metering" their arrival at the close battle, NATO would be better positioned to defeat them and not be overwhelmed by successive attacks. Soviet doctrine suggests that the Warsaw Pact would concentrate its ground forces, probably against NATO's weaker sectors, and have substantial freedom to move and redirect its main efforts. NATO, by contrast, would be very constrained in its ability to move ground forces laterally along the front in response. A FOFA capability could be used to compensate for this by redirecting the firepower of long-range weapons and interdiction aircraft along the front.

If the follow-on forces are very important to Soviet strategy (and if they can be found and attacked effectively), FOFA could be enormously effective. However, if the follow-on forces play a less important role, FOFA would be less valuable (although the weapons and other systems might not necessarily be any less useful). Evidence suggests that Soviet strategic, operational, and tactical planning is flexible and that the Soviets could reduce their dependence on the follow-on forces or the exposure of those forces to attack. The extent to which they could do so is subject to debate, as is the cost to them of taking these steps: on the one hand, they had reasons for adopting their current strategy; on the other, they may be "outgrowing' it for reasons not directly related to FOFA.

HOW MIGHT THE SOVIETS RESPOND?

Soviet writings suggest a wide range of political as well as military responses to both the FOFA concept and its implementing systems. Soviet military writings focus on: 1) adjusting strategy and operations (e.g., by deemphasizing the role of the follow-on forces, intermingling their forces with NATO's early in a conflict, and increasing protection of their rear areas); 2) developing operational and technical countermeasures to weapons and targeting systems; 3) adjusting their command and control to compensate for quick-acting FOFA systems; and 4) developing similar systems, but not necessarily for similar uses. Some Soviet responses could present NATO with opportunities. For example, moving more forces forward before attacking could provide NATO with longer warning which NATO could exploit. Keeping more forces closer to the close battle could make them easier to engage.

On the political level, the Soviets apparently have already been trying to influence European public opinion to inhibit the successful implementation of FOFA, and to exploit European concerns about FOFA to cause friction within the Alliance.

WHAT ARE THE ATTITUDES OF OUR ALLIES?

Our NATO Allies endorsed the concept in a very general form in November 1984; the definition of what has been agreed to and how it should be implemented is still evolving. The Europeans have been slower to accept the specifics than the United States has. This is due partly to the long lead times in their defense planning cycles, and partly to economic factors including an expectation that their defense budgets are likely to remain constant or to decline over the next few years. The Europeans expect that a significant FOFA capability will be expensive, and are concerned about it requiring increases in their defense burdens or decreases in their ability to perform other missions.

The Europeans are most interested in approaches to FOFA that incorporate what they have already been doing. Hence, they are most interested in enhancing the role of artillery and the new Multiple Launch Rocket System (MLRS), some forms of aircraft interdiction (but not all of those under discussion), remotely piloted vehicles, and command and control systems. They are wary of FOFA as a source of pressure to buy U.S. technology, and have been cautiously negotiating memoranda of understanding for multilateral development and production programs, some of which include the United States and some of which do not. The Europeans have recently expressed a willingness to consider cooperative ventures on systems capable of striking as deep as 150 kilometers, but it is still too early to judge the significance of this development.

Increasingly, the Europeans are coming to insist that cooperative programs not only result in spending for European production, but also invest in European technological development. As yet, the United States has not found formal European support for two major programs, Joint STARS and the Army's Tactical Missile System (ATACMS), but this does not mean that our Allies will never be interested in those programs. Indeed, informal interest appears to be growing. Several European systems with important implications for FOFA are under development.

Many in Europe hold a different view than the United States does of the proper balance between nuclear and conventional forces, and are less enthusiastic about conventional defense improvements. Furthermore, they are concerned that FOFA not draw resources from the close battle between opposing ground forces, which they see as having the highest priority. '

FOFA has evolved from a major political issue within the Alliance in 1984 to quiet negotiations among armaments experts in 1987. While the movement has been in the direction of consensus, FOFA has failed to generate much enthusiasm for increased spending. FOFA is no longer a threat to Alliance cohesion, even though the major opposition parties in Germany and the United Kingdom have declared themselves against the concept. These parties have more fundamental and troublesome objections to NATO defense policy, particularly the objection of the British Labour Party to nuclear weapons. However, Labour has suggested that by eliminating nuclear weapons it would spend much more on conventional defense.

'SACEUR'S position is that all the mission concepts are necessary and that priorities cannot be established among them. Some NATO governments have suggested that just such a prioritization should take place.

From the perspective of early 1987, FOFA appears to be a modest success story in the history of NATO. When the concept was first proposed, it evoked skepticism, misunderstanding, and political friction. But a rough mutual understanding has now developed. In the process, FOFA stimulated NATO's "conceptual military framework" process, which promises to be useful in coordinating military . planning over the full range of NATO missions. It has also served to provide an agenda for increasingly ambitious explorations in the area of armaments cooperation.

WHAT IS THE STATUS OF RELEVANT TECHNOLOGY AND DEVELOPMENTS?

A great deal of what is needed for FOFA is already in the field or in production. Most of the technology for the rest already exists and could result in fielded systems over the next decade. Engineering problems remain to be solved, and some important advanced systems have not been completely demonstrated, but there is less concern about being able to make the systems work than there is about the performance of combinations of systems in realistic countermeasure environments. There may be value in getting systems into the field so that the problems of integration can be worked out and unrecognized problems and benefits can be discovered.

Although discussion has tended to focus on those developments that are primarily American,[2] our Allies have developed and are developing systems that could be used for FOFA: the Tornado aircraft with its MW-1 dispenser; remotely piloted vehicles and drones; some surveillance systems; and various munitions. They are co-developing the Terminally Guided Warhead for the Multiple Launch Rocket System (MLRS/TGW). Their technology is, in many cases, equal to U.S. technology.

This focus on U.S. technology has raised a major political problem: how to balance a desire to buy the best capability most efficiently with growing allied pressure for a more equitable "two-way street" for NATO weapons procurement.

'The United States leads, but does not necessarily dominate, in major areas such as broad area surveillance and targeting systems, data analysis and dissemination systems, smart submunitions, and ground-launched missiles. This does not necessarily mean that the United States will successfully field more (or better) systems than the Europeans.

WHAT ARE THE ADVANTAGES AND DISADVANTAGES OF DIFFERENT APPROACHES?

There are several different approaches to attacking follow-on forces, with many having several variations. Implementing any single approach will require a complete package of several systems, including: systems to find and locate the targets; systems to deliver the weapons; the munitions; and supporting systems (e.g., for defense suppression and electronic warfare). If it were possible to fund everything, it would make military sense to procure the systems to support a range of approaches. But funding constraints are likely, and will limit choices. It will therefore be important to fund systems consistently so that the result is one or more complete packages, and not pieces of several incomplete ones, and perhaps to fund systems that offer the most flexibility. Some systems could contribute to many packages, but others have only specific applications. While choosing preferred operational concepts is a job for the military, Congress' funding decisions will determine which concepts are supported, and how well.

Different approaches to FOFA are primarily distinguished by what targets to attack, and the means to attack them. Attacks can be against moving combat units, supplies, command posts and other high-value units, or to create chokepoints in the transportation system by destroying bridges or laying mines. These attacks could be conducted with ground-launched weapons or by interdiction aircraft carrying a variety of weapons including air-launched missiles.

Analysis shows that directly attacking combat units could be very effective in slowing and reducing Pact forces. But it is not clear whether NATO will have both the means to target them effectively, and the weapons to kill the tanks. Although the tanks are a major worry, all the other armored combat vehicles are also needed by the Soviets for a combined arms offensive, and they are vulnerable to munitions now being procured. Opinions differ over the value of attacking supplies, which could be done with a variety of munitions. While supplies are necessary for an offensive, some analysts believe that the Soviets could lose a large number of supply trucks before combat capability would be degraded. Combat vehicles go into battle with significant amounts of fuel and ammunition on board. But small combat units such as battalions have little excess supply, and resupply is essential if an offensive is to be continued.

Advancing forces can be delayed by creating choke points (e.g., by destroying a bridge just as a unit is about to cross it, or by sowing a mine field). Analyses differ on whether sufficiently long delays could be produced. The ability of the Pact commanders to employ their forces could be disrupted by attacking command posts. These, however, would be difficult targets to find and attack, and the effect of doing so is difficult to gauge.

In general, the deeper into enemy territory an attack takes place, the less will be its direct effect on the battle and the greater will be both the Warsaw Pact ability to compensate and NATO's opportunities to continue the attack to produce the desired effects.

Ground-launched weapons like artillery, MLRS, and the ATACMS missile are generally simpler to operate than tactical aircraft, but would be more dependent on close coordination with sophisticated external surveillance and targeting systems. NATO forces are upgrading artillery and buying MLRS. But these weapons lack the flexibility y of the longer range ATACMS to be redirected over long distances, and waiting until the targets are close creates a risk that NATO forces will be overwhelmed as the targets dash forward. Missiles like ATACMS could be used by one corps to support another and to concentrate firepower across a wide segment of the front. If the United States is to preserve the option to deploy ATACMS, it will have to exercise care in arms control negotiations.

Aircraft have the advantage of a man on board, providing flexibility to compensate for shortcomings in targeting information and to respond to unforeseen circumstances. Air power generally allows for more flexible employment across the entire Central Region than ground-launched missiles do. Penetrating Warsaw Pact air defenses with acceptably low attrition requires sophisticated aircraft which are generally expensive and must be equipped with advanced navigation and target acquisition capability, electronic warfare systems, IFF (identification friend or foe) systems, and stand-off weapons. The U.S. employment concept calls for the use of large "packages" of attack aircraft, fighter escorts, jammers, defense suppression, etc. Planning such large packages requires several hours, although there is flexibility to alter plans almost up to takeoff. These sophisticated aircraft are likely to continue to be in short supply and to be called on for other urgent missions. It is not likely (but possible) that interdiction aircraft-such as F-16, F-15E, F-4, F-1 11, or Tornado—would be available in great numbers to attack follow-on forces during the first day or two of a war. But there are likely to be many high-value targets on day three and beyond.

The Air Force is now considering using B-52 bombers flying from bases in the United States to launch long-range cruise missiles over NATO territory to attack the Warsaw Pact rail transportation system.[3] This has the advantages of using an existing asset, the B-52s, in combination with a yet-to-be-developed variant of a new or existing cruise missile and of avoiding Pact air defenses. If successful, it could produce long delays in the arrival of the second Soviet strategic echelon, or produce greater warning for NATO by inducing the Soviets to move those forces forward through the rail network prior to the war beginning. However, the cruise missile variant has yet to be demonstrated, and-depending on the outcome of the negotiations currently under way—there may be serious arms control problems to solve.

‘Applications of B-52s with cruise missiles in other theaters are also possible.

WHAT IS THE LIKELIHOOD THAT PLAUSIBLE COMBINATIONS OF SYSTEMS WILL BE EFFECTIVE?

Plausible combinations of systems that could perform the tasks that fall under FOFA have been identified, but many of the components are still being developed. In order for any one concept to work, each piece must work (because each individual function is necessary), and they must be able to coordinate and interface.

Programs now under way are designed to overcome deficiencies in NATO ability to attack follow-on forces, now primarily limited to: aircraft attacking fixed targets like bridges, as well as targets that, while mobile, don't spend much of their time moving;[4] and possibly aircraft flying along roads looking for columns of vehicles. Capability will improve as each deficiency is corrected, although all deficiencies need not be corrected to have a useful capability.

As each of these improvements comes on line, FOFA capability will increase incrementally.

‘For example, command posts, surface-to-surface missile launchers, surface-to-air missile (SAM) batteries, resupply points, and communications links. These targets are difficult to locate and target: when broad-area moving target indicator systems—like Joint STARS—become available, these will be more difficult targets than moving units. The fact that these targets "dwell" for long periods of time can be used to NATO's advantage to piece together information from a variety of existing systems. The munitions exist to attack these targets effectively, if they can be located.

Deficiency	*Corrective Measures/Status*
1. Lack of ground-launched missiles	MLRS—in production ATACMS—in full scale development
2. Little ability to operate aircraft at night and in bad weather	LANTIRN[5]–in limited procurement F-15E–in procurement (MLRS, ATACMS[6])
3. Little ability to destroy masses of armored vehicles	CEM[7], DPICM[8]–in procurement (effective against all but heavily armored tanks) Smart anti-armor submunitions (sensor-fuzed weapons and terminally guided submunitions)—in development TMD[9]—in procurement NATO MSOW[10]–in development
4. Little ability to rapidly target moving combat units	Joint STARS–in full scale development Aquila RPV[11]—in full scale development other RPVs—various stages Joint Tactical Fusion Program-in full scale development
5. Little ability for Army corps to support adjacent corps	ATACMS–in full scale development
6. Enemy air defenses threaten both interdiction aircraft and surveillance aircraft	Various air defense suppression and avoidance programs in various stages Various RPV programs in various stages
7. No capability to attack very deep	B-52s carrying cruise missiles–no development yet

5Low Altitude Navigation and Targeting Infrared for Night. A system to aid aircraft in finding targets.
‘These are not aircraft systems, but they can operate at night and in bad weather.
‘Combined Effects Munition.
‘Dual Purpose Improved Conventional Munition.
“Tactical Munitions Dispenser. The dispenser part of the CEM; the munition itself is the CEB (Combined Effects Bomblet).
[10]Modular Stand-off W'capon.
‘ ‘Remotely Piloted t'chicle.

WHAT ARE THE OUTSTANDING ISSUES BEFORE CONGRESS?

Several FOFA-related issues are likely to be matters of controversy in Congress in the next few years. These are: the Joint STARS program; the recently severely scaled-down PLSS program; Aquila and other remotely piloted vehicles (or unmanned aerial vehicles) programs; advanced anti-armor submunitions; and co-development and co-production with our European Allies.

Joint STARS

This program has been a matter of controversy between House and Senate for the past few years. By providing an ability to locate, track, and target groups of moving vehicles, Joint STARS is supposed to contribute to the commanders' awareness of the battlefield and to target engagement, which are central to many concepts for FOFA and probably very important if FOFA is to be successful. Such a capability would also be very important for identifying and analyzing the main thrusts of a Soviet offensive, and for obtaining warning of suspicious movements prior to hostilities. FOFA could be done without a system like Joint STARS, but not nearly as well.

At the heart of the controversy is the question of how survivable the E-8A (modified 707) aircraft would be in a realistic combat environment. Critics contend that to be adequately survivable it would have to be operated so far from the FLOT[13] as to be virtually useless. Supporters argue that flying in protected NATO airspace with many other surveillance aircraft, benefiting from suppression of enemy air defenses, and protected by NATO fighters and

‘ ‘Forward Line of own Troops. The farthest line NATO troops occupy'.

SAMs,[14] it would be "survivable but not immortal.

It is likely that even with all this protection, Joint STARS would have to operate farther from the FLOT than originally envisioned in order to reduce its vulnerability. But its value would degrade slowly as it moves back, and it should be able to provide frequent coverage of broad areas out to final assembly areas, and perhaps somewhat beyond. This is the area in which frequent coverage is most needed because events will develop rapidly there. Deeper areas would be seen less frequently. This would provide a great improvement over current capabilities in area covered, frequency of coverage, timeliness, and accuracy. However, it is less than the nominal coverage usually assumed for the system. Prior to hostilities, the E-8A could operate up to the FLOT and provide much deeper coverage for indications and warning of attack.

Alternative systems that would be less detectable are possible; if operated so as to evade detection, they would also be limited in coverage, but the limitations would be different from those of the E-8A. Less area would be masked by terrain and vegetation if the platform were higher or closer to the FLOT. In combination with E-8As they might provide nearly complete coverage. *If* the alternative or complementary system were to operate in the same frequency band, it could probably use most of the radar hardware and software developed for the E-8A. As far as OTA is aware, no detailed operations analysis that compares the FOFA capability using the E-8A Joint STARS, alternative systems, and combinations of the two has been done. If this remains an issue, such a study probably should be done, but it ought not to delay Joint STARS development. That analysis should consider the possibility of reactive Soviet jammer development. In some cases, "customized" jammers could severely handicap either type of system, but the likelihood and practicality of such jammers needs further study.

"Surface to Air Missiles.

OTA has not had access to other than general information on possible alternative systems, and cannot comment on their status. Any decision to cancel Joint STARS and begin another program should also take into account when the alternative might become available, and whether that alternative would be suitable for peacetime deployments and deployments outside Europe.

Continuation of, or Successor to, PLSS

This year Congress and the Air Force decided not to fund procurement of the PLSS and to return it to a relatively low-level developmental program. PLSS was designed to satisfy a need to quickly and accurately locate and target emitters such as the radars of modern air defense systems that would pose a threat to NATO interdiction aircraft and to surveillance systems like Joint STARS. The system was cut partly because of technical problems, and partly because the Air Force believed it was no longer worth the cost. At the time of the decision it had not achieved the specified system reliability or emitter location accuracy; however, both have now reportedly improved to near specified values. Its demonstrated target location accuracy, reporting rate, and timeliness are unsurpassed by other tactical electronic intelligence systems, but it sometimes reports one emitting target as several.

Some within the Air Force argue that other assets are adequate to do the job of locating the targets. Others argue that there are important tasks that PLSS was supposed to do that no other system can. OTA knows of no other system that can locate emitters as quickly and accurately as PLSS. Congress will have to face the question of whether a system like PLSS is needed, and, if so, whether it should be obtained by continuing PLSS or starting another program.

RPV/TADARS

The Target Acquisition/Designation Aerial Reconnaissance System (TADARS), which employs the Aquila RPV, is currently in full-scale development. Major problems that held the system up appear to have been solved. This system lacks the broad area, continuous deep coverage of Joint STARS, but could provide dedicated targeting for Army systems. TADARS can perform accurate target location as well as laser designation for artillery and laser-guided bombs. Some have proposed procuring another RPV in place of Aquila, but procuring another RPV and equipping it with Aquila's capabilities would take longer and cost more than completing TADARS development. Several types of RPVs are currently operational and under development in Belgium, Canada, France, Germany, Italy, the United Kingdom, and Israel. The U.S. Army is developing a family of advanced unmanned air vehicles, of which Aquila is the most mature, and the Navy and Air Force also have RPV programs.

Advanced Anti-Armor Submunitions

Smart anti-armor submunitions with advanced warheads-such as Skeet,[15] SADARM,[16] and MLRS/TGW[17]–may be a key to FOFA: they are the only means of killing modern tanks in significant numbers beyond the close battle. *[8] But major uncertainties surround them, particularly the questions of whether technical and operational countermeasures could defeat their seekers and warheads. It will be necessary to keep a close watch on these development programs. One very valuable tool is the Chicken Little series of joint tests of munitions and munition concepts. OTA believes that this series, and others like it, ought to be supported and the results given serious consideration.

Defense Cooperation

Many of our Allies initially reacted cautiously to FOFA in part because it looked like another excuse to induce them to buy U.S. high-technology systems. They have a long-standing concern that the "two-way street" of NATO procurement favors the United States by a large margin. In recent years, Europeans have shown themselves willing to pay more for less capability to get equipment made at home. However, as the recent British decision to cancel the NIMROD and buy the AWACS demonstrates, they will not necessarily take this position to the extreme.

In the past year, the U.S. Department of Defense has been working to resolve this problem by encouraging the Europeans to identify systems they are developing and buying that could be used to support FOFA, negotiating agreements to explore co-development and coproduction of U.S. systems, and encouraging the Europeans to form consortia among themselves to develop and produce FOFA-related equipment. One particular vehicle for this effort has been the 1985 Nunn Amendment authorizing funding of cooperative development projects. The European members of NATO, including France, reacted very favorably to the principle of this amendment, and to the concept of joint development of new military systems. However, it is clear that before such joint development can take place, there will have to be some major changes in existing ways of doing business. The European Allies recognize the difficulty of "harmonizing' the specific interests of the various partners in cooperative ventures. They are somewhat skeptical about the ability of the U.S. armed services to do so and about Congress committing itself to programs years in advance. However, the Europeans are increasingly unwilling to simply "buy American" systems or technologies, and indeed there are some European developments in FOFA-related technologies which the United States could profit from not having to reinvent.

This may ultimately pose a dilemma for the United States. Cooperative programs usually cost more and take longer than projects pursued solely in the United States. And, of course, sharing production or buying European systems will cost U.S. jobs. Congress will have to deal with these programs one at a time as

"Smart anti-armor munition that fires a self-forging slug.

[16]Search and Destroy Armor: Smart artillery submunition that fires a self-forging slug.

"Terminally Guided Weapon for the MLRS: A smart submunition that carries a shaped charge warhead.

[18]Other existing and developmental munitions can destroy other armored and unarmored vehicles and have some effectiveness against tanks. Scatterable mines can delay the movement of tank units.

they come up, but it might be wise to develop an overall approach to striking a balance among accommodating the desires of the Europeans, funding U.S. companies, obtaining the best systems, and obtaining the most efficient production.

Chapter 2

Summary

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Summary

THE FOFA CONCEPT AND THE FOFA DEBATE

On several occasions, NATO's Supreme Allied Commander Europe (SACEUR), General Bernard W. Rogers, has warned that were the Warsaw Pact to attack NATO, it would only be a few days before he would have to ask NATO political leaders for permission to use nuclear weapons. Neither of the two implied choices—surrender or nuclear war-is a pleasant one. Some analysts believe that the Soviets might overrun NATO so quickly that NATO would not have time to decide to use its theater nuclear weapons. Only strategic nuclear weapons would be left.

With the strong backing of the United States, General Rogers has been pushing for a third alternative, to improve NATO's conventional defenses so that the credibility of NATO's deterrent is maintained. FOFA is a major element of this conventional force improvement.

Many observers have suggested that major changes are needed in NATO's conventional force structure, posture, and organization, as well as in its strategy for employing those forces and in its procurement procedures. But several major political and bureaucratic factors combine with geography to limit NATO's likely options. First, economic and political realities make it doubtful that the number of NATO army divisions and air force wings will be increased substantially. Early in its history, NATO decided to rely on both conventional and nuclear weapons because it could not afford a completely conventional defense. Second, NATO is a defensive alliance, and will not

Photo credit NATO

NATO members signing the Paris Agreement in 1954.

adopt publicly a strategy that calls for sending its ground forces deep into Warsaw Pact territory, even though that might give it a better chance of victory and of keeping conflict off NATO soil. Tactical counterattacks, however, would not be precluded, and opinions differ on how deep those might be. Third, NATO cannot plan to fall back deep into Germany in the face of an attack, trading space for time. Losing large parts of Germany would be catastrophic for the Alliance, and planning to do so would be unacceptable to German public opinion. These factors force NATO into a defensive posture close to West Germany's border with East Germany and Czechoslovakia, which, combined with a "share the burden" political policy that gives each member nation in the Central Region a section of the border to defend, sharply restricts freedom for major force movements along the front to counter Warsaw Pact force movements.

Within these constraints, NATO has decided both to improve the conventional forces it has in place, and to adopt the FOFA concept. These initiatives cannot overcome NATO's fundamental problems, but are designed to make better use of what Alliance members have procured and are procuring.

In simple terms, FOFA means using longer range weapons—airplanes, enhanced artillery, rocket launchers, and guided missiles-to attack enemy ground forces that have not yet come close enough to NATO's defending ground forces to engage them in direct combat. The purpose of attacking follow-on forces is to impede the ability of the Warsaw Pact commanders to bring their ground forces into the battle when they want to and at full strength. While it has application to operations in all parts of Europe, the primary focus of attention is on the Central Region.

Three major factors came together to produce the FOFA concept and make it a major part of NATO's defensive strategy. First is a recognition that successfully attacking the follow-on forces could have a profound effect on the ability of the Warsaw Pact to execute its offensive strategy. Second is a new emphasis on directly attacking the ground forces themselves, in addition to facilities such as air bases that would support them: NATO has always had plans for interdiction missions into enemy territory. Third-and perhaps most relevant to the issues before Congress-is the recognition that achieving a significant capability to attack follow-on forces depends strongly on exploiting new technologies. In theory, FOFA provides an opportunity to exploit technology to offset a fundamental East-West asymmetry.

The Warsaw Pact not only enjoys significant numerical superiority over NATO in the Central Region, it also has the advantage of conducting a strategically mobile offense while NATO's ground forces have much less freedom to maneuver in response. The Warsaw Pact, following Soviet doctrine and leadership, organizes its divisions into armies, which are organized into army groups (called fronts by the Soviets), all under the command of a theater commander.[1] NATO expects that these forces would be used not uniformly across the entire border, but to conduct rapid, deep, powerful thrusts into selected sectors of NATO's defensive line. These would be aimed at getting into NATO's rear area, disrupting NATO's ability to command and control its forces, capturing or destroying NATO's theater nuclear forces, and cutting off NATO's individual army corps from each other and from their support. These thrusts are likely to be directed at NATO's weakest corps sectors. The strongest—especially the U.S. corps—are likely to see only holding actions, designed to prevent them from redeploying to aid in defending against the main attacks. Of course, NATO cannot know in advance how the offensive would be conducted; surprise is a basic tenet of Soviet doctrine. This offensive would be preceded and accompanied by massive air and mis-

[1] Organizationally, Warsaw Pact armies are roughly equivalent to NATO corps, Pact fronts are roughly equivalent to NATO Army Groups, and the commander of the theater of military operations (TVD) is roughly equivalent to NATO's Central Region commander. However, at each level there are major differences between NATO and the Warsaw Pact, for example in manpower and firepower.

sile attacks against NATO's air bases and other fixed facilities, and by small attacks by special forces deep within NATO territory.

NATO expects that a Warsaw Pact offensive would be conducted with succeeding waves, or echelons, of ground forces. Once thought to be rigidly structured, this offensive is now believed likely to display a good deal of flexibility at several levels of organization. The fronts conducting the initial attacks would be divided into first echelon armies that would begin the attack, as well as operational maneuver groups (OMGs)[2] that would exploit it and second echelon armies that would continue it. The division among these elements is not rigidly set. It could vary among fronts and be altered as the front goes into battle. Each army would be divided into first echelon divisions to spearhead the attack, second echelon divisions, and mobile groups. And within each division there could be first and second echelon regiments. After the first fronts have done their jobs, the theater commander would have second fronts available to follow them. By NATO's definition, all those forces moving up behind the forces that are directly engaging NATO's defenders are follow-on forces.

NATO lacks a similar layered structure, although there is some ability for reinforcement. Defending NATO divisions would defend against one attack, only to be faced with another attack by fresh forces, and then another, and so on. So, for example, a single U.S. (or German, or Belgian) division might defend against two (or one, or three, or more) first echelon divisions of the first echelon army, and—depleted from that battle—be attacked by a fresh second echelon division of that same army, and then by a force from the first echelon of the second echelon army, etc. If the Soviet plan went forward unimpeded, there would be no time for the U.S. force to recover between assaults on it: each attack would find it weaker than the preceding one did. Alternatively, while occupied by an attack by the first wave, it might be bypassed by follow-on forces seeking to reach deeper objectives.

[2]Also called Mobile Groups.

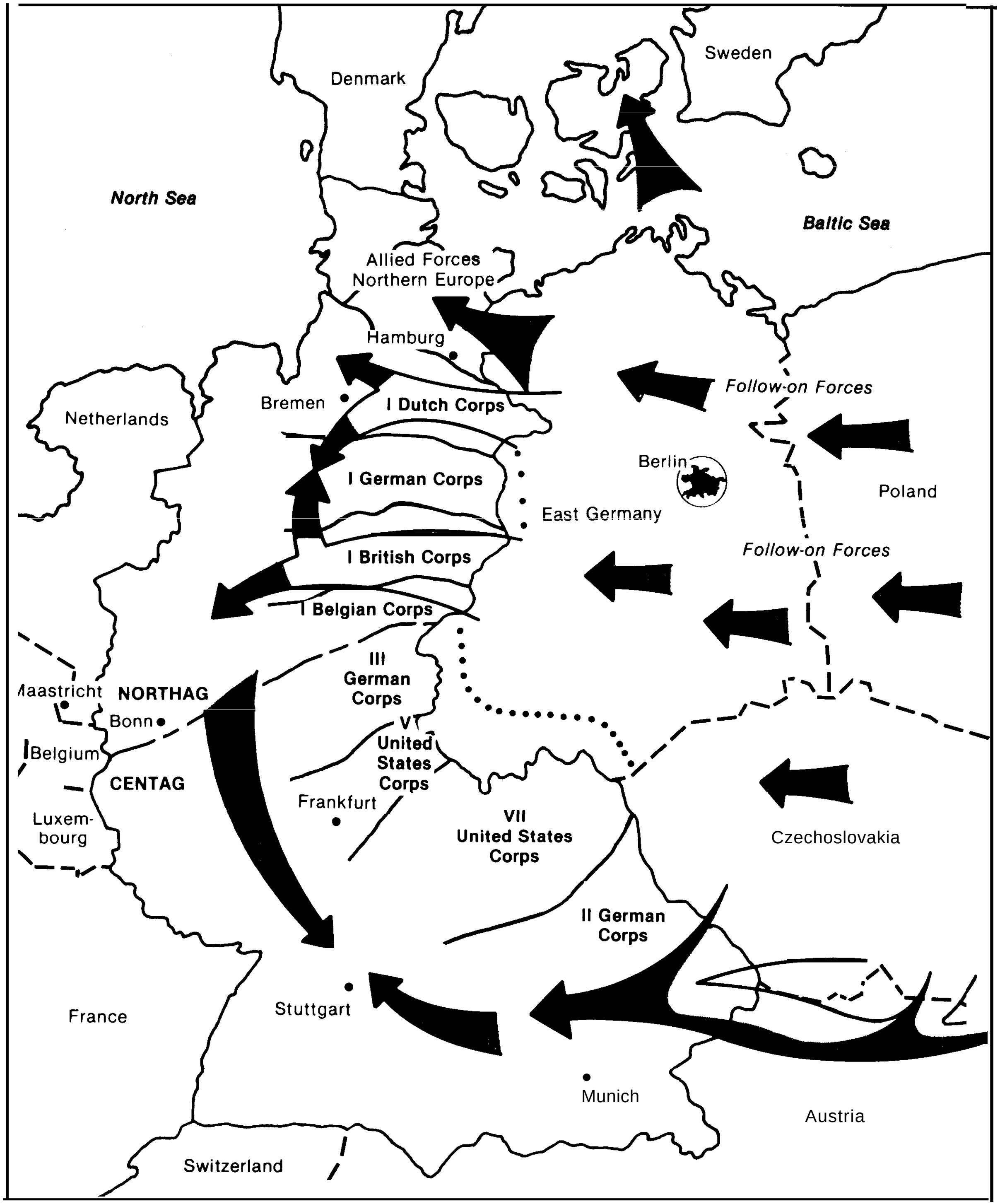
Because of evolving flexibility in the way the Soviets would use their forces, NATO cannot expect a "set piece" of equal waves attacking each division, or a uniform attack across the Region. It can rely on two fundamental aspects of a Pact offensive: that all the forces will not attack at once; and that the Pact has much greater freedom to maneuver their forces to attack heavily on selected parts of the front than NATO has to maneuver in response. FOFA seeks to oppose both of these: impeding the movement forward of follow-on forces, reducing the forces that NATO's defenders have to face and helping improve NATO's ability to recover from one battle before facing another; and moving firepower rapidly across the front to compensate for difficulties in moving ground forces across the front.

Some believe that simply directing firepower against forces moving up, or against main Soviet efforts, will not be effective: there are so many targets that not enough would be killed to make a difference. In this view, it will be necessary to find that small part of the force that is the focus of the attack and destroy it, thus causing the entire effort to fail. Doing this requires an ability to monitor and accurately assess Warsaw Pact force movements.

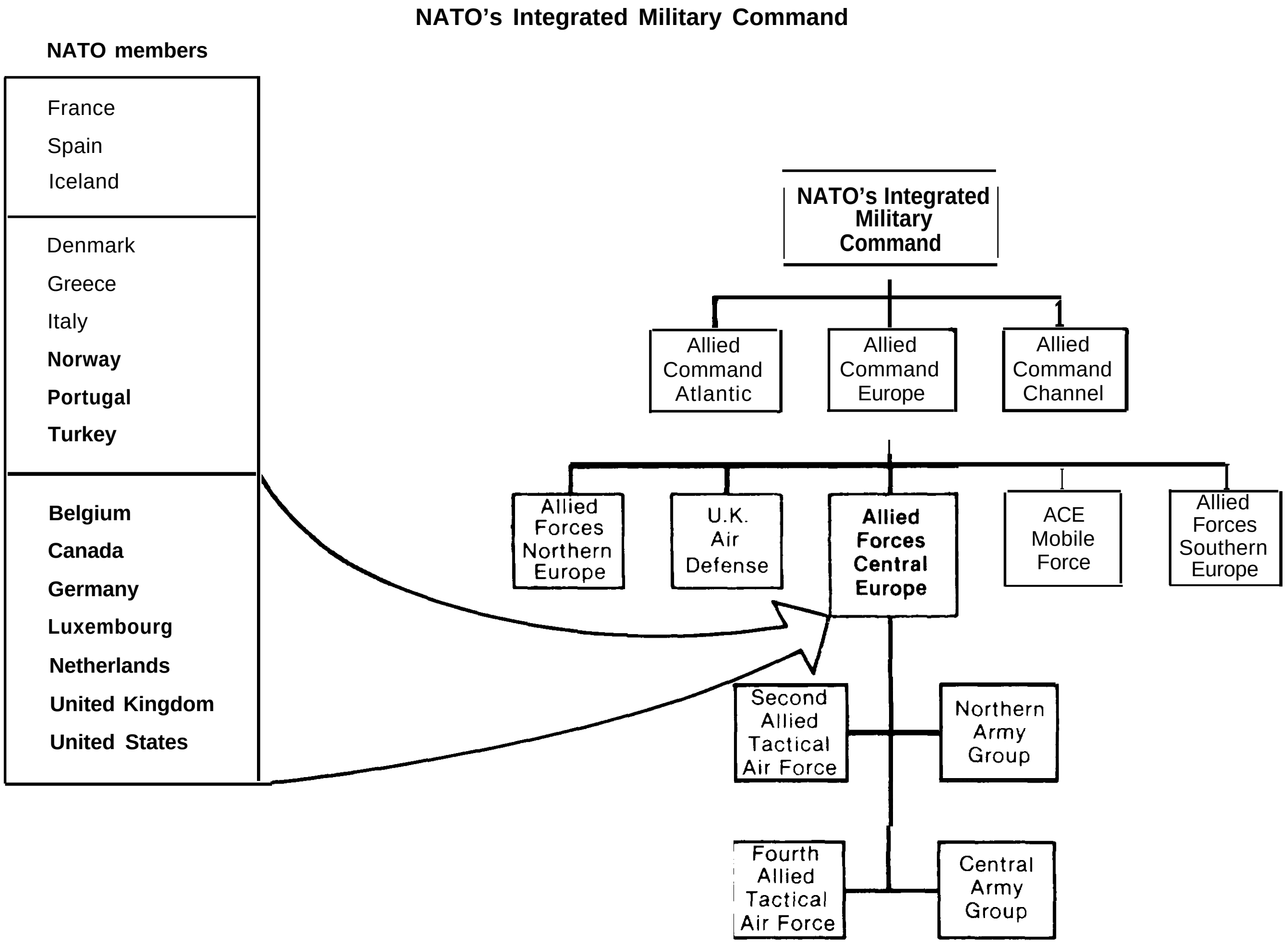
FOFA was a matter of some controversy when first proposed, and some still argue that it is not sound policy. Some Europeans, perhaps confusing FOFA with the U.S. Army's AirLand Battle concept, have seen it as offensive and inconsistent with NATO's defensive posture. Others argue that it is more efficient to wait until targets are close before attacking them, that attacking deep diverts resources from the close battle while providing little payoff. Still others believe that the follow-on forces will not be very important to the Soviet offensive, that most of the combat capability will be in the initial attack. Finally, there are several groups who argue that while the idea may be sound in principle, it will be very costly and extremely difficult—if not impossible—to implement.

The FOFA concept is still under development, and is seen somewhat differently by the

Figure 2-1.—Warsaw Pact Offensive



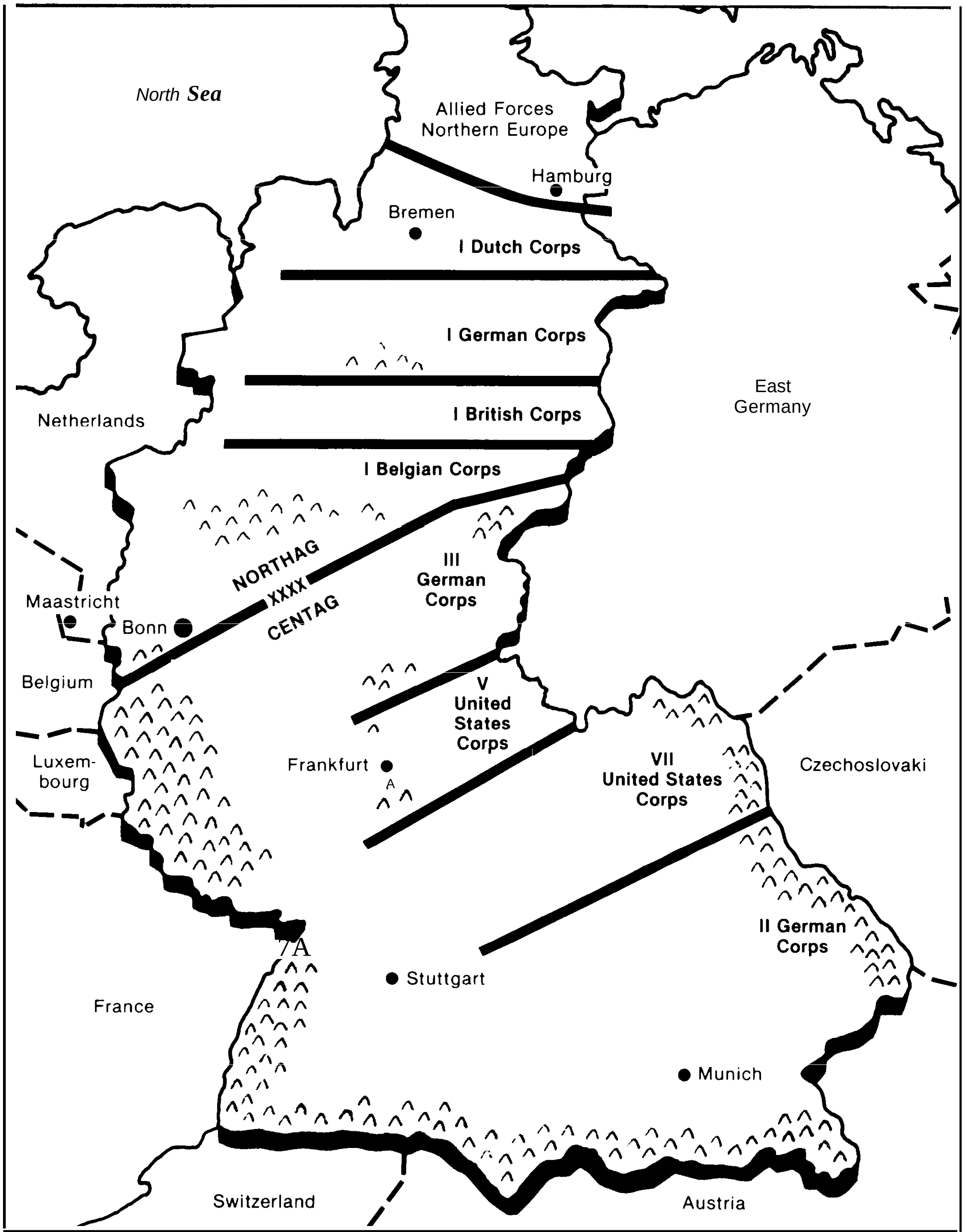
SOURCE: Adapted from John G Hines, Soviet Front Operations in Europe—Planning for Encirclement, a paper presented at a conference sponsored I the Alumni Association of the Norwegian National Defense College Study Committee, Apr 25-26, 1985



principal players: SHAPE (Supreme Headquarters Allied Powers Europe, the headquarters for NATO's Allied Command Europe); the U.S. Army; the U.S. Air Force; and the defense forces of our Allies. SHAPE's perspective is all of Europe including the entire Central Region, and it defines FOFA as delaying, disrupting, and destroying follow-on forces from just beyond the troops in contact to as far in the enemy rear as NATO systems can reach. SHAPE considers FOFA from the point of view of: 1) the corps commander, who wants to control the forces about to move in against his troops; 2) the Army Group commander, who wants to delay the second operational echelon (second echelon armies) until his corps have dealt with the first and his reserves are in place; and 3) the Central Region commander, who would like to make the second strategic echelon (second fronts) irrelevant to the war.

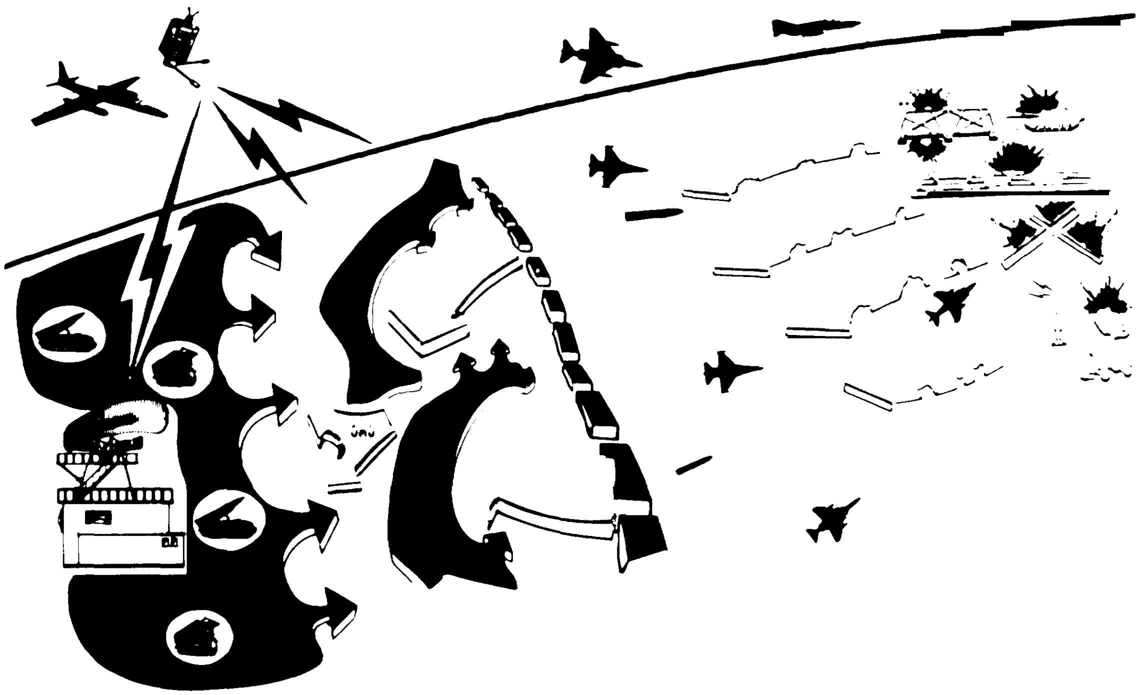
The U.S. Army sees FOFA as the "deep battle" part of its operations, as a means for "metering" the flow of enemy forces; its concentration is almost entirely on those sectors in which U.S. Army forces would be defending. As the Army sees it, striking deep not only reduces the threat to the defending ground forces, but also improves the effectiveness of the ground forces in handling the threat. Because their primary concern is the progress of the close battle, focused at the individual corps and subordinate division commanders' levels, the Army's approach puts great emphasis on

Figure 2-2.— NATO’S “Layer Cake” Defense



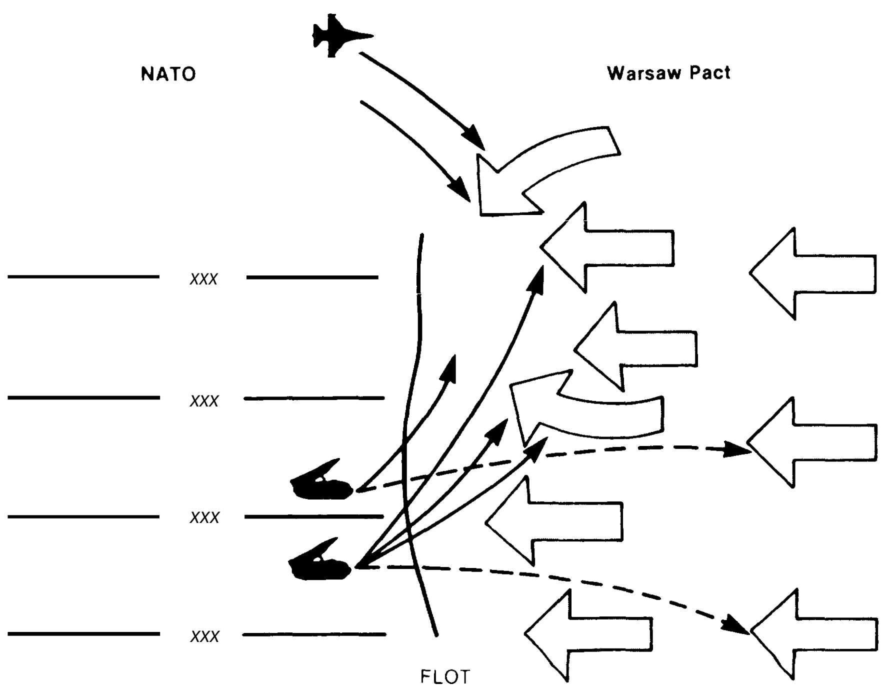
SOURCE. Off Ice of Technology Assessment, 1987

Figure 2-3.— FOFA Reduces Advancing Forces



SOURCE SHAPE

FOFA Provides Cross Corps Support



SOURCE Off Ice of Technology Assessment 1987 identifying and attacking those units-individual battalions, regiments, and possibly entire divisions-that pose the most pressing threat to its ground forces in the immediate future.

The U.S. Air Force, which sees FOFA as falling under its existing interdiction mission, views it primarily from the Army Group/ATAF (Allied Tactical Air Force) level, the command level above corps. While individual regiments and even battalions might be targeted at the request of corps commanders, the Air Force is more likely to think in terms of attacks on whole divisions or their component regiments, possibly before they become an immediate threat to a corps sector. Attacking these larger targets while they are farther out makes it easier to preplan takeoff times and attack routes—necessary to keep attrition down-and permits giving greater latitude to pilots to choose among specific target vehicles within the larger array. The Air Force is also interested in the concept of striking very deep to cause long delays in the arrival of the second fronts.

Is FOFA Appropriate to the Threat?

We can never know exactly what the Soviets would do if they went to war against NATO. Analysts working from similar sources have disagreed over whether the Soviets would launch a conventional offensive, and whether follow-on forces would play a significant role in that offensive. There is currently general (but not unanimous) agreement that the Soviets are at least preserving the option for a conventional offensive, and most observers argue that they would want to begin with a conventional offensive and keep it conventional as long as possible. Most observers also agree that while the Soviets are developing considerable operational flexibility in their use of ground forces and have considerable latitude to beef up the first echelons at the expense of the second echelons, there will be significant follow-on forces at all levels.

There is currently a great deal of uncertainty —and a great deal of controversy—concerning a number of factors of importance to FOFA. In particular:

1. how much flexibility Soviet ground forces commanders have at various levels of organization to change the direction of attack, to compensate for unanticipated situations, and to allocate their forces among first echelon, second echelon, and mobile groups;
2. how sensitive the Soviet offensive plan would be to delays and to destruction of some of its forces;
3. how robust and resistant to disruption the Warsaw Pact command and control system is;
4. how important the follow-on forces are to Soviet strategy; and
5. how much they could move their forces forward prior to hostilities.

Mobilization is an important factor in a war in the Central Region. It is thought unlikely that the Soviets would attack without any mobilization: not enough of their forces would be ready and in place. However, some analysts believe that by increasing the numbers, quality, and readiness of their forces in Eastern Europe, and by reforming their command structure, the Soviets may be developing a capability to do just that. NATO military planners are acutely aware that NATO would need several days of mobilization before it could effectively resist a massive attack, in addition to whatever time would be needed to recognize a Pact mobilization and decide to respond. Hence, NATO planners are very concerned about a Pact attack preceded by a short or concealed mobilization.

A NATO ability to attack follow-on forces would pose a dilemma for the Soviets: short mobilizations mean more Soviet forces would have to move forward during hostilities when NATO could shoot at them, and less opportunity to ‘front load’ the offensive; long mobilizations would risk giving NATO sufficient warning to also mobilize. This is part of the appeal of the concept (discussed below) of using B-52 bombers carrying cruise missiles to put the rail lines in Eastern Europe at risk. Second echelon fronts—and possibly elements of

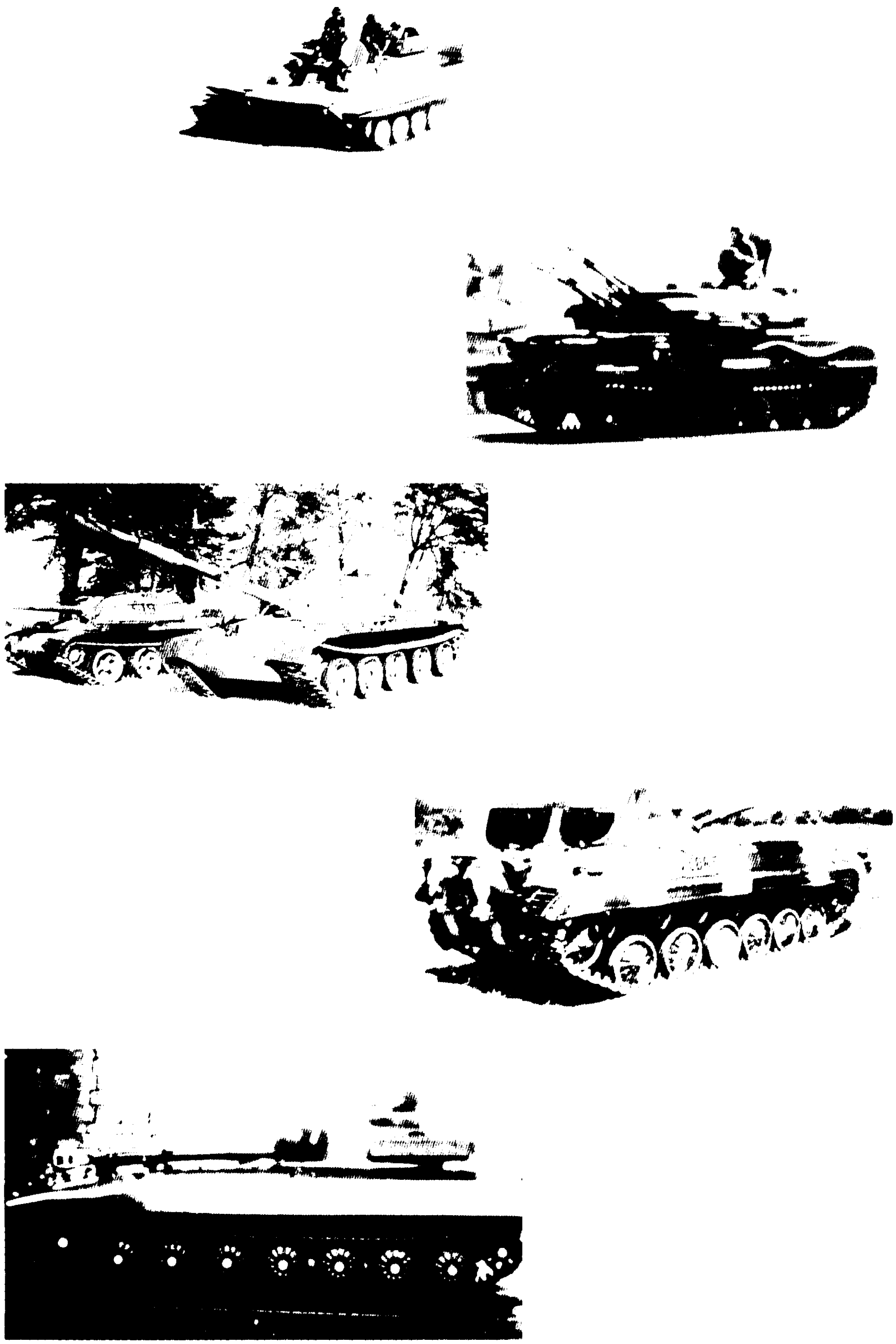


Photo credit U S Department of Defense

Elements of Soviet army forces.

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the first fronts—would have to come forward across Eastern Europe by rail to reach the battle. After leaving the rails, they would be transported on roads in Poland, Czechoslovakia, and East Germany, and finally move under their own power to join the battle.

It is widely believed that Warsaw Pact and NATO forces would be intermingled to considerable depth. There would be Pact penetrations into NATO territory and NATO penetrations into Pact territory—much like interlocking fingers. Some analysts believe that it therefore would be extremely difficult to pick out and attack the follow-on forces.

How Do Our NATO Allies View FOFA?

Our European Allies generally have been slower to accept FOFA than the United States has. Up through early 1986 there appeared to be little enthusiasm: conservative defense-minded governments were cautiously in favor; opposition Socialist parties were generally opposed. Underlying some European reactions have been long-standing transatlantic tensions on the degree to which NATO should rely on conventional forces, sharing of defense costs, and trade in defense equipment. This was heightened by a perception, especially among the Germans, that FOFA would draw resources from the close battle—their primary concern—and yield little in return. The situation was aggravated because FOFA came in the midst of several other (primarily United States, or at least viewed as such) initiatives that seemed to arrive at a faster pace than the Europeans could respond, and because of calls for still greater spending increases to implement FOFA.

There is mounting evidence that the Allies are moving toward greater understanding and acceptance of the FOFA concept, and are becoming more enthusiastic for developing and procuring systems that could support FOFA.

To the Germans, whose thinking strongly influences other Central Region nations, FOFA is of lower priority than fighting the close battle or air defense, a sentiment echoed by some other nations. However, they have apparently dropped their efforts to get NATO to assign priorities among the key mission concepts. It is difficult for the Germans to accept anything that might appear to reemphasize forward defense, which is a cornerstone of German public acceptance of NATO. And German membership is itself a basis of the Alliance.

The British, Germans, Dutch, and Belgians —as well as the French, who are not part of Allied Command Europe–have accepted the value of attacks out to the range of the Multiple Launch Rocket System (MLRS), and are planning to procure MLRS as well as enhanced artillery and targeting systems. However, for some this procurement is at least ten years in the future.

The Germans and British accept, in principle, the value of striking deeper with army systems, but have not yet decided whether it can be made practical and cost-effective. The Dutch and Belgians think that their defense establishments are too small to support the necessary complex packages of systems. All the air forces are interested in upgrading their interdiction capabilities, but here again the smaller forces are limited in the variety of systems they can support. Within the Conference of NATO Armament Directors, a FOFA baseline listing the basic capabilities needed for FOFA and specifying a near term interest in ranges out to 150 kilometers has been approved. Work is now underway to produce an agreed list of candidate systems to meet these basic needs.

Availability of funding will limit what all the nations can do (the United States included). This is particularly a problem for the British, whose defense budget is expected to decline in real terms (with significant declines in spending for conventional defense in order to fund Trident), and for the Belgians, who are more likely to apply whatever money is available primarily to improving their ability to fight the close battle.

The focus of attention appears to have shifted from the conceptual to the more concrete arena of arms production and cooperation. It seems clear that the Europeans are unlikely to be enthusiastic about FOFA if FOFA means buying

Photo credit NATO

Ministerial meeting of North Atlantic Council.

predominantly American technology. There is also evidence that they are becoming interested in producing and selling systems that could support FOFA. On the other hand, while it may be difficult to separate real concerns from rhetoric, it may be unwise to dismiss all previous European concerns as a rhetorical smokescreen for economic considerations. U.S. efforts to develop greater Alliance cohesion and cooperation on the development of FOFA systems have centered on the Department of Defense (DoD) Defense Science Board FOFA II Task Force, and the 1985 Nunn Amendment initiative. Both have apparently achieved some initial success in arousing European governmental and industrial interest, but it is too early to tell whether there will be significant concrete results.

Nonetheless, some major elements are discernible. The Europeans are most interested in those approaches to implementing FOFA that are most in consonance with what they have already been planning. In this they are not alone-the U.S. approach to FOFA also includes only systems that were underway before the term "FOFA" was invented. However, the U.S. approach is focused at longer ranges than the European, and one source of friction appears to be the reluctance of our Allies to jump to an approach centered on our products.

In particular, the Europeans are interested in shorter ranges—out to roughly 30 kilometers —where enhanced artillery and MLRS (which several are now buying) could be applied, and in air interdiction. The Europeans appear most interested in FOFA enhancements to systems in which they have already made large national investments, such as the Tornado aircraft, and continuing parallel development of sensor systems–e.g., Remotely Piloted Vehicles (RPV), the United Kingdom's Airborne Stand-Off Radar (ASTOR), and the French Observatoire Radar Coherent Heliporte d'Investigation Des Elements Ennemis (ORCHIDEE)–that may duplicate U.S. efforts. U.S./European cooperative efforts may thus focus largely on ensuring some degree of interoperability among competing systems. The Germans are developing attack drones for use against armor and air defenses, and advanced anti-armor weapons to be carried on combat aircraft. There appears to be little European enthusiasm for longer range attack missiles, like ATACMS. Indeed, political problems—centering on public perceptions of such missiles as being "offensive," on arms control considerations, and on notions that they are destabilizing because the Soviets might think they carry nuclear warheads and respond with nuclear weapons—surround the deployment of such missiles in Europe, and might cause problems as the United States seeks to deploy them.

There is a growing recognition within Europe —including France-that cooperative programs are the key to obtaining costly modern capabilities. But the Europeans have several concerns about cooperative programs. There is little sentiment for buying goods produced in the United States, and a growing reluctance simply to co-produce U.S. developments, because that stunts the growth of European technology. They prefer co-development programs that draw on and nurture the technological strengths of all parties. Many see in U.S. policy several impediments to cooperative programs: "buy American" sentiments; an inability to commit to a several year project; "black" programs that they cannot have access to; restrictions on transferring technology to our allies; and restrictions on sales of resulting products to third parties.

Based on past experience with cooperative arms production, the process of developing and procuring the many systems required for FOFA is likely to be quite time-consuming. There are several fora—formal and informal groupings of European states, bilateral and multilateral arrangements including the United States, industry-to-industry cooperative programs, and attempts to sell existing systems or their co-production— through which such deals can be arranged. All will have to be harmonized, and the final products gotten through their respective national governments.

Both the British Labour Party and the German Social Democratic Party appear to be deeply opposed to FOFA (and to a number of other basic NATO ideas). Labour stands a reasonable chance of coming to power. If this happens, NATO will face a very different situation, because both Britain and Germany are not only major players, but have a strong influence on how the smaller countries react. Even out of power, both these parties are important political forces in Europe.

How Might the Soviets Respond to FOFA?

The Soviets are likely to regard FOFA both as worrisome and as presenting an opportunity to stimulate and exploit a controversy within NATO. Their reactions to it have taken, and most likely will continue to take, two forms: political exploitation of a new controversy within NATO; and adjustment of their operations to take account of it.

Their propaganda has played on many of the concerns voiced in Europe, in particular: that FOFA is an offensive doctrine that threatens the East; that FOFA would be destabilizing because missiles carrying conventional warheads could not be distinguished upon launch from nuclear missiles; and that it would lower the nuclear threshold through the use of conventional weapons of high destructive potential. The Soviets have taken the position that FOFA is yet another manifestation of aggressive U.S. behavior and intentions, and has contrasted that to the peace-loving image they paint of themselves. They have drawn a picture of the United States developing an aggressive stance with new weapons having the destructive potential of "weapons of mass destruction" (i.e., nuclear weapons). They will try to use it to drive a wedge between the United States and Europe, and to stir up the European left.

Although these concerns may not be taken very seriously among defense professionals in Europe, they do have some support within the major opposition parties in Germany and Britain. Furthermore, these and similar arguments can be exploited by the Soviets to influence public opinion, and perhaps elections, in the democratic European states. The threat to NATO is both political and military. The Soviets would probably prefer to split NATO and separate the United States from Europe by political means if they could do so, rather than risk war.

On the military level, they are concerned both about the concept itself, and about the individual systems being designed to support it. In the first instance, they have added FOFA into their ongoing reevaluations of their strategy and operational art. Their reaction may ultimately take the form of deemphasizing the second echelon at all levels (and otherwise "front-loading' their offensive), or increasing the combat capability of their leading units, or both. However, geography and a desire to limit the vulnerability of massed forces to a nuclear strike will reduce their opportunities for front-loading. They can also be expected to take active and passive countermeasures against the weapons and other systems used by NATO to find and attack their follow-on forces. Each of these steps can be taken only at some cost.

The Soviets appear to have deep concerns about the rapid reaction capability of NATO's new strike systems. In the abstract, such systems could counter their plans faster than they could modify their plans in response, and steal the initiative from them. They will probably take measures to speed their planning cycles or protect them from FOFA weapons. They are also developing similar systems and the theory of their use on the modern battlefield.

IMPLEMENTING FOFA

Initially, a great number of different FOFA concepts were under discussion. But over the past few years, several important study efforts have helped to narrow the range of possibilities by taking into account both operational considerations and technological realities. Attacks could be conducted either by ground-launched missiles or interdiction aircraft against a variety of targets at many different ranges from the FLOT. The targets could be combat units, selected high-value elements of the combat units (e.g., command posts or surface-to-surface missile launchers), or the supplies for those units. Moreover, attacks could be launched to create chokepoints—for example, by dropping a bridge or sowing a mine field along a route of advance-just as a unit would be about to move through. Attacking the combat units might delay, disrupt, or destroy them; attacking their command posts could disrupt their ability to contribute to the offensive, and creating chokepoints would delay their advance,

What and Where to Attack

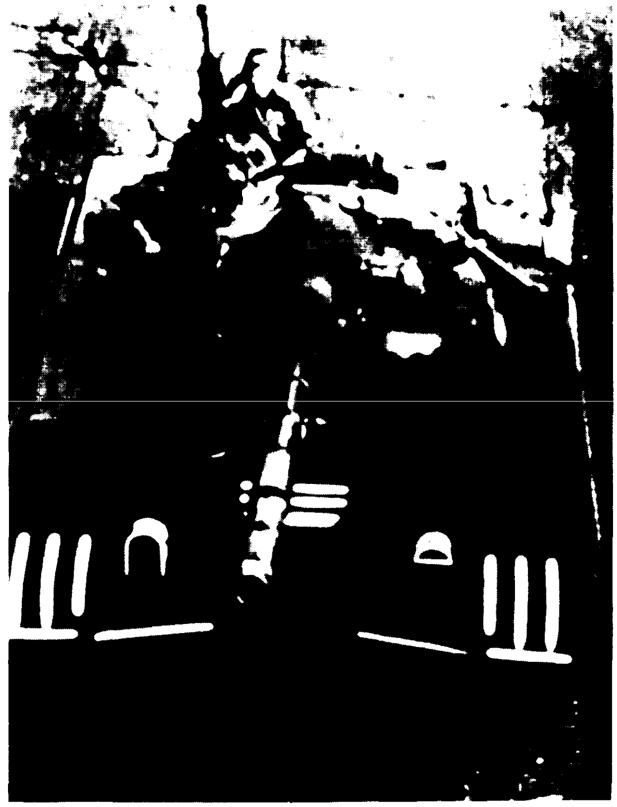
Of the three general types of targets-groups of vehicles, individual high-value units that, while mobile, tend to spend most of their time moving, and fixed chokepoint targets-the fixed targets are the easiest to target, requiring at most some indication that the time is right to hit them, in addition to information that can be gathered in peacetime. The high-value targets are inherently difficult because their presence can be obscured. When NATO deploys rapidly responding reconnaissance and targeting systems that can find moving vehicles (as well as the weapons to engage them) these targets will probably become easier to locate and destroy than the high-value targets. Until then, there is likely to be more interest, as a practical matter, in the high-value targets.

Quantitative analyses have tended to favor attack of moving combat units either in transit from division assembly areas (roughly 50 to 150 kilometers from the FLOT) to final assembly areas (out to perhaps 50 kilometers from the FLOT), or in their move out of final assembly areas to join the battle. Although opportunities to attack stopped units should not be ignored if they present themselves, attacking moving units provides a better basis for planning; stopped units are more likely to have taken measures to hide from both detection and attack.[3] The concept is to attack battalions or entire regiments, destroying so much of their combat capability that they can no longer be usefully committed to the assault as scheduled.

In attacking these units, emphasis could be put on killing tanks, the other armored vehicles, or the soft-skinned vehicles such as trucks. Destroying tanks is particularly difficult; their heavy armor is designed to protect against most munitions. Fewer than half the armored combat vehicles, however, are tanks. The others —armored fighting vehicles, armored personnel carriers, surface-to-air missile launchers, and surface-to-surface missile launchers, as well as armored engineering equipment needed by the combat vehicles-are easier to put out of action and are also important to the combined arms offensive. Fewer than one-third of the vehicles in a Soviet division are armored, but the closer the division gets to the battle, the more of its soft-skinned vehicles it leaves behind.

The supplies for these forces would be almost as hard to find as the forces themselves, but easier to kill. However, analyses differ on the value of attacking supplies. Although supplies are vital, the Soviets may have much more than they absolutely need. Some conclude that forces going into battle carry enough on board to do without resupply for a while. On the other hand, some analysts conclude that these are potentially valuable targets, especially supply units that are part of combat units (i.e., "organic supply"). In order to continue an attack or move forward and exploit it, a combat unit would need at least minimal critical supplies.

[3]The U.S. ASARS-II system now in Europe can detect stopped vehicles.



Close to the battle, combat vehicles would outnumber supply trucks, making each supply truck a more valuable target.

High-value targets such as command posts, missile launchers, and resupply points are worth attacking when they can be located. No means of routinely locating and engaging them has as yet been identified, but the fact that they tend to stay put for many hours increases the likelihood that clues from a number of sources can be pieced together successfully. If found, they could be killed with today's weapons; they are much fewer in number than the combat vehicles. The Army believes that attacking these targets could seriously disrupt the offensive. In the near term—until systems for locating moving units and weapons for attacking masses of armored vehicles become available-attacks would probably be limited

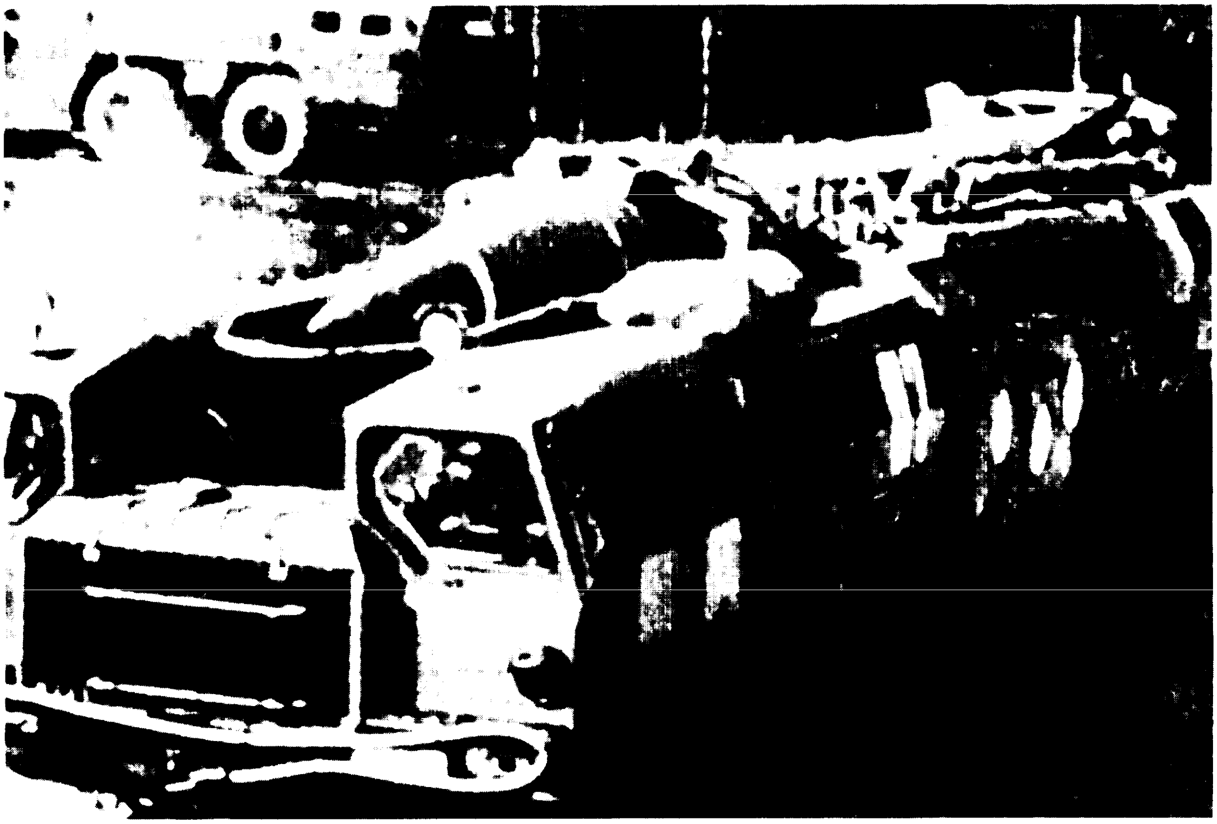


Photo credit U S Department of Defense

Less well-protected Soviet vehicles outnumber the tanks.

to such high-value targets and to creating chokepoints to cause delay.

Causing delays can be very useful if the delays are sufficiently long; however, studies indicate that most attacks would be incapable of causing significantly long delays. In many cases, there may be enough “slop” in the Soviets’ schedule to compensate. Two promising exceptions are: deep strikes against the rail lines in Eastern Europe, where delays measured in weeks may be possible; and strikes very close to the FLOT, where delays of just a few hours may be very significant. Some analysts believe that it is very important to delay the second operational echelon to allow NATO’s reserves to get into place, and to delay the second strategic echelon until NATO has successfully dealt with the first.

In general, the closer to the FLOT the attacks take place, the more systems can reach the targets, the more effective the attacks are likely to be, and the more direct their effect on the close battle. However, waiting for the enemy to get very close risks not being able to fire enough rounds in the time he is exposed to attack. Furthermore, this is not necessarily an argument in favor of short-range systems, because longer range systems have greater flexibility to redirect fire across the front.

Obtaining the Capability

The Systems: What’s in the Inventory, What’s Being Bought, What’s Under Development

Supporters of the FOFA concept believe that some or all of these approaches can be made to work, *if* all the necessary pieces can be procured. They differ as to which would be the most useful and the most feasible.

Implementing any of these approaches will require a package of systems, the major components of which are:

1. reconnaissance, surveillance, and target acquisition (RSTA);
2. data analysis and handling (data fusion);
3. attack platform;
4. munitions; and
5. systems to protect the airborne RSTA assets and to help the attack aircraft penetrate to their targets.

All of these will have to work and be available in sufficient quantity if the concept is to be viable.

This is illustrated in table 2-1, which suggests packages of systems to support specific operational concepts. None of these concepts could be fully implemented today, because systems are not yet deployed. Furthermore, a great many more systems than are shown here—both existing and developmental-might be brought to bear. Table 2-2 shows what the U.S. Army and Air Force are currently buying and developing. NATO favors an evolutionary approach to FOFA, i.e., implementing a limited capability while more effective systems mature.

Reconnaissance, Surveillance, and Target Acquisition (RSTA) Systems

Currently the Services have in Europe a number of different systems that can detect and locate fixed targets and targets that move infrequently. Most of these systems are based on aircraft, and locate their targets by imagery or by detecting electronic emissions. They lack an ability to look over broad areas for long periods of time to find moving units and rapidly (i.e., within seconds) report that information to users. The Joint Surveillance Target Attack Radar System (Joint STARS), currently in full-scale development, is designed to do that. Although strongly supported by DoD, it has been a controversial program in Congress.

Remotely piloted vehicles (RPVs) could also serve this function, but over a generally much smaller area. Whereas one Joint STARS might support several corps at once, one of the Army's Aquila RPVs might typically support a brigade's MLRS batteries. Aquila could see targets masked from Joint STARS by terrain and vegetation and could identify individual vehicles. It has also been a controversial program. Several other RPVs are under development both here and in Europe. The Europeans generally favor RPV systems, have many in the field, and are developing upgrades and new systems, particularly the CL289. The British are developing abroad area surveillance system—called ASTOR–and the French are developing a heliborne MTI system called ORCHIDEE.

The Precision Location Strike System (PLSS) has also been controversial and the program was recently scaled back by DoD and Congress. PLSS would have been used to locate radars of air defenses threatening NATO interdiction aircraft and RSTA platforms such as Joint STARS.

Data Analysis and Handling

NATO's ability to attack moving targets is also limited by data-handling systems that consume long periods of time getting information from RSTA systems to analysts and to attack systems. This problem has been compounded because modern collection systems can collect large amounts of data. The Joint Tactical Fusion program, as well as other efforts, are working on using modern computers to streamline this process. Systems like Joint STARS will be able to send data both to assessment centers to plan attacks, and directly to attack systems such as MLRS batteries.

Attack Platforms

Currently NATO has a variety of tactical aircraft-including U.S. F-16s, F-4s, and F-111s, British and German Tornados, and several other types—conventional artillery, and the Lance missile to strike into Warsaw Pact territory. All of these are limited in their ability to attack follow-on forces. Of the aircraft, only the Tornados and F-1 11s can operate at night and in bad weather,[4] and they will have other interdiction tasks as well.

'The others can fly at night, but because they lack systems to support effective navigation and weapons employment in the dark, they would not be particularly effective.

Table 2-1 .—illustrative Packages of Systems To Support Specific Operational Concepts (as yet, not all the pieces exist)

Operational concept	Reconnaissance, surveillance, and target acquisition: Reconnaissance, surveillance, situation assessment	Reconnaissance, surveillance, and target acquisition: Target acquisition, attack control	Attack: Platform	Attack: Weapon
1, MLRS and artillery attack of regimental columns: 5 to 30 km deep	GUARDRAIL, TRS, ASARS, Joint STARS, and ASAS	AQUILA and AFATDS	8-inch Artillery and MLRS	SAD ARM MLRS/TGW
2. Aircraft attack of division columns: 30 to 80 km deep	GUARDRAIL, TRS, ASARS, Joint STARS, and ENSCE	Joint STARS	F-16	MSOW carrying Skeet or TGSM or CEB
3. Ballistic Missile attack of division columns: 30 to 80 km deep	GUARDRAIL, TRS, ASARS, Joint STARS, and ASAS	Joint STARS and AFATDS	MLRS launcher	ATACMS carrying DPICM or TGSM or Skeet
4. Attack with aircraft:create chokepoints and then attack the halted vehicles: 80 to 150 km deep	GUARDRAIL, TRS, ASARS, Joint STARS, and ENSCE	ASARS and GACC	F-15E F-16	AGM-130, MSOW carrying various munitions Includ-ing mines
5. Air-launched cruise missile attack of rail network; 350 to 800 km deep	Various national systems	(on the weapon)	B-52	Cruise missile with various munitions

NOTES
1 Definitions
AFATDS—Advanced Field Artillery Tactical Data System provides target data to artillery and M LRS batteries
AGM-1 30—an air-launched missile
ASARS—Advanced Synthetic Aperture Radar System provides images of fixed objects
ASAS—a developmental Army center for collecting, analyzing, and disseminating surveillance data
ATACMS—Army Tactical Missile System a ballistic missile to be launched from MLRS launchers
AQUILA—a remotely piloted vehicle
CEB— Combined Effects Bomblet Similar to DPICM; designed to be dispensed by the Combined Effects Munition (CEM)
DPICM—Dual Purpose Improved Conventional Munition unguided submunition for use against light armor and soft targets
EN SC E—the Air Force version of ASAS
GACC—Ground Attack Control Center a developmental center for controlling air attacks against ground targets
GUARDRAIL–a tactical surveillance system
Joint STARS—Joint Surveillance Target Attack Radar System moving target Indicator and attack control
MLRS—Multiple Launch Rocket System
MLRS/TGW–Terminally Guided Weapon a smart anti armor submunition for MLRS
MSOW—Modular Standoff Weapon a weapons dispenser
SADARM –Search and Destroy Armor a smart anti.armor submunition for artillery
Skeet —a smart anti-armor submunition
TGSM —Terminally Guided Submunition a smart anti.armor submunition
TRS—Tactical Reconnaissance System carries various sensor suites
2 Reconnaissance surveillance, and situation assessment would be performed by a number of systems–particularly those shown here —feeding into the assessment center Although all need not find the target for the attack to take place, the more there are the greater the chances are that the target will be found, recognized and identified with sufficient accuracy to attack it
3 Not all the submunitions displayed in the table are necessarily being developed for deployment on the weapons shown, however, there is no fundamental reason why they could not be engineered onto those weapons

The Air Force is currently buying the LANTIRN system for the F-16, which will enable it to operate effectively at night. They have also begun to procure the F-15E which is designed for interdiction and carries the LANTIRN and a terrain-following radar. The F-15E has much greater range than the F-16.

The Army is procuring the Multiple Launch Rocket System (MLRS), which has about twice the range of 155mm artillery. The ATACMS ballistic missile,[5] which is designed to reach well over 100 kilometers into enemy territory with high accuracy, has entered full-scale development. It will be launched from the MLRS launcher. The Germans are developing attack drones for killing armor and air defenses.

Munitions

Munitions are another major limitation on NATO's ability to attack follow-on forces. Current generation weapons are effective primarily against single, soft targets; the Air Force has weapons (e.g., the GBU-15) that can be used to destroy bridges. The Air Force's Maverick missile can be used to kill tanks (and other

[5] Also called "Army TACMS" or just "TACMS." The Army split this development off from the Joint TACM S, or JTACM S program.

Table 2-2.—Status and Costs of Selected FOFA-Related Programs

		Air Force Programs Through FY 1987		Expected total	
System	Status[a] (3/1/87)	Funds[b] appropriated	Units procured[c]	Acquisition[d] Cost[b]	Units procured[c]
Platforms					
F-15A/B/C/D/E	proc/FSD	$ 35B	925	$ 46B	1,270
F-15E	proc/FSD		50		390
F-16A/B/C/D	proc	$ 23B	440	$ 48B	2,740
A-7 upgrade	FSD	$ 35M	N/A	$190M	N/A
ATF	DEM/VAL proto	$550M	0	TBD	750
Pods:					
LANTIRN	proc	$ 1.86	150 nav 10 tgt	$ 4B	700 nav 700 tgt
Munitions and direct-attack weapons'					
CEM	proc	$ 1.2B	48,000	$ 2.2B	96,000
SFW	FSD	$ 85M	0	$ 2.3B	14,000
GATOR	proc	$560M	10,200	$560M	10,200
HVM	adv dev	$ 34M		$ 1.8B	
missiles			0		100,000
fire control sys			0		200
HTM	FSD	0	0	$88M RDT&E	TBD
DAACM	pre-FSD	$ 19M	0	$340M	2,850
Standoff weapons					
GBU-15	proc ends	—	—	—	—
AGB	prop	TBD	TBD	TBD	TBD
HARM	proc	$ 1B	4,500	$ 2.1B	7,300
LCS	adv dev	$ 33M RDT&E	TBD	$ 67M RDT&E	TBD
AGM-65D/G	proc	$ 1.96	10,000	$ 6B	60,000
AGM-130	FSD	$110M	40	$ 2.1B	5,600
MSOW	RFP/PD rel 3/87	0	0	TBD	TBD
AMRAAM	FSD/proc	$ 1.8B	180	$ 8B	17,000
RSTA Systems:					
JSTARS E-8A	FSD	$625M	2	$ 3B	10
PLSS[e]	OUE	$675M		$675M	
AMS[e]			3 +		3+
SNS[e]			6		6
case			1		1
TRS[f]	proc	$ 1.5B	—	$ 1.9B	
TR-1s			27		27
SS[f]			14		14
PGS[f]			1		1
BGS[f]			1		2
F-O TRS[g]	adv dev	$ 27M	0	$ 1.6B	TBD
ESM	pre-FSD	$ 34M	0	$230M	34
GACC	pre-FSD	$ 3.5M	0	$ 40M	N/A
Communications and data fusion systems'					
JTFP	FSD	$ 80M	0	TBD	TBD
HAVE QUICK (I/II/IIA)	FSD/proc	$160M	22,000	$500M	43,000
Electronic warfare systems:					
EF-111A U/G[h]	FSD	$ 90M	0	$265M	38
F-4G WW[i]	FSD	$240M		$565M	
computers			150		150
receiver groups			0		124
Compass Call	FSD	$325M	16	$520	16

NOTES

[a]adv advanced, DEM demonstration, dep deployment, dev development, FSD full-scale development, OUE operational utility evaluation PD Program Directive proc procurement, prod production, prop proposed, proto prototype, RFP request for proposals, VAL validation

[b]Approximate in current ('then-year') dollars

[c]Approximate number planned

[d]Including cost of research, development, testing, evaluation, and procurement but not operation and maintenance

[e]PLSS Precision Location Strike System, AMS Airborne Mission Subsystem, SNS Suite Navigation Subsystem, CPS Central Processing Subsystem 3 + indicates three all-up AMSS plus a partial AMS requiring refurbishment

[f]TRS Tactical Reconnaissance System, SS sensor suite, PGS prototype ground station BGS bunkered ground station

[g]F-O TRS Follow-On Tactical Reconnaissance System (ATARS)

[h]LUG upgrade

[i]WW Wild Weasel

SOURCE US Air Force (SAF/LL), January 1987

Table 2.2.—Status and Costs of Selected FOFA-Related Programs—Continued

Army Programs

System	Status[a] (3/1/87)	Through FY 1987: Funds[b] appropriated	Through FY 1987: Units procured[c]	Expected total: Acquisition[d] Cost[b]	Expected total: Units procured[c]
Platforms					
MLRS	proc	$ 3.1B		$ 4.9B	
launchers			392		681
rockets			1951000		440,000
ATACMS	**FSD**	**$350M**	—	**$ 1.2B**	**TBD**
Reconnaissance, Surveillance and Target Acquisition (RSTA) Systems					
RPV/TADARS	FSD	$820M		$ 2.2B	
GCS			5[k]		53
AV[l]			12		376
IEW UAV[m]	dev	$ 28M		$110M	
GCS			2		6
AV[l]			12		46
JSTARS GSM	FSD	$240M	3	$730M	95
TRAC	adv dev	$ 25M		TED	1
Improved GUARDRAIL/ Common Sensor	proc	$300M	28	$1.0B	65
Munitions					
DPICM					
155 mm	proc	$ 2.0B	4.4M	$ 4.3B	9.4M
8-inch	proc	$620M	640.000	$640M	650,000
155 mm BB[n]	FSD	$ 56M	35,000	$ 2.2B	1.0M
MLRS/TGW	adv dev	$ 72M	—	TBD (Incl $310M RDT&E)	TBD
SADARM	adv dev	$190M			
MLRS rounds				$ 3.4B	50,000
155mm rounds				$910M	70,000
8-inch rounds				TBD	6,000
Communication Systems					
SINCGARS	**proc**	$480M		**$ 4.9B**	
air			150		14,000
ground			12,000		280,000
ADDS	proc	$280M		$ 2.4B	
NCS[o]			4		140
EPLRS[p]			670		22,000
JTIDS			10		580

NOTES

[a]adv adv anced DEM demo n strati in dep depl oy men t dev development FSD full scale develop ment OUE operational u tility evaluation PD Program Directive proc pr oc urement prod pr odu tion prop proposed proto prototype RFP request for proposals VAL validation

[b]A ppro $ imate n urrent the n , ear dol ars

[c]Approximate

[d]Including ost of resear h de , el r ment test I n g e, aluation and pro urement but n ot operation and maintenance

[j]GCS Grou nd Control Station

[k]Incomplete MICNS Remote G ound Term nals only

[l]AV A r Vehicle

[m]Data is for I n itial I EW UAV '01 low on Objective I E W U AV program is u nder development

[n]BB Base Bleed shell

[o]NCS Net C ontrol Statio n

[p]EPLRS E n h anced Positio n Locat n Report I n g S, stem

See Glossary for ot her terms

SOURCE U S Army (OSA/LL) January 1987

armored vehicles) one at a time,[6] but a capability to attack groups of vehicles with a single shot and to defeat masses of armor is generally lacking. Currently, the Air Force is buying the Combined Effects Munition (CEM), which dispenses about 200 bomblets (CEBs) from a tactical munitions dispenser dropped from an airplane. The CEB is effective against trucks and most armored combat vehicles except tanks. The Army is buying a similar munition, called Dual Purpose Combined Effects Munition (DPICM) for the MLRS. Although the DPICM could conceivably go in the ATACMS, current plans call for initial ATACMS to carry the anti-personnel-anti-material (APAM) munition which has essentially no capability against armor. The German Tornado carries the MW-

[6]1, A NT I RN will support shooting two Mavericks per pass, but the pilot must find a target for each Maverick he launches and line it up with the crosshairs on his cockpit display while flying his airplane. Many observers believe that multiple passes per launch are more likely than multiple launches per pass.

1 dispenser that drops the KB-44 anti-armor submunition as well as several other submunitions.

These munitions, although capable of hitting several targets per weapon launch (or an area target, or one whose location is imprecisely known), are all unguided, and hence most will fall on empty ground. Moreover, they have little effectiveness against tanks. The next generation of munitions, currently in development, will have both greater effectiveness against tanks and seekers to guide them to their targets. These include sensor-fuzed weapons, such as the Army's SADARM and the Air Force's Skeet, that fire a self-forging slug at a target, and the Army's Terminally Guided Submunition (TGSM, also called terminally guided weapon, or TGW) that guides directly to a target and detonates a shaped charge warhead. Technical issues still surround these programs, but these munitions are needed if attacking tank columns is to become a reality. The Germans are developing a new, improved, anti-armor submunition and a smart launcher for it to be carried by an airplane.

Whether or not scatterable mines can provide an effective means of creating chokepoints (or exploiting natural chokepoints, or augmenting the effects of dropping bridges) is a matter of some controversy. Advocates believe a scatterable mine system could provide great payoff for a small investment. Both Services have inventories of anti-vehicular and anti-personnel mines, and programs to develop smart mines that can sense targets at a distance and fire munitions (e.g., Skeets) at them. But mine programs tend to have low priority in both services.

In defense procurements, munitions have tended to get low priority. The munitions are just as important to FOFA as any of the other system components. If the concept is to work, the proper munitions will have to be bought and bought in sufficient quantities to do the job.

Assembling the Pieces: "Packages" of Systems

The five general packages of systems listed below are now under serious consideration. All are evolutionary in the sense that it is envisioned that capabilities will expand as new developments come online. With the possible exception of the last, all can be implemented with limited capability before all the pieces of the package are available:

1. package based on MLRS and artillery,
2. package based on the ATACMS ballistic missile,
3. package based on F-16,
4. package based on F-15E, and
5. package based on B-52s carrying cruise missiles for deep strike.

MLRS and Artillery

The Army is currently procuring the Multiple-Launch Rocket System.[7] This, combined with existing artillery, will provide some capability to engage follow-on forces during their movement from final assembly areas to the battle (see table 2-3). The DPICM[8] submunitions being procured for these rockets will have some capability against light armored vehicles as well as against high-value targets like command posts, but very little against tanks. Anti-armor capability will improve with the deployment of the MLRS/TGW submunition[9] and the SADARM for the artillery, both of which could be in production in the early 1990s. The Army plans to procure 350 MLRS launchers.

Important improvements in the ability to attack moving targets would be obtained from either Joint STARS or an RPV system that could target directly for an MLRS battery.

[7] Several of our Allies also have plans to acquire MLRS.
[8] Dual Purpose Improved Conventional Munition.
[9] MLRS/ Terminally Guided Warhead, a smart anti-armor submunition.

Table 2-3.—Packages Based on MLRS and Artillery

	Targets				
			Moving units		
	Stopped high value	Fixed chokepoints	Trucks	ACV	Tanks
Platform	MLRS (P)	MLRS (P)	MLRS (P)	MLRS (P)	MLRS (P)
RSTA	current	current		Joint STARS (F) or RPV (F, D, N)	
Munition	DPICM (P)	mines (various stages)	DPICM (P)	DPICM (P)	TGW (D)

KEY I In Inventory
P - In production
F = In full scale engineering development
N - Not yet in formal development

ACRONYMS
MLRS—multiple launch rocket system
DPICM—dual purpose Improved conventional munition
Joint STARS —Joint Surveillance Target Attack Radar System
RPV–remotely piloted vehicle
TGW—terminally guided weapon
ACV—armored combat vehicle

This concept has the advantage of being consistent with the preferences of our Allies, several of whom have plans to buy MLRS. And—if deployed across the Central Region-would provide a consistent capability across the region. The range of the MLRS limits its use in supporting other corps, and therefore the abilit y to concentrate firepower across the region.

ATACMS Ballistic Missile

Adding the ATACMS missile would give a U.S. corps the ability to attack divisions moving from division assembly areas to final assembly areas, helping to alleviate some of the short reaction problems in the previous approach. It would also provide some capability to support neighboring corps and to concentrate fire on massing forces. DoD's efforts to interest the Allies in ATACMS have thus far been unsuccessful,[10] but solely United States deployments could be of some value across nearly the entire Central Region.[11]

[10]This may be changing. Presentations to the NATO Army Armaments Group Panel on Surface-to-Surface Artillery in November 1986 generated interest on the part of Germany, Italy, and the Netherlands, but had not yet resulted in changes in official positions.

[11]ATACMS deployed in U.S. V corps could reach as far north as the British I corps sector. ATACMS deployed with U.S. III corps, if I I I corps is deployed into NORTHAG, can extend that coverage to the border of the Central Region. However, 11 I corps would be in reserve and would not likely be deployed at the beginning of the war.

The initial ATACMS will be procured with APAM submunitions which are not effective against armored vehicles. Without a system like Joint STARS, it would be limited to attacking soft high-value targets that don't move very often, such as command posts, missile launchers, communications links, and logistics links-when they could be adequately located. Joint STARS would support the attack of moving supply trucks, and-with the addition of anti-armor submunitions like TGW[12]—moving armored columns. These targets also might be located with RPVs or some combination of other systems. Attacking moving columns would also require systems to analyze and disseminate data quickly. Attacking small groups of moving vehicles or a specific group of vehicles within a larger column at 100 kilometers beyond the FLOT would require a cue that the target had arrived at the intended aimpoint just prior to missile launch. However, if the object is to attack any vehicles within a large column, less timely information would suffice.

Some observers consider the ATACMS to be too closely linked to the RSTA system and lacking in flexibility. They claim that breaking the link of rapid target observation, location transmission, and launch would render the system nearly useless against mobile targets.

[12]or I RTGSM, or SADARM, or DPICM, etc.

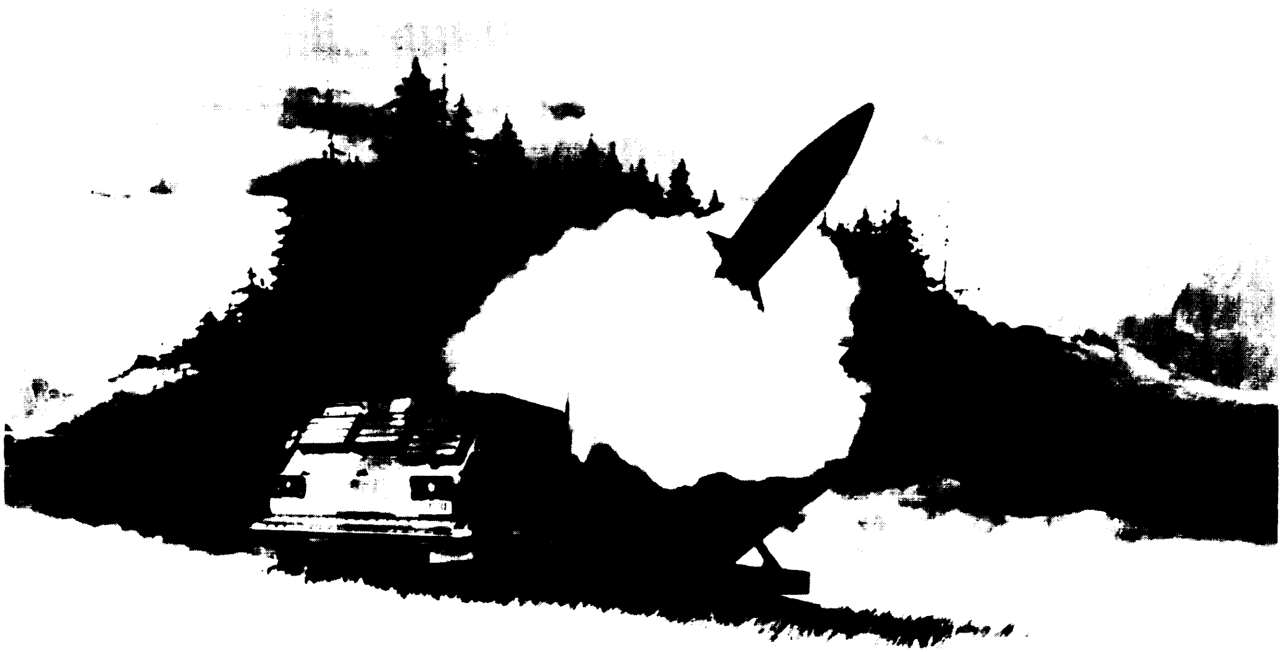


Photo credit LTV Aerospace & Defense Co

ATACMS missile, launched from MLRS launcher.

Others believe that these concerns are overblown, and that even without Joint STARS and advanced anti-armor submunitions, ATACMS would be very important.

Although the ATACMS missile makes good military sense, there may be political problems associated with deploying it. Some Europeans have voiced concerns that ballistic missiles launched into Warsaw Pact territory will be misinterpreted, leading to a nuclear response; others fear that it will strengthen the U.S. corps so much that the offensive will be channeled against weaker sectors. We do not know how serious or enduring these concerns are. The Soviets can be expected to play on at least the first of these. On the other hand, if the ATACMS works and is deployed, the Europeans may want it in their forces.

As arms control proposals get shuffled in the wake of Reykjavik, some may cause problems for the ATACMS; at one time the German Government was reported to have asked the United States to seek to include limits on ballistic missiles with ranges exceeding 100 kilometers in the intermediate range arms control negotiations with the Soviets. If the United States is to preserve the option to deploy ATACMS, negotiators will have to see to it that ATACMS is excluded from negotiated limits, either by limiting only missiles with longer ranges, or by some means of differentiating nuclear from conventional ballistic missiles. This would become difficult if ATACMS were to be made capable of carrying a nuclear warhead.

Compared to the next two concepts, which rely on tactical airpower, the MLRS and

Table 2-4.— Packages Based on ATACMS

	Targets: Stopped high value	Fixed chokepoints	Moving units: Trucks	Moving units: ACV	Moving units: Tanks
Platform	ATACMS (F)	ATACMS (F)	ATACMS (F)	ATACMS (F)	ATACMS (F)
RSTA	current	current		Joint STARS (F) or RPV (N, D, F)	
Munition	APAM (1) DPICM (P)	mines	APAM (1)	[TGW (D)] [DPICM (P)] [IRTGSM (D)]	[TGW (D)] [IRTGSM (D)]

KEY I In Inventory
P In production
F In full scale engineering development
N Not yet in formal development
[ ] The next generation submunition for the ATACMS has not yet been selected TGW or IRTGSM could fit, as could [he DPICM currently in production

ACRONYMS
ATACMS– Army Tactical Missile System
DPICM—dual purpose Improved conventional munition
IRTGSM—infrared (guided) terminally guided submunition
Joint STARS—Joint Surveillance Target Attack Radar System
RPV—remotely piloted vehicle
TGW—terminally guided weapon
ACV– armored combat vehicle

ATACMS concepts share some advantages and disadvantages. They are more dependent on the RSTA systems—airplanes have pilots who can compensate to some extent for late, inaccurate, false, or missing information; and although the ATACMS can be fired laterally into other corps sectors, the launchers cannot easily be moved large distances in response to movements in Warsaw Pact forces. Tactical airpower, by contrast, can be shifted rapidly across most of the Central Region.

Conducting air interdiction is much more complicated than launching a missile. Attacking aircraft would have to deal with enemy air defenses, requiring defense suppression, escort aircraft, and preparation of attack corridors. Although the Air Force practices attacks on fixed targets and moving targets that appear approximately where and when anticipated, planning large interdiction efforts against moving targets that may appear on short notice is difficult. Although it generally takes many hours to plan an attack, once planned it can be redirected on shorter notice, although not as quickly as a missile launcher can be reprogrammed. NATO can expect the Pact to make a strong effort to close NATO's air bases: effective airbase attacks would be likely to lead to a reduction in sorties available for FOFA. In addition, there are likely to be many competing demands for interdiction aircraft. In conversations in Europe, OTA found general agreement among Army and Air Force officers that few aircraft would be available for FOFA during the first few days, because the more immediate concerns of protecting NATO's airspace and ensuring NATO's ability to fly over the battle area should take precedence in the first few days. However, this is not set in stone, and if SACEUR and CINCENT decide that emphasis should be on interdiction the first day, it will be.

Because of the specific disadvantages of each approach—air interdiction and missile attack —a combination of the two would appear to be more effective than either alone.

F-16 Aircraft

This concept would provide coverage similar to that of the ATACMS, but with greater latitude to be moved to different sectors of the front. It would make use of an existing asset, the F-16, which is already in the force and in production. Furthermore, attacking into Pact territory with interdiction aircraft is accepted by U.S. Allies, who themselves have capable interdiction aircraft including F-16s and the

Tornado. The German Tornado, which carries unguided anti-armor submunitions in its MW-1 dispenser, may beat present NATO's best asset against masses of armor.

If used against combat units, this concept would almost certainly require a broad area RSTA system like Joint STARS, especially if it is to be responsive to Pact force movements across the Central Region. Until such a system becomes available, it might be possible to focus a complicated combination of other systems to obtain the necessary information. However, unlike the preceding concepts, this one would have greater capability to compensate for shortcomings in the RSTA system.

Other developments will be needed to complete this concept. The CEM is similar to the Army DPICM–it is effective against lightly armored vehicles, soft vehicles, and personnel, but has little effectiveness against modern tanks. If tanks are also to be attacked, it would have to be replaced, or supplemented, by a Skeet or some other terminally guided anti-armor submunition. The LANTIRN, as well as short stand-off missiles like AGM-130 or GBU-15 configured to carry a submunition dispenser or an inertially guided dispenser, would be valuable for increasing aircraft survivability.

F-15E Aircraft

Under current plans, the F-15Es will start to appear in Europe in the late 1980s. These two-seat airplanes, configured primarily for ground attack but retaining their fighter capabilities, will have much greater range and payload than the F-16s, as well as night and all-weather capability supported by LANTIRN and terrain-following radar. They will, however, cost considerably more than F-16s. The F-15Es will supplement United States Air Force in Europe's (USAFE's) deeper attack capabilities that currently reside exclusively with the F-111s.[13] F-15Es and F-111s could attack targets well into Western Poland. The F-15Es

Photo credit U S Department of Defense

F-1 11s, current mainstay of NATO's deep attack capability.

and some tasked F-111s[14] could be operated with or in place of the F-16s as described above, and could be used to extend FOFA capability to create chokepoints on the Oder and Neisse Rivers (the GDR-Polish border) and attack units in transit on road and rail in Western Poland.

If they operate beyond the range of the F-16s, the F-15Es will also be generally beyond the range of Joint STARS and similar tactical surveillance systems. This will not limit their ability to operate against fixed targets like airfields and bridges, but it will affect their ability to attack moving targets, and to create chokepoints at the optimum time. Furthermore, the deeper these aircraft operate, the more difficult it becomes to protect them. The greater range of the F-15E could also be exploited to operate out of bases that are farther from the battle (perhaps in Britain), and therefore less likely to be attacked than bases used by the F-16s. The greater range would also provide improved flexibility to operate throughout the Central Region in response to an evolving Pact offensive.

Deep Strike Using B-52s Carrying Cruise Missiles

The Air Force is considering the use of B-52 bombers carrying long-range cruise missiles to interdict the rail network across Eastern Europe. One variant of the cruise missile could

[13] This might also be augmented by B-52s, and possibly FB-111s.

[14] The F-1 11s, limited in number, already have several important missions including interdiction and air base attack, and standing nuclear alert.

Table 2-5.– Packages Based on F-16 Aircraft

	Targets				
			Moving units		
	Stopped high value	Fixed chokepoints	Trucks	ACV	Tanks
Platform	F-16/LANTIRN	F-16/LANTIRN	F-16/LANTIRN	F-16/LANTIRN	F-16/LANTIRN
RSTA	current	current	Joint STARS (F) Advanced RPVS (?)		
Weapon/Munition	Bombs, cluster bombs, TMD/CEM (P)	mines, bombs	TMD/CEM (P) cluster bombs	TMD/CEM (P) Rockeye (1) Maverick (I, P)	TM D/Skeet (D) Maverick (I, P)
Other	systems for defense avoidance and suppression and for protection of RSTA assets				

KEY I In Inventory
P - In production
F In full scale engineerlng development
N Not yet in formal development

ACRONYMS
LANTIRN –Low altitude navigation and targeting Infrared system for night
TMD—tactical munitions dispenser
CEM–combined effects munition (a TMD carrying Combined Effects Bomblets)
Skeet—an IR guided submunition that fires a self-forging slug Also called SFW, or sensor fuzed weapon
Rockeye —a cluster bomb containing anti armor submunitions
Maverick—an anti.tank guided missile
ACV—armored combat vehicle

Table 2-6.—Packages Based on F-15E Aircraft

	Targets				
			Moving units		
	Stopped high value	Fixed chokepoints	Trucks	ACV	Tanks
Platform	F-15E (P) F-ill (1)	F-15E (P) F-1 11 (I)	F-15E (P) F-1 11 (I)(?)	F-15E (P) F-1 11 (I)(?)	F-15E (P) F-1 11 (I)(?)
RSTA	current	current	Joint STARS (F)		
Weapon/Munition	Bombs, cluster bombs, TMD/CEM (P)	GBU-15 (1) AGM-130 (F) mines	TMD/CEM (P) cluster bombs	TMD/CEM (P) Rockeye (1) Maverick (I, P)	TM D/Skeet (D) Maverick (I, P)
Other	systems for defense avoidance and suppression and for protection of RSTA assets				

KEY I In inventory
P In production
F - In full scale engineering development
N Not yet in formal development

ACRONYMS
GBU 15–a highly accurate guided glide bomb
AGM-130—a powered version of the GBU-15
TMD—a tactical munitions dispenser
CEM —combined effects munition (a TMD carrying Combined Effects Bomblets)
Skeet—an IR guided submunition that fires a self-forging slug Also called SFW or sensor fuzed weapon
Rockeye—a cluster bomb containing anti-armor submunitions
Maverick—an anti.tank guided missile
ACV—armored combat vehicle

[a]F 11 1s are typically tasked for deep missions against targets like airfields and bridges

be configured to drop bridges, while another would sow smart mines along the rail lines. These aircraft would be flown from the United States to their launch points, launch their missiles against fixed targets, and return to bases in the United States. It has been estimated that by the mid-1990s suitable cruise missiles could be developed and built in sufficient numbers, and the airplanes could be released from their strategic nuclear roles through introduction of B-Is into the force.

The primary goal most likely would be to delay the arrival of forces rather than to cause attrition. In theory, this would prevent the second fronts from arriving in time to exploit the successes of the first fronts, and allow NATO time to reverse the situation.

Proponents of this concept contend that having the capability to hold the rail lines at risk in time of war could force the Soviets to a long mobilization, bringing their forces through the rail lines in peacetime and therefore providing NATO with long, unambiguous warning. A "long warning" scenario is generally more favorable to NATO than a "short warning" scenario, because NATO is expected to mobilize more slowly than the Warsaw Pact. However, the added warning would be of value to NATO only if NATO accepts it and reacts accordingly.

This concept would make use of existing assets, the B-52s. There would be no aircraft procurement costs, but operations and maintenance would be incurred to keep the force active for this (and other conventional) roles. Eventually, those B-52s would have to be replaced by more modern aircraft or extensively overhauled. Suitable tanker aircraft support would have to be made available. Because of the long range of the bombers and of the weapons they would carry, exposure to enemy air defenses could be kept to a minimum. Compared to the other four concepts, the requirements for timely surveillance are much less.

The proposed cruise missile could be developed from an existing type—e.g., the Boeing ALCM or the Tomahawk. Engineering studies have shown that this ought to be a straightforward task; it has yet to be demonstrated, however. Alternatively, a new missile could be developed.

Problems related to arms control may also have to be solved. Under the SALT II agreement, the B-52 was defined and counted as a strategic nuclear delivery vehicle. Whatever arms control agreements ultimately are produced in the wake of Reykjavik will have to come up with a definition of a strategic bomber. If this option is to be pursued, either some way will have to be found to keep conventionally armed B-52s from being counted as strategic nuclear weapons, or the United States will have to give up some nuclear capability to get conventional capability.

REMAINING ISSUES

There are a number of FOFA-related programs that Congress will decide on. Some—such as the F-15E and the ATACMS missile—do not appear very controversial, although that might change. The controversial issues are: Joint STARS, Aquila RPV, a successor to PLSS, and advanced munitions programs. In addition, Congress will have to deal with cooperative development and production with our Allies.

Joint Surveillance Target Attack Radar System (Joint STARS)

Although Army, Air Force, and SHAPE favor the Joint STARS, it has been the subject of much controversy, particularly in Congress. In each of the past 3 years, the House opposed the system while the Senate supported it. Conference action has supported funding for the system. The Joint STARS, now in full-scale engineering development, is built around a moving target indicator (MTI) radar carried on an E-8A (modified Boeing 707) aircraft. It would provide both surveillance information to assessment centers, and targeting information to command centers and directly to missile launchers or attack aircraft. From a patrol orbit behind the FLOT, it would provide broad area coverage over extended periods of time.

Opponents argue that the Joint STARS will be vulnerable to Warsaw Pact surface-to-air missiles (SAMs) and interceptor aircraft, and will either be shot down or have to retreat so far from the FLOT as to be not worth its cost. They favor stopping the program until a much more survivable version can be produced. Proponents acknowledge its vulnerability, but argue that a variety of protective measures could greatly enhance its survivability, and that even when taking protective measures it would be capable of providing a great deal of capability.

The capability that Joint STARS (or a system like it) would provide is very important to most FOFA concepts. FOFA could be done without it, but with much greater difficulty and probably much less effectiveness. The system would be very useful for identifying the focus and major movements of a Pact attack, and, before the shooting starts, for monitoring Pact troop movements and providing effective warning of an attack. The Air Force believes that an 13-8A-based system is necessary for deployments to areas other than Europe. Proponents argue that it would be useful to get a system into the field as soon as possible, so that crews can learn how to operate it and find out what it can really provide.

Prior to hostilities, the Joint STARS could operate very close to the FLOT and observe Pact movements deep inside East Germany and Czechoslovakia. In wartime, the Air Force would defend the Joint STARS (and the airspace it and other surveillance aircraft operate in), suppress enemy air defenses, and adjust the patrol pattern of the E-8A to reduce its vulnerability. At selected times it could surge forward, that is, patrol closer to the FLOT with dedicated defenses in order to look into selected deeper areas. As the war progresses and Pact defenses are suppressed, it should become possible to increase the amount of time spent patrolling closer to the FLOT.

If operated as the Air Force now intends, the E-8A Joint STARS should be capable of providing frequent broad area coverage to a depth of 50 to 100 kilometers beyond the FLOT. There will be a great many targets within this band, and more weapons can attack here than deeper. Attacking combat units in this band can be more efficient because many of the noncombat vehicles will be left behind as the units prepare to go into battle. Furthermore, frequent coverage is likely to be of greater importance within this band than deeper: the targets are expected to traverse this band rapidly and be less constrained to major roads. Surge operations would allow some coverage of deeper areas. This pattern of operations would generally require the Joint STARS to operate farther from the FLOT than the nominal setback usually discussed for it. The coverage would similarly be reduced from what a nominal orbit would provide,

Some opponents of the E-8A Joint STARS have suggested that consistently deeper coverage could be obtained by basing Joint STARS on an inherently more survivable platform that could operate closer to the FLOT without being detected. OTA has not been given access to information on such programs, and the reader should be aware that there is potentially relevant information that OTA does not have. In general, such a system would have its own limitations. For it to be stealthy, it will have to carry an equally stealthy radar, known as ‘LPI” (or low probability of intercept) radar, and a radar antenna that—when illuminated by a threat radar-is as difficult to detect as the airplane. LPI may be achieved in part by managing power, that is by reducing the amount of energy a radar transmits in a given time, which reduces the amount of information the radar can obtain. Therefore a stealthy Joint STARS would also not be able to gather as much data as the E-8A Joint STARS in its nominal orbit.

Because the reduction in coverage would take the form of “looking” less rather than moving back from the FLOT, coverage of both deep and shallow targets would be reduced.

We at OTA do not have enough information to compare the coverage of a E-8A Joint STARS taking evasive, protective action and a stealthy alternative, but we believe that such a comparison would be important. We believe that if Congress does not have enough information to make a decision on Joint STARS, it ought to mandate a study comparing the cost, survivability, coverage, and operational utility of Joint STARS and proposed alternatives operated in a realistic manner, but ought not to stop the development program in order to do so.

One alternative that might be considered is an E-8A Joint STARS complemented—rather than replaced—by a more survivable system. The E-8A Joint STARS could provide complete coverage to a limited depth, and each could provide limited coverage deeper in Pact territory. The coverage of both would be limited by terrain and foliage, but limitations might be less for the more survivable platform.

An important consideration for either a substitute or a complementary platform is whether the necessary LPI radar could be built from the Joint STARS radar, or would require an entirely new development effort. Without more information, OTA cannot answer this question in detail. However, the Joint STARS radar has substantial capacity for conversion to LPI operation. It appears to OTA that *if* the LPI radar were to operate in the same frequency band as the Joint STARS radar, much of the existing design could be used.

Replacement for the Precision Location and Strike System (PISS)

For fiscal year 1987, Congress decided, at the request of DoD, to deny funding for procurement of the Precision Location Strike System (PLSS, pronounced “pens”), and to appropriate $20 million for further development and testing. Congress and DoD now face the issue of whether a new system is needed to perform the function originally conceived for PLSS.

Until this year, PLSS–a developmental surveillance and control system designed to detect, identify, and accurately locate modern mobile, electronically agile radars and jammers in near real time—was an important part of the program for improving surveillance in Europe. However, the Air Force has not requested funding for procurement, and apparently has taken the position that other systems could adequately do the job for which PLSS was designed. Moreover, PLSS has encountered many problems and delays during its long development history.

Others still see value in PLSS, particularly for targeting modern mobile SAMs, and as a major contributor to the survivability of Joint STARS and other surveillance systems. It has demonstrated emitter location speed and accuracy which are superior to those of existing theater systems, as well as a high emitter reporting rate. These may be necessary if, as expected, at the outbreak of a war enemy radars shut down, move, change frequencies, and begin wartime operations in short on-time, electronically agile modes.

Modern mobile, electronically agile radars and jammers would accompany and protect follow-on forces; an ability to attack them soon after they are detected in a new location would be very valuable to protecting allied aircraft used to detect and attack follow-on forces. PLSS has demonstrated a capability to locate and report more such emitters per hour with greater accuracy and timeliness than all other U.S. systems now reporting to Europe combined. It would use electronic equipment carried aloft by three TR-1 aircraft operating together, each communicating with a central processing ground station. The ground station would report emitter locations, and could also control attacks against emitters.

During development, PLSS has failed to demonstrate emitter location errors as small as those required by its specifications, and its reliability has been a problem. However, recently its performance has steadily improved. Emitter location accuracy has approached the specified value, and the reporting rate requirement has been reduced to what PLSS has already demonstrated. In addition, the system has often reported each actual emitter as several. Some causes of this problem were identified and corrected.

Munitions Programs

There are three major concerns regarding munitions programs: 1) the effectiveness of anti-armor submunitions in a realistic combat environment; 2) buying enough munitions for FOFA to have an effect; and 3) what to do about mines.

Munitions programs-and the weapons to carry them—tend to be a neglected area. They are usually not glamorous, and are often candidates for scaling back and stretching out in order to save money. None of the FOFA concepts will work if there are not enough munitions to kill a large enough number of targets to have an effect. A multi-billion dollar investment in RSTA, data analysis centers, missiles, and airplanes of various types can be undercut by not buying enough munitions. OTA cannot say how many of each type are needed (indeed, that is a job for the Services). However, the Warsaw Pact forces in Eastern Europe have hundreds of thousands of vehicles, including many tens of thousands of armored combat vehicles.

Although current-generation unguided submunitions can be effective against most vehicles, including most armored combat vehicles, advanced guided anti-armor submunitions now under development may be the key to being able to destroy groups of tanks. Because they are guided, they may also be much more effective against less heavily armored vehicles. Two types are under development: sensor fuzed weapons—e.g., the Air Force Skeet and the Army SADARM—that sense the presence of a target within their search areas and fire a self-forging slug at it; and terminally guided submunitions--like the Army's TGW for MLRS —that search a large area, guide to the target, and detonate a shaped charge warhead on impact.

These concepts have been demonstrated in controlled environments, but important questions remain regarding their ability to operate in the presence of countermeasures to both warheads and seekers. Both operational and technical countermeasures are of concern. There has been concern that enemy forces could use the cover of both forests and villages to obscure the signature of the target vehicles and to deflect incoming warheads so that they lose momentum or do not hit the armor at an angle that permits them to penetrate. Dashing between covered locations could reduce the exposure of the targets. Both spreading formations out and bunching them tightly up could affect the number of vehicles a group of submunitions hits. There is also concern that the damaged vehicles littering the battlefield might attract submunitions away from functioning vehicles.

Smoke and various types of material covering a vehicle could reduce the ability of a sensor to find it. Various schemes have been suggested that would cause the munition to guide to a spot off the target rather than one on it, as have devices that would cause a shaped charge warhead to detonate before reaching its target.

Various advanced types of armor are under development in the East and in the West. Some are very effective against shaped charge warheads; others are more effective against kinetic energy weapons like self-forging slugs. How well advanced munitions do against advanced tanks will depend in part on how well the warhead characteristics match the armor characteristics of the target.

Not all suggested countermeasures are practical and effective. However, it is very important to test munitions against various types of targets employing various types of countermeasures. Programs like the joint Chicken Little series of tests can be very valuable in this regard.

Remotely Piloted Vehicles

The Army is developing a family of unmanned aerial vehicles (UAVs, a term which includes both remotely piloted vehicles and drones) to perform a variety of functions including surveillance, reconnaissance, target designation, jamming, and attack. The most mature member of the family, the Aquila RPV of the TADARS (Target Acquisition/Designation Aerial Reconnaissance System) now in full-scale development, has been a matter of concern in Congress.

UAVs could usefully complement airborne stand-off radar systems like Mohawk, ASARS-II, and Joint STARS: these could quickly search large areas and tell UAVs whereto look; and UAVs could find the targets and discriminate among them. UAVs could also find or follow targets hidden from airborne radars by hills or trees. Aquila could locate shallow tar-

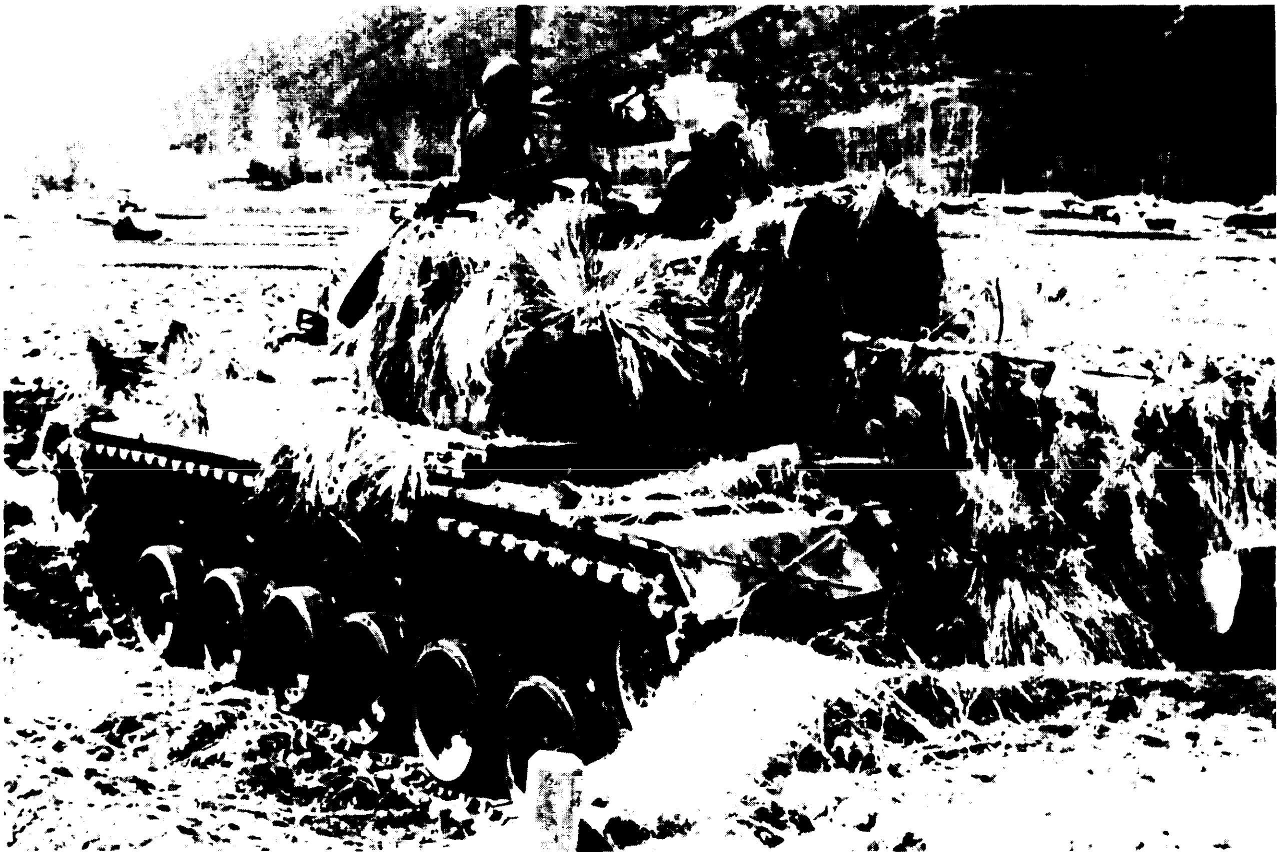


Photo credit U S Department of Defense

Simple countermeasures, such as a camouflaged tank, may be able to outwit smart submunitions.

gets with greater precision and designate them with a laser for either Copperhead artillery rounds or laser-guided bombs. Several types of UAVs are now operational or under development in Belgium, Canada, France, Germany, Italy, the United Kingdom, and Israel.

Since 1978, the estimated time to develop TADARS has more than doubled and the estimated program cost has quadrupled; the number of RPVs to be produced has been halved. However, the major problems which have beset the system now appear to have been solved. TADARS will have unique capabilities for accurate location and laser designation of shallow targets. These could be useful for FOFA: TADARS could find and locate targets for artillery, MLRS, and ATACMS, and designate for laser-guided bombs.

Other RPVs have been proposed as alternatives to Aquila, but lack its target location accuracy, laser designation capability, and jam-resistance. According to the General Accounting Office, procuring another RPV and equipping it with the laser designator, navigation, and communications systems developed for Aquila would cost about $100 million more and take a year longer than completing TADARS.

Arms Cooperation

When FOFA was first advanced, some Europeans tended to see it as a vehicle to sell them American defense systems. The Defense Department has been working to dispel this problem by encouraging European-American arms cooperation programs as well as the identifi-

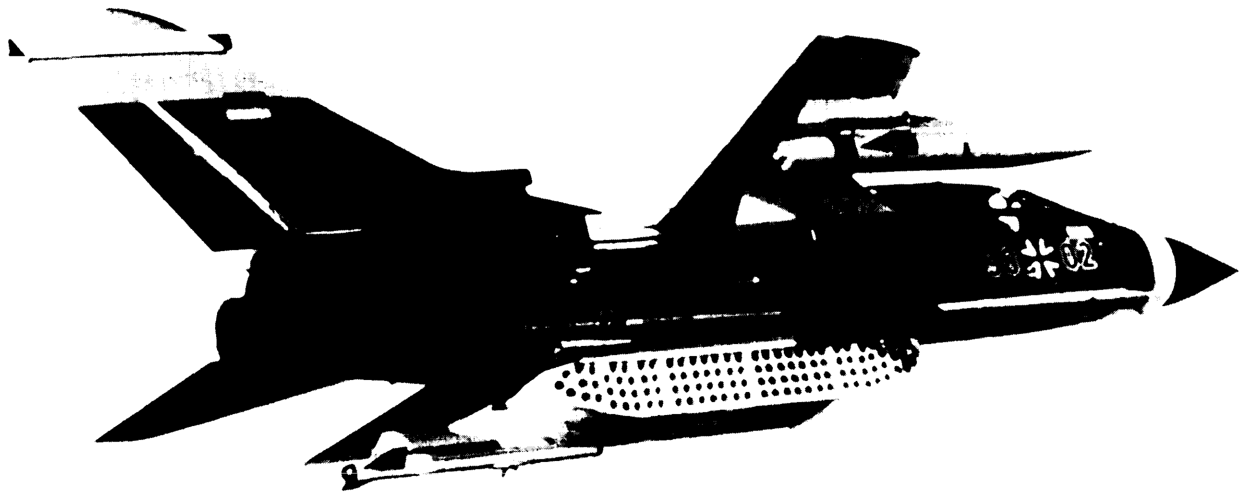


Photo credit NATO

Tornado aircraft, result of European collaboration, carry in the German MW-1 munitions dispenser.

cation of European systems that could support the concept.

The principal foci of activity have been the NATO Conference of National Armaments Directors (CNAD) and the Defense Science Board FOFA II Task Force. A major stimulus to cooperation has been the money made available under the 1985 Nunn Amendment.

The FOFA II Task Force has been working with similar advisory groups associated with European governments to identify potential areas of cooperation that could then be recommended to their respective governments for further action. The group will report during the first half of 1987 on strategies to achieve cooperation on several programs.

There are two major activities related to the CNAD. The first is a FOFA ad hoc working group that is preparing a paper outlining the types of systems that are necessary to achieve a FOFA capability. This activity is important because it helps define what the allied governments (as distinct from NATO itself) agree constitutes FOFA. Concurrently, the United States is negotiating a number of memoranda of understanding concerning co-development of systems, only some of which are FOFA related.

There has been a meeting of the minds on a number of questions, but thus far the Europeans have shown no official interest in either ATACMS or Joint STARS[15] (although there is interest in interoperability among Joint STARS and the British ASTOR and French ORCHIDEE MTI systems). Although some of the arguments against these systems have been on fairly fundamental grounds, interest may develop in the future, particularly after the systems are fielded and their real capabilities become known.

This process will pose three important issues for Congress. First, if Congress supports this form of cooperation, they will have to provide the requisite funding for cooperative programs. Second, Congress may have to make choices between slowing programs to bring the Europeans on board and proceeding only in the United States. Finally, the Europeans may

[15] There reportedly has been interest on the working level.

seek to sell us their equipment, to smooth the two-way street. Congress will then have the usual choice between buying American or buying European.

The Europeans are enthusiastic about the possibilities for joint programs; however, they are somewhat skeptical about the possibilities for successful cooperative ventures, especially with the United States as a partner. National interests generally complicate such efforts, and U.S. policies are seen as complicating them still further. Nevertheless, the trends are away from buying U.S. products, and toward greater intra-European cooperation. The Europeans believe that their technology equals that of the United States in many areas and may surpass it in some.

PART II
Analyses

Chapter 3

Introduction and Background

CONTENTS

Chapter 3

Introduction and Background

INTRODUCTION

In late 1984, the North Atlantic Treaty Organization (NATO) adopted the Follow-On Forces Attack (FOFA) concept as one of a few critical warfighting tasks for its conventional forces. Although the concept had been under development for several years at the Supreme Headquarters Allied Powers, Europe (SHAPE), it was adopted in general terms only. This precipitated much activity on the part of the member nations, SHAPE, and the NATO international staff to define more clearly what FOFA is, how it is to be implemented, and what the individual nations are going to do to support its implementation.

As part of the U.S. effort, the Office of Technology Assessment (OTA) was asked by the House Committee on Foreign Affairs, the House Committee on Armed Services, and the Senate Committee on Armed Services to conduct a study of options for implementing FOFA. In particular, OTA was asked to:

- discuss the military and deterrence rationale;
- survey the status of various applicable capabilities and programs, including those to develop advanced conventional munitions;
- review relevant Soviet doctrine and plans;
- review the attitudes of our NATO Allies;
- assess the strengths and weaknesses of various existing and proposed alternatives;
- assess the likelihood that various plausible combinations would meet U.S. and NATO goals; and
- discuss a range of policy options, their pros, cons, and timing of availability.

This report is the final product of that study. An earlier report—*Technologies for NATO Follow-on* Forces Attack Concept: *A Special Report of OTA's Assessment on Improving NATO Defense* Response–released in July 1986, accomplished the first two tasks listed above. This report covers the others. In the special report, OTA suggested to Congress that in considering how best to support the FOFA concept, systems ought to be considered not individually, but as complete packages to support clearly defined operational concepts; nonetheless, some systems will be "key systems"; all component systems will have to be procured in sufficient quantities; practice and training will be important; and some redundancy may be desirable. Readers wishing an elaboration on these points, or greater background on the FOFA concept and the technologies of interest, are referred to that special report.

After outlining the rest of the report, this chapter provides a brief review of the history of the FOFA concept, and of how FOFA fits into NATO's strategy. A fuller description is found in the special report.

Chapter 4 addresses the threat: Warsaw Pact forces, and what we know about that part of Soviet doctrine that is relevant to FOFA. All Warsaw Pact forces will follow Soviet doctrine. There has been some controversy in the West regarding Soviet doctrine and the appropriateness of FOFA as a response. This chapter reviews those areas of controversy.

Chapters 5 and 6 discuss the specific objectives for several different types of attacks on follow-on forces, and the operational concepts being considered for achieving those objectives. This sets the stage for the discussion of packages of systems to implement these concepts and the technical issues surrounding those systems, found later in the report.

Chapter 7 analyzes possible Soviet responses to FOFA, and chapter 8 reviews the attitudes of our Allies toward FOFA. FOFA was conceived by SHAPE as an Alliance-wide effort (although primarily concerning those nations with forces in the Central Region); its value would be diminished if only the United States were to implement it, or if national responses were uncoordinated. NATO's current abilities to attack follow-on forces are reviewed in chapter 9.

The technological advances that are important for FOFA were described at some length in the special report. Although these are primarily mature technologies that could result in fielded systems over the next decade, major issues—technical and other—remain, particularly regarding Joint STARS, PLSS, remotely piloted vehicles, and advanced smart anti-armor weapons. These are the subject of chapters 10 and 11.

Chapter 12 analyzes how existing and new systems could be brought together into complete packages to implement the operational concepts discussed in chapter 6.

Chapter 13 reviews previous studies of implementing FOFA, summarizes their conclusions, and discusses major common threads.

BACKGROUND

History

In the late 1970s, both the U.S. Army and U.S. Air Force began to study seriously the idea that much could be done to break up a Soviet-style offensive by attacking deep into enemy territory. Air bases and other major fixed facilities, major formations of ground forces, logistics, transportation nodes, and individual high-value targets like command posts and missile launchers were among the targets considered. To be sure, attacking into enemy territory was nothing novel for either service. The Air Force had always had interdiction of various forms as a major mission, and the Army had always relied on firepower delivered by these interdiction aircraft and by its own artillery to "soften up" the enemy forces prior to engaging them. And within NATO's integrated military command, into which elements of both services would be integrated in the event of war, nuclear planning had always considered such targets to be of prime importance.

At the same time, the Army-in part because of long-standing criticism that accused it of being too static and insufficiently mobile for modern warfare-was developing a new doctrine called "AirLand Battle. " AirLand Battle, officially published in 1982, called for a combination of deep fires to break up the enemy's offensive, and counterattacks to restore losses and seize the initiative. The Air Force declared its support for AirLand Battle, and in late 1982 the services signed the *Joint Operational Concept Joint Attack of the Second Echelon (J-SAK)* that laid out procedures for cooperation between Army and Air Force units in deep attack.

Also in 1982, the staff at SHAPE produced a study of attacking follow-on forces. This led to the NATO Defence Planning Committee (DPC) formally approving SACEUR's Long Term Planning Guideline for FOFA on November 9, 1984, making FOFA officially part of NATO strategy.

Although FOFA was a SHAPE development (known at various times as 'deep strike, "strike deep, and the 'Rogers plan' '), its connection to the United States was inescapable, and amplified by General Rogers' also holding the job of Commander-in-Chief of U.S. forces in Europe. The AirLand Battle concept was unpopular among Europeans because of its emphasis on counterattack, and it soon became confused with FOFA in the debate that followed. In addition, many were (and some remain) skeptical of the value of attacking deep rather than waiting to engage the advancing enemy forces in the close battle.

After the November 1984 DPC meeting, the concept was turned over to the NATO international staff for coordination and refinement, and subsequently to the office of the Assistant Secretary General for Defence Support to provide a forum for the member nations to coordinate their armaments programs. The focus has now largely shifted from doctrine development to arms procurement, particularly arms trade and cooperation. However, the attitudes of the individual members regarding FOFA have not as yet completely jelled.

On a parallel track, SHAPE is still developing the concept. The original rather general approach, of delaying, disrupting, and destroying enemy forces from just beyond the range of direct fire weapons to as far in the enemy rear as NATO's forces can reach, is becoming a set of more specific goals phased to coincide with the introduction of new capabilities. Meanwhile, both the Army and the Air Force continue to refine their deep battle and interdiction concepts taking FOFA into account.

The Role of FOFA in NATO Strategy

Flexible Response is a strategy for deterring aggression, underwritten by a triad of conventional, theater nuclear, and strategic nuclear forces. NATO would respond to any attack at an appropriate level of violence, and reserves the right to escalate a conflict, including the first use of nuclear weapons. This strategy creates a risk to the Warsaw Pact that aggression can lead to nuclear warfare at a level such that the cost to them would far outweigh whatever they would hope to gain by attacking in the first place. NATO would resist a conventional offensive with conventional means, and would escalate to the use of nuclear weapons only if it proved necessary.

While there is agreement among the Allies on this principle, there is debate and disagreement over how much conventional defense capability NATO should have: too little would lead to being overrun before NATO could decide to escalate, while too much would risk a lengthy and destructive war on NATO territory and perhaps encourage a Pact attack in the belief that NATO would fight a conventional war which would carry little risk to the Pact, Either, it is argued, would decrease deterrence. Although no one wants a nuclear war, the nations that would be the most likely battlefield in a conventional war-such as Germany—have the greatest interest in sending the Soviets a clear message that aggression would lead quickly and directly to nuclear war.

Although NATO anticipates a conflict that would involve its Northern and Southern Regions in Europe (as well as the Atlantic), the focus is expected to be the Central Region. Warsaw Pact successes there would split the Alliance and make the defense of the rest of Europe all but untenable. Furthermore, Germany is the focus in the Central Region: its collapse would almost certainly produce defeat in the Central Region.

NATO strategy for a conventional defense in the Central Region is dictated by political and geographic considerations as well as by the threat facing it. Ground and air forces of the United States, the United Kingdom, the Federal Republic of Germany, the Netherlands, and Belgium are under the command of the Commander-in-Chief Central Region, who in turn reports to the Supreme Allied Commander Europe (SACEUR). SACEUR is responsible for the Northern, Central, and Southern Regions. France, although a member of the Alliance, is not part of this integrated military command. In the Central Region, the German border is divided into eight corps sectors, each defended by the ground forces of one nation. These are organized into two Army Groups, each supported by a multinational Allied Tactical Air Force. A relatively small force—much of which would come from the United States—would be held in reserve.

NATO is committed to a forward defense, both because there is little room to fall back, and because falling back would yield German territory which would weaken Germany and be politically unacceptable to the Germans. This is not to say that NATO will defend right at the border, but that it will take defensive positions as close as practical to the border and defend them with a *tactically mobile* defense.

It is, however, a *strategically static* defense having little ability to move forces north/south along the border to respond to the way the Soviets choose to attack. NATO is also generally constrained from counterattacking across the border, because it is a defensive alliance that wishes to avoid a provocative, offensive posture.

The Warsaw Pact not only enjoys significant numerical superiority over NATO in the Central Region, but it is organized according to Soviet doctrine for a *strategically mobile* offense. NATO believes Warsaw Pact ground forces would concentrate to smash through NATO's weaker corps sectors, allowing highly mobile divisions into NATO's rear. NATO can expect this attack on its rear to be aided by airplane, missile, airborne, and special forces attacks.

NATO is very constrained in its options for responding to this threat. It will not make major increases in its force structure. The corps that are attacked cannot fall back to reorganize their defenses, and the stronger corps that are not heavily attacked cannot counterattack deep into Warsaw Pact territory. By attacking the follow-on forces before they join the offensive, NATO hopes to reduce them to manageable proportions (i.e., reduce them through attrition) and meter their arrival at the close battle (delay them so they arrive in "drips and drabs" and not all at once). It also provides the opportunity to mass fire against concentrations of forces before they hit NATO's defensive line, thereby compensating at least in part for NATO's inability to shift its ground forces in response.

Chapter 4

The Soviet/Warsaw Pact Ground Forces Threat to Europe

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The Soviet/Warsaw Pact Ground Forces Threat to Europe

In 1984, SACEUR General Rogers described FOFA as "an attempt to come to grips with the realities presented by Soviet doctrine for offensive operations and the continuing massive Soviet conventional force build-up. This chapter examines some of these realities, both what we know about a potential Soviet ground offensive in Central Europe, and the uncertainties surrounding those realities.

The Soviets have massed in Europe a large number of ground forces with an enormous amount of firepower: at present, the strength of the in-place Warsaw Pact forces in the Central Region-in terms of divisions, tanks, and artillery-is in each category close to twice that of NATO's in-place forces, and Warsaw Pact forces possess a good deal more strategic depth, for defensive purposes and to bring more forces to bear.[2] NATO, being a defensive alliance, must be prepared to react to however the Soviets might choose to use those forces should a conflict arise. But how the Soviets might actually launch an offensive has generated a good deal of controversy.

This chapter, therefore, examines what we know and do not know about those aspects of Soviet strategy, operational planning and tactics of significance for FOFA: the role of conventional forces in Soviet doctrine; the Soviet ground forces facing NATO; the principles which govern Soviet military planning and strategy; the way a Soviet conventional offensive into Western Europe might be waged; and implications for FOFA.

[1]General Bernard W. Rogers, "Follow on Forces Attack (FOFA): Myths and Realities," *Nato Review*, No. 6, December 1984, p. 1.

[2]While the territory of the Warsaw Pact extends thousands of kilometers back into the U. S. S. R., NATO has little depth for defensive purposes: it is less than 500 kilometers from the inter-German border to the English channel; and the importance of Germany as a NATO land power in the Central Region makes it more difficult for NATO to trade space for time than it would be for Warsaw Pact forces to fall back when attacked to reorganize and counterattack. The U.S.S.R. is also better placed than NATO to bring additional forces forward to sustain those at the front line, as a good portion of NATO's reinforcements of men and equipment would have to come across the Atlantic from North America.

SOVIET MILITARY DOCTRINE

Among Western analysts, one of the most controversial aspects of Soviet military planning is the role of conventional weapons in an offensive. This is due largely to different assessments of Soviet military "doctrine' and military thought.

Soviet military doctrine lies at the heart of the overall Soviet approach to war, which is quite different from that of the West. War, as the Soviets see it, is a science, something governed by certain "laws" and principles reflected in military history, and past and present wars, tests, maneuvers, and the like. Soviet military "doctrine" comprises a set of views defining the goals and nature of a possible war, and how the U.S.S.R. should prepare for and conduct such a war should it be deemed necessary. It provides a context for deciding the size and composition of the Soviet Armed Forces, and for integrating their organization, tactics, training and equipment into a cohesive fighting force. Although viewed as scientific, military doctrine is not rigid or fixed; instead, it has proven to be quite dynamic but, once decided on, is rarely questioned except at the highest levels.

It is generally accepted among Western observers that a major shift in Soviet doctrine occurred in the mid-1960s, from a near total reliance on nuclear weapons in Soviet military planning, to a more balanced approach to developing nuclear and conventional forces. From the late 1950s until the mid 1960s, the Soviets believed any potential war would begin with massive nuclear strikes that would totally, and irreparably, destroy the losing side's entire social and political system. With the ouster of Khrushchev, however, and the adoption of a strategy of Flexible Response in the West, the Soviets began to consider the possibility of a war remaining conventional. Although they continued to believe that nuclear weapons would be decisive in any conflict, the Soviet military no longer contended that a conflict would inevitably escalate to all-out nuclear war. Since the mid 1960s, then, the Soviets have emphasized the need to be able to win at all levels of conflict, and have developed the capabilities to fight with or without nuclear weapons.

These developments have led to a good deal of controversy in the West regarding current Soviet doctrine and possible intentions. Some observers contend that the Soviets still place great weight on a "nuclear option" so that, should military conflict start, nuclear weapons would play a role from the beginning of that conflict. According to this view, "the Soviets perceive a totally integrated nuclear-conventional operation, within the framework of which nuclear and conventional weapons supplement and reinforce each other, creating the synergistic effect deemed necessary for the attainment of victory."[3]

A more common view among Western observers, however, is that should war be precipitated, the Soviets would want to keep the conflict conventional and regard nuclear release only as a last resort. They believe that the Soviets have become increasingly skeptical about the usefulness of nuclear weapons in combat today–both for ideological reasons, and for operational ones.[4] These observers view the continued Soviet buildup of nuclear capabilities not as meant necessarily to wage a nuclear offensive, but instead: 1) to discourage initial NATO nuclear use; and 2) should NATO call for nuclear release, to be prepared to win at whatever level of nuclear conflict might ensue.[5]

The fact that these differing views are derived from Soviet sources and actions suggests the possibility of some degree of debate among Soviet military planners themselves. For now, the Soviets are apparently keeping their options open, with Soviet doctrine stipulating that any potential wars could begin with *either* conventional or nuclear weapons. If they are initiated with conventional weapons, it stipulates that they may still escalate to a nuclear exchange.[6]

What this means for FOFA, and for NATO as a whole, is that NATO cannot rule out, and thus ought to be prepared for, a conventional phase in any potential Soviet offensive. *What it also suggests is that—whatever strategies the West may adopt, or whatever systems we may buy today--evidence for assessing Soviet concepts is patchy and controversial, and Soviet strategy and tactics may change.* Since this report deals with the conventional defense of Europe, the remainder of this chapter examines how the Soviets might conduct a conventional offensive today should such an action be precipitated.

[3]1. Kass and M. Deane, "The Role of Nuclear Weapons in the Modem Theater Battlefield: The Current Soviet View, " *Comparative* Strategy 4(3):212, 1984.

[4]Nuclear weapons would lower the Soviet rate of advance and greatly confuse the battlefield, disrupting troop control and fairly precisely defined operational plans. See, for example, Lt. Col. John Hines and PhilLip Petersen, "The Soviet Conventional Offensive in Europe, " *Military* Review, April 1985, p. 3.

[5]See vol. 2, app. 4A, note 1. Volume 2 contains the classified appendices to this report.

[6]See, for example, Capt. 1st Rank A. Belyayev, "Scientific Concepts of Modern Warfare-An Important Element in the Awareness of the Soviet Fighting Man, " *Kommunist Vooruzhennykh Sil*, *No.* 7, 1985, as translated in Joint Publication Research Service, JPRS-UMA-85-050, Aug. 29, 1985, pp. 17-22.

WARSAW PACT FORCES IN THE WESTERN THEATER OF MILITARY OPERATIONS

The Soviet threat facing Western Europe is a matter both of the numbers and equipment of Warsaw Pact forces, and of Soviet strategy for employing those forces. The main non-nuclear threat comes from the continental forces of the Warsaw Pact, concentrated in Central Europe along the eastern border of West Germany in what the Warsaw Pact designates as its Western Theater of Military Operations (TVD).[7] This region contains generally-although by no means exclusively–flat terrain (especially northern Germany), well suited to the movement of armored combat units, and the road to the key economic and political centers of Western Europe.

The Warsaw Pact's Western TVD consists of Soviet and non-Soviet Warsaw Pact (NSWP) forces in Poland, East Germany, and Czechoslovakia, and the Baltic, Belorussian and Carpathian military districts of the U.S.S.R. With a standing force of roughly 4 million personnel facing Europe, this area houses the Warsaw Pact largest, most ready, and most modern force, which far outnumbers NATO's in-place forces.[8] The Soviet forces include roughly 19 divisions in the Group of Soviet Forces Germany (GSFG) in East Germany, five divisions in the Central Group of Forces (CGF) in Czechoslovakia, and two divisions in the Northern Group of Forces (NGF) in Poland. NSWP forces include somewhere around 6 East German, 15 Polish, and 10 Czech divisions. Another 38 Soviet divisions lie in the three western military districts of the U. S.S.R.[9]

All of the Soviet Groups of Forces stationed in Eastern Europe are considered "ready" forces, i.e., are highly manned, well-equipped and trained, and are at least minimally prepared for combat with little or no mobilization and preparation. Most of the approximately 38 divisions in the western military districts of the U.S.S.R. are characterized as "not-ready"—i.e., they would require extensive mobilization and are not available for immediate combat operations.[10] The Warsaw Pact forces in the Western TVD are equipped with close to 30,000 tanks and 20,000 artillery and mortar pieces. About two-thirds of these tanks and about three-fourths of all artillery is concentrated in the Soviet divisions, with the remainder in the NSWP divisions.[11] By contrast, NATO forces comprise far fewer ready divisions in Central Europe,[12] and roughly half as many tanks, artillery and mortars, armored personnel carriers and attack helicopters. Figure 4-1 presents some rough comparisons of NATO and Warsaw Pact strengths in the Central Region as published by the U.S. Department of Defense. There are disagreements, however, among published estimates due to differences such as state of mobilization, which forces are counted, and age of data.

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[7]For planning purposes, the Soviets have divided the areas contiguous with their borders into five "theaters' of military operations or TVDs--the Northwest, the Western, the Southwestern, the Southern, and the Far Eastern—in which they would expect military action on a strategic scale; the military assets employed in each TVD vary, but the strongest force is considered to be in the Western TVD. The Soviet Union itself is divided into 16 military districts.

The Soviet *term–teatr voennykh deistv*—has been variously translated in Western writings as Theater of Military Operations (TMO), Theater of Strategic Military Actions (TSMA), and Theater of Military Actions (TMA). This report follows DOD's current usage of 'theaters of military operations. and the acronym taken from the Russian, TVD.

[8]According to a 1984 NATO force comparison, the Warsaw Pact countries have a standing force of about 6 million personnel, of which about 4 million face NATO in Europe. The standing force of the NATO countries comprise about 4.5 million personnel, of which about 2.6 million are stationed in Europe. See *NATO and the Warsaw Pact: Force Comparisons,* NATO Information Service, Brussels, 1984, p. 4.

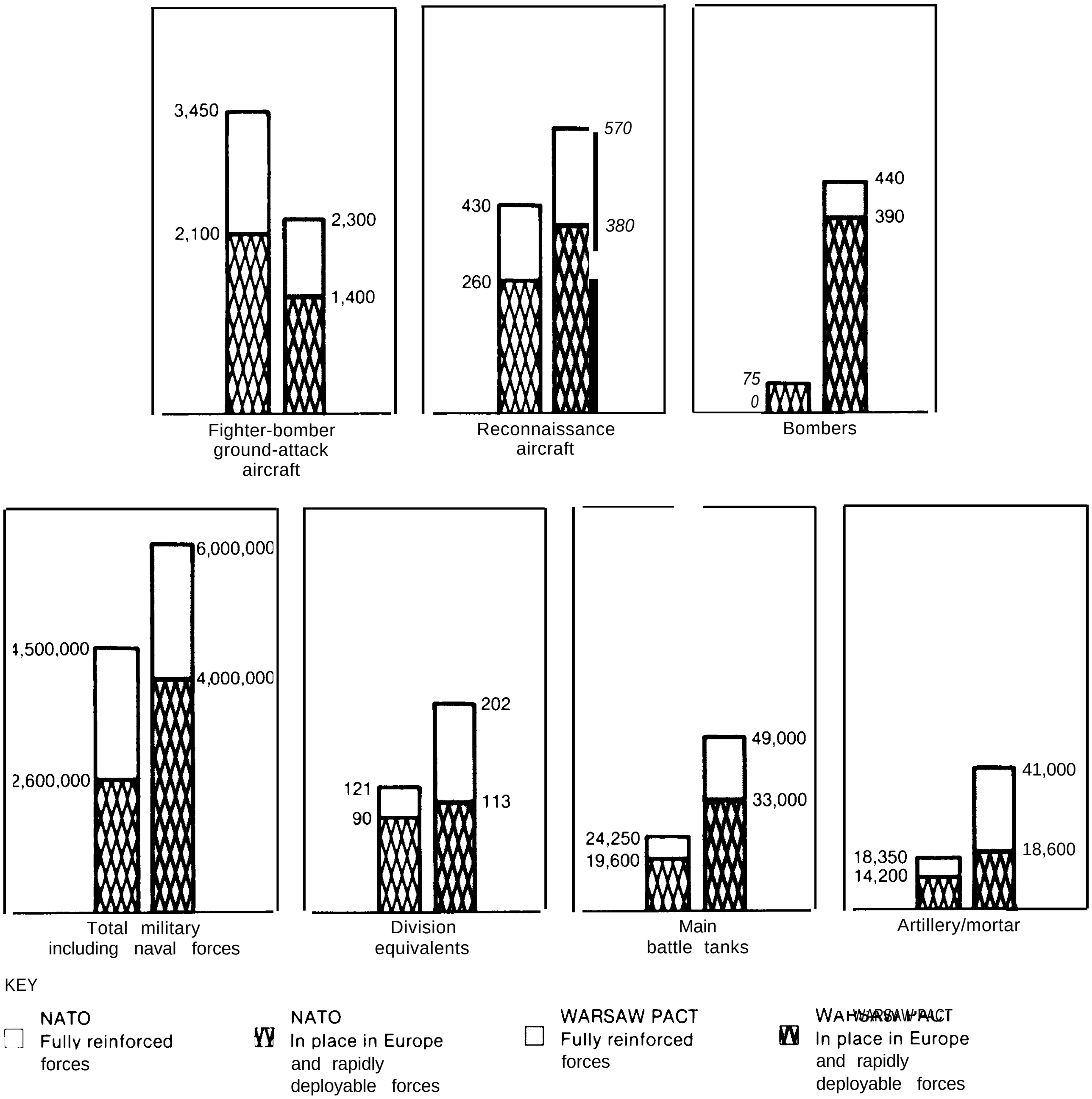
[9]See vol. 2, app. 4A, note 2. For an unclassified discussion, see Laurence Martin, *NATO and the Defense of the West,* New York: Holt, Rinehart & Winston, 1985, p. 24.

[10]See vol. 2, app. 4A, note 3.

[11]U.S. Department of Defense, *Soviet Military* Power, *1986*, p. 12. See vol. 2, app. 4A, note 4.

[12]Unclassified estimates vary on the number of NATO and Warsaw Pact divisions in the Central Region, and there are many differences–in personnel and equipment–between NATO and WP divisions. These numbers, therefore, provide the basis for a rough force comparison, but should not be viewed as a comparison of equivalent units. See *Soviet Military Power, 1987,* estimates from the International Institute for Strategic Studies (11SS), London, and L. Martin, *NATO and the Defense of the Wrest,* pp. 24-25.

Figure 4-1.—NATO/Warsaw Pact Force Comparisons[a]



[a]Estimates vary in the unclassified literature regarding all of these force comparisons The above should be taken only as a guide as viewed by the U.S. Department of Defense The chart reflects U.S. estimates of 1985 data NATO estimates exclude France and Spain

SOURCE *Soviet Military Power, 7986,* pp 89, 91

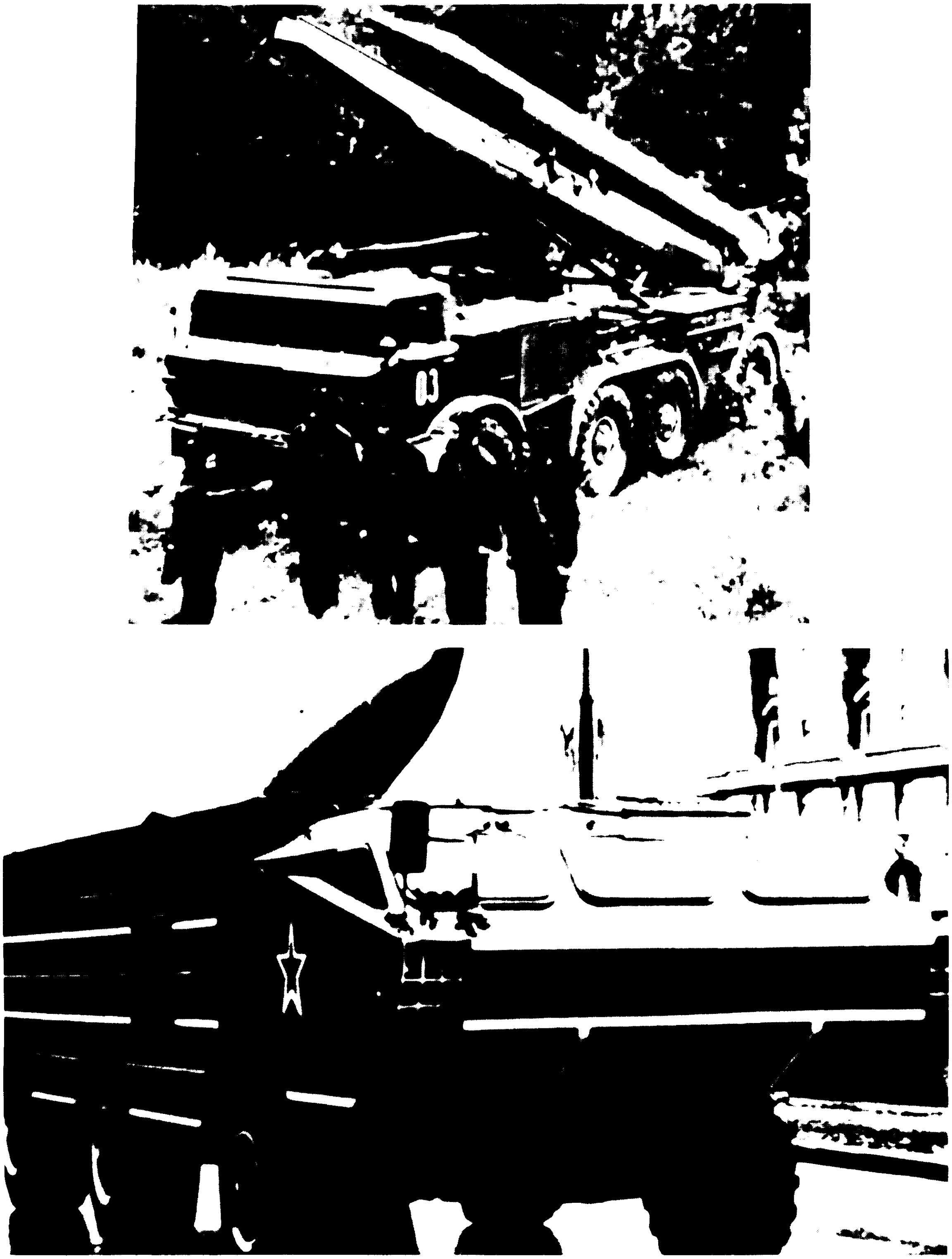


Photo credit: U S Department of Defense

Soviet **missile launchers.**

The main elements of the Soviet ground forces are the tank, motorized rifle, and airborne divisions.[13] Each of the tank and motorized rifle divisions contains a similar complement of artillery, anti-aircraft guns and missiles, tactical surface-to-surface missiles, and support units, with the chief difference between them lying in the number of motorized rifle regiments and tank regiments in each: a Soviet tank division (estimated at about 11,000 men) includes three tank regiments and one motorized rifle regiment; the motorized rifle division, slightly larger (an estimated 13,000 men), has three motorized rifle regiments and one tank regiment[14] (table 4-l). An important point to note with regard to FOFA, however, is the overall ratio of armored to non-armored vehicles: in both tank and motorized rifle divisions, there are more than twice as many trucks and other light vehicles as there are armored vehicles[15] (table 4-2). The airborne divisions include three airborne regiments and combat support and service units. In addition to the regular airborne divisions, the Soviets have also formed air assault brigades and battalions.

According to preliminary research from the Royal Military Academy, Sandhurst, the Soviets may now be moving toward a more flexible organization of their forces as well, by turning more toward the corps/brigade structure as a possible alternative to the focus on divisions and regiments. Researchers at Sandhurst believe the reorganization of some Soviet divisions into corps may presage a larger reorganization of the Soviet force structure overall. Such changes would only reinforce the belief of the U.S. DoD that these forces have been and are being expanded and reorganized to create a larger, more capable and higher-speed fighting force for a conventional or nuclear battlefield.

[13] See vol. 2, app. 4A, note 5.

[14] See Soviet *Military Power 1986*, p. 65, and U.S. Department of the Army, *Soviet Army Operations*, April 1978, IAG-13-U-78, pp. 2-10-2-13.

[15] See vol. 2, app. 3A, footnote 6.

Table 4-1 .—Structure of Soviet Motorized Rifle and Tank Divisions

	MR	Tank
Total personnel	12,695	11,470
Division HQ & HQ company	245	245
Tank regiments	1 regiment 1,145 personnel	3 regiments, each w/1 ,575 personnel
MR regiments (BMP)	1 regiment 2.225 personnel	1 regiment 2,225 personnel
MR regiments (BTR)	2 regiments, each w/2,31 5 personnel	
Artillery regiment.	1,030	1,030
SAM regiment (SA-6)	480	480
FROG battalion	170	170
Multiple rocket launcher battalion	255	255
Antitank battalion	195	—
Reconnaissance battalion	340	340
Engineer battalion	395	395
Signal battalion	270	270
Motor transport battalion	370	370
Maintenance battalion	230	250
Chemical defense battalion	225	225
Medical battalion	175	175
Artillery command battery	70	70
Mobile field bakery	45	45
Helicopter squadron	200	200

SOURCE Defense Intelligence Agency *Soviet Divisional Organization Guide* DDB-1 100333-82 July 1982, reprinted May 1985 pp. 9 80

Table 4-2.—Vehicles Soviet Tank and Motorized Rifle Divisions

	Motorized Rifle Division	Tank Division
Total combat vehicles	1,029	976
of which		
Tanks	220	238
Armored personnel carriers	649	488
Artillery	108	108
Air defense	52	52
Trucks	2,501	2,427

SOURCE Defense Intelligence Agency *Soviet Divisional Organization Guide* DDB-1 100-33382 July 1982 reprinted May 1985

PRINCIPLES OF SOVIET STRATEGY

In assessing Soviet strategy, the extent to which the Warsaw Pact is dominated by the U.S.S.R. means that what the Soviets think and do will generally apply to the entire Warsaw Pact: all Warsaw Pact armies are organized along the same lines, have highly standardized equipment, and have largely the same tactics and doctrine as in the U.S.S.R. During wartime, the NSWP forces would be completely subordinated to the Soviet Supreme High Command through intermediate-level theater commands.

Soviet writings outline a number of principles which would govern the use of these forces in any Warsaw Pact conventional offensive into Western Europe. The overriding principle would be to adopt a strategy, operational plans and tactics that would allow Soviet forces to penetrate and neutralize NATO's defenses very quickly, while at the same time: 1) minimizing the risk of escalation to a nuclear catastrophe, and 2) keeping the conflict off the territory of the U.S.S.R. The Soviet aim would be to get rapidly into NATO's depths and seize key objectives–NATO's nuclear arsenals, C^3I assets, air force assets, logistic elements, etc.—before NATO would have a chance to fully mobilize, before reinforcements would be able to arrive from the United States, and before NATO could reach a decision to use nuclear weapons.

Of key importance in achieving this principle, the Soviets emphasize, are the two factors of speed and *surprise*. In order to reach their objectives quickly—i.e., before Western countries could prepare their defenses fully or agree to use nuclear weapons—the Soviets believe that a European war must start suddenly, taking NATO by surprise. This does not necessarily mean total surprise, or even military surprise, but political surprise—i.e., an offensive which would catch off guard those NATO leaders who make the political decision to mobilize, prepare defenses, or release nuclear weapons. Although there could never be total surprise, a reasonable degree is regarded as essential, largely as an important force multiplier: a certain degree of surprise would make it possible to reach objectives with fewer forces than would be needed against an enemy prepared for battle.

To achieve this speed and surprise, a Soviet offensive would probably be accompanied by some kind of *deception* scheme to make troop movements and mobilizations appear to be occurring for reasons other than planned aggression. Many believe that NATO would be far less likely to react if any Soviet preparations for war were ambiguous. And once an offensive is initiated, the Soviets emphasize the importance of speed—i.e., of *seizing and holding the initiative*, retaining the *offensive*, and *maintaining a high rate of advance*. The Soviets place overriding stress on the offensive as the only "decisive" and therefore the only possible form of war.

In an initial offensive, the Soviets would likely *concentrate their efforts* along certain fronts, attempting deep, heavy thrusts along narrow sectors, and would look to *exploit the enemy weaknesses*. The purpose would be to confront NATO with an overwhelming attack on a few small areas which NATO would not be able to match. With the different NATO corps at different states of readiness, the Soviets are expected to exploit the gaps in NATO's defense, and to place the main weight of attack on the more vulnerable areas-i. e., on the U. K., Belgian, Dutch and Danish contingents. (The U.S. and German corps are considered to be the most formidable forces in NATO, so it is considered unlikely that the Soviets would attack them head-on.) This concentration of power in narrow sectors would be conducted as part of an overall plan that would be designed to lead to a rapid penetration of NATO defenses and NATO's collapse.

The Soviets would divide their forces into theater level forces—consisting of *fronts* and armies-and tactical units, consisting of divisions, regiments, battalions, and smaller. In other words, fronts would be comprised of armies; armies are comprised of divisions; divisions, of regiments; regiments, of battalions; and battalions, of companies and platoons. Fronts have no fixed organization. Anywhere from one to six fronts might be put together to participate in a specific strategic operation in a TVD (Soviet military theater).[16] Armies consist of two main types: the Tank Army, (comprised of mainly tank divisions), and the

"For a fuller description, see Soviet *Army Operations*, Department of the Army, U.S. Army Intelligence and Security Command, and U.S. Army Intelligence and Threat Analysis Center, IAG-13-u-78, April 1978.

Combined Arms Army, (with more motorized rifle divisions). When tailored for combat operations, either type of Army would normally include: three to seven divisions; SSM brigade; several artillery brigades; antitank units; AAA units; SAM regiments; signal regiment; combat engineer units; pontoon units; assault crossing units; transport units; supply facilities; evacuation and repair units; medical units and facilities.[17] Soviet forces are also divided into corps and brigades; corps are generally comprised of two or three divisions, for operations which would not require a full army.

In order to threaten a quick breakthrough and a rapid, continuous penetration deep into NATO territory, these forces have been organized into successive waves, or echelons, dispersed in great depth. The purpose is to be able to bring fresh forces against the adversary at the right times to buildup pressure and force and sustain a breakthrough. Thus, Soviet forces throughout the entire force structure down to the battalion level are divided into "echelons"--first, second, and perhaps even third-and reserves. Each regiment contains first and second echelon battalions; each division, first and second echelon regiments; each army, first and second echelon divisions; each front, first and second echelon armies; and the entire theater of operations would likely have first and second echelon fronts. As figure 4-2 illustrates, NATO Central Region ground forces in their main defensive positions would likely have to contend with three different "second echeions, " or waves of enemy forces following the lead divisions of the assault armies: the Second Tactical Echelon, or the follow-on divisions of the assault armies; the Second Operational Echelon, or the follow-on armies deploying from Poland, Czechoslovakia and Western Military Districts; and the Second Strategic Echelon, or Second Echelon Front, consisting of the follow-on armies from the western military districts (WMD). As illustrated below, however, the Soviets have demonstrated a good deal of flexibility in how echelonment may be carried out, and these "waves" would not necessarily be of equal weight or significance.

Each Warsaw Pact unit would probably be assigned a sector to attack and, if of division size or larger, a main and secondary axis of advance within that sector. In addition, all units of brigade size or larger would be assigned a depth of attack which contains an immediate and subsequent objective or mission. In this sense, therefore, second echelons would not be reserves in the usual sense, but rather would act *as precommitted* reserves that would have been assigned their pre-planned missions before the offensive begins. The reserves, a small proportion of Warsaw Pact forces,[18] would be contingency forces to use against unanticipated threats and to take advantage of unexpected opportunities.

To exploit these breakthroughs, the Soviets have revived the World War II concept of mobile groups, which would take advantage of any breakthrough to move into NATO's rear. It is believed that these independent divisions, armies, or regiments-with their new capabilities, now commonly called *Operational Maneuver Groups* (OMGs)—would be assigned to operate on their own to capture key objectives in the NATO rear that would both pave the way for the follow-on forces and neutralize NATO's theater nuclear threat. In this way, their task would be to create the conditions for turning a tactical success–i.e., an initial breakthrough of NATO defenses–into an operational success, by paving the way for the second echelons of the army or front of which they are a part to achieve their preassigned objectives.

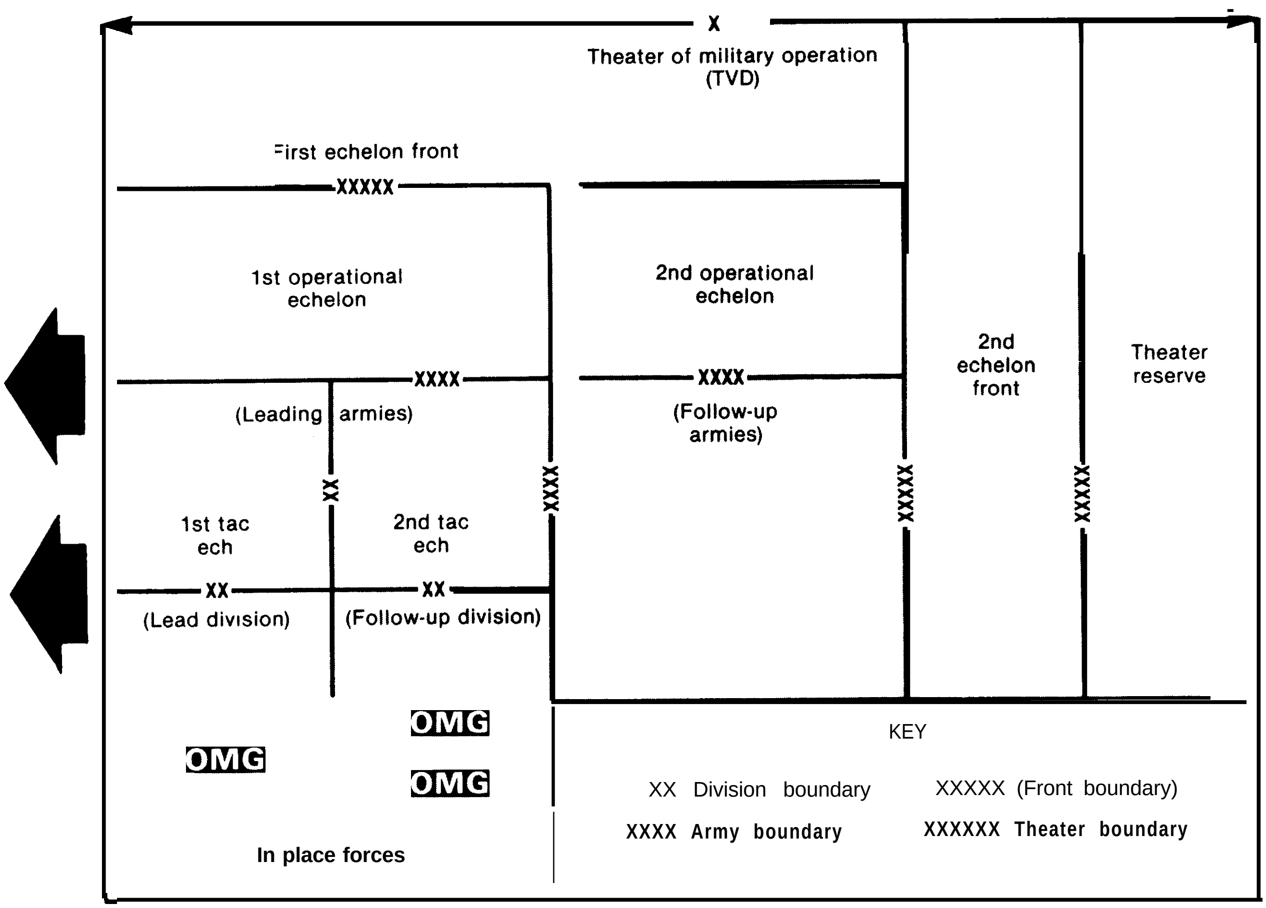
The Soviets expect a battlefield that would be very confused. There would be no clearly discernible front line, forces would mingle in depth and would engage primarily in battles of encounter (i.e., when both sides engage while on the move).[19] The Soviets plan to win a decision quickly, but are prepared to fight a long war if they have to.

"Ibid, pp. 2.7-2.10.

'*See vol. 2, app. 4A, note 7.

¹⁹See Christopher N. Donnelly, "The Warsaw Pact View of the Future Battlefield, *120A National Security Report* (Royal Military Academy, Sandhurst, A68), pp. 11-14.

Figure 4-2.—Warsaw Pact Concept of Employment



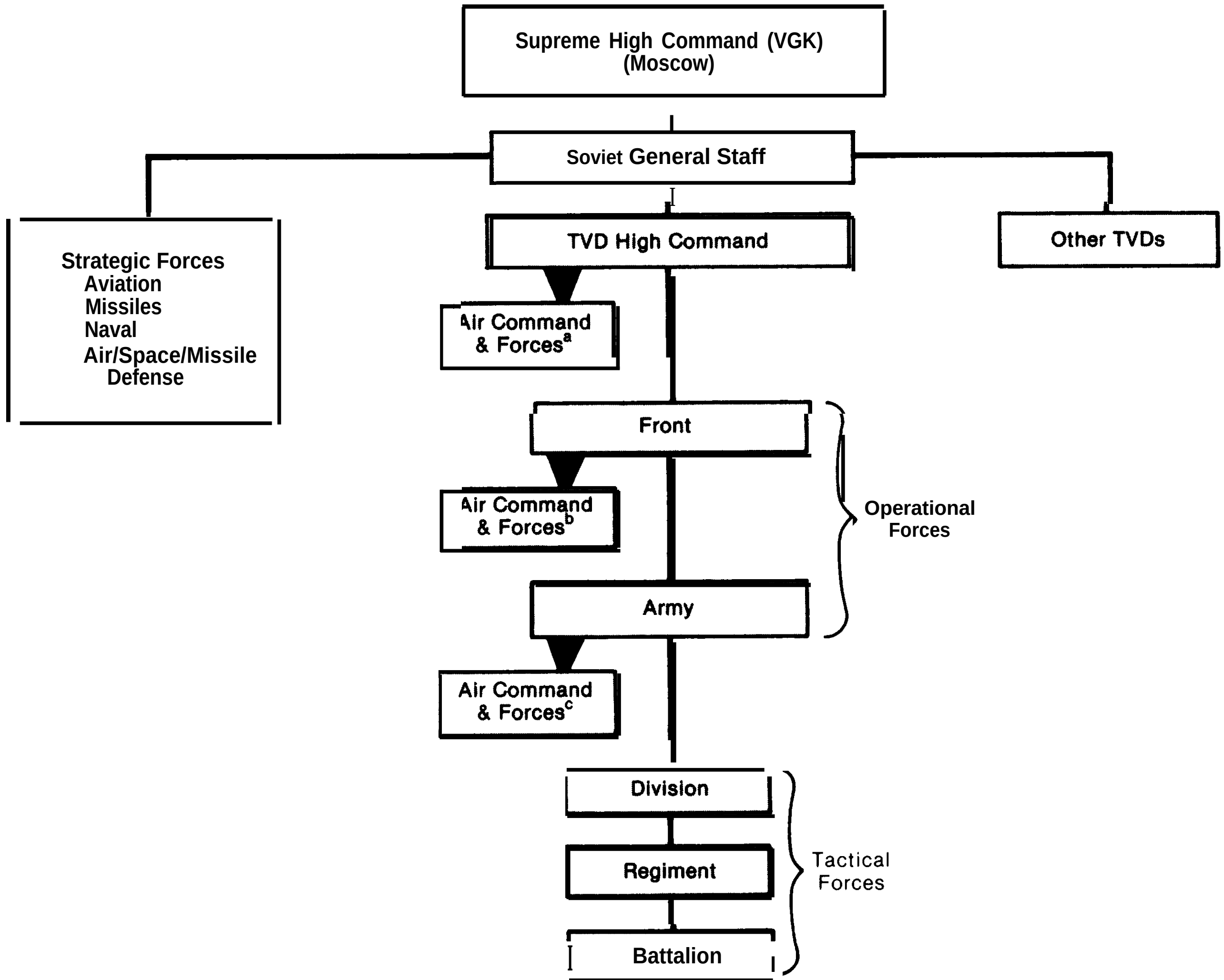
NOTE It is important to keep in mind that this diagram is highly schematic, for illustrative purposes only The Warsaw Pact forces have demonstrated flexibility in echeloning forces First and second echelons— whether tactical, Operational. or strategic —would likely not be of equal weight or significance (See text)

SOURCE General Bernard W Rogers, Follow-On Forces Attack (FOFA) Myth and Realities,' *NATO Review*, No 6, December 1984 p 2

Soviet planners believe that their system of command and control, or 'troop control, has been structured in the best way to meet the demands of such an offensive. The Soviet theater command structure is highly centralized, with all Warsaw Pact forces under a single, centralized military command authority, the Soviet Supreme High Command (VGK) and the Soviet General Staff.[20] The Soviets emphasize a "top down" command and control system, with commanders at the TVD establishing concrete strategic goals, and then moving particular missions and requirements down the hierarchy, to the front, the army, division, and so on (figure 4-3). The Soviets also engage in a good deal of "pre-planning" of operations, i.e., anticipating what future operations might look like, and providing specific "norms" by which commanders would make decisions. Thus, less initiative would be expected of Warsaw Pact commanders at the tactical levels than in the West.

[20]For a comparison of the Warsaw Pact and NATO command and control systems, see John Hines and Phil Petersen, "Is NATO Thinking Too Small? A Comparison of Command Structures," *International Defense Review, No.* 5, *1986,* pp. 563-572.

Figure 4-3.—Soviet/Warsaw Pact Wartime Command Organization



In time of war, the NSWP forces would be brought under direct Soviet command and integrated with the various Soviet fronts.

[a]Counter air and deep interdiction
[b]Counter air and deep interdiction and air support for front
[c]Air support for army

SOURCES Adapted from Phil Petersen and John Hines, "Changing the Soviet System of Control," *International Defense Review*, No 3, 1966, and Science Applications, Inc., *Soviet/Warsaw Pact Battlefield Planning Procedures*, Draft, SAIC-86/6064—FSRC, May 26, 1966.

SOVIET/WARSAW PACT GROUND OFFENSIVE INTO EUROPE: A NOTIONAL SCENARIO

Although there is a good deal of uncertainty about how the Soviets might put these principles into practice should war in Europe occur, the following notional scenario suggests what a Soviet offensive into Europe might entail.

Should hostilities be initiated, the organization of forces in the Soviet Western TVD would probably include three first echelon fronts: a Northern *Front,* comprised mainly of Polish forces, with its headquarters drawn from the Polish Ministry of Defense; a *Central Front,* formed from the GSFG, NGF, and East German forces, with its headquarters staff drawn from the staff of the GSFG headquarters; and a Czech *Front,* consisting of Czech forces and the Soviet CGF, with its headquarters drawn from the Czechoslovak Western Military District headquarters.[21] During wartime, the Northern Front would likely be deployed to the northern GDR, tasked to attack northern West Germany, the Netherlands, and Denmark and, along with airborne and amphibious operations, to take the Danish straits. The Central Front would conduct the main theater attack across West Germany and into Belgium, the southern Netherlands and Luxembourg. The Czech Front's mission would likely be to attack from Czechoslovakia into the southern FRG to the FRG-Swiss-Austrian border. In addition, a Danube Front, formed from the Soviet Southern Group of Forces (SGF) in Hungary and from the Hungarian Army, might be tasked to attack through Austria into the Southern FRG. Soviet forces in the Belorussian and Carpathian Military Districts might comprise two second echelon fronts, with the Baltic Military District providing theater reserves.

As discussed above, the Warsaw Pact ground forces vary widely in their peacetime levels of readiness, with a good number of divisions manned at levels well below their wartime authorizations; these forces would require extensive preparation for war. The preparation would include mobilizing personnel, training and preparing them to conduct combat operations, moving units from their dispersal locations, making final preparations, and, finally, deploying units to combat.[22]

Because the Soviets would likely want some of their follow-on forces to be prepared to exploit any successes at the FLOT, it is expected that they would mobilize partially and begin deployment before they would attack NATO. Most of the Warsaw Pact's first and second operational echelons are at high states of readiness in peacetime. Accordingly, these units can be rapidly deployed from their peacetime locations into assembly areas. For many of those forces in the rear, however, it would take a good deal longer, depending on what level of proficiency the Soviets would want them to reach before hostilities begin. Because of the Soviet emphasis on surprise, and on depriving NATO of any unambiguous warning of an attack, NATO planners believe that the bulk of Soviet forces would be well back from the border between NATO and the Warsaw Pact before hostilities would start. According to one source, NATO's strategy for meeting a Soviet conventional attack is based on the assumption of at least some *96* hours warning time, ” although some believe it might well be shorter.”

Soviet doctrine for deploying these forces would pose some demanding requirements on the timing of movement of the second echelon divisions, armies and fronts. These would be deployed according to a carefully coordinated plan, where each succeeding echelon would be committed at the time and place considered most effective for exploiting the success of its predecessor and advancing deeper into NATO territory. Thus, second echelon divisions of the first echelon armies would start at a particu-

[21] However, estimates vary on the number and composition of fronts, and how they would likely be deployed during war.

[22] *See* vol. *2,* app. 4A, note 8.

[23] Laurence Martin, op. cit., p. 50.

[24] See vol. 2, app. 4A, note 9

lar distance behind the forces at the FLOT, to be committed to battle to achieve objectives a certain distance beyond the FLOT according to schedule. Second echelon armies would be scheduled to arrive a few days later, having started some distance behind in Warsaw Pact territory and with an objective deeper into NATO territory. Second echelon fronts would likewise start even farther back, with a schedule for attaining objectives even farther into NATO's depths. OMGs—parts of armies or fronts designed to carry out deep penetrations and raids as the opportunities arise on the main axes of the attack—would be committed early and would operate well into NATO's rear areas on their own, without the support of the usual supply lines.[25]

Thus, depending on levels of readiness and how they fit into the overall Soviet offensive plan, the follow-on forces would start anywhere from just behind the initial attack forces, to farther back in East Germany, Poland, Czechoslovakia, and then the U.S.S.R. itself. Those farthest back would be transported across a relatively sparse highway and rail network in eastern Poland. According to one set of calculations, the Soviets might bring forward an average of two divisions per day by rail,[26] and up to one division per day by road.[27] It is estimated that at least 140 trains would be needed per day to transport forces across the seven East-West rail lines in Poland. According to these calculations, this would suggest about 20 trains departing along each rail line per day, departing just about every hour with an average maximum spacing of about 35 kilometers between trains.[28] After crossing most of Poland, units would proceed to Forward Assembly Areas.

Closer in, the follow-on forces would group into combat units and continue under their own power toward the battle. Tanks and other armored vehicles would first be loaded onto tractor-trailer transporters before being unloaded to move under their own power. An armored combat division would, if possible, move on two, three, or four parallel routes; thus, any one division moving over roads could stretch well over 40 kilometers.[29]

A division on the move would stop from time to time in assembly areas: to reorganize, maintain vehicles, and rest. Soviet doctrine calls for short or long stops, depending on the reasons, the distance from the FLOT, and the division's schedule. Upon arrival in the immediate battle area, a division would assemble in "final assembly areas, " or "departure areas" before forming into a tactical march formation to be committed to battle. At this point, the majority of support vehicles would move away to their own assembly areas, so that columns moving forward from this point on would consist mainly of armored vehicles. Having been committed, a division's regiments would again stop closer in—somewhere in the range of 5 to 30 kilometers from the FLOT—in regiment assembly areas for their final move forward into battle.[30]

[25] *See* vol. *2,* app. 4A, note 10.

[26] The actual number may well be higher.

[27] Those forces being transported by train would arrive at transloading complexes near the Russian/Polish border, where they would change from broad gauge to narrow gauge before starting across most of Poland. There are about eight complexes along the Russian/Polish border where equipment is off-loaded from Russian broad gauge to East European narrow-gauge; time for transloading is estimated at about 4 hours per train.

[28] *See* vol. *2,* **app**. 4A, note 11.

[29] See vol. 2, app. 4A, note 12.

[30] See vol. 2, app. 4A, note 13.

SOVIET AND WARSAW PACT VULNERABILITIES

The above scenario implies some potentially serious vulnerabilities in the Warsaw Pact system—such as rigidity in Soviet planning, their C3 system, the vulnerability of large columns of Warsaw Pact troops on the march, and the fact that Warsaw Pact troops will have to move through critical "chokepoints"--which could suggest important targets for FOFA.

For example, some argue that the large number of Warsaw Pact follow-on forces, and the precise timing with which they would move forward, would leave little room for flexibility in a Soviet offensive; if this is true, a changing situation in the movement of follow-on forces, such as might be caused by FOFA, could significantly disrupt the Warsaw Pact timetable for war.[31] Likewise, they contend, a highly structured plan could strain Soviet command and control, whose disruption would also cause Warsaw Pact planners serious problems. The size of the Warsaw Pact columns could comprise another major weakness, leaving Warsaw Pact forces vulnerable to air attack. And potential chokepoints, such as at bridges over the Oder and Elbe Rivers, would also be potentially major vulnerabilities; creation of these chokepoints would delay and disrupt Warsaw Pact follow-on forces, and as the delayed forces bunch up, would offer good targets for follow-up attacks." As Soviet rear services centrally control all logistic support activities and supplies, disrupting ammunition resupply and delaying the arrival of the second echelon could also disrupt Soviet operations.

Thus, within the framework of this general scenario, key targets for FOFA might include not only fixed targets-such as bridges across the Oder and Elbe/Vltava rivers, railyards, depots, etc.–but the Warsaw Pact forces themselves, including columns of second-echelon ar-

"See vol. 2, app. 4A, note 14.

"See vol. 2, app. 4A, note 15.

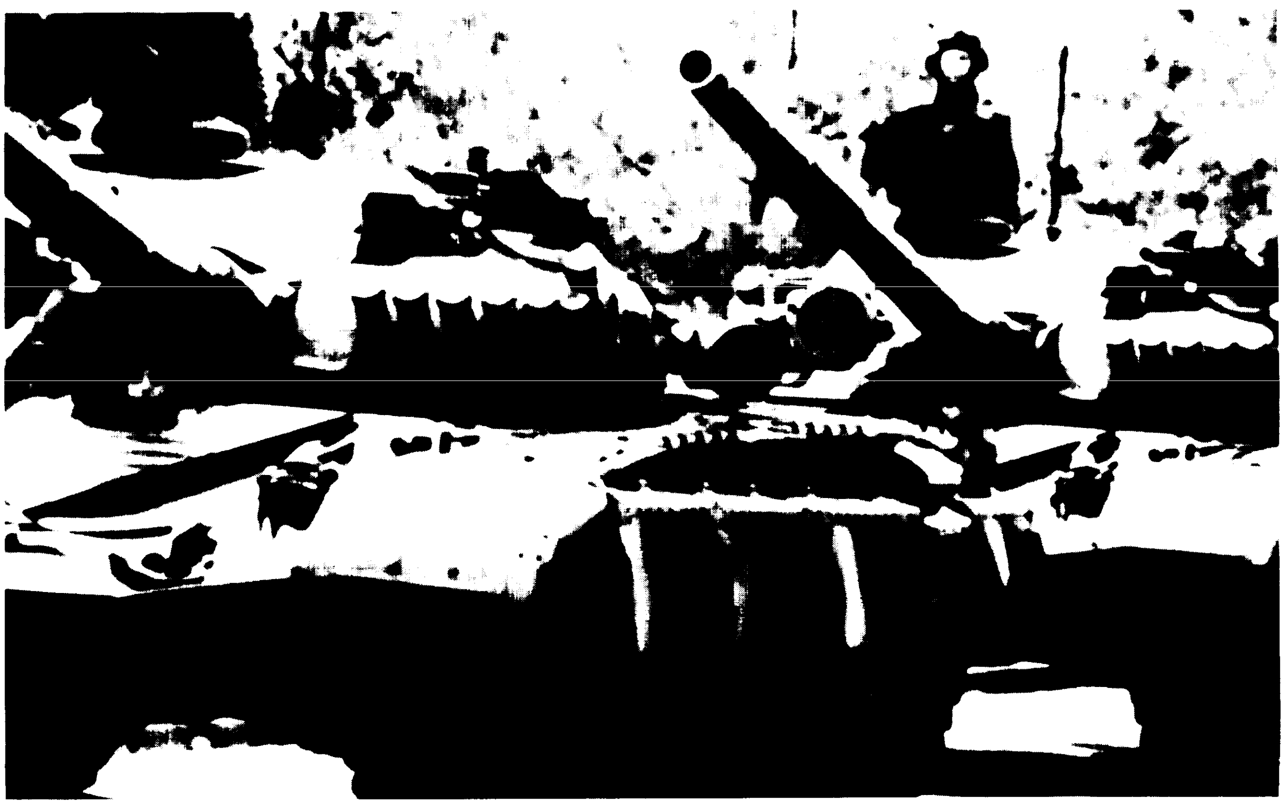


Photo credit U S Department of Defense

Soviet tanks.

mored and support vehicles (moving both by rail and by road), units in assembly areas, chokepoints, and Warsaw Pact headquarters and command posts. Identifying OMGs prior to their commitment to battle is also sometimes considered a major task for FOFA. Attacking these targets would likely delay the enemy reinforcement and resupply at the FLOT, and might so erode morale in the rear, that the Soviet offensive would be degraded and made more manageable for NATO forces at the front.

AREAS OF CONTROVERSY AND UNCERTAINTY

This overall scenario, however, has raised a number of serious questions among Western observers. In general, these questions concern how flexible the Soviets might be in implementing this overall plan, and thus what it would take to delay or disrupt Warsaw Pact follow-on forces enough to have a significant effect on the overall war. In the above scenario, the value of FOFA would depend on two important conditions:

1. that there will be follow-on forces, and that these follow-on forces will be important to Warsaw Pact strategy; and
2. that NATO's attack on the follow-on forces can have a significant effect on their utility —i.e., enough losses can be inflicted to matter; delays cannot be sufficiently compensated for; Warsaw Pact C2 can be degraded enough to make a difference; morale can be eroded enough to significantly affect the cohesion of Warsaw Pact troops.

Each of these conditions, however, is controversial.

With regard to the first, although Soviet doctrine may call for the echelonment of forces, there is not necessarily a prescribed formula or particular mix of forces necessary for this, and the Soviets have demonstrated a good deal of flexibility in how echelonment may be carried out. In an offensive into Western Europe, the Soviets may well "frontload" their forces in the first echelon, and Soviet field commanders may well echelon their forces differently from each other. These decisions would probably depend on: 1) how ready the NATO forces are facing them, and how much surprise they could expect; and 2) over what kind of terrain they would have to deploy. Especially given long mobilization times, the Soviets could "front load" their forces, enhancing the threat at the FLOT and reducing the importance of the follow-on forces[33] (figure 4-4).

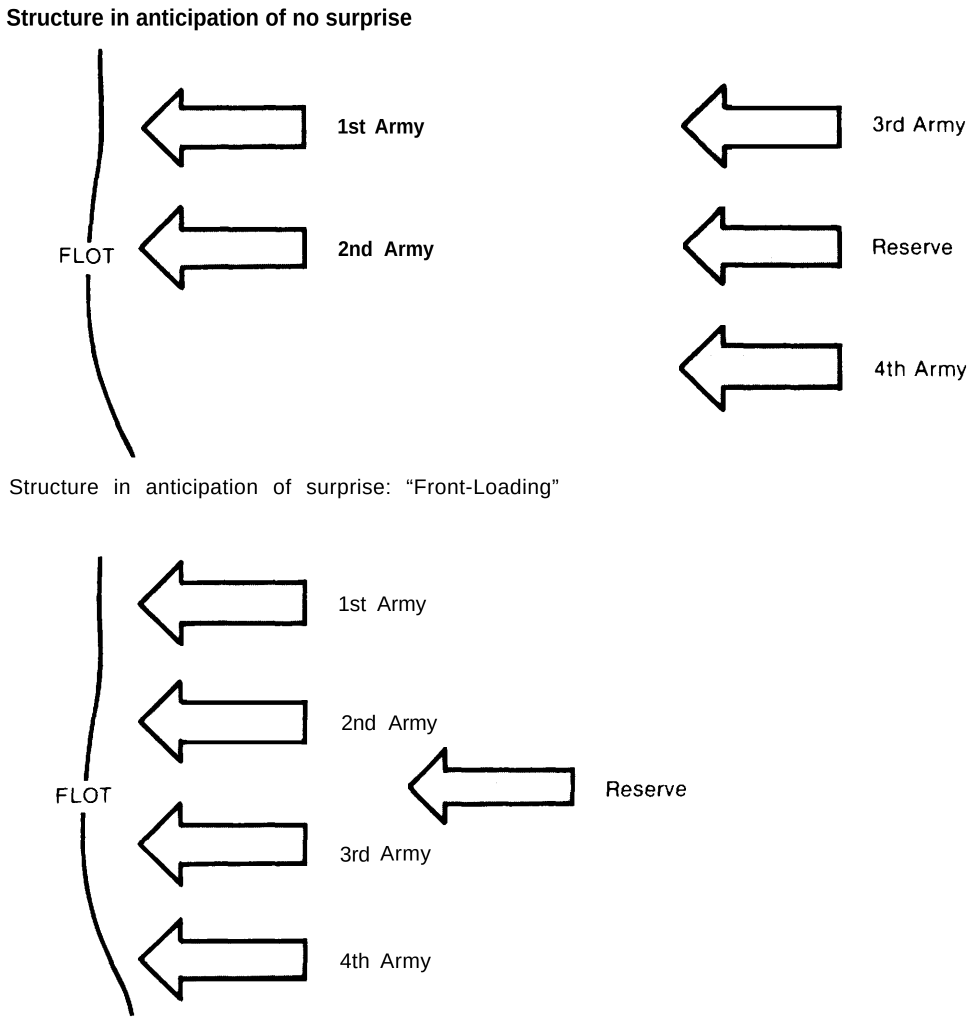
The question is how much the Warsaw Pact might "front load" its forces, and what this would mean for the value of the follow-on forces. However flexible Soviet planning may be, it still makes sense that any "front loading" of forces would be limited by certain physical and doctrinal constraints. Terrain is limited; and placing a good deal more forces up front would complicate logistics problems, reduce the amount of surprise, and would make Warsaw Pact forces more vulnerable to NATO's nuclear or high-accuracy conventional weapons. Thus, it is expected that there will always be a certain number of follow-on forces coming up behind. As stated by General Rogers:

> .,. critics . . . err in assuming that we are unaware that under certain circumstances the Soviets might press their second echelon forces up against, or among, those forces of the first echelon. Not only are we aware of this possibility, we also take account of the fact that terrain can only accommodate a finite number of Warsaw Pact battalions abreast, thus causing the rest to be out of contact, i.e., to be follow-on forces.[34]

Indeed, some contend that the Soviets would find it difficult to significantly front load their forces beyond those already in place without exceedingly long mobilization times.[35] It is likely that if the Soviets were preparing to initiate an offensive, they would provide a good

[33] See vol. *2*, app. 4A, note 16.
"General Bernard W. Rogers, op. cit., p. *4.*
[35] *See* vol. *2,* app. 4A, note 17.

Figure 4-4.— Example of Soviet “Front-Loading” of Forces



SOURCE' Soviet Studies Research Center, Royal Military Academy, Sandhurst, UK

deal of training for newly mobilized, “not ready” units, and conduct relatively comprehensive preparations before bringing them up to the FLOT. But doing so would take a good deal of time.

Physical constraints, however, would still allow the Soviets to place many more forces forward than are now estimated to be there,[36] and many Western observers contend that doing so might well lower the target value of the follow-on forces for the overall offensive–not just quantitatively, but qualitatively. This was reflected by U.S. Air Force’s Headquarters in Europe, in a briefing which spelled out the following concern with FOFA (as distinct from interdiction):

[36] According to one observer, current Warsaw Pact organization and operational doctrine suggests that there would likely be around 20 to 25 divisions in the first echelon of an attack against NATO’s Central Region. Analysis of the terrain in Western Europe, however, suggests that this region could support well over 30 divisions in the first echelon. In order to increase the combat power of the first echelon by at least 20 percent, therefore, this observer suggests that the Warsaw Pact need do little more than make changes in operational **plans**—“**a** relatively ‘quick fix’ option. ” See Boyd D. Sutton, et al., “Deep Attack Concepts and the Defence of Central Europe, ” Survival, March/April *1984,* pp. *64-65.*

Photo credit: U.S. Department of Defense

Soviet self-propelled artillery.

> Soviet doctrine calls for the wave, or echelon, attack arrangement. We here at USAFE do not believe this is the only possible scenario. A minor shift in Soviet employment concept and/or change in their reinforcement plan may leave us with attack capabilities for which there are few targets. Few targets, that is, that will produce tangible returns in a limited span of time.[37]

Others have pointed out similar concerns. For example, some point out that a concept that considers attacking forces in transit across Poland tacitly assumes that those forces would be mobilized and moved after D-Day. Should these forces be mobilized earlier, however, and thus be in East Germany when the war starts, interdiction in Poland would be futile. Even if follow-on forces are present, many believe their value would be limited in terms of affecting the overall war. "It is the extended first echelon that is now critical . . . The reinforcing formations from the Western military districts . . . serve a vital function, but they are redundant in numbers and they are mostly *not* first-line combat units . . . It is the GSFG itself that must be destroyed . . . If these are not contained, they will collapse NATO's ability (and will) to defend."[38]

These questions are complicated by uncertainties over what it would take for attacks on individual follow-on forces to have a significant impact on their effectiveness. How precisely timed would a Soviet offensive be? If a Soviet second-echelon division is delayed a certain number of hours, would its mission have been obviated? Or might it make up that time elsewhere, for example, by staying for shorter times in assembly areas? At what level

[37] *FOFA: USAFE View*, Briefing to OTA staff, HQ USAFE, Apr. 16, 1986.

[38] See Steven L. Canby, "The New Technologies, " November, 1983, p. 25. These sentiments were repeated to OTA staff by West Europeans in the FRG and Belgium, April 1986.

of damage would the performance of a Soviet unit-at any level—be degraded enough to significantly affect the overall war? And what would it take to target OMGs or command posts?

As mentioned, some suggest that Warsaw Pact operations are so precisely timed that disruption of that plan could throw their entire operation off course.[39] But Soviet writings suggest that the Soviets may build a good deal of slack time into operational plans—for example, into waiting times in assembly areas—to compensate for delays. Similarly, it is uncertain how critical delay of logistics support might be, given that the Soviets keep a good amount of their stocks already forward.[40] While delaying the follow-on forces would clearly have an effect, therefore, there is a good deal of debate concerning how high a level of damage there would have to be for delaying these forces to have a significant effect on the overall war.

A similar debate surrounds the relevance of the OMG to a follow-on forces attack concept. The OMG has commonly been viewed as comprising a specialized formation, specific in its structure and mission, so that an OMG might well be an identifiable target in the enemy's rear.[41] According to General Rogers:

> We consider the OMG to be a high priority target for FOFA . . . Much of the new target detection and sensing capability we seek to acquire is necessary for us to identify which follow-on forces are organized as OMGs so they can be attacked early on.[42]

But others emphasize that the OMG may also be considered as a task, a *concept* of operations, without necessarily any definite structure. In this sense, the OMG would not comprise something that could be targeted in depth, but rather something that would not be identifiable until deployed–i.e., until relatively near the FLOT. Viewed this way, individual divisions or armies would not necessarily be structured in advance to work as an OMG, but rather resources would be allocated as necessary to exploit breakthroughs and get into NATO's rear. The Soviets may be providing capabilities in such a way that perhaps any group of regiments, combining fire power, air assets, and mobile forces, could be put together as an exploitation force, or "OMG," as deemed necessary.

There is also debate over the degree to which disruption of Warsaw Pact C^3I in the rear might disrupt Soviet forces as a whole. The inherent difficulties in detecting and targeting Warsaw Pact command posts are many: 1) Soviet command posts are well defended and camouflaged; 2) they are dispersed widely; 3) there is a good deal of redundancy in command posts and in various communications modes; 4) command posts at the front and army level are largely prepared in advance and therefore are bunkered or hardened; and 5) because transmitter antennas are generally several kilometers from command posts, it would be difficult to determine the precise locations of command posts.[43]

Aside from these difficulties, there is difference of opinion over how much damage could be done should certain units be "decapitated," and how much flexibility may be worked into the Soviet decisionmaking process. Some argue that because the Soviet command and control system is so highly centralized—where commands pass down a strictly hierarchical system and where, at the tactical level, information is limited and initiative discouraged—disrupting command and control would be the most effective way to stop a Warsaw Pact offensive. But Soviet writings also reflect a good deal of effort to introduce more flexibility into their decisionmaking process to take any potential disruptions into account.[44] It is unclear how flexible Soviet troop control would prove to be in combat.

A final area of contention concerns the effect of FOFA on the cohesion among Soviet and Warsaw Pact forces—i.e., the effect of

[39] See vol. 2, app. 4A, note 18
[40] See vol. 2, app. 4A, note 19
[41] See vol. 2, app. 4A, note 20
[42] General Bernard Rogers, op. cit., p. 4
[43] See vol. 2, app. 4A, note 21
[44] See vol. 2. app. 4A, note 22

FOFA operations on Soviet and Warsaw Pact morale, and how that might affect the capabilities of their troops for implementing Soviet operational plans. FOFA could well have a profound psychological effect on the enemy's forces, by extending the battlefield into the enemy's depths. According to one military historian, "hitting units while they are still on the line of march, and do not expect it, will have a far more serious effect than hitting them harder later, when they are deployed and expecting casualties."[45] Most people, this historian suggests, can face terrors, such as going into battle, on a predictable basis; they become psychologically prepared. But FOFA would make the line of battle unpredictable. And with a military doctrine that emphasizes the importance of taking the offensive from the first shot, Soviet troops might quickly acquire a profound loss of confidence or sense of defeat. "It is by using indirect fire to breed this fear, it is by killing the morale of 90 percent of the enemy in addition to killing the bodies of 10 percent of his soldiers, that we can make our most effective contribution to the defence of the Central Front."[46]

Many believe that these psychological effects might only be compounded in the Warsaw Pact, given the already questionable loyalty among many Soviets and East Europeans toward Moscow. Questions have been raised as to whose side the East Europeans would fight on should hostilities begin, and whether FOFA would further erode the cohesion of an already tenuous alliance. Likewise, demographic change in the U. S. S. R., and the growth in the number and proportion of non-Russians in the Soviet armed forces, has raised important questions about loyalty and performance in the USSR's own forces. For example, the fact that an estimated one-fourth to one-third of all Soviet conscripts are projected to be of Muslim descent within the next 10 to 15 years-with lower educational and technical training, often severe lack of Russian language skills, and questionable loyalty-has raised serious questions about the potential performance of the non-Russian nationalities in combat. Evidence of recent "riots" among Soviet conscripts who refused to go to Afghanistan, and defections of Central Asians and Russians within Afghanistan itself, have only highlighted these concerns.

But the Soviets are also aware of these problems, and have taken steps to deal with them. Moscow has tightened institutional controls over its Warsaw Pact allies-e. g., by creating peacetime TVD High Commands in the late 1970s, which creates a clearly defined, preplanned wartime command structure in which Eastern Europe is clearly subordinate to Moscow; and by assuring that procedures, C2 systems and equipment are all standardized, and that Russian is the language of command. At home, Soviet discussions focus on the need to train all of their nationality groups to be better soldiers—e.g., through increased Russian language training, better technical training, and retaining mixed nationality units for better control—and for restructuring their own forces to take account of the changing composition of the conscript pool. On the evidence available, it would be impossible to gauge their level of success on either count.

All of these questions remain complex and controversial. Several efforts are now underway to attempt to resolve them, or at least to narrow the margin of uncertainty, but many of the answers cannot be known. At present, these questions remain at the heart of the debate over how much emphasis should be placed on FOFA in the West, and how it should be implemented.

"Richard Holmes, "The Psychological Effects of Artillery Fire, " lecture presented to a DRA (Director Royal Artillery) tactical seminar, June 1983. Quoted with permission of the author.

[46]Ibid.

Chapter 5

Objectives for Attacks of Follow-On Forces

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Chapter 5

Objectives for Attacks of Follow-On Forces

STRATEGY

NATO's strategy for attack of follow-on forces is a result of the growth of conventional military power of the Warsaw Pact and of the improved mobility of Warsaw Pact ground forces. At present, one might offer the superficial argument that NATO's forces, though smaller than those of the Warsaw Pact, could probably defend successfully against an attack spread equally across the front. But the implication of this argument is that the Warsaw Pact would attack NATO's strength, when it makes much more military sense to attack NATO where it is weakest. The Warsaw Pact surely would not distribute its attack assets uniformly across the theater. Rather it would use the minimum force sufficient to pin down NATO's defenders, and concentrate its forces to break through NATO's weakest sectors. Once through, the attacking elements and follow-on forces would move rapidly and devastatingly through NATO's rear.[1]

NATO is not likely to increase significantly the size of its forces to meet this threat, or to add a reserve which could be used to counter Warsaw Pact breakthrough operations. Equipping and operating this large force, even if it could be manned, would be enormously expensive. Nearly all of the Allies, including the United States,[2] agree that manpower requirements of even the current forces are considerable. For these and other reasons, the option

Photo credit U S Department of Defense

U.S. 3rd Armored Division in Germany,

of increased numbers of ground forces is not politically open to discussion. '

Another logical approach to the situation is to exploit technology. Simpler, more lethal weapons might be enough to blunt a Soviet offensive. Such new technology might be applied to strengthen the close-in defense forces, but increasing the close-combat capability of every division enough to withstand a Warsaw Pact massed assault could be prohibitively expensive.

Thus, there has been great interest in technologies that would improve NATO capability to impede the Warsaw Pact ability to concentrate forces, or to neutralize them if they do concentrate. As stated recently by NATO's Supreme Allied Commander Europe (SACEUR), General Bernard W. Rogers, "Allied Command Europe can prevent the attacker from maintaining the momentum of his assault by tar-

'The Soviet and Warsaw Pact strategy and posture is discussed in greater detail in ch. 4.

'For example, the Federal Republic of Germany foresees a serious problem of manpower shortages:

> owing to [numerically] weak age groups coming up for induction, the number of young men liable to military service will drop so drastically in the next decade that, beginning in 1994, there will be a deficit of 100,000 men per annum in the *Bundeswehr*'s yearly replenishment requirement of 225,000 conscripts, If no remedial action were taken, the strength of the *Bundeswehr* would decrease [from 495,000] to barely 300,000 by the end of the nineties.

[Source *White Paper 1985- The Situation and the Development of the Federal Armed Forces*, The Federal Minister of Defence (F' RG), June,191985

[3]See also Stanley R. Sloan, *NATO's Future." Towards a New Transatlantic Bargain* (Washington, DC: National Defense University Press, 1985), pp. 139-149 for further discussion of NATO's options.

geting these follow-on forces . . . before they hit our General Defensive Position."[4]

The term "follow-on force" can cover a great many types of force elements, but interest has focused on primary ground combat elements such as tank and motorized rifle[5] regiments and divisions that are not "engaged," or in active combat with NATO forces at the battle area.

[4]Gen. Bernard W. Rogers, "Follow-On Forces Attack (FOFA): Myths and Realities," *NATO Review, No. 6,* December 1984, p. 2. See also vol. 2, app. 5-A, note 2.

[5]Motorized rifle units have a mission and composition generally similar to U.S. Army mechanized infantry units.

"DELAY, DISRUPT, AND DESTROY"

The basic concept of FOFA is to delay, disrupt, and destroy the enemy's follow-on forces before they can be brought to bear effectively against NATO forces.[6] Precise definitions of "delay, disrupt, and destroy" prove a bit elusive under close scrutiny. None of these three terms is defined in a NATO- or DoD-wide publication. "Delay" and "destroy" are defined respectively in Allied Command Europe publications, in terms of slowing down enemy operations and inflicting sufficient damage to render enemy forces ineffective.[7] However, no definition of 'disrupt is given. Further, even in the definition of "delay" there is reference to inflicting damage. Proposed doctrine for the deep battle in defense emphasizes denying the enemy the ability to concentrate combat power against forward divisions by disrupting the tempo of follow-on forces.

It is worth noting that U.S. Air Force and U.S. Army discussions of disrupting enemy follow-on forces emphasize somewhat different effects. Air interdiction is carried out to disrupt the enemy's scheme of operation and control of operations, while Army deep attacks aim to disrupt the tempo of commitment of follow-on forces. Although these Air Force and Army concepts are not inherently contradictory, they are different: the emphasis in the first is on disrupting plans; the emphasis in the second is on disrupting timing.

The objectives of "delay," "disrupt," and "destroy" are perceived as being progressively harder to achieve for a given force. For example, disrupting a division is more difficult than delaying it, and destroying it is harder still. In any case, NATO attacks on Warsaw Pact follow-on forces can only directly cause attrition to elements of a unit or damage to bridges and other such structures or facilities needed by the unit. Whether such damage will cause delay or disruption, or whether such attrition should be considered destruction of the unit as a whole, is open to considerable interpretation.[8]

NATO cannot always guarantee a particular result from its attacks of follow-on forces, even at a given level of damage. "Destruction" is usually defined in terms of the fractions of combat vehicles, personnel, or supplies that must be "killed' in order to render a force element ineffective.[9] "Delay" can be imposed either through obstacles which take the enemy some time to remove, or by damaging necessary equipment. But the enemy's response to the creation of obstacles or damage cannot be controlled by NATO, so it may be difficult to ensure a given amount of delay. For example, a minefield may cause a Soviet column to go around or halt until it is cleared, or it may cause the Soviet commander to decide to "bull through" and accept some damage instead of a delay.

[6]See vol. 2, app. 5-A, note 3 for a more detailed discussion of these terms from a NATO perspective.

[7]See vol. 2, app. 5-A, note 3 for details.

[8]For more detail, vol. 2, app. 5-A, note 4.

[9]The concept of "killing" vehicles is commonly analyzed in U.S. military terms of "firepower kill" and "mobility kill." In the former, a vehicle is damaged so that its weapons cannot be used; in the latter, a vehicle's propulsion capability is destroyed. Both kills can be further elaborated in terms of the time it would take to repair the damage.

The objective of "disruption" is the most elusive of the triad. Disrupting the enemy's plans or timing depends on delaying or destroying critical force elements. Usage appears to imply that disruption often involves undermining unit integrity, for example by degrading some critical element (such as a command post or communication system).

TARGETS: SOVIET DIVISIONS

The attack of follow-on forces focuses on ground combat units that are not yet engaged with NATO forces, but are to join the attack at some time in the future. This section describes the targets presented by the basic combat unit or the division, and outlines some of the ways it can be delayed, disrupted, or destroyed.

The structure of the Soviet combat divisions is described in chapter 4. A division on the move (or halted in an assembly area) consists of vehicles, both "armored combat vehicles" (ACVs)[10] and trucks, clustered in some fashion according to their organization for march. In a recent study, the Institute for Defense Analyses (IDA) has analyzed this typical organization, and concludes that a division on the march normally includes about 55 march units with an average of 60 vehicles each (nominally battalion-sized), and about 15 smaller (company-sized) units.[11] About 25 of the larger march units along with the smaller units contain nearly all of the division's ACVs; the other 30 or so march units are nearly all trucks. The units containing ACVs are about 50 percent ACVs and 50 percent trucks; the overall division is about 30 percent ACVs. These march units are the potential targets for attacks on a follow-on division, both while on the march and while in assembly areas (the grouping of vehicles in assembly areas is much the same as for road march).

As the division moves forward toward commitment to battle, its component regiments go into final assembly areas, or "departure areas." When the regiments leave these areas on their final move to battle, the combat components go first, and much of the support equipment and personnel stay behind. The division rear elements[12] also stay behind. Therefore, as the unit moves to battle, a much higher fraction of its vehicles are ACVs.

Regiments and divisions can be affected by attacks in many possible ways. Damage to vehicles can be catastrophic or repairable. One way of disrupting a division or regiment is to damage specific "critical" elements, especially the command posts (CPs). Damaging the CP (and possibly killing some of the command staff) may seriously disrupt the functioning of the unit, by degrading the decisionmaking, planning, and coordination of activities. On the other hand, given the level of reliance on drill and routine procedures, the "scientific' planning of operations and doctrine,[13] and the inherent momentum of attacking rather than defending, the Warsaw Pact forces may be less disrupted by CP attack than, for example, U.S. forces would be.

Another type of attack that can delay (or possibly disrupt) is to create "chokepoints," which restrict or prevent the forward movement of forces. The most often-discussed chokepoint results from damaging abridge, preferably just before (or as) a unit starts to use it. Bridges across rivers are seen as particularly important, because the river provides a barrier to further movement. The Soviets have planned for this eventuality by procuring extensive tactical bridging equipment for its ground forces, and by pre-positioning replacement bridges in some areas.

[10] The term 'armored combat vehicle' refers to tanks, armored fighting vehicles (AFVs), armored personnel carriers, armored cavalry vehicles, self-propelled artillery, and surface-to-air missile (SAM) launchers.

[11] W.J. Schultis, et al., Follow-On *Force Attack (U)* (Alexandria, VA: Institute for Defense Analyses, Report R-302, draft final version, April 1986), vol. II, p. 11-20, table 11-10.

[12] The division rear includes the combat service support units, such as transport, supply, maintenance, and medical services.

[13] As discussed in ch. 4.

RANGE AND DESIRED MILITARY EFFECTS

The concepts of "delay, disrupt, and destroy, " when applied to the echelons of Warsaw Pact forces, can give objectives for FOFA in terms of range of attack and desired military effects.[14] Taking into account SHAPE objectives and the various enemy echelons to be attacked, FOFA objectives can be grouped into five categories, as shown in table 5-1.

The important features of the target categories are the size of the enemy unit (e.g., regiment, division) and its location in the Warsaw Pact rear (e.g., 30 to 80 kilometers east of the Forward Line of Own Troops, or FLOT). The term "second echelon" is shorthand for both the second echelon of the initially deployed Warsaw Pact forces and all follow-on units of the same size as they move into similar positions. For example, "second echelon regiments of engaged divisions" (category 1) includes both the second echelon regiments of the first echelon division at the beginning of the assault, *and* the regiments of all follow-on divisions as they move into the same range band (5 to 30 kilometers east of the FLOT).

Category 1

In this category, follow-on regiments of engaged divisions would be attacked from just beyond the range of direct-fire weapons,[15] or about 5 kilometers from the FLOT, out to about 30 kilometers, the region of the Fire Support Coordination Line (FSCL).[16] The desired effect of the attacks would be to 'kill' the regiment, that is, damage enough of the regiment combat assets (vehicle, personnel, essential supplies) to render it ineffective.[17] That is not to say that delaying the regiment, particularly at some critical time, may not be a useful objective.

Table 5-1 .—Objectives of Attack of Follow-On Forces

Category	Desired effect	Target echelon	Approximate range (km) (east of FLOT[a])
1	Destroy	2d echelon regiments of engaged divisions	5 to 30
2	Destroy	2d Tactical Echelon (2d echelon divisions of 1st echelon armies)	30 to 80
3.	Disrupt	2d Tactical Echelon	80 to 150
4.	Disrupt/delay	2d Operational Echelon (2d echelon armies of 1st echelon fronts)	150 to 350
5.	Delay	2d Strategic Echelon (2d echelon fronts)	350 to 800

[a]Forward Line of Own Troops

SOURCE Off Ice of Technology Assessment 1987

Category 2

In this category, follow-on divisions of first-echelon armies would be attacked and destroyed while they move on roads from their concentration areas'* (divisional assembly areas) forward and into departure areas (regimental assembly areas). The range of such attacks would begin at the region of the FSCL, about 30 kilometers, and go out to about 80 kilometers, stopping short of the concentration areas. This region would include the departure areas. The objective in this category, like the previous one, is destruction of the enemy force, only here the attack is directed against divisions rather than regiments. These attacks would be well within the area of responsibility of the NATO corps.

Category 3

In this category, follow-on divisions would also be attacked, here with the objective of disrupting or delaying their movements and disrupting the operations of the first echelon armies. The range of such attacks would begin

[14]See vol. 2, app. 5-A, notes 5-7.

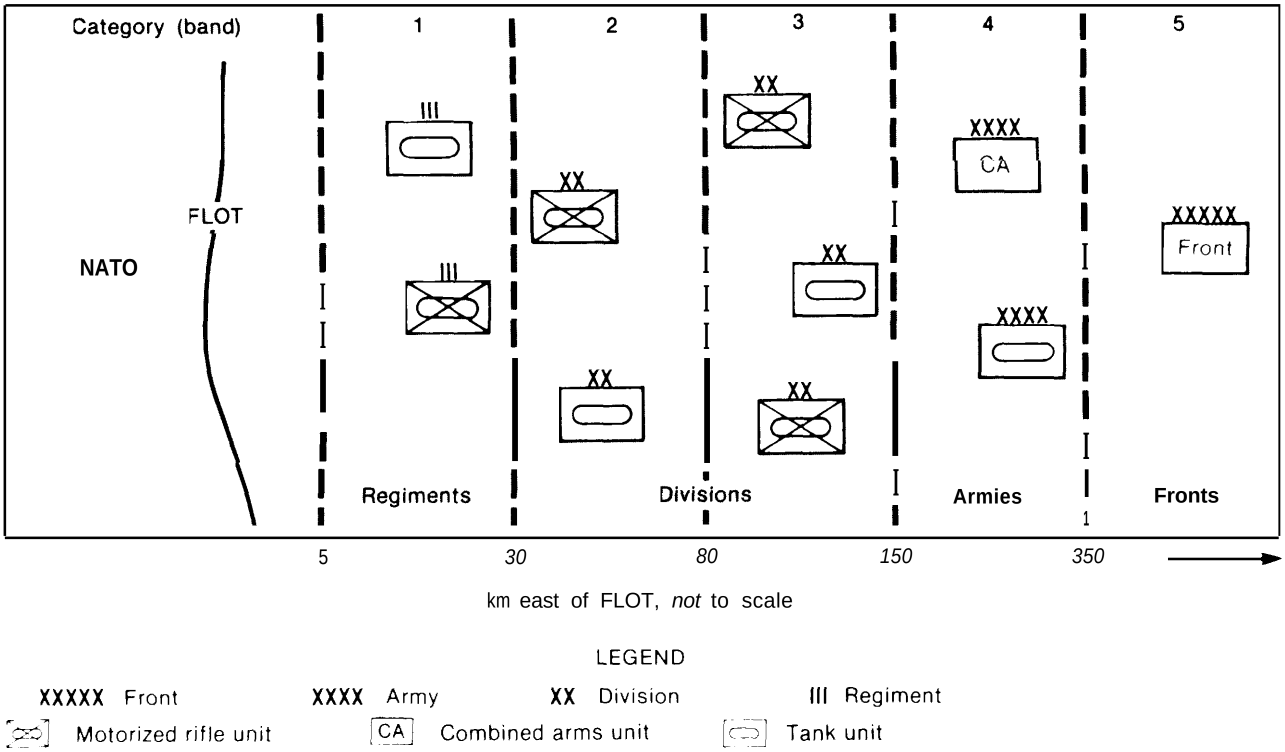
[15]"Direct (or observed) fire weapons include small arms and other infantry weapons, tanks, helicopters, and close air support aircraft under the control of a forward air controller.

[16]The FSCL is established by the ground commander to coordinate air- and ground-based fires against targets closer than the line. It usually corresponds roughly with the range of artillery weapons.

[17]The precise amount of damage that constitutes a kill cannot be established with certainty, but it is certainly less than 100 percent. It relates to the amount of damage that would render a unit incapable of accomplishing its mission, and requiring reconstitution as a new unit. The U.S. Army view of the relevant level of damage is shown in vol. 2, app. 5-A, table 5-A-1.

*Contrary to the appearance of this term, enemy vehicles are likely to be more dispersed in "concentration areas' than when on the road. The term derives from the process of bringing the whole division together in one area at one time, not from any process of increasing the density of vehicles within the area.

Categories of Objectives for FOFA Operations



SOURCE Off Ice, of Technology Assessment 1987

approximately 80 kilometers from the FLOT, and go out to approximately 150 kilometers from the FLOT, the limit of the NATO corps' area of responsibility. This region would include the concentration areas (division assembly areas), which would probably be the farthest forward that Warsaw Pact armored forces would be transported on vehicle carriers. The creation and maintenance of such a barrier could delay the division and perhaps disrupt the division's movements, and disrupt the operations of the army to which the division belongs, by making the division unavailable for its designated mission. Also in this area would be the divisional and army command posts, the attack of which might also disrupt operations.

In considering the desired effect of disruption, it may be that enough delay would accomplish the purpose. The amount of delay sufficient to do so might be the difference between the expected time of arrival of a unit and the expected time of arrival of the next highest echelon, because imposing such a delay would prevent the division from being employed in its usual echelon as planned.[19]

Category 4

In this category, follow-on armies would be attacked in order to disrupt or delay their movement forward. The range of such attacks would begin at about 150 kilometers from the FLOT, beyond the area of responsibility of the corps, and would go back to about 17° east longitude, 300 to 400 kilometers east of the IGB and extending through central Poland. This region would include the Oder and Neisse rivers (at the border between the German Democratic Republic and Poland), which could also be used to create a barrier by attacking the bridges. Units would move into this region

[19]This criterion results in a certain number of days of delay constituting disruption, as discussed in vol. 2, app. 5-A, note 8.

from the east generally by train and off-load onto roads, on which they would travel either on transporters or under their own power.

Category 5

In this category, elements of follow-on *fronts* would be attacked in order to delay their arrival at the main battle. The area of these attacks would range from about 170 east longitude to and perhaps across the Soviet border, which is 600 to 850 kilometers east of the IGB. This region contains the Vistula and Dunajec rivers and the rail transloading areas at the Polish/Soviet border where the rail gauge changes. Movement of forces through this area would be primarily by rail. The amount of delay necessary is not established, but it appears reasonable that a delay similar to that for category 4 attacks would be operationally significant.

Chapter 6

Operational Concepts for Attacks of Follow-On Forces

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Chapter 6

Operational Concepts for Attacks of Follow-On Forces

This chapter discusses those concepts for achieving the objectives presented in chapter 5 that OTA has been able to identify as feasible and under serious consideration by the military. According to DoD, a' 'concept of operations" is defined as:

> A verbal or graphic statement, in broad outline, of a commander's assumptions or intent in regard to an operation or series of operations . . . The concept is designed to give an overall picture of the operation. It is included primarily for additional clarity of purpose. [1]

A concept of operations defines the requirements for systems and organizations. For that reason, a concept of operations can be used as a framework for acquisition strategies to develop, acquire, and deploy equipment (and develop procedures) to provide the needed capability:

> Only with the use of explicit concepts of operations can one provide a basis for the identification of the component parts, whether they be surveillance systems, assessment centers, control centers, delivery systems, weapons, or munitions. [2]

There are many different possible concepts of operations for FOFA, involving various weapons and attack schemes. The discussion below details several approaches for achieving the objectives discussed in chapter 5 and describes the concepts of operations for the approaches that appear feasible. The approaches require certain target acquisition and weapon capabilities, which are discussed subsequently. Some of these target acquisition and weapons needs apparently cannot be met, for reasons given below.

[1]*Department of Defense Dictionary of Military and Associated Terms,* Joint Chiefs of Staff, JCS Pub. 1, 1 June 1979. This document incorporates NATO STANAG 3680, "NATO Glossary of Terms and Definitions for Military Use (AAP-6)."

[2]Lt. Gen. Glenn A. Kent, USAF (Ret.), *Concepts of Operations: A More Coherent Framework for Defense Planning* (Washington, DC: The Rand Corp., Rand Note N-2026-AF, August 1983), pp. 11-12.

APPROACHES FOR FOFA

The categories of FOFA objectives (as defined inch. 5) depend primarily on the echelon of force to be attacked and on the range of the attack. Each objective can be achieved through one or more approaches. These different approaches–summarized in table 6-l–are outlined below in terms of the targets and kinds of attack for each approach.

Category 1—5 to 30 Kilometers

The objective of category 1 FOFA operations is the destruction of second-echelon regiments.[3] The most feasible approach to destroying these targets appears to be to attack them while they are moving on roads on their final approach to battle.[4] These regiments will be moving in battalion columns of approximately 40 to 50 vehicles, with the combat battalions in the lead. There are about eight battalion-sized column targets per regiment. In these columns the fraction of armored combat vehicles is roughly 70 percent. The support elements of the combat regiment are not likely to leave the departure area with the combat elements.

[3]As explained inch. 5, the term "second echelon" denotes both the second echelon of the initial deployment and elements of follow-on forces that are in the same range band and disposition, as the follow-on forces become deployed and engaged.

[4]Details of march considerations for Soviet units on the attack are discussed in U.S. Army Intelligence and Security Command, Soviet *Army Operations* (Arlington, VA: U.S. Army Intelligence and Threat Analysis Center, IAG-13-U-78, April 1978), pp. 3-20 through 3-31. Unit sizes and compositions were discussed in ch. 5 of this report; see in particular table 5-2.

Table 6-1: Summary of Targets and Objectives for FOFA[a]

Targets	Range (kilometers beyond FLOT) 5 to 30	30 to 80	80 to 150	150 to 350	350 to 800
Moving columns	1	1	2		
Units in assembly areas	1	1	2		
Command posts		2	2		
Chokepoints and halted units			2	2	
Units transported on roads				2	
Units in off-loading areas				2	
Units transported on rails					3
Rail network					3

Levels of damage[b]
1 "Destroy"
2 "Disrupt"
3 "Delay"

[a]This choice of objectives for FOFA operations is based on information received from SHAPE, US Army, and US Air Force sources, as discussed in ch 5 This choice of targets and objectives is for OTA analysis only, and *is not* intended *to* be exhaustive or definitive
[b]See ch 5 for discussion of desired levels of damage

SOURCE Office of Technology Assessment, 1987

According to the Institute for Defense Analyses (IDA),[5] each column will be on the road for only about 30 to 60 minutes, and it will take the entire regiment between 1.5 and 2.1 hours to accomplish the move forward. In a single day, a corps facing a Warsaw Pact main attack may see seven such second-echelon regiments moving forward,[6] and their movements may span a total of 9 hours of the day.

The amount of time a target battalion is moving is so brief that it may not be feasible to reattack it. Therefore, individual attacks should be "sized" to destroy a battalion in one attack.

Category 2—30 to 80 Kilometers

The objective of FOFA operations in this category is the destruction of second-echelon divisions. Within this range, divisions will be moving between their division assembly areas (concentration areas) and the departure areas and then occupying the departure areas.[7]

While on the move, the division marches by regiments along two or more roads. The organization for march is illustrated in figure 6-1. Compared to category 1 attacks, a smaller fraction of the vehicles will be armored combat vehicles. Of the 55 or so battalion-sized columns in a division, about 25 will contain armored combat vehicles, and these 25 will average about 50 percent armored vehicles.[8] Overall, about 30 percent of the vehicles in a Soviet combat division are armored. In one day, a NATO corps facing a Warsaw Pact main attack will see a single division moving in this range.

This portion of the division's movement will last about 6 to 8 hours; any one battalion-sized column will take about 1.5 to 3 hours to traverse this distance. Compared to Category 1, there will be more opportunity to attack each target and perhaps opportunity to re-attack.

Another approach to destroying second-echelon divisions is to attack their component regiments in their assembly areas.[9] These areas will be occupied for at least several hours, while the units perform final preparations for battle (including maintenance, supply, and rest). Although the term "assembly area" may give an impression of a concentrated target set, in fact the clusters of vehicles maybe rather dis-

[5]Institute for Defense Analysis, "Follow-On Forces Attack, Volume II: Reconnaissance, Surveillance, and Target Acquisition (RSTA) Architecture To Support FOFA, " IDA Report R-302.
[6]Ibid., pp. II-4 through 11-10. The number of regiments moving per day is derived assuming that the corps faces an initial deployment of three first-echelon divisions plus one follow-on division entering the battle in 24 hours.
[7]For more detail, see vol. 2, app. 6-A, note 2.

[8]*See* ch. *5* for further details, especially table 5-1.
[9]See vol. 2, app. 6-A, note 4 for details.

Photo credit U S Department of Defense

Tanks traveling on West German Autobahn.

persed in a large area. Further, units are likely to take every possible advantage of cover and concealment; wooded areas and urban areas are preferred. However, there may not be enough areas with good cover available to meet the needs of all the units moving through, and those areas that are used may not provide good cover after a few days of combat.

Category 3—80 to 150 Kilometers

At this range, the objective of attacking follow-on forces is limited to disruption. In addition to the types of attacks discussed above, other approaches are also under consideration.

Second-echelon divisions can be attacked directly while they move in this range, and perhaps while in assembly areas.[10] They move on roads, with the tracked vehicles either on transporters ("low-boys' or moving under their own power. Although the moving targets are predominantly the same as in the previous categories, armored combat vehicles on transporters are "cold" (engines off and cool) rather than "hot" (engines on and emitting hot exhaust).[11]

Two other approaches to disrupting second-echelon divisions (and first-echelon armies) are often advanced. In the first, "chokepoints" are created in front of moving Warsaw Pact units, and the units are subsequently attacked while they are halted trying to clear the chokepoint. The other approach is to attack command posts. The classic concept for chokepoint attack is to destroy bridges across a major river just prior to the arrival of an enemy unit. In this range, the Elbe, Saale, and Vltava rivers provide a major north-south barrier. Other possible chokepoints include narrow roads through towns or natural defiles, tunnels, and dikes. The advantage of this approach is that the target division will be halted at the chokepoints, simplifying the problem of target location because targets will not be moving. Further, the density of vehicles (and personnel) will be greater than for either moving units or assembly areas, making area munitions more destructive.

A recent major study considered destruction of the bridges over the Elbe river for a period of up to 10 days as a means for creating a barrier that would delay the introduction of follow-on forces into the battle. The expected impact of these attacks was unclear, and the effort needed to enforce an effective barrier was seen as being potentially very large.[12] This is because the ability of the Warsaw Pact to repair roads and bridges is often quite high, and the Warsaw Pact forces are thought to have large

[10] See vol. 2, app. 6-A, note 5 for further detail.

[11] Whether engines are cold or hot is important to certain kinds of smart anti-armor munitions, because some detect and engage warm targets by the infrared energy they emit. See ch. 11 for further discussion.

[12] Institute for Defense Analysis, "Follow-On Forces Attack, Volume I: Summary, " IDA Report R-302.

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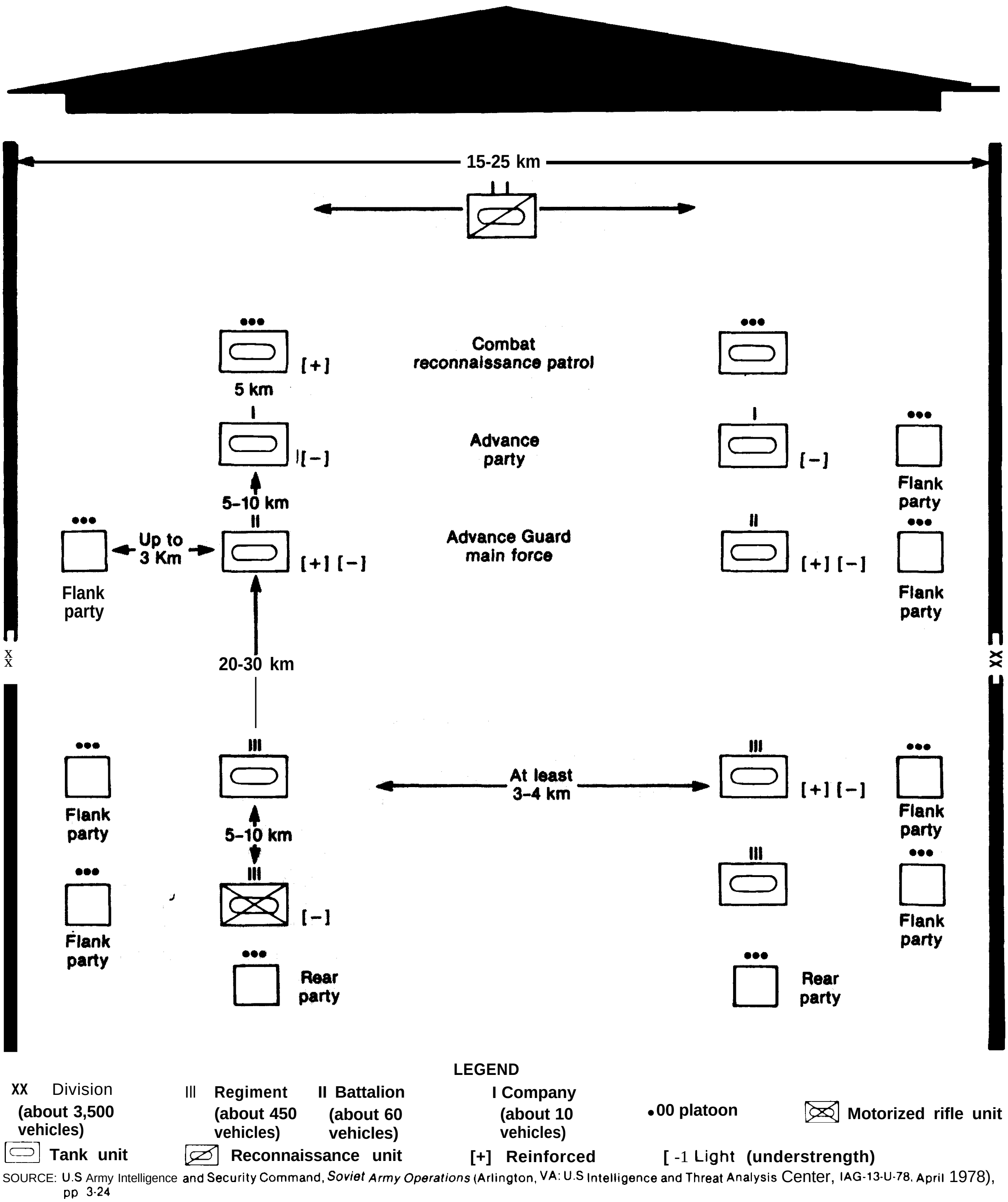
Figure 6-1 .—Typical March Formation, Soviet Tank Division



SOURCE: U.S Army Intelligence and Security Command, *Soviet Army Operations* (Arlington, VA: U.S Intelligence and Threat Analysis Center, IAG-13-U-78, April 1978), pp 3-24 quantities of mobile tactical bridging equipment and stockpiles of temporary bridges at prepared crossing sites. Attacking road bridges may have the same problems, and the dense network of roads in central Europe may often offer alternative routes.

The other approach to disrupting second-echelon divisions (and first-echelon armies) is to attack their command posts. '3 It is likely that a command post can be destroyed if its location is known, but the effect on combat effectiveness of destroying the command post is not clear.[14] Further, the Soviet practice is to have several command posts available at division and army levels, typically a main post, an alternate, and a rear.[15] Thus, it is difficult to predict the effect of destroying one or more command posts in the division.

Category 4—150 to 350 Kilometers

The objective here is to disrupt and delay second-echelon armies. General approaches are attacking units moving on roads, and creating chokepoints and barriers to their further movement forward.

"See vol. 2, app. 6-A, note 8 concerning CP locations and dwell times.

"This relates to the question of tactical flexibility (and rigidity) of Soviet forces, which is discussed in ch. 4.

[15]While moving, there may be additional CPs (e.g., forward). Also, other division command and control centers such as the artillery fire control group might assume the CP function, if necessary.

Photo credit: U.S. Department of Defense

Tanks on transporters.

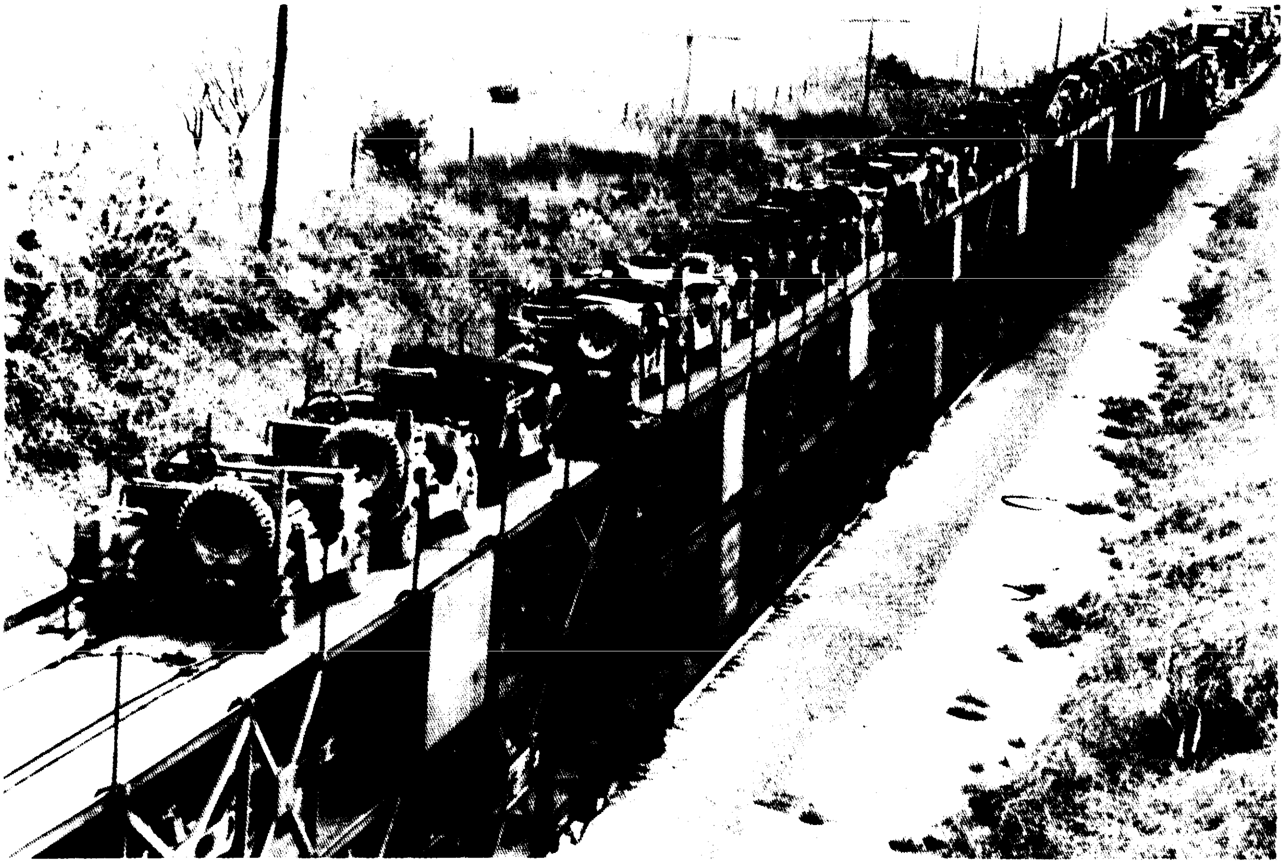


Photo credit U S Department of Defense

Military unit transported by rail.

Divisions of the second-echelon armies will move toward this region from the east on rail, and move onto roads at off-loading areas (OLAs) in this region. From that point they will move forward on roads, with the armored vehicles either on transporters or moving under their own power. The possible targets for direct attack include trucks and armored vehicles in the OLAs, trucks moving forward with armored vehicles on transporters (' 'cold" tanks), and armored vehicles moving under their own power ("hot "). Divisions will be moving with their full combat services support and rear support complement.

Chokepoint attack could take advantage of the Oder and Neisse rivers by attacking road bridges over these rivers. Also, the units halted behind dropped bridges could be attacked directly.[16] For this approach to be effective the bridges must be attacked just as or before the enemy division uses them, and the subsequent attack of forces would have to follow closely. Due to the Warsaw Pact capability to rebuild or replace road bridges, the rivers would have to be under surveillance every 12 to 24 hours to discover new bridges. Pontoon bridges just below the river surface would present a particular problem for surveillance systems.

Category 5—350 to 800 Kilometers

In this deepest region, the objectives of FOFA operations are to delay the second-echelon fronts during the 10 to 20 days after D-day in which the fronts mobilize and move

[16]See vol. 2, app. 6-A, note 9 for additional details.

forward.[17] These units originate in the Soviet Union, and are transported by rail from garrison areas to the theater of battle. Attacks to delay this movement can be targeted against the units themselves, or against the rail transportation system being used.

There are a number of rail bridges across the Vistula river that could be attacked to delay movement. These would also be more difficult to repair than most road bridges, due to the alignment necessary for rail repair and the loads that must be carried by the repaired bridge. Reattack of bridges after 10 to 15 days would allow repairs to be monitored and new bridges identified and targeted. Also, elements of the rail network itself could be attacked with mines that would damage the rails and disable trains when they approached. Because the train would be derailed, a delay of 18 to 24 hours could be expected before the rail line would be clear.[18] The routes for repair trains would themselves be mined, further aggravating the delay. The use of such mines and rail bridge attack could impose substantial delays on rail movements.

Attacks against units on trains in Eastern Europe would be aimed at causing sufficient damage to delay the unit by at least several days. Attacks would be repeated every 3 to 4 days.

As the component Soviet divisions cross from the Soviet Union into Poland and Czechoslovakia, because of the rail gauge change, "transloading" must take place between trains. There are a number of transloading zones at the Soviet border, comprising many yards,[19] whose destruction would inhibit this movement, and which could provide especially valuable targets if attacked while occupied. Other high-value infrastructure targets include the power stations in Poland that provide electricity to the rail system, and the (relatively few) control stations that schedule and coordinate rail movement.

[17] If the Warsaw Pact has a sufficiently long mobilization period prior to war these units may have already moved forward, and this approach could not be effective.

[18] The use of mines against vehicles on roads is not expected to be as effective in damaging forces or delaying movements, due to the substantial mine-clearing equipment of Warsaw Pact forces and the flexibility of road vehicles for bypassing mine areas.

[19] See vol. 2, app. 6-A, note 10 for details.

FUNCTIONAL NEEDS

Several functions must be accomplished in order to implement these approaches, including:

- suppression of enemy air defenses,
- surveillance and reconnaissance,
- situation assessment,
- target acquisition,
- attack control,
- weapon delivery, and
- target kill.

Because some of these tasks are quite difficult to accomplish under longer range conditions, they illustrate the advantages and disadvantages of the approaches discussed above.

Suppression of Enemy Air Defenses

In order to find or attack follow-on forces and survive, NATO tactical aircraft must be supported by effective suppression of enemy air defenses (SEAD). Warsaw Pact air defenses are formidable, particularly in target areas. The use of stand-off weapons could reduce or eliminate attrition of weapon delivery aircraft in the target area, but not en route to the target areas.

Surveillance and Reconnaissance

Surveillance is the routine collection of information for situation assessment, target acquisition, attack control, or cueing of reconnaissance systems. Reconnaissance is the collection of information about specific areas of high interest for situation assessment, target acquisition, or attack control. Either maybe performed by manned or unmanned aircraft equipped with stand-off sensors, by ground-based sensors, by ground forces penetrating enemy territory, and by other means. Most proposals for enhancing Allied Command Europe's (ACE 's) FOFA capability will require current surveillance and reconnaissance capabilities to be enhanced.

A number of systems now in development could contribute to NATO's capability to find and track follow-on units; some are already providing limited operational capabilities. Electronics intelligence (ELINT) sensors such as SENIOR RUBY, TEREC, and PLSS[20] could locate air defense radars.[21] Communications intelligence (COMINT) sensors such as SENIOR SPEAR and GUARDRAIL can monitor radio traffic used to control unit movements. Imagery intelligence (IMINT) sensors such as ASARS-II and AQUILA[22] could provide radar and electro-optical imagery of vehicle clusters stopped in assembly areas. And moving target indication (MTI) radar, such as Joint STARS,[23] could detect vehicle motion and measure vehicle velocity, thereby providing a form of measurement and signature intelligence (MASINT).

Situation Assessment

Fusion (i.e., correlation) of data of several disciplines (e.g., ELINT, COMINT, IMINT, and MTI MASINT) may be required to reliably recognize, track, and count follow-on units. For example, fusion of MTI MASINT and IMINT can help distinguish moving combat units from other traffic.[24] Analysis of the data is required to infer enemy activities and intentions for reliable situation assessment. Failure to fully implement all the enhancements identified by SHAPE[25] would limit, but not eliminate, ACE capability for situation assessment in the 1990s. That is, while all of these systems are desirable and would be useful, the lack or loss of any one of them would not be catastrophic.

Target Acquisition

Additional data beyond that required to detect or recognize a unit is required to "acquire" it as a target-i. e., to locate it with sufficient accuracy and timeliness to attack it effectively. The accuracy required for targeting will depend on target type and disposition (e.g., moving or stopped) and on the types of munitions, weapons, and weapon platforms available for use.

Stationary Targets

Acquiring stationary targets in assembly areas requires some form of high-resolution imagery, such as can be provided by electro-optical, forward-looking infrared, or film cameras, by infrared line scanners, or by synthetic-aperture radar. This information must be available to the attacking weapon when the vehicles are stationary. Targets in assembly areas are expected to dwell there several hours, so timeliness of target location data does not appear to be a critical problem in this case. COMINT data will not usually be sufficient for attack of enemy combat units, because a unit may use communications antennas several kilometers away from itself.

[20] SENIOR RUBY and TEREC are operational systems; PLSS is in development. See ch. 10 for details.

[21] The units could depend on the area air defense radar network for long-range coverage and tactical warning of attack by NATO tactical aircraft.

[22] ASARS I I is in production, with a limited operational capability already fielded; AQUILA is in development. See ch. 10 for details.

[23] Joint STARS is in development; see ch. 10 for details.

[24] "Interspersed throughout the Warsaw Pact rear will be a great deal of military traffic, mostly trucks, re-supplying and otherwise supporting engaged and forward units. Armored elements are expected to comprise only about 10 to 14 percent of military traffic in this area, and an even smaller percentage of total (including civil) traffic.—*Model of Vehicle Activity in the Warsaw Pact Tactical Rear During a Conventional Attack Against NATO* (Santa Monica, CA: The Rand Corp., Rand Note N-1 495-AF, September 1980).

[25] See vol. 2, app. 6-A, note 11 for details.

Moving Targets

An attack on moving combat units requires timeliness on the part of the attacker. Real-time radar coverage could be provided by airborne MTI radar or by electro-optical or forward-looking infrared cameras on unmanned aerial vehicles. Automated data communications systems could provide the links necessary for timely transmission of target location data to the weapons platform. For attacks by tactical aircraft, the target motion during the aircraft's flight must be taken into account, so it may be useful to provide updated target location information to the aircraft. It may also be desirable to provide an in-flight update to an attacking missile, although the missile's flight time is much shorter than that of aircraft.

As an alternative, target acquisition could be provided by systems on board the weapon platform itself. For example, target acquisition radar on board attacking tactical aircraft could provide the final target location data to the weapon launched from the aircraft. This approach has the disadvantage of exposing the attacking aircraft to the target air defenses for the extra time it takes to acquire the target, but allows the attacking platform to operate independently of a separate target acquisition system.

Special Targets

Target locations for permanent bridges can be determined in peacetime. In wartime, temporary bridges may be built to augment these, and damaged bridges will probably be repaired requiring reconnaissance to determine when they are again active. Information on temporary and repaired bridges might be obtained from imagery.

Command posts (CPs) maybe very difficult to detect and identify; there is no known routine, reliable means for targeting them.[26] They are primarily known by their communications (and other) emissions, but these radiate from antennas that may be some distance from the CP itself." The vehicles in a CP are not individually distinguishable from many others in a division, although it is sometimes argued that the vehicles of a CP deploy in unique and identifiable patterns, allowing their location by careful analysis of imagery .28

Deep Targets

Reconnaissance systems held at the national level primarily for strategic reconnaissance missions might be made available to the theater commander, who could task them to support reconnaissance, surveillance, and acquisition (RSTA) needs. These capabilities, if made a sufficiently high priority relative to other missions, could provide a great deal of information about movement in the enemy's rear. In particular, this information could provide cues to general movement activity in given areas, enough to task attack assets which would then acquire targets autonomously. Also, attacks into the two deeper bands could destroy infrastructure targets that support movement but are not moving themselves. Although it may be possible to attack combat units deep in the enemy rear on occasion, these national capabilities are not likely to be able to support an overall FOFA strategy based on this approach.

There is no known system that would provide imagery surveillance of the possible offloading areas (OLAs) with sufficient timeliness to support attacks while they are occupied. Although such an arrangement could be imagined, it is not likely to be an efficient use of national assets to attempt to "catch' enemy units in OLAs. The RSTA needs for this approach are thus apparently prohibitive.

Similarly, creating a chokepoint followed by attack of halted units can be dropped from consideration at this range. Warsaw Pact road bridge repair and replacement capability is sufficient to require reconnaissance of a river every 12 to 24 hours, in order to maintain a barrier. This timeliness is not likely to be met by the national level sensors available. The creation of a barrier for a specific unit, and its

[26]See vol. 2, app. 6-A, note 12 for further discussion.
"See Institute for Defense Analysis, '*Follow-On Forces Attack, Volume I: Summary, " IDA Report R-302, Draft Final, April 1986, p. ES-35.

[28]Examples of command post data are given in "Interdiction Target Set for Analysis, " draft, BDM Corp., BDM W-84-0145-TR.

subsequent attack, is likely to be even less feasible.

The Warsaw Pact rail transportation system could be attacked to delay the movement of Soviet armies, by destroying bridges and mining segments of railroad. Targeting can be accomplished in peacetime. The Warsaw Pact has substantial capability to repair damage, and some revisit of the destroyed rail bridges is necessary to maintain the barrier they provide. Revisit within 5 to 10 days is likely to be sufficient,[29] and national reconnaissance systems are likely to be capable of this mission.

Warsaw Pact units moving through the transportation system can be attacked directly. In this case target acquisition may be provided by systems onboard the platform (aircraft) or the weapon (missile) itself. Such an approach depends on there being a high density of targets, so that each attacking platform or weapon has a high probability of acquiring a target.

Attack Control

Some form of command and control support system is needed to coordinate and control attacks within, between, and across NATO command echelons. For those attacks against targets within the Fire Support Coordination Line (FSCL), close coordination between ground- and air-based attack assets is necessary to ensure coverage of targets without duplication of effort and to avoid damaging NATO aircraft. If a ground-based capability to attack beyond the FSCL is developed, similar coordination will be necessary at greater range.

Many operational concepts also require new attack control capabilities. NATO forces must accomplish quickly the processes of assigning targets to weapons and of providing final target location updates to platforms in order to support attack of moving targets.

Weapon Delivery

The term "platforms," the systems that deliver weapons, includes bombers, some fighters, and transporter-erector-launcher vehicles for ground-based missiles. Free-fall bombs must be released near their targets; glide bombs may be released at a short stand-off range; air-launched missiles may be launched from a greater stand-off. All these require aircraft as weapon delivery platforms. Ground-launched missiles need only be delivered to a launch site and launched.

Target Kill

Killing targets requires weapons, which contain munitions and, in some cases, guidance systems.

Anti-Armor Munitions

Certain munitions embodying "emerging technologies" show promise of much higher lethalities against heavily armored vehicles than current-generation munitions provide. Two such technologies are self-forging fragment technology, which is used in sensor fuzed munitions such as Skeet, and terminally guided shaped-charge technology, which is used in munitions such as the Terminally Guided Warhead (TGW) for the Multiple Launch Rocket System (MLRS).[30] Munitions of either type can be packed as submunitions into dispensers on air-delivered weapons or ground-launched missiles or artillery rounds,[31] each of which might kill several armored vehicles.

Other technologies go along with the advanced kill mechanisms to provide multiple armor kills per weapon. These include dispenser technology, or ways of dispersing submunitions in a controlled fashion such that they give optimal engagement of vehicles in the "footprint" of the weapon. Also important is the sensor technology that makes the submunition "smart," or able to detect and follow moving target vehicles.

[29] Note that the time to repair a rail bridge is substantially longer than the time to repair a road bridge, due to the alignment necessary for the rails and the larger weight of loaded rail cars that the bridge must support.

[30] *See* ch. 11 for further discussion.

[31] Specific munitions and submunitions programs are geared to specific platforms, however.

Weapon Guidance

Ground-launched weapons with dispenser, sensors, and effective submunitions can produce multiple armor kills only if guided (or delivered) with sufficient accuracy to the target location. Even with highly accurate target location data, lack of weapon delivery accuracy can render these weapons ineffective. Missiles must have accurate guidance in order to engage targets at ranges of 100 to 200 kilometers or more. Various guidance technologies are applicable to this problem, including fiber-optic gyroscopes for inertial navigation and miniature Global Positioning System (GPS) receivers for navigation via satellite.

Tactical aircraft can launch weapons at a "stand-off" distance from the target, staying far enough away to avoid the air defenses in the immediate target area, about 20 to 30 kilometers for Soviet regiments and divisions.[32] In this case the weapon must have a propulsion system to get it to the target, as well as a guidance system to keep it on course.

For attacks beyond the range of the theater bombers (Buccaneer, F-1 11, and Tornado), long-range cruise missiles, if developed, could be used. For attacks of rail bridges, an electro-optical scene correlator (such as presently used by Tomahawk missiles) could guide the weapon to the target area, and a laser radar could provide final guidance to achieve the necessary accuracy. For mining rail segments, the missile could use either present terrain comparison (TERCOM) guidance or GPS, coupled with some type of infrared or millimeter wave sensor for detecting the rail lines. For attacks of trains on railroads, a cruise missile would need a capability to navigate to the neighborhood of the rail line, recognize the railroad, and then fly along the rails until it detected a train.[33]

[32]The primary division air defense units are the SA-6, with a nominal range of 30 kilometers, and the SA-8, with a nominal range of 12 kilometers; see U.S. Department of Defense, Soviet *Military Power* (Washington, DC: U.S. Government Printing Office, 5th cd., March 1986). Countermeasures can reduce these effective ranges.

[33]Since the tactical vehicles would be on rail cars and "cold," and perhaps not loaded with ammunition and fuel, munitions that would damage the trucks, personnel, and perhaps light armor may give the greatest effectiveness to such attacks.

OPERATIONAL ISSUES

Sifting through the advantages and disadvantages of different operational concepts is a complex task. There are many different options for constructing operations concepts, with different target types, target dispositions, attack objectives, platforms and weapons, target acquisition systems, and ranges. Table 6-2 lists the various options in each of these areas. The relative advantages and disadvantages of all of these options are discussed below, by way of introduction to those operational concepts that appear to be feasible and that have been determined by OTA to have some serious support in military circles.

Target Type

Tanks present the greatest threat to NATO because of their combination of mobility and firepower, and the emphasis in Soviet military thought on attack with heavy armor." From this perspective they are high-value targets. However, tanks are specifically designed to be highly survivable and resistant to damage.

Light armor includes the other armored combat vehicles, such as armored fighting vehicles, armored personnel carriers, and self-propelled artillery. These pose a substantial threat because they have combat capability.

Trucks contain supplies (primarily ammunition and fuel, which are the most critical supplies for combat capability) and some personnel, and specific support capabilities (e.g., engineer, maintenance, and repair). These are the easiest vehicles to damage because they are not armored, but the damage does not im-

[34] *See* ch. 4

Table 6-2.—Options for FOFA Operations

Target type	tanks, light armor, trucks, selected high-value units, bridges.
Target disposition	fixed, sitting, moving on transporters, moving under own power.
Platform and weapon	artillery, direct attack aircraft, ground-launched ballistic missile, tactical aircraft with short-range standoff weapon, long-range cruise missile (air- or ground-launched).
Target acquisition	on-board systems, external systems.
Range	close-in (5 to 30 km), intermediate (30 to 150 km), long (150 to 800 km).

SOURCE Off Ice of Technology Assessment, 1987.

mediately affect combat capability and may not be felt for several days.

Selected high-value units include command posts (CPs) and surface-to-surface missile (SSM) units.[35] These units, when they can be found, are (usually) priority targets, but it is very difficult to locate and target them. The impact of destroying a CP is not clear. On one hand, the rigidity of Soviet command and control suggests that the unit would be unlikely to exert the initiative of going forward without strong command; on the other hand, the reliance on extensive pre-planning of operations using routine drill procedures suggests a tendency to carry the operation forward without the need for further command decisions.

Different target vehicles require different munitions. Anti-tank munitions may have little capability to kill trucks, because the infrared and millimeter wave signatures (for the engagement sensor to detect) are different for trucks and for tanks, and single holes in trucks are often repairable fairly quickly.[36] "Anti-personnel anti-materiel" (APAM or "dual purpose") munitions are good at putting lots of holes in trucks (primarily tires and radiators) that require more time to repair, but do not damage tanks. Lightly armored vehicles are an intermediate case, somewhat vulnerable to both types of munitions. Bridges usually can be destroyed only by large unitary warheads that are accurately delivered.

Target Disposition

Fixed targets such as bridges generally can be located in peacetime with high precision. Target location errors are low, allowing high weapons effectiveness. However, for the same reasons, these types of targets are hardened, proliferated, or both. For example, temporary bridges and repair segments are stockpiled, and organic repair and tactical bridging capabilities are high in Soviet units.

Sitting targets (e.g., units in assembly areas) are mobile targets that are not moving when attacked. These targets are likely to choose a location that maximizes cover and concealment, but the number of suitable locations is limited.[37] A tree canopy or urban environment may conceal sitting targets from the sensors of smart munitions[38] and provide cover which reduces the effects of A PAM munitions by absorbing blast and fragments. On the other hand, personnel may be dismounted from and unprotected by sitting vehicles and more vulnerable than in other dispositions.

Targets on road or rail transporters are moving targets, so target location data must be updated either by the platform or weapon or provided to the platform or weapon in near-real-time.[39] High-value targets (tanks) are more clustered on transporters (especially rail) than when moving under their own power or sitting, and are arranged in regular arrays that may increase their vulnerability to attacks with particular weapons. But because the vehicles are

[35] SSM units are not necessarily follow-on forces, but they will deploy in the Warsaw Pact rear to reduce their vulnerability. SSMs are not considered in detail in this assessment.

[36] Tank kills often occur because of the spalling of armor inside the vehicle, killing personnel and setting off ammunition or fuel.

[37] See app. 6-A (vol. 2), paragraph 13 for further details.

[38] For example, see Institute for Defense Analysis, Follow-On Forces Attack, Volume III: Weapon Effectiveness and Combat Unit Effectiveness, " IDA Report R-302.

'gin this context, "near-real-time" means that the time delay between target location and weapons delivery does not reduce the accuracy of the weapon so much that its effectiveness is lost. More generally, "near-real-time" means that only electronic data processing and transmission delays are involved in data transmittal, and that no manual action is involved.

Photo credit U S Department of Defense

A portable bridge (this one is American).

not themselves operating, their signatures (especially infrared) will be different and unrecognizable by some smart weapons. Also, armored combat vehicles are probably not loaded with fuel and ammunition, and personnel are not on board, so many weapons may not have the desired effect.

Targets moving under their own power require that target location updates be provided to the weapon, either by on-board sensors or by direct link from some external sensor system, within a few minutes of attack. Armored combat vehicles are also loaded with fuel, ammunition, and crew, which increases munitions effects as does being away from cover (such as trees) that can degrade munitions effects. Finally, if NATO can make enemy movement down roads sufficiently risky that the enemy must go off-road, it will substantially delay movement forward and contribute to FOFA objectives possibly without having to attack them at all.

Platform and Weapon

Artillery now exists, and will certainly continue to be organic to all NATO divisions and corps. Both gun and rocket-launched artillery (e.g., mortars and MLRS) are available. Their range is limited to 25 to 30 kilometers beyond the FLOT. "Tube" artillery can deliver more rounds (or pounds) of ordnance per hour than can missiles or direct-attack aircraft, but has shorter range and cannot relocate quickly.

Direct attack aircraft delivery capability also presently exists and will certainly continue. The bulk of attack aircraft (F-4, F-16) are range-limited to about 150 kilometers east of the Inner German Border (IGB); the remaining aircraft (F-1 11, TORNADO, F-15E) are limited to about 350 kilometers east of IGB. Tactical aircraft (TACAIR) can concentrate firepower almost anywhere across the battle front, and relocate quickly and flexibly. But TACAIR must penetrate into enemy airspace in order to deliver direct attack weapons, and penetration usually requires extensive support (escort fighters, electronic countermeasure pods, stand-off jammers, hunter-killer aircraft, and artillery or other suppressive fires) to reduce attrition, and attrition may still be substantial.

Ground-launched ballistic missile capability does not currently exist.[40] The expected range of the Army Tactical Missile System is 100 to 150 kilometers east of the FLOT, including a setback of the launcher behind the FLOT to increase its survivability. This range would allow some concentration of fires laterally across the front, but from any one corps probably only the adjacent corps could be supported. "Shoot and scoot tactics are required to enable good launcher survivability .41 Competing missions are not defined, except for suppression of enemy air defense (SEAD), but may evolve later.

Tactical aircraft with short-range stand-off weapons is now an option using command-guided weapons. However, after launching such a weapon (e.g., Maverick), the aircraft must remain within line-of-sight of the target while the pilot (or another crew member) guides the weapon to its target. An autonomous air-launched weapon with a range of up to 50 kilometers would allow the attacking aircraft to avoid enemy air defenses in the vicinity of the target, which are likely to be substantial. This stand-off would reduce TACAIR attrition, but penetration is still likely for many FOFA missions.

A new cruise missile or a modified version of an existing U.S. cruise missile could have a range of about 1,200 kilometers with a conventional payload of 800 to 1,000 pounds,[42] and would provide a deep delivery capability without the need for extensive air defense suppression and the risk of attrition of long-range bombers. The weapon would be launched from NATO's rear (whether from the ground or from an aircraft); the launcher would, therefore, have excellent survivability. This weapon would support rapid relocation and concentration of fire nearly any place in the theater. Because of the required range and guidance capabilities, the weapon may be very costly relative to all others, but if retired strategic cruise missiles can be modified for this mission, the cost may be much less.

Long-range conventionally armed cruise missiles, like strategic bombers used for this mission, could raise a problem of confusion in wartime. Their use in the conventional role might appear to be escalator, inducing the enemy to escalate to nuclear weapons. In addition, the development of non-nuclear cruise missiles to be launched from B-52s would raise new problems of definition and scope for certain arms control agreements. Further negotiations concerning these weapons may be necessary.

Target Acquisition

On-board systems are systems with sensors on either direct-attack aircraft, or the weapons, or both. These systems allow an attacking platform and weapon to engage targets independently of any external target acquisition system (or associated communication system), which may fail or be defeated when needed, rendering the mission ineffective. On-board systems are generally the most accurate because the target acquisition system continually tracks the target.

External systems could be used for attack by ground-launched missiles and stand-off aircraft, and could also support direct-attack aircraft. External target acquisition systems could either stand back behind the FLOT using long-range sensors, or observe the enemy from a penetrating unmanned platform. These systems support target engagement from enough distance to allow the weapons platform to avoid terminal area defenses.

[40] The current MLRS launcher capability is planned to support this type of weapon in the Army Tactical Missile System, so launcher capability may be considered as already existing. The Lance weapon system, though it has a nominal conventional role, is not sufficiently accurate to contribute greatly to FOFA operations, and is considered a nuclear asset in this context.

[41] Given the problems perceived by NATO in attempting to target Soviet SS-21 and SS-23 launchers, these tactics are likely to achieve good survivability.

[42] The feasibility of a weapon of this type is discussed inch. 11.

Range

At close-in range (5 to 30 kilometers), a large proportion of the vehicles in target arrays are armored, allowing efficient destruction of the enemy's combat capability. Virtually everything that moves forward from the final assembly area is moving to combat and is a high-value target for attack. Damaging these forces is likely to have a nearly immediate effect on the battlefield. The Warsaw Pact must in general expend resources to bring its forces to the battle area, and attacking at the "last minute" means that the greatest amount of mobilization and transportation effort must be made by the enemy. Other advantages are that the widest variety of RSTA assets can "see" targets at this range with the least obscuration by terrain or vegetation, and the greatest number of weapons are available for attacks at this range (including artillery and stand-off aircraft that need not penetrate).

The primary operational disadvantage is the risk inherent in waiting to attack the enemy forces until they are just about to close with friendly forces. This approach may still allow enemy forces to concentrate with no subsequent chance to attack them before they attack. The regiments may dash forward on this final march, particularly if it is known that NATO has a very effective attack capability in this range.

Intermediate range (30 to 150 kilometers) includes targets that are still heavy in armor, though not as much so as at closer range. A major advantage is that the time and distance available in which to engage moving target units is much greater than for close-in attacks (6 to 8 hours per division v. 1.5 to 2 hours per regiment), relaxing the need for very efficient "conversion" of attack opportunities to actual attacks. A related advantage is that, for attacks to disrupt, there are several types of targets (e.g., CPs, Elbe bridges) that are not prevalent closer in. At these ranges there is still a wide variety of attack assets with sufficient range,[43] and the most powerful RSTA assets (e.g., ASARS, Joint STARS) also have coverage to this depth. However, compared to close range, attacks at these ranges are more costly.

Long-range attacks (150 to 800 kilometers deep) would hit targets that are likely to be high value and concentrated on certain transportation routes. Advantages include the fact that attacks do not need coordination with ground forces, and can force enemy units to posture their moves so as to minimize exposure to possible attack. Disadvantages of attacks at long range are both that the cost is high (in capability, attrition, or weapon cost) and that the effects on the battlefield are the most removed and hardest to predict.

[43] Only artillery drops out relative to closer-in attacks.

OPERATIONAL CONCEPTS FOR FOFA

Only a few of the many possible operational concepts will be described here, chosen so that they illustrate the primary issues without necessarily being exhaustive. These operational concepts are discussed below, in terms of generic systems and the approaches already discussed.[44]

[44] App. 12-A contains a complete list of packages embodying the operational concepts discussed above; ch. 12 discusses some of them in detail.

Artillery Attack of Regiment Columns: Category 1 (5 to 30 km)

The target regiments are probably originally located well before they occupy their final assembly areas. This location process uses several different sources of data, including COMINT and ELINT sensors and MTI radar for location cues, fusion of this data along with cartographic and intelligence preparation of the battlefield (IPB) data to identify assembly areas, and high-resolution SAR imagery for confirmation of the regimental locations.

This fused and confirmed data is sufficient to assign resources to attack the battalion columns of the regiment when they move forward.

Within this range, gun and missile artillery can deliver unguided anti-armor rounds with substantial potential destruction. A capability for artillery to effectively attack moving targets would be new, dependent on a target acquisition system capable of following the targets and a smart anti-armor round. A remotely piloted vehicle (RPV) target acquisition system that was normally dedicated to artillery use could be used for this mission. In this concept the RPV would loiter near the assembly area until the columns started moving, and then follow each column in turn (providing location data) until it was attacked successfully, at which point the RPV would find the next column. The RPV data, which could be MTI radar or E-O imagery, would be provided directly to the artillery fire-direction center. The artillery rounds may each have only a fractional probability of kill of an armored vehicle,[45] but a barrage of many (6 to 12 or more) rounds may provide multiple kills per attack.

The primary advantage of this concept is its use of widely proliferated artillery assets, allowing any NATO corps or division with the requisite target acquisition system and the appropriate ammunition to prosecute these kinds of attacks of follow-on forces. It also does not require close coordination across corps, because each corps would be attacking within its own area with organic assets. This allows a great deal of firepower to be generated. However, the primary disadvantage is closely related: the necessity for proliferating this capability across the whole front, in order to permit defense in all corps sectors. This concept would require distributing firepower, without the capability to concentrate this firepower in the critical areas.

Stand-Off Air Attack of Division Columns: Category 2 (30 to 80 km)

FOFA operations at this depth would attempt to destroy enemy divisions in their movement forward on roads from division assembly areas, or destroy the regiments of the divisions in their final assembly areas.

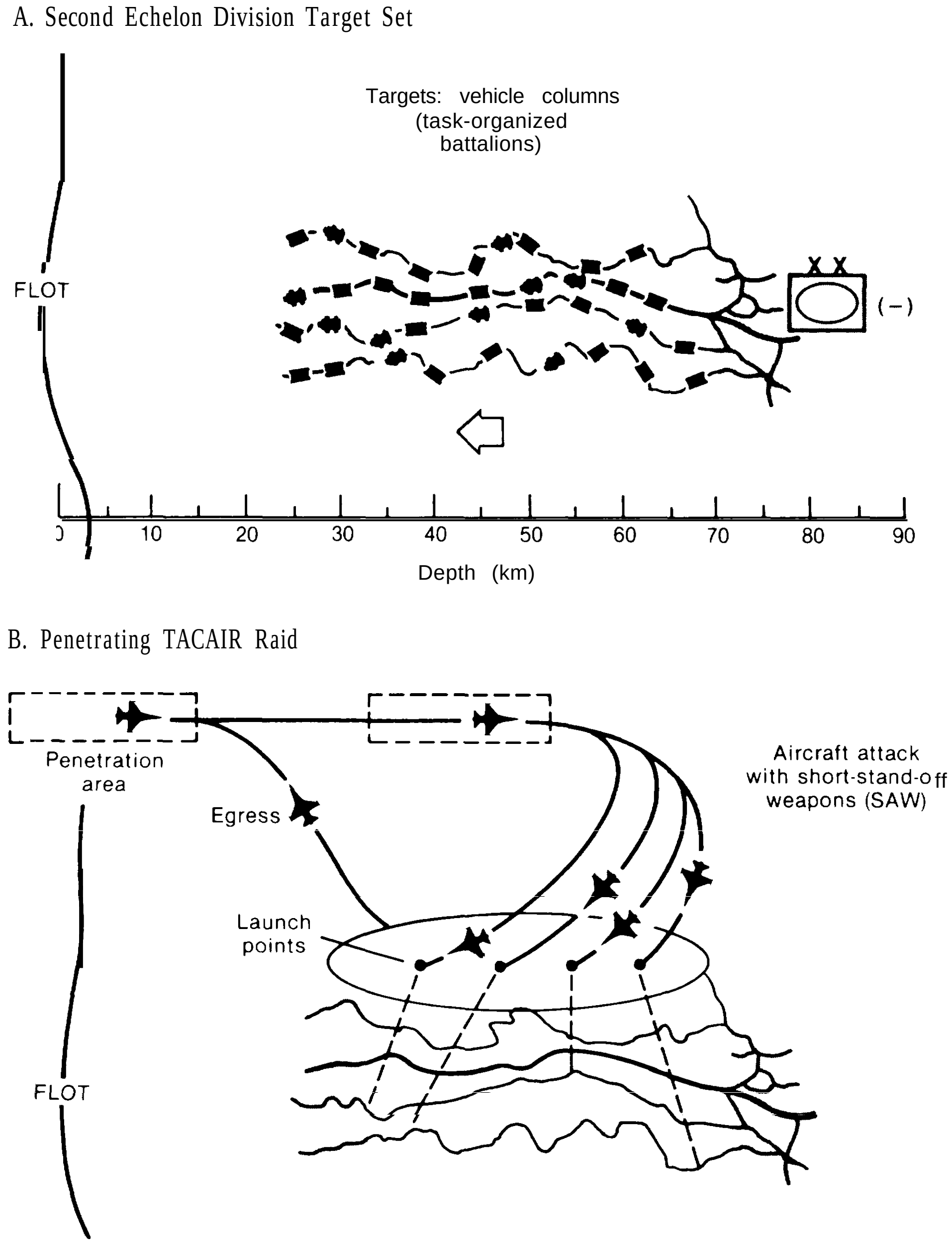
This concept employs RSTA activity cues to initiate an attack and MTI radar target acquisition data for an aircraft to deliver a short-range weapon that dispenses smart anti-armor submunitions. Anti-personnel anti-materiel munitions may also be used, in order to damage the soft and lightly armored vehicles in the division that contain personnel, ammunition, fuel (petroleum, oils, and lubricants, or POL), and other support (e.g., maintenance, communications). A data link from the target acquisition system to the aircraft would update the target location immediately prior to launch of the weapon, which would then use inertial guidance to fly the 25 to 30 kilometers to the target. This concept, illustrated in figure 6-2, would probably use penetration by a relatively large "force package" of 25 to 40 aircraft[46] in a less active area adjacent to the target area, and attack from the side, in order to minimize relative losses. The force package includes 16 to 20 attack aircraft, each delivering 2 weapons against target columns.

This concept has the advantage that the attack aircraft need not fly over the target, and each weapon may be capable of killing several armored vehicles. Indeed, the force package would be able to inflict a great deal of damage in the span of a few minutes on a large portion of a division. The primary disadvantages of this concept are that it requires penetration support, an external target acquisition system, and lengthy, centralized planning.

[45] Laser-guided artillery rounds such as Copperhead, when used with an RPV (e.g., TADARS) that designates targets with a laser, may have a high kill probability against armor.

[46] As discussed in U.S. Congress, Office of Technology Assessment, *Technologies for NATO Follow-On Forces Attack Concept-Special Report, OTA-ISC-312* (Washington, DC: U.S. Government Printing Office, July 1986), pp. 81, 96-97.

Figure 6-2.—Stand-Off Air Attack of Division Columns



SOURCE Institute for Defense Analyses, *Follow-On Force Attack, Volume II Reconnaissance, Surveillance, and Target Acquisition (RSTA) Architecture to Support Follow-On Force Attack,* IDA Report R-302, Draft Final April 1986, pp v-4, V-7

Missile Attack of Division Columns: Category 2 (30 to 80 km)

This concept uses ground-launched missiles to attack the same targets (moving columns of a second-echelon division), also using target location data from the target acquisition radar. This data would be updated via a fire control data system to the missile launcher just prior to launch. A setback of one-third of total range (a typical artillery rule of thumb), implies a minimum missile range of 120 kilometers. A longer range of 150 to 250 kilometers would allow coverage from adjacent corps. The missile would use a high-quality navigation system, and deliver submunitions.

The advantages of this approach are: 1) that no separate support is needed (as it is for penetrating aircraft), 2) the long-range capability allows concentration of fires from adjacent corps, and 3) several armor kills per missile are possible. Disadvantages include the need for cross-corps coordination and the dependence on a separate system for target data.

Air Attack of Chokepoints and Halted Units: Category 3 (80 to 150 km)

Detecting and tracking unit movements is important in this concept. This process would be accomplished by the same mix of RSTA sensors and fusion capabilities used to track units for road and assembly area attacks. The chokepoint target, assumed to be a road bridge at a river or other barrier, is targeted in peacetime and can be attacked without further target location data. High-resolution synthetic aperture radar (SAR) keeps the area behind the chokepoint under surveillance, until bunching of vehicles in the area is observed. This data is reported to an attack control center, which matches targets to attacking aircraft and transmits target location data to the aircraft (which may be forming up or holding on the NATO side of the FLOT preparing to penetrate). A force package of tactical aircraft then attacks with stand-off weapons dispensing APAM munitions to damage the equipment and personnel bunched behind the chokepoint. In addition, mines may be mixed with the APAM munitions, to further disrupt the attacked units and their subsequent attempts to seek cover and repair the damage.

The advantage of this concept is that it may allow the use of munitions in a fairly open area, where they are more effective, against a target area with a high density of vehicles and exposed personnel. Also, stand-off weapons do not require overflight of the target area.

Cruise Missile Attack of Deep Rail Network: Category 5 (350 to 800 km)

Attacks at this depth will attempt to delay enemy movements of follow-on fronts.

Attacks of this type can be tasked as soon as cross-border operations are authorized by NATO. Heavy bombers would fly to the fringes of enemy territory, with minimum exposure, and launch missiles would engage their rail and bridge targets independently. Each missile would navigate to the vicinity of its target (either rail segment or bridge), recognize it, and "engage" it. For bridge attacks this would involve damaging a critical structural member. For rail segment attacks a "stick" of mines would be dispensed, that would embed themselves in the rail bed.[47]

These mines would have a delay before activation, and then actuate (all four at once) at a random time in a given period (say, 3 days). This would mean that the rail segment would suddenly (and uneventfully) become dangerous to a passing train. Were a train to come by, one or more mines would be detonated.

The advantages of this approach include the obviation of wartime target acquisition and the need to penetrate. Risks remain that enemy redeployment of air defenses would impede barrier maintenance, or that during a long mobilization Soviet fronts would deploy so far forward as to render this concept ineffective.

"Perhaps four mines could be carried by each missile, comprising a stick to close one rail segment with high confidence.

Chapter 7
Soviet Responses to FOFA

CONTENTS

Chapter 7
Soviet Responses to FOFA

Soviet writings suggest that FOFA has become an important issue in the U. S. S. R., one that might generate important political and military responses. Soviet planners are clearly concerned about FOFA, both as a strategy for the West, and as a reflection of a new set of NATO capabilities they call reconnaissance ("recce") strike complexes, or RSCs. The Soviets have launched a propaganda campaign, at home and abroad, to counter FOFA and to use the controversy FOFA has generated to drive a wedge into NATO. They have also discussed changes in military operations that could well change the threat that FOFA is responding to.

This chapter examines what the Soviets are now saying about FOFA, what Soviet political and military responses to FOFA may already have been, and what possible responses we might see in the future. It is important to keep in mind, however, that the Soviets view FOFA primarily against the backdrop of a bigger whole, as another piece in the overall U. S./ NATO military strategy. Soviet responses to FOFA, therefore, should be viewed as responses to the whole changing nature of a possible East-West confrontation, and not necessarily just to FOFA per se.

POLITICAL RESPONSES

The Soviet political response to FOFA has been strong since the U.S. Army's adoption of AirLand Battle in 1982 and the approval of FOFA by the NATO Defense Planning Committee in 1984. Although FOFA has not become as big a political issue in the U.S.S.R. as arms control or SDI, the Soviet press, both domestic and foreign, has been replete with articles and statements about the destabilizing effects of FOFA and its dangers for all mankind.

This portrayal addresses several Soviet goals both abroad and at home. Abroad, it allows the Soviets to play on already existing European apprehensions about the feasibility and cost of FOFA and the possible negative impact of FOFA for deterrence and arms control. By so doing, it works toward two ends: to drive a wedge between the United States and Europe; and, by painting the United States as the clear aggressor threatening world peace, to present a more peace-loving image of the U.S.S.R. This "peace offensive" is laced with threats that, should such a clearly offensive and aggressive NATO strategy be adopted, the U.S.S.R. unfortunately would be forced to build yet more military systems in response. Ultimately, the Soviets hope to use these arguments to delay or prevent NATO from acquiring FOFA systems. Within the U. S. S. R., these arguments justify further military buildup as a necessary defensive response to U.S. aggression, and aim to rally domestic support behind the current Soviet leadership.

Thus, the Soviet press consistently depicts FOFA as offensive and aggressive; as representing an attempt by the United States to gain conventional superiority and give NATO forces a "first strike" capability; and as having the potential to lower rather than raise the nuclear threshold by bordering on the capabilities of theater nuclear weapons. As discussed in the Soviet military newspaper Red Star, for example:

> In a word, this weapon [recce strike complex] relates to the offensive with the goal of achieving military superiority over governments of the socialist commonwealth, and securing with military strength a one-sided superiority by the application of sudden strikes and the conduct of protracted military activities.

> The arguments of NATO leaders, that with the application of a new concept they would diminish the danger of nuclear war in Europe, lack any basis and are deliberate lies. As shown by the press, the new forms and systems of common types of weapons . . . approach the destructive potential of low-yield nuclear munitions. Moreover, with the acceptance of these concepts, Pentagon and NATO strategies do not at all reject the possibility of applying nuclear weapons first. Witness the deployment in Europe of American first-strike missiles.[1]

FOFA is also painted as a "provocative escalation, creating a new and expensive arms race:

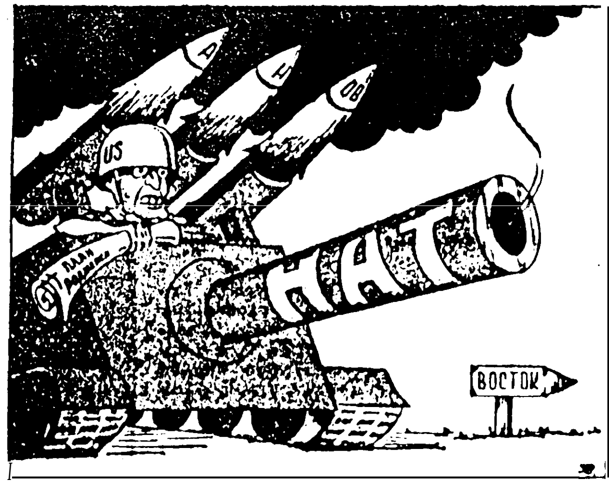
> Hiding behind false references to a "Soviet military threat, " the U.S. administration is initiating a new, dangerous spiral in the arms race, of which the illusory objective is to achieve superiority over the armed forces of the socialist fraternity. This is why the Pentagon foresees creating qualitatively new resources of armed conflict, besides improving nuclear weapons.[2]

It is painted as militarily dangerous and destabilizing, in that the Warsaw Pact would be unable to distinguish between a conventional and nuclear strike and would be forced to respond with a nuclear barrage:

> . . . But the main danger with which the implementation of this concept is fraught for Europe lies somewhere else: It is utterly impossible to tell the difference between cruise missiles with conventional warheads and cruise missiles with nuclear warheads. Therefore, with the approach of these missiles to "second-echelon targets, " the side subjected to an attack will have no other option than to launch a retaliatory nuclear strike necessitating a switchover to automatic well in advance.[3]

And in economic terms, FOFA is painted as clearly American, an attempt by the United

Soviet Cartoon Depiction of the "Rogers Plan"



"They are taking aim ., ."

A caption with the cartoon reads: "In Brussels, the Military Planning Committee of NATO has embraced a new aggressive concept—the so-called 'Rogers Plan'. The plan foresees a strategy of striking deep into the territory of the enemy—i.e., the territory of the socialist countries—in the event of a 'crisis situation '."

SOURCE *Krasnaia Zvezda (Red Star), Nov 13, 19S4,* p 3 Reprinted with permission of the Embassy of the U S S R , Washington, DC

States to manipulate its NATO Allies into being tied not only to a U.S. strategy, but to U.S. technology:

> Europe has been allotted the role of a figure intended to be sacrificed in another project . . . Rogers declares that this [equipping NATO with FOFA weapon systems] will require from the European countries an additional military spending of 30 billion dollars . . . The USA will naturally be the chief purveyor of the new weapons systems.[4]

Ultimately, FOFA is presented as not just militarily destabilizing, but politically counterproductive to the overall East/West relationship. According to Mr. A. Kokoshin, of the USA-Canada Institute in Moscow, "the implementation of the Rogers Plan can undermine all chances for success of the negotiations on the reduction of armed forces and arms in central Europe and seriously hinder a constructive solution to the problem of confidence building measures . . ."[5]

[1] Lt. Col. A. Sergeev, "Pazvedyvatel'no-udarnye kompleksy: Rasskazyvaem po pros'be chitatelei" ("Reconnaissance Strike Complexes: Discussion at the Request of Readers"), *Krasnaia Zvezda*, Feb. 14, 1986, p. 3.

[2] Maj. Gen. M. Belov and Lt. Col. V. Shchukin, "Razvedyvatel'no-porazhaiushchie kompleksy armii S. Sh.A, " ("Reconnaissance-Fire Complexes of the U.S. Army"), *Voennyi Vestnik*, *No.* 1, January 1985, p. 86.

[3] Nikolai Portugalov, "FOFA and Other Atlantic Monsters, " *Moscow News*, Dec. 30, 1984, p. 5.

[4] Ibid.

[5] A. Kokoshin, "The Rogers Plan: Alternative Defense Concepts and Security in Europe, " *Ekonomika, Politika, Ideologiia*, Aug. 13, 1985, pp. 3-14.

MILITARY RESPONSES

Beyond politics, the Soviets view FOFA as presenting real, if not potentially "revolutionary" military challenges. "Such a qualitative leap in the development of conventional weapens, " Marshal Ogarkov writes, "inevitably entails a change in the nature of preparing and conducting operations."[6]

Soviet concerns with FOFA are twofold: the concept itself, and the development of new weapons systems associated with, *but not necessarily restricted to implementing those concepts.* The Soviet press indicates that Soviet responses are also twofold: to modify their tactics and field new weapons to lessen the vulnerability of their follow-on forces to attack—i.e., by increasing the combat power of the first echelon, increasing protection of the rear troops, and focusing more attention in speeding up the command and control process; and to develop the capability to preemptively attack these NATO reconnaissance ("recce") strike complexes, or RSCs.

As a concept, the Soviets are concerned that FOFA will extend the battle into their rear:

> The emergence in the armies of the developed capitalist countries of new, and especially high-precision weapons, is greatly changing the "face" of modern combat by constantly raising the intensity of the fire struggle. Whereas in past wars the predominant place belonged to a close exchange of fire, present conditions have seen a sharp increase in the significance not only of the close exchange of fire, but also of the long-range exchange of fire-that is, simultaneous fire against practically the entire depth of the enemy's combat formation.[7]

One Soviet response might be to increase the combat power of the first echelons by reallocating units from the second to the first echelons, such as by bringing more divisions forward. Indeed, FOFA might well force the Soviets to mobilize earlier and more overtly. If the Soviets were convinced that the West had the capability to attack their forces on roads and/or railroads, it would force the Soviets to choose between surprise and an assured ability to bring their forces forward. Should they decide to bring them forward before the war starts, the West would be provided with a more unambiguous warning of their mobilization and intentions.

Alternatively, the Soviets could attempt to increase the strength of existing units already forward, such as through changes in organization and equipment, or by placing more Soviet (as opposed to East European) divisions up front.[8] According to some Western observers, the Soviets have already been doing the former over the past several years and might well increase their efforts. The U.S.S.R. has had a continuing program to modernize ground forces in Central Europe, apparently adding a new generation of tanks and fielding new artillery, infantry combat vehicles, anti-tank weapons, and close support aircraft and helicopter gunships. Some believe this indicates that the Soviet Union already "has quite significantly downgraded the strategic importance of follow-

[6]Marshal of the Soviet Union N. V. Ogarkov, "Zashchita sotsialisma: opyt istorii i sovremennosti " ("The Defense of Socialism: The Experience of History and the Present Day' '), *Krasnaia Zvezda*, May 9, 1984, pp 2-3.

[7]Maj. Gen. I. Vorob'yev, "Sovremennoe oruzhie i taktika" ("Modem Weapons and Tactics"), *Krasnaia Zvezda*, June 20, 1984, p. 2.

[8]See Boyd D. Sutton, "Deep Attack Concepts and the Defence of Central Europe, " *Survival*, March/April 1984, pp. 64-65.

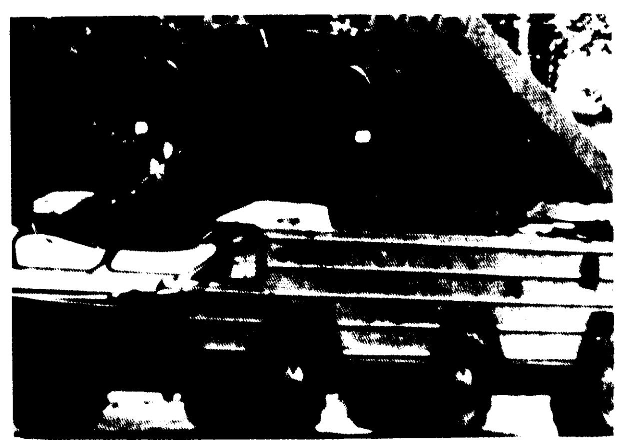


Photo *credit: U S Department of Defense*

Example of a camouflaged military vehicle.

on conventional forces precisely at the moment when some in the West are trying to persuade us that we should divert large resources to attacking them."[9]

In addition, Soviet writings emphasize the need for "significant changes in tactics"[10] and increased protection of forces in the rear through increased air defense and camouflage. Previously, Soviet combat forces moving up in the rear were not in a combat environment. With FOFA, they would have to deal with being in a combat situation possibly from the beginning:

> High-precision weapons considerably increase troop vulnerability and, accordingly, generate increased requirements for ensuring the survivability and reliable protection of units . . . [11]

Soviet doctrine and writings consistently emphasize the importance of maskirovka--a term encompassing the concepts of deception, camouflage, and the masking effects of ground, smoke, dazzling light, etc. Commanders in the rear must devote greater efforts to "the skillful utilization . . . of natural features of the local terrain, the careful preparation of field defenses, the implementation of deception measures, and to misleading the enemy with regard to the unit true location."[12] Likewise, the Soviets may also change timing, spacing, modes of transportation, or build more redun-

[9]Col. Jonathon Alford, "NATO, ET and New Conventional Strategy," *Atlantic Quarterly,* vol. II, No. 4, winter 1984, p. 297.

[10]Major Gen. I. Vorob'yev, op. cit.

[11]Major General 1. Vorob'yev, "Sovremennoe oruzhie i taktika, " op cit.

[12]Ibid.

dancy or mobility into their system. They may well have to operate with troops highly dispersed and camouflaged-as if in a nuclear environment—so as not to present easily destroyable targets, even though operating this way might significantly slow down their rate of advance.[13] And the Soviets continually discuss the need for increased protection of their rear forces through improved air defense and counter-air capabilities.[14]

Soviet writings, however, suggest that the Soviets may be less concerned about FOFA as a concept than they are about the weapons systems themselves, and in particular, the potential ability of quick-reacting and precision-guided weapons to act more quickly than their command and control cycle can respond:

> The introduction of super-accurate self-guiding systems combining recce and strike functions allows for very short times to acquire the target, prepare and fire the weapon, and hit the target. Systems such as Assault Breaker, self-homing and laser-guided, infrared or radio-seeking projectiles coupled with automated artillery fire control systems . . . allow engagement times to be reduced by a factor of 10-15.
>
> The general speeding up of the battlefield has sharply curtailed the time available to commanders and staff for making and implementing decisions. This has made it most important to speed up the collection of intelligence, its analysis, making a decision, giving orders, organizing cooperation and so on. The guidelines of the past are no longer appropriate. In the Great Patriotic War, a regiment and a battalion often had up to 3-4 days to prepare for an offensive—now it is *much* less. [15]

As discussed in chapter 4, the Soviet C* structure was designed according to certain norms, and in such a way that the nature of the process itself would be somewhat adaptive to the time available. But if decision time becomes too short, the Soviets emphasize, the quality of decisions will greatly erode. Perhaps the greatest challenge from FOFA, therefore, is that it cuts down on the time available for decisionmaking, leading to a reduction in cycle time for planning and replanning an operation. This may be viewed as only exacerbating what the Soviets have seen as a long-standing challenge of improving their troop control system so that it can operate within the time available and still allow for sound decisions.

Soviet writings suggest that the Soviets see possible responses to this problem in two directions. The first includes "technical' responses, in terms of further automation of command and control systems. A great deal of effort is being devoted to streamlining and automating C^2 procedures both to speed the pace of decisionmaking and to improve the quality of decisions. In addition, the Soviets have emphasized "operational-tactical" responses, "relating to the methods of work of commanders and staffs, their training and the way they use C^2 means. " This may indicate a rethinking of some of the methods used to make decisions and plan, so that reactions can take place much faster.

Included here is the long-standing problem of initiative. For some time now, the Soviet system has been pulling in two directions. In principle, the Soviet military system requires that a soldier be able to perform simple battlefield tasks in any conditions on the battlefield. These are learned by drill, so that when "initiative' may be asked of soldiers, it is generally restricted to initiating the appropriate drill under whatever circumstances he may find himself.

With the sharp reduction in time which the Soviets see for making and executing these decisions, however, Soviet writings are now reflecting an apparent encouragement of greater initiative at lower levels, for example, for junior officers at the platoon, company, and bat-

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[13]See, for example, Gen. V. G. Reznichenko, *Taktika*, Moscow, 1984, and Michael J. Sterling, *Soviet Reactions to NATO's Emerging Technologies for Deep Attack*, The Rand Corp., N-2294-AF, August 1985.

[14]See, for example, Col. Gen. I. Golushko, "Tyl v usloviiakh primeneniya protivnikom vysokotochnogo oruzhita" ("The Rear Area Under Conditions of the Enemy's Use of High-Precision Weapons"), *Tyl i Snabzheniy, No. 7, 1984,* pp. 13-17.

[15]Maj Gen I. Vorob'yev, "Vremia v boiu " ("Time in Battle"), *Krasnaia Zvezda, Nov. 9, 1985,* p. *2.* According to Vorob'yev, "six to ten minutes are needed for the 'search and destroy' cycle of the RSC Assault Breaker to be performed. This amount of time limits troop operations. Troops must be able to move out from under a strike or use other defensive measures during this short time period. "

talion level. For example, in addition to the concept of "initsiativa"—which suggests selecting the right drill in the right circumstances-two concepts have received renewed emphasis in Soviet parlance: "smekalka," which implies doing something unconventional in those situations where no drill may apply; and "tvorchestvo, " connoting a longer term solution, an imaginative choice of the correct drill.[16]

This not only complicates Soviet planning, but Soviet commanders must also deal with subordinates who are the products of a society where initiative has always been discouraged, if not penalized, and where reluctance to take on responsibility is strong. There will be major social and cultural hurdles to jump over, not only for reconciling the notion of initiative itself with Soviet command and control, but also to effectively imbue their fighting force with fundamentally new attitudes.

Finally, the Soviets are discussing the need to preemptively attack the weapons systems associated with FOFA, or Western recce-strike complexes (RSCs), and allege that they may be forced into developing their own "recce-strike" and "recce-fire" complexes[17] should FOFA be implemented. As Vorob'yev has noted:

> It is believed that the use of high-precision weapons will call for significant changes in tactics. . . . It will be more important to deliver preemptive fire strikes to destroy high-precision weapons systems . . .
>
> Success in a battle being waged with quick-reacting, long-range, high-precision combat complexes demands active reconnaissance in order to detect the enemy's preparations in time to inflict fire attacks, the maintenance of units in constant readiness to repulse the enemy's employment of new weapons systems, and the concealment of measures undertaken in preparation for the battle. It is important to ensure reliable air cover for the units, to undertake protective measures in a timely fashion, and to preempt the enemy in the opening fire to immediately destroy his weapons . . .[18]

As of now, the Soviets are apparently focusing on using existing force elements for these kinds of missions, combining existing reconnaissance assets with target assessment centers and then having a group of weapons "on call" to attack the targets as soon as they are identified. Although apparently less sophisticated than Western efforts, Soviet capabilities in this area would undoubtedly grow as new technology becomes available. Although the Soviets have said that their RSCs area direct response to FOFA, evidence suggests that they are an important part of Soviet military planning as it assesses the overall context of a potential East-West military confrontation.

[16]See, for example, Kh. Grishchenko, "Proiavliaia smekalku i smelost' ("Displaying Native Wit and Boldness' '), *Voennyi Istoricheskie Zhurnal*, February 1986, p. 39.

[17]The Soviets make a distinction between recce-strike and recce-fire complexes. According to Maj. Gen. Belov, "if the strike element annihilates the target by fire (for example with conventional artillery or rockets) the complex is called a reconnaissance-fire complex, while if it does so by a missile strike (tactical and army aviation, tactical and operational tactical missile launchers,) it is called a reconnaissance-strike complex. Therefore reconnaissance-fire complexes are more of a tactical resource while reconnaissance-strike complexes are operational resources. " See Maj Gen A. Belov, op. cit.

[18]Maj. Gen I. Vorob'yev, op. cit.

Chapter 8

European Views on FOFA

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European Views on FOFA

INTRODUCTION

FOFA, when first proposed, appeared to be quite ambitious and evoked considerable skepticism—and some outright opposition—on the part of the European members of NATO. As this report goes to press, the European attitude has become one of cautious support, tempered by concern over funding limitations and a great reluctance to buy U.S. weapons or even U.S. weapons technology. The governments of the Federal Republic of Germany (FRG) and the United Kingdom (U. K.) have taken a cautious approach, emphasizing that FOFA implementation will be slow and incremental; the opposition parties have generally declared themselves against the concept. The smaller nations in the region have generally followed the approach of the German Government.

Clarification and refinement of the initial FOFA concept–particularly to answer European concerns–led to the November 1984 approval of the Long Term Planning Guideline for FOFA by the NATO Defense Planning Committee. While this provided a political-level endorsement by the Allies of FOFA as one of several key mission concepts, commitments did not extend further than to study how FOFA should be implemented. Much skepticism remained among the Europeans regarding its implementation and the priority it should have within NATO's strategy.

Over the past 2 years, the European Allies have come to understand that some of their early objections were based on misunderstandings of FOFA, while military planners at Supreme Headquarters Allied Powers Europe (SHAPE) and in the Pentagon have come to redefine FOFA in ways that are less technically challenging and more in keeping with the common views of the Allies.

The staff at SHAPE has been working to define FOFA in more specific terms as a basis for operational and procurement planning, and discussions have been proceeding in the Conference of National Armaments Directors (CNAD) and other fora to define the systems the nations will procure to support FOFA. As these proceed and interact, there is movement toward a consensus: the individual nations are becoming more supportive of FOFA as a concept, and FOFA is being modified to take into account their concerns and their existing defense programs.

Currently, the ability to attack follow-on forces to great depths remains part of the FOFA concept and a possible long-term goal. In the near term, however, interest has focused on shorter ranges. Agreement is emerging to define systems already in the development pipeline-e. g., artillery enhancement, MLRS and RPVs—as contributions to FOFA, and some progress has been made toward signing agreements for cooperative development and production of other systems such as the modular stand-off weapon. As yet, the United States has obtained no official European interest in what it views as two key systems: Joint STARS and ATACMS, although within some nations there is growing interest.

This chapter reviews the current positions of our Allies and the evolution of those positions, discussing the reasons for their early opposition and why this opposition has so greatly diminished. It provides insights into some of the underlying differences in national interests of the NATO Allies, and into the process by which these differences can be reconciled, given an overriding political commitment to keep NATO working together. In particular, the chapter:

- discusses the positions of the Central Region Allies regarding FOFA;
- presents the principal European views of

FOFA, including those of major opposition parties;

- describes the evolution of European attitudes toward FOFA;
- analyzes the factors that underlie the European positions; and
- identifies ways the United States might gain additional support for FOFA.

CURRENT POSITIONS OF THE ALLIES

In contrast to such issues as Pershing II deployment in Europe, which required the Allies to make sharp and clear choices, FOFA provides ample room for each nation to define its contribution in the way it chooses. FOFA could encompass all systems that reach from just behind the close battle to as far into eastern Europe as possible, and thus could include missions that have previously been considered as traditional close air support and interdiction fire support within NATO. Although the United States has favored an ambitious deep strike effort, the Europeans have a pronounced preference for shorter range systems. Thus, European response to FOFA thus far has been largely a re-labeling of previously planned short-range weapons, sensor systems, and air interdiction improvements as contributions to FOFA, but there also appears to be growing interest in developing and producing more advanced systems.

The process of defining national positions and arriving at a consensus within NATO on major initiatives such as FOFA has traditionally been slow, and may still be in an early stage of evolution in the case of FOFA. The concept was originated by SHAPE and refined by the NATO international staff; it has now passed primarily to the CNAD to work out the means

Photo credit: U.S. Department of Defense

The Multiple Launch Rocket System, which most Central Region Allies plan to buy.

of implementation. The characterization of a European position on FOFA is further complicated because the concept is still undergoing development and revision by its two original supporters, SHAPE and the United States.

Nonetheless, there appear to have been significant shifts in European attitudes over the past year. Despite two major NATO studies that found great merit in the FOFA concept (one conducted by the SHAPE Technical Centre and the other by the NATO Defence Research Group), early 1986 evidenced much skepticism, particularly among the Germans, who argued that FOFA should be no greater than third priority, after the close battle and the air battle. FOFA was seen as a new dimension of warfare, competing with and detracting from the close battle. There was also skepticism regarding the feasibility of the technologies needed to implement FOFA.

More recent indications suggest that the initial strongly skeptical attitude has been changing. The Europeans now appear willing to discuss possible development of FOFA systems with ranges up to 150 kilometers beyond the FLOT, in distinction to their previous position which would limit consideration of FOFA systems to a range of about 30 kilometers. Concern for diverting resources from the first echelon battle, and insistence on setting a relatively low priority for FOFA have become muted. Emphasis is on cost, cost-effectiveness, comparisons of U.S. and European systems, and how to produce the necessary systems. Work is now under way to agree on the systems that would be candidates to fill the various needs that fall under FOFA.

These developments were paralleled during 1986 in the activities of the FOFA II working group, a quasi-official body created by the U.S. Department of Defense (DoD) Defense Science Board to explore strategies for cooperation on FOFA systems with the Allies on a bilateral basis. Participation of European governmental and industrial representatives in the meetings of the FOFA II working group has broadened. It is expected that the working group will be able to offer recommendations on five to seven FOFA-related programs when it reports to NATO in the spring of 1987.

West Germany

The FRG, as the major European contributor to NATO and the country most likely to be affected by FOFA deployments, wields considerable influence on the Allies' views concerning FOFA. While affirming support for FOFA in principle, the FRG has thus far underlined that FOFA ranks behind first echelon defense and counter-air in its military priorities, although the Germans appear to have dropped an effort to get NATO to assign priorities among the key missions.[1] The German Government views FOFA as a supplement or supporting function for the main mission of forward defense and preventing a breakthrough.

This arises, at least in part, from fundamental political considerations: forward defense is a cornerstone of membership in NATO for the FRG with one-third of its population and one-fourth of its industry within 60 miles of the Warsaw Pact. Early German concerns that FOFA was too aggressive for NATO, and that rapid advances by the stronger nations would discourage the weaker nations and put strains on NATO—although still present—appear to be waning.

Nevertheless, Germany is procuring some systems for FOFA, is developing others, and is at least exploring cooperative efforts on still others. The Germans believe that killing deep is more expensive than killing at shorter ranges, and that therefore only a limited FOFA capability will be affordable. This cannot be applied in a "hose" approach, but must rather be related to finding and blunting the "schwerpunkt, " or focus of an attack.

[1] FRG officials have consistently emphasized the first echelon threat in commenting on FOFA. FRG Defense Minister Woerner stated: "It (FOFA) is a concept we support, but there must not be the slightest doubt that stopping the first echelon has first priority for the FRG and the Alliance as a whole, because it would make little sense to fight the second echelon once the first one has reached the Rhine. " Quoted in *Wehrtechnik*, February 1984.

Photo credit Messerschmitt-Bolkow- B/ohm GmbH

West German Tornado aircraft dispensing KB-44 submunitions.

The Bundeswehr is interested in improving 155mm artillery and buying the Multiple Launch Rocket System (MLRS), as well as in improving reconnaissance through the CL289 and other RPVs. For longer ranges, they see ballistic missiles, like ATACMS, as primarily suited to stationary soft targets, and are developing combat drones to attack tanks.[2] For air interdiction, the Luftwaffe wants to upgrade the combat role of the Tornado fighter aircraft, which it produces jointly with the United Kingdom and Italy. The Germans believe that the KB-44 submunition dropped by the Tornado is the best anti-armor submunition currently available. For the future, they are investigating the "vertical ballistic weapon, a sophisticated dispenser for a submunition of greater lethality than the KB-44, and are participating in the Modular Stand-Off Weapon (MSOW) program.

The Germans may be slowly developing an interest in Joint STARS, but they appear to be very cautious about it. Although they recognize the value of continuous broad area surveillance, they see Joint STARS as going beyond the Army's needs (out to 75 kilometers), but not satisfying the Air Force's needs for surveillance out to as much as 500 kilometers.

'The FRG Ministry of Defense has budgeted DM 650 million for reconnaissance RPVs during 1989-97. Antitank combat drones are not budgeted until 1997. See Karl Schnell; "Pilotless Small Air Vehicles for the Army, " *Wehrtechnik*, May 1985.

The FRG position appears to be evolving. Some U.S. observers have linked this to a recently heightened West German concern, frequently enunciated by Defense Minister Manfred Woerner, about the need for defense against the threat posed by Warsaw Pact conventionally armed theater ballistic missiles (TBMs). Although TBM defense could involve a wide variety of active and passive measures outside the scope of FOFA, an important element might be the development of a conventional missile that could strike Warsaw Pact TBM launchers beyond present artillery range. It should be noted, however, that thus far the FRG has not indicated an interest in the development or deployment of such a missile.

The Germans are great believers in cooperative ventures; roughly 70 percent of their capital expenditures are for cooperative programs. However, unlike the British and French, their focus is almost exclusively on systems for use in the Central Region and they tend to shy away from exporting military equipment. Consequently, their defense industries are not nearly as large as the British or French. They believe that successful development programs ought to stimulate technology development among all the partners, but that the partners ought to be on comparable technological levels. They see themselves as being advanced in munitions, delivery sensors, and attack drones.

United Kingdom

While maintaining some reservations about whether the concept and technology can actually be made to work, the British are quite receptive to FOFA. From a pragmatic perspective, however, neither the Army nor the Royal Air Force (RAF) is confident about getting the resources to implement it. Continued economic problems in the United Kingdom will sharply limit Britain's ability to invest in expensive new systems. The U.K. defense budget will likely decline in real terms over the next several years,[3] and heavy commitments for the Trident II program will make it very difficult for the United Kingdom to undertake any major initiative in conventional defense improvements.

Like the other Europeans, the British are planning to improve their artillery and buy the MLRS. Investment in any longer range ground systems would occur farther in the future, if at all. The British are concerned about having the targeting systems to employ even MLRS in their corps sector. Beginning in 1988, they will procure the Phoenix Remotely Piloted Vehicle (RPV) for this purpose. They are developing the ASTOR system and keeping an open mind on the possibility y of a jointly funded Joint STARS for the entire Central Region. For interdiction, the British are planning to improve the BL755 anti-armor cluster weapon and procure an improved Harrier aircraft with longer range. The mainstay of their interdiction capability will remain the Tornado.

The British believe that they have strong defense industries that can contribute to cooperative programs in important ways. However, they point to difficulties of cooperating with the United States, particularly on highly classified (so-called black) programs.

France

Although France is not a member of the NATO integrated command, it exerts considerable influence on European thinking about conventional defense issues. The French have no direct involvement in a SHAPE concept; the French military has expressed some interest, however, in equipping its forces stationed in France and the FRG with deep strike conventional weapons. Budget constraints, however, and a lack of strong interest in such systems by the French armaments industry will serve to limit French options. The French take it as a general principle that their forces should be light and mobile; they are hesitant to burden their ground forces with cumbersome systems for deep attack, and they build small aircraft that are less capable than those of other nations of carrying the larger ordnance loads necessary for FOFA.

In general, the French are not enthusiastic about major conventional defense enhancements in NATO, which they see as diluting the threat of nuclear retaliation on which France bases its defense strategy. The trend, however, is toward greater French interest in participation in NATO's conventional defense, and the French have been active in technological developments. This may reflect recent efforts at improving coordination with the FRG on conventional defense matters as well as the desire of the French armaments industry to keep up with developments that may affect the NATO arms market.

Because France exports about half of its armaments production, it is extremely sensitive to the economic and commercial aspects of U.S. defense initiatives such as the "Emerging Technologies" program, SDI and FOFA, and thus has tended to crystallize European discontent with what is perceived to be an unfair imbalance in U.S. high-technology defense trade with Europe.[4] The recent decline in Middle East oil revenues has sharply affected French arms exports, and has increased French

[3] For 1987, the British defense budget is scheduled to remain flat in cash terms, with a forecast real decline of 3 to 4 percent. See "Pay Up or Cut Up, " The *Economist*, Mar. 29, 1986.

[4] The threat to French industry from FOFA was noted by a leading French journal: ". . . it is impossible to ignore the American pressure to sell this new generation of [FOFA] weapons to its European Allies. The future of the French armaments industry—No. 3 in the world—and hundreds of thousands of French jobs are at stake. " "Can France Defend Herself?" Le *Nouvel Observateur*, January 1984.

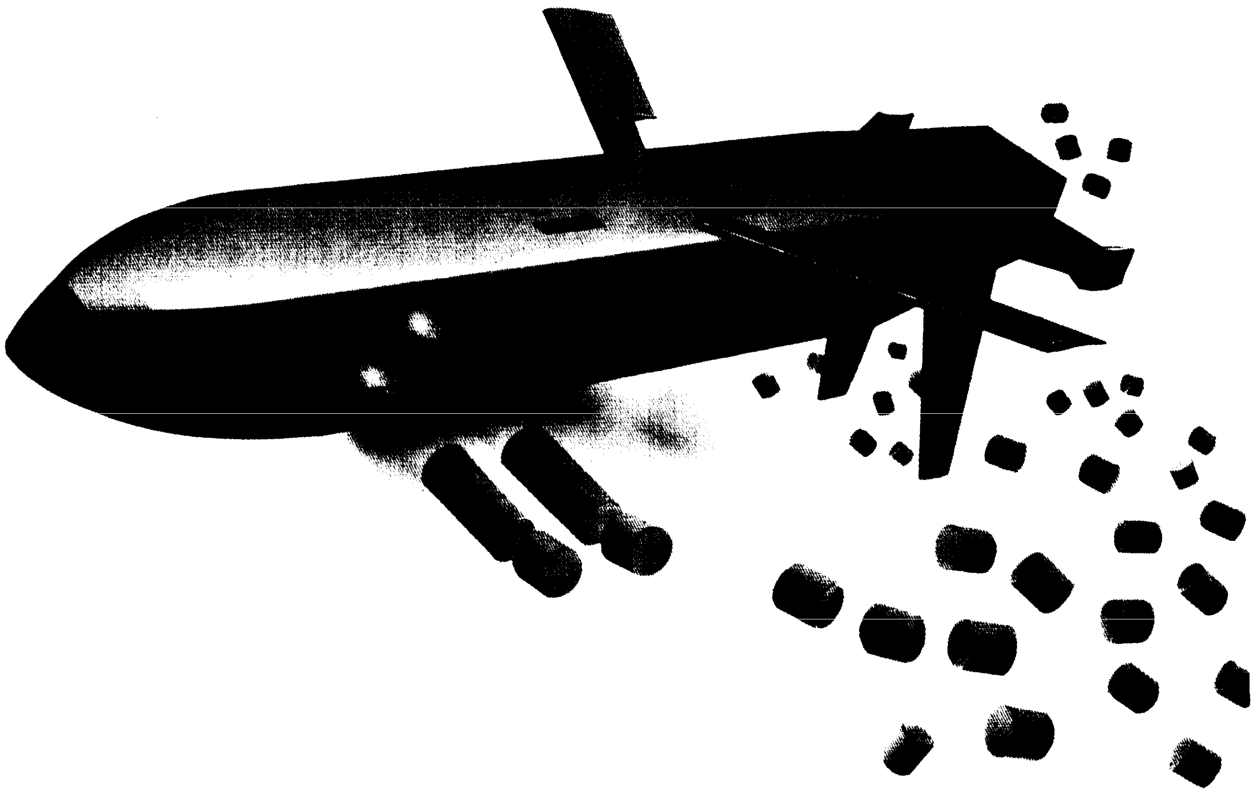

Photo credit: Messerschmitt-Bolkow-Blohm GmbH

Developmental French-German Apache dispensing submunitions.

interest in the NATO market and intra-European cooperative production arrangements, including some short-range FOFA systems. The French are very interested in cooperative ventures, but view them as complex affairs and are skeptical about their potential success. Protection of French cash flow, defense industries, and technology base will all be factors in joining cooperative programs.

The Netherlands

The Dutch fully support FOFA as a key mission concept, but within their own forces, place higher priority on defeat of the lead echelon, air defense, and air support of the Army. They support NATO's current focus on the region within 150 kilometers of the FLOT, but will focus their own efforts on ranges out to about 30 kilometers, and on improvements in the ability of the Royal Netherlands Air Force to perform battlefield air interdiction.

The Royal Netherlands Army believes that greatest effect can be obtained by attacking ground combat units, particular those regiments of the second tactical echelon that are moving to join the battle. These can best be identified when they are 25 to 30 kilometers beyond the FLOT. To satisfy these requirements, they look to improved 155mm artillery, MLRS, and improved RPVs with real-time capabilities. The Dutch are buying MLRS directly from the United States to avoid delays in the European cooperative MLRS program. They believe that the systems necessary for deeper attack are beyond their means, although they might be interested in NATO–as distinct from national-procurement of systems like Joint STARS.

The Dutch have an all F-16 Air Force which they are interested in upgrading with better munitions, self-protection, reconnaissance pods, and equipment to allow them to operate at night. Both the Army and the Air Force are interested in smart anti-armor submunitions.

The Dutch are interested in cooperative programs as preferable to simple purchase of military equipment abroad, but tend to be cautious. They have withdrawn from some programs which did not meet their needs–e.g., the MLRS program because it was too slow, and some air-delivered weapons because they became incompatible with single-seat F-16s. While recognizing the success of the F-16 program, they are uncomfortable with co-production of systems designed elsewhere, because these do not stimulate Dutch technological development.

Belgium

The Belgians have never doubted the soundness of the military principles behind, or the need for, FOFA, but their ability to contribute is limited both by funding and by a problem common among small nations–the inefficiency inherent in a small force maintaining a large variety of systems.

The Belgian Army falls far short of what it believes it needs to defend with high confidence against the lead echelon. Future funding is therefore likely to be directed primarily toward the close battle. Belgium would like to buy the MLRS, but that would be at least 10 years into the future and would require timely RSTA and C^3 that the Belgian corps currently does not have. The Belgians are looking toward improvements to their Epervier drone system, first fielded in 1964, to make it more compatible with MLRS and to programs such as Limited Operational Capability-Europe (LOC-E) and Battlefield Information Collection and Exploitation System (B ICES). Belgium has the conventionally armed Lance missile which, when targeted by Epervier, could be used against soft targets that do not move often (although its accuracy is not high). In considering a replacement for Lance, first priority would be on the nuclear mission. They would be unlikely to buy a conventional tactical missile system, such as ATACMS.

The Air Force is not likely to invest in high-tech, special-purpose weapons anytime soon. They consider themselves to be too small to maintain a variety of weapons and supporting systems. Instead, they will concentrate on general-purpose bombs—including some laser guidance kits—that can be used to support a variety of missions. They see themselves as contributing to delay and disruption, and are willing to accept a large degree of specialization among the various national air forces.

Intra-European Cooperation on FOFA

While FOFA has contributed to intensifying intra-European discussion of independent armaments production, it appears that cost considerations, among other factors, will tend to limit the range of cooperative interest to shallow strike weapons and sensors. The Independent European Programme Group currently lists 31 cooperative projects, only 5 of which have direct FOFA application: RPVs; Surveillance and Target Acquisition; 155mm artillery; Maverick D; and third-generation Anti-Tank Guided Weapons. Most of these systems are for attack at ranges of less than 50 kilometers. Further, intra-European cooperation on weapons production has been hampered due to divergent national interests and priorities. Long-range FOFA systems are not likely to be of priority cooperative interest due to their high cost and specificity to the Central Front threat, which makes them unlikely candidates for export to third countries.[5]

‘The relationship between range, cost and export potential which influence European thinking about FOFA systems production is evidenced in an article by Emile Blanc, then French Delegate General for Armaments:

> What is involved in the case of emerging technologies that are repeatedly mentioned are terminal guidance, microelectronics, highly sensitive sensors and the like. These are relatively difficult to solve, but not unsolvable, As for the danger to ex-

The 1985 Nunn Amendment

In an effort to respond to European industrial concerns, reduce duplication of effort, and improve the climate for U.S./European armaments cooperation, the 1985 Nunn Amendment authorized DoD funding of cooperative research and development projects and side-by-side comparative tests of U.S. and European weapons systems. The appropriation for these purposes for fiscal year 1986 was $145 million, which was increased to $185 million in fiscal year 1987. To qualify for funding, proposals must have at least one European partner. The forum for discussion of Nunn Amendment proposals has been the CNAD, in which national armaments directors may indicate initial interest in participating in a cooperative venture by issuing "statements of intent, which may result in signing of contracts among armaments firms in the interested countries. The first such contracts are expected to be signed in the fall of 1987.

Although the Nunn Amendment was not specifically designed to foster cooperation on FOFA, five of the ten proposals for which "statements of intent" have been issued thus far have a FOFA application. These are:

1. MSOW–Modular Stand-off Weapon (air-launched, short and long range for fixed and moving targets, independent guidance);
2. APGM—155mm Autonomous Precision Guided Munition;
3. ARDS–Air Radar Demonstration System (ground based data systems to demonstrate the interoperability of the U.S. Joint STARS, the French ORCHIDEE and the U.K. ASTOR sensors);
4. NIS–NATO Identification system (Identification Friend or Foe); and
5. BICES–Battlefield Intelligence and Communications Exploitation System (C' I and data fusion)

All except ARDS predated FOFA.

European reaction to the Nunn Amendment initiative has been quite positive but it is not evident that the positions of the Allies in this regard have been influenced much by FOFA. Of the five proposals noted above, only ARDS appears to have directly resulted from NATO's adoption of FOFA as a key mission concept, and here the concern is to ameliorate what may be an undesirable duplication of effort on national sensor systems. European North Atlantic Assembly parliamentarians have commented that none of the agreed proposals would commit the Alliance to a "deep strike" posture.

The United States withdrew a proposal for cooperation on ATACMS because no European partner could be found. There has also been a fair amount of criticism from European academics about the economic and political justification for cooperative projects with the United States, on the grounds that this is a distraction from essential intra-European technology cooperation, and that Europe is in danger of giving away its technology too cheaply to the United States. Thus far the Europeans seem to prefer European-produced systems, even if that eventually means paying more for less capability.

Initial European Reaction to FOFA

The concept of striking behind the enemy's lines to blunt an attack has been a standard part of warfare for centuries and an agreed element of NATO defensive strategy since the founding of the Alliance. Over the years, significant improvements in NATO's ability to accomplish this mission with conventional artillery weapons and air forces—including the capability for deep strike at Warsaw Pact (WP) airfields and other fixed targets-have been introduced as a matter of course. Moreover, the idea of employing NATO's superior technological capacity for producing advanced

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port, I would like to differentiate between medium range and long range types. Medium range types are unlikely to become too expensive. For the long ranges it appears that the technological goals have been set very high, Therefore the whole thing can look expensive.

See, "High Priorities to French-German Arms Development, " *Wehrtechnik*, February 1984.

deep strike weapons and thereby offsetting the WP advantage in ground forces received enthusiastic endorsement from distinguished military experts on both sides of the Atlantic.[6]

Nevertheless, when FOFA was formally introduced for NATO-wide consideration in 1982 —in the form of a SHAPE recommendation to the Defence Planning Committee—the concept aroused considerable controversy among the Allies.[7] The following concerns and objections were noted among the Europeans; we do not know how widespread or strongly held they were:

- The WP first echelon is by far the greatest threat to NATO. In concentrating on the defeat or disruption of the follow-on forces, FOFA sets the wrong priorities and may siphon off resources needed to respond to the more urgent threat.
- FOFA presupposes a deep echeloning of WP forces to achieve overwhelming local force superiority and breakthroughs by standard attrition warfare. However, recently observed developments in WP doctrine suggests a greater emphasis on a first echelon attack, with the creation of Operational Maneuver Groups (OMGs) designed to penetrate quickly into NATO's rear. FOFA also assumes that a WP attack can be repulsed by delaying the arrival of follow-on forces, but observations of WP maneuvers indicate there is considerable slack time planned in the movement of forces, and delays occasioned by FOFA deep strikes can be recouped. FOFA is thus not applicable to NATO's current understanding of the WP threat.[8]
- The FOFA concept, in particular the idea of deep strikes against moving armored targets, relies too much on the development of unproven technologies. Deep strike systems would be costly and vulnerable to WP countermeasures. Even if individual components of FOFA systems could be demonstrated to work under ideal test conditions, there is no guarantee that highly complex FOFA systems would function as supposed in a battle environment.[9]
- The deployment of highly lethal deep attack systems on the Central Front is too aggressive a stance for a defensive alliance such as NATO. Conventional weapons that could reach hundreds of kilometers into eastern Europe are not consonant with NATO's goals, and change the character of the Alliance from defense to that of offense.[10]

[6]The 1983 and 1985 reports of the privately funded European Security Study (ESECS 1 and 2) which figured prominently in the evolution of the FOFA concept had extensive participation of European military experts, including retired Bundeswehr General Franz-Joseph Schulze and retired UK Chief Air Marshal Sir Alistair Steedman. It should be noted, however, that as early as 1983 General Schulze cautioned:

> the strengthening of our conventional deterrence anyway can only be implemented gradually', not only for reasons of limited budgetary funds, established armed forces and armaments plans, available equipment and weapons, but also for reasons of differences in the national interest situation, For the United States, the solutions will possibly look quite different simply because of its obligations outside the NATO area.

Speech to the Clausewitz Society, Hamburg, August 1983.

[7]SACEUR General Bernard Rogers wrote an extensive rebuttal of European criticisms of FOFA: "Follow-on Forces Attack: Myths and Realities, " NATO Review, December 1984. However, the major European objections to FOFA are reiterated in a report of the North Atlantic Assembly, a group of European parliamentarians considered pro-NATO. See *Conventional Defense in Europe: A Comprehensive Evaluation,* NAA Sub-Committee on Conventional Defense in Europe, Karsten Voigt, Rapporteur, December 1985.

[8]One European analyst writes:

> (The WP Operational Maneuver Group) is a means to an end, the end being the rapid collapse of NATO and the limiting of the war to the battlefield, and the means being a surprise attack on a broad front with several axes, I f the offensive is in one operational echelon, NATO's plans for interdiction against a second operational echelon wilf be in vain. There may be no such second echelon within Eastern Europe for several days.

Christopher Donnelly, quoted in NAA *Conventional Defense in Europe,* pg. 25.

[9]Farooq Hussain, Director of Studies at the U.K. Royal United Services Institute for Defense Studies, commented on the application of "emerging technologies" for FOFA:

> . . . vulnerability would considerably reduce the predicted effectiveness of the weapons, requiring that they be bought in large numbers or expensively re-designed to reduce their vulnerability. These considerations would seem to accord FOFA a far lower priority than other conventional defense weapons whose characteristics and costs are more familiar and predictable.

See, "NATO's Conceptual Military Framework, " *Armed Forces,* September 1985.

[10]The charge that FOFA is an aggressive strategy was the rallying point of European leftist criticism during 1984 and early 1985. "Concealed behind the name (FOFA) is the further development of a military doctrine which in the years ahead could saddle the Alliance with a new arms race—thus making the already precarious balance of terror even shakier, opined the West German mass circulation weekly *Der Spiegel, Nov.* 26, 1984.

- The presence of FOFA systems on the Central Front would be destabilizing in a crisis. Faced with a "use or lose" situation, field commanders may be tempted to launch preemptive deep strikes with weapons that may be dual capable. The WP would be unable to distinguish between a conventional FOFA deep strike and a tactical nuclear attack during the time of flight of the initial missiles, and may respond immediately with a nuclear barrage.
- FOFA would set back prospects for arms control. The WP response would be to field a new generation of conventional weapons, for both defense and offense, and fuel a new round of the arms race. It would also be likely to make the Soviets more intransigent on Mutual and Balanced Force Reduction (MBFR) negotiations, and cause them to further front-load the WP forces.
- The basis of NATO's defense is the threat of nuclear retaliation. FOFA is designed to make a conventional defense of Europe more calculable, and thereby signals wrongly to the WP that a conventional attack might not be met with a nuclear response.

To some extent, these and other European objections to FOFA represented differences of expert opinion, and reflected views of some U.S. critics of FOFA.[11] However, there were other more general political and economic factors that may serve to explain the Allies' largely negative reaction during the time the endorsement of FOFA was under consideration in NATO.

The Political Background

During the early 1980s all of the European Allies were deeply embroiled in domestic political debates concerning Intermediate-range Nuclear Forces (INF) deployments. Even strongly pro-NATO governments, such as the Conservatives in the United Kingdom and the Christian Democrats in West Germany, felt the INF issue left little room for maneuver within their political constituencies for major new defense efforts, however meritorious. Associated with the INF issue was the rise—for the first time since the 1950s–of anti-NATO "peace" movements in most European countries as significant political forces. Having lost on the INF issue, some of these political movements, such as the Greens and the left-wing Social Democrats in West Germany, believed they had found a new avenue of attack in FOFA. They were aided in this regard by a commonly held view in Europe that FOFA—while ostensibly an independent SHAPE recommendation to NATO—was in fact of U.S. origin, and closely associated with on-going conventional deep-strike weapons developments of the U.S. Army and Air Force.

Particular emphasis was placed on the alleged relationship between FOFA and the "AirLand Battle" doctrine recently adopted by the U.S. Army.[12] The charge that FOFA was a thinly disguised attempt to impose a new, more aggressive and unpredictable strategy on NATO found considerable resonance in the FRG that for domestic political reasons cannot adhere to a declaratory defense policy which envisages either strategic advances or withdrawals much beyond the inner-German border. The West German opposition parties formally condemned FOFA, and put forward alternative conventional defense concepts, such as small and lightly armored anti-tank units, which they claimed would make NATO physically incapable of aggressive action. These ideas were shared in large measure by the U.K. Labor Party and other European socialist parties.

[11] See, for example, *The New Technologies: Technological Brilliance or Military Folly?* by Steven L. Canby, November 1983.

[12] AirLand Battle was promulgated by the U.S. Army in Field Manual 100-5: *Operations* in 1982. In envisaging the integrated use of chemical, nuclear and conventional forces in "rapid, violent and disorienting" operations, AirLand Battle became a prime target for the European left. The specific charge was that the U. S., through the "Rogers Plan" (i.e., AirLand Battle and FOFA), wants to ready NATO for an attack on the WP in the event of a U. S,-Soviet clash in the third world. See, for example, *Angriff als Verteidigung: Airland Battle, AirLand Battle 2000, Rogers-Plan*, a major study published in 1984 by the West German Greens which focuses on U.S. plans for "lateral escalation."

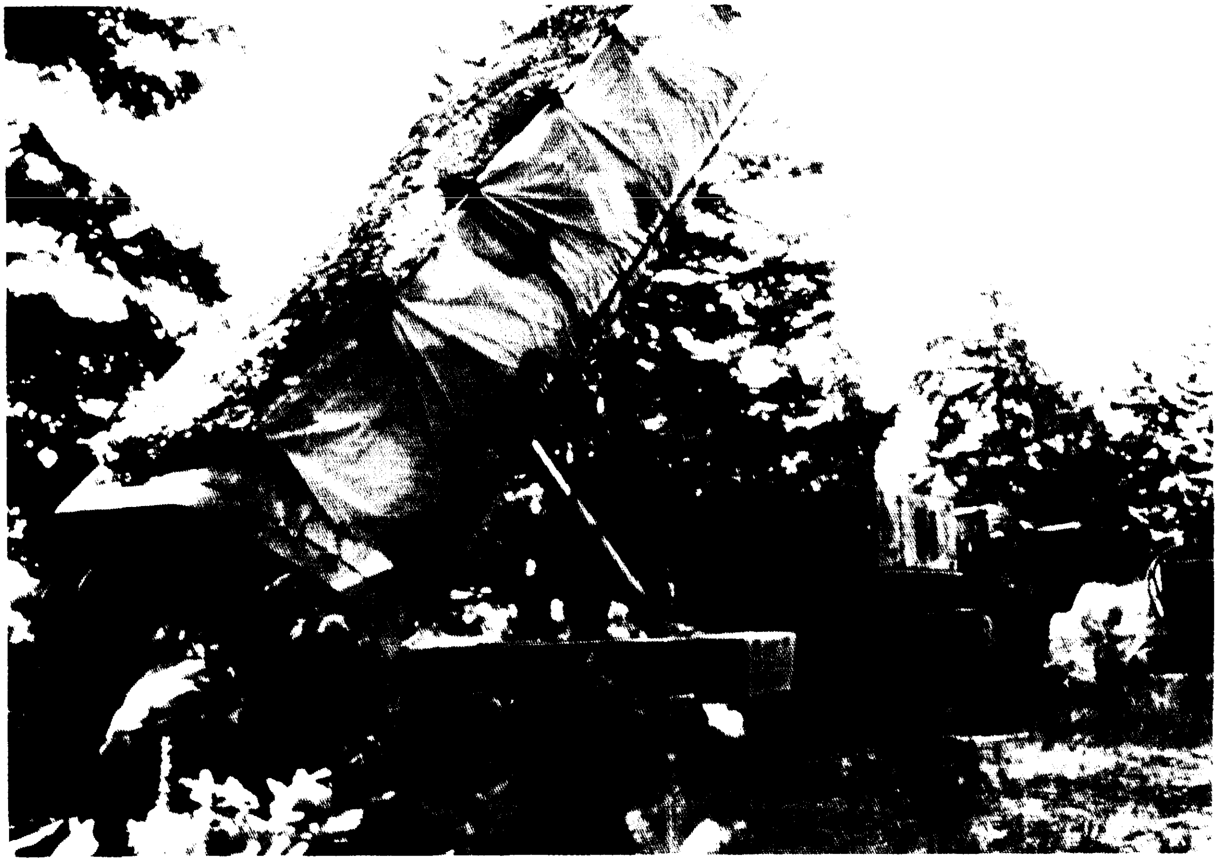

Photo credit: NATO

Protest against deployment in Europe of nuclear weapons, such as the ground-launched cruise missile shown below, formed a backdrop to the initial FOFA debate.

The European left was able to dominate the public discussion of FOFA, due in part to the reluctance of pro-NATO governments to engage in polemics on a NATO issue. In the view of many European political leaders, any publicity about NATO initiatives was undesirable, because it enabled the opposition to draw on latent anti-NATO and anti-American sentiment. For these leaders, what NATO needed most was a period of relative calm. As a new and potentially major departure for NATO, FOFA thus found few political advocates in Europe.

The "Burden Sharing" Issue

A further constraint on European acceptance of FOFA was the ongoing debate with the United States over equitable sharing of NATO's defense costs. Due to continued high unemployment and lagging economic growth, most European Allies felt it increasingly difficult to meet previous defense commitments to NATO. Their 1978 pledges to strive for increases in real defense spending of 3 percent per year had in most cases not been fulfilled. Likewise, none of the conventional force deficiencies identified in the 1978 NATO Long Term Defense Program had been adequately addressed. While the Europeans were unable to meet past obligations, newer studies—largely of U.S. origin-pointed to the need for even greater defense efforts. In addition to FOFA, other ideas–SDI, Emerging Technologies, Counter-Air 90, chemical weapons and the 1984 Nunn-Roth Amendment—appeared as politically difficult and potentially costly new issues.

Faced with what some European parliamentarians called an "acronym avalanche," the Allies were uncertain where FOFA stood in U.S. priorities.[13] The 1984 Nunn-Roth Amendment,[14] while it failed to pass the Senate, sent a strong signal of U.S. displeasure about lagging European conventional defense efforts, but was mainly directed at improving first echelon sustainability. It thus appeared to the Allies that, whatever priority the United States attached to FOFA, increased European spending for FOFA could not be offset by reduced attention to other NATO missions.

Although SACEUR General Rogers and other FOFA advocates initially claimed that FOFA deployment could be covered by an additional 1 percent real increase over the 3 percent spending pledge, a later study by the Defence Research Group (DRG)[15] reached significantly higher estimates: i.e., $40 billion to $50 billion over a 10-year period. Assuming that FOFA implementation would be shared by the Allies in rough proportion to their overall financial contributions to NATO, this would have required the major Allies to achieve between two to three times the rates of defense spending increases they had been able to make in recent years. Initial European reluctance to endorse FOFA can thus be understood, in part, as an unwillingness to make or imply a further financial commitment the Allies would be unable to fulfill, and thereby exacerbate the "burden sharing" issue.[16]

[13] The reaction of many Europeans to U.S. defense activism in 1984 may be reflected in the following quote from a U.K. member of Parliament at the time of the November 1984 Defence Planning Committee meeting: "Governments can't even meet their existing commitments. When you add the cost of SDI to the cost of FOFA and all the other things, it is mind-boggling." Bruce George, rapporteur to the North Atlantic Assembly's Political Committee; cited in *Aviation Week and Space Technology*, Mar. 18, 1985.

[14] The 1984 Nunn-Roth Amendment called for the phased withdrawal of U.S. forces if the European Allies failed to increase their conventional defense efforts to:

1. meet the annual 3 percent real defense expenditure increase,
2. meet the NATO sustainability goal,
3. raise infrastructure funding for aircraft shelters and support facilities for U.S. tactical air reinforcement, and
4. make progress in raising the nuclear threshold.

[15] The Defence Research Group is an advisory body to NATO's Defence Planning Committee. The DRG study of FOFA, *Relative Value of Attack on Follow-on Forces,* was issued July 10, 1985.

[16] Final 1984 NATO statistics indicate that, without the United States, the Alliance failed to meet its 3 percent spending goal, and that in 1985 fewer NATO Allies met this goal than in 1984. *AP Wire,* May 13, 1986.

EVOLUTION OF EUROPEAN ATTITUDES TOWARD FOFA

Despite the Allies' political and economic reservations about FOFA, they had little desire to act divisively on an issue which appeared of high interest to the United States, particularly at a time when the INF debate had taken on the overtones of a test of Alliance solidarity. The 1984 decision by the Defence Planning Committee (DPC) can be seen as something of a compromise solution, in that it provided a general endorsement of the FOFA concept, but without an indication of its priority or a financial commitment regarding its implementation.[17] As an additional precaution, on West German initiative, NATO agreed to undertake simultaneously a Conceptual Military Framework study, to place FOFA in the context of overall NATO defense priorities.

Since the DPC decision, some of the sharp edges have worn off the transatlantic discussion of FOFA. The successful resolution of the INF issue has given European governments some additional political scope to concentrate on other defense priorities, although budgets for most of the Allies continue to remain very tight.

Public pronouncements by NATO headquarters and allied governments have been low key, emphasizing that NATO would concentrate first on the shallow strike systems in which a present capability exists; decisions on deep strike systems—which aroused particular European concerns—could be deferred well into the next decade. The European left, which

[17] During the DPC debate, some of the European allies reportedly insisted that they could endorse FOFA only on the condition that no additional defense spending be required. See. *Aviation Week,* Mar. 18, 1985.

had controlled the public debate on FOFA in 1984, has also markedly abated its criticisms.

Opposition parties have found that FOFA is too complex and abstract an issue to raise much public attention. Moreover, the rise in popularity of many of the "peace" movements was based largely on the scare of nuclear war; to be now perceived as attacking too strongly NATO's conventional alternative would lose the centrist votes they had attracted. The intrusion of SDI and arms control issues have also contributed to keeping FOFA off the front pages.

In contrast to the previous year, the Allies also sensed during 1985 that there was some easing of the U.S. posture on FOFA and other conventional defense issues. European pledges to increase ammunition stocks and infrastructure spending have responded in some measure to U.S. concerns reflected in the 1984 Nunn-Roth Amendment,[18] and have added weight to the European argument that financial limitations will necessitate slow FOFA implementation. Another favorable development lay in the 1985 Nunn Amendment, which provided a financial incentive for greater U.S.-European cooperation on FOFA systems research. FOFA was again routinely endorsed at the May 1985 conference of NATO Defense Ministers, which pledged "special and coordinated efforts to strengthen conventional defense with the means available, but without designation of FOFA as a priority.[19]

The European Allies thus appear comfortable with the present trend. Criticism by the opposition parties has been muted. Allied governments view the on-going studies and consultations within NATO as tending to confirm their preference for concentrating effort on air interdiction, reconnaissance and short-range fire support improvements, which accord with standard NATO conceptions regarding artillery and air interdiction missions, and which were well under way before NATO's endorsement of FOFA.[20] There is also the perception that the United States has scaled back its expectations for FOFA in the light of the Gramm-Rudman spending cap and the present emphasis on SDI. Some European analysts have gone as far as to state that FOFA, as a definable initiative, is already over.[21]

During 1986, the focus of FOFA activity moved "indoors" to expert military fora such as the CNAD ad hoc FOFA working group, the FOFA II working group and the Independent European Program Group (IEPG). Although recent developments within these groups offer some basis for encouragement, it will ultimately be the parliaments of the NATO countries that will decide how, and at what pace, FOFA will be implemented. Whether current political and economic conditions in Europe will permit the type of broad consensus needed for a significant FOFA deployment is still at best questionable.

[18] For example, in May 1985, the Defence Planning Committee pledged $3 billion to construct 665 aircraft shelters by 1990. At the same time, the FRG indicated expenditures for munitions would be 13 percent higher than initially planned for the period 1984-87. See, Reserves, Reinforcements Stressed at NATO Defense Conference; *Suddeutsche Zeitung,* Mar. 18, 1985.

[19] At this meeting, FRG Defense Minister Woerner reportedly emphasized: "special efforts do not mean special programs. *Quoted in Suddeutsche Zeitung,* May 23, 1985.

[20] In early 1986, for example, senior Dutch Ministry of Defense officials indicated in a briefing to OTA staff that NATO's endorsement of FOFA had not at that time affected defense procurement planning in the Netherlands.

[21] "FOFA has lost much of the political attention that was once focused on it to the Strategic Defense Initiative . . The high technology all-conventional defense of Europe is back on the drawing boards. " Farooq Hussain, "Conventional Weapons Have a Long Way to Go, " *New Scientist,* July 18, 1985.

FACTORS UNDERLYING EUROPEAN ATTITUDES TOWARD FOFA

A common view is that European reluctance to go as far or as fast on a conventional defense initiative such as FOFA is due largely to the unwillingness or inability of the Allies to increase their overall defense spending. This is true up to a point, but is hardly the whole story. Although the Allies' ability to raise defense budgets will vary with general economic

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conditions (which at present are not favorable) the divergence of U.S. and European opinion about FOFA also reflects fundamental transatlantic tensions on two key issues in the Alliance: i.e., the degree to which NATO defense should rely on conventional forces, and the role of high technology in force modernization. How these more general issues are resolved will strongly affect the future course of FOFA.

The Role of NATO's Conventional Forces

Since the founding of the Alliance, the linchpin of NATO defense has been the deterrent threat of a U.S. strategic nuclear strike in the event of a WP attack on Europe. During the period in which the United States possessed strategic nuclear superiority over the Soviets, the task of defending Europe through the threat of massive retaliation was relatively straightforward and did not pose an undue economic burden. However, beginning in the 1960s, as the Soviets built up their nuclear forces and attained strategic parity, the situation became considerably more complicated. In the European view, ensuring that the United States remained strategically coupled to the defense of Europe–despite the risk of annihilation of American cities by a Soviet nuclear response—and convincing the Soviets of this coupling became of paramount importance.

In 1967, the Alliance responded to the changed situation by adopting the Flexible Response strategy, based on a triad of forces—conventional, theater nuclear, and strategic nuclear-to deter and frustrate the WP across the broad spectrum of threat scenarios. The continued presence of large numbers of U.S. forces on the Central Front constituted the visible guarantee of the coupling of U.S. strategic deterrence to the defense of Europe. While

Flexible Response does not require NATO to match the WP tank for tank or division for division (which the Allies maintain is not economically or politically possible), the credibility of the strategic deterrent became linked to a robust NATO conventional force posture. The presence of U.S. troops in NATO's conventional force structure is not only to serve as a "nuclear trip wire, " but to aid in deterring an all-conventional WP attack and, if deterrence fails, to ensure NATO's ability to escalate to a nuclear response if necessary.

Since the promulgation of Flexible Response, the question of how much conventional defense is enough has become the source of considerable transatlantic friction. Successive U.S. administrations have urged the Europeans to greater conventional defense efforts to counter the rapid rise in WP conventional force capabilities. The lackluster European reaction has been due, in part, to the greater costs of upgrading conventional rather than nuclear forces, especially when the latter is paid for largely by the United States. However, to a substantial number of Europeans, U.S. pressure for increasing NATO's conventional defenses on the Central Front is perceived as partly motivated by the desire to reduce U.S. nuclear exposure in Europe, by making a conventional war fought solely in Europe more calculable and thinkable.[22]

SACEUR General Rogers, in advocating FOFA, has attempted to bridge the gap between the U.S. and European perceptions by dramatizing that the credibility of nuclear deterrence has been eroded through the WP conventional force build-up.[23] His argument is that FOFA and other conventional force improvements are needed because the ability of NATO to exercise its nuclear option is put in doubt if the WP has the ability to overrun the Central Front in a matter of days. Yet none of the European Allies have publicly seconded General Rogers' assessment, reflecting the generally skeptical reaction to U.S. efforts to gain more public support in Europe for defense increases, such as the DoD annual *Soviet Military Power* and other public reports. Some European defense experts have questioned the factual basis for General Rogers' scenario,[24] while others indicate that U.S. emphasis on the precariousness of NATO's Central Front posture—even if accepted—tends to weaken political support for NATO.[25]

The psychological impact of the issue of the role of conventional defense is most strongly felt in West Germany, in which one-third of the population lives within 100 kilometers of WP forces. To many West Germans, the devastation caused by the outbreak of conventional war on their-soil would be equivalent to defeat, no matter which side technically "wins." The INF issue has so sensitized the West German populace to the nuclear threat that many now believe that any change in NATO's posture somehow increases the

"European fears of the U.S. nuclear decoupling from the defense of Europe has led some Europeans to adopt what they call the doctrine of "conventional insufficiency. " This is based on the assumption that what deters the Soviets is the threat of nuclear destruction of the Soviet homeland, a consequence all out of proportion to what the Soviets could hope to gain by an attack on Europe. Deterrence would actually weaken if NATO conventional forces became too robust, because this would undermine the certainty of a NATO nuclear strike in the event of a WP conventional attack. "In the view of some Europeans, should conventional forces become too strong, deterrence would be undermined as the risks of war become more calculable. " North Atlantic Assembly: *Conventional Defense in Europe,* p. 6.

[23]"If war breaks out today, it would only be a matter of days before I would have to turn to our political authorities and request the initial release of nuclear weapons. " General Rogers, cited in Conventional Defense Improvements; "Where Is the Alliance Going, " James Moray Stewart, *Nato Review,* 1985.

*'See, for example, *Extended Deterrence; implications for Arms Limitation and Reduction,* by Eckhard Lubkemeier, Friedrich Ebert Foundation, Bonn:

> . . . the conventional force balance in Europe is not nearly as bleak as NATO's estimates would have it. For many years now, the International Institute for Strategic Studies has been stating that "there would still appear to be insufficient overall strength on either side to guarantee victory. Given this situation, conventional force improvements are not superfluous undertakings; however, NATO can do without those massive rearmament proposals advanced by SACUER and the ESECS group, entailing spending increases which NATO governments would not be able to sustain anyhow.

"The distinguished British historian, Michael Howard, describes the situation as follows:

> A certain American tendency to hyperbole, an attachment to worst-case analysis and some unfortunate attempts to make our flesh creep with official publications in gorgeous Technicolor whose statistics have been questioned by our defense specialists, have not improved matters. Such propagandistic efforts are widely discounted, and even when they are believed they are likely to engender not so much resolution as despair.

"Deterrence, Consensus and Reassurance in the Defense of Europe; published in *The Domestic Aspects of Western Security,* Christoph Bertram (cd.), IISS, 1983.

chances of war. In addition, the special relationship the FRG has assiduously cultivated with the GDR has considerable influence on attitudes regarding the types of weapons and forces NATO should have that are capable of striking into eastern Europe. These concerns are codified in the doctrine of Forward Defense, which in theory at least envisages that a WP conventional attack could be repulsed at the inner-German border, and that NATO incursions into eastern Europe could be limited to tactical and operational counter-attacks near the border.

FRG official policy tries to achieve a difficult balance between the need to provide declaratory support for FOFA in the interests of Alliance solidarity, and the requirement to affirm Forward Defense for domestic consumption." U.S. actions that might upset the delicate balance required by the politics of Forward Defense would likely be met with resistance. A senior Bundeswehr General indicated, for example, that the FRG would reject the unilateral deployment of deep strike FOFA systems in the U.S. sectors, on the grounds that this would demoralize the Allies in the sectors that were less well-equipped, and would tend to funnel a WP attack into these weaker sectors." This argument, which ignores the already great imbalances among the Central Front corps and the cross-corps support role FOFA might serve, maybe judged on its own merits. It is, however, indicative of the difference in U.S. and West German expectations regarding conventional force improvements.

High Technology and NATO Defense

The balance of NATO's nuclear and conventional forces is largely the concern of military experts and academics; of much more immediate concern to allied governments is the relationship between NATO defense, employment, high technology, and national economic advantage. The Europeans seem to have, in general, less enthusiasm than the United States about the potential for high technology to correct NATO's deficiencies. In the broadest sense, this may reflect the more pervasive view in Europe that high-technology "fixes" seldom work as advertised, and almost always cost more than planned. Contributing to this difference in expectations is the European view that advanced U.S. systems are frequently developed and tested under ideal conditions, such as the U.S. desert, which would bear little relationship to a warfighting situation on the Central Front.

For most of the past decade, the Europeans have been troubled by high unemployment rates and sluggish economic growth, coupled with the perception that European high technology is falling rapidly behind that of Japan and the United States.[28] It has also been a period of increasing transatlantic disputes over general trade issues and the economic aspects of NATO defense, including 'burden sharing, sanctions and export trade controls. The extraordinary sensitivity of European governments to U.S. influence in the defense sector was demonstrated in 1985 by the near collapse of the Thatcher government over the proposed purchase of the Westland helicopter company by a U.S. firm. In this environment, suspicion of U.S. defense policies and initiatives runs high.

[26]The compatibility of AirLand Battle and FOFA deep strikes with the doctrine of Forward Defense seems to trouble the FRG military. The difficulties in presentation can be discerned in the FRG 1985 Ministry of Defense White Paper:

> In the future, other long-range conventional weapons will be available to the Alliance, permitting effective operations against the Warsaw Pact follow-on forces before they can join the battle once the WP attack gets started. These operations have nothing to do with offensive operations. (p. 29)
>
> . . . the Bundeswehr and the allied forces are not equipped, organized, trained or prepared for a strategic offensive in the Central Region. (p. 79)
>
> AirLand Battle . . . is only applicable in Europe in so far as it is reconcilable with the underlying principles of NATO defense. There can be no question of any intention of the U.S. to revise the principles of NATO strategy by national operational doctrines. (p. 30)

[27]1n a 1986 briefing to OTA staff.

[28]European perceptions of U.S. high-technology dominance appear to be considerably exaggerated. In 1955, for example, the U.S. export share of the world high-technology market was 35 percent. In 1980, the U.S. share dropped to 18 percent, while the combined shares of the FRG and France alone accounted for 30 percent of world high-technology export trade. See *Science Indicators*, The National Science Board, 1983, p. 23. As of 1986, the United States became a net importer of high technology.

For example, in February, 1986 the European Parliament voted a unanimous resolution rebuking the United States for alleged manipulation of COCOM trade controls to obtain commercial economic advantage.[29] Recent U.S. defense initiatives such as FOFA, SDI, and Emerging Technologies have been perceived as threatening the European technology base (in part by luring away engineers) and costing jobs, and have resulted in calls for greater intra-European armaments development cooperation and demands that the United States reduce alleged protectionist practices.[30]

There is also a widespread belief that the United States enjoys a very large defense trade balance, on the order of 10 to 1, while U.S. claims that the difference in the "two-way street" has grown much narrower in recent years have not been received with much credence.[31] U.S. overtures to allay European concerns, such as funding SD I research contracts in Europe and the 1985 Nunn Amendment, have been criticized by some Europeans as attempts to obtain European expertise at bargain prices and interfere with the development of intra-European high-technology cooperation.

The sensitivities of European governments to high-technology defense issues have tended to dampen the desire for the introduction of advanced armaments in European military circles. European military leaders are acutely aware that national economic policies make it risky to request the procurement of foreign-produced, high-technology systems, particularly because the long-term outlook for static defense budgets implies that expensive new procurements would divert funds from current military readiness. This situation may serve to reinforce an intrinsic conservatism in European military circles about the deployment of advanced armaments.[32]

'The European Parliament resolution states that U.S. unilateral defense related export controls:

> . . can only be assumed to be intended to restrict Western Europe's access to American technology on normal commercial terms and is contrary to good neighborly policy among allies . A common view in Europe is that U.S. provisions which exceed those agreed by COCOM are in part motivated by general national commercial practices emanating form political rather than business circles.

Quoted in *Journal of Commerce,* Feb. 24, 1986.

[30]Francois de Rose, a former French representative to the Atlantic Council and an advocate of stronger European conventional defense, stated:

> It is obviously inconceivable that a modernization effort would be limited to Europe's purchasing massive quantities of American weapons incorporating new technologies . The United States should thus face this problem at both the governmental (Administration and Congress) and industrial levels with a breadth of vision we are unaccustomed to in this area.

Politique International, summer 1984.

[31]See, "Two Way Street Balance Falls to 2:1, Most Equitable Ratio Ever, " *Armed Forces Journal International,* April 1986.

"In an article which pleads for more competitive European buying of weapons as a means to reduce costs, an influential European journal nevertheless concludes:

> Politically astute generals and admirals know the money saved would probably not come to them: they might not get even as much as they do now, It is one thing to ask for a ship to be built in a national shipyard. It is quite another to ask for one to be built abroad, never mind that it might be better and cheaper. That is why they tend to cling to the do-it-at-home approach.

"Cheaper Weapons: Europe Does It the Second Best Way, " *The Economist,* June 21, 1986.

OPTIONS FOR CULTIVATING ADDITIONAL EUROPEAN SUPPORT FOR FOFA

SACEUR General Rogers and other U.S. military leaders are well aware of European reservations about FOFA and a number of useful remedial steps already have been taken. In addition, the following options for further stimulating European support for FOFA have been suggested. If the U.S. Congress believes that the United States should try to stimulate greater European support, it might want to consider some or all of them.

Clarify the U.S. Priority for FOFA

The Europeans profess to some confusion as to where FOFA stands in U.S. military priorities. They note, among other signals, the first echelon priority signaled by the 1984 Nunn Amendment, and question how FOFA will compete with SDI for scarce U.S. R&D funds under the Gramm-Rudman spending cap. Some also seem to believe that FOFA may be a "pet project" of SACEUR General Rogers, and that U.S. attention may wane under his successor. The United States should again clearly state its intentions regarding FOFA and, to respond to specific European objections and concerns, indicate the relative importance it attaches to shallow strike (i.e., up to 50 kilometers) versus deep strike systems. To avoid making FOFA a public issue again, U.S. views should be communicated largely through nonpublic NATO channels, such as the Conceptual Military Framework study.

Set Realistic Funding and Deployment Goals

Currently available studies of FOFA, such as ESECS and DRG, estimate costs for full FOFA deployment at between $20 billion and $50 billion over a 10-year period. Some critics claim these figures are gross underestimations. But even if they were accepted, it is unrealistic to expect the Allies to cover their proportionate share of the cost through increased defense spending at a time when European defense budgets are static or heading downwards. If trade-offs are acceptable, the United States should specify what other NATO missions could take a lesser priority to balance increased European spending for FOFA. The 10-year deployment goal, including systems that are now in the research phase, seems too optimistic in light of NATO's national R&D planning cycles and its track record on force modernization. It might be useful at first to narrow the focus to a few shallow strike weapons and sensor systems—such as improved MLRS and RPVs–which are relatively inexpensive and are at or close to the production stage, and which would not require complex data fusion systems. A demonstration that FOFA is effective at the shallow ranges, and with systems that could be produced in Europe, could boost allied support for the more ambitious FOFA goals.

Present FOFA in a More Positive Light

The major argument for FOFA by the United States and SACEUR until now has been that it is needed to raise the nuclear threshold to preserve the deterrent credibility of NATO's triad of conventional, theater nuclear, and strategic nuclear forces. However necessary this appears to military strategists, the prospect of spending large sums of money merely to stave off the collapse of the Central Front for a few more days is not a strong selling point from the European perspective. A more appealing approach might be to link FOFA to crisis stability and deterrence.

A major question mark for NATO has always been the length of time which the Warsaw Pact would need for mobilization before launching an attack: while obviously the Soviet commanders would need at least a few days for mobilization and would prefer a few weeks, short Pact mobilization might well make it difficult for NATO to decide upon and implement its own mobilization before the attack commenced. Furthermore, longer Pact mobilization would provide time for NATO to demonstrate its resolve (by counter-mobilization) and then negotiate a satisfactory settlement of the crisis.

A strong NATO FOFA capability would call into question the ability of the Soviets to bring their forces forward after a war had started, and therefore increase their need for pre-attack mobilization. FOFA can therefore be seen as a means of deterring the Soviets from rushing to attack before NATO is ready. Increasing deterrence and negotiating time in a crisis is a far more popular objective in Europe than increasing NATO's staying power in a conventional war.

FOFA might also usefully be linked in the future to negotiations for withdrawal of intermediate-range nuclear forces from Europe. The immediate reaction of European leaders to reports that INF withdrawals had been discussed by President Reagan and Soviet Premier Gorbachev at their October 1986 meeting in Reykjavik was sharply negative, due in part to the realization that the current conventional force imbalance would pose an even greater threat to European security in the absence of INF missiles. Focusing European public attention on the need to redress this imbalance as a necessary precondition for such withdrawals might gain additional support for conventional force improvements such as FOFA.

Emphasize Dual-Use, Reemphasize Dual-Capable

The Europeans give highest priority to conventional weapons and surveillance improvements against the first echelon threat. The United States might clarify to the Europeans that deep strike weapons and sensor systems would enhance NATO's capabilities against both the first and follow-on echelons. On the other hand, proposals that tend to blur the distinction between FOFA and tactical nuclear weapons cause Europeans a great deal of anxiety. An idea tentatively advanced in 1984, for example, to modify Minuteman missiles to carry conventional warheads and base them in Europe to perform conventional missions, was emphatically denounced.[33] Likewise, proposals for conventional versions of the Pershing II or the successor to the Lance missile have been questioned by the Europeans on the grounds that they would decrease crisis stability.

Accommodate European Industrial Interests

The Europeans have made it amply clear that FOFA implementation cannot be premised on their purchasing U.S.-produced weapons systems. Discussions in NATO have correctly focused on the need to standardize FOFA systems and reduce overall R&D costs in the Alliance by eliminating duplication of effort through cooperative industrial projects among the NATO partners. In this regard the financial incentive offered by the 1985 Nunn Amendment has proved particularly promising in fostering U.S./European cooperative ventures. Congress may wish to consider continuing Nunn Amendment funding at a level of $200 million per year to maintain the momentum of cooperative projects now under study and allow for a number of new starts each year.

Special emphasis might be placed on reaching agreement on a NATO-wide IFF[34] system in the Nunn Amendment context, because NATO's present capacity to carry out deep strike interdiction relies exclusively on air forces. If no agreement can be reached on IFF, which all Alliance partners agree is urgently necessary and which has been under discussion for the last 20 years, the likelihood of U. S.-European cooperation on the more controversial elements of FOFA would appear dim.

Clarify Unilateral Deployments

There seems to be some opposition in the FRG to a unilateral U.S. deployment of deep strike FOFA missile systems in the U.S. sectors of the Central Front, on the grounds that this would concentrate the WP thrust into the other sectors. To counter this argument, the United States could attempt to provide the FRG with a better appreciation of the role FOFA could play in cross-corps support which would tend to level rather than heighten the current inequalities among the Central Front sectors. If, nevertheless, the FRG position were not to change, the United States might consider an offer to consult formally with the FRG on deployments when the deeper strike systems become available.

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[33] In a 1985 press conference, FRG Defense Minister Woerner rejected stationing of Minuteman missiles in Europe for conventional defense purposes. He reportedly labeled the missiles "incredible hulks" at the press conference. See, Interview with Dr. Manfred Woerner, *Armed Forces Journal,* August 1985.

[34] "Identification, Friend or Foe, A system for identifying aircraft so that NATO's air defenses do not kill NATO's aircraft. Also called the NATO Identification System (NIS).

Clarify the Relationship Between FOFA and AirLand Battle

While the United States has affirmed that elements of AirLand Battle are appropriate in the Central Region only to the extent that they are compatible with NATO doctrine, the Europeans evince some confusion and concern about how FOFA would be integrated under this arrangement. One major difficulty is that AirLand Battle envisages counter-attack by ground forces up to 150 kilometers beyond the close battle, which seems incompatible with the doctrine of Forward Defense, and has been questioned by the Europeans on political and military grounds. Another issue is the allocation of air resources for deep strike missions, since AirLand Battle appears to center control at Corps level or lower, while FOFA would require multi-corps and multinational coordination.

Emphasize the Role of FOFA in Enhancing Deterrence and Improving Crisis Management

One of NATO's widely recognized weaknesses is that it must mobilize for at least several days before it can put up a credible defense. In particular, the period during which troops would arrive from the United States by air, take equipment out of storage sites in the FRG, and organize themselves into battle-ready divisions would be a period of vulnerability which might tempt the Soviet Union to attack preemptively. The possibility of such an early Soviet attack would not only be threatening in a military sense, but would reduce the time available for negotiations to resolve the crisis short of war. FOFA, by threatening the Soviet forces moving up from rear areas once a war has started, would give the Soviets an incentive to defer any attack until after extensive Warsaw Pact mobilization, which in turn would buy time for NATO mobilization and for crisis management efforts.

Emphasize the Role of Joint STARS, in Particular, in Crisis Management

Apart from all the questions and issues about the survivability and value of Joint STARS in battle, nobody doubts that it would greatly enhance NATO's ability to monitor Warsaw Pact troop movements during a crisis. Accurate and extremely timely information about such troop movements during a crisis could be invaluable to NATO for crisis management. Such information would facilitate NATO decisionmaking, thus enhancing deterrence by discouraging Soviet hopes of dividing the Allies; it would also facilitate deployment of NATO forces to meet the evolving threat, thus enhancing deterrence by discouraging Soviet hopes of victory by quickly breaking through maldeployed and unprepared NATO forces.

FOFA AND THE NATO ALLIANCE

In the light of the history of the FOFA initiative, it is not currently possible to predict with any certainty its future course in NATO. There have been a number of plusses and minuses. On the positive side, it has helped focus attention on recent developments in WP doctrine, such as the Operational Maneuver Groups, and contributed to the discussion of what should be the appropriate NATO response. It has also highlighted current NATO deficiencies in air and ground fire support, reconnaissance and C^2, and may ease the introduction of advanced sensors such as Joint STARS, even if the Allies remain uncertain concerning the deep strike elements of FOFA. At the very least, FOFA could add cogency to U.S. arguments for increased European attention to the first echelon threat, which the Allies claim FOFA underestimates.

FOFA has also been the object of considerable criticism by the Allies, although this does not mean that the concept itself is inherently devisive. FOFA, like any major initiative in

NATO, has brought to the surface the long-standing underlying transatlantic frictions concerning burden sharing, the nuclear threshold and defense trade. The Allies, as a group, have a fundamental resistance to any major change in NATO strategy, which, whatever its defects, has preserved peace in Europe for two generations. This resistance is manifest in their skepticism of U.S. "bean counts' of WP forces, and in their arguments that substantial change in NATO force structure would necessarily weaken the political cohesion of the Alliance.

This conservatism, however, also has its positive points with regard to the future of FOFA. Now that the Alliance has given FOFA its political blessing, it would be unlikely that the Europeans would be moved to renounce the DPC decision, even if the opposition parties which are now on record as condemning FOFA win in forthcoming elections, but this is not a certainty. This does not mean that FOFA will be implemented as originally conceived or could not again become a devisive issue if, for example, the United States decides on unilateral deployment of deep strike missiles in the U.S. corps sectors.

At the most basic level, the differences in the U.S. and European views on FOFA, and all its associated issues, will tend to narrow or widen depending on the degree to which the NATO partners can achieve a common perception of the political and military aspects of the WP threat. In a 1986 discussion with OTA staff on FOFA, European parliamentarian members of the North Atlantic Assembly described the current difference in threat perception as follows: "You Americans believe the situation on the Central Front is like 1938; we believe it is more like 1914"–i.e., the greatest threat to peace is an uncontrolled escalation of belligerency, not the failure to deter a determined aggressor. This view has historical merit if the sole criterion of NATO's success is to deter the WP from a direct attack on Europe; it has been a long time since the Europeans had to consider this seriously as an imminent possibility. Judged by other factors, such as denying the Soviets the ability to coerce Europe economically and politically through the growing imbalance between NATO and the WP in conventional forces, the record of the Alliance is not as certain.

The history of the FOFA initiative thus far suggests there is still some variance between U.S. and European understanding of some of the basic purposes of the Alliance. It also suggests that it is possible for the United States and its Allies to work together, given time and a willingness to accommodate each other's views.

Chapter 9

Current Capabilities

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Chapter 9
Current Capabilities

INTRODUCTION

NATO's ability to attack follow-on forces is provided today almost exclusively by aircraft operating at depths of 150 kilometers or less and carrying weapons that are most effective against fixed targets (guided bombs) or soft area targets (cluster bombs). Although such attacks may play some part in impeding the forward advance of Warsaw Pact forces, they are only a subset of the operational concepts that have been proposed for attacking follow-on forces. In particular, they would not destroy armored forces.

The implementation of the other operational concepts runs up against several major limitations in current fielded systems. Perhaps the most important is that NATO's current reconnaissance and command, control, and communication systems and procedures are not designed to provide timely information on the precise location of mobile targets. Although aircraft are partially able to make up for a lack of precise target data by placing a human observer on the scene, additional time spent over enemy territory in searching for a target will increase exposure to the very heavy Warsaw Pact air defenses.

A second major limitation is that most existing air-delivered weapons cannot destroy armored vehicles in significant numbers. The best weapon for the task today may be the Tornado aircraft flown by the British and German air forces. But its anti-armor submunitions, dispensed in large numbers, are unguided. These weapons require aircraft to fly very close to—or even directly over—the target, exposing the aircraft to fire from terminal air defenses. Cluster bombs, which are effective against soft targets, have a quite low kill rate against armored vehicles, requiring multiple attacks—and thus repeated exposure to anti-aircraft fire-to achieve a given objective. The U.S. Maverick missile is effective against tanks, but requires the pilot to engage tanks individually. The Low Altitude Navigation Targeting Infra Red for Night (LANTIRN) will support launching two Mavericks per pass, but the pilot will still have to find a target for each and point the missile seeker at it.

Capability against fixed targets such as bridges and power stations is somewhat better; guided bombs can provide the high accuracy needed to destroy these targets while allowing the aircraft to remain out of range (up to 20 kilometers or so) of terminal defenses. Few NATO aircraft can reach more than 150 kilometers beyond the East German border, however, where a large number of important fixed targets are located (railroad bridges, for example).

Aircraft face several other limitations as well. Few NATO aircraft are able to operate well at night or in bad weather, and all face competing demands from other missions, including opposing enemy air forces, close air support, and nuclear standby. In the first few days of a war, NATO aircraft in the Central Region will be committed largely to fighting the air battle and to providing close air support, with little leeway to carry out attacks against follow-on forces.

Ground-launched weapons, which could complement aircraft particularly at times when few aircraft are available (night and bad weather and the first days of a war), have little to offer at present. Artillery and the Multiple Launch Rocket System (MLRS) now entering the inventory, are of short range (less than 30 kilometers), have a relatively low delivery accuracy, and carry cluster munitions that are relatively ineffective against tanks.

TARGETING INFORMATION[1]

Any plan to use existing NATO forces to attack Warsaw Pact follow-on forces quickly runs up against the limitation imposed by existing technology for locating mobile targets beyond the immediate battle area. Current reconnaissance systems provide data for general situation assessment, especially at short ranges, but the data are generally neither timely enough nor precise enough to guide weapons to specific targets.

The bulk of NATO's surveillance, reconnaissance, and target acquisition capability is still provided by manned aircraft carrying a variety of sensors (see table 9-l). Aircraft penetrating enemy airspace to obtain reconnaissance photographs are obviously vulnerable to enemy air defenses, and may be forced to fly restricted routes; it is difficult for reconnaissance aircraft to cover broad areas.

Unmanned drone aircraft, currently deployed by German, British, and Belgian armies, are able to perform limited reconnaissance of heavily defended areas. Their small size makes them difficult to detect and they do not place a human pilot at risk. Some fly a preprogrammed route; others can be controlled from the ground. They carry a variety of sensors, some of which transmit directly to the ground and others return film or tapes that must be processed before the information can be extracted. Compared to manned reconnaissance aircraft, ranges are limited.[2]

Radars and equipment to pickup enemy radio communications and radar emissions are carried on a number of U.S. aircraft and permit those aircraft to remain over friendly territory while looking as far as hundreds of kilometers into the enemy's rear. The systems that detect radar signals (ELINT, or electronic intelligence) and radio communications (COMINT, or communications intelligence) may be of great value for finding command posts, surface-to-air missile (SAM) sites, and surface-to-surface missile radars.

Table 9-1 .—Surveillance and Reconnaissance Aircraft

	Nation	Wartime control
Reconnaissance aircraft:		
RF-4C	United States	NATO
RF-4E	Germany	NATO
RF-104	Netherlands	NATO
Jaguar	United Kingdom	NATO
Mirage 5	Belgium	NATO
OV-1D	United States	U.S. Corps
TR-1 RC-12D RV-1D	United States	NATO
RPVs and drones:		
CL-89	United Kingdom, Germany, Canada	Corps
Epervier	Belgium	Corps
CL-289	Germany, Canada	Corps
ARGUS	Germany	Corps

SOURCE Office of Technology Assessment, 1987

The ASARS-II radar carried on the TR-1 aircraft can provide very detailed images allowing discrimination between tanks, armored personnel carriers, and other vehicles. The ASARS-II radar is, however, designed primarily for observing fixed objects, and has only a very limited capability to spot targets that are in motion. A prototype of this system is now flying in Europe; full operational capability is to begin in 1987. Although control of these U.S. systems would be transferred to SACEUR in wartime, U.S. security restrictions on the disclosure of intelligence capabilities to foreign countries—including members of NATO—could, unless waived, impede the timely flow of information from some of these systems to NATO commanders.

[1] A more detailed version of this section is found in app. 9-A in Vol. 2.

[2] *Jane All the World's Aircraft, 1985-86* (London: Jane's Publishing Co. Ltd., 1985).

DELIVERY SYSTEMS

Within NATO today, aircraft constitute the primary means of delivering munitions beyond the immediate battle area. Ground-launched artillery and the Multiple Launch Rocket System are short-range weapons (about 30 kilometers), and the munitions they carry-the Im-

Photo credit US Department of Defense

NATO's current capabilities rely primarily on aircraft such as F-4s and F-16s (pictured).

proved Conventional Munition, essentially a cluster bomb—are effective mainly against soft targets, such as trucks, self-propelled artillery, and other lightly armored vehicles (including Soviet BMP infantry fighting vehicles and field command posts). Although nominally capable of penetrating a portion of the lighter armored top surfaces of current Soviet tanks, these munitions in practice would have a very low kill probability against tanks. Furthermore, these ground-launched systems are not very accurate.

The ground-launched Lance missile has a considerably greater range (up to 125 kilometers), but because of its relatively poor accuracy, its role is mainly carrying tactical nuclear warheads. The conventional APAM (antipersonnel, antimateriel) warhead for Lance is designed for use against soft area targets, such as SAM sites, and is ineffective against armored targets.

About 1,000 tactical aircraft that could be used to strike targets beyond the immediate battle area would be assigned to support the NATO Central Region in wartime. All have other jobs to do besides attacking follow-on forces, however, and an important issue in the implementation of FOFA is how early in a war those aircraft would become available. F-16s, for example, which can carry out both air-to-air and air-to-ground missions, would be called upon heavily in the first few days of a war to assist in the air battle and for close air support at the immediate battle area. Long-range aircraft such as the F-111 are expected to carry out attacks against airfields and interdiction targets that may or may not be related to follow-on forces. Moreover, a significant proportion of the F-1 11s as well as some other aircraft will be held for nuclear missions.

Range is another limiting factor. Only a portion of these 1,000 aircraft (140 U.S. F-1 11s, 10 British Buccaneers, and-when full deployment levels are reached-about 430 British and German Tornados) can reach targets beyond about 150 kilometers from the FLOT. None can reach beyond about 400 kilometers without refueling (see table 9-2). Furthermore, few of the escort aircraft that would be included in an attack package can operate at these longer ranges.

The F-ills are the only aircraft fully able to operate at night and in bad weather. F-16s are beginning to acquire a night/all-weather capability with the addition of the LANTIRN navigation and targeting pods. Tornados are equipped with terrain-following radar which permits operation at low altitudes even under poor visibility, and a ground-mapping radar that could allow them to navigate to and locate large area targets at night; but they lack an

Table 9-2.— Delivery Systems

Ground-launched:

	Country	Range (approx.)
Artillery	all	30 kilometers
MLRS	US, GE, UK	30 kilometers
Conventional Lance	US, NL, BE	120 kilometers

Aircraft:

	Country	Range	Night/weather
F-4	US,GE	short	limited
F-5	NL	short	no
F-16	US, NL, BE	short	no
CF-18	CA	short	no
F-104 [a]	GE, NL, BE	short	limited
F-ill	US	medium	full
Tornado	GE,UK	medium	good
Mirage 5	BE	short	no
Jaguar	UK	short	no
Buccaneer	UK	medium	limited

Ranges Short up to roughly 150 kilometers beyond the FLOT
Medium up to roughly 350 kilometers beyond the FLOT

[a]Being replaced by F-16 and Tornado

SOURCE Office of Technology Assessment, 1987 infrared targeting system that would enable them to carry out precise attacks at night.

Some of the B-52 bombers of the Strategic Air Command could be made available for conventional missions; crews are beginning to be trained to fly such missions.[3] The range of these aircraft is sufficient to fly from bases in the United States to targets throughout Eastern Europe. Whether they can, or must, successfully penetrate Warsaw Pact air defenses and whether existing on-board targeting systems are adequate for the job are critical questions, however.[4]

[3]"NATO Deploys Boeing B-52s in Deep-Strike Attack Exercise," *Aviation Week and Space Technology,* Sept. 9, 1985.

[4]*See* vol. 2, app. 9-B.

MUNITIONS

Cluster munitions currently represent the primary means for attacking combat vehicles and other mobile targets (see table 9-3). Many small bomblets—packed into an air-delivered dispenser, artillery shell, or rocket–are scattered over a wide area (typically a few hundred meters). This large kill radius compensates for imprecise delivery and permits engaging multiple individual targets per pass or per round. Although these munitions are capable of doing considerable damage to soft targets such as personnel, trucks, field command posts, and lightly armored vehicles such as self-propelled artillery and BMPs, their ability to penetrate heavy armor is small.[5] Unless a bomblet happens to strike a tank at a particularly vulnerable spot on its top surface, it is unlikely to do any serious damage. Because the typical pattern on the ground of these weapons is one bomblet per 20 square meters, the probability of killing a tank with these munitions is quite low. Another drawback of these munitions is that when delivered by air, they require the aircraft to fly within a few kilometers of the target-in the case of Combined Effects Munition (CEM) and Rockeye, which, like ordinary bombs, can be dropped from a distance in a 'lobbed' trajectory-or even directly over the target (in the case of the Tornado's MW-1 dispenser, which remains fixed to the bottom of the aircraft).

[5]A typical penetration depth is 25 mm of ordinary steel (rolled homogeneous armor). The APAM warhead carried on the conventional Lance missile has essentially no armor-penetrating ability.

Table 9-3.— Munitions Fielded by NATO Forces

General. purpose bombs:	
Mk-82, Mk-84, others	aircraft
Cluster munitions:	
ICM	artillery, MLRS
APAM	Lance
Rockeye	aircraft
CEM	aircraft
MW-1/KB-44	aircraft (German Tornado)
BL755	aircraft (British)
Scatterable mines:	
Gator	aircraft
RAAM, ADAM	artillery
MW-1/MIFF	aircraft (German Tornado)
Guided bombs:	
Maverick	aircraft (F-16, F-4, F-1 11)
Paveway II	aircraft (F-4, F-1 11)
GBU-15	aircraft (F-4, F-1 11)
TV-guided Martel	aircraft (British Buccaneer)

SOURCE Office of Technology Assessment, 1987

A different type of air-launched weapon, the Maverick guided missile, has a high kill probability against armored vehicles, but is expensive (over $100,000 each) and is capable of hitting at most one target per round and at most a few per pass. It also requires the attacking aircraft to fly to within a few kilometers of the target.

Other guided bombs, the laser-guided Paveway and the TV-guided GBU-15, provide a significant capability for attacking fixed targets such as bridges, hardened command posts, and power stations, mainly by virtue of their high accuracy. Both also allow the aircraft to stand off a modest distance (as much as 20 kilometers) from the target.

Land mines that can be delivered by artillery or aircraft also provide a current capability for attacking follow-on forces. Unlike land mines used in the past, which had to be emplaced by hand and which generally did little damage to tanks—perhaps merely blowing off a tread, causing a minor delay—these new mines can be quickly emplaced where needed and they make use of improved lethal mechanisms that may allow them to be effective in halting or even destroying armored vehicles. A major limitation of the current scatterable mines is that they are easily seen on roads and can be cleared with the forks and rollers carried by Soviet tanks or even by machine-gun fire.

Chapter 10

Technology Issues: Reconnaissance, Surveillance, and Target Acquisition to Support Follow-On Forces Attack

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Chapter 10

Technology Issues: Reconnaissance, Surveillance, and Target Acquisition to Support Follow-On Forces Attack

INTRODUCTION

Attacking follow-on forces requires an ability to collect intelligence about the enemy situation from which enemy strength and intentions may be inferred. This intelligence may be collected by routine efforts (surveillance) or by efforts to obtain more information about a specific area of interest (reconnaissance). FOFA also requires an ability to acquire targets—i.e., to detect and identify enemy forces and to determine or predict their locations with sufficient accuracy to attack them. At present, only fixed targets and vehicles which halt for relatively long times can be acquired reliably. There will be important improvements—especially in timeliness—as systems and procedures for using ASARS-II radar imagery are improved, but shortfalls will still remain, especially in the ability to acquire moving vehicles ("movers") out to about 150 kilometers.

Several programs that could help are at issue now before Congress; these include the Joint Surveillance Target Attack Radar System (Joint STARS) program and various unmanned aerial vehicle (UAV) programs. The Precision Location Strike System (PLSS)–procurement of which has been deferred by the Air Force–could also contribute to FOFA if remaining developmental problems (discussed below) are corrected. [1]

[1]Much information about RSTA systems is classified. U.S. citizens holding SECRET clearances are referred to vol. 2 of this report and to ch. 5 of OTA, Technologies for NATO's Follow-On Forces Attack Concept (U), 10 February 1986. The appendices to this chapter contain extensive additional material.

Reconnaissance, Surveillance, and Target Acquisition (RSTA) Functions

Attacking follow-on forces requires:

1. detecting, recognizing, and roughly locating targets (surveillance or reconnaissance);
2. assessing their value and intent (situation assessment);
3. choosing the targets to be attacked (command decision);
4. identifying opportunities and means to attack them (targeting);
5. planning the attack;
6. tasking attack and reconnaissance platforms to perform the attack;
7. accurately locating the targets to be attacked (target acquisition); and
8. quickly providing target updates to the attack platforms (attack control). If the attack is to be conducted by aircraft, information on enemy air defenses must also be provided.

NATO today has a variety of systems to feed data into this process. Although it is difficult to generalize about a large number of very different systems, we can generally observe that while NATO's current systems are probably capable of supporting the attack of targets that do not move very frequently, they fall far short of providing continuous, broad, deep coverage and of being able to provide targeting data on highly mobile systems-especially those which do not emit radar or radio signals-without undue delays.

Issues

There is concern that the E-8A aircraft proposed as platforms for Joint STARS would not be adequately survivable if operated as close to the FLOT as originally intended, and that if operated farther from the FLOT, their coverage would be inadequate to justify their cost. The Air Force decided not to request fiscal year 1987 funds for procurement of PLSS, which is designed to accurately locate and control attacks against surface-to-air missile (SAM) radars, but did request and receive fiscal year 1987 funds for further development and testing of PLSS avionics. PLSS has almost attained specified emitter location accuracy but has not yet demonstrated specified system reliability (partly because of TR-1 aircraft failures). The Aquila remotely piloted vehicle (RPV) program has suffered cost and schedule overruns, leading some to consider procurement of an existing-possibly foreign-made—RPV which could be modified to have capabilities comparable to those required of Aquila.[2] U.S. procurement of an RPV made by a NATO partner would visibly reinforce U.S. efforts to pave a "two-way street" for intra-alliance arms sales-at the expense of the U.S. trade balance.

RSTA Requirements for FOFA

Ideally, FOFA would be supported by the collection of raw intelligence of several disciplines-communications intelligence (COMINT), electronics intelligence (E LINT), image intelligence[3] (IMINT), and measurement and signature intelligence[4] (MASINT)–-across the full breadth and depth of the enemy's rear area under all weather and lighting conditions. Ideally, RSTA systems would be capable of determining and reporting the locations of all targets with accuracy and timeliness adequate to guide attack platforms and weapons to them.

OTA has reviewed a number of analyses which have been performed by or for SHAPE, the Department of Defense, and allied ministries of defense to estimate the RSTA capabilities needed for FOFA (or interdiction). Most provide insight into RSTA capabilities needed for FOFA and the difficulties of estimating them. These analyses and other considerations lead OTA to the following observations:

- Reconnaissance and surveillance needs vary greatly according to the specific operational concepts to be implemented. Current concepts for FOFA require relatively little RSTA support; they seek primarily to delay and disrupt follow-on forces by route attacks intended to create obstacles, and to destroy follow-on forces by attacking them when halted at obstacles. Some new operational concepts—e.g., use of cruise missiles to mine rail lines and destroy key bridges–would likewise require little or no additional procurement of RSTA systems.
- The most ambitious FOFA concepts require some sort of airborne moving-target-indicating (MTI) radar system capable of almost continuous broad coverage to the depth of divisional assembly areas (70 to 100 + kilometers) and near-real-time display, because:
  –Deep, wide-area surveillance is needed for situation assessment. To allow friendly forces time for planning and movement, massing enemy forces must be detected while they are still far (100 to 150 kilometers) from the FLOT. Rapid revisit would facilitate tracking[5] and re-

[2]The House Armed Services Committee recommended, in its markup of the fiscal year 1987 Omnibus Defense Authorization bill, that the Target Acquisition, Designation, and Aerial Reconnaissance System (TADARS) program under which the Aquila RPV is being developed, be terminated. The Senate Armed Services Committee approved fiscal year 1987 appropriations for further development but prohibited expenditures for procurement until the ability of the system to meet all operational requirements has been demonstrated.

[3]Including radar imagery and visible and infrared electro-optical and photographic imagery.

[4]Including, for example, moving-target indication (MTI) provided by radar.

[5]Under conditions likely to be encountered in central Germany, one scan ("revisit' every 30 seconds would be ideal for tracking small formations (10 vehicles), whereas a 60-second revisit interval would suffice for tracking larger formations (50 vehicles). Longer revisit intervals would reduce the probability of successful tracking. See R.K. Little and J.R. Bloomfield, *Trade Stud"es: Tracking With Intermittent* Radar *Coverage* (Minneapolis, MN: Honeywell Systems and Research Center, Aerospace and Defense Group, Technical Report No. TS-01 (Draft), September 1983); n.b. fig. 3 on p. 24.

duce double-counting of enemy units, but is not essential.

–Rapid revisit would be needed to track deep high-value movers to planned engagement zones or between stops where they could be attacked.

–Wide coverage about once a minute to a depth of about 80 kilometers would be needed to track and target units moving forward out of division assembly areas. Prompt display of target locations would be needed to control attacks against them. A capability to distinguish tracked vehicles from wheeled vehicles would allow armored units to be distinguished from supply convoys, etc.

–More frequent coverage (twice a minute) would be needed to target the more numerous smaller units which would advance from regimental assembly areas closer to the FLOT; shallow coverage (to a depth of about 30 kilometers) would suffice.

Without such capabilities, FOFA would mainly consist of: attacks against halted, long-dwell, high-value, soft targets, such as command posts and SAM batteries,[6] attacks to create obstacles and delay moving units, and some attacks against moving units which might be located accurately and reported quickly by coordinated use of diverse RSTA systems, planned well in advance. Only airborne MTI radar systems can frequently search large areas for vehicles moving in radio silence at night or in adverse weather; they cannot, however, detect targets masked by terrain or vegetation.

- Fusion of intelligence from multiple disciplines facilitates situation assessment and targeting. Hardware, software, and systems now being developed by the Army-Air Force Joint Tactical Fusion Program (JTFP) could be used by USAFE and by U.S. Army corps and divisions in Europe to automate and speed intelligence fusion, analysis, and dissemination. These systems and national systems used now in Europe could interface with the Battlefield Information Collection and Exploitation System (BICES), a NATO-wide intelligence fusion system now being planned. NATO's Tri-Service Group for Communications and Electronic Equipment has established a BICES project group, which is estimating the intelligence requirements of Major NATO Commanders (e.g., SACEUR) and Major Subordinate Commanders (e.g., CINCENT) and considering the designs of interfaces that should be established between their intelligence generation control elements and national systems, as well as interfaces that should be established among the national intelligence systems.[7]
- It will be necessary to destroy mobile SAM batteries which would protect all other follow-on forces from airborne surveillance and air attack.
- It may be necessary to destroy jammers; if so, it would be important that the weapons used be relatively inexpensive.
- Survivability of air bases and command and control facilities is also essential to RSTA. NATO and the U.S. Air Force have programs (outside the scope of this report) intended to reduce the dependence of RSTA on vulnerable facilities.

[6] Individual systems such as the Tactical Reconnaissance System could provide infrequent, broad, deep, all-weather, day/night coverage of fixed targets as well as continuous, broad, deep coverage of emitters to support situation assessment and to cue limited-coverage target-acquisition systems such as UAVs.

[7] See Loren Diedrichsen, "Toward a Functional Model of NATO C'," *Signal*, October 1986, pp. 43-47, and Brigadier A.L. Meier, OBE, "BICES—A Central Region Perspective," *International Defense Review*, October 1986, pp. 1445 ff.

JOINT STARS

Description

The Joint Surveillance Target Attack Radar System (Joint STARS) is an airborne surveillance and attack control system designed to detect and indicate[8] moving ground vehicles and to guide attacking aircraft and missiles to moving or halted formations of enemy vehicles. An outgrowth of the Air Force PAVE MOVER and Army Standoff Target Acquisition System (SOTAS) programs, Joint STARS is to complement the Airborne Warning and Control System (AWACS), which detects aircraft. It will scan a broad, deep coverage area frequently to support situation assessment, attack planning, and real-time control of interdiction attacks by missiles or aircraft. The radar could be operated, and attacks controlled, by operators on board Joint STARS aircraft (E-8 As) or in mobile Ground Station Modules (GSMs) being developed by the Army.

The Joint Surveillance Target Attack Radar System will include both airborne and ground-based segments. The airborne segment includes the radar system, the Operations and Control (O&C) system, a communications system, and the E-8A aircraft-a modified Boeing 707—which carries them. These are being developed and are to be procured and operated by the U.S. Air Force. A Weapon Data Link (WDL) is being developed to provide target updates to in-flight Air Force direct-attack aircraft—F-15Es, F-16Cs, and F-16Ds—and to Army and Air Force missiles equipped with Weapon Interface Units (WIUs).[9] The ground-based segment includes transportable Ground Station Modules–including Down-sized Ground Station Modules (DGSMs)-–which are being developed and are to be procured and operated by the U.S. Army. A Surveillance and Control Data Link (SCDL) is being developed to satisfy Army needs for tactical mobile, in-weather, anti-jamming communications of all radar data to an unlimited number of GSMs. The Joint Tactical Information Distribution System (JTIDS) will provide C^2 communications with Air Force users and threat warning and air track information from AWACS and other air defense elements. The E-8A platform will provide cross-link communications between SCDL and JTIDS users.

Small, transportable ground beacons are also being developed for use by Joint STARS aircraft as radio navigation aids while awaiting full capability of the NAVSTAR Global Positioning System (GPS). Thereafter they could serve as a backup to the GPS. These components are illustrated in figure 10-1.

Status

As of March 1, 1987, Joint STARS aircraft and GSMs were both in full-scale development. A total of $715 million had already been appropriated for RDT&E through fiscal year 1987: $675 million for the Air Force and $240 million for the Army.[10] Two FSD models of Joint STARS E-8A aircraft are being produced for the Air Force by Grumman Melbourne Systems on a $657 million contract, but these have not yet been delivered. Norden Systems is producing the radio-frequency components of the radar subsystems on a subcontract from Grumman. Boeing 707 airframes in commercial use with documented maintenance histories will be purchased for about $10 million each and converted to the EC-18B configuration[11] by the Boeing Military Aircraft Co. under subcontract to Grumman.[12] Grumman will con-

‘Any airborne radar can **detect** moving targets, but in order to **indicate** moving targets as such, an airborne MTI radar must distinguish fixed targets and ground clutter–which are moving relative to the radar-from targets which are moving relative to both the radar and the ground. The signal processing required for airborne MTI radar is more complicated than that required for ground-based air-surveillance radars, which do not move relative to ground clutter.

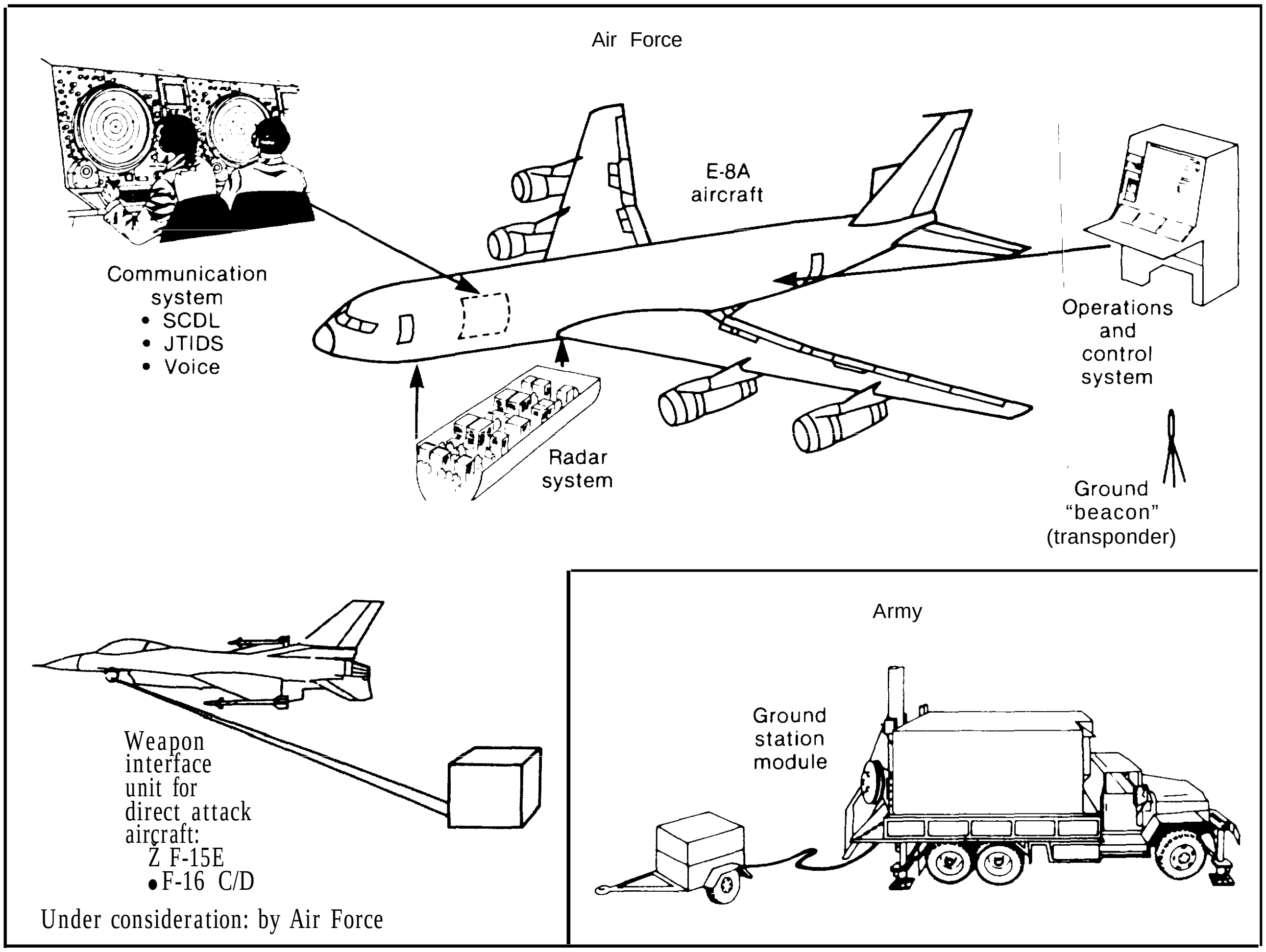
⁹The services have not requested appropriations to procure operational WI US, but prototype units are being developed as part of the full-scale development program to flight test and verify WDL performance.

‘('In current (i.e., “then-year”) dollars.

¹¹Used by Air Force Advanced Range Instrument Aircraft (ARIA).

‘*The last new 707 airframes produced cost about $30 million each. After the last 707 airframes were produced (for AWACS), Boeing closed its 707 production line.

Figure 10-1.—Joint STARS Components



SOURCES U S Army (DAMA CSC ST), U S Air Force (SAF/LLW); and Office of Technology Assessment, 1987

vert these to E-8As by installing the prime mission equipment at its facility at the Melbourne Regional Airport near Melbourne, Florida.

Issues

Although Joint STARS has received broad support within the Army, the Air Force, Allied Command Europe, and the Office of the Secretary of Defense, it has been a matter of contention in Congress. Opponents claim that the C-18 is too vulnerable to attack and must be replaced with a more survivable platform. They also contend that the radar required for the more survivable platform could not be developed from the radar now under development. Therefore, they argue, the program should be canceled and a new one started.

Proponents argue that the E-8A-based Joint STARS will be "survivable but not immortal," and that when operated in the proper manner, with proper support, it will be capable of doing what is needed. They further argue that more survivable platforms will not, by themselves, satisfy requirements, but that they could usefully complement E-8As as Joint STARS platforms. The Air Force contends that Joint STARS may need to be deployed to areas outside Europe in crises, and that more survivable platforms could not carry all the equipment that E-8As could, nor could they be used to "show the flag' in peacetime without compromising the secrecy of design features on which they would rely for survivability. Proponents also argue that it is important to get something into the field as soon as possible so that the troops can learn how to use this complex capability.

Resolution of these issues will require answering four questions:

1. Why is the capability promised by Joint STARS needed?
2. How serious are the problems of vulnerability to attack and susceptibility to electronic countermeasures (ECM)? Specifically, how would they affect the operational utility of the proposed Joint STARS fleet?
3. What are the alternatives? What are their advantages and drawbacks?
4. If an alternative is desired, could Joint STARS avionics systems developed or procured for E-8As be used by alternative systems? What systems could not be used? Could Joint STARS E-8As themselves complement alternative systems?

Need for Airborne Moving-Target-Indicating Radar Surveillance

As noted above,[13] the most ambitious FOFA concepts require some sort of airborne moving-target-indicating (MTI) radar system capable of frequently "revisiting" (i.e., scanning) broad deep areas. Only an airborne MTI radar system can detect vehicles moving in radio silence at night or in adverse weather and revisit a large area of interest often enough to track such vehicles moving in it. Joint STARS was designed to provide the kind of frequent, deep, wide-area MTI surveillance needed to implement these ambitious FOFA concepts. The MTI capabilities of other operational, developmental, and proposed MTI systems known to OTA fall far short of those needed to support highly effective FOFA:

- The currently operational MTI radar carried by the OV-1D "Mohawk" twin-turboprop aircraft is a side-looking airborne radar (SLAR). Its beam cannot scan and therefore revisits a target only twice per orbit. It would operate within range of multiple types of surface-to-air missiles.[14]
- The British ASTOR-I MTI SLAR system has these inadequacies and others as well: it has no data link and cannot provide moving-target indications until after aircraft recovery when recorded radar echoes can be processed.[15]
- The French ORCHIDEE heliborne MTI radar system, now in development, will also operate close to the FLOT at low altitude and will also have inadequate range and coverage.
- The ASARS-II radar has some MTI capability now and, because its platform (a TR-1) operates at high altitude, it is less affected by terrain and vegetation masking than Joint STARS would be at nominal stand-off range (or at equal stand-off range). However, ASARS-II requires a large ground station to process radar data before it is transmitted to Army and Air Force users. This dependence on a ground station compromises the mobility and survivability of ASARS-II.
- The ASARS-II radar could be enhanced to have even greater MTI capability. It could also be equipped with an SCDL air data terminal, so that its MTI data could be broadcast directly to tactical users. However, the MTI capabilities of an enhanced ASARS-II radar would be inadequate to support highly effective FOFA and inferior to those of Joint STARS. Although it would suffer less masking by terrain and vegetation, it would have several disadvantages:[16]
  —a minimum detectable velocity about twice that of Joint STARS,

[13]See ch. 5 and the section above on RSTA requirements.

[14]Fixed SAMs could be attacked and others evaded, but evasive maneuvering would interrupt surveillance. In the future, new mobile SAMs are expected to pose a greater threat to Mohawks as well as other aircraft.

[15]The SCDL developed for Joint STARS has been used experimentally to transmit ASTOR-I MTI data to a GSM.

[16]See also the Joint STARS Cost and Operational Effectiveness Analysis being completed by the U.S. Army TRADOC Analysis Center as this report goes to press.

—a detection range two-thirds that of Joint STARS,
—one-fifth the coverage of Joint STARS at a comparable revisit rate,
—inferior moving target location accuracy, and
—vastly inferior electronic countermeasures (in MTI modes).

None of the above-mentioned systems has, or will have, an attack planning and control capability. An integrated surveillance and control capability, such as Joint STARS will provide, would greatly reduce the time between detection of a target and engagement of the target, thereby permitting halted vehicle formations to be engaged and permitting moving columns of vehicles to be attacked by missiles or aircraft.

To engage units on the move with missiles armed with wide-area munitions, the units must be tracked to planned engagement zones, at which time missile launch must be triggered. Last-minute confirmation of a target's approach to an engagement zone is needed just before launch, with minimal delay for maximum effectiveness. Attack aircraft will also need in-flight guidance-which could be provided by voice radio or data link-in order to attack designated moving targets (as distinct from targets of opportunity). Without in-flight guidance, they would be more exposed to observation and fire while searching for designated moving targets and they would suffer higher attrition.

Vulnerability to Attack[17]

Any of several Warsaw Pact SAMs or interceptor aircraft could destroy an unprotected Joint STARS E-8A in a hypothetical one-on-one engagement. In reality, Joint STARS will not operate alone; NATO will provide protection to all such aircraft in NATO airspace. Joint STARS would benefit from general measures such as air defense suppression and offensive counter-air operations using attack aircraft and missiles, and defensive counter-air operations by high-altitude combat air patrol aircraft (e.g., F-15s) and NATO SAMs (e.g., Patriots). It is expected that Warsaw Pact SAMs and interceptors will be increasingly (but not completely) suppressed as a war progresses. When Joint STARS is attacked, it would be forewarned by on-board display of hostile aircraft data from air defense elements (e.g., AWACS) so that it could take evasive action or employ countermeasures. It would also be protected by other Air Force aircraft capable of jamming enemy radars and radios. The addition of on-board threat warning and countermeasure capabilities is being considered to counter Soviet interceptor aircraft and SAM threats.

Even with such protection, Joint STARS would probably be vulnerable to fixed and mobile SAMs and to interceptor aircraft if operated, early in a war, at the setback range originally planned. If operated at a greater range from the FLOT, its vulnerability would decrease, but so would its coverage. Air Force planners may want to hold E-8As back from the FLOT most of the time early in a war and surge them forward, with suitable support, for limited periods of intense activity. It is expected that surge periods could be increased as war progresses and enemy defenses are depleted.

Operating this way, an E-8A could provide good coverage to at least the range of an MLRS rocket, where frequent coverage is most needed. It could provide valuable coverage deeper, but deep targets would be masked more frequently by terrain and foliage and could be masked more easily by jamming. Its deep coverage would still be useful for situation assessment, but its ability to track units would be degraded. The resulting increased likelihood of double-counting units could make situation assessment less certain, and the ability to engage high-value targets deep would be degraded to an extent not yet quantified. OTA is not aware of any thorough analysis of the

[17] In preparing this report, OTA staff were not granted access to "Special Access Required" information about programs and technologies which might be of use in improving the survivability of Joint STARS. It is possible that options not considered by OTA could provide benefits significantly different from those discussed here.

Photo credit: "Soviet Military Power," U.S. Department of Defense

The SA-X-12 air defense system.

utility of Joint STARS as a FOFA system operating in this manner, although a major study coordinated by the Army Training and Doctrine Command's TRADOC Analysis Center is nearing completion. Smaller studies for the Army[18] and Air Force[19] have examined or are now examining the impact of such revised operational concepts on selected operational capabilities.

[18] E.g., by the BDM Corp.

[19] E.g., by the Rand Corp. for the Directorate of Operational Requirements (AF/RDQ).

Susceptibility to Jamming

Joint STARS is designed to have very capable electronic counter-countermeasures, but its performance could be degraded by severe jamming. Two types of jamming might be attempted against Joint STARS: sidelobe jamming and mainlobe jamming. Successful sidelobe jamming would require very powerful or highly directional jammers. The jamming signal must be strong enough so that even if received by the airborne radar when its beam is pointing away from the jammer,[20] it will be powerful enough to mask received radar

[20] I.e., when the airborne radar receiver is relatively insensitive to the jamming signal.

echoes. In principle, the entire area scanned by an airborne surveillance radar could be masked by a single jammer, if sufficiently powerful.[21] Unless highly directional, a sidelobe jammer would have to be immensely powerful and would probably interfere with enemy radar systems.

If necessary, the electronic counter-countermeasures of operational Joint STARS aircraft could be upgraded to counter sidelobe jamming threats more severe than those which the two developmental aircraft are required to counter, Growth capabilities are built into the Full-Scale Development radar to permit such enhancement without modifying the radar's design. Alternatively–or additionally--sidelobe jammers could be attacked. Whether immensely powerful or highly directional, sidelobe jammers would be relatively expensive and hence high-value targets for jammer-suppression attacks using anti-radiation missiles or other weapons.

Successful mainlobe jamming occurs when the beam of an airborne radar is pointing at a jammer; the airborne radar is then most sensitive to the jamming signal, which need not be very powerful. If sufficiently strong relative to the radar echoes from the area near the jammer, the jamming signal will mask those echoes, and the radar will be unable to detect targets near the jammer. However, although successful mainlobe jamming would require relatively little power, a single jammer would mask only a small area. A large number of jammers would be required to intermittently mask the whole coverage area specified for Joint STARS; more would be required to mask the specified coverage area continuously.

If effective mainlobe jammers are developed and proliferated, lethal suppression may be necessary to counter them, although relatively minor upgrades to Joint STARS could provide a significant amount of additional anti-jam margin. If, in the future, an effective mainlobe jamming threat is projected, and if lethal suppression is deemed necessary to counter it, identification of the least-cost means of killing mainlobe jammers will require further study.[22] A comparison of the cost to NATO of killing such jammers with the cost to Warsaw Pact nations of producing and operating them would indicate which alliance would suffer more economically if both were to compete in a jammer/counter-jammer competition; however, other incentives will affect decisions to compete in or refrain from such a competition.

[21] App. 10-C in vol. 2 of this report discusses OTA's assessment of the susceptibility of Joint STARS to sidelobe jamming by existing and anticipated Soviet jammers.

Alternatives

There are several alternatives to funding the Army and Air Force Joint STARS programs as proposed, or canceling them. These include:

1. development (if necessary) and procurement of add-on systems to enhance the utility and survivability of Joint STARS E-8 AS;
2. development (if necessary) and procurement of an alternative platform more survivable or protectable than an E-8A; and
3. development (if necessary) and procurement of complementary platforms intended to operate in coordination with E-8As, enabling the E-8As to operate in a more survivable (or protectable) manner.

Add-On Systems

If Joint STARS is procured, its utility and survivability could be enhanced by procuring accessories:

- Non-lethal self-defense suites could be procured for E-8As to enhance their survivability. These could include expendable and non-expendable electronic and infrared countermeasure systems, some of which are already used on other aircraft. Joint STARS E-8As and other platforms could

[22] Jammers and radars could be attacked by manned aircraft (e.g., F-4G Wild Weasels) or by kamikaze drones, such as the air-launched TACIT RAINBOW drone being developed by Northrop for the Air Force and Navy. TACIT RAINBOW is expected to complete full-scale development in fiscal year 1988. During initial operational testing and evaluation, the drones are being launched from B-52, A-7, and A-6E aircraft. [*Aerospace Daily*, Jan. 8, 1987; *Aviation Week and Space Technology*, Apr. 27, 1987, p. 34.

be equipped to tow or dispense expendable decoy emitters[23] which could be developed to draw fire and jamming from the Joint STARS E-8As. The Joint STARS Program Office is now evaluating several self-defense suite concepts and will present its findings to the Joint Requirements and Management Board in March 1987 for a decision on self-defense suite acquisition.

- An air-to-air missile system for last-ditch defense against surface-to-air and air-to-air missiles could also be developed and procured.
- Weapon Interface Units (WIUs) could be procured for ground-attack aircraft. These digital data links could guide ground-attack aircraft to more distant targets more accurately than voice radio or a JTIDS data link could, so the aircraft could find moving columns of armored vehicles with less searching, exposure, and attrition.

Alternative Platforms

Alternatively, a less observable (i. e., "stealthy' high-altitude aircraft could be used as a platform for Joint STARS; it could fly closer to the FLOT with a much lower probability of being detected and attacked, and its susceptibility to sidelobe jamming would also be reduced,[24] as would masking of targets by terrain and vegetation.[25] The Department of Defense has considered proposals to develop a more survivable platform than the E-8A. However, information about the concept or concepts considered by the Department of Defense is highly classified and unavailable to OTA. Some potential benefits and limitations of reducing the observability of the Joint STARS platform, radar, and signal are discussed in volume 2 of this report, which is classified. (Authorized readers interested in this important topic are referred to app. 10-C in vol. 2. However, readers should be aware that there are facts and concepts that OTA is unaware of, and that could conceivably change OTA's observations.)

The use of a stealthy platform would not, by itself, guarantee low-observable operation: the detectability of the radar antenna by a threat radar would have to be reduced, and the detectability of the radar emissions would also have to be reduced. Balanced reduction of the platform and antenna cross-sections" and the radar's signature would be needed: if any one of these were readily observable, the system could be readily detected.

Many things could be done to reduce the detectability of radar emissions; some would not reduce radar performance. However, when all else has been done, further reduction of detectability, if necessary, would require reducing the radar's power, which would require reducing its coverage area or revisit rate, increasing the minimum detectable velocity, or a combination of these trade-offs. It would also increase susceptibility to jamming. Hence, if operated in a stealthy manner, a stealthy Joint STARS would "see" less than an E-8A would. Although it would be able to view some areas which would be hidden from a lower, rearward E-8A by terrain and foliage, its beam could not frequently revisit the broad area near the FLOT–where frequent revisit is most

[23] See Marc Liebman, "Expendable Decoys Counter Missiles With New Technology, " *Defense Electronics*, October 1986, pp. 69 ff.

[24] If enemy radars could not detect **and** track a Joint STARS platform or its antennas, and if enemy direction-finding equipment could not reliably detect **and** recognize Joint STARS radar emissions **and** track their source, jammer beams could not be aimed at the radar. However, operating Joint STARS equipment in a stealthy manner may require operation at reduced power. This would reduce the power of radar echoes and hence the power required for mainlobe jamming.

[25] Masking of targets in central Germany by summer vegetation would be significant: cf. figures 1 and 2 of V.L. Lynn, "Terrain and Foliage Masking for Long-Range Surveillance; A Sample of Measurements in Central Germany" (Lexington, MA: Massachusetts Institute of Technology, Lincoln Laboratory, Project Report TST-35, June 15, 1979), Defense Technical Information Center accession No. AD-B040205 See vol. 2 of this report for further discussion of masking.

[26] An object **radar cross-section** is an index of its observability by radar; it depends on the frequency of the radar signal, the polarizations of the transmitting and receiving antennas, and the directions to these from the target.

needed[27]—without compromising its low observability .

For this reason, some analysts believe that a significantly more survivable Joint STARS would not be able to gather all the information "required" by the Joint Service Operational Requirement for Joint STARS. This does not mean such a system would be useless—it might be very useful—but OTA knows of no analysis of the contribution to FOFA of such a reduced capability. In order to judge the value of a stealthy Joint STARS, a detailed analysis is needed comparing the separate and combined contributions to FOFA capability of an E-8A operated for survivability and a stealthy platform operated near the FLOT.

Rather than reduce power to the extent required to completely avoid detection, deception could be used to make enemy identification, tracking, and engagement of a low-observable Joint STARS platform improbable. Expendable decoy emitters–discussed above–would need less power to mimic a low-power, stealthy Joint STARS than to mimic a high-power E-8A-based Joint STARS.

Complementary Platforms

The surveillance capabilities of E-8As could be increased or supplemented by other aircraft operating in coordination with them; these could include aircraft of three distinct types:

1. stealthy aircraft with comparable radars used to observe deep areas;
z. aircraft with less capable radars, which could observe some targets masked from E-8 As; and
3. stealthy aircraft used primarily to passively observe deep areas "illuminated" by E-8As at greater stand-off range.

Development of stealthy platforms to complement (not replace) E-8As would avoid several shortcomings of a force consisting solely of stealthy platforms. E-8As could be used before complementary platforms are operational. Thereafter:

- In peacetime, E-8As could be used in Europe to provide indications of Pact mobilization and warning of attack. Stealthy platforms should not be used routinely because their routine use would risk compromising their security and survivability.
- In crises, E-8As could be deployed from Europe to other theaters where it would be difficult to deploy GSMs quickly. Stealthy platforms, if small, would be unable to carry much operations and control equipment. Joint STARS E-8 As, like AWACS E-3 A/B/Cs, could be used to "show the flag"; stealthy platforms, if observed, might be more easily countered later.
- In wartime, the stealthy platforms of a "mixed" force could view selected deep areas frequently, or broad deep areas infrequently, with little terrain masking, whereas E-8As normally at a greater distance from the FLOT could revisit the close battle area frequently with their powerful radar beams. The E-8As could approach the FLOT more closely when provided extra defense support or after enemy air defenses have been degraded; they could also serve as operations and control centers, complementing GSMs.

Less capable airborne radars could observe some targets masked from E-8 As; these include ASARS-II, enhanced ASARS-II, Mohawk, ASTOR-I, and ORCHIDEE, which were mentioned above,[28] as well as radars on unmanned aerial vehicles, which are discussed later in this chapter. These could not replace E-8As but could complement them; for example, a short-range MTI radar being developed for the Army's Intelligence and Electronic

[27] In experiments using simulated imagery, the success rate of operators tasked to track company-size formations (10 vehicles) for 24 minutes decreased from about two-thirds to about one-half when the revisit interval was increased from 30 to 60 seconds. Their success rate tracking battalion-size formations (50 vehicles) decreased similarly when the revisit interval was increased from 60 to 120 seconds. See Little and Bloomfield, op. cit., p. 24, fig. 3. Masking of targets by vegetation was simulated in these experiments, and a stationary radar location was assumed.

[28] See *also* ch. 8, above, and the section below, in this chapter, on "The Two-Way Street, " where the NATO Airborne Radar Demonstrator System (ARDS) program is discussed.

Warfare Unmanned Aerial Vehicle could be used to monitor targets in areas masked from E-8As by hills.

In the more distant future, it might be possible to build a bistatic ("two-station") MTI radar system employing a powerful transmitter on an airplane or satellite at a presumably safe distance to irradiate the coverage area while an airplane closer to the coverage area receives and processes the radar echoes.[29] The receiver platform would not divulge its location by beaming radar pulses into enemy territory and, if sufficiently stealthy, might therefore escape attack and sidelobe jamming even if very close to enemy territory. It would still be susceptible to mainlobe jamming, although potentially less so than a low-power radar. Its advantage over baseline or low-power systems is that it could scan close and deep areas at a high revisit rate. The platform location determination and signal synchronization and processing required for such a system would be very challenging. However, if and when it is feasible, Joint STARS E-8As might be used to irradiate the coverage area from a safe distance, while a complementary airplane, possibly using most of the avionics components developed for E-8 As, collected and processed radar echoes and transmitted MTI data rearward to E-8 As, which could downlink it to Army ground station modules and other users and service their requests for radar tasking and attack control.

[29]George W. Stimson, *Introduction to Airborne Radar* (El Segundo, CA: Hughes Aircraft Co., Radar Systems Group, 1983); pp. 576-577.

Potential Commonality of Joint STARS Prime Mission Equipment for E-8As and Other Platforms

If a decision were made to develop a low-observable platform for Joint STARS, it appears that all the radar components developed for the E-8A except the antenna could be used on such a platform without major changes, if that system were to operate in the same frequency band. Operations and control consoles developed for the E-8A would not be usable on a small platform, but could be used, if desired, on other aircraft or in ground-based facilities.

THE PRECISION LOCATION STRIKE SYSTEM (PLSS)

The Precision Location Strike System (PLSS: pronounced "pens") is a developmental surveillance and control system designed to detect, identify, and accurately locate modern mobile jammers and electronically agile[30] radars in near real time.[31] Such emitters would accompany and protect follow-on forces. An ability to attack these emitters soon after they are detected in a new location would be very valuable for protecting allied aircraft that detect and attack follow-on forces. PLSS has demonstrated a capability to locate and report more such emitters per hour with greater accuracy and timeliness than can all other U.S. systems now reporting to Europe combined. However, development of PLSS has been delayed by several problems, and the Air Force decided last year not to begin procurement of PLSS in fiscal year 1987. This year, the Air Force reconsidered procurement of PLSS after an operational utility evaluation of PLSS was completed in April, and recommended cancellation of the program.

[30]Capable of quickly changing frequency or emitting brief pulses after long, irregular intervals.
[31]HQ TAC, TAF ROC 314-74.

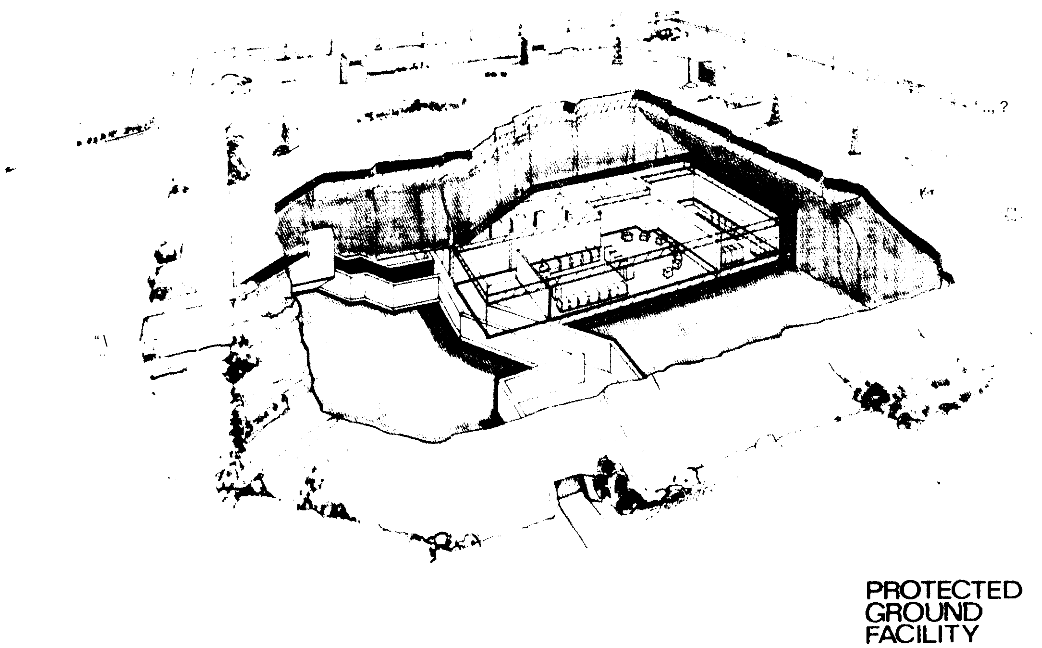
PLSS would use electronic equipment carried aloft by three TR-1 aircraft operating together, each communicating by means of an Interoperable Data Link (IDL) with a Central Processing Subsystem (CPS), which could be transportable or based in a hardened PLSS Ground Station (PGS: see figure 10-2).

To locate emitters both accurately and quickly, PLSS uses a combination of distance-measuring equipment (DME), time difference of arrival (TDOA), and direction of arrival

Figure 10-2.—Components of the Precision Location Strike System (PLSS)

The TR-1 high-altitude reconnaissance aircraft.

SOURCE U S Department of Defense



Artist's conception of a hardened PLSS Ground Station.

SOURCE *Signal* (the official journal of the Armed Forces Communications and Electronics Association) January 1986 Copyright 1986 reprinted by permission

(DOA) techniques: The TR-1 aircraft determine their own locations using DME; TDOA comparisons produce a few very precise candidate locations for each emitter; and DOA sensing determines which of them is the correct one.[32]

The necessity that three airborne receivers simultaneously detect a radar pulse requires that each receiver be very sensitive and use high-gain antennas, because at least two of the three receivers will be in an emitter's sidelobes (or backlobe) when it emits a pulse. To attain the antenna gain required, each airborne receiver uses a phased array of antennas. A high-gain antenna pattern is necessarily directional, so the phased array is designed to form multiple receive beams which collectively cover the specified coverage area without scanning; scanning would risk missing the signal of a "short on-time" emitter.

Emitter locations reported by PLSS, when correlated with intelligence from other disciplines, could be used for situation assessment and targeting. These activities could be performed by the proposed PLSS Intelligence Augmentation Subsystem (PI AS), or in existing intelligence fusion and targeting facilities. Once targets have been selected and attacks planned, near-real-time emitter location reports from PLSS could indicate when missiles should be launched, and could be relayed to attack aircraft using a variety of communications systems. Attacks against emitters could be controlled from the PGS.

Components and Programs

Components used by or related to PLSS are being developed or procured under six separate programs:

1. PLSS
2. TR-1
3. IDL
4. ELS
5. ATDL
6. PIAS

PLSS

Equipment developed by the PLSS program, per se, includes the airborne mission subsystem (AMS) carried by each TR-1 aircraft; the Central Processing Subsystem (CPS), and the Site Navigation Subsystem. AMS consists of an airborne intercept element (AIE: antennas, intercept receiver, and control system), distance-measuring equipment, and government-furnished Interoperable Air Data Link (IADL) equipment for the IDL. The CPS includes government-furnished Interoperable Ground Data Link (IGDL) equipment to communicate with the TR-1s, signal and data processing equipment, and a PLSS Interface Module (PIM) for selecting, formatting, and disseminating PLSS location reports to various users according to their needs. Each Site Navigation Subsystem (SNS) is a transportable DME transponder.[33]

TR-1

PLSS airborne mission subsystems must be carried aloft aboard TR-1 reconnaissance aircraft. Late-model TR-1s can carry either a Tactical Reconnaissance System (TRS) payload[34] or a PLSS AMS, but not both simultaneously. TRS and PLSS payloads can be swapped in about an hour. During development and testing, PLSS airborne mission subsystems have been carried aboard TR-1s flying training missions. PLSS could provide a limited operational capability, if desired, using TR-1s procured for the TRS, training, or other missions. A greater operational PLSS capability, if desired, would require procurement of additional TR-1s.

[32] R. Hale, "Precision Location Strike System," *Signal*, January 1986, pp. 51 ff.

[33] Ibid.

[34] Consisting of an ASARS-II airborne radar system, etc.

IDL

Interoperable Data Link equipment is in production and will be provided to the prime contractor for PLSS as government-furnished equipment. It includes both IADL equipment for installation on TR-1s and IGDL equipment for use by the PLSS CPS.

ELS

PLSS was designed to locate pulsed radars; the Emitter Location System (ELS) program is developing software and hardware to give PLSS the ability to locate non-pulsed emitters.

ATDL

Until 1986, Adaptive Targeting Data Link (ATDL) equipment was under development for installation in aircraft or weapons. ATDL-equipped aircraft and weapons could be guided to emitter locations determined by PLSS. Starting in fiscal year 1990, Block 30P F-16s were to be equipped with ATDL transponders, which would allow them to receive guidance from controllers in the PGS via relay equipment in the TR-1s. If equipped with ATDL transponders, missiles and other weapons could also be guided to emitter locations by PLSS. Weapons which have been considered (and, in some cases, tested) for this application include the GBU-15 glide bomb,[35] air- and ground-launched versions of the T-16 Patriot and T-22 Lance missiles,[36] the Conventional Stand-off Weapon (CSW) proposed by the Air Force,[37] and the now-defunct JTACMS (Joint Tactical Missile System).[38] Unlike an antiradiation missile (ARM), which can home on a radar antenna only when it is transmitting, an ATDL-equipped missile would attack a radar antenna location and could disable it even when it is not transmitting.

PIAS

To enhance the intelligence value of PLSS by improving analysis, exploitation, and reporting capabilities, a PLSS Intelligence Augmentation Subsystem (PIAS) is being developed under the PLSS Intelligence Augmentation Program (PIAP). Originally, two subsystems were to be developed. One was to be located with the PLSS CPS in a hardened PGS to be constructed in Europe; the other—a transportable facility-was to be used for training at Nellis Air Force Base under normal circumstances. PIAS would use some equipment now used by the ground control processor of the Senior Ruby ELINT system; enhancements would be made available for use by Senior Ruby.

Status

PLSS completed Developmental Testing and Evaluation in 1986 and Operational Utility Evaluation in April. PLSS was intended to be operational by now to counter a "circa 1985" threat. However, its development and procurement have been delayed by several problems, which are discussed below. Last year, the Air Force decided not to request funds for procurement of PLSS in fiscal year 1987 and not to develop ATDL transponders for installation in F-16s.[39] Currently, $675 million[40] has been appropriated through fiscal year 1987 for RDT&E to procure, for the purpose of development, testing, and evaluation, one CPS, six

[35] Department of Defense Appropriations for 1983, Hearings before a Subcommittee of the Committee on Appropriations, House of Representatives, 97th Cong., 2d sess., Part 1 (Washington, DC: U.S. Government Printing Office, USGPO 92-690 0, 1982), pp. 842-866.

[36] Ibid.

[37] Ibid.

[38] Department of Defense Appropriations for 1984, Hearings before a Subcommittee of the Committee on Appropriations, House of Representatives, 98th Cong., 1st sess., Part 4 (Washington, DC: U.S. Government Printing Office, USGPO 19-163 0, 1983), p. 725; Department of Defense Appropriations for 1985, Hearings before a Subcommittee of the Committee on Appropriations, House of Representatives, 98th Cong., 2d sess., Part 5 (Washington, DC: U.S. Government Printing Office, USGPO 34-7740, 1984), pp. 71-76.

[39] If desired, Joint STARS aircraft could receive target updates from the PLSS CPS (via JTIDS) and relay them (via the Joint STARS Weapon Data Link) to aircraft and (optionally) missiles equipped with Joint STARS Weapon Interface Units (WIUs). The Air Force does not currently plan to procure WIUs but began reconsidering procurement of WIUS when plans to procure ATDL transponders— which would have functioned as WIUs–were canceled.

[40] In current (i.e., "then-year") dollars.

SNSs, and three all-up AMSs and a partial AMS requiring refurbishment." No TR-1s have been procured specifically for PLSS.

The results of the Operational Utility Evaluation of PLSS have been reviewed by the Air Force, which recommended program termination. The Department of Defense could concur, recommend continued development, or seek procurement of quantities needed for some level of operational capability. If so directed, the Air Force Systems Command could turn PLSS hardware over to the Tactical Air Command in May 1987 for use in training and to provide a limited operational capability. If TAC desires only a limited operational capability, the Air Force might choose to have the Air Force Logistics Command (AFLC/AZ) manage PLSS as a "unique system."

Problems and Progress

PLSS has encountered several problems and delays during its development. It has not yet demonstrated the system reliability, emitter reporting rate ("throughput"), or emitter location accuracy originally specified. Moreover, during developmental testing, it often reported each actual emitter detected as several distinct emitters. However, its performance has been improving. During developmental testing:

- PLSS achieved an "adjusted" system reliability of about 0.7; the specified system reliability is 0.83.[42]
- PLSS achieved two-thirds of the originally specified throughput; meanwhile, the throughput requirement was reviewed and reduced by one-third, to the value demonstrated by PLSS.
- PLSS demonstrated an emitter location accuracy which improved during the test period for which data was available to OTA and approached specified accuracy on most days at the end of that period.[43] Location errors were very large on some days; however, a 4-day moving average of emitter location error demonstrated decreased to 2.7 times that specified.[44] Some specific causes of high location errors (e.g., loose connector contacts) were identified and corrected.

The tendency of the PLSS CPS to report each actual emitter detected as several distinct emitters is known as the "association problem." During the test period for which data was available to OTA, four emitters were reported, on the average, for each actual emitter detected. This overreporting indicates a failure of the CPS to recognize successive intercepted signals as coming from the same emitter. When a "hit" occurs (i.e., when the AMSs intercept a signal), the signal parameters are reported to the CPS, which logs them in a buffer. The CPS also estimates an emitter location for each hit, and logs it with the other signal parameters. Before reporting a "new" emitter, CPS software attempts to determine whether the signal parameters of the new hit can be well correlated with those of a previous hit. If so, CPS software would assume that the intercepted signal was emitted by a previously reported emitter and would not report a new emitter.[45] However, because a modern emitter can vary many of its signal parameters (e.g., frequency), CPS software relies heavily on the emitter locations estimated for each hit in attempting to associate logged hits with specific emitters. Hence any fault which reduces emitter location accuracy will reduce the probability of correct emitter-hit association and result in overreporting.

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[41] USAF (SAF/LL) private communication.

[42] The "adjusted" system reliability is an estimate of the probability that 1 CPS, 3 AMSs, and 9 SNSs would have completed an 8-hour mission without critical failure if 1 CPS, 4 AMSs, and 16 SNSs had been available and prepared for operation. It is based on demonstrated CPS, AMS, TR-1, and SNS reliabilities—0.99, 0.90, 0.87, and 0.99, respectively.

[43] AF/RDPV and AFSC/SDWD private communication.

[44] A 4-day moving average of emitter location accuracy demonstrated using only two TR-1s—which takes longer—approached six times that specified.

[45] It would, however, refine its estimate of the location of the previously reported emitter.

Some specific faults causing incorrect emitter-hit association were identified and corrected during testing. Improvements in the accuracy with which emitter location can be determined from a single hit would further reduce overreporting. Residual overreporting could be reduced by increasing the tolerance (i.e., the allowable distance) between single-hit emitter location estimates which can be associated with one emitter. This would, however, decrease the accuracy of emitter location reports. If a PLSS Interface Module is installed in the CPS (as originally planned), operators in the PIM could review PLSS location reports before they are disseminated to users and could cancel dissemination of obviously duplicative reports." The PLSS Intelligence Augmentation Subsystem, if fully developed and procured, might also reduce overreporting by "residue processing"—a more sophisticated and time-consuming method for correlating reported signal parameters than that used by the PLSS CPS.

Operational Utility: The View From USAFE

Until this year, PLSS was an important part of the program for improving surveillance in Europe. However, the Air Force has taken the position that other systems or combinations of systems can adequately perform the important functions of PLSS. Attack aircraft can be guided to approximate emitter locations using ELINT from currently operational systems. The systems and procedures used would be too slow and inaccurate to guide missiles to emitter locations, but USAFE opposes procurement of ground-based missiles-or surveillance and control systems for such missiles—on the grounds that they would be too vulnerable[47] and inflexible.[48] These concerns are valid, and the argument has some merit. However, the concern expressed about vulnerability of critical links could apply to other facilities which support air defense suppression, air interdiction, and other tactical air missions. Moreover, PLSS is designed to support air defense suppression, not FOFA; suppression of enemy air defenses would be important even if enemy forces were front-loaded.

Others still see value in PLSS, particularly for targeting modern mobile SAMs. It has already demonstrated an emitter location accuracy which is superior to that of existing theater ELINT systems, as well as a high emitter reporting rate ("throughput") which will be needed to rapidly reconstruct our picture of the enemy's "electronic order of battle" (numbers, types, and locations of emitters) at the outbreak of war if, as expected, enemy radars shut down, move, change frequencies, and begin wartime operation in short on-time, electronically agile modes." Proponents and opponents agree that "association" and reliability must be improved; proponents are more confident that they can be, soon.

Alternatives to PLSS

Combinations of other systems could do the job PLSS was designed for, but not as well. For example:

- ELINT from a Senior Ruby or Guardrail/ Common Sensor system could be used to

[46] Overreporting is not peculiar to PLSS, but occurs to some extent in other intelligence collection and fusion systems. Human judgment is generally necessary-but not infallible—for recognizing duplicative reports. Because PLSS is capable of issuing so many reports per hour, overreporting by PLSS would be particularly bothersome.

[47] USAFE has argued that:

> systems necessary to feed precision attack ground-based sy - tems ., become high priority targets for the enemy. We believe the Soviets might make whatever sacrifice necessary to destroy one of these critical links. These same high technology systems enhance the precision attack capability of manned systems, yet without them, man can be given the approximate target location and rough timing estimates. He then becomes the precision attack system.
>
> HQ USAFE. FOFA: USAFE View, briefing to OTA Staff, Apr. 16 1986.

[48] USAFE opposes investing in systems designed specifically to support FOFA. USAFE has argued that if Warsaw Forces are massed forward ("front-loaded") rather than echeloned, there would be few follow-on forces to attack, and systems designed specifically to attack them would be largely useless. Manned attack aircraft could be used for other purposes. [I bid.]

"Private communication.

cue an ASARS-II or Joint STARS radar to scan a suspected SAM deployment area in an attempt to recognize and precisely locate the SAM battery. However, Senior Ruby is less sensitive than PLSS and might not detect sidelobe or backlobe pulses from modem radars-it might have to wait for a mainlobe pulse. The whole process of emitter location estimation, tasking of ASARS-II or Joint STARS, and interpretation of the returned radar imagery would take much longer than would emitter location estimation by PLSS.

- Alternatively, AN/TPQ-37 "Firefinder" radars could be used to locate SAM launchers as soon as they fire. The nominal range of these radars is less than that of the above-mentioned systems, although they might detect large SAMs at greater than nominal range.
- The originally planned ability of PLSS to provide in-flight target updates to aircraft and missiles could be emulated by using Joint STARS aircraft to relay updates from the surrogate sensors to aircraft and missiles. To receive target updates, each attack aircraft or missile would have to be equipped with a Joint STARS Weapon Interface Unit.
- An alternative to providing missiles with in-flight target updates would be to attack emitters with long-endurance ARMs which have loiter capability, such as the TACIT RAINBOW missiles being developed for the Air Force. Unlike a PLSS-guided missile, an ARM could not attack a radar antenna after it ceases radiating. However, a TACIT RAINBOW missile could loiter until a target radar turns on again (or until its fuel is exhausted).

Summary

PLSS continues to be troubled by technical problems, but its performance is improving and it could provide unique and valuable RSTA and attack control capabilities. Some, but not all, capabilities demonstrated by PLSS could be provided in the near term by combinations of other systems such as Joint STARS and the Tactical Reconnaissance System. The Commander in Chief, United States Air Forces Europe (CINCUSAFE) has judged that the additional capabilities of PLSS are not worth its cost in resources diverted.

UNMANNED AERIAL VEHICLES

Unmanned aerial vehicles[50] could be used to perform RSTA for FOFA. They would be cheaper than manned aircraft and less hazardous to pilots. Small UAVs could not simultaneously provide the coverage and revisit rate that Joint-STARS would. However, they could reconnoiter more limited areas, particularly areas masked from Joint STARS by terrain and vegetation, and could be used to distinguish armored from unarmored vehicles. They could support attacks using MLRS or ATACMS; close in, they could be used for artillery fire direction and adjustment. UAVs are being developed for the Army, Navy, Air Force, and Marine Corps; others are in development, production, and use by allied nations.

UAVs which could be used for FOFA include:

- the Aquila RPV, which is being developed for the U.S. Army[51] to perform reconnaissance and target designation functions primarily in support of close combat;
- various domestic and foreign-made "non-developmental" UAVs which have been proposed as alternatives to Aquila;
- smaller "Light Division UAVs" of more limited capability to support smaller units;

[50] Unmanned aerial vehicles (UAVs) include remotely piloted vehicles (RPVs)—unmanned aircraft which require remote control by human pilots-as well as autonomous aircraft (drones), which do not. They also include aerial vehicles which permit, but do not require, remote control by human pilots.

[51] By the Austin Division of the Lockheed Missiles& Space Co.

- a larger, longer-range Intelligence and Electronic Warfare (IEW) UAV which could perform multiple missions to the depth of a corps commander's area of interest;
- expendable UAVs for jamming and lethal attack ("kamikaze UAVs");
- air-launched UAVs for reconnaissance, jamming, and lethal attack; and
- advanced-technology UAVs, in the more distant future.

The Aquila RPV

The Aquila (figure 10-3) is the airborne platform used by the Target Acquisition Designation Aerial Reconnaissance System (TADARS), which also includes truck-mounted rail launchers, recovery nets, air vehicle transporters, maintenance shelters, and ground-control stations. The Aquila RPV is intended to perform reconnaissance, target acquisition, artillery fire adjustment, and damage assessment, and laser designation of targets for the Copperhead cannon-launched guided projectile (CLGP), Hellfire and the AGM-65E Maverick[52] anti-armor missiles, and laser-guided bombs. Aquila carries a Modular Integrated Communications and Navigation System air data terminal (MICNS ADT) and a mission payload system (MPS) consisting of a laser rangefinder/designator system and a TV camera (for daytime use). It could carry other payloads which are now being developed—e.g., a forward-looking infrared (FLIR) sensor (for daytime or nighttime use), or a bistatic radar module for detecting vehicles illuminated by a Joint STARS radar or aircraft illuminated by an AWACS radar.[53]

Problems and Progress

The TADARS program schedule and budget have been overrun several times. The program office and the prime contractor attribute major delays primarily to unforeseen difficulties meeting payload mass constraints, stabilizing the TV camera and especially the laser designator, and operating with the data rate reduction and processing delay incurred when the MICNS is operated at high anti-jam levels.[54] Human factors were also cited: in some early tests, TADARS was operated by contractor personnel or by highly trained aviation or intelligence specialists. The program has since been transferred from the Army's Aviation Systems Command (AVSCOM) to the Missile Command (MICOM), and in recent tests TADARS has been operated by personnel of lower Military Occupational Specialty (MOS) level (Specialist 4).

The ability of the program to achieve its technical goals appeared doubtful in September 1985, when the Army stopped the developmental test program after test systems failed to pass 21 of 149 performance specifications. Subsequently, Lockheed's Austin Division conducted, at its expense, a test-fix-test effort, and demonstrated correction of most shortcomings, as well as an ability to designate stationary and moving targets for Copperhead shells and Hellfire missiles.

During Developmental Test 11A, begun in February 1986, TADARS met all but two system performance specifications: total system mission reliability (0.75 specified for IOC, 0.62 demonstrated) and probability of autotracking for 95 percent of 3 minutes (0.9 specified, 0.75 demonstrated). TADARS subsequently exceeded the total system mission reliability specification during collective training (0.77 demonstrated), and Lockheed reports that an autotrack probability of 0.92 was demonstrated in subsequent company tests.[55]

[52] A Marine Corps weapon launched from A-6E Intruder aircraft to provide close air support to Marines, who now designate targets using the hand-held Modular Universal Laser Equipment (MULE) to assist A-6 crews with IFF (identification: friend or foe).

[53] Dom Giglio and Phil Emmerman (USA HDL), "Radar Technology/Signal Information Processing, in Symposium, 28-30 January 1986, Reconnaissance, Surveillance, and Target Acquisition (RSTA), Compendium of Government Briefings, Volume 2 (Adelphi, MD: U.S. Army Harry Diamond Laboratories, 1986)].

[54] A non-secure data link was used in early tests.

[55] Lockheed Missiles & Space Co., Inc., Austin Division, briefing to OTA staff, Dec. 10, 1986.

Figure 10-3.—The Aquila Remotely Piloted Vehicle

SOURCE Lockheed Missiles & Space Co Inc (Austin Division)

Status

As of March 1,1987, TADARS is in full-scale development. $820 million[56] has already been appropriated for RDT&E through fiscal year 1987; 12 air vehicles and 5 Remote [MICNS] Ground Terminals (RGTs) have been procured for development, testing, and evaluation. The Army proposes to begin serial production of air vehicles and Ground Control Stations this year for an initial operational capability (IOC) date of 1991. The Army currently plans to procure a total of 376 air vehicles and 53 Ground Control Stations. The Army estimates that total program acquisition cost will be $2.2 billion-i. e., appropriation of about $1.4 billion more will be required.

Alternatives to Aquila

Problems with TADARS have stimulated suggestions that a domestic or foreign-made "non-developmental" UAV be procured as an alternative to Aquila. UAVs which could perform some of the functions of TADARS include:

- Skyeye (made in the United States by Lear-Siegler)

[56] In current (i.e., "then-year") dollars,

- Pioneer 1 (made in Israel by AAI/ Mazlat)[57]
- CL-289 (made in Canada by Canadair)
- Heron-26 (made in Italy by Meteor)[58]
- Mirach-100 (made in Italy by Meteor)
- Phoenix (made in the United Kingdom by GEC Avionics)

Two of these—Skyeye and Pioneer l–are now in service with U.S. forces but are not specifically designed to operate in the climate and jamming expected in central Europe and do not have the target location and designation capabilities of TADARS. In fact, none of these meets all specifications for, or provides the capabilities of TADARS, and modification of one to have capabilities roughly comparable to those of TADARS would probably cost more and take longer than would completing development and procurement of TADARS.[59] Now that TADARS is performing as specified, arguments for procuring one of these UAVs in place of TADARS rest upon cost rather than performance or schedule: A reconnaissance UAV with no laser designation capability and little[60] or no jam resistance could be purchased immediately and at lower cost, although delivery might take as long as delivery of Aquila.

However, procurement of one of these in lieu of TADARS would have the following drawbacks:

- None of these meets all specifications for TADARS, which requires use of components, and assembly, testing, and documentation practices which meet standard military specifications.
- None of these could provide the target location accuracy of TADARS without relying on an operator to identify map features on the TV display. Their target location errors (without such map-display correlation) are too large to locate targets for artillery and missiles but adequate to locate targets for aircraft flying armed reconnaissance missions or to cue sensors which could locate targets more accurately.
- None of these, without modification, could designate targets by laser. This would seriously limit utilization of Copperhead;[61] however, with its range of about 16 kilometers, Copperhead could reach only about 10 kilometers beyond the FLOT.
- Some have inferior or nonexistent electronic counter-countermeasures (ECCM). For example, the Pioneer-1, entering service with the U.S. Navy and the U.S. Marine Corps for evaluation, lacks ECCM to protect its data links from jamming,[62] as does the Skyeye RPV, which has been used by the Army in Thailand and Honduras. Good ECCM will be essential to counter Warsaw Pact jamming in Europe; RPVs with inadequate ECCM might be of little value.
- None has a target-autotrack feature; none is designed to interface with TACFIRE and AFATADS. Most lack ballistically hardened ground control stations with nuclear-biological-chemical protection.[63]
- Some have radar cross-sections higher than that of Aquila, but the differences are of little consequence.[64]

[57] The Pioneer 1 is a successor to Mazlat's Mastiff Mk3 and Scout-800 RPVs, which are no longer offered for sale.

[58] The Heron-26 is an improved version of Meteor's Mirach-20 "Pelican," Its manufacturer, Meteor Costruzioni Aeronautiche ed Elettroniche, is represented in the United States by Pacific Aerosystems.

[59] U.S. Congress, General Accounting Office, *Aquila Remotely-Piloted Vehicle: Recent Developments and Alternatives* (Washington, DC: General Accounting Office, report GAO/NSIAD-86-41BR, January 1986). This would require installation of the MICNS ADT, laser rangefinder/designator, and TV (or FLIR) camera developed for Aquila.

[60] GEC Avionics Phoenix and its ground station both use highly directional antennas, which would contribute to the claimed jam resistance of its control and data links, Meteor claims that the data link of its Mirach-100 is jam resistant. OTA knows of no analysis that compares the jam resistance of these systems with that of TADARS. The uplink (control link) of the Pioneer 1 has anti-jam features; its downlink (data link) relies on terrain masking against ground-based j ammers.

[61] Unless Copperhead seekers are replaced by autonomous seekers now being developed. See U.S. Congress, Office of Technology Assessment, *Technologies for NATO's* Follow-On Forces *Attack Concept—Special* Report, OTA-ISC-312 (Washington, DC: U.S. Government Printing Office, July 1986).

[62] B. M. Greeley, Jr., "Symposium Display Underscores RPV Advances, Service Needs, " *Aviation Week and Space Technology*, Aug. 4, 1986, pp. 124-125.

[63] The ground control station for the Phoenix has nuclear-biological-chemical environmental protection; ballistic protection is not claimed.

[64] Doubling a UAV's radar cross-section would increase by only 20 percent the range at which it could be detected by enemy radar.

The Light Division UAV

The Army is developing a "Light Division UAV" which is smaller and of lesser capability than Aquila. It could be more easily launched, controlled, and recovered by Army division elements operating near the FLOT.

The IEW UAV

The Army hopes to field a larger, longer range Intelligence and Electronic Warfare (IEW) UAV by late 1987. The Army plans to select a non-developmental platform this summer after a fly-off;[65] candidates may include some RPVs which have been proposed as alternatives to Aquila, as well as others.[66] It could fly to the depth of a corps commander's area of interest, carrying some of the UAV payloads now being developed by the Army to perform surveillance (by means of synthetic-aperture radar, MTI radar, and infrared or millimeter-wave passive thermal imaging); collection of electronic intelligence, communications intelligence, and meteorological intelligence; communications relaying; and radar or communications jamming.[67] With some of these payloads, the UAV could be very valuable for FOFA.

Expendable UAVs

The Army is also developing expendable UAVs to perform jamming and to support special operational forces, as well as "kamikaze" UAVs to attack certain targets. Although useful for FOFA, these would not be intended primarily for RSTA.

Air-Launched UAVs

The Navy and Air Force are developing air-launched UAVs for reconnaissance, jamming, and lethal attack. An air-launch capability could give them great range and simplify their employment in coordination with strikes by manned aircraft.

Advanced-Technology UAVs

These concepts do not begin to exhaust the possibilities of UAVs which could someday perform RSTA for FOFA. UAVs incorporating advanced technology (e.g., radioisotope-powered heat engines) or merely ingenious design could operate for very long periods at high altitude.[68]

Issues and Options

TADARS has been an issue in Congress primarily because its schedule and budget have been overrun. Congress has several options for future funding of TADARS:

- Congress could fund procurement of TADARS and development of a FLIR for TADARS, subject to the requirement (stipulated in the fiscal year 1987 Defense Authorization and Appropriations Acts) that TADARS meet performance specifications and that the Army negotiate a contract which limits its liability.
- Congress could deny funding for TADARS and express an expectation that the Army would cancel the program and make do without TADARS. This would save money, and some functions which TADARS was to perform could be performed by other systems.[69] The effectiveness of artillery and MLRS—which can be used for

[65] Private communication.

[66] Don Dugdale, "Tapping the Potential of Unmanned Air Vehicles," *Defense Electronics*, October 1986, pp. 109 ff.

[67] Don Kurtz (NASA Jet Propulsion Laboratory), "The ADEA UAV Payload Testbed Program," in Symposium, 28-30 January 1986, Reconnaissance, Surveillance, and Target Acquisition (RSTA), Compendium of Government Briefings, Volume 2 (Unclassified) (Adelphi, MD: U.S. Army Harry Diamond Laboratories, 1986). See also vol. 2 of this report.

[68] See, e.g., R. Dale Reed, "High-Flying Mini-Sniffer RPV: Mars Bound?" *Astronautics and Aeronautics*, June 1978, pp. 26-39; Victor C. Clarke, et al., "A Mars Airplane?" *Astronautics and Aeronautics*, January 1979, pp. 42-54; and vol. 2 of this report.

[69] For example, acquisition of moving targets for MLRS could be performed by Mohawk now, or by Joint STARS or the Army's proposed IEW UAV in the future, if these programs continue. However, Mohawk imagery is not available continuously or in real time, and the IEW UAV is not required to locate targets with great precision or to designate them with a laser.

short-range FOFA— would suffer without TADARS.

- Congress could deny funding for TADARS and express an interest in considering a request for appropriations to procure a non-developmental U.S. or foreign-made UAV. No such UAV has the capabilities of TADARS, and many would be too susceptible to jamming or environmental extremes, but some could perform RSTA for FOFA.

Concern about duplication of effort has emerged as another issue because of the apparent proliferation of UAV programs. Congress addressed this in the fiscal year 1987 Defense Authorization and Appropriations Acts, which required the Department of Defense to submit a "Master Plan" for UAVs with its fiscal year 1988 funding request. This "Master Plan" should justify the capabilities required of the various UAVs now in development and may indicate why a diverse mixed force is preferred over a smaller force of multi-role UAVs.

Summary

Unmanned aerial vehicles could perform RSTA for FOFA. Small UAVs could not have the coverage and revisit rate of large airborne radars such as Joint STARS, but they could reconnoiter limited areas masked from Joint STARS by terrain and vegetation and could distinguish armored from unarmored vehicles. UAVs are being developed for the Army, Navy, Air Force, and Marine Corps, and by our NATO Allies.

The Army's TADARS could perform short-range RSTA for FOFA. It appears that all major problems which have plagued TADARS have been corrected. Completing development and procurement of TADARS would probably be quicker and no more costly than procuring and modifying a different RPV system to have comparable capability. Some other U.S. and allied UAV systems are cheaper but less capable; many are unsuitable for use in Central Europe, but some could be useful for FOFA. Some U.S. and allied UAV systems now in development could perform RSTA for FOFA at longer range; the Army's IEW UAV may be particularly useful.

THE TWO-WAY STREET: OPPORTUNITIES FOR COOPERATIVE DEVELOPMENT AND PRODUCTION OF RSTA SYSTEMS

Because of security concerns and technological disparity, development and production of RSTA systems usually provide fewer opportunities for Alliance cooperation than do development and production of weapons and munitions. However, the United States has recently bought some foreign-made reconnaissance systems— Israeli RPVs—and could buy others from its NATO partners. Candidates include unmanned aerial vehicles, Airbus Industrie A300 aircraft for use as platforms for Joint STARS, and equipment which would enable Joint STARS Ground Station Modules to receive, process, and display radar imagery from allied airborne radar systems such as the British ASTOR I and ASTOR C systems and the French ORCHIDEE system. Candidate UAVs were discussed above, in the section on UAVs; this section discusses opportunities for cooperation with Allies in producing airborne radar systems.

Interoperable or Co-Produced Airborne Radar Systems

The Airborne Radar Demonstrator System (ARDS) project is a U.S.-British-French effort to achieve interoperability[70] of airborne sur-

[70] Specifically, level-4 interoperability: compatibility at the data link level and below, in terms of the Open Systems Interconnection (0S1) terminology defined by the International Standards Organization (1S0).

face-surveillance systems. ARDS is directed by Project Group 21 (P/G 21) of NATO's National Army Armaments Group (NAAG). Among the airborne platform/sensor configurations being evaluated are:

1. The ASTOR-I Airborne STand-Off Radar system[71] developed for the British Ministry of Defense. It uses a Ferranti MTI radar on a Pilatus Britten-Norman BN-2T twin-turboprop Islander.[72]
2. The ASTOR-C system, which consists of a British Aircraft Corp./English Electric Canberra twin-turbojet platform carrying a fixed-target-indicating Demonstration Synthetic-Aperture Radar (DEMSAR), which is based on the design of the U.S. UPD-7 radar.
3. The French ORCHIDEE[73] radar system—now in development—which will be carried by Super Puma helicopters.[74]

The ASTOR-I and ASTOR-C were designed to record radar data for post-flight processing; they have no airborne data link. They would be of much greater utility for FOFA if equipped with a data link to permit near-real-time exploitation. In one series of demonstrations by P/G 21, an ASTOR I platform used a Joint STARS Surveillance and Control Data Link air data terminal to transmit MTI data to a Joint STARS Ground Station Module. P/G 21 may also attempt to demonstrate the capability of an SCDL air data terminal to transmit raw fixed-target imagery ("phase history") from a ASTOR-C DEMSAR to a GSM for processing and display by equipment which would have to be added to the GSM.

ORCHIDEE platforms will be equipped with Electronique Serge-Dassault (E SD) data link terminals to transmit MTI information to similarly equipped ORCHIDEE ground stations. Army GSMs could be adapted to receive and display MTI information from ORCHIDEE in a variety of ways. The most straightforward would be for ORCHIDEE ground stations to transmit MTI information to Army GSMs via electrical or optical cable or using the French-Belgian RITA mobile telephone equipment now being procured by the Army. P/G 21 is likely to attempt a demonstration of ORCHIDEE/GSM interoperability in this fashion. Alternatively, ORCHIDEE platforms could be equipped with SCDL air data terminals for two-way or down-link data communications with similarly equipped GSMs.

If ASTOR or ORCHIDEE platforms were equipped with SCDL equipment, GSMs could receive and exploit the information they collect. With relatively little modification, GSMs could receive and exploit MTI data from ASTOR-I or ORCHIDEE; processing and exploitation of fixed-target imagery from ASTOR-C would require more extensive modification. These interoperabilities, if implemented, would provide Army users with additional sources of airborne MTI surveillance data and would provide U.S. GSM equipment manufacturers with opportunities for foreign sales or production licensing.

Airbus Industrie A300 Platforms for Joint STARS

It appears that Airbus Industrie A300 jet transport aircraft could be modified to serve as platforms for Joint STARS prime mission equipment.[75] Modifications which the Air Force would probably require include interior reconfiguration and installation of militarized flight-deck avionics, single-point and air-to-air refueling ports, and a radome.[76] A300 aircraft, if ordered soon for use as operational platforms, could be modified and "stuffed" with Joint STARS prime mission equipment as soon as E-8As could.[77]

This possibility presents opportunities for the United States to purchase A300 platforms

"Formerly called CASTOR: Corps Airborne Stand-Off Radar.
"*Jane's All the World's Aircraft 1985-86* (New York: Jane's Publishing, Inc., 1985), pp. 297-299.
[73]Observatoire Radar Coherent Heliporte d'Investigation Des Elements Ennemis.
"Anon., "The Orchidee Battlefield Surveillance System,' *International Defense Review*, June 1986, p. 720.
"USAF, AF/RDPV, private communication.
[76]ANSER Corp., personal communication, July 22, 1986.
"They could not be ready for use as full-scale development platforms; two E-8As (modified and stuffed EC-18Bs) have already been ordered for full-scale development use.

for U.S. Joint STARS aircraft, for Allies to purchase Joint STARS prime mission equipment for use on allied Joint STARS aircraft, and for co-production of Joint STARS aircraft for U.S. and allied procurement. Allied use of Joint STARS would generate sales of GSMs or their components.

The Joint STARS Joint Program Office has proposed investigation of possibilities for Alliance cooperation on Joint STARS to the Air Staff. Neither the Air Force nor the Department of Defense have yet announced a position on the proposal.

Chapter 11

Technology Issues: Munitions and Delivery Systems

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Chapter 11
Technology Issues: Munitions and Delivery Systems

INTRODUCTION

Munitions currently in the inventory and being procured, as described in chapter 9, are designed mainly to attack soft area targets (e.g., formations of trucks or lightly armored vehicles, or field command posts) and hard fixed targets (bridges, power stations). The technologies embodied in these munitions—cluster munitions for soft area targets, large unitary munitions for fixed targets-are straightforward; the munitions themselves are relatively inexpensive and are considered effective against their intended targets. An important question is whether new anti-armor munitions now under development can be made effective and affordable.

New anti-armor munitions under development, called "smart submunitions, make use of sensors that autonomously search a target area for a tank and are designed to strike the tank on its lightly armored top surface, in some cases using novel lethal mechanisms. If successful, these smart submunitions will clearly add a major new capability to attack armored vehicles beyond line of sight and without direct operator control, but their very "smartness" leads to greater cost, greater technical risk, and greater risk of being spoofed by countermeasures. Thus, if, as a matter of policy and analysis, it becomes clear that substantial effort should be devoted to attacking tanks, a number of technological questions come into play concerning these new munitions:

- Can they be made to operate reliably, under realistic conditions?
- Can they be made to resist likely countermeasures? Or will the deployment of effective countermeasures impose a substantial economic or military cost on the enemy?
- Can these goals be achieved at a reasonable cost?

At this stage of development, it is not possible to say with confidence whether such a practical balance among reliability, countermeasure resistance, and cost can be achieved in the design of smart submunitions, nor which designs are most likely to succeed. To date, tests of prototype smart submunitions have been carried out under artificial conditions that make targets easier to detect—clear weather, high contrast backgrounds, and, in some cases, artificially enhanced thermal signatures. Because of the considerable differences between U.S. and Soviet armored vehicles (Soviet vehicles generally are harder to detect) and between the climates and terrain of U.S. test ranges and potential European battlefields (more often obscured by fog, rain, and vegetation), it is essential that testing be carried out with realistic targets, under realistic conditions. A rigorous testing program, such as that provided now by the Chicken Little and Special Projects efforts at Eglin Air Force Base, may well be an essential continuing element in the development and evaluation of these submunitions.

A second issue is the role of mines. Historically, mines have been relatively ineffective weapons and have received correspondingly little analytical attention. A major limitation was that they had to be emplaced by hand, a slow process that allowed little flexibility to react to changing circumstances. New technologies that permit mines to be delivered by aircraft or artillery may allow mines to play a more immediate and responsive role in the attack of armored units. For example, mines might quickly be emplaced immediately in front of a moving unit, creating a concentration of vehicles that could then be directly attacked. Such mines are now being procured; however, the lack of a clear doctrine for their employment appears to be hindering plans for the acquisition of significant quantities. Mines that incorporate new lethal mechanisms-giving them a high probability not only of halting or delaying a tank but of actually destroying a tank-are farther down the road. Again, the role that such a weapon could play in follow-on forces attack is a key question that needs to be addressed.

ANTI-ARMOR MUNITIONS

The development of effective anti-armor munitions for follow-on forces attack is complicated by two facts: First, the number of targets is large, and they are in enemy territory. An effective weapon will have to be able to engage multiple targets per pass, and will have to tolerate less than pinpoint delivery accuracy. Second, Soviet armored vehicles have over the past two decades undergone substantial improvements in armor protection, a trend that is continuing. Armor has become thicker, new materials such as ceramics which offer greater protection per pound than steel have been incorporated, and add-on reactive applique armors which are very efficient in deflecting high-explosive anti-tank munitions are being installed both on new tanks and as a retrofit on older tanks.[1]

All of this has meant that, to be effective, new anti-armor munitions must be able to penetrate greater thicknesses of armor and must have a higher probability of hitting the tank accurately—and ideally at a specific, vulnerable point on the tank's surface. Because armor protection has been concentrated on the front surfaces of tanks to meet the primary threat of direct fire from opposing tanks and infantry-fired anti-tank guided missiles, it is the top and bottom surfaces that are the most lightly protected and thus the most vulnerable. Almost all new anti-armor munitions designed to engage armored vehicles at some distance exploit these vulnerabilities. Increased probability of hitting a target is achieved, first, by making the munitions smaller so that more can be dropped over the target area; and second, in the case of "smart" munitions, by adding sensors that can detect the target and guide or aim the munition for an accurate hit.

There is, of course, nothing magic about top attack; indeed if the threat against tanks shifts substantially to top attack, future tanks may well be designed with added top armor protection. Clearly the most effective course in the long run–though likewise the most expensive—is to maintain a balanced variety of weapons that attack from all aspects, forcing the Soviets to make compromises in their tank designs. In the short run, however, top-attack weapons are likely to prove difficult to counter. As discussed below in the section on ballistic countermeasures, existing Soviet tank designs are not well suited to retrofitting with top armor because of the prohibitively large weight that effective armor would add and because of the need to maintain unobstructed air flow to the engine radiators.

The choice of warhead technology is another factor in armor/anti-armor competition. Armor which is most effective against one of the two principal types of warheads used in wide-area anti-armor weapons is not generally most effective against warheads of the other kind: Shaped-charge warheads typically penetrate greater thicknesses of armor than do explosively formed penetrators (EFPs) but can be more easily countered; EFPs typically penetrate less armor' but are harder to counter. If

I For more information, see vol. 2, app. 1 l-A, fig. 1 l-A-l.

'Not considered here is another important class of kinetic-energy warheads which are less suitable for submunitions: long, inert, preformed projectiles, such as are used today in armor-piercing, fin-stabilized, discarding-sabot (APFSDS) artillery rounds. They may be fired by an electromagnetic gun being developed by the Army, DARPA, and DNA. The Air Force's developmental high-velocity missile (HVM), although powered, is also a long, inert (i.e., nonexplosive), preformed projectile.

a proposed tank were expected to f ace a threat consisting primarily of warheads of a single type, its designers could optimize its armor against that type by trading off protection against the other type. An adversary's ability to use warheads of multiple types forces designers to forego ideal protection against one type in order to seek balanced protection against all.

Top-Attack Munitions

Three generations of top-attack munitions could be used for FOFA. These are cluster munitions (the current generation), and two generations of "smart" submunitions now in development: sensor-fuzed and terminally guided submunitions.

Cluster Munitions

Current-generation anti-armor munitions are unguided cluster bombs. They blanket a large area with a randomly dispersed shower of small bomblets. The air-delivered Rockeye, the Combined Effects Munition (CEM), the German MW-1 submunition dispenser system, and the artillery- or MLRS rocket-delivered Improved Conventional Munition (ICM, also called DPICM: dual-purpose improved conventional munition) all incorporate armor-piercing shaped-charge warheads. The armor-penetration capability of these munitions is, however, small, so they are most effective against trucks and lightly armored vehicles such as self-propelled artillery, armored personnel carriers, and infantry fighting vehicles. Against tanks, they are effective only if one of the bomblets strikes the vulnerable area over the engine compartment and the turret—which can be as little as 1 square meter out of 15 square meters of surface on the top of the tank. Because the typical pattern on the ground of these munitions is one bomblet per 20 square meters, the probability of stopping a tank is obviously not very great.[3] But against soft targets, cluster weapons have the potential to cause multiple kills per shot;[4] they are also relatively inexpensive (see table 11-1); and the technology and manufacturing experience are well in hand.

Possible countermeasures include the use of applique armor to add extra protection to lightly armored vehicles and armor skirts[5] to protect the vulnerable tires and radiators of trucks, dispersing vehicles, and emplacing vehicles such as self-propelled artillery in earth revetments.

Sensor-Fuzed Munitions

A second generation of anti-armor munitions–the first generation of "smart" anti-armor submunitions—is now under full-scale development (see figure 11-1). These submunitions--called sensor-fuzed munitions-employ autonomous sensors that detect a vehicle and trigger the firing of an explosively formed penetrator, also known as a self-forging fragment, at the target. The use of a sensor to replace the random scattering of cluster munitions can increase the kill probability, so fewer munitions would be wasted on empty space, and fewer rounds have to be fired or fewer sorties flown to achieve the same result. The sensor can also select a particular, vulnerable aimpoint. Thus the air-delivered Skeet submunition uses an infrared sensor to find the hot engine compartment of a target vehicle; the artillery-delivered SADARM uses a combination of infrared (IR) and millimeter-wave (MMW) radar sensors to locate the center of the tank, where the turret is.

These warheads are expected to be effective in top attack against existing Soviet tanks; the retrofitting of top-attack protection armor to these vehicles would be very difficult.' The major lethal effect of the explosively formed penetrator against armor, however, results from spalling: bits of metal fly off the inside of the vehicle's armor at high speeds when the

[3] 1ncreasing the density of bomblets so as to increase the number of hits per tank becomes a losing proposition because the area of empty space between tanks is much greater than the area of tops of tanks.

[4] Some submunitions, such as GEM, DPICM, and the A PAM (anti-personnel, anti-material) also include fragmentation charges that can destroy a truck without hitting it.

[5] For more information, see note 1, app. 11-A, vol. 2.

[6] For more information, see note 2, app. 1 l-A, vol. 2.

Table 11-1.—Anti-Armor Munitions

	Status	Delivery	Targets	Representative cost*
TOP ATTACK MUNITIONS				
Cluster munitions (small shaped charge; unguided)				
Rockeye	inv	air	trucks, self-propelled	$100
MW-1	inv	air	arty, other light armor	(20,000)
CEM	proc	air		
ICM	proc	arty/MLRS		
Sensor-fuzed munitions (explosively formed penetrator; sensor)				
Skeet	FSD	air	same as above	5,000 (200,000)
SADARM	FSD	arty/MLRS	same plus current infantry vehicles, some tanks	
Terminally-guided munitions (shaped charge; guided)				
MLRS-TGW	R&D	MLRS	same plus	50,000
IRTGSM	R&D	ATACMS	tanks	(1,000,000)
MINES				
Scatterable mines				
GATOR	proc	air	armored vehicles	500
RAAM	proc	arty		(50,000)
AT-2	FSD	MLRS		
Smart mines				
ERAM	dead	air	armored vehicles	10,000
Army mine	R&D	arty, helo		(100,000)

*cost per individual submunition (cost per 1,000-lb load)

arty:	artillery
inv	Inventory
light armor	armored combat vehicles, excluding tanks
proc	procurement
FSD	full-scale development
R&D	research & development prior to FSD

warhead strikes and have a high probability of killing the crew. Tanks being transported on trucks or trains to the front, without crews, fuel, or ammunition on board, may suffer little damage from these munitions. In some cases the munitions may do little more than drill a small hole that can later be patched or ignored.

In the long run, new tanks might be designed with armors that could defeat munitions of current designs without adding prohibitively to the overall weight of the vehicle.[7] To increase the penetrating capacity of explosively formed penetrators to match these improvements would mean increasing the caliber of these munitions, thereby undoing the key objective of carrying multiple munitions in each rocket, artillery shell, or aircraft dispenser load.[8] But these developments in Soviet armor are many years' away and of course do not come easily or cheaply: they will be expensive and will still likely add some weight to the tank. The paramount issue in considering countermeasures is not simply whether they are possible, but rather what cost they impose on the other side in terms of economics, weapon effectiveness, flexibility, and so on.

Because the search area of these munitions is small,[10] they are most effective when used against concentrated groups of vehicles. The small search area allows relatively unsophisticated sensors to be used, keeping costs down. But placing the job of detecting the target in the hands of an autonomous sensor, without human intervention, raises the obvious possibility that these weapons can be fooled,[11] possibly by standard camouflage techniques that

“For more information, see note 3, app. 1 l-A, vol. 2.

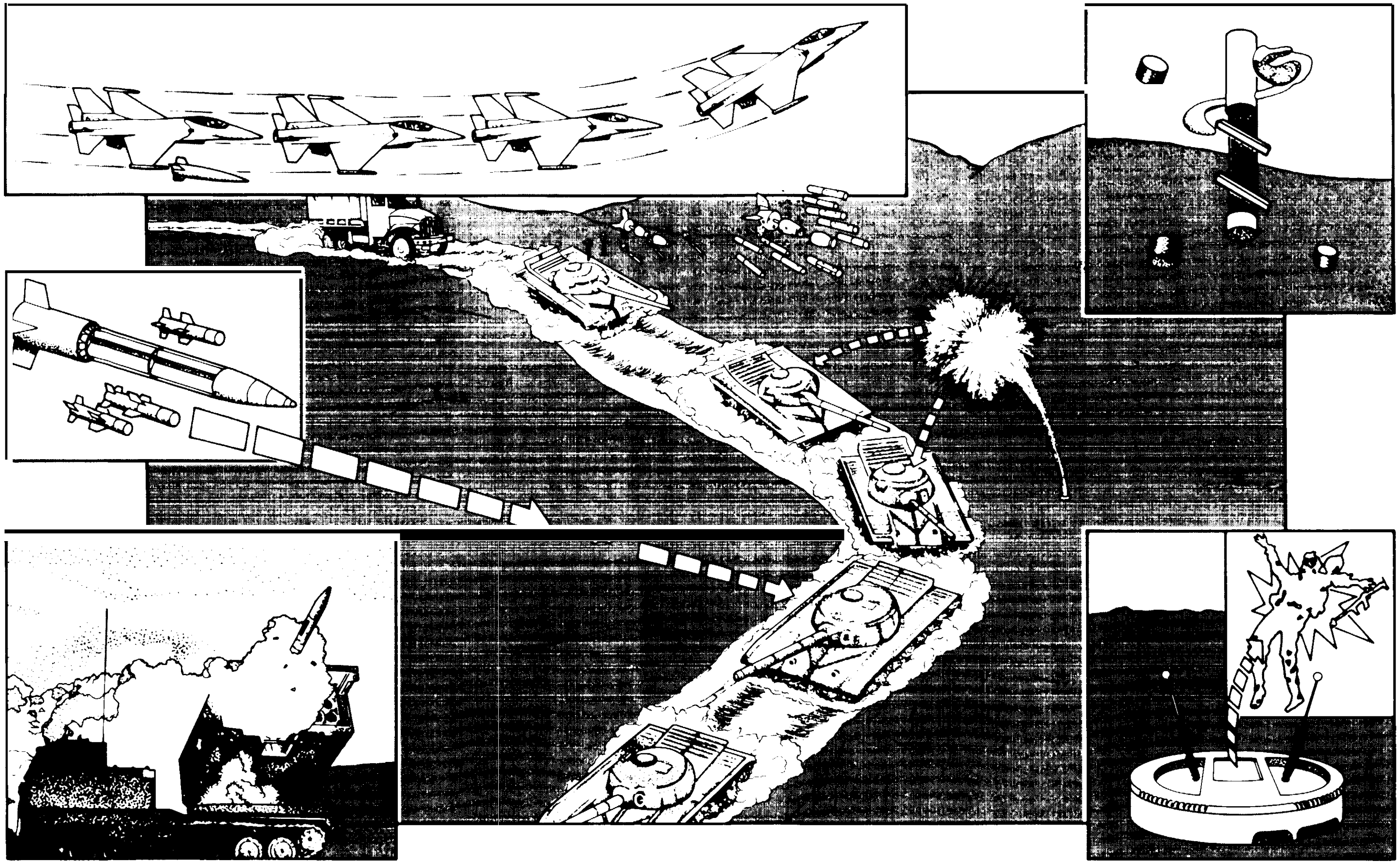
‘Defense Science Board, Armor Anti-Armor Competition (Washington, DC: U.S. Department of Defense, OUSDRE, Final Report, October 1985), p. B-5; T. Hafer, Warhead Technology Options (Arlington, VA: System Planning Corp., Final Summary Report SPC 924, June 1983), p. 13.

‘For more information, see note 4, app. 1 l-A, vol. 2.

[10]For more information, see note 5, app. 1 l-A, vol. 2.

[11]For more information, see note 6, app. 1 l-A, vol. 2.

Figure 11-1.—Smart Anti-Armor Submunitions



Terminally guided submunitions (TGSMs): More widely dispersed targets could be attacked by terminally guided submunitions, such as the Terminally Guided Warheads dispensed by MLRS rockets. These would search for, steer toward, and fly into tanks, detonating a shaped-charge warhead on impact. Three or six TGWs might be dispensed from each rocket (inset, left center), 12 of which could be carried and launched by each MLRS transporter-launcher (inset, below left), which could, alternatively, carry two longer range ATACMS missiles armed with TGSMs.

Smart mines: Two Skeet could also be lobbed toward the tanks by each of nine smart ERAM mines previously scattered along or beside the road (right center) from a TMD. As each Skeet descends, it spins and searches for tanks; if it detects one, it fires an explosively formed penetrator at the tank's engine compartment. Each mine (inset, below right) could also sense footsteps of approaching troops and lob three antipersonnel fragmentation grenades to hamper mine-clearing.

SOURCE: Office of Technology Assessment, 1987.

the Soviets are known to practice, such as placing fresh foliage or nets over the vehicle, which reduces the ability of these simple sensors to detect them against background "noise" or "clutter."[12]

Clutter is a particular problem when vehicles are in wooded or urban terrain, as they would be when halted in assembly areas; it is less of a problem when vehicles are on open roads. Camouflage becomes less practical as the tanks approach the area of the direct battle; camouflage piled on top of a tank to conceal it from overhead observation by humans or electronic sensors makes it more visible to direct line of sight observation. The use of smoke or metallic chaff to obscure sensors or decoys to distract them could be effective, but these methods are, from an operational point of view, far less practical.

The choice of sensor makes some difference in which countermeasures are likely to be most effective; however, both IR and MMW sensors have their vulnerabilities (see table 11-2).[13] Increasing the sensitivity of the sensors can help to detect camouflaged targets, but also drives up the false alarm rate. Use of multiple sensors in different wavelength bands ("dual-mode" sensors) can likewise help to discriminate between real targets and clutter; but that greater discrimination is paid for in greater cost and, possibly, reduced reliability. Extensive testing under realistic conditions will be needed to determine whether a practical balance between countermeasure resistance and cost can be achieved in the design of these munitions. The Army-Air Force Chicken Little and Special Projects test programs and the work of the Army Vulnerability Assessment Laboratory should provide much of this needed data.

[12] Briefings from the "Chicken Little" program office, Eglin Air Force Base, and U.S. Army Vulnerability Assessment Laboratory, White Sands Missile Range.

[13] These are discussed in more detail below in the section on sensor countermeasures.

Table 11-2.—Smart Submunition Sensors

	Sensor Mode	
	Infrared (IR)	Millimeter-Wave (MMW)
advantages	aimpoint accuracy	performance in weather
disadvantages	targets must be hot; Soviet tanks are I R-suppressed; affected by weather; decoys possible	jamming possible; multi-domain analysis necessary to reject simple decoys

The problem of dealing with countermeasures aside, costs are very uncertain at this stage. Although the fundamental technology involves no new concepts, no manufacturing experience exists for some key elements, particularly sensors.[14] Likewise, although the Assault Breaker project of the Defense Advanced Research Projects Agency demonstrated that the basic technology is feasible and available, it left unanswered the question of how much it will cost to produce a reliable total system. As shown in table 11-3, in none of the 14 flight tests carried out under Assault Breaker were all functions tested and found successful, although in three tests all functions tested were successful, including engagement of multiple targets by submunitions in one test. Successful demonstrations of prototype smart submunitions in Assault Breaker, and since, have taken place under artificial conditions-in clear weather, against low clutter backgrounds, and against targets with enhanced thermal signatures. Again, a thorough, realistic test program in the development stages could reduce this uncertainty.

Terminally Guided Munitions

Top-attack munitions, which are now in the research and development phase, employ sensors to locate the target and guide the munition into a direct impact. The terminally guided munition is larger than the sensor-fuzed munition, containing a larger, shaped-charge warhead and a more sophisticated-and considerably more expensive-electronics package that is needed to translate sensor images into steering instructions for the tail fins that guide it.[15]

[14] Defense Science Board, op. cit., p. C-2.

[15] For more information, see note 7, app. 11-A, vol. 2.

Table 11 -3.—Assault Breaker Results

Mission function	Missile													
	T-16										T-22			
Test number:	1	2	3	4	5	6	7	8	•	9	1	2	3	4
Target acquisition (radar)	—	—	—	U	U	S	S	S	—	—	—	—	—	S
Target position to missile	—	—	—	U	U	S	S	S	—	—	—	—	—	S
Missile launch	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Precision guidance (inertial)	U	S	S	S	U	S	U	—	S	S	S	S	S	S
Radar track target	—	—	—	U	U	S	S	S	—	—	—	—	—	S
Radar acquire and track missile	—	—	—	U	U	S	S	S	—	—	—	—	—	U
Radar provide guidance update	—	—	—	U	U	S	S	S	—	—	—	—	—	S
Missile trajectory correction	—	—	—	—	—	—	S	S	—	—	—	—	—	S
In flight dispense	—	P	S	S	P	S	S	S	S	S	S	S	P	P
Payload pattern generation	—	P	S	S	P	S	S	S	S	S	u	s	U	P
Payload descent functioning	—	U	U	U	S	U	—	—	—	S	U	U	U	P
Payload target acquisition and lock-on	—	—	S	U	S	U	—	—	—	S	—	—	—	—
Target engagement (single)	—	—	U	U	S	U	—	—	—	S	—	—	—	—
Target engagement (multiple)	—	—	—	—	U	U	—	—	—	S	—	—	—	—
Target engagement (moving)	—	—	—	—	—	—	—	—	—	—	—	—	—	—

S — successful test
P —partially successful test
U —unsuccessful test
— not tested
• — calibration test for fixed site radar used in test 9

SOURCE Steven L Canby, 'The Operational Limits of Emerging Technology, *International* Defense *Review*. August 1985, pp 875.880

This larger warhead is expected to have a greater kill capability than the explosively formed penetrator; it also has a much higher probability than the explosively formed penetrator warhead of causing catastrophic damage to a tank.

The search area of these munitions is greater than that of the sensor-fuzed munitions. Countermeasure issues are largely the same, but weather will be a greater problem because the terminally guided munitions begin their search at an altitude of 1 kilometer or so, and are therefore more susceptible to the absorbing effects of low-lying clouds.

A major issue is whether the larger search area and greater lethal effect of Terminally Guided Submunitions (TGSMs) as compared to sensor-fuzed weapons will justify their order-of-magnitude greater cost.

Mines

New "scatterable" mines and "smart" mines could also be used for FOFA. Mines have histonically been used to delay or harass enemy forces at best. The need to emplace mines by hand limited flexibility and imposed a large logistics burden as well. With the development of scatterable mines that can be deployed by aircraft or artillery (GATOR and RAAM, now being procured by the Air Force and Army, and the MLRS-delivered AT-2 under joint development by the United States and several European nations) and the incorporation of more effective lethal mechanisms, mines may play a more direct role in halting or destroying armored vehicles.

The major weakness of current remotely deliverable mines is that they are easily seen on roadways and can be easily cleared from roadways; in Warsaw Pact forces, several tanks per battalion have rollers or forks mounted in front for mine-clearing. The effectiveness of remotely deliverable mines will clearly be greater when used against a force moving off the roads.

"Smart" mines, which can sense and attack a tank at some distance, could command a road from concealed off-road positions.[16] They are,

[16] A more detailed description of these systems appears in OTA's earlier Technologies *for NATO's Follow-On Forces Attack Concept--Special Report, OTA-ISC-312* (Washington, DC: U.S. Government Printing Office, July 1986), pp. 33-34.

however, expensive, and they raise many of the same countermeasure, reliability, and cost issues raised by sensor-fuzed weapons. The Air Force recently decided against proceeding with full-scale development of its smart Extended-Range Anti-armor Mine (ERAM) for budgetary reasons; the Army is still studying the concept.

Countermeasures

The competition between new anti-armor weapons and increased armor protection is a continuing one. The critical questions are whether quick, easy, and inexpensive countermeasures can defeat the new weapon, and, if not, what cost is imposed on the defender if he decides to develop and deploy an effective counter. For example, anew anti-tank weapon may require the defender to place heavier armor on his tanks, increasing their weight, thus requiring larger engines which consume more fuel (increasing the logistics burden or hindering mobility) and requiring a larger vehicle which is more easily seen and hit on the battlefield. In addition, there is a synergism among munitions: The greater the variety of munitions, the more difficult becomes the job of defending effectively against them all. If, however, a new weapon could be defeated by a trivial change in operations or hardware, there is clearly a strong case against developing it.

Ballistic Countermeasures

A shaped-charge munition penetrates armor by detonating a precisely shaped explosive warhead which forms an intense jet of gas and molten metal. Explosively formed penetrators (self-forging fragments) are metal slugs which smash through armor by virtue of their high speed and mass—i.e., their kinetic energy. Although formed by explosives, they contain no explosives at the moment of contact with the target and are called kinetic-energy penetrators. The penetrating capabilities of these warheads are proportional to their calibers (i.e., diameters); a shaped-charge warhead can penetrate roughly 10 times deeper into ordinary steel armor than can a comparably sized explosively formed penetrator.[17]

On the other hand, shaped charges are much easier to defeat with current armors.[18] In the early 1960s, the only armors were aluminum alloys and steel. Increasing the thickness of such armors obviously increased protection, but at a considerable weight penalty. The trend in new armor development has thus been toward armors which achieve a level of protection equivalent to a given thickness of steel (usually expressed as millimeters of Rolled Homogeneous Armor Equivalent) with lighter new materials, such as ceramics, laminates, and reactive armors, which contain small explosive charges that detonate when struck by an incoming warhead, thereby deflecting the shaped-charge jet. These armors are not very effective against kinetic-energy penetrators, however.

Improved armor has been applied primarily to the front surfaces of tanks to protect them against the major threat on the battlefield—direct fire from enemy tanks and anti-tank weapons.[19] The tops of tanks remain relatively unprotected.

Thus the first-generation smart munitions (Skeet and SADARM), which contain explosively formed projectile warheads, are indeed sufficient to penetrate existing Soviet tanks with a top attack. Retrofitting existing tanks with additional top-attack protection does not appear feasible: a steel deck to protect the turret and engine deck of an existing tank would add a prohibitive amount of weight.[20]

Future tanks might use more efficient composite and hybrid armors to provide effective top-attack protection against Skeet and SADARM at a weight penalty less than that for steel armor.[21] Even so, there is always a

[17] A longer, preformed kinetic-energy penetrator (such as an APFSDS artillery round) can penetrate a thickness of homogeneous armor proportional to its length; it can be made to penetrate farther by increasing its length or velocity rather than caliber.

[18] For more information, see vol. 2, app. 11-A (note 8, table 1 l-A-2, and figure 1 l-A-2).

[19] For more information, see note 9, app. 11-A, vol. 2.

[20] For more information, see note 10, app.1 l-A, vol. 2.

[21] For more information, see note 11, app.1 l-A, vol. 2.

trade-off between using more efficient armor to add protection and using it to build a lighter tank with no additional protection. The hybrids and composites are not suitable for a retrofit to existing tanks because they must be made as an integral part of the armor; they cannot simply be bolted on top. Ceramics, for example, are brittle and have to be sandwiched between layers of steel in the manufacturing process. The effectiveness of these new armors against explosively formed penetrators cannot, however, be predicted with certainty by existing theoretical models; improvement of models is needed, as are simple controlled experiments.

Operational Countermeasures

Because the sensors employed on smart munitions can search only a limited area, perhaps the most obvious countermeasure is to increase the spacing between vehicles both on the road and when halted in assembly areas. This would have a greater effect on sensor-fuzed weapons than on TGSMs, which can search much larger areas.[22]

Another operational tactic that could reduce the effectiveness of smart munitions would be to take advantage of terrain that produces high "clutter" (natural background camouflage), making it difficult for the sensors to pick out the target from a sea of confusing signals. Urban areas produce severe clutter in both the IR and MMW bands; using towns as assembly areas would make an attack with these munitions very difficult.[23]

Weather may be exploited to counter sensors. Dry snow provides a very high clutter background that can swamp the signature of a vehicle. The frequently occurring low-level clouds and fog in central Europe interfere with the performance of IR sensors. Rain affects both IR and MMW sensors. Moving when visibility is poor and halting when it improves results in reduced vulnerability, as well as rate of advance.

Camouflage, Decoys, and Jamming

There are two basic technical approaches to fooling sensors. The target can be made to blend into the background, either by camouflaging the target or by artificially increasing the background noise or clutter level with electronic jamming, smoke, or chaff; alternatively, false targets can be created, either by deploying decoys or by broadcasting a carefully tailored signal which fools the sensor into thinking it has spotted a target.[24]

Counter-countermeasures for dealing with camouflage and clutter include the use of dual-mode (active and passive) and multi-spectral sensors (which are sensitive in more than one wavelength band), and the use of more sophisticated "multi-domain" analysis of the information obtained from a single-mode MMW sensor. For example, analysis of the delays of the echos of an MM W radar signal from different features of an object can yield information about the spacing of distinguishing features, which can help to distinguish a tank from background objects. Use of multiple wavelength bands increases the chances of finding one wavelength at which the background clutter at any given time will not be too bad.

These measures, of course, will increase the cost and complexity of the submunition and are not infallible. Multi-domain analysis, for example, reduces susceptibility to deception jamming but does not eliminate it, as discussed below.

Another approach to making target detection difficult is jamming. The aim can be simply to produce so much background noise that the target no longer stands out. To jam an active MMW sensor would require high power over a wide band of wavelengths and may be infeasible if the sensor has good counter-countermeasures.[25] The possible use of lasers

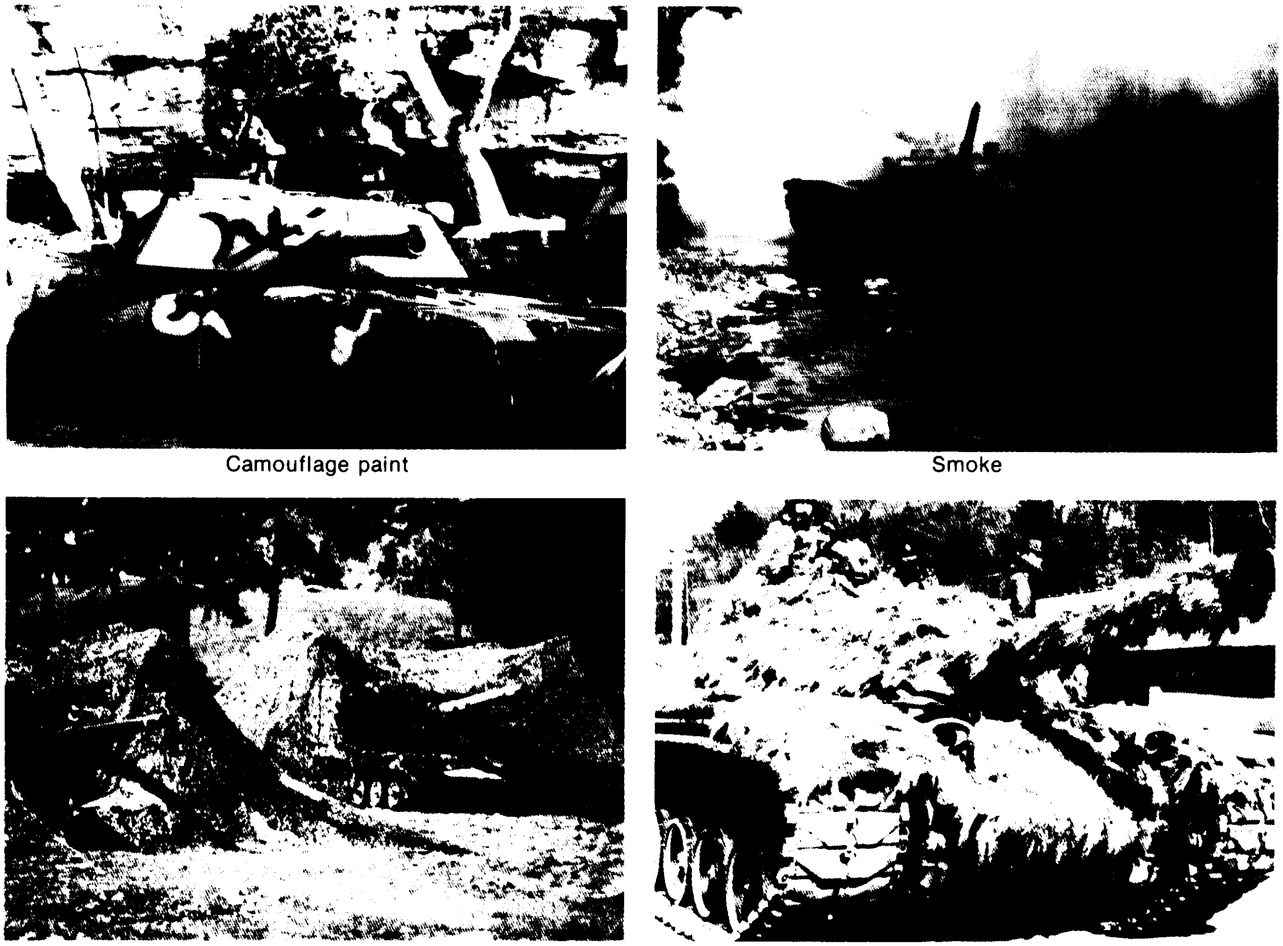
[22] For more information, see note 12, app. 1 l-A, vol. 2.

[23] Steven Canby, "The Conventional Defense of Europe: Operational Limits of Emerging Technology" Working Papers No. 55, International Security Studies Program, The Wilson Center, Smithsonian Institution, pp. 24-32; also briefing from Vulnerability Assessment Laboratory.

[24] For more information, see note 13, app. 1 l-A, vol. 2.

[25] Briefing from the U.S. Army Vulnerability Assessment Laboratory.

Examples of Simple Countermeasures



Camouflage paint

Smoke

Camouflage nets

Foliage

Photo credit: U.S. Department of Defense

to jam IR sensors has been raised; but tracking a rapidly moving submunition and aiming a laser at it is likely to be extremely difficult in practice.

Finally, smoke and chaff are standard deception devices. Soviet tanks are equipped with smoke generators, and the Soviets have considerable experience in using smoke to mask ground movements from visual observation. However, ordinary smokes are relatively transparent to IR and, especially, MMW radiation. Chaff might also be used.[26] To shield tanks against smart submunition sensors, the chaff would obviously have to be near the ground and would have to be renewed at least every few minutes; at the wavelengths in question, large quantities would be required. Both smoke and chaff suffer from the drawback that adequate warning of an attack is essential to their effective use.

Decoys in general pose less of a problem to sensors than do jamming or camouflage. Simple decoys, such as MMW corner reflectors, are easily rejected by multi-domain analysis. To fool multi-domain MMW sensors, decoys must resemble full-scale models, which obviously are of limited practicality. Simple IR decoys such as flares or fires **can** similarly be

[26] For more information, see note 14, app. 11-A, vol. 2.

rejected.[27] IR sensors may, however, be susceptible to decoys that more faithfully reproduce the power output and temperature of a tank engine.[28]

Even with multi-domain processing, active MMW sensors are susceptible to deception jamming–the broadcasting of signals which resemble the radiation reflected or emitted by a target, insofar as the sensor and its processor can determine. Deception jamming is not an inexpensive countermeasure, and it requires some knowledge of the operating wavelength of the sensor and its processing algorithm, but it is nonetheless straightforward from a technology point of view. The Soviets deploy a large variety of radar jamming equipment, and thus have the technical and operational base for developing and deploying such a system. Passive MMW sensors are also susceptible to deception jamming, which would require only modest power over a wide band of wavelengths simultaneously; while feasible, this would require several advanced-technology jammers.

[27]For more information, see note 15, app. 11-A, vol. 2.

[28]According to the Vulnerability Assessment Laboratory, such an I R decoy would require 1 kilowatt of primary power; a small propane bottle of the kind used for soldering torches or camping stoves could supply this power level for several hours.

DELIVERY SYSTEM ISSUES

Introduction

Aircraft today provide virtually the only means of delivering munitions to targets beyond the immediate battle area. Aircraft have a flexibility in deployment that ground-launched systems do not; they also place a human observer at the scene. They are limited, however, when used in direct attacks against follow-on forces: as discussed in more detail in chapter 9, few aircraft have a night or all-weather capability; all of the NATO aircraft that could play a role in attacking beyond the immediate battle area have other missions to perform as well; and the very heavy Warsaw Pact air defenses could result in significant losses of attack aircraft, particularly if those aircraft must fly very close to or directly over targets in enemy territory .29

The high cost, long development cycles, and long procurement programs for new aircraft mean that current aircraft-with the sole addition of the planned F-15E—will constitute NATO's ground attack air force at least until the turn of the next century.

The improvements in delivery capabilities that will occur over the next two decades or so can be expected to come principally from air-to-ground missiles that will allow attack aircraft to remain a safe distance from enemy air defenses,[30] and from ground-launched missiles that will complement aircraft in reaching deep targets, particularly at night and in bad weather or when aircraft are needed elsewhere. Missiles can incorporate precision guidance systems that offer substantial improvements in accuracy over that attainable with ground-based artillery, unguided rockets, or air-delivered free-fall bombs. High accuracy becomes crucial in attacking hard, fixed targets such as bridges and the increasing number of heavily fortified command, control, and communications facilities in Eastern Europe. And regardless of the type of target, to the extent that precision guidance can increase the probability of a kill, the use of missiles can reduce the number of sorties or rounds required to achieve a given objective.

“For more information, see note 16, app. 1 l-A, vol. 2.

Missile Guidance Technology

The propulsion and airframe technologies of missiles are mature. The chief technology choice in these systems is between ballistic missiles and cruise missiles. Ballistic missiles fly faster and thus can reach moving targets before they move far; cruise missiles have the potential to achieve higher terminal accuracy on target,

[30]Improved means for suppressing enemy air defenses are another important approach to this problem.

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though they may take hours rather than minutes to reach their targets and will require in-flight guidance updates or special seekers to hit moving targets. They may also be more vulnerable to interceptor aircraft and ground-based air defenses. The major area where new technology may play a role in airframe design is in the application of low-observable techniques to cruise missiles to reduce their vulnerability.

What distinguishes the major differing approaches to tactical missile design today and what most determines their differing capabilities is the technology used for guidance. Two different guidance functions-mid-course and terminal guidance—may be needed. These might use different technologies:

1. For guiding a missile to the general target *area-mid-course guidance-some* form of inertial guidance is almost always required. The only exceptions are very short range air-launched missiles that lock onto their targets before launch using one of the precision terminal guidance technologies described below,[31] or that fly their initial course in a pure ballistic trajectory. Although inertial guidance is a well-developed technology that has been used for decades aboard ships, aircraft, space vehicles, and ballistic missiles, the technology has historically been quite expensive; costs rise quickly with the increasing accuracy that is required for longer flight times. Thus, the major technical challenge in applying inertial systems to conventional missiles is reducing cost.

   The precise inertial systems used on nuclear-armed ballistic missiles or fighter aircraft, for example, cost far too much to justify their one-time use on low-cost, conventionally armed missiles. However, new technologies promise to reduce the cost of inertial guidance systems substantially, particularly for short-range applications. Inexpensive miniature inertial systems using fiber-optic gyros could be used in short-range weapons—and in longer range weapons, if complemented by any of several devices now available to recalibrate the system in flight (e.g., miniature Global Positioning System receivers). For the specific case of long-range attacks against moving targets, another important issue is whether the mid-course guidance system needs to include some means of receiving an in-flight update of the target's location.
2. For attacking hard fixed targets such as bridges or bunkers, mid-course guidance alone is not sufficient; precise *terminal guidance,* sometimes to within an accuracy of a meter or less, is needed. (For other types of targets, inertial guidance will as a rule suffice; if the missile can be delivered to within 100 meters or so of the target, cluster munitions can be used to attack soft area targets and smart submunitions to attack armored combat vehicles. See table 11-4 and, for a more

[31] To deliver such a missile, the aircraft must line itself up with a near straight-line path to the target. Inertial systems may be needed by short-range missiles that are to be able to fly to a target substantially off axis.

Table 11-4.—Missile Guidance Technologies

	Range	
Target Type	Short	Long
soft area fixed	Inertial	better Inertial
soft area moving		
(unarmored unit)	inertial	better inertial (+ automatic target recogition or In-flight target update for cruise missiles)
(armored unit)	inertial + smart submunitions	better inertial + automatic target recognition or in-flight target update + smart submunitions
hard fixed	man in loop or automatic target recognition	better inertial + automatic target recognition

SOURCE Office of Technology Assessment 1987

Box A.—Delivery Error Budget

Missiles that carry nuclear warheads can get by with inertial systems, even at very long ranges (thousands of kilometers for ICBMs) and even when targeted against hard point targets, because the kill radius of the warhead is large enough to tolerate inaccuracies often of hundreds of meters in delivery. However, when conventional warheads are used against hard fixed targets such as bridges, accuracies on the order of a meter are often essential: a specific support element of a bridge may have to be struck. Inertial systems operate by guiding the missile to an absolute geographic coordinate. Even if the guidance system were perfectly accurate, it would be limited by the uncertainty with which the absolute geographic coordinate of a fixed target is known-and that uncertainty is too large to allow the required one meter or less accuracy,

detailed discussion of the limitation of inertial systems in attacking fixed-point targets, see box A. Precision terminal guidance on existing missiles is achieved through the use of a human controller—a "man in the loop' '—who, for example, might observe the target through a TV camera mounted on the nose of the missile and steer the missile into it by radio control.

A key issue in precision terminal guidance is how much effort should be given to developing a next-generation system that can operate autonomously. An automatic target recognition system could reduce the burden on a human controller; in the case of air-launched missiles, for example, it would allow the pilot to launch his missile and immediately exit the area. In certain proposed missions that could strain the capabilities of man-in-the-loop systems (e.g., long-range attack of hard fixed targets), automatic target recognition may be essential. Yet the development of such systems involves a high technical risk; so far, none of the many laboratory efforts or prototypes have proved reliable enough to justify procurement, and indeed critics suggest that automatic target recognition faces fundamental obstacles that may prove insurmountable.

Mid-course Guidance

Inertial.—An inertial navigation system continually recalculates its current position by adding up the many small changes it senses in the missile's acceleration and rotation. Even small errors in those measurements are quickly compounded, causing the accuracy of the system to decrease with time (drift). Measures to reduce drift quickly drive up the costs of traditional mechanical inertial navigation systems.

The new technologies of ring-laser gyroscopes and (especially) fiber-optic gyroscopes promise to reduce the costs of inertial systems substantially, although not necessarily to improve performance. Such inexpensive and less accurate inertial systems could have important applications in short-range missiles (e.g., a short-range air-launched stand-off missile carrying smart submunitions that have a large search area to compensate for delivery errors), and in longer range missiles if used in conjunction with techniques to periodically recalibrate the inertial system. These techniques include the Global Positioning System satellites, which can provide, via an on-board receiver, a geo-

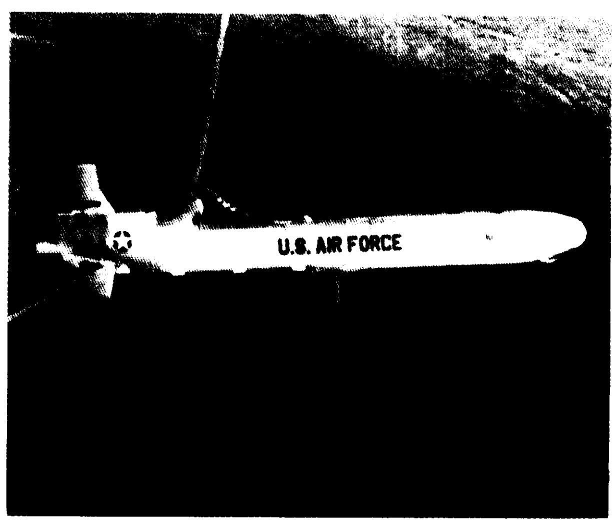

Photo credit U S Department of Defense

Air-launched cruise missile uses TERCOM and other precision guidance, graphic fix within 13 meters in absolute coordinates; and various map update systems such as terrain comparison (TERCOM) which, at set intervals, compares the terrain profile below with a stored map to correct any drift in the inertial system. GPS receivers are likely to be jammed in the immediate target area, so terminal accuracy is determined by the drift of the inertial system from the last (unjammed) update. The services have in addition been reluctant to place themselves in a position of having to rely on the survival of satellites in wartime. TERCOM, which is employed on existing U.S. cruise missiles, is an alternative technique, although mission planning is time-consuming, detailed maps are required, and thus retargeting flexibility is obviously very limited.

In-flight Target Location Update.–At longer range, a moving target will have moved farther by the time a missile arrives; this is especially the case for slow-flying cruise missiles. One possible solution, discussed below, is to equip a cruise missile with an automatic target recognizer so that it can search for the target as it flies a course along a likely route, such as a road. Another approach, employed in the Assault Breaker demonstration program (and applicable to both cruise and ballistic missiles) is to relay updated target location data to the missile in flight. This data would be developed by a radar surveillance and target acquisition system such as Joint STARS, and transmitted to the missile via a radio link.

Because of cost and technical problems, provision for an in-flight update was dropped from the design of at least initial versions of the Army Tactical Missile System (ATACMS); it maybe added later as a block improvement. Analysis has shown that the loss incapability due to lack of update is not severe for ATACMS. Technical issues that need to be considered are beaming of an update to a missile while lofted (or acquisition of the guidance signal by the missile at lower altitude in time to act on it) and the susceptibility of such an update link to jamming.

Precision Terminal Guidance

Man in the Loop.–The current generation of precision-guided conventional missiles makes use of technology that was first employed by the U.S. Air Force in Vietnam some 20 years ago. Human control of the missile is maintained to acquire and select the target and, in some cases, to guide the missile throughout its entire flight. A variety of techniques are used (see table 11-5); for example, a laser seeker

Table 11-5.—Guidance Technology—NATO Conventional Missiles

	Launch mode	Targets	Status	Guidance technology
primarily inertial				
conv. Tomahawk	sea	area	proc	inertial/TERCOM
ATACMS	ground	area, armor	FSD	inertial (ballistic)
SRSOM	air	armor	R&D	inertial (+ sensor?)
IAM	air	fixed	R&D	inertial
precision terminal (man in loop)				
HVM	air, ground	armor	FSD	laser command guidance (“beam rider”)
FOG-M	ground	armor	R&D	fiber-optic data link
MAVERICK	air	armor	inv	IIR lock-on before launch
COPPERHEAD	artillery	armor	inv	laser designator
PAVEWAY 2	air	fixed	inv	laser designator
GBU-15	air	fixed	inv/proc	TV/n R radio data link
AGM-130A	air	fixed	FSD	TV/n R radio data link
precision terminal (automatic target recognition)				
LRSOM	air(/ground)	area	R&D	inertial/GPS/TERCOM + terminal seeker
CMAG	ground/air	all	R&D	LADAR, SAR, MMW

targets: area: soft area targets (SSMS, SAMs, field command posts)
fixed: hard fixed targets (bridges, power stations, bunkers)
armor: moving armored combat vehicles

status: inv inventory
proc procurement
FSD: full-scale development
R&D research and development, prior to full-scale development

SOURCE Office of Technology Assessment, 1987 on the missile can guide the missile to a spot on the target illuminated by a laser beam, or a TV camera on the missile can send a picture back to the aircraft cockpit where a weapons officer is steering the missile via radio control.[32] All these techniques share some common characteristics. High accuracy—on the order of meters—is possible; the presence of a' 'man in the loop" may avoid many countermeasure problems such as electronic decoys or background clutter; the technology is for the most part mature and involves little technical risk; and costs are, very roughly, on the order of $100,000 per missile.

On the other hand, these missiles are all of relatively short range (tens of kilometers); most require a clear line-of-sight to the target; and thus most of the air-delivered models still require aircraft to fly close to their targets and to remain there throughout the flight of the missile. A general problem with laser-guided weapons is that the laser can be obscured by smoke around the target area; laser-guided weapons are also somewhat less accurate than TV-guided models. A general problem with radio data links, used to transmit TV pictures from the remotely guided GBU-15s, is that they can be jammed.

Despite these basic limitations, some improvements in this generation of weapons are possible without going to a radically new generation of technology. Range can be extended: for example, the AGM-130 has roughly double the range of the GBU-15 from which it is derived by the addition of a simple (but expensive) solid-fuel rocket motor. Jam-resistant data links are being developed for the GBU-15 and AGM-130. Fiber-optic data links could provide jam resistance for missiles launched from the ground.

Automatic Target Recognition.—Automatic target recognition, if successful, clearly could increase the effectiveness of missiles in all missions, and could increase the survivability of aircraft by allowing them to leave the area immediately after launching the missile. However, as indicated in table 11-4, automatic target recognition may bean enabling technology for attacking hard fixed targets at long range with nonnuclear missiles.

At long distances, attacking hard fixed targets would strain the capabilities of the man-in-the-loop guidance systems that are now the only means of providing the required precise terminal accuracy. Establishing radio contact with the missile as it approaches the target area is difficult at long range. The control aircraft would have to arrange to be in position at the right instant to have a clear line of sight to the missile, unobscured by terrain or vegetation, and jamming of the radio data link presents an increasing threat at greater range from the control aircraft. Automatic target recognition, which could free the missile from the need for human control while providing high terminal accuracy, is the only practical alternative.

For a second mission-long-range attack of moving armored combat vehicles whose location will have changed substantially during the flight time of the missile-a possible solution, discussed above, is to provide an in-flight update of the target location from a system, such as the Joint STARS radar, with weapon guidance capability. Alternatively, the missile could be equipped with an autonomous capability to search for the targets while flying along a likely route such as a road.

Both of these missions would also require a mid-course guidance system capable of delivering the missile to the general target area (see discussion of inertial systems above).

The technology for automatic target recognition has proved problematic to date. The sensor (e.g., a TV camera or radar) must provide a high-quality image of the target area for recognition; even then, picking out the target from a complex image, and distinguishing it from similar objects (e.g., a tank from a truck) is a very challenging computational task, especially because it must be carried out in real time. Mobile targets pose a special problem in that they may be facing any direction-and

[32]These specific technologies are described more thoroughly in OTA's special report, *Technologies for NATO's Follow-On Forces Attack Concept,* July 1986, pp. 24-27.

Photo credit' McDonnell Douglas Corp

F-15E equipped with LANTIRN pods.

a tank looks quite different when viewed from different angles.

All sensors are subject to countermeasures, including decoys and camouflage as discussed above in the section on smart submunitions; signatures of fixed targets may be quite variable depending on the season and weather as foliage and snow cover change. Although elements of an automatic target recognize have been demonstrated in the laboratory, complete working systems have remained elusive. For example, continuing problems in achieving reliable automatic target recognition in the Low Altitude Navigation and Targeting Infrared for Night (LANTIRN) infrared targeting system for fighter aircraft may lead to that feature being dropped from LANTIRN. An automatic target recognize for an autonomous missile would have to perform even more reliably: LANTIRN was designed to identify the target but still allow a human to make the final launch decision; an autonomous missile would be entrusted to perform the entire job on its own.

Even if the technology can be made reliable, placing an automatic target recognize on a cruise missile poses some engineering challenges as well. An imaging sensor and its associated computer processor would add a considerable power requirement over that of existing cruise missile electronics; this will require heavier generators and, with the extra heat generation, a cooling system for the electronics." Advances in the miniaturization of electronics may solve this problem. The use of currently available sensor technology—millimeter wave radar and imaging infrared—would also pose a packaging problem, because an additional system would be required for terrain following. A more advanced sensor, CO_2 laser radar, is being pursued by several contractors; both target-acquisition and terrain-following/obstacle-avoidance functions could be carried out by this single sensor. Much additional development of this sensor will be required; however, it is also likely to be the most expensive option.

The lowest technical risk approach to automatic target recognition might involve clever combination of existing capabilities to perform a limited mission. For example, low-cost inertial/GPS guidance could be used to steer a cruise missile close to a road or railroad, and a relatively simple imaging sensor could identify the road and keep the missile precisely on track; it could also detect trains or groups of vehicles. An autonomous capability against fixed targets might be provided in the near term similarly by demanding less than complete autonomy or flexibility. A short-range standoff missile could be guided from a preset launch point to the target area by a simple inertial system; a sensor system, supplied with information about the orientation of the target and its general characteristics (e.g., type of bridge, number of spans), might then be able to perform the somewhat simplified target recognition task.[34]

[33]Capt. R.B. Gibson, USAF, et al., *Investigation of the Feasibility of a Conventionally Armed Tactical Cruise Missile, Vol. I* (Wright-Patterson Air Force Base, OH: Air Force Institute of Technology, report AFIT/GSE-81D-2, December 1981), p. 7.

[34]This concept is being pursued in the Autonomous Guided Bomb program of the Air Force Armaments Laboratory.

Chapter 12

Packages of Systems and Capabilities for Attacks of Follow-on Forces

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Table

Chapter 12

Packages of Systems and Capabilities for Attacks of Follow-On Forces

In the special report on FOFA,[1] OTA observed that systems ought to be procured so as to form complete "packages' that perform all of the functions to support operational concepts (such as those described in ch. 6). These packages could include both existing systems as well as new developments such as those discussed in chapters 10 (RSTA) and 11 (weapons). This chapter illustrates how packages could be built to underwrite the operational concepts outlined in chapter 6.

Several factors complicate any attempt to specify what these packages might or should be for attack of follow-on forces:

- There are a great many potential packages—many operational concepts, several choices of systems for certain functions, and many ways of mixing systems for each function.
- Packages may evolve over time, as new systems are deployed.
- Many choices are subject to complex cost-effectiveness trade-offs, particularly for systems in development.
- Some systems will have considerable "flexibility," or application over abroad range of concepts, and can contribute to several packages.
- Many systems will have important applications-to missions other than FOFA.[2]

The particular packages discussed below are chosen to illustrate the major issues of development and procurement, and are *not* intended to be "preferred' or "recommended. A more complete analysis of packages for FOFA is in appendix 12-A.

The flexibility of systems for FOFA is especially important. Flexibility would allow the battlefield commander to use the best operational concept for a particular tactical situation—for example, to strike deeper against a division, and then to strike closer in against the weakened regiments of the division, rather than always having to strike either deeper or closer in.

Unfortunately, the use of many system names and acronyms is unavoidable in the discussion below and in the appendices; a glossary of system names and acronyms is provided at the end of this volume.

[1]U.S. Congress, Office of Technology Assessment, *Technologies for NATO* Follow-On Forces Attack Concept—Special *Report, OTA-ISC-312* (Washington, DC: U.S. Government Printing Office, July 1986).

[2]Multi-mission capability is likely to be the most common case; these "general purpose forces" are acquired for the inherently unpredictable needs of tactical warfare.

ILLUSTRATIVE CAPABILITY PACKAGES FOR FOFA

Table 12-1 presents capability packages for FOFA. Each package implements a given operational concept (listed in the first column), and consists of systems to perform the various necessary functions (listed in the remaining columns). For example, the first package implements artillery attack of regiments that are moving forward from final assembly areas, within about 30 kilometers of the FLOT.[3] This package includes a suite of systems for reconnaissance and surveillance and situation assessment (R&S/SA), two systems for target acquisition and attack control (TA/AC), two types of platforms (or launchers), and two possible

[3]*See* ch. *6* for a description of this operational concept.

Table 12-1.—Summary of Selected Packages for Attack of Follow-on Forces

OPERATIONAL CONCEPT	RECONNAISSANCE, SURVEILLANCE & SITUATION ASSMNT	TGT ACQ & ATTACK CONTROL	PLATFORM	WEAPON	SUPPORT
ARTILLERY ATTACK REGIMENTAL COLS[a] 5-30 KM	GR/CS +TRS + ASARS +J(S)TARS[b] +ASAS	AQUILA + AFATDS	MLRS +8-INCH	MLRS/TGW + SADARM	—
STANDOFF AIR ATK[c] DIVISION COLUMNS[a] 30-80 KM	GR/CS +TRS +ASARS + J(S)TARS + ENSCE	JS(TA)RS[d] + WIU	— F-16	MSOW + SKEET/TGSM[e] +CEB	PLSS +ATACMS
MISSILE ATTACK DIVISION COLUMNS 30-80 KM	GR/CS +TRS + ASARS +J(S)TARS +ASAS	JS(TA)RS + AFATDS	MLRS	ATACMS +SKEET/TGSM + DPICM	—
AIR ATTACK CHOKPT+ HLTD UNIT[f] 80-150 KM	GR/CS +TRS +ASARS +J(S)TARS + ENSCE	ASARS +GACC	F-15E + F-16	GBU-15 + MSOW + CEB/MINES	PLSS +ATACMS
CRUISE MISSILE ATK RAIL NETWORK 350-800 KM	ACTIVITY CUE —	(ON WPN)	B-52	CALCM-X[g] +GPS/TERCOM + RAIL MINES[a]	—

NOTES: Acronyms used here are defined in the Glossary at the end of this volume.
[a]REGIMENTAL COLUMNS and DIVISION COLUMNS are targets for attack when they are moving on roads after exiting assembly areas
[b]J(S)TARS denotes the MTI surveillance capability of Joint STARS
[c]STANDOFF AIR ATK denotes air attack from standoff of 25-50 km, using a weapon such as the MSOW (Modular Standoff Weapon) now under study in NATO.
[d]JS(TA)RS denotes the target acquisition and attack control capability of Joint STARS.
[e]SKEET/TGSM denotes the use of either sensor. fuzed weapon or terminally-guided submunition technology, or both, for anti-armor munitions
[f]CHOKPT + HLTD UNIT is a target in the concept where a chokepoint is created by attack (e.g. dropping a bridge) just prior to the arrival of an enemy unit, which, when halted behind the chokepoint, is then itself attacked
[g]CALCM-X denotes a conventionally-armed air-launched cruise missile, possibly ALCM-B retired from SIOP duty and modified to have less range with more payload
[h]RAIL MINE denotes a mine t. damage track and derail moving trains, possibly based on a modified ant! -bunker munition and a Mk-75 fuze

SOURCE Off Ice of Technology Assessment, 1987

weapons. No particular support measures are required for the first package; other packages, which use tactical aircraft that penetrate enemy airspace, require support for that function. Each of these illustrative packages is discussed below.

Overall, several features of this table stand out. One is the recurrence of the *suite of systems for R&S/SA.* A suite of this type is essential to many different packages, and has broad flexibility for FOFA (as well as for other missions). Another feature is *the recurrence of certain systems* in the table. For example, Joint STARS appears four times for R&S/SA, and twice for TA/AC. This is an example of system flexibility for FOFA. A third feature is the *number of different platforms and weapons* that can contribute to packages for FOFA.

Command and Control

To the extent that these packages for FOFA represent new capabilities for which command and control (C^2) procedures have not been developed, they will generate new requirements for C^2 activity and for processing of information. The discussion of the packages below assumes the capability to process and communicate data as needed. These capabilities may prove to be very difficult to provide, and could be critical to successful FOFA operations. *Failure to successfully develop the necessary data processing and communications capabilities could greatly reduce the capabilities of the RSTA/platform/weapons packages.* In this case, failure to spend enough resources (especially budget and personnel) on the C^2 part of the problem would greatly reduce the value of the much larger investments in equipment and munitions.

Locating Moving Combat Units

The first three of the packages in table 12-1 are for attacking moving columns of combat units. These packages, as well as the fourth, depend on a capability to detect, locate, and track moving combat units (regiments and divisions) to a depth of at least 150 kilometers beyond the FLOT, and benefit from an ability to distinguish them from resupply or other support traffic in the enemy rear. The capability to attack preferentially the enemy's combat elements, and directly reduce their combat strength, is essential to the effectiveness of FOFA operations with limited resources.

The same reconnaissance, surveillance, and situation assessment suite can serve all of these operational concepts. The suite includes SIGINT sensors, radar imagery and moving target surveillance, and a processing system for fusion and situation assessment.[4]

Both the GUARDRAIL/Common Sensor (GR/CS) system and the Tactical Reconnaissance System (TRS) have integrated SIGINT suites, containing both COMINT and ELINT sensors. The COMINT sensors can intercept radio traffic used to control unit movements and maintain contact with higher headquarters. The ELINT sensors can locate the air defense radars that protect the moving unit. This sensor data is not enough to detect and locate a unit, however. SIGINT, although very sophisticated, can be defeated either by spoofing or by very strict emissions control discipline. For this reason, imagery and MTI radar data is fused with SIGINT data to provide confident detection and accurate location of an enemy unit.

The Joint STARS wide-area surveillance capability (indicated by J(S)TARS in table 12-1) would provide moving target indication over a large area. This data can be combined with the SIGINT data to identify potential target areas. In order to confirm the presence of a unit, the Advanced Synthetic Aperture Radar System (ASARS) can provide high-resolution radar imagery of specific locations. This is an example of a "cue and confirm" approach to RSTA.[5] In general, surveillance systems provide cues and reconnaissance systems provide confirmation.

For example, ELINT and COMINT may provide indications of a division arriving in an assembly area and a rough estimate of its location. When MTI data collected over the previous and subsequent hours are studied, they may show a large number of vehicle "tracks" which lead into the area and disappear because the vehicles slowed or stopped. There may also be characteristic helicopter movements near the headquarters area. Armed with this data, the assessment center can task the ASARS to obtain high-resolution imagery of the suspected assembly area, which can be used to precisely locate vehicle clusters and identify characteristic arrangements of vehicles typical of command posts or other high-value targets.

A fusion capability is vital to this approach for locating follow-on forces. Table 12-1 lists two data fusion systems, the ASAS (Army) and the ENSCE (Air Force), the twin products of the current Joint Tactical Fusion Program. These systems will be very similar, with much commonality between them in equipment and software. They will accept data from the sensors, and support the situation assessment process by providing the capability to fuse or combine the information in appropriate ways for operator evaluation.

This suite of SIGINT, radar, and fusion systems is expected to provide the capability to detect, locate, and track follow-on regiments and divisions. This capability will extend to a depth of 100 to 150 kilometers beyond the FLOT.[6] This flexibility of reconnaissance, surveillance, and situation assessment systems is an example of the flexibility of particular systems for FOFA, and their ability to support different operational concepts.

[4]See James L. Jones and Peter W. Lert, *Follow-On Force Attack, Volume II: Reconnaissance Surveillance, and Target Acquisition (RSTA) Architecture to Support Follow-On Force Attack* (Alexandria, VA: Institute for Defense Analyses, report R-302, for an analysis of such a suite of systems, which illustrates a possible structure for the suite and analyzes its capability to locate and track combat units.

[5]In this example, SIGINT provides initial cues, MTI data provide further cues and tentative confirmation, and SAR imagery provides final confirmation.

[6]See app. 12-A (vol. 2), paragraph 3 for discussion of this range limitation.

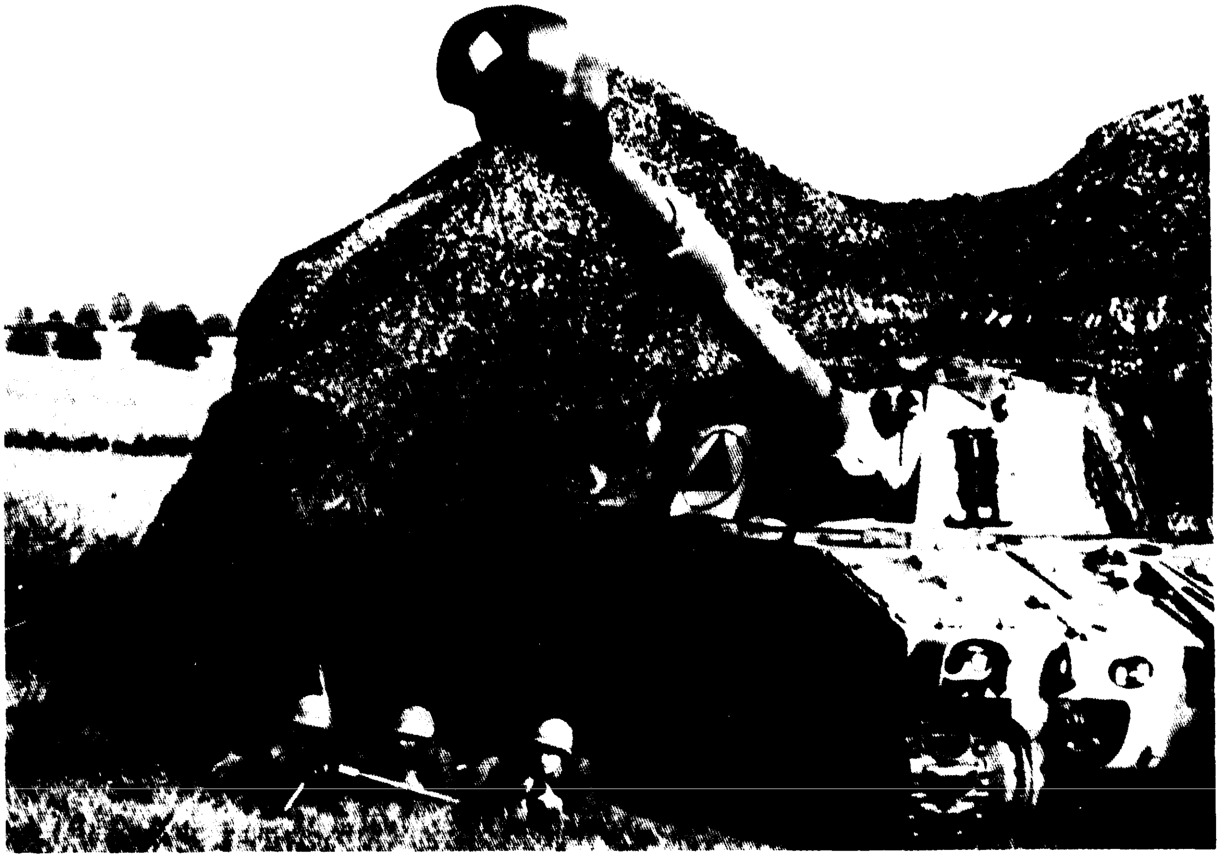

Photo credit U.S. Department of Defense

155-millimeter howitzer.

Artillery Attack of Regiment Columns (at 5 to 30 km)

This package uses the high firing rate of artillery to destroy enemy regiments on their final road march toward the battle area. As described in the *OTA Special Report*, the Army approach for deep attack of "decide, detect, and deliver" would be used. In this approach, resources are allocated to the mission and the areas or road segments in which the attack will be focused (engagement zones) are designated ahead of time (decided) by analyzing terrain and possible enemy actions. Surveillance is maintained to detect the regiment move out of its final assembly area and the movement of battalion columns toward and into the engagement zones at which time the artillery de*livers* its planned ordnance.

The R&S/SA suite for locating moving combat units is basic to this package. The TA/AC capabilities for this package include the Aquila RPV system and the Advanced Field Artillery Tactical Data System (AFATDS). The Aquila RPV can loiter in the target area and provide precision imagery for targeting[7] to the corps artillery Fire Support Element, which controls artillery operations through the AFATDS. Both rocket (MLRS) and tube (8-inch) artillery have smart anti-armor rounds in development:[8] the TGW (Terminally Guided Warhead) for MLRS, and SADARM (Search and Destroy Armor Munition) for the 8-inch gun. This package has no special support re-

[7]Aquila imagery can also be used for damage assessment.
[8]See ch. 11 for discussion.

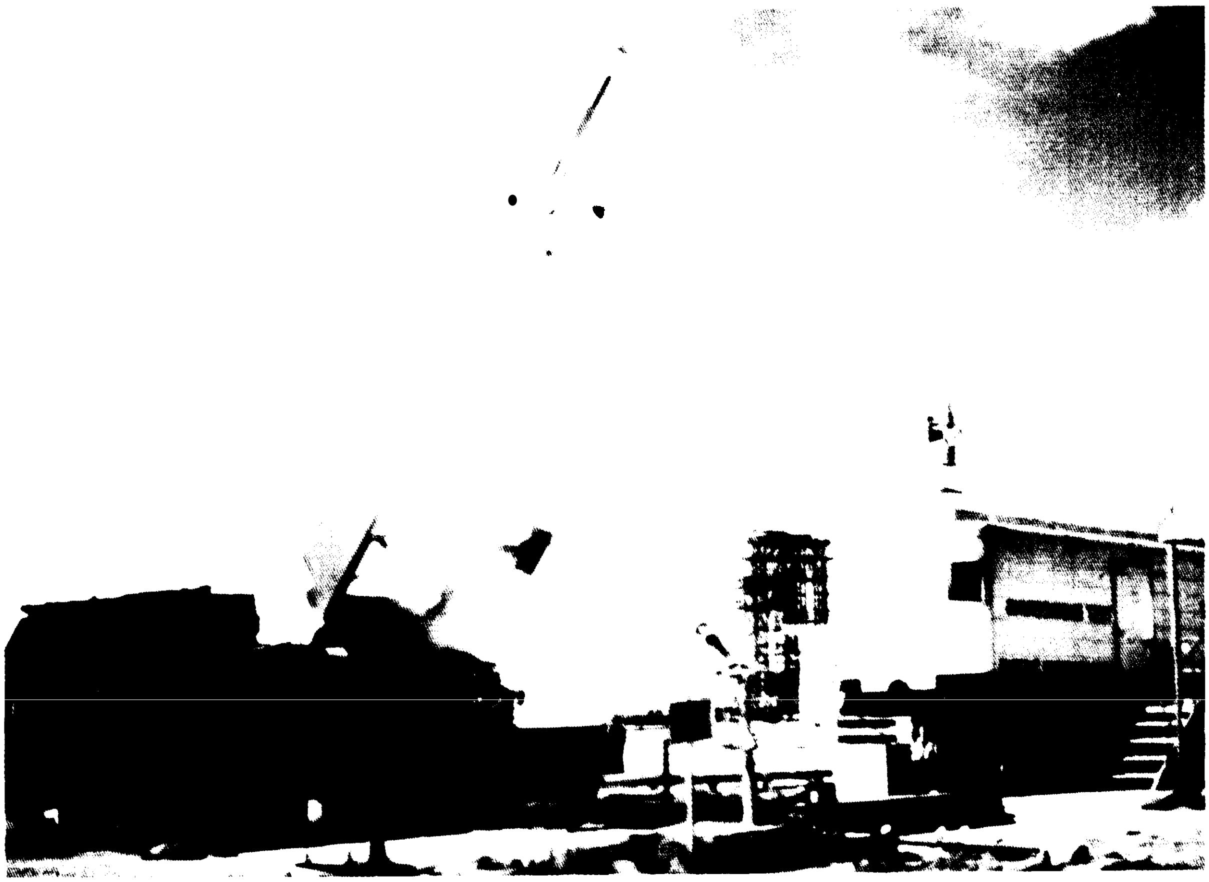

Photo credit U S Department of Defense

Multiple-Launch Rocket System (MLRS).

quirements, because it does not involve penetrating enemy airspace.[9]

Standoff Air Attack of Division Columns (at 30 to 80 km)

This package uses TACAIR with stand-off weapons to destroy enemy divisions on the road when they leave their assembly areas. The F-16 platform attacks with a Modular Stand-Off Weapon (MSOW) that flies a distance of 25 to 50 kilometers and then dispenses smart submunitions against targeted columns of vehicles within the division that is moving.

The situation assessment capability to track follow-on divisions, as described above, is essential. With it, NATO forces can attack just the combat divisions and not the total vehicle traffic in the Warsaw Pact rear. The output of the situation assessment process is provided to the air command and control element, which assigns aircraft to attack the division when it makes its move forward. Joint STARS provides target location data by tracking columns of vehicles out of the assembly area and down their routes. The attack F-16s penetrate in a less well-defended area near the target area, and fly to a launch point within range of the target area. Meanwhile, because the targets move while the aircraft are flying, target location updates are provided to the aircraft in flight just prior to weapons release. Joint

[9]The general requirements for C' and logistics support are understood, without being specifically called out, for this and all other operational concepts and packages.

Photo credit: U.S. Department of Defense

The Maverick missiles carried on this A-7 have short stand-off. Each can kill at most one target.

STARS transmits this data to Weapons Interface Units (WIUs) on the attack aircraft via signals encoded in the radar beam, providing highly jam-resistant data links to the F-16s over enemy territory. The target updates are fed into the weapons by the aircraft fire control systems, and the MSOWs are launched from the F-16s.

In order for this package to be effective, the penetrating aircraft need support.[10] This Suppression of Enemy Air Defenses (SE AD) could be provided by PLSS and ATACMS.[11] PLSS would target air defense radars and provide data to the MLRS units that fire ATACMS missiles. Joint STARS and ASARS may also be capable of targeting elements of air defense units (ADUs).

[10]Penetration support such as escort fighters and electronic warfare aircraft are also needed.

[11]This was the subject of Initiative 15 in the "Memorandum of Agreement on U.S. Army -U.S. Air Force Joint Force Development Process" between the Chiefs of Staff of the Army and Air Force signed May 22, 1984.

Missile Attack of Division Columns (at 30 to 80 km)

This package uses ground-launched missiles to attack the same targets with the same objective as that of the previous package. The weapon system is the Army Tactical Missile System (ATACMS), which is launched from standard MLRS launchers. This package embodies an operational capability generally similar to the Assault Breaker technology demonstration program of DARPA, and is its closest descendant.

Photo credit: LTV Aerospace & Defense Co.

The developmental Army TACMS missile, designed to be launched from the MLRS launcher.

The operational concept again follows the U.S. Army "decide, detect, deliver" approach for deep attack. The situation assessment capability detects, locates, and tracks follow-on divisions, and the corps Fire Support Element (which controls the attack) allocates launchers to this mission and determines engagement zones in which to engage columns of vehicles. Joint STARS supports attack planning and control by tracking vehicle columns departing the assembly area, forecasting times and locations at which they can be engaged, and providing missile-launching batteries with last-minute confirmation that targeted columns are entering planned engagement zones. Joint STARS data is passed to the MLRS launchers via AFATDS, allowing updates of engagement time and place just prior to launch. When the missile arrives at the target, it dispenses either smart anti-armor submunitions (Skeet or TGSM), or cluster munitions with capability against trucks and light armor (Dual Purpose Improved Cluster Munitions--DPICM), or both, also depending on detailed munitions effectiveness. As with the artillery package, no special support is needed by this package.

Air Attack of Chokepoints and Halted Units (at 80 to 150 km)

This package attacks follow-on divisions as they move on roads toward their concentration areas (division assembly areas). The attack is conducted in two phases. First, a chokepoint is created along a division's route by dropping a bridge just before the division column arrives. Second, after a period of time sufficient to let enough of the division arrive at the chokepoint and halt there, the resulting bunches of stationary vehicles are attacked by tactical aircraft using short stand-off weapons.

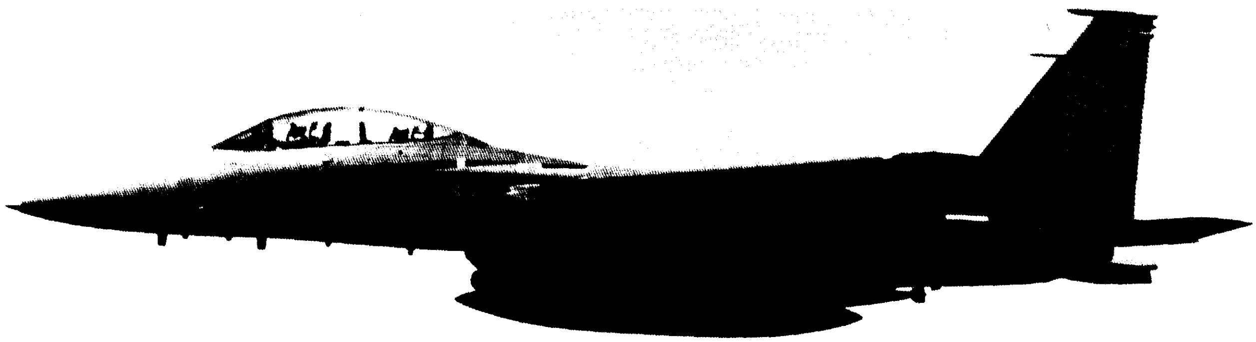

Photo credit' McDonnell Douglas Corp

F-15E carrying a laser-guided bomb.

The situation assessment capability to detect, locate, and track follow-on divisions is again necessary to identify target divisions and likely attack times and places. Once these targets are chosen by the air command and control elements, the two phases of the attack are planned and coordinated. One or two F-15Es attack the target bridge by delivering one or two GBU-15 Glide Bomb Units, which can be guided with sufficient accuracy to drop the bridge.[12] After the bridge is dropped, the area behind it is kept under surveillance by ASARS to observe the arrival and buildup of elements of the division. This information is passed to the Ground Attack Control Center (GACC), which controls the subsequent attack. When the GACC determines that targets are (or will be) there, F-16s in a strike package are given the target locations and scrambled or assembled to make the attack. This package penetrates with its escort and other support, and flies to a point some distance from the halted division in order to launch MSOWs. This avoids facing the division's air defenses, which are likely to be expecting attack (because the bridge attack can be interpreted as tactical warning).

The F-16s launch their weapons, which fly to designated target points and dispense a mix of APAM munitions and mines to both damage and disrupt the halted division.[13] Because the targets are relatively dense vehicle clusters, and the personnel may not be in protective vehicles, APAM munitions are likely to cause more damage to the division's fighting power than anti-armor munitions would; mines will then make more remote the possibility of recovering from the attack.

Cruise Missile Attack of the Deep Rail Network (at 350 to 800 km)

This package provides a capability to attack the rail network across eastern Europe, in order to delay the movement of Soviet divisions through this area. It does not use the same type of situation assessment capability as the other packages. The platform is a long-range bomber, the B-52, based in the CONUS. Over NATO territory, these aircraft launch long-range cruise missiles which conduct the actual attack. A B-52 can carry about 20 such weapons.

[12]The target division has not arrived yet; the air defenses at the bridge, then, are not likely to be heavy.

[13]The targets are not moving; no target location update, then, is necessary.

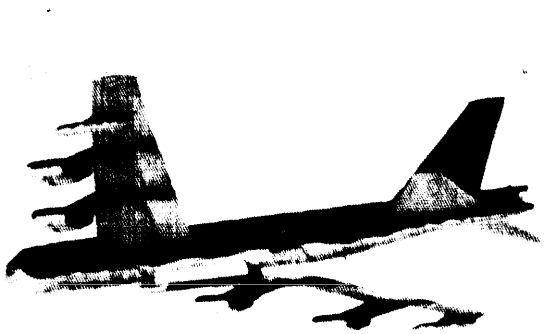

Photo credit U.S. Department of Defense

B-52 bomber launching a cruise missile.

Once launched, these missiles navigate autonomously (using GPS or some other system) to the vicinity of the chosen rail line. Upon encountering the rail at the designated location, the weapon dispenses mines which embed themselves in the rail bed. These mines activate after a preprogrammed delay, and then attack a passing train. This attack will blow a hole in the rail bed and derail the train. Clearing the area and repairing the track will take 18 to 24 hours.

Because the bombers do not penetrate enemy airspace, no special support is needed for this package.

FLEXIBILITY OF SYSTEMS FOR FOFA OPERATIONS

The set of capability packages summarized in table 12-1 is just a small portion of the total set of packages for FOFA listed in appendix 12-A. This longer list is itself not exhaustive; it gives only one package for each operational concept listed.

Appendix 12-B contains a table of the contributions of systems across the full range of operational concepts outlined in appendix 12-A. These systems are grouped into the same four functional areas[14] used in presenting the capability packages:

1. reconnaissance, surveillance, and situation assessment;
2. target acquisition and attack control;
3. platform; and
4. weapon.

Each system is considered for each operational concept, and its capability rated as "full, " "limited," or none for the given function. This illustrates the flexibility of systems for FOFA operations, by showing the ways in which a given system can contribute to a number of capability packages. Further, it indicates how fallback capabilities may exist in particular areas (e.g., targeting moving columns) if specific systems cannot fulfill the needs of a given operational approach. For systems currently in development, these ratings presume that the system is procured and deployed with the capabilities presently specified.

The suite of sensor and fusion systems for reconnaissance, surveillance, and situation assessment for attack of moving combat units offers full capability to implement all concepts for attacks within about 150 kilometers of the FLOT. This suite–which includes GR/CS, TRS, ASARS, Joint STARS, and the JTF systems–gives the operational commander great flexibility to use any concept that fits the tactical situation and can be implemented with available platforms and weapons. Attacks deeper than this will need other assets for situation assessment, and on-board systems for target acquisition.

RPV and UAV systems can provide full or limited support to situation assessment for all of the attack concepts out to about 150 kilometers beyond the FLOT. These systems also

[14] The "support" category is not considered here.

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provide great flexibility, although capability is limited by the lack of wide area coverage.

Joint STARS and ASARS provide full or limited capability for target acquisition for all attack concepts within about 150 kilometers of the FLOT. These systems are also complementary, each providing a fallback capability for the other. A mixed deployment of both systems would provide a commander with great flexibility in conducting attacks with available weapons, and being able to target these weapons effectively. With WIUs, attacking aircraft or missiles could receive target data updates directly from Joint STARS, or indirectly from the systems, via the Weapon Data Link of Joint STARS. This would provide limited or full capability for target data communications for nearly all attack concepts using Joint STARS target acquisition and would provide substantial flexibility for the attack control function.

Tactical aircraft such as the F-16, F-15E, F-111, and Tornado provide great flexibility for attack concepts within their mission ranges, which extend to about 150 kilometers beyond the FLOT for the F-16 and up to 350 kilometers for the other aircraft.

The MLRS platform also provides substantial flexibility to about 150 kilometers, considering its capability to launch either the current artillery rocket or ATACMS rockets.

An air-launched stand-off weapon such as the MSOW and a ground-launched weapon such as ATACMS together provide excellent flexibility as well as a capability to execute nearly any attack concept within about 150 kilometers of the FLOT.

A mix of smart anti-armor munitions (e.g., TGSM or Skeet) and APAM munitions also provides flexibility in attacking effectively the full spectrum of targets in this range. Mines can provide a flexible supplement to other munitions. They can contribute limited capability across nearly the full range of operational concepts, but provide full capability in only one concept.

Weapons such as the MLRS/TGW, GBU-15, and AGM-130B can provide important capabilities, but only in one or a few concepts each. These weapons do not individually provide flexibility to the commander, although they may contribute to his flexibility in combination with other weapons.

Appendix 12-A

Summary of Packages for Attacks of Follow-On Forces

The table below provides a summary of capability packages for attack of follow-on forces. Operational concepts are listed in the first column, and the remaining columns list systems that could perform the various key functions: reconnaissance, surveillance, and situation assessment; target acquisition and attack control; weapons platform; weapon; and necessary support (primarily for penetration of hostile airspace). These operational concepts have all been identified by OTA as being under consideration by the U.S. or Allied military and appear to be technically feasible, but they do not necessarily represent an exhaustive set of operational concepts for FOFA. Similarly, the packages (and systems chosen for the packages) are meant to be illustrative, and do not represent a complete list of systems or packages for FOFA.

Many systems names and acronyms are necessary for this table; they are defined in the Glossary at the end of this volume. Specific notes are given at the end of the table.

OPERATIONAL CONCEPT	RECONNAISSANCE, SURVEILLANCE & SITUATION ASSMNT	TGT ACQ & ATTACK CONTROL	PLATFORM	WEAPON	SUPPORT
DIRECT AIR ATTACK REGIMENTAL COLS[a] 5-30 KM	GR/CS+TRS +ASARS+J(S)TARS[b] +ENSCE	LANTIRN +GACC	F-16	SFW	PLSS +MLRS +F-4G
STANDOFF AIR ATK[c] REGIMENTAL COLS 5-30 KM	SAME	JS(TA)RS[d] +GACC	F-16	MSOW +SKEET/TGSM[e]	---
MISSILE ATTACK REGIMENTAL COLS 5-30 KM	GR/CS+TRS +ASARS+J(S)TARS +ASAS	JS(TA)RS +AFATDS	MLRS	ATACMS +SKEET/TGSM	---
ARTILLERY ATTACK REGIMENTAL COLS 5-30 KM	SAME	AQUILA +AFATDS	MLRS +8-INCH	MLRS/TGW +SADARM	---

OPERATIONAL CONCEPT	RECONNAISSANCE, SURVEILLANCE & SITUATION ASSMNT	TGT ACQ & ATTACK CONTROL	PLATFORM	WEAPON	SUPPORT
DIRECT AIR ATTACK DIVISION COLUMNS[a] 30-80 KM	GR/CS+TRS +ASARS+J(S)TARS +ENSCE	LANTIRN +GACC	F-16	SFW	PLSS +ATACMS +F-4G/F-15
STANDOFF AIR ATK DIVISION COLUMNS 30-80 KM	SAME	JS(TA)RS +WIU	F-16	MSOW +SKEET/TGSM +CEB	PLSS +ATACMS
MISSILE ATTACK DIVISION COLUMNS 30-80 KM	GR/CS+TRS +ASARS+J(S)TARS +ASAS	JS(TA)RS +AFATDS	MLRS	ATACMS +SKEET/TGSM +DPICM	---
DIRECT AIR ATTACK REGT ASSY AREAS 30-80 KM	GR/CS+TRS +ASARS+J(S)TARS +ENSCE	ASARS +WIU	F-16	TMD +CEB	PLSS +ATACMS +F-4G/F-15
STANDOFF AIR ATK REGT ASSY AREAS 30-80 KM	SAME	IEW UAV +FTI/E-O[f] +GACC	F-16	MSOW +CEB	PLSS +ATACMS
MISSILE ATTACK REGT ASSY AREAS 30-80 KM	GR/CS+TRS +ASARS+J(S)TARS +ASAS	IEW UAV +FTI/E-O +AFATDS	MLRS	ATACMS +DPICM	---
DIRECT AIR ATK MOVING COLUMNS 80-150 KM	GR/CS+TRS +ASARS+J(S)TARS +ENSCE	LANTIRN	F-16	SFW	PLSS +ATACMS +F-4G/F-15
STANDOFF AIR ATK MOVING COLUMNS 80-150 KM	SAME	JS(TA)RS +WIU	F-16	MSOW +CEB	PLSS +ATACMS
MISSILE ATTACK MOVING COLUMNS 80-150 KM	GR/CS+TRS +ASARS+J(S)TARS +ASAS	JS(TA)RS +WIU	MLRS	ATACMS +DPICM	---
AIR ATTACK DIV ASSY AREAS 80-150 KM	GR/CS+TRS +ASARS+J(S)TARS +ENSCE	ASARS	F-16	MSOW +CEB	PLSS +ATACMS
MISSILE ATTACK DIV ASSY AREAS 80-150 KM	GR/CS+TRS +ASARS+J(S)TARS +ASAS	IEW UAV +FTI/E-O	MLRS	ATACMS +DPICM	---

OPERATIONAL CONCEPT	RECONNAISSANCE, SURVEILLANCE & SITUATION ASSMNT	TGT ACQ & ATTACK CONTROL	PLATFORM	WEAPON	SUPPORT
AIR ATTACK CHOKPT+HLTD UNIT[g] 80-150 KM	GR/CS+TRS +ASARS+J(S)TARS +ENSCE	ASARS +GACC	F-15E +F-16	GBU-15 +MSOW +CEB/MINES	PLSS +ATACMS
JOINT ATTACK CHOKPT+HLTD UNIT 80-150 KM	GR/CS+TRS +ASARS+J(S)TARS +ASAS	IEW UAV +FTI/E-O +AFATDS	F-15E +MLRS	GBU-15 +ATACMS +DPICM	---
AIR ATTACK COMMAND POSTS 80-150 KM	GR/CS+TRS +ASARS+J(S)TARS +ENSCE	ASARS	F-16	MSOW +APAM/CBU	PLSS +ATACMS
MISSILE ATTACK COMMAND POSTS 80-150 KM	GR/CS+TRS +ASARS+J(S)TARS +ASAS	IEW UAV +FTI/E-O	MLRS	ATACMS +M-74	---
AIR ATTACK UNITS ON ROADS 150-350 KM	ACTIVITY CUE	LANTIRN	F-15E F-ill TORNADO	AGM-130B +CEB	PLSS +F-15
CRUISE MISSILE ATK UNITS ON ROADS 150-350 KM		--(ON WPN)	B-52	CALCM-X[h] +AUTO TGT +CEB	---
CRUISE MISSILE ATK RAIL NETWORK 350-800 KM	ACTIVITY CUE	--(ON WPN)	B-52	CALCM-X +GPS/TERCOM +RAIL MINES[i]	---
CRUISE MISSILE ATK RIVER BRIDGES 350-800 KM	PEACETIME INTEL (COORDINATES)	--(ON WPN)	B-52	CALCM-X +GPS/LADAR +WDU-25B	---
CRUISE MISSILE ATK UNITS ON RAILS 350-800 KM	ACTIVITY CUE	--(ON WPN)	B-52	CALCM-X +AUTO TGT +CEB	---

Notes :

a) REGIMENTAL COLUMNS and DIVISION COLUMNS are targets for attack when they are moving on roads after exiting assembly areas.

b) J(S)TARS denotes the MTI surveillance capability of Joint STARS.

c) STANDOFF AIR ATK denotes air attack from standoff of 25-50 km, using a weapon such as the MSOW (Modular Standoff Weapon) now under study in NATO. This weapon would employ a dispenser and either anti-armor or APAM submunitions.

d) JS(TA)RS denotes the target acquisition and attack control capabilities of Joint STARS.

e) SKEET/TGSM denotes the use of either sensor-fuzed weapon or terminally-guided submunition technology, or both, for anti-armor munitions.

f) FTI/E-O for the IEW UAV denotes a target acquisition package on the IEW UAV using either radar or electro-optical sensors, or both.

g) CHOKPT+HLTD UNIT is a target in the concept where a chokepoint is created by attack (e.g. dropping a bridge) just prior to the arrival of an enemy unit, which, when halted behind the chokepoint, is then itself attacked.

h) CALCM-X denotes a conventionally-armed air launched cruise missile, possibly ALCM-B retired from SIOP duty and modified to have less range with more payload. For attack of units on trains, this weapon would have automatic target recognition (AUTO TGT) ; for bridge attack a laser radar (LADAR) and the BULLPUP warhead (WDU-25B) would be used.

i) RAIL MINE denotes a mine to damage track and derail moving trains, possibly based on a modified anti-bunker munition and a Mk-75 fuze.

SOURCE: Office of Technology Assessment, 1987.

Appendix 12-B

Flexibility and Application of Systems for Attacks of Follow-On Forces

The following table indicates the application of systems to the functions of FOFA operations outlined in chapters 6 and 12. The range of applicability illustrates the flexibility of these systems, in being able to support several different operational concepts for attacks of follow-on forces.

Many system names and acronyms are necessary for this table—they are defined in the Glossary at the end of this volume.

LEGEND :

FULL	Full operational capability (expected) for specified function .
Limited	Limited or partial operational capability (expected) for specified function .
--	No operational capability (expected) , or not applicable , for specified function.

SOURCE : Office of Technology Assessment, 1987, [based on information supplied by sources cited in the full document].

5-30 KM ATTACKS

OPERATIONAL CONCEPTS
1 DIRECT AIR ATTACKS OF REGIMENT COLUMNS*
2 STANDOFF AIR ATTACKS OF REGIMENT COLUMNS*
3 MISSILE ATTACKS OF REGIMENT COLUMNS*
4 ARTILLERY ATTACK OF REGIMENT COLUMNS*

	OPERATIONAL CONCEPTS			
RS/SA SYSTEM	1	2	3	4
GR/CS	FULL	FULL	FULL	FULL
TRS	FULL	FULL	FULL	FULL
ASARS	FULL	FULL	FULL	FULL
J(S)TARS	FULL	FULL	FULL	FULL
ENSCE	FULL	FULL	--	--
ASAS	--	--	FULL	FULL
AQUILA	-Limited	Limited	Limited	Limited
IEW UAV/FTI-EO	Limited	Limited	Limited	Limited
ACTIVITY CUE	--	--	--	--
PEACETIME INTEL	--	--	--	--
TA/AC SYSTEM				
LANTIRN	FULL	--	--	--
JS(TA)RS	Limited	FULL	FULL	Limited
AQUILA	Limited	Limited	FULL	FULL
IEW UAV/FTI-EO	--	--	--	--
ASARS	Limited	Limited	Limited	Limited
WIU	Limited	FULL	FULL	--
GACC	FULL	FULL	--	--
AFATDS	--	--	FULL	FULL
PLATFORM				
MLRS	--	--	FULL	FULL
8-INCH	--	--	--	FULL
F-16	FULL	FULL	--	--
F-15E	FULL	FULL	--	--
F-111	FULL	FULL	--	--
TORNADO	FULL	Limited	--	--
B-52	--	--	--	--
WEAPON				
SFW	FULL	--	--	--
MSOW	Limited	FULL	--	--
ATACMS	--	--	FULL	--
MLRS/TGW	--	--	--	FULL
GBU-15	Limited	--	--	--
AGM-130B	--	Limited	--	--
CALCM-X	--	--	--	--
TGSM/SKEET/SADARM	FULL	FULL	FULL	FULL
CEB/DPICM	--	Limited	Limited	Limited
MINES	--	Limited	Limited	Limited

*Regiment is attacked when it is moving forward after exiting final assembly area. Individual targets are battalion-sized columns within the regiment.

30-80 KM ATTACKS

OPERATIONAL CONCEPTS

5 DIRECT AIR ATTACKS OF DIVISION COLUMNS*
6 STANDOFF AIR ATTACKS OF DIVISION COLUMNS*
7 MISSILE ATTACKS OF DIVISION COLUMNS*
8 DIRECT AIR ATTACKS OF REGIMENT ASSEMBLY AREAS
9 STANDOFF AIR ATTACKS OF REGIMENT ASSEMBLY AREAS
10 MISSILE ATTACKS OF REGIMENT ASSEMBLY AREAS

*Division is attacked when it is moving forward after exiting assembly area, Individual targets are battalion-sized columns within the division.

OPERATIONAL CONCEPTS

RS/SA SYSTEM	5	6	7	8	9	10
GR/CS	FULL	FULL	FULL	FULL	FULL	FULL
TRS	FULL	FULL	FULL	FULL	FULL	FULL
ASARS	FULL	FULL	FULL	FULL	FULL	FULL
J(S)TARS	FULL	FULL	FULL	FULL	FULL	FULL
ENSCE	FULL	FULL	--	FULL	FULL	--
ASAS	--	--	FULL	--		FULL
AQUILA	--	--	--	--	--	
IEW UAV/FTI-EO	Limited	Limited	Limited	Limited	Limited	Limited
ACTIVITY CUE	--	--	--	--	--	
PEACETIME INTEL	--	--	--	--	--	
TA\AC SYSTEM						
LANTIRN	FULL	--	--	FULL		
JS(TA)RS	Limited	FULL	FULL	Limited	Limited	Limited
AQUILA	--	--	--	--	--	--
IEW UAV/FTI-EO	--	--	--	Limited	FULL	FULL
ASARS	Limited	Limited	Limited	FULL	FULL	FULL
WIU	Limited	FULL	FULL	FULL	FULL	FULL
GACC	FULL	Limited	--	FULL	FULL	--
AFATDS	--	--	FULL	--	--	FULL
PLATFORM						
MLRS	--	--	FULL	--	--	FULL
8-INCH	--	--	--	--	--	--
F-16	FULL	FULL	--	FULL	FULL	
F-15E	FULL	FULL	--	FULL	FULL	
F-111	FULL	FULL	--	FULL	FULL	--
TORNADO	FULL	Limited	--	FULL	Limited	
B-52	--	--	--	--	--	--
WEAPON						
SFW	FULL	--	--	FULL	--	
MSOW	Limited	FULL	--	Limited	FULL	
ATACMS	--	--	FULL	--	--	FULL
MLRS/TGW	--	--	--	--	--	
GBU-15	Limited	--	--	Limited	--	
AGM-130B	--	Limited	--	--	Limited	--
CALCM-X	--	--	--	--		
TGSM/SKEET/SADARM	FULL	FULL	FULL	--	--	--
CEB/DPICM	Limited	FULL	FULL	Limited	FULL	FULL
MINES	Limited	Limited	Limited	Limited	Limited	Limited

80-150 KM ATTACKS

OPERATIONAL CONCEPTS

11 DIRECT AIR ATTACKS OF DIVISION COLUMNS*
12 STANDOFF AIR ATTACKS OF DIVISION COLUMNS*
13 MISSILE ATTACKS OF DIVISION COLUMNS*
14 AIR ATTACKS OF DIVISION ASSEMBLY AREAS
15 MISSILE ATTACKS OF DIVISION ASSEMBLY AREAS

*Division is attacked when it is moving towards its assembly area. Individual targets are battalion-sized columns within the division.

	OPERATIONAL CONCEPTS				
RS/SA SYSTEM	11	12	13	14	15
GR/CS	FULL	FULL	FULL	FULL	FULL
TRS	FULL	FULL	FULL	FULL	FULL
ASARS	FULL	FULL	FULL	FULL	FULL
J(S)TARS	FULL	FULL	FULL	FULL	FULL
ENSCE	FULL	FULL	--	FULL	--
ASAS	--	--	FULL	--	FULL
AQUILA	--	--	--	--	--
IEW UAV/FTI-EO	Limited	Limited	Limited	Limited	Limited
ACTIVITY CUE	--	--	--	--	--
PEACETIME INTEL	--	--	--	--	--
TA/AC SYSTEM					
LANTIRN	FULL	--	--	--	--
JS(TA)RS	Limited	FULL	FULL	Limited	Limited
AQUILA	--	--	--	--	--
IEW UAV/FTI-EO	--	Limited	Limited	FULL	FULL
ASARS	Limited	Limited	Limited	FULL	FULL
WIU	Limited	FULL	FULL	FULL	FULL
GACC	FULL	Limited	--	FULL	--
AFATDS	--	--	FULL	--	FULL
PLATFORM					
MLRS	--	--	FULL	--	FULL
8-INCH	--	--	--	--	--
F-16	FULL	FULL	--	FULL	--
F-15E	FULL	FULL	--	FULL	--
F-Ill	FULL	FULL	--	FULL	--
TORNADO	FULL	Limited	--	Limited	--
B-52	--	--	--	--	--
WEAPON					
SFW	FULL	--	--	--	--
MSOW	Limited	FULL	--	FULL	--
ATACMS	--	--	FULL	--	FULL
MLRS/TGW	--	--	--	--	--
GBU-15	Limited	--	--	--	--
AGM-130B	--	Limited	--	Limited	--
CALCM-X	--	--	--	--	--
TGSM/SKEET/SADARM	Limited	Limited	Limited	--	--
CEB/DPICM	Limited	FULL	FULL	FULL	FULL
MINES	Limited	Limited	Limited	Limited	Limited

80-150 KM ATTACKS (CONTINUED)

OPERATIONAL CONCEPTS

16 AIR ATTACK OF CHOKEPOINTS AND HALTED UNITS*
17 JOINT ATTACK OF CHOKEPOINTS AND HALTED UNITS*
18 AIR ATTACK OF COMMAND POSTS
19 MISSILE ATTACK OF COMMAND POSTS

*A chokepoint is created by attack (e.g. dropping a bridge) just prior to the arrival of an enemy unit. Resulting bunches of halted vehicles are attacked.

	OPERATIONAL CONCEPTS			
RS/SA SYSTEM	16	17	18	19
GR/CS	FULL	FULL	FULL	FULL
TRS	FULL	FULL	FULL	FULL
ASARS	FULL	FULL	FULL	FULL
J(S)TARS	FULL	FULL	FULL	FULL
ENSCE	FULL	--	FULL	--
ASAS	--	FULL	--	FULL
AQUILA	--	--	--	--
IEW UAV/FTI-EO	Limited	Limited	Limited	Limited
ACTIVITY CUE	Limited	Limited	--	--
PEACETIME INTEL	--	--	--	--
TA/AC SYSTEM				
LANTIRN	--	--	--	--
JS(TA)RS	Full	Limited	Limited	Limited
AQUILA	--	--	--	--
IEW UAV/FTI-EO	FULL	FULL	FULL	FULL
ASARS	FULL	FULL	FULL	FULL
WIU	FULL	FULL	FULL	FULL
GACC	Limited	--	FULL	--
AFATDS	--	FULL	--	FULL
PLATFORM				
MLRS	--	FULL	--	FULL
8-INCH	--	--	--	--
F-16	FULL	--	FULL	--
F-15E	FULL	FULL	FULL	--
F-ill	FULL	FULL	FULL	--
TORNADO	Limited	Limited	Limited	--
B-52	--	--	--	--
WEAPON				
SFW	FULL	--	FULL	--
MSOW	FULL	--	FULL	--
ATACMS	--	FULL	--	FULL
MLRS/TGW	--	--	--	--
GBU-15	FULL	FULL	-Limited	--
AGM-130B	Limited	--	Limited	--
CALCM-X	--	--	--	--
TGSM/SKEET/SADARM	-Limited	Limited	--	--
CEB/DPICM	FULL	FULL	FULL	FULL
MINES	Limited	Limited	Limited	Limited

150-350 KM ATTACKS OPERATIONAL CONCEPTS

20 AIR ATTACKS OF UNITS ON ROADS
21 CRUISE MISSILE ATTACKS OF UNITS ON ROADS

350-800 KM ATTACKS OPERATIONAL CONCEPTS

22 CRUISE MISSILE ATTACKS OF RAIL NETWORK
23 CRUISE MISSILE ATTACKS OF RIVER BRIDGES
24 CRUISE MISSILE ATTACKS OF UNITS ON RAILS

	OPERATIONAL CONCEPTS				
RS/SA SYSTEM	20	21	22	23	24
GR/CS	--	--	--	--	--
TRS	--	--	--	--	--
ASARS	--	--	--	--	--
J(S)TARS	--	--	--	--	--
ENSCE	--	--	--	--	--
ASAS	--	--	--	--	--
AQUILA	--	--	--	--	--
IEW UAV/FTI-EO	--	--	--	--	--
ACTIVITY CUE	FULL	FULL	--	--	FULL
PEACETIME INTEL	--	--	FULL	FULL	--
TA/AC SYSTEM					
LANTIRN	FULL	--			--
JS(TA)RS	--	--			--
AQUILA	--	--			--
IEW UAV/FTI-EO	--	--			--
ASARS	--	--			--
WIU	--	--			--
GACC	--	--			--
AFATDS	--	--			--
PLATFORM					
MLRS	--	--	--	--	--
8-INCH	--	--	--	--	--
F-16	--	--	--	--	--
F-15E	FULL	--	--	--	--
F-ill	FULL	--	--	--	--
TORNADO	FULL	--	--	--	--
B-52	Limited	FULL	FULL	FULL	FULL
WEAPON					
SFW	--	--	--	--	--
MSOW	--	--	--	--	--
ATACMS	--	--	--	--	--
MLRS/TGW	--	--	--	--	--
GBU-15	--	--	--	--	--
AGM-130B	FULL	--	--	--	--
CALCM-X	--	FULL	FULL	FULL	FULL
TGSM/SKEET/SADARM	--	--	--	--	--
CEB/DPICM	FULL	FULL	--	--	FULL
MINES	Limited	--	FULL	--	--

Chapter 13

Summary of Recent Studies of Follow-On Forces Attack

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Chapter 13
Summary of Recent Studies of Follow-On Forces Attack

Several recent studies have considered the broad technical, operational, and cost issues involved in attack of follow-on forces. These studies, summarized below, have provided essential background to this OTA assessment.[1] Some studies have attempted to analyze the effects of military improvements on a possible conventional conflict in Europe; these have been of particular interest to OTA.

Several conclusions about FOFA are common to most or all of these previous studies:

- *Current NATO conventional defense capabilities are not adequate.*
- *Improving capabilities for FOFA would make an important and substantial contribution to NATO conventional defense and to deterrence.*
- *Improved FOFA should be based on attack capabilities by both aircraft and ground-launched missiles. No* study has argued for a "pure" ground- or air-based capability.
- *Improvements in FOFA capabilities should be deployed throughout the Central Region.* Improvements in the U.S. sector, if not reflected in related improvements for the other corps defending the Central Region, would not provide sufficient enhancement to NATO's capabilities.
- *Critical technologies for improved FOFA are anti-armor munitions and stand-off target acquisition sensors.* Of particular importance in the munitions area are sensor technology to guide munitions against individual vehicles, and improved lethality against armored vehicles. A stand-off sensor which several studies consider essential is the U.S. Joint Surveillance Target Attack Radar System (Joint STARS), which is being developed to provide wide area surveillance and attack control capabilities against moving vehicles. Remotely piloted vehicle (RPV)-based sensors are also mentioned in several studies as capable of providing important capabilities.
- With improved sensors and munitions, *one approach to FOFA, preferred by nearly all the studies, is to attack enemy combat units after they have left assembly areas and are moving byroad toward the Forward Line of Own Troops (FLOT).*[2] Another related approach is to *block chokepoints* such as river bridges just before moving units would use them, *and then attack the halted units.* A third approach advocated by some studies is to *create a barrier in the enemy rear by dropping the bridges* across a major river line such as the Elbe-Vltava or the Oder-Neisse. Other approaches seen as less attractive include: attack of roads to delay movement, attack of enemy command posts to disrupt operations, and attack of logistics.
- Nearly all of the studies conclude that *attacks of follow-on forces less than 100 to 150 kilometers from the FLOT should be emphasized.* This includes attacks of follow-on regiments and divisions moving forward from assembly areas. Attacks within this range will have the most immediate effect on the ability of NATO's front line forces to maintain a successful defense.
- Before enemy combat units can be attacked, they must be located by a situation assessment process that uses sensor data of many different types. This proc-

[1] Earlier studies were reviewed by the Institute for Defense Analyses in a 1983 review summarized at the end of this chapter.

[2] Division assembly areas are expected to be located at depths of 70 to 150 kilometers, and regiment assembly areas at 30 to 70 kilometers.

ess operates on a time scale of several hours. The enemy units must be kept under surveillance until subsequent attacks can be made. To attack moving combat units, the attacking forces need target location and prediction information within minutes before the attack. *Command and control centers must be capable of performing both these situation assessment and attack control functions.*

Some divergent views emerge in these studies:

- *One study argues against deep attack,* which is interpreted to mean beyond artillery range. Attack of follow-on regiments would fall within this range, and would be supported.
- *Another study supports for very deep attack,* using conventionally armed cruise missiles launched from B-52s over NATO airspace. This approach would attempt to slow the Soviet reinforcement of Warsaw Pact forces. The resulting capability would be useful only if there was not a long mobilization prior to war, and thus is seen as serving as a deterrent to a short-mobilization attack.

The individual studies reviewed by OTA are summarized below.

INSTITUTE FOR DEFENSE ANALYSES FOFA STUDY

The Institute for Defense Analyses (IDA) recently completed an extensive study of FOFA for the Office of the Secretary of Defense.[3] The purpose of the project was 'to provide an integrated conceptual structure for assessing NATO's defense requirements and the detailed technical/cost information necessary for organizing and managing Department of Defense (DoD)-wide efforts to create an effective follow-on force attack capability."[4] The analysis considered weapon effects as well as unit-level operations (e.g., a tactical fighter wing attacking an enemy division), and used a full theater-level simulation (IDA's TACWAR model).

IDA finds that "The FOFA concept is technically feasible and potentially operational within the 1990s,"[5] with a mix of sensor and weapons systems allowing considerable flexibility of employment. The cost, though high, is seen as much less than the cost of armored divisions providing equivalent capability to halt a Warsaw Pact attack.

More specifically, IDA finds that the primary technology requirement for FOFA is sensor systems capable of providing information for situation assessment, target acquisition, and attack control.[6] Also, advances in antiarmor munition and terminal guidance technologies are considered essential. A new ground-launched missile system (e.g., the Army Tactical Missile System, or ATACMS) for FOFA should have a range of 150 to 200 kilometers, even if used to only 50 kilometers or so of depth, in order to provide sufficient stand-off from the FLOT and to provide cross-corps support. In the C^3 area, IDA finds that "the situation assessment and attack control functions must be separated and the time for C^2 processes reduced"[7] relative to current practice.

IDA estimates a "basic system cost" at about $20 billion. This 15-year life cycle cost does not include weapons, which adds another $10 billion to $30 billion. The effectiveness of these systems, in various combinations and employment concepts, is assessed in terms of the average Warsaw Pact advance in 30 days of combat (as calculated in the TACWAR

[3] Institute for Defense Analyses, *Follow-On Force Attack* (Alexandria, VA: Institute for Defense Analyses, report R-302, April 1986). This report is in five volumes and is referred to hereinafter as the IDA FOFA Study.

[4] IDA FOFA Study, op. cit., vol. 1, p. iii.

[5] IDA FOFA Study, op. cit., vol. 1, p. ES-10.

[6] See app. 13-A (vol. 2), paragraph 3.

[7] IDA FOFA Study, op. cit., vol. 1, p. ES-15. See app. 13-A (vol. 2), paragraph 4.

model). Without FOFA this advance is typically 300 kilometers; with 30 billion to 50 billion dollars' worth of FOFA systems the advance could be reduced to less than 50 kilometers. [8]

IDA considers a broad range of options for attacking armor. The attack strategies deemed the best are to engage combat units (regiments and divisions) when they are moving forward from assembly areas. For regiments these moves are generally within about 30 kilometers of the FLOT; for divisions, between 30 and 90 kilometers of the FLOT. These units are detected and tracked by a situation assessment process using sensor data from many sources. Also, a capability to distinguish truck columns from armored columns within unit formations can reduce the weapons requirement by one half, and would thus be highly desirable. Attacking units in assembly areas is not deemed effective for the cost involved.

Other types of targets are also considered. Dropping the bridges across the Elbe and maintaining this barrier for 10 days or more has a good payoff, but substantial numbers of air sorties are needed and precision delivery is required. Attacking command posts (CPs) is unattractive, because no means of effectively targeting CPs is available and the delays produced, even if CPs were destroyed, do not noticeably affect the results of the theater simulation.

Emphasis is given to a ground-launched missile (ATACMS). Attacking at short range against regiments is compared to attacking deep against divisions. The shallow attack approach is more effective at slowing the enemy advance, but the deeper attack approach runs less risk of saturating the firing rate or target handling capacities. A Warsaw Pact advance can be halted with about 4,000 missiles used shallow or about 10,000 missiles used deep.[9] "Some mix of each kind of attack should be planned so that commanders can make best use of the situation assessment they are presented with and their own concept of operation."[10]

Other weapons systems are also considered in this study. Penetrating tactical aircraft delivery of precision guided munitions is evaluated as an effective tactic, especially after a few days of ATACMS attacks on moving combat units, and especially with ATACMS also used to suppress enemy air defenses. According to IDA, using about 1,800 ATACMS missiles against enemy SAMs over 30 days of conflict can reduce aircraft attrition per sortie from about 13 percent to about 4 percent (for attacks out to about 100 kilometers beyond the FLOT) and from 2 to 1 percent for close air support. Upgraded artillery is also considered for FOFA, but has the disadvantage that large numbers of rounds must be procured and deployed across the whole front in order to have them available in sufficient quantity where and when needed. However, greatly expanded purchase of Multiple Launch Rocket System (MLRS) Terminally Guided Warhead (TGW) (50,000 to 100,000 rounds in NATO) and the use of large numbers of guided gun and mortar rounds[11] (200,000 to 400,000 rounds) can be highly effective against the enemy attack. In fact, upgrading the artillery with these anti-armor munitions appears to be among the least costly options considered, and can also improve the close-in combat capability of NATO forces.

[8]IDA does not argue that attrition and FLOT movement are accurately reflected in an absolute sense in their model; rather, the model results should be used only to compare system alternatives within the assumed constraints.

[9]These numbers of weapons relate to usage across the entire Central Region.

[10]IDA FOFA Study, op. cit., vol. 1, p. ES-22.

[11]Such rounds include the Sense and Destroy Armor (SADARM) artillery round for 155mm and 8 inch howitzers, and the Guided Antiarmor Mortar Projectile (G AMP).

NATO DEFENCE RESEARCH GROUP PANEL REPORT

A panel of the NATO Defence Research Group produced a report in mid-1985 concerning the value and costs of various approaches to FOFA.[12] It draws heavily on analyses done by IDA and by analysis agencies in the United Kingdom and NATO. The report of this panel is summarized in appendix 13-A (vol. 2), paragraphs 5 through 9.

[12] *An Analysis of the Relative Value of Attacks on Warsaw Pact Follow-On Forces in the NATO Central Region: Report by Panel VII/RSG.14 on the Value of Interdiction of Follow-On Forces and the Cost-Effectiveness of Possible Augmentations of the Current Capability,* Defence Research Group, Panel on the Defence Applications of Operational Research, AC/243 D/1022, AC/243 (Panel VII) D/99, June 1985.

SHAPE STUDY

Personnel at the Supreme Headquarters Allied Powers Europe (SHAPE) have also been studying FOFA concepts and requirements. A report of this work is summarized in appendix 13-A (vol. 2), paragraphs 10 through 16.

SHAPE TECHNICAL CENTRE STUDY

The SHAPE Technical Centre (STC) has been conducting a study of Follow-On Forces Attack in Allied Command Europe for their sponsor, SHAPE. This effort has been reported recently,[13] and is summarized in appendix 13-A (vol. 2), paragraphs 17 through 19.

[13] "Results from the STC FOFA Study (Project 84-2) With Particular Reference to the Central Region, Working Paper No. 2, Issue No. 2 (Draft)," SHAPE Technical Centre, STC 9980/OR/S.27/86, March 1986.

INDUSTRIEANLAGEN-BETRIEBSGESELLSCHAFT STUDIES

The Industrieanlagen-Betriebsgesellschaft mbH (IABG)[14] of Munich, FRG, has studied alternatives for improving conventional defense, using analysis and simulations up to the theater level. Unclassified discussions of some of these studies were held with OTA personnel, and an unclassified paper by the study leader was made available to OTA.[15] This paper concludes that "there are several reasons for not supporting the concept of combat in depth."[16] One area of concern is resources: the costs of systems will go up with effective range and required accuracy and survivability; and the "qualitative manpower requirement" will go up as systems become more complex. On both of these grounds, deep attack systems will divert resources from other important areas. In particular, the application of new technologies to improve close-in defense "can be done more efficiently, with less risk and for less cost than battle in depth."[17]

The notion of deep battle considered in this study is unclear, but it appears to emphasize attacks well beyond the range of current artillery weapons. Thus, it is not clear whether

[14] IABG is a major analytical establishment that works for the Ministry of Defense and for the military/aerospace interests of the FRG.

[15] "Zum Kampf in der Tiefe," Klaus Niemeyer, IABG M-SO-2125/13, December 1983. "This manuscript only reflects the personal opinion of the author and in no way represents the official views of The Industrieanlagen-Betriebsgesellschaft mbH (IABG) or the Federal German Ministry of Defence." However, it is consistent with other analytical work performed at IABG.

[16] "Zum Kampf in der Tiefe," p. 15.

[17] Ibid.

IABG studies would support an emphasis on FOFA at the nearest ranges (attacking follow-on regiments during their final move forward within about 30 kilometers of the FLOT). It appears to OTA that this emphasis would be supported by IABG.

EUROPEAN SECURITY STUDY

The European Security Study (ESECS) sponsored by the American Academy of Arts and Sciences has published two reports on "Strengthening Conventional Deterrence in Europe."[18 19] A capability for attack of follow-on forces is considered necessary (among other missions) for successful deterrence and defense. In the initial study (ESECS I) the emphasis for FOFA is on attack of fixed targets to delay and disrupt enemy formations. In ESECS II, attack of both chokepoints and units on the move is considered for FOFA, but the emphasis is still on delay and disruption rather than on attrition. The most effective and practicable NATO attacks would be from about 30 to 150 kilometers from the FLOT, but deeper attacks for special purposes (such as destroying rail and road bridges across the Oder-Neisse River line) could also be important.[20]

Long-range conventional weapons systems are considered critical to a successful FOFA capability.[21] The suggested (or "exemplary") program for modernization to improve FOFA capabilities includes ground-launched missiles with a range of perhaps 200 to 300 kilometers,[22] and stand-off weapons for air delivery with ranges from about 10 to 150 kilometers. Both types of weapons would dispense anti-armor munitions such as Skeet. In addition, aircraft would have capabilities to deliver improved anti-armor mines (also using stand-off dispensers) and improved laser-guided weapons capable of destroying bridges. The ESECS II exemplary FOFA program procurement costs are estimated at $5 billion (in fiscal 1984 dollars), and the program includes 1,800 ground-launched missiles, a total of 5,300 air-delivered dispensers of various types, and 400 laser-guided bombs. These weapons costs are in addition to surveillance and target acquisition system costs. The exemplary program to improve target acquisition capabilities (for both FOFA and close-in defense) includes procurement of five real-time stand-off imaging radars and 48 real-time RPV-based optical systems per corps, and associated ground stations and processing capabilities; it would cost NATO an estimated $2.85 billion.

[18] *Strengthening Conventional Deterrence in Europe; Proposals for the* ***1980s,*** Report of the European Security Study (ESECS) (New York: St. Martin's Press, 1983).

[19] *Strengthening Conventional Deterrence* in *Europe: A Program for the 1980s,* European Security Study Report of the Special Panel (E SECS II), (Boulder, CO: Westview Press, 1985). The Special Panel consisted of General Andrew J. Goodpaster, General Franz-Joseph Schulze, Air Chief Marshal Sir Alasdair Steedman, and Dr. William J. Perry. The study was supported by the BDM Corp.

[20] ESECS II, p, 71,

[21] ESECS 11, p. 70.

[22] Specifically, the T-22 (Improved Lance) missile of the Corps Support Weapons System then in development by the U.S. Army is recommended. The current successor to this program is the ATACMS program.

U.S. ARMY STUDIES

The U.S. Army has recently completed studies supporting both development of doctrine for Deep Attack[23] and a proposed program for enhancing conventional defense capabilities[24] that is "consistent with U.S. Army doctrine (AirLand Battle), NATO's FOFA sub-concept, and U.S. Army long-range plans and development processes."[25] The work on deep attack doctrine included simulations of corps operations with the CORBAN model

[23] *Corps Deep Operations,* FC 100-15-1.

[24] *Analysis of US Army Conventional Capabilities,* HQ U.S. Army DAMO/FD, May 20, 1986.

[25] *Analysis of US Army Conventional Capabilities,* p. 1

developed by the Army.[26] The later study of Conventional Capabilities built on the corps-level simulation with theater-level studies using the Army's CEM simulation model and IDA's TACWAR simulation model.

The Deep Attack study focuses on the objective of disrupting the enemy's attack "tempo."[27] According to this new Army doctrine, attacks against follow-on forces should employ a "decide, detect, deliver" approach.[28] This approach has separate situation assessment/planning and target acquisition/engagement phases. Battle planning, including decisions to commit resources to deep attacks, is accomplished at the corps headquarters using Intelligence Preparation of the Battlefield (IPB) and fusion of data from a number of sources. The planning is oriented toward time blocks of 4 to 6 hours. Engagement opportunities are predicted some 12 to 36 hours ahead, and sensor and attack systems are tasked to coordinate operations for attacks in the appropriate time blocks.[29] Sensors are then focused to detect predicted enemy activity in the preplanned target area.

The detection of this activity, and its subsequent confirmation (if necessary), serves to trigger the planned attack process, using either ground-launched missiles or offensive air support (OAS) provided by tactical aircraft.[30]

[26]CORBAN was developed by the Training and Doctrine Command (TRADOC) Studies and Analysis Activity (TRASANA), supported by the BDM Corp.

[27]*Corp Deep Operations,* FC 100-15-1, p. 2-13. See app. 13-A (vol. 2), paragraph 20 for certain details.

[28]*Corp Deep Operations,* FC 100-15-1, p. B-2.

[29]*Corp Deep Operations,* FC 100-15-1, p. B-6,8.

[30]*Corp Deep Operations,* FC 100-15-1, p. B-9,10.

Appropriate sensors for this function include Joint STARS, PLSS, the Tactical Reconnaissance System (TRS), Guardrail Common Sensor system, and the corps Intelligence and Electronic Warfare (IEW) RPV system.[31] Then, when the weapons are prepared and the target is properly oriented, the sensor provides final target location update to the attacking unit and the weapon is launched or released.[32]

In its broader study of conventional enhancements, the Army found that a balanced investment in close and deep combat capabilities was optimal. The deep attack systems considered included the ATACMS, and Joint STARS and other sensors.[33] Improved anti-armor munitions for artillery and rocket systems, such as MLRS/TGW and SADARM, were included in close combat systems. This approach, of making current forces more capable, was considered preferable to other possible approaches, including increasing NATO's combat forces, creating barrier defenses in the FRG, deploying light infantry or militia-based area defenses, or maintaining a posture of counter-invasion to deter aggression. The conventional enhancements proposed by the Army involve accelerating the development and procurement of the indicated systems (and others) such that they can be fielded by 1993.[34]

[31]*Corp Deep Operations,* FC 100-15-1, p. B-9.

[32]Certain weapons and sensor requirements are summarized in app. 13-A (vol. 2), paragraph 21.

[33]Other sensors included the Guardrail Common Sensor and the Unmanned Aerial Vehicle/Intelligence and Electronic Warfare (UAV/IEW). In addition, the Army component of the Joint Tactical Fusion program, the All Source Analysis System (ASAS) was listed as a deep battle system.

[34]The enhancement program for FOFA is summarized in app. 13-A (vol. 2), paragraph 22.

RAND CORP. STUDIES

The Rand Corp. has several studies underway for the U.S. Air Force, considering various aspects of conventional defense of Europe. One such effort focuses on intelligence support for a range of operations concepts to support the defense of Europe.[35] The concepts considered include several ways of attacking follow-on forces.

Another Rand study is analyzing a concept for deep attack of Warsaw Pact follow-on forces using conventionally armed cruise missiles

[35]"A Critical Time Evaluation of USAF Intelligence Support for Effective Defense of Central Europe," briefed to OTA staff and FOFA Study Advisory Panel, June 18, 1986.

launched from B-52s.[36] Both studies have been presented to OTA in briefings, but reports have not yet been published. These studies assess the feasibility of several operations concepts and the value of carrying out such attacks against Warsaw Pact forces. The latter study includes a theater-level simulation to quantify the value of such attacks in terms of the overall ground war.

The first study finds several approaches attractive for attacking follow-on forces, because the United States is expected to have substantial end-to-end capability to attack worthwhile targets. These *attractive* approaches include:

- attack of second-echelon regiments moving to battle from their final assembly areas, which are 30 to 50 kilometers behind the FLOT;
- attack of maneuver elements of follow-on divisions moving forward on roads about 30 to 250 kilometers behind the FLOT; and
- attack of follow-on division elements queued up behind blocked chokepoints, 30 to 250 kilometers behind the FLOT.

Approaches that are considered *marginal or unattractive* include:

- attack of division elements while halted in assembly areas,
- attack of bridges to create a north-south barrier at major rivers, and
- attack of divisions moving toward assembly areas on roads more than 250 kilometers beyond the IGB.[37]

The second Rand study sets forth a concept for interdicting Soviet divisions moving by rail. The concept uses B-52s based in the United States to launch conventionally armed long-range cruise missiles from friendly airspace deep into the Warsaw Pact rear. These weapons deliver mines that will damage trains at given points in the rail net and cause links in the rail net to be closed for periods of time. Similar weapons are also used to drop key rail and road bridges. The total effect of these attacks is estimated to reduce by 50 percent the quantity of forces arriving at the FLOT during the 2 to 3 weeks of the attacks.

The resulting reduction in forces available to the enemy is analyzed in a theater-level simulation. Although the proposed improvement in capability is not sufficient to stabilize the FLOT near the IGB, it is seen as making an important contribution to NATO's defense. One limitation of this approach is that it would not be as effective if, prior to war, there were a Warsaw Pact mobilization long enough for follow-on Soviet armies to move forward to western Poland, Czechoslovakia, and East Germany. However, it is argued that this long mobilization scenario would be the best case for NATO. From this perspective, the proposed deep attack capability can be viewed as a deterrent against a short mobilization attack, which is seen as the greatest threat to NATO.

[36] "Interdiction of the Soviet Armies With B-52s," briefing by G.L. Donohue, Rand Corp., to OTA Staff, 19 August 1986.

[37] See app. 13-A (vol. 2), paragraph 24 for other approaches considered for FOFA.

EARLIER STUDIES

In late 1983 IDA published a review of earlier studies of issues relating to FOFA.[38] Of 77 studies surveyed at that time, 20 were selected for review and summary. These selected studies are listed in table 13-1. The resuiting summary of results is discussed in appendix 13-A (vol. 2), paragraphs 25 through 30.

[38] *Interdicting Warsaw Pact Second Echelon Forces–A Review of Selected Studies*, Institute for Defense Analyses, 1 DA Paper P-1 731, October 1983. Referred to below as IDA 1983 Review.

Table 13-1.–Studies Reviewed by IDA in 1983

Date	Author	Title
	U.S. Air Force	
1981	Scientific Advisory Board	Non-Nuclear Armament
1980	Directorate of Aerospace Studies	Employment of Antiarmor Munitions Against 2nd Echelon Moving Armor
1979	Tactical Fighter Weapons Center	Joint Close Air Support/Battlefield Interdiction Mission Area Analysis
	U.S. Army	
1982	CSWS Special Task Force	Corps Support Weapon System Cost and Operational Effectiveness Analysis (Preliminary)
1981	Field Artillery School	Fire Support Mission Area Analysis
1981	Concepts Analysis Agency	Forward of the FEBA Weapon System Cost Benefit Study, Phase I and Phase II
	Other U.S. Government Studies	
1982	Joint Chiefs of Staff	JCS Interdiction Study
1979	General Accounting Office	Progress in Strengthening Interdiction Capabilities in the NATO Central Region
1976	Defense Science Board	Summer Study on Conventional Counter Force Against a Pact Attack
	NATO and European Organizations	
1982	SHAPE (NATO)	SHAPE Study to Attack and Destroy Second Echelon Forces
1981	Defence Research Group (NATO)	Interdiction—An Aspect of Air Campaign in the 1990s
1981	Defence Research Group (NATO)	Implications of New Technologies for Land Operations in the NATO Central Region
1981	Defence Operational Analysis Establishment (U. K.)	UK Analyses Related to the Value of Attacks on Second Echelon Forces
1980	Advisory Group for Aerospace Research and Development (NATO)	Project 2,000 Overview
	Other Analytical Studies	
1983	IDA	Indirect Fire Support, Phase I and II
1981	The Rand Corp.	Analysis of the Warsaw Pact Tactical Rear: Summary Report
1981	The Rand Corp.	Air Interdiction: Lessons from Past Campaigns
1981	The BDM Corp.	The Military Utility of Delaying and Disrupting Warsaw Pact Second Echelon Forces
1980	QUEST Research Corp.	Historical Effects of an Interdiction Campaign
1979	The BDM Corp.	Holding Pact Second Echelon Forces at Risk

SOURCE IDA 1983 Review, tables 1 and 2

Glossary of Terms and Acronyms

Glossary of Terms and Acronyms

8-INCH: Used in this report to denote a U.S. Army artillery gun which fires 8-inch diameter shells.
A300: Model designation of a jet transport aircraft made by Airbus Industrie, a consortium of Belgian, British, Dutch, French, German, and Spanish companies.
A-7: The Corsair 11 light attack aircraft, produced in several versions for the U.S. Navy and Air Force and other nations. The Air Force is developing improved avionics and engines (for longer range) to upgrade its A-7s to a version unofficially called the "A-7 +."
AAA: Anti-aircraft artillery.
ACE: Allied Command Europe.
Activity Cue: As used in this report, indication of enemy movement provided by a surveillance or reconnaissance system, used for planning an attack.
ACV: armored combat vehicle. A tank, armored fighting vehicle (AFV), armored personnel carrier (Ape), armored cavalry vehicle, self-propelled artillery piece, or a mobile surface-to-air missile launcher.
ADAM: Area Denial Artillery Mine. A scatterable antipersonnel mine produced for the U.S. Army. A 155mm artillery shell can dispense 36 ADAMs.
ADDS: Army Data Distribution System. A data communications system now being procured by the U.S. Army to provide timely secure communications among corps commanders, their intelligence, fire support, and other staffs which would plan deep attacks, and the surface-to-surface missile batteries and tactical aircraft which would perform deep attacks. ADDS includes Joint Tactical Information Distribution System (JTIDS) terminals, Enhanced Position Location Reporting System (EPLRS) terminals, and net control stations. Formerly called PJH [PLRS-JTIDS Hybrid].
ADT: MICNS Air Data Terminal for the Aquila RPV; the Aquila uses an ADT to receive commands from, and transmit television imagery to, a MICNS Remote Ground Terminal (RGT) of a TADARS Ground Control Station (GCS). See MICNS, TADARS.
ADU: Air defense unit.
AFATDS: Advanced Field Artillery Tactical Data System. A U.S. Army follow-onto the TACFIRE artillery fire control system.
AFV: Armored fighting vehicle.
AGB: Autonomous Guided Bomb. A glide bomb in preliminary development by the Air Force, to be capable of recognizing and steering toward a vulnerable point on a fixed target.
AGM: Air-to-ground missile.
AGM-65: The Maverick air-to-ground missile (any of several versions: AGM-65A/B/D/E/F/G),
AGM-65A: TV-guided Maverick. [In inventory]
AGM-65B: TV-guided Maverick with greater magnification for use against smaller targets or at longer range. [In inventory]
AGM-65D: IR-guided Maverick for use at night or in adverse weather. [Being procured]
AGM-65E: Laser-guided Maverick for U.S. Marine Corps. [Being procured]
AGM-65F: Navy Maverick. Anti-shipping–IR-guided with alternate warhead and selectable-delay fuze. [In development]
AGM-65G: "Alternate Warhead Maverick. " A modified AGM-65F with a heavier warhead for use against ships, armored vehicles, and overburdened fixed targets. [In advanced development]
AGM-88A: The HARM High-Speed Anti-Radiation Missile (q.v.).
AGM-130: A short-range, rocket-powered, air-to-ground missile derived from the GBU-15. The AGM-130A uses a unitary 2,000-lb Mk-84 warhead. The AGM-130B, which is not presently funded, is a version of this weapon with a submunitions dispenser as the payload.
AI: Air interdiction. A tactical air mission.
Air Attack: As used in tables in this report, an operational concept using penetrating tactical aircraft (TACAIR) as weapons platforms. *Direct* air attack uses TACAIR flying directly over, or within sight of, the target. *Stand-off* air attack uses a weapon such as the Modular Stand-off Weapon (MSOW) launched by tactical aircraft at a standoff (distance) of 25 to 50 km from the target.
ALB: AirLand Battle. U.S. Army doctrine (endorsed by the U.S. Air Force as appropriate) for the conduct of Army operations.
ALCM: Air-launched cruise missile.
AMS: Airborne Mission Subsystem of the Aquila RPV.
AMTI: Airborne moving-target indicating (radar system). Detects and indicates objects (e.g., vehicles) moving with respect to the ground.
AN/TPQ-37: "Firefinder" radar system for tracking missiles and projectiles to locate missile launchers and artillery batteries.
AOI: (1) Area *of* interest: in NATO and U.S. Army doctrine, the area including, but extending be-

yond, a commander's area of responsibility (AOR, q.v.), in which the commander must monitor enemy activity which could affect the future situation in his AOR; (2) *Area of influence:* the area in which a tactical commander has a capability to fight the enemy.

AOR: Area of responsibility. A specific zone or sector assigned to a commander in which he is responsible for fighting the enemy. Also called area of operational responsibility in NATO doctrine, and area of operations in U.S. Army doctrine.

APAM: Anti-personnel anti-materiel. A type of submunition usually designed as a small grenade or bomblet that damages unarmored vehicles and people. Examples are the Army M-74 grenade and the Air Force BLU-61 and BLU-63 bomblets.

APGM: Autonomous Precision-Guided Munition for 155mm artillery.

Aquila: U.S. Army-developed remotely piloted vehicle.

ARDS: Airborne Radar Demonstrator System, A NATO project to make certain U. S., British, and French airborne ground-surveillance radar systems compatible.

ARIA: Advanced Range Instrumentation Aircraft. A modified Boeing 707 jet transport (designated EC-18B) used by the U.S. Air Force.

ARM: Anti-radiation missile.

Artillery Attack: An operational concept using artillery guns or rocket-launchers as weapons platforms.

ASAC: All-Source Analysis Center, which supports the intelligence function at division and corps tactical operations centers.

ASARS: Advanced Synthetic Aperture Radar System (specifically, ASARS 11). A U.S. Air Force high-resolution ground-surveillance imaging radar system, which can detect stationary objects. The ASARS 11 can be carried by the high-altitude, long-endurance TR-1 aircraft.

ASAS: All-Source Analysis System. An intelligence fusion system being developed by the U.S. Army. Both the ASAS and the U.S. Air Force's Enemy Situation Correlation Element (ENSCE) are being developed under the Joint Tactical Fusion (JTF) program and will use some common equipment.

ASIC: All-Source Intelligence Center.

Assault Breaker: A technology development program sponsored by the U.S. Defense Advanced Research Projects Agency (DARPA) in which T-16 (Patriot) and T-22 (Lance) missiles were guided, by the Joint STARS-like Pave Mover airborne radar and weapon guidance system, to concentrations of armored vehicles, where they dispensed Skeet sensor-fuzed smart submunitions.

ASTOR: Airborne STand-Off Radar (formerly called CASTOR: Corps Airborne STand-Off Radar). Either of two airborne ground-surveillance radar systems developed for the British Ministry of Defence. ASTOR-C indicates fixed targets; ASTOR-I indicates moving targets.

AT-2: A scatterable mine being developed by the Federal Republic of Germany for MLRS rockets.

ATACMS: Army Tactical Missile System. A ballistic missile currently in development by the U.S. Army. ATACMS missiles will be launched from unmodified MLRS launchers.

ATAF: Allied Tactical Air Force (of NATO).

ATARS: Advanced Tactical Air Reconnaissance System (also called Follow-On Tactical Reconnaissance System). A program to develop a TV camera and digital data link for use on either manned aircraft or unmanned aerial vehicles.

ATDL: Adaptive Targeting Data Link. A proposed radio data link which could transmit target location data from Joint STARS or PLSS aircraft to weapon delivery platforms such as F-16 fighter aircraft equipped with ATDL equipment or possibly to advanced weapons—such as ballistic or cruise missiles-which could be equipped with ATDL equipment.

ATF: Advanced-Technology Fighter being developed for the U.S. Air Force.

ATR: Automatic target recognition.

AUTO TGT: A notional automatic target recognition capability for attack of units on trains using CALCM-X.

AVSCOM: Aviation Systems Command of the U.S. Army.

AWACS: Airborne Warning and Control System (E-3A/B/C) used by the U.S. Air Force and NATO.

B-52: A heavy bomber operated by the U.S. Strategic Air Command.

BAI: Battlefield air interdiction. A tactical air mission.

BICES: Battlefield Information Collection and Exploitation System, a NATO project.

BL775: A British anti-armor cluster weapon.

BMP: A Soviet-made infantry combat vehicle.

BN-2T: A twin-turboprop aircraft (the Turbine Islander) made by Pilatus Britten-Norman; see *Turbine Islander.*

BTR: A series of Soviet-made armored personnel carriers. Some are used for command, control, and communications.

Buccaneer: A British fighter-bomber.

Bullpup: U.S. Air Force AGM-12C command-guided weapon, designed to attack hard fixed targets. It includes a WDU-25B 974-pound warhead.

Bundeswehr: The West German Army.

C2 (or C'): Command and control.

C3 (or C'): Command, control, and communications.

C3I (or C^3I): Command, control, communications, and intelligence.

CALCM-X: An acronym used in this report for a proposed conventionally armed, air-launched cruise missile, possibly ALCM-Bs retired from SIOP duty and modified to carry more payload to a shorter range.

CASTOR: Corps Airborne STand-Off Radar. Now called ASTOR (q.v.).

CBU: Cluster Bomb Unit. A class of Air Force weapons consisting of a dispenser filled with (usually 200 to 600) bomblets, designed to attack an area target by dispersing the bomblets.

CEB: Combined Effects Bomblet. U.S. Air Force submunition (denoted BLU-97/B)

CEM: Combined Effects Munition. U.S. Air Force weapon (denoted CBU-87/B) consisting of a TMD containing 202 CEB bomblets. CEM weighs 945 lbs, can be carried by F-16, F-Ill, and F-15E aircraft, and is effective against personnel and unarmored and light armor targets.

CENTAG: Central Army Group of NATO's Allied Command, Europe.

Central Region: The region for which NATO's Allied Command, Europe, is responsible, including the Federal Republic of Germany.

CGF: Central Group of Forces. Soviet Forces stationed in Czechoslovakia, consisting of about five divisions.

Chicken Little: A joint Army-Air Force program for testing advanced anti-armor munitions.

CHOKPT: A contraction used in this report for "chokepoint an obstacle to the advance of Warsaw Pact forces, either preexisting (e.g., a bridge) or created by NATO forces (e.g., a mined road).

CINC: Commander-in-Chief

CINCENT: Commander-in-Chief, Allied Forces, Central Europe

CINCNORTH: Commander-in-Chief, Allied Forces, Northern Europe

CL289: An unmanned aerial vehicle (UAV) made in Canada.

CLGP: Cannon-launched guided projectile.

CMAG: Cruise Missile–Advanced Guidance. A program to develop sensors (LADAR, MMW, and SAR) and software for automatic target recognition and precision terminal guidance of cruise missiles.

CNAD: Conference of National Armaments Directors of NATO.

COCOM, CoCom: Coordinating Committee on Multilateral Export Controls.

COMINT: Communications intelligence. Information gained from intercepting enemy electronic communications signals, either voice or message.

Command Posts: Groups of trucks and lightly armored vehicles used by commanders of Warsaw Pact regiments, divisions, and armies, and their staffs; possible targets for attacks against follow-on forces.

Compass Call: Air Force EC-130 aircraft designed for jamming enemy radio communications.

Copperhead: The M712 cannon-launched guided projectile, a U.S. Army 155mm artillery shell that homes on a target illuminated by a laser designator.

Copperhead 11: A developmental autonomously guided artillery projectile which does not require that its target be designated (i.e., illuminated) by a laser. A Copperhead II shell would be made by replacing the laser seeker of an M712 Copperhead shell with an autonomous seeker now in development.

CP: Command post.

CPS: Central Processing Subsystem (of PLSS).

Cruise Missile Atk: An operational concept using cruise missiles launched from airborne platforms (in friendly airspace) to penetrate and attack targets deep in the Warsaw Pact rear.

DAACM: Direct Airfield Attack Combined Munition.

DARPA: Defense Advanced Research Projects Agency. An agency of the U.S. Department of Defense.

D-Day: As used here, hypothetically, the day on which NATO is overtly invaded or attacked by Warsaw Pact forces. In general, the first day of a real or hypothetical war or a military operation during a war.

DDR: Deutsche Demokratische Republik: East Germany. Also GDR: German Democratic Republic.

DF: (Radio) Direction-Finding.

DGSM: Down-sized Ground Station Module for Joint STARS.

DIRECT AIR ATK: See *AIR ATTACK.*

DIV: Division.

DIV ASSY AREAS: Division assembly areas, also known as "concentration areas, " for Warsaw Pact divisions. These areas are usually within the range band of 80 to 150 km from the FLOT.

Assembly areas are large enough that the density of vehicles is relatively low, and are chosen by the Warsaw Pact forces to take maximum advantage of cover and concealment.

Division Columns: Groups of vehicles moving on roads, which comprise a division on the march. The actual groupings of vehicles are usually battalion-sized, about 40 to 60 vehicles per column, with spacing between columns using the same road.

DME: Distance-measuring equipment. Radionavigation equipment consisting of transponder units and interrogator units which can determine how far away the transponders are. In some radionavigation systems, such as that used by PLSS, the interrogator units are carried by aircraft and the transponder units are at surveyed locations on the ground. In other radionavigation systems, the transponder units are carried by aircraft and the interrogator units are at surveyed locations on the ground.

DNA: Defense Nuclear Agency. An agency of the U.S. Department of Defense.

DOA: Direction of arrival. A technique for determining the direction from which a radio signal is being received—i.e., the direction toward the radio transmitter.

DoD: U.S. Department of Defense.

DPC: Defence Planning Committee (of NATO). It is composed of the representatives of member countries participating in NATO's integrated military structure. The DPC meets at either the Ambassadorial or Ministerial (Defense Minister) level.

DPICM: Dual-Purpose Improved Conventional Munition. An APAM munition used in artillery shells and rockets.

DRG: Defence Research Group (of NATO).

E-3: The AWACS Airborne Warning and Control System. A modified Boeing 707 jet transport carrying air surveillance radar and communications equipment. Several models (E-3A/B/C) are currently used by the U.S. Air Force and NATO.

E-8A: The Joint Surveillance/Target Attack Radar System (Joint STARS). A modified Boeing 707 jet transport carrying aground surveillance radar and communications equipment. In development for the U.S. Air Force.

EC-18B: The Advanced Range Instrumentation Aircraft (ARIA). A modified Boeing 707 jet transport used by the U.S. Air Force.

ECCM: Electronic counter-countermeasures.

ECM: Electronic countermeasures.

EF-111A: An Air Force airborne jamming system for jamming radars; also called "Raven."

EFP: Explosively formed penetrator. A type of anti-armor munition.

ELINT: Electronics intelligence. Intelligence obtained by interception of non-communications signals (e.g., radar signals).

ELS: Emitter Location System. An upgrade which would allow PLSS to locate non-pulsed emitters.

ENSCE: Enemy Situation Correlation Element. An intelligence fusion system being developed by the U.S. Air Force. Both the ENSCE and the U.S. Army's All-Source Analysis System (ASAS) are being developed under the Joint Tactical Fusion (JTF) program and will use some common equipment.

EO, or E-O: Electro-optical. Employing vacuum tubes or semiconductor devices to convert optical (visible, ultraviolet, or infrared) radiation into electrical currents, to serve as a TV camera.

Epervier: A Belgian remotely piloted vehicle used for reconnaissance.

EPLRS: Enhanced Position Location Reporting System, a component of ADDS.

ERAM: Extended-Range Antiarmor Mine, partially developed, then abandoned, by the U.S. Air Force.

ESD: (1) Electronic Systems Division of the U.S. Air Force Systems Command; (2) Electronique Serge-Dassault, a French electronic systems manufacturer.

ESECS: European Security Study. A study of options for increasing the combat capability, and hence the presumed deterrent effect, of NATO's non-nuclear forces in Europe. The study was sponsored by the American Academy of Arts and Sciences; its findings were published in two reports known as ESECS I and ESECS 11.

ESM: Electronic warfare support measures. Radio direction-finding and signals intelligence (COMINT and ELINT) activities performed in support of electronic warfare (jamming, etc.).

EW: Electronic warfare.

F-4: The Phantom fighter-bomber; developed in the United States; also used by the Federal Republic of Germany.

F-4G: The version of the F-4 fighter designed and equipped to attack enemy air defenses, dubbed the "Wild Weasel. "

F-15: The top-line air superiority fighter of the U.S. Air Force, dubbed the "Eagle."

F-15E: The ground-attack version of the F-15 Eagle, dubbed the "Strike Eagle, " now in development by the U.S. Air Force. The primary mission of the F-15E will be air interdiction.

F-16: The dual-role (air- and ground-attack) fighter of the U.S. Air Force and several other NATO countries, dubbed the "Fighting Falcon. "

F-ill: A U.S. Air Force long range interdiction aircraft.

FARRP: Forward area re-arming and refueling point, for helicopters.

FBA: Fighter bomber aircraft.

FEBA: Forward edge of the battle area. The approximate line along which opposing ground forces are in contact; compare FLOT (q.v.).

Firefinder: A tactical radar system (designated AN/TPQ-37) used by the U.S. Army for tracking missiles and projectiles to locate missile launchers and artillery batteries.

FLIR: Forward-Looking InfraRed. A TV-like camera sensitive to the infrared radiation emitted by all (especially warm) objects; useful at night and less affected by fog, smoke, or haze than TV.

FLOT: Forward line of own troops. Unlike a FEBA (q.v.), a FLOT (e.g., Inner-German border) can exist in peacetime.

FOG: Fiber-optic gyro. In development for missile inertial attitude reference and navigation systems.

FOG-M: Fiber-Optic Guided Missile. In development for the U.S. Army.

FRG: Federal Republic of Germany (West Germany).

front: A Soviet command echelon above "army."

FSCL: Fire support coordination line. A line established at approximately the range of fire of NATO artillery, or about 25 to 35 km into enemy area across the FLOT.

FSD: Full-Scale Development.

FTI: Fixed target indicator. A type of radar useful for surveillance of stationary objects such as shelters or parked vehicles.

fusion: Combining intelligence information from multiple sensors or disciplines (e.g., SIGINT and IMINT) **to** assist interpretation.

GACC: Ground Attack Control Capability (or Center). For controlling air attack of ground targets, now under development by the U.S. Air Force.

GAMP: Guided Antiarmor Mortar Projectile. Partially developed, then abandoned, by the U.S. Army.

Gator: Air delivered anti-tank and anti-personnel mines.

GBU-15: A Glide Bomb Unit, which is "thrown" by an attacking aircraft and guided toward the target from the aircraft, but which has no propulsion of its own. The GBU-15 weighs 2,500 lbs, including the Mk-84 2,000-lb warhead, and can be carried by the F-4, F-111, and F-15E (when available).

GDR: German Democratic Republic. East Germany. Also DDR: Deutsche Demokratische Republik.

GPS: Global Positioning System. A system by which a user vehicle can determine its position on the ground to high accuracy. GPS will use a constellation of NAVSTAR satellites to allow a terminal on the vehicle to compute its location in earth-fixed coordinates.

GR/CS: GUARDRAIL/Common Sensor. An upgrade to GUARDRAIL.

GSFG: Group of Soviet Forces, Germany.

GSM: Ground Station Module. A mobile ground station being developed by Motorola for the U.S. Army for use with the Joint STARS airborne radar system.

GUARDRAIL: A communications intelligence system.

hard: Highly resistant to damage by weapon effects (e.g., blast), either by design or inadvertently,

harden: To make highly resistant to damage by weapon effects.

hardened: Highly resistant, by design, to damage by weapon effects.

HARM: The AGM-88A High-Speed Anti-Radiation Missile. An air-launched missile used by the Navy and Air Force to attack radar antennas by homing on the signals they emit.

HAVE QUICK: An Army-Air Force program to provide or upgrade the jam resistance of certain tactical radios.

Heron-26: An Italian-made remotely piloted vehicle which can be used for reconnaissance.

HLTD UNIT: a contraction used in tables in this report to denote a halted enemy unit which is the target of an attack against follow-on forces.

HTM: Hard Target Munition. A bomb being developed by the Air Force to attack hard fixed targets (e.g., bunkers).

HVM: Hypervelocity Missile. An air-launched antiarmor missile being developed for the U.S. Air Force. It will use CO, laser command guidance and kill by kinetic energy.

IABG: Industrieanlagen Betriebs GmbH (Gesellschaft mit beschraenkter Haftung). A West German corporation which performs research, development, and operations analysis for the West German Ministry of Defense and for West German industries.

IADL: Interoperable Air Data Link. IDL equipment carried by TR-1 aircraft used as Precision Location Strike System (PLSS) platforms.

IAM: Inertially-Aided Munition. A developmental glide-bomb program.

ICM: Improved Conventional Munition, An APAM munition used in artillery shells and rockets. Also called DPICM: Dual-Purpose ICM.

IDA: Institute for Defense Analyses (Alexandria, Virginia).

IDL: Interoperable Data Link. A radio data link used by the Precision Location Strike System (PLSS).

IEPG: Independent European Programme Group, composed of European members of NATO.

IEW UAV: Intelligence and Electronic Warfare Unmanned Aerial Vehicle. One of the family of UAVs proposed for development by the U.S. Army.

IFF: Identification–friend or foe. A system for identifying aircraft as friendly or other (foe or neutral) e.g., using coded radio signals.

IGB: Inner-German border. The boundary between West and East Germany. Sometimes called the inter-German border.

IGDL: Interoperable Ground Data Link. Ground-based IDL radio equipment used by the Precision Location Strike System to communicate with IADL radio equipment on TR-1 aircraft.

IIR: Imaging infra-red (adj.). Using a TV-like camera which is sensitive to long-wavelength infrared radiation and can "see" in the dark and, to some extent, through fog.

IITS: Intra-Theater Imagery Transmission System. A facsimile system used by U.S. forces in Europe.

IMINT: Image (or imagery) intelligence. Intelligence obtained from photographic imagery, electro-optical imagery, radar imagery, or other types of imagery (e.g., radiometric).

INF: Intermediate-range Nuclear Forces.

IPB: Intelligence Preparation of the Battlefield.

IR: Infrared. Electromagnetic radiation having wavelengths longer than those of visible light but shorter than those of radio waves (i.e., 0.0007 to 1 millimeter).

I^2R: Imaging infrared. See IIR.

IRTGSM: Infrared Terminally-Guided Submunition.

Islander: A twin-engine aircraft made by Pilatus Britten-Norman in both piston and turbine versions. See *Turbine Islander.*

Jaguar: A British aircraft used for reconnaissance.

Joint Attack: An operational concept using both ground- and air-launched weapons. For example, an air-launched weapon (GBU-15) could be used to destroy a bridge and create a chokepoint, and ground-launched missiles (ATACMS) could be used to attack units that halted and bunched up at the destroyed bridge.

Joint STARS: Joint Surveillance Target Attack Radar System. A developmental airborne radar system carried on E-8A aircraft intended to locate moving (and certain fixed) targets on the ground and to control attacks against such targets using tactical aircraft or guided missiles.

JSTARS: See *Joint STARS.*

J(S)TARS: Used here to denote the MTI surveillance capability of Joint STARS (q.v.).

JS(TA)RS: Used hereto denote the target acquisition and attack control capabilities of Joint STARS (q.v.).

JTF: Joint Tactical Fusion.

JTFP: Joint Tactical Fusion Program.

JTIDS: Joint Tactical Information Distribution System. A joint (U.S. Navy/U.S. Air Force) jam-resistant radio system used to send digital messages between aircraft and between aircraft and ground stations.

KB-44: A small shaped-charge anti-armor submunition developed to be dispensed from the MW-1.

LADAR: Laser Detection And Ranging. A system for determining the position of an object using visible-wavelength radiation, analogous to radar (which uses radio-wavelength radiation).

Lance: The T-22 dual-capable (nuclear or conventional) missile used by NATO corps.

LANTIRN: Low-Altitude Navigation/Targeting InfraRed for Night. A system designed to give tactical aircraft low-altitude all-weather navigation and targeting capabilities.

LCS: Low-Cost Seeker (for the HARM High-speed Anti-Radiation Missile). Under development by the Navy and the Air Force. Also called Low-Cost Anti-Radiation Seeker.

LOC: Lines of communication.

LOC-E: Limited Operational Capability-Europe: a U.S. intelligence fusion system in Europe, derived from the Battlefield Exploitation and Target Acquisition (BETA) testbed.

LOCPOD: Low-Cost Powered Off-boresight Dispenser: NATO development project for air-launched standoff submunition dispenser.

LPI: Low probability of interception.

LRSOM: Long-Range Standoff Missile: a proposed long-range cruise missile being considered in a tri-national feasibility study by the United States, the United Kingdom, and the Federal Republic of Germany.

Luftwaffe: Air Force [viz., "air weapon"] of the Federal Republic of Germany.

M-74: An Army APAM submunition to be used in ATACMS missiles for attack of unarmored targets.

Martel: A British TV-guided bomb.

MASINT: Measurement and signature intelligence —e.g., a measurement of a target's closing velocity obtained using moving target indicating (MTI) radar.

Maverick: A guided short-range air-to-ground anti-armor missile used by the U.S. Air Force (designated AGM-65, q.v.).

MICOM: U.S. Army Missile Command.

MICNS: Modular Integrated Communications and Navigation System—used by the Target Acquisition Designation Aerial Reconnaissance System (TADARS).

MIFF: An air-delivered anti-tank mine made in the Federal Republic of Germany to be dispensed by MW-1 dispensers on Tornado aircraft.

Mine: A destructive device detonated after its emplacement, usually by some action of its target.

Mirach-100: An Italian-made remotely piloted vehicle which can be used for reconnaissance.

Mirage 5: A Belgian aircraft used for reconnaissance.

Missile Attack: An operational concept using ground-launched missiles such as ATACMS.

Mk-82: A general-purpose 500-lb bomb.

Mk-84: A general-purpose 2,000-lb bomb.

MLRS: Multiple Launch Rocket System. An artillery system now in procurement by the U.S. Army and several other NATO nations.

MLRS/TGW: Terminally Guided Warhead for MLRS. An anti-armor TGSM, now in development by the U.S. Army.

MMW: Millimeter-wave. Sensing or using electromagnetic radiation with wavelengths between one millimeter and one centimeter.

MNC: Major NATO Commander (SACEUR, SACLANT, or CINCHAN).

Mohawk: A U.S. Army airborne ground-surveillance radar system carried by OV-1D aircraft.

MOS: Military Occupational Specialty designations used by the U.S. Army.

Moving Columns: Groups of vehicles moving on roads as part of a combat unit on the march. The actual groupings of vehicles are usually battalion-sized, about 40 to 60 vehicles per column, with spacing between columns using the same road.

MPS: Mission Payload System for the Aquila RPV.

MR: Motorized rifle.

MSC: Major Subordinate Commander (e.g., CINCENT, CINCNORTH)

MSOW: Modular Stand-Off Weapon. An air-launched weapon now in concept development in NATO. This weapon would provide 25 to 50 km of stand-off, and would employ a dispenser and either anti-armor or APAM submunitions.

MTI: Moving target indicator. A type of radar useful for surveillance of moving objects such as aircraft or ground vehicles.

MW-1: Multipurpose Weapon, a submunition dispenser made in the Federal Republic of Germany for the Tornado aircraft; it can dispense several types of submunitions.

NAA: North Atlantic Assembly. An organization composed of selected members of the parliaments of NATO member nations.

NAAG: National Army Armaments Group (of NATO).

NGF: Northern Group of Forces. Soviet Forces stationed in Poland, consisting of about two divisions.

NIS: NATO Identification System. An IFF system being considered for adoption by NATO.

NORTHAG: Northern Army Group of NATO's Allied Command Europe.

NIMROD: An airborne early warning system developed in the United Kingdom for the Ministry of Defense. The United Kingdom has since decided to procure U.S. E-3 AWACS aircraft instead.

NSWP: Non-Soviet Warsaw Pact,

O&C: Operations and control (for Joint STARS).

OLA: Off-loading area.

OMG: Operational Maneuver Group.

ON WPN: On weapon. Used here to describe autonomous target acquisition systems installed on weapons (e.g., cruise missiles).

ORCHIDEE: Observatoire Radar Coherent Heliporte d'Investigation Des Elements Ennemis. A developmental French airborne ground-surveillance radar system which will be carried by Super Puma helicopters to indicate moving targets.

OV-1D: The U.S. Army "Mohawk' observation aircraft equipped with an airborne ground-surveillance radar system.

OUSDRE: Office of the Under Secretary of Defense for Research and Engineering, in the U.S. Department of Defense.

Patriot: A modern surface-to-air missile system used by the U.S. Army in Europe; it uses a phased-array radar and fires T-16 missiles.

Pave Mover: An experimental airborne radar and weapon guidance system carried by an F-111 aircraft and used in DARPA's Assault Breaker program; Joint STARS will use similar but improved technology.

Paveway: A series of laser-guided bombs used by the U.S. Air Force, built around the Mk-82 (500-lb) and Mk-84 (2,000-lb) bombs, denoted GBU-12B and GBU-10C, respectively.

Peacetime Intel: As used here, peacetime intelligence which can be used to locate certain fixed targets (e.g., bridges, power stations, and rail segments) with high accuracy.

PGS: PLSS Ground Station. A hardened facility in Europe proposed (but no longer planned) to house a PLSS CPS.

Phoenix: An unmanned aerial vehicle made in England by GEC Avionics.

PIAP: PLSS Intelligence Augmentation Program. An Air Force program under which the PLSS Intelligence Augmentation System (PI AS) is being developed.

PIAS: PLSS Intelligence Augmentation System, A proposed facility for augmenting the analysis, reporting, and exploitation of data collected by PLSS.

PIM: PLSS Interface Module. A proposed facility within a PLSS Central Processing Subsystem for selecting, formatting, and disseminating PLSS location reports to various users according to their needs.

Pioneer-1: An unmanned aerial vehicle made in Israel by AAI/Mazlat.

PLSS: Precision Location Strike System. An airborne surveillance and control system developed for TR-1 aircraft to detect, identify, and accurately locate advanced (pulsed, frequency-hopping) enemy radar transmitters and some types of jammers in near real time and to guide weapons or aircraft to such targets with sufficient accuracy to destroy them.

PLSS GS: PLSS Ground Station.

POL: Petroleum, oil and lubricants.

RAAM: Remote Anti-Armor Mine, produced for the U.S. Army.

RAF: Royal Air Force of the United Kingdom.

Rail Mine: Used here to denote a hypothetical mine designed to damage track and derail moving trains. Such a mine could use a modified anti-bunker munition and a Mk-75 fuze.

Raven: The Air Force EF-111A aircraft, which is equipped to jam enemy radars,

R&D: Research and development.

RDT&E: Research, development, testing, and evaluation.

recce: Reconnaissance (slang).

reconnaissance: As used here, collecting information about specific areas or activities of particular interest using any of several types of sensors.

Regimental Columns: Groups of vehicles, which comprise a regiment moving on roads. The actual groupings of vehicles are usually battalion-sized, about 40 to 60 vehicles per column, with spacing between columns using the same road.

REGT ASSY AREAS: Regimental assembly areas, also known as "departure areas, " for Warsaw Pact divisions. These areas are usually located within the range band of 30 to 80 km from the FLOT, outside of the range of NATO artillery. Assembly areas are large enough that the density of vehicles is relatively low, and are chosen by the Warsaw Pact forces to take maximum advantage of cover and concealment.

RF-4C: A reconnaissance version of the F-4 Phantom fighter-bomber, used by the U.S. Air Force. Some carry TEREC equipment.

RF-4E: A reconnaissance version of the F-4 Phantom fighter-bomber, used by the Luftwaffe.

RF-104: A reconnaissance version of the F-104 Starfighter, used by the Royal Netherlands Air Force.

RGT: (1) Remote [MICNS] Ground Terminal for TADARS; (2) regiment.

RITA: Mobile radio-telephone equipment made by a consortium of Belgian and French companies; being purchased by the U.S. Army for use in Europe.

RLG: Ring-laser gyro. A laser device that can provide rotation rate measurements for navigation and guidance systems; it has no rotating parts but can substitute for a gyroscope, which previously was required for this purpose.

Rockeye: A U.S. cluster bomb which dispenses 247 unguided anti-armor shaped-charge bomblets.

RPV: Remotely piloted vehicle: an unmanned vehicle which is guided by operators in a control station, where television imagery or other information transmitted by the vehicle is displayed. In this report, the term refers only to aircraft. See also *UAV*.

RSC: Reconnaissance-strike complex. A Soviet military term for integrated surveillance/attack systems such as those demonstrated by DARPA in its Assault Breaker program.

R&S/SA: Reconnaissance and surveillance/situation assessment.

RSTA: Reconnaissance, surveillance, and target acquisition.

SAC: Strategic Air Command of the U.S. Air Force.

SACEUR: Supreme Allied Commander, Europe.

SADARM: Search and Destroy Armor, Smart anti-armor submunition for surface-to-surface weapons.

SAM: Surface-to-air missile.

SAR: Synthetic aperture radar. A type of airborne or orbital radar used for obtaining high-resolution radar images of stationary objects. A SAR can obtain imagery much more detailed than that obtainable by a real aperture radar having an antenna of comparable size.

SCDL: Surveillance and Control Data Link (for Joint STARS).

SEAD: Suppression of enemy air defense.

SENIOR RUBY: A tactical ELINT system.

SENIOR SPEAR: A tactical COMINT system.

SFW: Sensor Fuzed Weapon. A U.S. Air Force anti-armor weapon now in development, consisting of a Tactical Munitions Dispenser (TMD) containing ten BLU-108 Skeet dispensers, each of which releases four Skeet submunitions.

SHAPE: Supreme Headquarters, Allied Powers, Europe.

SIGINT: Signals intelligence. Consisting of both communications intelligence (COMINT) and electronics intelligence (E LINT).

SINCGARS: Single-Channel Ground-Air Radio System. A jam-resistant voice radio system used for communications between aircraft and ground units of the U.S. Air Force and the U.S. Army.

SIOP: Single Integrated Operational Plan. For U.S. use-of strategic nuclear weapons.

Skeet: A "smart" puck-shaped anti-armor submunition developed by the Air Force to sense a target and discharge a high-velocity explosively-formed penetrating projectile at it. "Skeet" is a trademark of Avco Corp.

Skeet/TGSM: In this report, denotes smart anti-armor munitions: either Skeet or TGSM or both.

Skyeye: An unmanned aerial vehicle made in the United States by Lear-Siegler.

SLAR: Side-looking airborne radar.

SNS: Site Navigation Subsystem of PLSS.

SOTAS: Stand-Off Target Acquisition System. A heliborne MTI ground-surveillance radar system developed by the U.S. Army. The SOTAS program has been canceled and superseded by the Joint STARS program.

SRSOM: Short-Range Stand-Off Missile; NATO feasibility study.

SSM: Surface-to-surface missile,

Standoff Air Atk: See *AIR ATTACK.*

STARS: See *Joint STARS.*

STC: SHAPE Technical Centre.

surveillance: As used here, routine monitoring using any of several types of sensors (e.g., airborne radar).

T-16: The Patriot missile.

T-22: The Lance missile.

TA/AC: Target acquisition/attack control

TAC RECCE: Tactical reconnaissance, A tactical air mission.

TACAIR: Tactical aircraft, air forces, or airpower.

Tacit Rainbow: A long-endurance missile (an expendable lethal air-launched unmanned aerial vehicle) being developed in the United States to attack radio emitters such as radars and jammers.

TACMS: Tactical Missile System (see *ATACMS).*

TADARS: Target Acquisition/Designation Aerial Reconnaissance System. A reconnaissance and target acquisition and designation system being developed for the U.S. Army. It includes the Aquila unmanned aerial vehicle as well as truck-mounted rail launchers, recovery nets, air vehicle transporters, maintenance shelters, and ground-control stations.

target acquisition: Detection and recognition of a potential target and estimation or prediction of its location with sufficient accuracy to permit attacking it effectively with available weapons.

TBM: Tactical ballistic missile.

TDOA: Time difference of arrival. A radiolocation technique–used by the Precision Location Strike System (PLSS)–by which a network of radio receivers can determine the relative location of a transmitter. Also: a related technique—used by other military and civil radiolocation systems such as LORAN—by which a single radio receiver can determine its location relative to those of synchronized radio transmitters,

TERCOM: Terrain Comparison. A system and method for high-accuracy navigation, presently employed on certain cruise missiles.

TEREC: ELINT reconnaissance equipment carried by some RF-4C aircraft.

TGSM: Terminally-Guided Submunition. Smart anti-armor submunition under consideration for ATACMS missiles. The TGSM has the capability to search an area for the target vehicle and then fly toward the target and kill it by detonating a shaped charge on contact.

TGW: Terminally Guided Warhead. A developmental warhead for MLRS rockets which will release TGSMs.

TLE: Target location error.

TMA: Theater of military action. Also known as TMO, TSMA, and TVD.

TMD: Tactical Munitions Dispenser. A U.S. Air Force system (denoted SUU-65/B) to dispense submunitions over a given target area. Many different types of submunitions can be used in the TMD, including the CEB, Gator, and Skeet.

TMO: Theater of military operations. (Also TMA, TSMA, and TVD.)

TMSA: Theater of military strategic action. (Also TMO, TMA, and TVD.)

Tomahawk: A cruise missile manufactured by General Dynamics in several versions: some armed with nuclear warheads, others with non-nuclear warheads.

Tornado: An advanced air interdiction aircraft in production and being fielded by the FRG, Italy, and the United Kingdom.

TR-1: A high-altitude, long-endurance aircraft used by the U.S. Air Force for surveillance and reconnaissance. It is used by the Tactical Reconnaissance System (TRS) and by the Precision Location Strike System (PLSS).

TRIGS (pronounced "triggs"): TR-1 Ground Station. A buried, hardened facility designed to receive, process, and exploit data from Tactical Reconnaissance System sensors carried by TR-1 aircraft, When operational, TRIGS will replace or augment the Tactical Reconnaissance Exploitation Development System (TREDS); it will provide additional capabilities such as dynamic (i.e., in-flight) retasking of TRS sensors.

TRAC: (1) the TRADOC Analysis Center of the U.S. Army; (2) Tactical Radar Correlator. A mobile ground station being developed by the U.S. Army for receiving, processing, exploiting, and disseminating data from airborne radar systems.

TRADOC: The Training and Doctrine Command of the U.S. Army.

TREDS: Tactical Reconnaissance Exploitation Development System. A developmental transportable ground station for the Tactical Reconnaissance System (TRS). TREDS includes: 1) a Mission Control Element (MCE), 2) an Interoperable Ground Data Link (IGDL), 3) a Tactical Ground Intercept Facility (TGIF), 4) a Ground Control Processor (GCP), 5) a SAR Ground Facility (SGF), 6) a Wide-Band Communication Element (WBCE), 7) a TREDS Communications Element (TCE), 8) an ASARS-II Interface Device (AID), and 9) a TREDS Support Facility (TSF).

TRS: Tactical Reconnaissance System. An airborne reconnaissance system which includes the ASARS-11 radar system.

tube artillery: Artillery guns, as distinct from missile artillery.

Turbine Islander: A twin-turboprop aircraft (designated BN-2T) made by Pilatus Britten-Norman in several versions; one—the CASTOR Islander –has been modified to carry the British ASTOR-1 side-looking airborne radar (formerly called CASTOR-I).

TVD: Teatr voennykh deistv. A Soviet military term variously translated as theater of military action (TMA), theater of military strategic action (TMSA), or theater of military operations (TMO); see ch. 4.

UAV: Unmanned aerial vehicles, including remotely piloted vehicles (RPVs), which require remote control by human pilots; autonomous aircraft (drones), which do not; and aerial vehicles which permit, but do not require, remote control by human pilots.

UHF: Ultra-high frequency. Radio frequencies between 300 megahertz (million cycles per second) and 3 gigahertz (billion cycles per second).

UK: United Kingdom of Great Britain.

UMV: Unmanned vehicle. Refers only to an unmanned aerial vehicle (UAV) in this report.

USAFE: U.S. Air Forces, Europe.

USAREUR: U.S. Army, Europe.

VGK: The Soviet Supreme High Command (transliteration of a Cyrillic acronym).

VHF: Very-high frequency. Radio frequencies between 30 megahertz (million cycles per second) and 300 megahertz.

WASP: (1) a now-defunct Air Force air-launched mini-missile development program; (2) an airborne computer system being developed for the F-4G Wild Weasel aircraft.

WDL: Weapon Data Link of Joint STARS, using the Joint STARS radar to transmit target data and a Weapons Interface Unit installed on an attack aircraft or missile to receive it.

WDU-25B: See Bullpup.

Wild Weasel: U.S. Air Force TACAIR hunter-killer system (denoted F-4G) for attacking enemy air defense units.

WIU: Weapons Interface Unit. A component of Joint STARS which would be installed on attack aircraft or missiles to receive target data updates from Joint STARS aircraft via the Weapon Data Link. A WIU is being developed, and the Air Force is considering procuring it.

WP: Warsaw Pact.

WW: Wild Weasel.