Appendix
Delivery Systems and Munitions

Two major areas of development are of particular interest for the follow-on forces attack (FOFA) concept: reconnaissance, surveillance, target acquisition, and data handling; and munitions and delivery systems. Little can be said about the former in an unclassified report. This appendix provides information on munitions and delivery systems.

A weapon system is a combination of a delivery system and a munition. The delivery system—an aircraft, a missile, or an aircraft launching a missile—needs to have several general capabilities if it is to be of use in follow-on forces attack:

- **range:** FOFA targets will be located anywhere from 30 km back to as far as the Polish-Soviet border, some 800 km from the inter-German border;
- **accuracy:** depending on the target and the munition, the delivery system must be able to land a munition to within anywhere from 100 m or so to less than 1 m of the target; and
- **survivability:** aircraft and missiles must be able to reach the target (and aircraft must make the return trip as well) without getting shot down.

The choice of delivery system ranges from a manned aircraft flying directly over the target and dropping a munition, to a ground-launched missile that flies autonomously to the target. In between are a range of possibilities involving missiles launched from aircraft at increasingly longer "standoff" distances. As that distance increases, the survivability of the aircraft increases, but the time during which the missile must fly autonomously increases as well—which means less capability against targets which can move between the time the missile is launched and the time it arrives over the point at which it was aimed, unless the missile receives mid-course target location updates. Ground-launched missiles eliminate the aircraft altogether, but are vulnerable before launching–missile launchers will be high-priority targets for the Warsaw Pact. A manned aircraft is also able to compensate for imprecise target-location information and for the movement of targets by placing a human observer on the scene. Short-range missiles can incorporate relatively simple guidance systems that offer substantial improvements in accuracy over free-fall munitions; but at longer ranges, providing high accuracy becomes a complex engineering challenge.

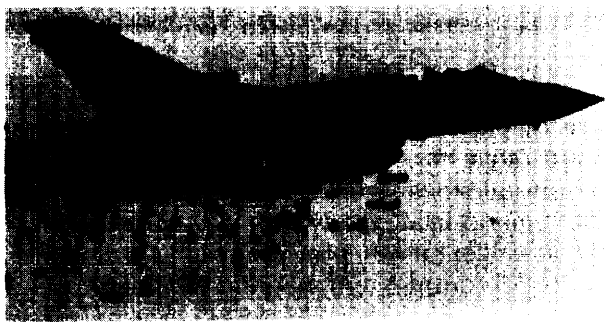
Munitions for follow-on forces attack can be as simple as conventional high-explosive bombs. But improvements in two general areas can significantly increase the usefulness of a munition in follow-on forces attack:

- **kill radius:** a conventional 500-lb high-explosive bomb must land within a meter of a tank to put it out of action; a munition with a greater area of effect need not be delivered so accurately and may in addition be able to engage multiple targets; and
- **lethality:** hardened targets, such as armored vehicles and reinforced concrete command posts, are becoming resistant to conventional high explosives; moreover, a more sophisticated lethal mechanism that uses smaller amounts of explosives increases the number of targets that can be killed per pound of aircraft or missile payload.

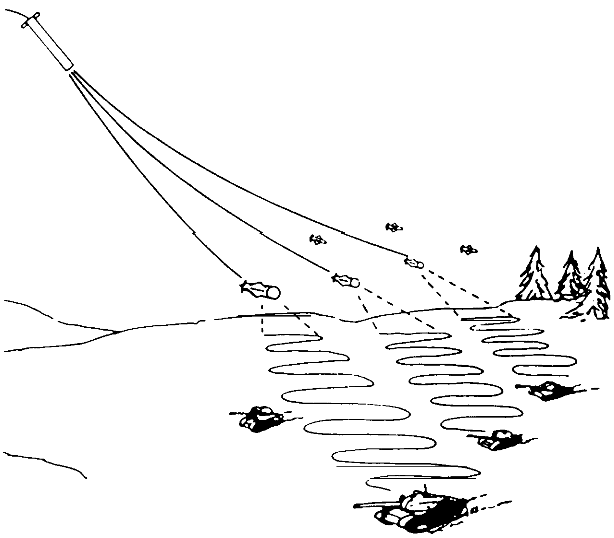
Munitions concepts are, broadly speaking, variations on three themes: unitary explosives, such as bombs and artillery shells; cluster weapons, which contain many small "submunitions" that blanket a large target area; and "smart" submunitions that search out an area with electronic sensors and selectively engage the targets they find. Figure A-1 illustrates these approaches.

Although it is often convenient, as above, to separate delivery systems from munitions—and indeed that is the way procurement requests are presented to Congress—the two elements do in fact form a complete, interacting system. Choices in one determine the range of choices available for the other, An inaccurate missile, for example, could not use a munition with a very small kill radius. On the other hand, a munition capable of engaging multiple targets per pass could inherently increase the delivery system's surviv-

Figure A-1.—Munitions Concepts



(a) MW-1 Dispenser releasing "dumb" submunitions



(b) Terminally guided submunitions frying out to seek targets

SOURCES: Photo—MBB Corp. (Messerachmitt-Bokow-Blohm (GmbH)); drawing—General Dynamics Pomona Division.

ability by reducing the number of sorties required to kill a given number of targets. The effectiveness of any one component can be measured only by examining how well the entire system functions.

Delivery Systems

Aircraft

Historically, only aircraft have been able to reach the sorts of depths behind enemy lines required to attack follow-on forces. "Air interdiction" —the Air Force's term for attacking ground targets beyond the immediate battle area—is however just one of several missions that NATO's air forces are charged with carrying out, a fact reflected in the capabilities and relative numbers of the various aircraft now in the inventory.

The United States aircraft that can play a part in follow-on forces attack fall into three general categories:

1. long-range ground-attack fighter/bombers (F-111 and future F-15E);[1,2]
2. multi-purpose fighter/bombers that, as competing demands permit, could assume some ground-attack missions (F-4 and F-16); or
3. strategic bombers which could be designated-to support NATO (B-52, FB-111, and future B-1 B).

Aside from the obvious question of range (see figure A-2), a number of factors determine the suitability of an aircraft for follow-on forces attack missions:

- **Targeting equipment: In** order to locate and attack targets day and night and in all weather, aircraft require aids such as high-resolution ground-mapping radar and forward-looking infrared (FLIR, which is used for precise targeting close-in; the LANTIRN targeting pod, to be acquired for the F-16 and F-15E, contains a FLIR along with electronics for controlling precision-guided bombs).
- **Crew size:** Flying an aircraft in an extremely hostile environment and operating modern precision-guided ground-attack weapons are both demanding jobs; a two-man crew permits one member to give full attention to each task.
- **Low-altitude flight:** Because of the dangers of being spotted by enemy radar and being shot down by ground-based air defenses, aircraft penetrating enemy territory may fly very low–200 feet or so;[3] not all combat aircraft are equipped with the terrain-following radar or infrared navigation equipment needed to maintain these low altitudes safely at night or in bad weather. (The LANTIRN navigation pod provides both.)

[1]The F.15E will retain the F-1 5's air-to-air combat capabilities, and in fact may be called on early in a conflict to carry out air superiority missions, but is built primarily for ground attack.

[2]This report deals with U.S. systems. Airplanes that are in the inventories of our Allies, but not our own, are not discussed, Principal among these is the Tornado aircraft, currently in production. The ground attack versions being procured by the Germans carries the MW-1 submunition dispenser, aspects of which are discussed in this appendix.

[3]This doctrine is being reconsidered, however; some analyses suggest that medium-altitude flight may prove safer, in some cases.

Figure A-2.—Combat Radii of Unrefueled U.S. Ground-Attack Aircraft

Assumptions: HI-LO-LO-HI profile from England; LO-LO-LO from Germany
LO flight at 480 knots and 200 feet
4,000 lb of ground-attack ordinance plus self-defense weapons*

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* The assumed loads listed below were provided by the Air Force to place the range comparisons on a common basis; they are not meant to represent the preferred ordinance for actually attacking follow-on forces.

F-1 11 F: ECM Pod, PAVE TACK
2 x AIM-9
2 x Mk-84

F-4E: ECM Pod; 2 external fuel tanks
2 x AI M-7
2 x Mk-84

F-16A: ECM Pod; 2 external fuel tanks
2 x AIM-9
2 x Mk-84

F-15E: LANTIRN nav + trgt pods; 2 conformal, 3 external fuel tanks
2 x AIM-9; 2 x AIM-20 (AMRAAM)
2 x Mk-84

- **Availability:** The multi-purpose fighters will be largely committed to fighting the air superiority battle for at least the first few days of a war in Europe, according to Air Force analyses; committing aircraft to FOFA missions would reduce the Air Force's ability to gain or maintain air superiority. In addition, some of the ground-attack fighter/bombers (particularly F-1 11s and designated F-4s) probably would be held on alert for tactical nuclear missions and would be unavailable for conventional air interdiction.

Because of the long development time for new aircraft, NATO is likely to continue well into the 1990s with current equipment and the equipment entering the inventory in the next few years. (See table A-1.)

When flying directly over the target, a manned aircraft has the advantage of placing a human observer in a position to adjust his plans to the immediate situation on the ground. On the other hand, the accuracy with which direct-overflight munitions—bombs, or dispensers holding submunitions—can be delivered to targets can be relatively low. For a dive-bombing attack, the accuracy is very good. For a "toss" delivery, in which the aircraft remains several kilometers away from the target and releases the bomb during a climb—in effect lobbing the bomb to the target—accuracy is lower. In both cases, too, the aircraft may be very exposed to ground-based air defenses.

Table A.1 .—Ground-Attack Aircraft Characteristics

F-111
IOC[a]: 1988
Crew: *2*
Take-off weight: 42,000 kg
Targeting: ground-mapping radar
FLIR on F-111Fs with PAVE TACK pod
Night/all-weather: yes

F-15E
IOC: 1989
Crew: 2
Take-Off weight: 37,000 kg
Targeting: ground-mapping radar; FLIR[b] with LANTIRN[c] targeting pod
Night/all-weather: yes, with LANTRIN nav pod

F-16
IOC: 1979
Crew: 1
Take-off weight: 15,000 kg
Targeting: visual; LANTIRN will add FLIR
Night/all-weather: at present, no; LANTIRN nav pod could provide capability

F-4
IOC: 1961
Crew: 2
Take-off weight: 28,000 kg
Targeting: visual; PAVE TACK on F-4Es add FLIR
Night/all-weather: no

[a]IOC—Initial operational capability.
[b]FLIR—forward-looking infrared.
[c]LANTIRN—low altitude navigation targeting infrared night.

SOURCES: *Jane's All the World's Aircraft* 7985-&3 (London: Jane's Publishing Co. Ltd., 1985). *Nuclear Weapons Databook, Volume I* (Cambridge, MA: Ballinger Publishing Co., 1984). "The F-15E" *International Defense Review,* August 1985.

The standard bombs in the Air Force inventory are the 500-lb Mk-82 and 2,000-lb Mk-84 free-fall, general-purpose bombs. A variety of dispensers have been developed to hold submunitions; most are released like bombs, but are fuzed to break open after a set interval or when a set altitude is reached, scattering the submunitions.

Close-Range Air-to-Ground Missiles

By adding a guidance system and controllable tail fins to free-fall bombs or submunition dispensers, accuracy has been greatly improved. Wings, which permit the bomb to glide aerodynamically, or a small rocket motor give these missiles a modest range that permit the aircraft to remain several kilometers away from the target. The guidance concept of these missiles, however, requires that the target be in sight at the time that they are launched.

Two basic approaches to guidance are employed: laser-spot designation and autonomous TV-tracking. In the former, a laser beam is aimed at the target either by the attack aircraft or a second, "buddy" aircraft, and the missile homes in on the reflected laser light; in the latter, a TV or imaging-infrared camera is mounted on the nose of the missile, the pilot or weapons officer lines up the target in cross-hairs on a TV screen, and the missile then locks on to that point and guides itself in.

Paveway.–The Paveway series of laser-guided bombs consists of kits that are attached to conventional Mk-82 and Mk-84 bombs. The laser "designator," which produces a coded beam that matches a code fed into the bomb's electronics before take-off, is carried in a pod mounted either on the attack aircraft or on a second aircraft which could remain at a safe distance from the target while the attack aircraft flies in and releases the bomb. The current designator pod, PAVE TACK, has a forward-looking infrared (FLIR) camera which sends a picture of the ground ahead to the cockpit; the weapons officer uses a joystick to line up the target in cross-hairs and must keep it there manually until the bomb impacts. It is currently deployed on F-4 and F-1 11 aircraft, which have two-man crews. A new targeting pod, LANTIRN,[4] is being developed for the F-16 and F-1 SE; once a target is initially selected, LANTIRN can be locked on, automatically keeping the laser designator pointing at it, and freeing the pilot or weapons officer to perform other tasks.

The older Paveway IIs in the inventory cannot be dropped from low altitude because of their small airfoil, a fact that severely hinders their usefulness in the face of antiaircraft defenses. A new version, Paveway III, also known as the Low-Level Laser-Guided Bomb, has an improved guidance system. The Air Force decided in spring 1985 to cancel its planned procurement of paveway III because of rising costs, however. The 5,000 Mk-84 versions (known as the GBU-24) purchased with fiscal year 1985 funds will be delivered by 1987; some 500 have been delivered so far (along with 200 of the Mk-82 versions, known as GBU-22).

Maverick.–The Air Force has in operation with F-4, F-1 11, and F-1 6 aircraft a TV-guided antiarmor missile, the Maverick AGM-65B. In operation, the pilot can slew the TV camera located on the nose of the bomb to line up the target in cross-hairs on a TV display in the cockpit; the Maverick is then launched and flies autonomously to the indicated target. It is propelled by a small solid-fuel rocket motor. Approximately 30,000 TV Mavericks have been produced.

A new version, now in production (the AGM-65 D), substitutes an imaging infrared **(IIR)** seeker for the TV. Its operation is similar to that of the TV version; but in addition it can be used at night and under low visibility, and it roughly doubles the range at which targets can be recognized even in daylight. The IIR version also can be used in conjunction with the LANTIRN targeting pod, which simplifies the job of finding and locking onto a target. (F-16 and F-1 SE aircraft are to be equipped with the LANTIRN system, which consists of a targeting pod and a navigation pod. The navigation pod includes a terrain following radar, which allows the pilot to fly at low altitudes even at night, and a forward-looking infrared (FLIR) camera that gives the pilot a night-vision picture of the ground below.) The LANTIRN targeting pod can give the pilot a wider field-of-view picture than does the Maverick's own camera; once the pilot locates a probable target on the wide field-of-view LANTIRN display, he can switch to a higher magnification to identify it and then lock

[4]For "Low-Altitude/Navigation and Targeting Infrared System for Night."

the Maverick seeker onto it.[5] Without LANTIRN, the entire search would have to be carried out by slewing around the small field-of-view Maverick seeker, a difficult job for the pilot of a single-seat aircraft who must at the same time keep the aircraft flying at low altitude and avoid hostile fire. The Air Force Mavericks carry a 60 kg shaped-charge warhead for penetrating armored vehicles.

Short= to Medium- Range Air-to-Ground Missiles

Longer range air-to-ground delivery systems incorporate guidance systems that do not require a direct line of sight to the target at the time of launch from the aircraft. They also permit aircraft to stay out of range of the enemy's terminal air defenses (in the case of the short- to medium-range missiles in this section) or even to avoid having to penetrate enemy airspace altogether (in the case of the long-range missiles discussed below).

For the medium-range missiles in this category, the two systems used are command guidance, in which a radio data link allows the operator to steer the missile throughout its flight; and inertial guidance, in which the missile is programmed before launch with the relative geographic coordinates of the target and then flies out on its own. Ranges of tens of kilometers are characteristic of these systems. A third basic guidance system, which allows the missile to recognize the target automatically and home in on it, is in laboratory stage of development, and may be incorporated into the Autonomous Guided Bomb, discussed below.

GBU-15/AGM-130.—The Air Force is now acquiring the GBU-15, a command-guided glide-bomb built around a 2,000-lb Mk-84 warhead. A TV camera mounted on the nose transmits a picture back to the cockpit during its flight. The weapons officer uses a joystick to steer the GBU-15, making course corrections as needed; once the target is well in view, it can be lined up in cross hairs and the guidance system locked on to automatically guide the final approach. (If the target is in sight before launch, the target can be locked on from the start.) As with the Paveway, control can be handled either by a weapons officer in the attack aircraft or from a second aircraft that remains farther from the target; the radio link of the GBU-15, however, allows this buddy aircraft to be much farther away, provided it maintains a direct line of sight to the bomb's flight path. The aircraft controlling the GBU-15–currently F-4E, F-1 11 F, and, when it arrives, the F-15E–must carry a 200-kg data link pod.

Since production began in 1980, 1,600 have been purchased and 700 delivered. The unit cost has fallen from $194,000 in 1980 to $128,000 in 1985. An imaging infrared version, to allow night and poor-weather operation, is now in initial low-level production; full production is scheduled to begin in 1988. The seeker was adapted from the imaging-infrared Maverick.

The range of theGBU-15 can be roughly doubled by adding a small rocket motor;[6] such a system, designated AGM-130, is now in full-scale development, with initial production of one version scheduled for fiscal year 1987. That version, the AGM-130A, carries a 2,000-lb Mk-84 bomb. The AGM-130B, which would instead carry a submunition dispenser, is not currently funded. (Although only one submunition load, designed for airfield attack, was being planned for the dispenser version, in principle other submunitions could be used as well.) Current plans also call for incorporating the improved 2,000-lb bomb, designed to penetrate hardened targets, in fiscal year 1988 in a third version of the AGM-130. The Air Force is currently planning to begin work late in fiscal year 1986 on a new data link that will be more resistant to jamming than the present model; the first improved models would be produced in fiscal year 1990.[7]

[5]An automatic target recognition (ATR) system is being developed for possible installation on advanced versions of the targeting pod. Developmental versions of this system have been tested.

[6]The actual range improvement depends on launch altitude, with the greatest relative improvement at low-level release.

[7]Several other concepts for improving the utility of the GBU-15/AGM-1 30 have been suggested. Inertial guidance could, for example, allow the pilot to release the bomb while flying obliquely to the target; it would also reduce the workload on the weapons officer, making it feasible to control more than one bomb at a time, switching from one to another only as each one reached the final approach to the target. The data link is already configured to handle four channels, thus allowing four bombs to be in flight at once; studies by Rockwell, the prime contractor for theGBU-15 and AGM-130, suggest that the workload of fourGBU-15s with inertial guidance is comparable to that of one standard GBU-15.

Inertially Aided Munitions.–A demonstration program is in progress at the Air Force Armament Laboratory to incorporate a low-cost inertial navigation system into a guided Mk-82 bomb (the concept is equally applicable to the Mk-84). The coordinates of a fixed target would be entered before take-off; Global Positioning System data would provide the position of the aircraft at the time the bomb is released. Because the time of flight of the bomb is so short (on the order of a minute), drift of the inertial system is not a serious problem, and a low-quality system can be tolerated. Inertial navigation would allow the bomb to be released at a location preselected to be safe from antiaircraft defenses; the target need not be in view; and a second crew member is not needed to control the bomb to the target. When released at a distance from the target, the accuracy would be better than that attained in conventional dive-bombing with free-fall bombs. The 2-year demonstration program started in fiscal year 1986; a further 2 to 3 years would be needed for full-scale development. The cost objective is $10,000 each.

LOCPOD,SRSOM.–The United States, Italy, Spain, and Canada are jointly funding a feasibility study for a low-cost, probably inertially guided, powered submunition dispenser. The principal targets would be airfields; a range of 15 to 30 km is contemplated. A feasibility study for a similar dispenser that would carry antiarmor submunitions for attacking armored combat vehicles may begin in late 1986; the United States, Britain, and Germany are now involved and other NATO members have expressed interest. Discussions are under way to fold both programs together into a single NATO cooperative development program for a "modular standoff weapon. "

Autonomous Guided Bomb.–For attacking some high-value fixed targets, such as bridges, the accuracy of a pure inertial system is insufficient. One way to combine the autonomy of the inertially aided munitions with the precision of the command-guided bombs is to equip the bomb with an automatic capability to recognize the target and guide itself in to a precise impact point. The Air Force Armament Lab is cataloging imaging infrared features of "generic" targets and developing algorithms to automatically recognize key features. An early version, of which the Air Force is planning to begin full-scale development in 1988, would be programmed before take-off with information about the target and its location relative to a preplanned release point. It would probably be built around the Low-Level Laser-Guided Bomb or the AGM-130. A research program is also exploring the application of automatic target recognition to millimeter-wave sensors for the GBU-15 and Maverick.

Long- Range Air-to-Ground Missiles

The Air Force has for several years been interested in a longer range (several hundred kilometer), conventionally armed, air-launched cruise missile, primarily for airfield attack. At these ranges, inertial guidance alone is no longer sufficient: the accumulated drift in even very expensive inertial systems is simply too greats Periodically correcting the inertial guidance system by comparing the missile's actual location—as measured by sensors which scan the terrain below—against prestored maps can improve the accuracy; this is the technique (known as TERCOM, for terrain comparison) used in nuclear-armed cruise missiles. But accuracy is still not sufficient for conventionally armed missiles, which—at least for hard targets such as bridges and reinforced-concrete buildings—must get to within a matter of a meter.

Even correcting the inertial system with data from the Global Positioning System satellites may not solve the problem if the exact location of such fixed targets is not known with sufficient accuracy. Thus inertial guidance would likely be applicable only to mid-course guidance of a conventional, long-range cruise missile.

Terminal guidance, involving a sensor that looks at the actual target, would be needed to fine-tune the missile's course on the final ap-

[8]The high-accuracy mechanical gyroscopes used in commercial aircraft inertial navigation systems typically have a position error that increases at a rate of 0.s km per hour; ring-laser gyroscopes which are far less expensive and more compact, have a higher drift rate. (See *Proceedings of the IEEE,* October 1983, 71, pp. 1121-1232.) A cruise missile flying 600 km at high subsonic speeds would, if it relied on inertial navigation alone, wind up at least several hundred meters off target. Fiber optic gyros, currently under development, promise to be cheaper and more accurate than ring-laser gyros (see *IEEE Spectrum,* March 1986).

preach. The two basic approaches are scene matching, which compares an optical or imaging infrared image with a stored picture of the actual target; and automatic target recognition, which combines a sensor (laser radar, TV, imaging infrared) with a processor that recognizes the key features of generic types of targets. The former is already in use in the conventionally armed ground- and sea-launched Tomahawk cruise missile and the reentry vehicle of the Pershing II ballistic missile; the latter is in the laboratory stage.

JTACMS.–An outgrowth of the **now-defunct** MRASM medium-range air-to-surface missile program, JTACMS is a joint Air Force-Army effort to develop a new conventionally armed missile.

LRSOM.–The United States, Britain, and Germany are working jointly on a feasibility study for a conventional cruise missile known as the NATO Long Range Standoff Missile (LRSOM); the project began in April 1985. No hardware is being built yet, however. The main target for such a missile would be heavily defended airfields, and the missile would be designed chiefly to carry runway cratering submunitions and mines. The concept could in principle be adapted to other missions, however. Some form of terminal guidance would be necessary in either case. The missile would be launched from an aircraft (although ground launching might be an option) and have a range of up to 600 km (the limit set by the SALT II agreement on cruise missiles launched from aircraft other than strategic bombers).

Ground-Launched Missiles, Rockets, Artillery

Ground-launched weapons that might otherwise be suitable for follow-on forces attack have, until very recently, had little capability of reaching much beyond the range of conventional artillery—about 30 km. Although some longer range tactical surface-to-surface ballistic missiles (currently, Lance) have had a nominal capability to carry conventional explosives, their essential purpose lies in the tactical nuclear mission. Proposals have from time to time been made to adapt intermediate-range ballistic missiles to conventional missions, for example using the first stage of the Pershing Ia or II for airfield attack, g but there are no actual programs at this time; similarly, the nuclear-armed ground-launched Tomahawk cruise missile could be armed with a conventional warhead (as is in fact done in two ship-launched versions of the Tomahawk), though there are no plans to do so at present.

The Army's decision in December 1985 to proceed with full-scale development of a new conventionally armed ballistic missile known as ATACMS will however change this picture significantly. Extended-range artillery, if eventually combined with guidance systems or smart submunitions, could also provide some follow-on forces attack capabilities. Smart submunitions and guidance systems are currently being incorporated into conventional artillery and rockets, with some application to very short-range FOFA missions.

MLRS.–The multiple launch rocket system consists of a 25-ton tracked vehicle that can launch 12 rockets without reloading. Its chief role is to generate the rapid surge of artillery fire needed to counter enemy artillery. A new warhead, containing smart submunitions, is being developed to give the MLRS rockets an antiarmor capability.

The United States has acquired 250 launchers to date; current plans call for a total procurement of 348 by 1988. An additional 143 launchers would be procured to handle the extra assignment of the ATACMS missile. The British, French, Germans, and Italians also plan to acquire MLRS launchers.

ATACMS.–Originally a part of the joint Army-Air Force JTACMS program, ATACMS split off in June 1984 when the Army decided to proceed at once with development of a ballistic missile that could be fired from existing MLRS launchers. Unlike the Assault Breaker missile from which it is descended, ATACMS will not have the capability to receive target course corrections while in flight; coordinates will be fed into the system just before launch. In-flight updates could allow the missile to engage targets that would other-

'strengthening Conventional Deterrence in Europe ESECS II **(Boulder, CO: Westvievv Press, 1985), pp. 55-62.**

wise have moved out of the missile warhead's kill radius during the 3-minute flight time, and that capability might be added in the future as a block improvement.

Although the accuracy of ATACMS is to be considerably better than that of Lance, it still will not have the terminal guidance that would be needed to score a precise hit on a point target. Warheads being developed for ATACMS, discussed below, are thus designed to disperse a large number of submunitions over a wide target area.

The existing MLRS launchers, which the U.S. Army and other NATO armies have already begun to acquire, will be able to handle the ATACMS without modification. The ATACMS will be packaged in canisters (one ATACMS per canister) identical in outward appearances to the MLRS canisters (containing six MLRS rockets); all U.S. MLRS batteries will be equipped with both. Thus the higher value and more threatening ATACMS will be dispersed among a larger number of MLRS rounds, making it difficult for the enemy to single out the smaller number of ATACMS for selective attack.

Munitions for ATACMS are discussed below; they are the APAM cluster warhead now used on conventional Lance, a smart antiarmor submunition (possibly an I R-Terminally Guided Submunition), and possibly a wide-area smart submunition for attacking surface-to-surface missile units.

Lance.–Development work on Lance began in 1962; it was deployed in 1976. Although a conventional warhead is deployed, the principal role of Lance is nuclear. It has a range of 5 to 125 km. Lance, which is fired from its own mobile launcher, will continue to have the nuclear role after ATACMS is deployed.

Extended-Range Artillery .-A rocket-assisted artillery shell is already in the Army's inventory; it has a maximum range of approximately 40 km. The Army Armament Research and Development Center and DARPA are also supporting research on solid-fuel ram jet rounds for 155 mm and 8 inch artillery, which may be able to extend the range to 60 to 80 km. A generic problem with all efforts to add propulsion to artillery rounds is that less and less space is available for the warhead and for a guidance system, which starts to become a necessity at longer ranges as the accuracy of a purely ballistic round degrades; or, conversely, that the round grows larger and larger.

Guided Artillery .-The Army is now acquiring a "smart" 155 mm artillery shell known as Copperhead that homes in on a target illuminated by a laser designator. Although Copperhead (also known asM712) is a short-range weapon in terms of follow-on forces attack scenarios (16 km) and requires a forward-observer (or a remotely piloted vehicle) to handle the laser designator, the principles involved in Copperhead could be extended to longer ranges if it proves feasible to incorporate such guidance systems into rocket-assisted or ramjet-powered rounds. A new sensor is being developed for Copperhead (Copperhead II) that would allow the projectile to home in on the target autonomously. (The sensor is a two-color IR detector that looks for the characteristic "signature" of a tank. It is being developed in a joint project that will also have applications to the terminally guided submunition (TGSM) being developed for the ATACMS missile, discussed below.) The cost of Copperhead is now $35,000 per round.

EM Guns.–Much further in the future are electromagnetic guns, or "rail guns, " that would achieve greater ranges through an entirely new propulsion technology. Electric generators, perhaps powered by diesel fuel, would provide the propulsion energy now provided by an explosive charge. In principle, an electromagnetic gun would be easier to resupply (diesel fuel is easier to move than the conventional artillery propellant) and would have a longer range; in addition, an EM gun would not subject the projectile to the very high initial acceleration of artillery that requires electronics systems incorporated into artillery projectiles (guidance and smart submunitions) to be engineered to withstand that shock. Even optimistic projections, however, do not place initial production of an EM gun before the first decade of the next century.

Munitions

The representative approaches to carrying out follow-on forces attacks described in the summary identified three broad classes of targets: armored maneuver units; "hard" fixed targets, such as bridges and heavily reinforced concrete command posts; and "soft" area targets, including movable command posts, air defenses, surface-to-surface missile units, and other lightly armored or unarmored vehicles within the maneuver units.

Combat Vehicles

The principal targets for follow-on forces attack are the follow-on forces themselves, which are made up of large numbers of armored combat vehicles (e.g., tanks, personnel carriers, infantry fighting vehicles) along with about twice as many trucks and other light vehicles. They may be on trains moving across Poland, or, closer to the battle area, moving along roads either on transporter trucks or under their own power; at intervals they may also be stopped, either pulled off along roads or arrayed in assembly areas.

The fact that they are moving much of the time, however, and the fact that at least the tanks (less so the other armored vehicles) are heavily protected against conventional high explosive munitions, imposes some special requirements on he munition-delivery system package. During the i me that elapses from the moment a target is located, to the time that that intelligence can be processed, an order to attack issued, and a delivery system finally arrives over the target area, he target may well have moved. Thus either the nunition must have a large kill radius to compensate for the uncertainty in the target's final position, or the delivery system must have some utonomous capability—either a human or a sophisticated automatic target recognition system—o look for the target and adjust its course accordingly.

The increasingly heavy armor on Soviet tanks means that a virtual direct hit is required to cause ny damage—a 500-lb Mk-82 bomb would have o land literally within a meter of a tank to be effective. One solution to this problem is the use of "smart" precision guidance on the delivery system, as is done in the Maverick air-to-ground missile. The solutions that apply directly to munitions are of two general types:

1. cluster bombs, which blanket the target area with many small, unguided submunitions; and
2. smart submunitions, which incorporate guidance or sensor electronics into the submunitions themselves.

By spreading the kill mechanism over a wide area, both of these approaches increase the effective kill radius of the weapon as compared to a unitary warhead of equivalent weight; they also permit several targets to be killed with a single weapon. In the case of air-delivered munitions, this means the pilot need only look for an array of vehicles rather than pinpointing each individual vehicle and attacking it separately, one target per pass; for both air and ground delivery, it reduces the delivery accuracy needed.

The use of smaller submunitions in the place of a single 500 lb or 2,000 lb bomb in turn, however, requires the development of lethal mechanisms more sophisticated than simple high explosive blasts. The two principal technologies are the shaped charge, which focuses a relatively small explosion into a concentrated jet of gas that more readily penetrates armor (but which, conversely, has to hit the target directly to be effective); and the self-forging fragment or explosively formed penetrator, a thin, extremely high velocity metal slug that impacts (and may penetrate) the tank armor, causing fragments of armor to span off on the inside of the tank. A number of the concepts discussed below—particularly those employing explosively formed penetrators, which, as a rule, are less able to penetrate armor than shaped-charge warheads—envision attacking tanks from the top, where the armor is the thinnest.

Armored combat units can also be attacked by mines. Traditionally, mines have been considered a delaying tool; in a typical scenario they would be used to create a chokepoint where vehicles back up, forming a lucrative target for direct attack by air- or ground-delivered weapons. Recent technological developments, though, which allow mines to be emplaced remotely–either by aircraft, or by artillery or rockets—and which incorporate smart sensors and an extended area of effect into mines, may increase their effectiveness to the point where they can be considered antiarmor weapons in themselves.

All of these new antiarmor systems face continuous improvements in Soviet armor. Composite armors with spacings between layers provide significant increases in protection. Reactive armor—layers containing small explosive charges that are set off when hit by an antitank weapon —can degrade the effectiveness of modest-sized shaped charges. Other advances in armor effectiveness are likely to be made by the time many of the new antiarmor systems discussed here can be fielded.

CLUSTER BOMBS

Rockeye.– Built in the 1960s and procured in considerable quantities, the Rockeye is a 500-lb-class bomb; after release, a time fuze triggers the bomb to break apart, releasing 247 unguided antiarmor shaped-charge bomblets.

According to the Air Force, Rockeye is not effective against the newer Soviet tanks; it would, however, be effective against more lightly armored vehicles and older tanks still in the inventories of non-Soviet Warsaw Pact armies.

CEM.–The principal new Air Force cluster weapon is the Combined Effects Munition, which consists of 202 beer-can-sized bomblets in a Tactical Munitions Dispenser; the TMD is a new general-purpose, 1,000-lb-class submunition dispenser designed to be dropped from as low as 200 feet. An air bag on each bomblet causes it to descend vertically, increasing its probability of hitting the vulnerable top of an armored target. The CEM bomblets consist of a shaped charge for penetrating armor, inside a fragmenting case which produces shrapnel that can damage trucks at 20 m and aircraft or personnel at 80 m; a zirconium incendiary capable of igniting diesel fuel at a distance of 3 m is also included. Against tanks, however, it is effective only on the more lightly armored surfaces. The TMD can be adjusted to produce a pattern of bomblets on the ground ranging from roughly 100 to 300 m long. Deliveries to inventory began this year; approximately 30,000 are to be purchased by the end of fiscal year 1988; and the procurement goal is 200,000 to 300,000. The cost is approximately $20,000 per fully loaded TMD.

KB-44.–Designed for use in the MW-1 submunition dispenser, the KB-44 is a small, shaped-charge bomblet weighing half a kilogram. Tail fins stabilize its flight. A fully loaded MW-1 dispenser delivers 4,500 KB-44s. The MW-1 dispenser is carried on the German-British-Italian Tornado fighter; it remains fixed on the aircraft's underbelly and rapidly ejects the submunitions in sequence when the aircraft passes over the target. (It thus requires the aircraft to fly directly over the target; a toss delivery is not possible.) The MW-1 is too long to fit on other aircraft; Germany is developing another version—the Modular Dispenser System–to be compatible with all NATO aircraft.

DPICM.–The current warhead for the MLRS rocket launcher—so-called MLRS phase I—contains 644 dual-purpose improved conventional munitions (DPICM) per round which are scattered over a 100-meter-radius circle on the ground. Each DPICM contains a small shaped charge surrounded by a fragmenting case, so that it is effective against both light armor and materiel and personnel. (The DPICMs are slightly smaller than the CEM bomblets.) The United States has so far acquired 14,000 MLRS rockets with DPICM warheads; plans call for a total inventory of 362,000.

SMART SUBMUNITIONS

Smart submunitions offer in principle several advantages over either conventional bombs, cluster bombs, or precision-guided bombs. The two major types of smart submunitions, terminally guided submunitions and sensor-fuzed submunitions, both operate by searching out an area on the ground for a tank or other armored vehicle and accurately delivering a projectile to it. (The terminally guided submunitions fly directly into the target, sometimes described as "hit-to-kill"; the sensor-fuzed submunitions shoot an explosively formed penetrating rod into the target from a distance of 100 m or so, described as "shoot-to-kill.") Because they are small, several submunitions can be packed in the space of a single conventional bomb; because they can search out areas 100 to several hundred meters across, they do not have to be precisely delivered by aircraft or surface-to-surface weapons; and because they are able to detect and precisely locate the target, autonomously, they can achieve a greater number of kills per pass.

Two sensor technologies have been used to date in smart submunition designs: **infrared** detectors, which sense heat—typically coming from the tank's engine compartment; and **millimeter wave** detectors, which can either be passive—which sense a different wavelength of heat radiation than do infrared detectors, but with poorer resolution—or active, which is a form of radar, with better resolution than typical longer wavelength radars.

How well these sensors can detect tanks under a variety of conditions, including the presence of countermeasures that the Soviets might deploy, is currently being tested in a joint Army-Air Force program. The performance of the warheads is also being tested. The results of these tests are expected to influence strongly the course of development of new sensors and the choice of submunitions for new weapons systems.

The major issues that will determine the choice between a terminally guided submunition (TGSM) and a sensor-fuzed weapon in any given application are:

- cost (sensor-fuzed weapons are cheaper by a factor of 5 to 1 O);
- "footprint' '-the area on the ground searched (TGSMS cover an area some 50 times greater); and
- lethality (TGSMs, which use a shaped-charge explosive, have a greater penetration than the explosively formed penetrators).

TGSM.–The terminally guided submunition incorporates some of the automatic target recognition and guidance concepts discussed in connection with cruise missiles; however, because it is specifically an antitank weapon and as such has a limited target set to search for, the technology is simpler—it is not so much target recognition as target detection. In the typical deployment, TGSMs would be released from a missile, rocket, artillery shell, or aircraft and, after falling to an altitude of several hundred meters, would begin to glide at a steady altitude with their seekers scanning back and forth across a track on the ground, ***500*** to 1,000 m wide. The length of the search "footprint" depends on the speed and altitude at which the TGSMs are released; it might typically be several kilometers. When the seeker detects an object on the ground that matches the characteristics of a tank, it sends a signal to the guidance system to steer toward it by adjusting its control fins. A shaped-charge warhead, containing a few kilograms of explosive, detonates on impact.

A TGSM was developed for the Assault Breaker demonstration project. Closest to actual deployment is a millimeter-wave TGSM now being developed for the MLRS rocket (usually referred to as MLRS phase Ill, or the MLRS Terminally Guided Warhead (TGW)). The project is a French-German-British-United States collaboration, with 40 percent of the funding coming from the United States and the remainder split equally among the other three partners. Low-level initial production is scheduled to begin in late fiscal year 1989 with full production by fiscal year 1992. Current plans call for six TGSMs to be packed into each MLRS rocket, though there are some doubts that it will prove feasible to keep the size of the TGSMs under the 26-inch length limit that this goal prescribes; three larger TGSMs (which would on the other hand have larger warheads) might be used instead.

The U.S. Army has favored an infrared sensor for the TGSM, and is planning a l-year program, beginning in June 1986, to develop a candidate two-color IR seeker for use in an ATACMS missile (known as ATACMS Block II; Block 1 is the conventional APAM warhead discussed below). A decision to proceed with full-scale development of the ATACMS Block I I would come in fiscal year 1989. The seeker would be gun-hardened—that is, capable of withstanding the shock of being fired from mortar or artillery-so that it could also be used in a guided artillery shell such as Copperhead II.

The Air Force is also supporting an analysis project that is examining the utility of air-launching TGSMs from a Tactical Munitions Dispenser or a dispenser version of the air-to-ground missile, AGM-130.

Skeet, Search and Destroy Armor (SADARM). –Unlike the TGSMs, the sensor-fuzed weapons do not fly into the target; they descend in a fixed vertical or parabolic free-fall trajectory, scanning a much narrower piece of ground for a target, and fire a self-forging penetrator when they detect a target. Because of the narrower search area, much simpler infrared (IR) or millimeter wave detectors can be used (they are referred to as "sensors" to distinguish them from the much more sophisticated "seekers" employed in TGSMs) and the expensive guidance systems of the TGSMs which are needed to translate the data collected by the seeker into control signals for the steerable tail fins are eliminated altogether. (As a rule of thumb, ***70*** or ***80*** percent of any guided missile's cost is in the guidance systems; cost of one SADARM is estimated to be several thousand dollars as compared to $20,000 to $50,000 for a TGSM.)

The Air Force's version (known by the Air Force as simply the Sensor-Fuzed Weapon or SFW or by the contractor's name for the submunition, "Skeet") is designed to be dispensed from a Tactical Munitions Dispenser. All of the sensor-fuzed weapons must spin while descending so that the fixed sensor or sensors on the submunition can scan out an area on the ground. The Air Force SFW employs a complex deployment sequence to achieve this spin and to allow deployment at low altitudes; the Skeet are ejected, spinning, in a 100-m long parabolic trajectory. Each TMD contains 40 Skeets; all together they cover an area on the ground, with the theoretical possibility of hitting as many as 40 vehicles in that area. The SFW submunitions employ a two-color IR sensor, which "looks" for the engine compartment of a tank.[10] In a test conducted at Sandia, New Mexico in September 1985, in which four Skeets were mechanically tossed over tanks, all four hit the targets; three of the four hits were considered to have been "kills" that would have put the tanks out of action. The Air Force recently decided to proceed with a $57 million full-scale development program. Production could begin in fiscal year 1989; the procurement objective is 14,000 TMD-loads at a total cost of approximately $2 billion.

The Army's sensor-fuzed submunition program, known as SADARM (for "Sense and Destroy Armor"), is about to begin engineering development of submunitions for 155 mm artillery and MLRS rockets. Both will use simple IR and millimeter wave sensors. In each case, the SADARMs are deployed from the shell on a parachute that is designed to rotate as it drops, causing the submunition to spin around the vertical axis. The sensor, which looks down at a 30-degree angle from the vertical, thus scans out a collapsing spiral on the ground, covering a circle with a diameter of roughly 150 m. The accuracy of the shot is determined in effect by the accuracy of the sensor.

A SADARM has already been developed for the larger 8-inch artillery shell, and was successfully demonstrated in a test-firing in April 1985, in which a shell containing one SADARM submunition was shot 10 km and the SADARM deployed and hit its target. The Army has decided not to proceed with production of the 8-inch version, however. The MLRS effort began in the second-quarter of fiscal year 1986, with the 155 mm to follow in fiscal year 1987; both will be gun-hardened and the goal is that they will have 70 percent of parts in common. Initial low-level production would begin 2½ years after the start of the development work in each case; the first ones would be fielded in 4½ years. The MLRS SADARM can be of the same diameter as the SADARM developed for the 8-inch gun, and can thus be available sooner than the 155 mm version; the major challenge is reducing the cost. The 15S mm version poses a greater technical challenge, as the 8-inch version (which has an outer diameter of 6.9 inches) will have to be shrunk to a 5.9 inches outer diameter. (The smaller size makes packaging the sensors more difficult; it also requires using a smaller penetrator, which will be less lethal.) An MLRS rocket could carry six SADARMS, which together would cover an area of roughly 400 m by 400 m on the ground.

[10] The original version, which used only a single-color IR Sensor, suffered from a problem known as "fratricide": the flash of one Skeet firing would be picked up by the IR sensors of all of the other Skeet in the area, triggering them to go off as well. Two-color sensors are able to estimate the target's temperature and thus distinguish a warm tank from the flash of other Skeet firing and from flares which might be used as decoys.

MINES

Two major advances in technology have occurred that may make mines attractive candidates for follow-on forces attack missions. First, methods for dispensing mines remotely—from artillery, rockets, or aircraft-have been developed; and second, the lethality of mines against armored targets has been greatly increased. The usual concept of employing mines calls for antipersonnel mines to be scattered along with the antiarmor mines in order to make clearing the minefield with infantry as difficult as possible.

FASCAM.–The Army and Air Force have developed and are now acquiring two basic types of remotely deliverable mines—antitank and antipersonnel–known generically as FASCAM (for "family of scatterable mines"). The Air Force version, known as GATOR, consists of a 1,000-lb-class tactical munitions dispenser containing 72 antitank mines and 22 antipersonnel mines. The mines land over a 200-foot by 300 to 400 foot area on the ground when the TMD is dropped at an altitude of 200 feet. The TMD can be carried on all NATO aircraft. The Army versions are delivered in a 155-mm artillery shell, carrying 36 antipersonnel mines (known as ADAM) or 9 antitank mines (RAAM) per shell. Helicopter, truck, and hand emplaced versions are also being acquired.

Although there are differences in the Air Force and various Army versions, most of the components of the mines are shared. The antitank mine has a magnetic sensor that is activated when a tank passes directly over; an explosive charge is then set off which forms a steel plate at the top of the mine into a high-speed slug which penetrates the lightly armored belly of the tank. The antipersonnel version unreels long (20 feet for ADAM, 40 feet for GATOR) triplines on descent; a large fragmentation grenade is set off when the triplines are disturbed. Both mines self-destruct after a preset time. The Air Force began purchasing GATORs in 1983, at a cost of $55,000 per GATOR; approximately 1,500 are now in the inventory. Both ADAM and RAAM are currently in production; approximate costs are $4,000 per ADAM shell and $5,000 per RAAM shell.

The Army Armament Research and Development Center is examining new sensors, including acoustic, seismic, infrared, and optical sensors that may be more resistant to countermeasures; remote control of mines (which could for example allow mines to be emplaced and activated or cleared by radio command at a later time); and new warheads.

MIFF.–The West Germans have developed a similar air-delivered antitank mine, MIFF. At present, it can be delivered only by the German-British-Italian Tornado aircraft equipped with the l0,000-lb MW-1 submunition dispenser; 896 MIFFs are spread over a large area, 500 m wide by 180 to 2,500 m long. The MIFF employs seismic and magnetic sensors and a shaped charge explosive,

AT-2.—West Germany is developing a scatterable mine to be carried in MLRS rockets; the program is designated MLRS Phase II. The mines–28 per rocket—descend on a parachute and automatically right themselves after landing. A wire antenna which mechanically senses a tank passing over sets off a shaped-charge explosive. Although the United States is committed to assisting the research effort by developing the packaging needed to integrate the mine into the rocket, there is little interest in the Army to purchase the mine when full-scale production begins in 1988. The U.S. Army Training and Doctrine Command is, however, reviewing the need for an MLRS-deliverable mine. West Germany and Italy are committed to purchasing the AT-2; Britain and France have expressed interest.

ERAM.-The Air Force has developed a prototype "smart" mine that is indicative of the direction in which mine technology is heading: ability to control a wide area (and thus the ability to command a road from a concealed position to one side), to discriminate between tanks and lower value targets, and to attack the lightly armored areas of the tank (in this case the top). The ERAM (extended-range antiarmor mine) consists of nine mines (BLU-101 submunitions in the Air Force's designation) in a tactical munitions dispenser, The TMD is dropped, and the mines dispensed sequentially, falling by parachute over a ground pattern typically 200 to 300 m long.

When a seismic sensor picks up a tank's vibration, the mine's main electronics are switched on and three acoustic sensors begin to track the tank's movement; the seismic and acoustic sensors together can determine the location of the tank, its speed and direction, and can distinguish between tanks and other vehicles. When the tank reaches its closest approach to the mine, the mine rotates and fires a Skeet submunition up and over the tank. The submunition, which itself contains an infrared sensor (a more complete description appears above in the section on smart submunitions) flies in a 200-foot-long, 50-foot-high arc, searching for the precise location of the tank. When the IR sensor detects the tank (it looks particularly for the hottest spot on the tank, namely the lightly protected engine compartment), the Skeet fires a self-forging fragment directly down onto the top of the tank. The mine thus covers a range of 200 feet in all directions; it is equipped with two Skeets, as well as three fragmentation grenades that are lobbed out when the detectors sense the approach of personnel,

After final tests of a prototype, the Air Force decided not to proceed with full-scale development in fiscal year 1987 as originally planned. The estimated cost is $75,000 per TMD-load. The Army Armament Research and Development Command is exploring an almost identical concept for development by the Army,

Hardened Fixed Targets

Bridges and tunnels, which may be important targets in the effort to halt the movement of follow-on forces forward, are representative of a class of hard, fixed targets. Their location is known in advance; but to destroy them requires a very precise hit with high explosives. Taking out a bridge, for example, may require hitting a support member to within a meter or less. The hardness of these targets poses other problems for conventional munitions as well: a bomb may actually bounce off, it may fail to penetrate far enough into the target before detonating, or the fuzes may be damaged on impact.

Two general approaches to munitions are being pursued to deal with these targets: bomb cases can be hardened to increase their penetration; or rocket motors can be added to accelerate the projectile through the fortifications ("kinetic energy penetration"). Although most of the existing boosted kinetic energy penetrators have been developed for cratering runways, the basic concepts are applicable to penetration of other hardened targets.

I-2000/HAVE VOID.–The conventional 2,000- lb Mk-84 bomb is capable of penetrating 3½ feet of concrete if it strikes it perpendicularly; the penetration drops off sharply as the angle of impact decreases, to the point where the bombs may actually bounce off. In addition, penetration of hard targets sometimes damages the fuze of the bomb, which then fails to detonate. The Air Force has initiated a quick program to develop an improved Mk-84 to be used with a Paveway II laser guidance kit on the F-4E fighter. A forged steel case will replace the rolled and machined steel of the Mk-84; and the nose and aft fuzes of the Mk-84 will be replaced with a single aft fuze. Penetration of 6 feet of concrete with a perpendicular impact and 3 feet at a 45-degree angle is expected. The fuze is factory set to detonate the bomb at a fixed time interval after impact to allow the bomb to penetrate. A production contract was awarded in June 1985 and a limited buy of 1,300 is planned. Cost is $14,000 per bomb; the Paveway II guidance unit adds another $15,000.

1-2000 P31.–A longer term program, with production planned to begin in fiscal year 1987, will adapt the initial 1-2000 bombs from the HAVE VOID program for use with the GBU-15, Paveway III, or as an unguided bomb; it will preserve the mechanical characteristics of the Mk-84 and will be compatible with the F-4, F-15, F-16, and **F-1 11** aircraft.

Hardened Target Munitions.–The Air Force Armament Lab is planning a development program, beginning in 1987, to examine several advanced concepts for hard target penetration, including a "smart" fuze that could be adjusted to detonate the bomb only after several layers of concrete and voids had been penetrated (which would allow the bomb, for example, to penetrate a selectable number of floors through a building), and rocket-boosted penetration, discussed below

Durandal.–France has developed a 500-lb bomb which is deployed on a parachute; when the bomb has decelerated and is aiming toward the ground at an angle, the parachute is jettisoned and a rocket motor ignites, driving the bomb into the target. The fuze sets the bomb off after a delay to allow it to reach an appropriate depth. The Air Force has purchased the Durandal as a stopgap while the BKEP (see below) is developed; but it is generally considered a cumbersome weapon for its intended purpose because it is a large unitary weapon—each one making only one hole—requiring many sorties before a runway is covered with enough holes to make it unusable over its entire length. It is also not suitable for use as a guided weapon in its current form.

BKEP, JP-233, STABO, ASW.–All four of these submunitions are much smaller weapons than the Durandal[11] and are designed to be deployed by a dispenser (BKEP in a tactical munitions dispenser or a dispenser version of the AGM-130;[12] STABO and ASW in the MW-1; and JP-233 in a similar dispenser also built for the Tornado aircraft). All use some form of boosted penetration; BKEP, which is slated by the Air Force for full-scale development in fiscal year 1986, and JP-233, a British weapon that the Air Force was at one time participating in the development of, are quite similar in operation to the Durandal. The STABO, and the ASW (designed to penetrate aircraft shelters), use a shaped charge to create an entry hole in the target on contact and then ignite a small charge to drive in the projectile; a time delay sets off the main charge.

None of these submunitions can themselves be guided; rather, they seek to make up for a lack of terminal accuracy in numbers, blanketing the target area.

Soft Area Targets

Soft targets–surface-to-air or surface-to-surface missile launchers with their associated communications and radar trucks, supplies and trucks in a depot, field headquarters—are generally movable (rather than fixed, as bridges; or mobile, as tanks) and spread out over some area. The principal weapons against these targets are cluster bombs that contain fragmenting bomblets. Smart weapons are also being considered for the special case of surface-to-surface missile launchers which can relocate after firing; it is the firing that gives away its position, but by the time that a munition can be delivered against it, the launcher will be on the way to a new and safer position and may be a half a kilometer or more away.

APAM.–The conventionally armed Lance missiles are—and at least the first batch of ATACMS (referred to as ATACMS Block 1) will be–armed with antipersonnel/anti materiel (APAM) cluster-bomb submunitions designated M74; these are spherical, baseball-sized bombs with a tungsten fragmenting case. The ground pattern can be controlled by the height at which the warhead is fuzed to air-burst. The APAM is ineffective against armor.

AMIS.– Diesel fuel is an attractive target, both in supply dumps and in light vehicles; but it is relatively hard to ignite. The AMIS, or antimateriel incendiary submunition, breaks into fragments designed principally to pierce truck fuel tanks, producing a mist of diesel fuel; an incendiary then ignites the vapor. It is designed to kill a diesel-fueled vehicle at a range of **40** feet. The AMIS is designed to be carried in a standard aircraft tactical munitions dispenser, 30 per dispenser load. Advanced development has been completed, and the Air Force has no plans at present to continue with the program.

Focused-Fragment SADARM.—TO be effective against an imprecisely located surface-to-surface missile launcher, a munition will need to have a very large kill radius. A program to develop a smart submunition for this task, to be used in an ATACMS missile (designated ATACMS Block III), is beginning in fiscal year 1986. Both SADARM and TGSM submunitions are candidates.

To be effective as an area weapon against soft targets, the SADARM's explosively formed penetrator rod would be replaced with a "focused fragment" warhead that produces a large number of larger-diameter, though shorter, fragments. (Against lightly armored or unarmored targets the single long explosively formed penetrator is relatively ineffective: it owes its lethal effect to the

[11] The BKEP for example, is 4 inches in diameter and 43 inches long and weighs only 45 lbs, of which a mere 6.5 lbs is high explosive—as against the 500 lb Durandal.

[12] The actual deployment for airfield attack would contain a mix of BKEPS (to damage the runways) and mines (to hinder repair operations) in each dispenser load.

spalling that occurs when it strikes heavy armor. When it strikes a truck, for example, it simply forms a small hole and passes right through without producing any collateral damage.)

The large search "footprint" needed to cover the wide target area would be achieved by improving the SADARM sensor and by dispensing many SADARMs—the SADARM is smaller and less expensive than the TGSM, which makes this a reasonable idea.

Large-Footprint TGSM.–In order to search out a greater area on the ground, a TGSM for ATACMS Block III will require an improved seeker able to detect and begin homing in on the target from a greater distance. Two technology projects are now under way, looking at a dual-mode seeker, which combines IR and millimeter wave in a single seeker, and an imaging infrared seeker, which produces a picture-quality infrared image of the scene containing far greater detail than the very "patchy" digital picture of the conventional IR seekers. The advanced technology seekers could also be incorporated into the ATACMS Block II at a later stage to improve their antiarmor capability.

Costs are uncertain at this stage; estimates range from **$20,000** to **$50,000** per TGSM.