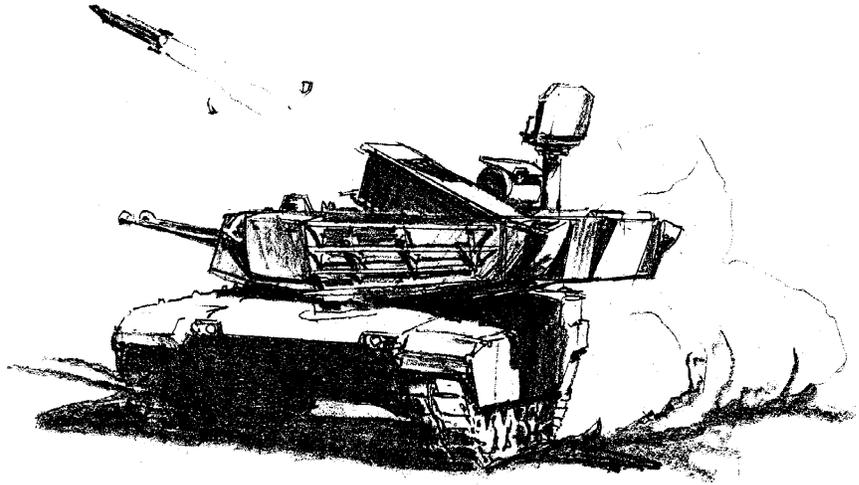


# Forward Area Air-Ground Defense

## *Do We Need A Dual-Role Hybrid Air-Ground Defense System for the Armored Forces?*

by Dr. Asher H. Sharoni  
and Lawrence D. Bacon



### Operational Requirements

Combined Arms Team (CAT) forward area armored maneuver forces are currently deficient in close tactical air and ground defense protection. The requirement for armored formations to be accompanied by self-propelled air-ground defense system (AGDS) vehicles, comparably mobile and ballistically protected, is nowadays widely acknowledged. Typically, air defense (AD) systems utilize radar-directed, light to medium gun systems or 'surface-to-air' guided missiles against a variety of aerial and ground targets.

Operational needs for an effective and crucial protective 'coverage' for the CAT have substantially escalated over the last two decades. The predominant rationalization is the proliferation of: a) ground-attack tactical fighter (fixed-wing, low-altitude aircraft) and antitank missile-launching, advanced attack helicopters; b) precision guided munitions (PGM); c) remotely piloted vehicles (RPV) and cruise missiles (CM); and d) a plethora of antitank weapon systems operated by armored fighting vehicles (AFV) or dismounted infantry.

A modern dual-role hybrid AGDS for the armored forces, at the brigade or division level, must be capable of keeping up with forward armored combat elements. Additionally, it *must* survive the extremely hostile 'armor vis-à-vis armor' intense battlefield environment. Consequently, an effective air-ground defense role may be accomplished by providing a timely and protective defense "umbrella" against most

antiarmor threats encountered in the modern battlefield presently and in the foreseeable future.

A highly-effective AGDS is characterized by:

- Cost-effectiveness in acquisition, procurement and operational deployment (affordable 'life cycle cost' -LCC)
- High operational availability and readiness
- Autonomous rapid fire control and weapon reaction
- Air/ground long-range target identification, acquisition, prioritization, and tracking with high 'hit and kill' probability
- Ammunition lethality and effective engagement range against all air/ground antiarmor designated targets
- All-weather, day/night, extended fighting capability
- Search and shoot 'on-the-move' overall capability
- Optimum crew ballistic protection, mobility and agility comparable to the M1-series tank

The typical advanced attack "tank-hunter" helicopter is predominantly perceived as a major, practically unchallenged threat to the armored forces. In fact, if the CAT is not equipped with effective antihelicopter ammunition or counterattack measures, it can do very little, if anything at all, to threaten and

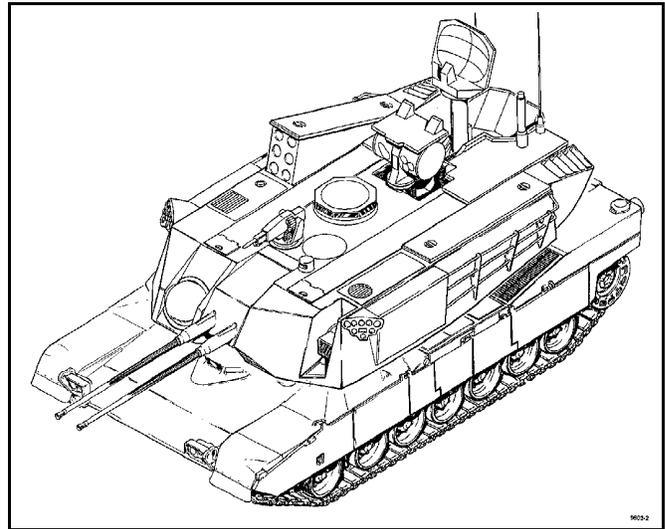
encounter this predator on equal terms. The reader will find it hard to conceive that one or two attack helicopters, effectively operated, may strike havoc, temporarily disrupt, and disable a whole armored formation if the latter is not provided nor equipped with adequate protection and effective countermeasures.

In addition to its enhanced capabilities against low-altitude, fixed-wing attacking aircraft and antitank helicopters, a modern AGDS *must* be capable of effectively engaging and defeating most ground targets, including tanks(!) and heavy armored vehicles (primarily in a *self-defense* mode). More often than not, the AGDS will be accompanied by tanks, so apparently there is no categorical need to provide it with a predominant 'tank kill' capability. Nonetheless, occasionally, while operating on the battlefield's forefront, an AGDS may encounter enemy tanks all by itself. In such a scenario, it needs to have the capability on board to survive.

Furthermore, its inherent antitank capability could be *selectively* exploited to engage vital-point, high-priority targets such as command vehicles (tanks), tank destroyers, and other highly sensitive targets. Indisputably, the AGDS's inherent capability to effectively engage such "hard" and "soft" ground targets as mounted or dismounted infantry, will substantially enhance the close-support and protection provided to the CAT.



The ill-fated DIVAD ("Sergeant York").



Proposed AGDS turret on M1 tank chassis.

### A Proposed Solution: The Hybrid AGDS for the CAT

As a viable, cost-effective and practical solution to the above mentioned threats, a hybrid AGDS must be capable of providing adequate defense for tanks and armored formations by creating an effective and close "fire screen." A hybrid AGDS epitomizes the best of both AD worlds — missiles and guns. Though 'surface-to-air' guided missiles demonstrate high kill probability at long ranges (10-12 km), they are expensive to operate and vulnerable to Electronic Warfare (EW) and Electronic Counter Measures (ECM). Consequently, it is essential to include a complementary weapon system, comprised of automatic barreled weapons against low-level aircraft, RPVs, helicopters, and various ground targets operating at short ranges (2.5-3 km). Thus, a modern AGDS must be equipped with a hybrid, completely integrated weapon system, optimized to engage air and ground targets/threats at required ranges under all adverse battlefield conditions.

### History: Division Air Defense Gun System (DIVAD)

The U.S. Army recognized the need for a new AD system two decades ago. In January 1978, the DIVAD ("Sergeant York") program was embarked upon by the U.S. Army for the design, development, fabrication, and test of two prototypes. The reasoning for the program was that the Army's forward maneuver forces were recognized to be severely lacking in air-defense coverage. Prototypes were scheduled for delivery to the U.S. Government in mid-

1980 for a comparative test and evaluation.

Development contractors employed existing European cannons and U.S.-made fire control systems and radars. The chassis, as prescribed by the U.S. Army, was a modified, Government Furnished Equipment (GFE), M48A5 tank. The U.S. Army planned to operationally deploy the first DIVAD units in the mid-1980s. Contractors were given ample flexibility to encourage design of a cost-effective system that could successfully achieve operational requirements commensurate with the threats. One prototype had as the main armament twin 40-mm L70 Bofors (Sweden) guns, while the other twin 35-mm KDA Oerlikon (Swiss) guns.

For various reasons, the DIVAD program did not live to see actual deployment. Nevertheless, the operational need did not vanish nor diminish. Conversely, it has steadily and persistently evolved to a degree that constitutes a clear and present threat to the CAT. The authors believe it is high time that the threat definition and present air-ground defense operational capabilities be reassessed, the operational requirements revisited and updated, and subsequently, an AGDS be fielded.

### AGDS/M1 Major Operational Capabilities Overview

The proposed AGDS/M1 is an armored, self-propelled, mobile, autonomous, cost-effective, technologically superior, and economically affordable integrated weapon system. It is designed to function as a dual-role, hybrid Air-Ground Defense System for

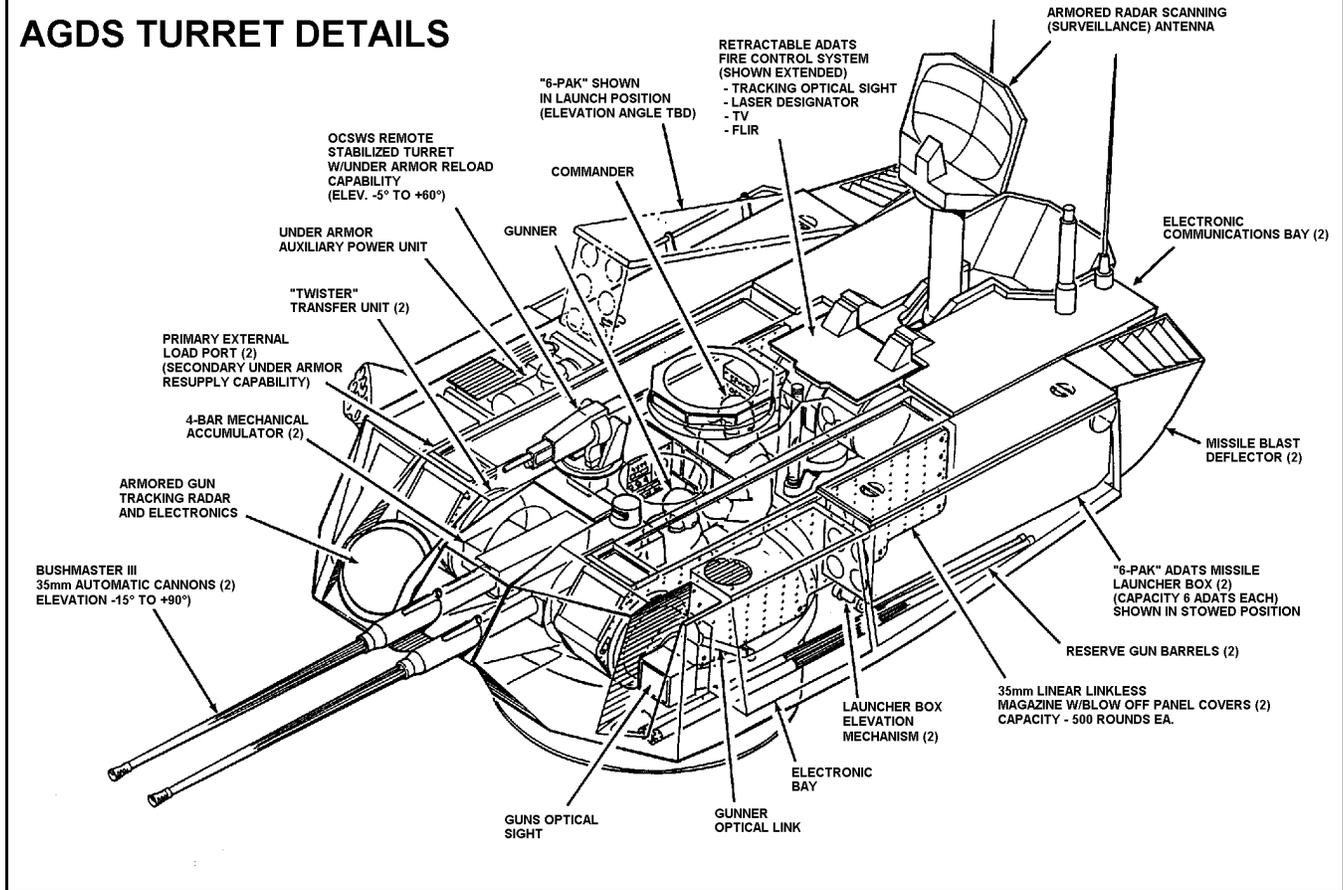
the CAT. The AGDS/M1 is a self-contained "fire unit" employing its own surveillance/tracking radars, fire control systems and main armaments for early detection and destruction of low-flying ground attack aircraft and aerials, antiarmor attack helicopters, and antiarmor ground targets. The AGDS/M1 is based on the battle proven, highly reliable M1 Abrams tank chassis.

The AGDS/M1 concept represents an extremely potent weapon system which, through effective sub-system integration, constitutes a significant leap-ahead in current armored air-ground defense conception and capabilities. It utilizes available proven weapon systems and mature technologies to address a pressing operational need. The following is an overview of its major operational capabilities related to the main armaments:

- **Primary Weapon System Candidate: 'Surface-to-Air' and "Surface-to-Surface" Guided Missile:** Air Defense, Anti-Tank System (ADATS) 'type' missile system is selected as the best overall 'system' choice for a primary weapon because of its inherent advantageous characteristics. ADATS was developed as an international private joint-venture undertaken by Martin Marietta (USA) under contract to Oerlikon-Bührle (Switzerland). ADATS is a single-stage, multipurpose, highly accurate, day/night and adverse weather missile system. It has a true and *unique* dual-target capability for engaging low-flying aircraft, advanced attack antitank helicopters, and armored vehicles.

The proposed AGDS/M1 consists of a passive electro-optical sensor retractable head containing a FLIR, TV, a la-

## AGDS TURRET DETAILS



ser rangefinder and a laser beam guidance sensor. Two banks of six missile retractable launchers each (12 missiles in a 'ready-to-fire' mode) are located and integrated at either side of the turret. ADATS was originally designed to permit flexible installation on a variety of wheeled and tracked vehicles and therefore could be modified and adapted to the AGDS/M1 configuration without major difficulty. The additional 'surface-to-surface' antiarmor capability of the ADATS is considered essential, but complementary to its principal anti-air role. It can penetrate the equivalent of 900+ mm (with growth potential) rolled homogeneous armor steel, sufficient to defeat most armored targets (composite/reaction) today and in the foreseeable future. In its various test programs, ADATS has undergone highly successful operating trials in all types of conditions and environments.

**AGDS/M1 Individual Mode of Operation:** On detection of an aerial target, it is handed off to the passive optical tracking system (high-resolution TV or thermal imaging IR) which is immune to both anti-radiation missiles and ECM. Following passive tracking

of the target in the Line of Sight (LOS), the missile is launched when the target is within range, subsequent and final guidance only being by encoded laser beam radiated from the launching vehicle or an external source. In an antitank 'surface-to-surface' operation, the target is acquired and tracked with FLIR/TV and a laser rangefinder ensures optimal engagement. Launch and guidance of the missile is performed with an encoded laser beam. AGDS/M1 could receive information on targets from a Skyguard fire control station.

The passive guidance system, combined with a smokeless, solid fuel rocket motor propellant, further enhance the system's survivability on the battlefield. The dual-purpose warhead, with fragmentation effects against air targets and shaped-charge against armored vehicles, is detonated by a nose-mounted, impact/crush fuze. An electro-optical proximity fuze is used for aerial targets only. The ADATS missile weapon system will be deployed to intercept air targets at ranges between 3 to 10 km and ground targets between 500 meters and 10 km.

**AGDS/ADATS Operating as an Air Defense 'Network':** A 'network' of six AGDS/M1, at the division level, can prioritize and engage up to 20 aerial and vital-point ground targets at any given time. The regional AD commander has a complete and expedient picture of the surrounding tactical area with inputs from all subordinate AGDS/M1s. The commander transmits information and targeting assignments to the individual AGDS/M1 over a data link. One or more surveillance radars of the AD network can provide necessary target information to other vehicles, which can then track and engage targets in a 'radar-silent' mode to minimize exposure.

**ADATS Missile Major Specifications:** Length: 2.08m; Diameter: 152mm; Weight: 51 kg (at launch); Dual-Purpose Heavy Warhead: shaped (hollow) charge and HE fragmentation (12.5 kg); Fuze: electro-optical range-gated laser proximity fuze with variable fuze delay and nose-mounted crush/impact fuze; Propulsion: solid, smokeless, rocket motor; Max. Speed: Mach 3+; Max. Intercept Range: 10 km (slow-air/ground targets), high

speed maneuverable aerial targets: 8 km; Max. altitude: 7 km.

• **Secondary Weapon System Candidate: Air-Ground Defense Automatic Guns:**

Two Bushmaster III 35-mm automatic cannons were selected as the best overall 'system' choice for a secondary weapon because of their inherent advantageous characteristics: American-designed and to be produced in the USA; near end of development; fires NATO standard 35-mm ammunition; demonstrates high reliability, superior durability, exceptional accuracy, and safe operation under all firing conditions. Bushmaster III is virtually an 'upscaled' design and incorporates all the battle-proven features of the Bushmaster 25-mm M242 gun which serves as the primary armament on the Army's Bradley Fighting Vehicle.

Bushmaster III combines design simplicity, external operation, positive round control, ease of maintenance and constant velocity feed to enhance reliability of gun and feed systems. Fired cases are ejected forward (overboard). Longer dwell after firing eliminates gun gas buildup 'under armor.' Bushmaster III capitalizes on the use of externally powered operation to separate mechanism motion from cartridge ballistics. This allows for a precisely timed and fully controllable operating cycle. A key feature assuring outstanding reliability is 100% positive cartridge control from the time the ammunition enters the feeder until the fired case is ejected from the weapon. It is readily adaptable to advanced, high performance, antiair and antiarmor penetrating rounds currently being developed to defeat present and projected future threats.

Utilization of the 'twins' will be limited to targets at ranges not greater than 2.5-3.0 km. To be effective, and yet preserve ammunition, single fire bursts must take no longer than 1.5-2.0 seconds. A very high rate of fire is not necessarily a decisive and mandatory factor at such a short range. Nowadays we have stabilized, highly accurate fire-control systems with enhanced computerized tracking and 'smart' programmed proximity fuses. These render the philosophy of "filling the sky with bullets..." — to increase hit probability — obsolete. The rate of fire is also adequate for engaging relatively slow moving ground targets. Therefore, a rate of fire of 250 rounds per minute,

500 rounds per minute total on target, should be sufficiently effective in hitting and killing air/ground targets within the designated ranges.

**Bushmaster III Gun Major Specifications:**

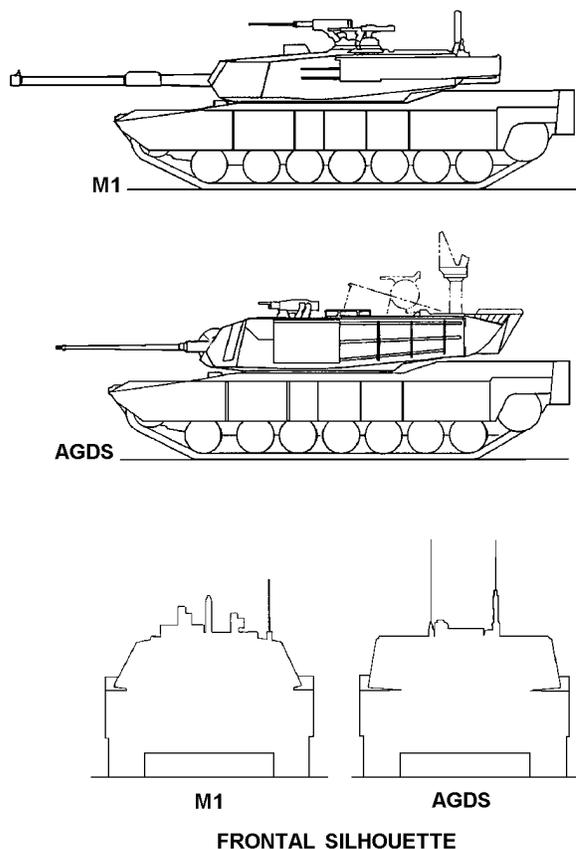
Caliber: 35mm; Muzzle velocity: 4540 fps; Peak recoil: 14,000 lb; Total weight: 535 lb; Overall length: 158.1 inch; Rate of fire: Single shot, 250 spm; Power required: 3.0 hp @ 28 VDC; Clearing method ('cookoff' safe): open-bolt; Safety: Absolute Hangfire Protection; Case ejection: forward (overboard).

**Ammunition (NATO Standard 35mm):**

Antiair and soft to medium ground armored targets-HEI/T (High Explosive Incendiary, T-tracer); SAPHEI-T (Semi-Armor Piercing +HEI); FAPDS (Frangible Armor Piercing Discarding Sabot). Oerlikon-Contraves has recently developed the AHEAD antiair/missile ammunition to keep abreast of the ever escalating threat scenario.

The essence of the AHEAD concept is the high-precision determination of time and projectile location in space to within 1/1000 of a second and one meter of distance from target. The actual velocity of each projectile leaving the muzzle is measured by muzzle velocity measuring coils and processed instantly by the fire control computer. Time of flight is calculated and imparted through electronic induction via front coil to the projectile's base fuse. When the projectile's timer hits the 'zero' mark, the fuse detonates the payload ejection charge, erecting a 'cone' of 100-200 heavy-metal, spin stabilized sub-projectiles that are directed towards the target with devastating terminal effects. This type of ammunition reduces the need for a high rate of fire to achieve a 'hit and kill' of an aerial target.

**M1/AGDS SILHOUETTE COMPARISON**



Anti-Armor - FAPDS, APDS-T (Armor Piercing Discarding Sabot), APFSDS-T (Armor Piercing Fin Stabilized Discarding Sabot) to combat armored targets. Evidently, if Bushmaster III is selected, 35-mm NATO standard ammunition must be produced in the U.S. under license. NATO 35-mm standard ammunition, when fired to ranges up to 3 km, is characterized by a short time of flight which ensures flat trajectories with resultant high hit probability.

It has excellent armor-piercing performance by use of discarding sabot shell and excellent final ballistics. Storage, transportation, handling and firing criteria are all in full compliance with the U.S. Army and NATO specifications.

• **Surveillance/Scanning Radar:** A dual beam, X-band, pulse Doppler surveillance radar, 25 km range with enhanced ECM resistance; High-elevation angle search antenna ensures long-range rapid target detection, IFF interrogation, acquisition and tracking with high survivability.

- Primary (ADATS) Fire Control System:** Comprised of Forward Looking Infra-Red (FLIR) and TV trackers, a Nd-YAG laser rangefinder and a laser beam rider using digitally encoded carbon-dioxide laser which provides a guidance beam for the beam-riding ADATS missile. It is fitted with search 'on-the-move' (preferably fire 'on-the-move'), 'track-while-scan' and automatic threat IFF interrogation, acquisition and prioritization for up to 10 targets.

- Secondary (Guns) Fire Control System:** High-powered armored tracking radar transmitter in the J/X-band (preferably 'off-the-shelf') provides enhanced performance against enemy threat and Electronic Warfare (EW) countermeasures; precision angle radar tracking for enhanced direct hit capability; rapid search, track and fire 'on-the-move'; target identification, acquisition and IFF interrogation by radar; Passive tracking FLIR, TV and optical sight; Active tracking by radar.

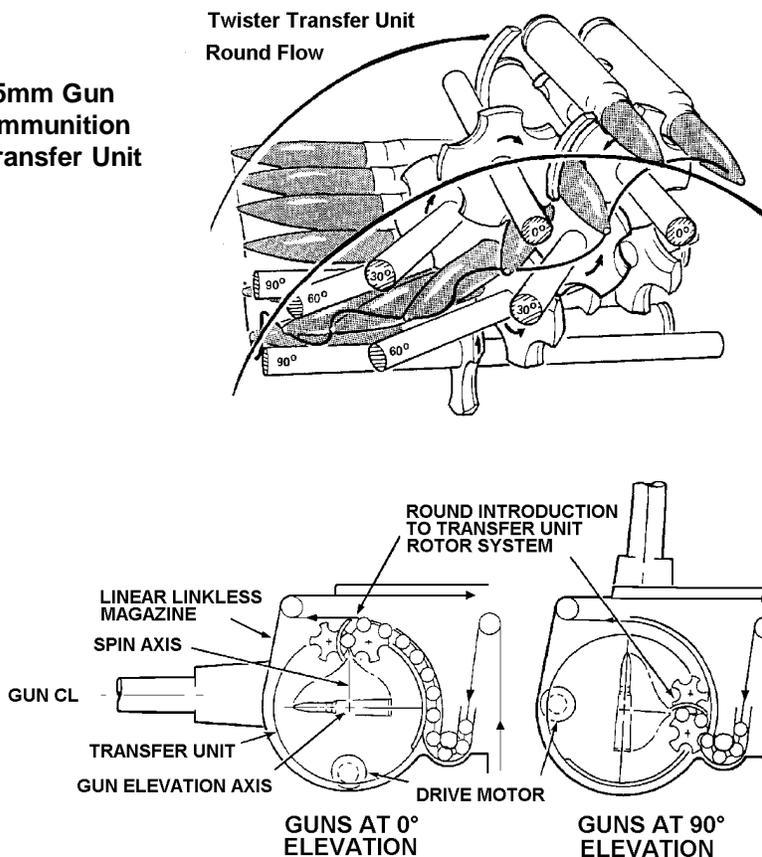
- Gun Optical Sight and Optical Target Designator:** Stabilized, dual-power sight for search, track, identification, and kill assessment while stationary or 'on-the-move'; Computer aided optical tracking against evasive maneuvering targets; Integrated night sight (FLIR) capability; Dual-beamwidth laser rangefinder for accurate air/ground target engagements; open hatch operation would require an optical target designator which provides quick target designation to the tracking radar or the optical sight.

- Command Control and Communications (C3):** C3 net allows the AGDS/M1 to be linked with higher echelon defenses and command centers, other radars and weapon systems for automatic response to saturation and time-compressed coordinated attacks.

- Armored Turret:** The turret's external envelope configuration and level of ballistic protection will resemble an M1 tank but it is not an M1 turret. This will make it more difficult for the enemy to 'single-out' the AGDS/M1 from the M1-series tank fleet as a high priority target. To enhance crew and vehicle survivability, "blow-off" panels will be installed in the magazine compartments.

- Gun Ammunition Handling System (AHS):** The AGDS/M1 utilizes a unique Ammunition Handling System (AHS). This system is comprised of a

### 35mm Gun Ammunition Transfer Unit



linear-linkless magazine, transfer unit ("Twister") and a 4-bar mechanical accumulator. It is a high-density system that minimizes the required volume such that the AHS approximately fits into an existing M1 tank turret envelope. The unique feed system also permits the elimination of flexible chutes which take up large volume, introduce mechanical complexity and substantially reduce reliability. Linear Linkless (LL) AHS is characterized by 60-70% increase in ready ammunition, enhanced operational effectiveness, lower LCC, less susceptibility to jamming and less chance of round damage.

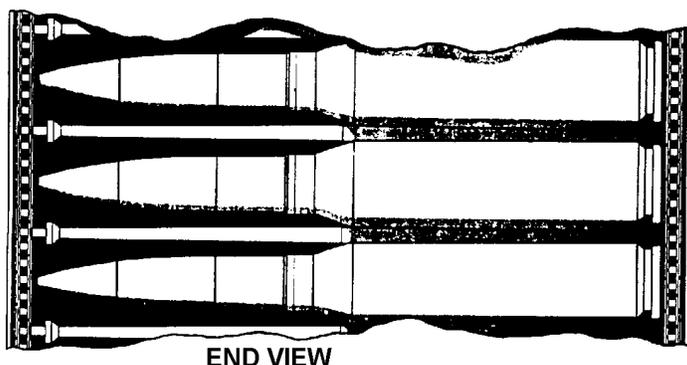
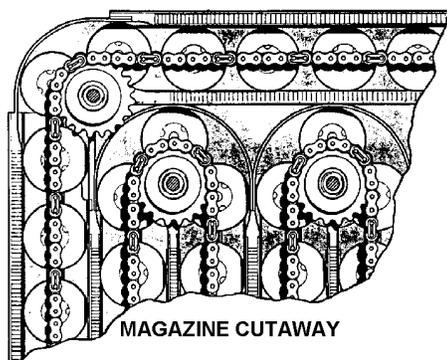
- Dual Feed Capability:** Bushmaster III has a dual feed capability. Anti-air ammunition is stored in the main magazines (2x500 rounds total). Antiarmor ammunition is stored in two additional small magazines (40-50 rounds capacity each), both located above the guns and each elevating with one gun to allow switching and immediate feeding of antiarmor ammunition in emergency situations. This dual feed arrangement reduces cost and volume, keeps the design simple, and maintains the highest possible system reliability.

- Crew:** 3-man crew (commander, gunner and driver) with one man full armament non-intense operation. Commander and gunner can interchange roles.

- Crew-Served Weapon System (CSWS):** The CSWS (currently under development) delivers a heavier volume of fire than contemporary crew-served weapons. It is primarily employed to defeat or suppress area-targets such as: personnel under cover and concealment, protected and unprotected personnel, unarmored and lightly armored vehicles, slow flying aircraft and ground emplacements. The CSWS will be installed on a stabilized, remotely operated turret with 'under-armor' loading capability (100-rd. magazine) It will be utilized as a day/night supplementary suppressive weapon system against enemy infantry operating antiarmor weapons.
 **Specifications:** Weight: 38 lb; Effective Range: 2000 m; Suppression: high at all ranges; Hit probability: high up to 2000 m; Operational Environment: all-weather, 24-hour, against air and ground targets.

- M1-Series Tank Chassis:** The preferred chassis for the AGDS is ostensi-

## 35mm Linear Linkless Magazine Details



bly the M1-series tank. If the AGDS is to provide close and immediate support to the CAT, it stands to reason that it should equally share the same levels of ballistic protection, mobility, and agility as the forces it is designated to protect. Otherwise, it will not survive, or not be there when its critical support is required. Oftentimes, we tend to make the misconceived decision of selecting a 'degraded' chassis for weapon systems that assume a combat support role. Over the life of the system, it generally proves to be erroneous, both operationally and economically. The M1 tank chassis will require only minor modifications to allow adaptation to the AGDS turret. The AGDS/M1, based on an M1 tank chassis, will benefit from imminent and future fightability and maintainability improvements planned for the M1-series tank fleet.

The M1A2 chassis provides mobility, agility, and maneuverability. It can keep up with armored formations and provide optimum crew ballistic protection with an inherent 20-25% weight

and combat load growth potential. An AGDS/M1, if not heavier than 55-60 tons, will have better mobility and agility than the M1-series tanks it is designated to protect. This unprecedented mobility and agility will permit the AGDS/M1 to exploit its firepower potential to the utmost and provide the necessary 'coverage' when and where it is required.

### Concluding Remarks

This article was written to capture the attention and imagination of the reader and trigger a creative and productive thought process within the defense community. The AGDS/M1 concept presented herein, may not be the optimized solution after all. Detailed, quantitative system engineering analyses may indicate alternative choices of guns and missiles. The operational requirement for a dual-role AGDS for the armored forces is more valid today than ever before. The authors believe

that prototypes could be feasibly developed in about 30-36 months and the first systems deployed within 48-60 months if an AGDS/M1 is devised and developed as proposed herein. For this to occur, the U.S. Government must adopt a true "hands-off" approach for procurement in the old spirit of "Prototyping for Production" and vigorously implement the new policy for streamlining the procurement and acquisition processes.

Potential sales of the AGDS/M1 internationally should be another paramount economic consideration in the development process. Foreign sales preserve the industrial base, keep production lines alive, and ultimately reduce the cost of procurement to the Government. An AGDS/M1 is likely to be procured by those foreign countries that operate the M1-series tank and have the logistic infrastructure already in place.

Western Design Howden (WDH), is a small defense company in Irvine, California, which specializes in the design, development, and production of ammunition and material handling systems for the U.S. and International military markets. WDH's track record includes a variety of air, land, and seaborne weapon systems which require automated feed, resupply, and optimized ammunition packaging.

Mr. Lawrence D. Bacon is the Director of Graphic Arts at WDH where, for the past 16 years, he has been responsible for creating numerous concepts for automatic ammunition handling, loading, and storage systems.

Dr. Asher H. Sharoni is the Director of Engineering at WDH. He holds a Sc.D. in Mechanical Engineering from MIT and an M.Sc. and B.Sc. from the Technion, Israel Institute of Technology. Dr. Sharoni is a former colonel in the Israeli Defense Forces in which he was involved in various major armored weapons developments.