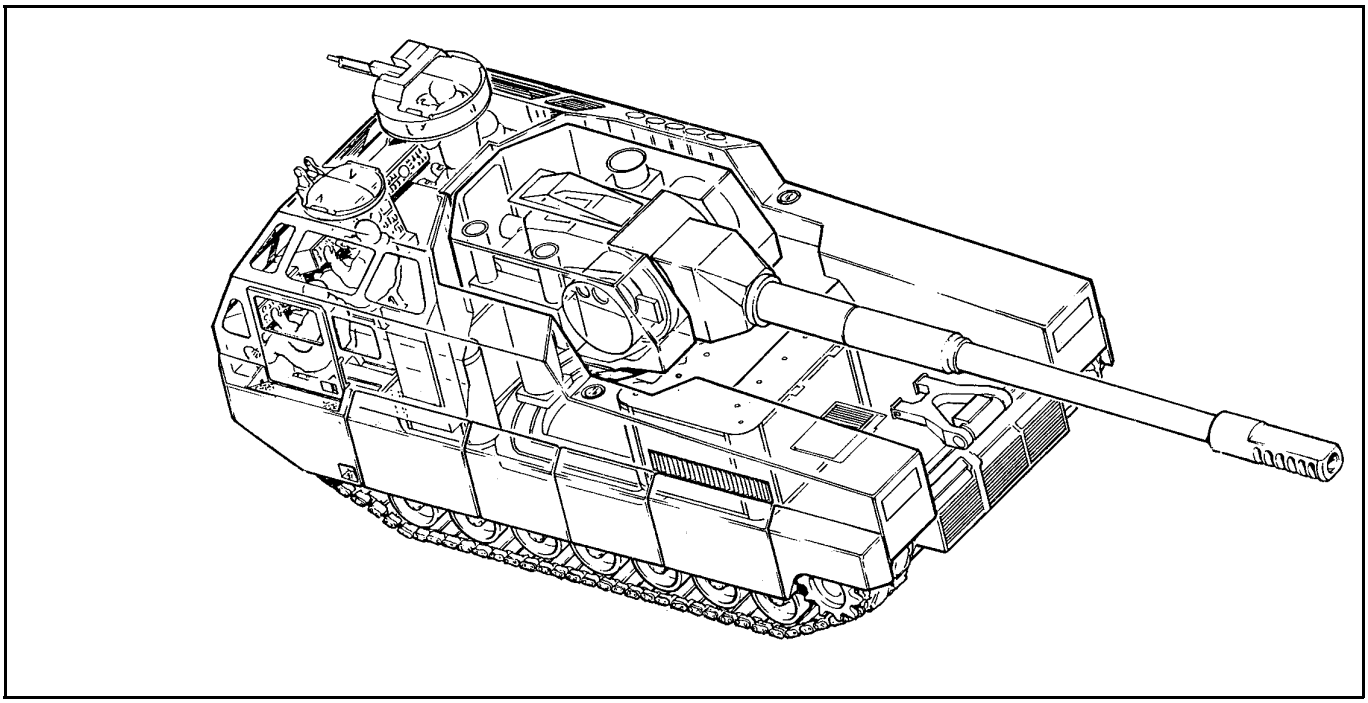


The Common Chassis Revisited:

Should the Next Howitzer Be Built on the M1 Tank Chassis?

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

At a recent armor conference at Ft. Knox, I was amazed to see that the principal topic of discussion was the Advanced Field Artillery System (AFAS), otherwise known as the Crusader program. Like any good tanker, I have a great appreciation for the value of accurate and timely fire support; however, I was somewhat bemused by its prominent role in this annual gathering of treadhead intelligentsia! Subsequently, I decided to explore alternatives to the Crusader that might truly benefit both the Artillery and Armor communities.

The quest for a modern self-propelled howitzer has captured the full attention and efforts of both the U.S. Army and industry, as the Crusader program is one of the very few "new starts" in combat vehicle development. Self-propelled howitzers are key players on the modern battlefield, and once equipped with an effective and autonomous command and control system, they are capable of expeditious deployment and rapid relocation of concentrated fire power. To accomplish the fire support mission under all weather and combat scenarios, a modern self-propelled howitzer must possess these *basic* characteristics:

- Autonomous rapid firing reaction
- High operational availability
- Optimum crew ballistic protection
- Significant reduction of manpower workload intensity.

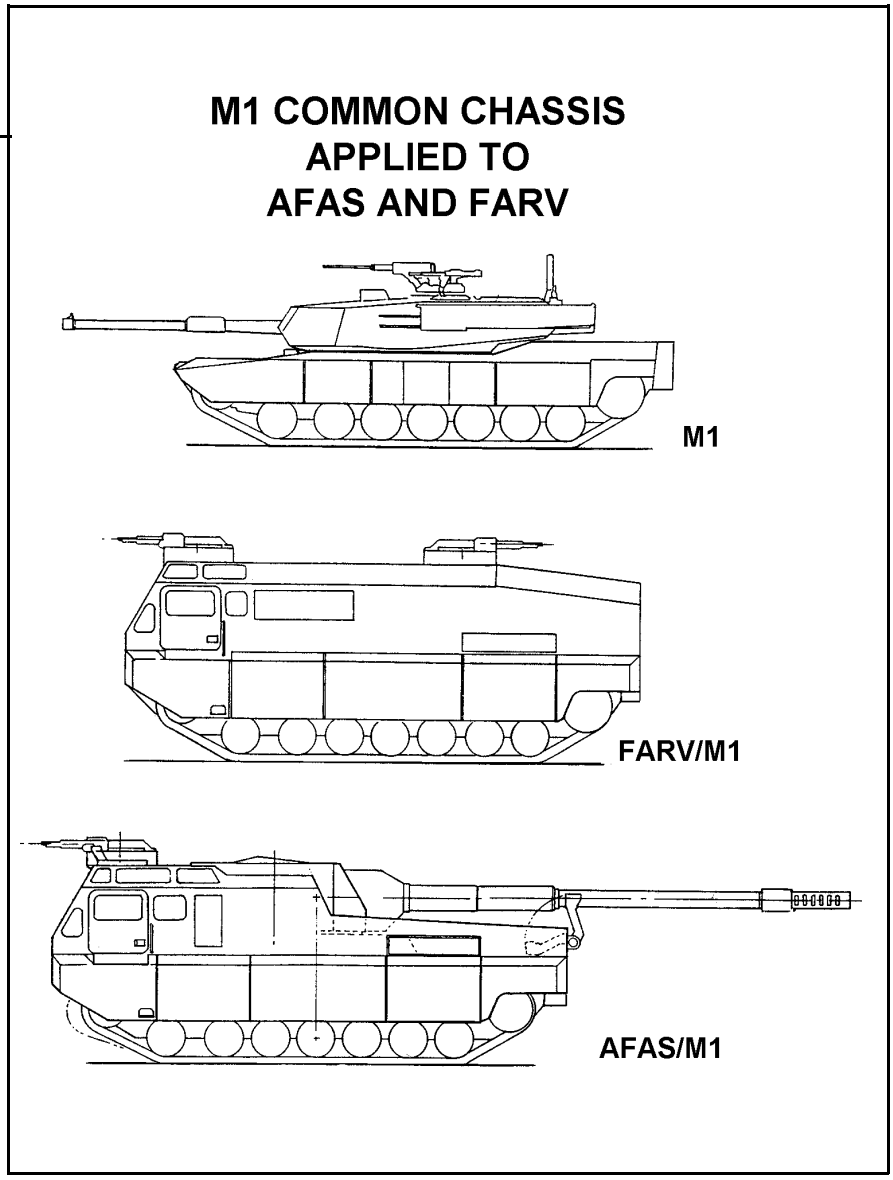
The current Paladin M109A6 howitzers are deficient in range, lethality, and survivability, and also lack the mobility to keep up with the rest of the maneuver force. These limitations, combined with a heavy crew workload, severely impede the Paladin's ability to engage in close support maneuvers and effectively demonstrate its full firepower potential.

The revised post-cold war U.S. Army mission calls for a new and revolutionary way of restructuring procurement and acquisition philosophies for modernization of armored vehicles. The ever changing global political situation is straining an invariably decreasing defense budget. It is, therefore, paramount that the U.S. consider new approaches in developing, implementing, and fielding an advanced field artillery system. The Crusader program was devised to fully comply with the Army's operational requirements while serving as a "technology carrier" for future combat vehicles. Nonetheless, due to persistent technical challenges, it is conceivable that Crusader will be reassessed and ultimately revised. Without editorializing, the reasons include:

- An adverse political environment reflected by congressional involvement and concern
- Significant R&D costs
- High technical risk associated with the Regenerative Liquid Propellant Gun (RLPG) technology
- Controversial selection of a water-cooled powerpack (ignoring the Army's investment in the Advanced Integrated Propulsion System (AIPS) technology)
- Significant costs of procurement & acquisition

The keystone technology of the Crusader program, and its overall weapon-system approach, is the revolutionary Regenerative Liquid Propellant Gun (RLPG). Technical problems (consistent performance, corrosion, and weight growth) continue to delay satisfactory demonstration of this weapon, and fur-

Scale drawing at right shows size relationship between current M1 tank and the proposed howitzer variant and its companion vehicle.



thermore, the U.S. is undertaking the RLPG development on its own, without a standardization agreement with NATO. One must consider that a comparable and equally potent weapon system may be devised by utilizing available systems and mature technologies effectively integrated and packaged to address operational requirements. For example, there is a gun presently available which demonstrates adequate long range performance (30/40 km) with sufficient "built-in" growth potential. This gun is designated as the *155mm L52* and was developed and produced in accordance with the Joint Ballistics Memorandum of Understanding (JBMOU) endorsed by France, Germany, Italy, the United Kingdom, and the United States. Coupled with the Modular Artillery Charge System (MACS), the U.S. Army can achieve most of the Crusader firepower goals while maintaining weapon/ammunition commonality within NATO.

The Thinking Tanker's Alternative Solution to Crusader

In the mid-1980s, MG Bob Sunnell's "think-tank" came up with a concept called "the Armored Family of Vehicles" (AFV). Although the AFV offered many interesting life-cycle and logistics savings, with its $30 billion procurement price tag, it was preordained to go by the wayside. Nonetheless, the concept of a common chassis for frontline armored fighting vehicles has great merit, and in today's environment, where we are struggling to maintain some semblance of a tank industrial base, we may have a perfect opportunity to achieve multiple kills with one sabot.

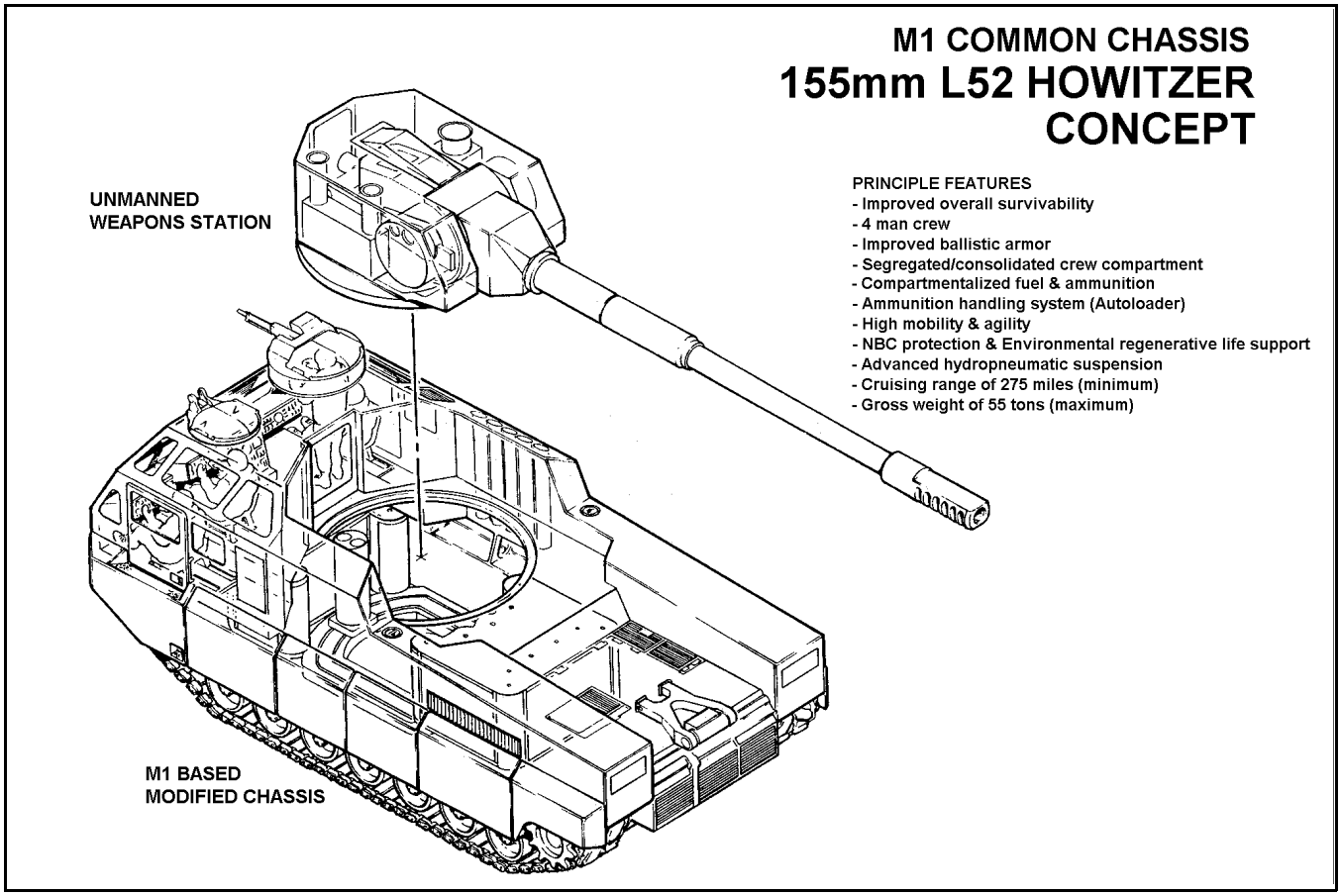
M1 Common Chassis

As a cost-effective and affordable alternative to the Crusader, the authors propose a "system of systems" comprised of an Advanced Field Artillery System and a companion Future Armored Resupply Vehicle, both commonly based on the readily available, battle proven and reliable M1 chassis, built by General Dynamics Land Systems. AFAS/M1 would be a self-propelled howitzer equipped with the 155mm L52 conventional gun, coupled with an automatic ammunition handling system to provide the required lethality, survivability, and range with a much less manpower-intensive gun. FARV/M1, the companion resupply vehicle, would provide ample storage space under armor, enhanced carrying capacity, excellent agility and survivability, and equivalent mobility to its counterpart. This system combination would have significantly increased capabilities over the current M109-series fleet. Further, any requirement potentially provided by the Crusader would be provided with higher confidence and less technical risk by the AFAS/FARV/M1 weapon system at a relatively cost-effective and affordable price. Though RLPG technology may possess an inherent potential for greater range, rate of fire and lethality, it is not readily available for near future implementation. Declining budgets, design immaturity, and enormous technical challenges place the RLPG outside the window of opportunity for the Crusader.

Operational Capability Overview

AFAS/FARV/M1's performance characteristics combine to provide an affordable, cost-effective, low technical risk and extremely potent weapon system which constitutes a significant quantum leap in force effectiveness:

- The 155mm L52 Joint Ballistics Memorandum of Understanding can-

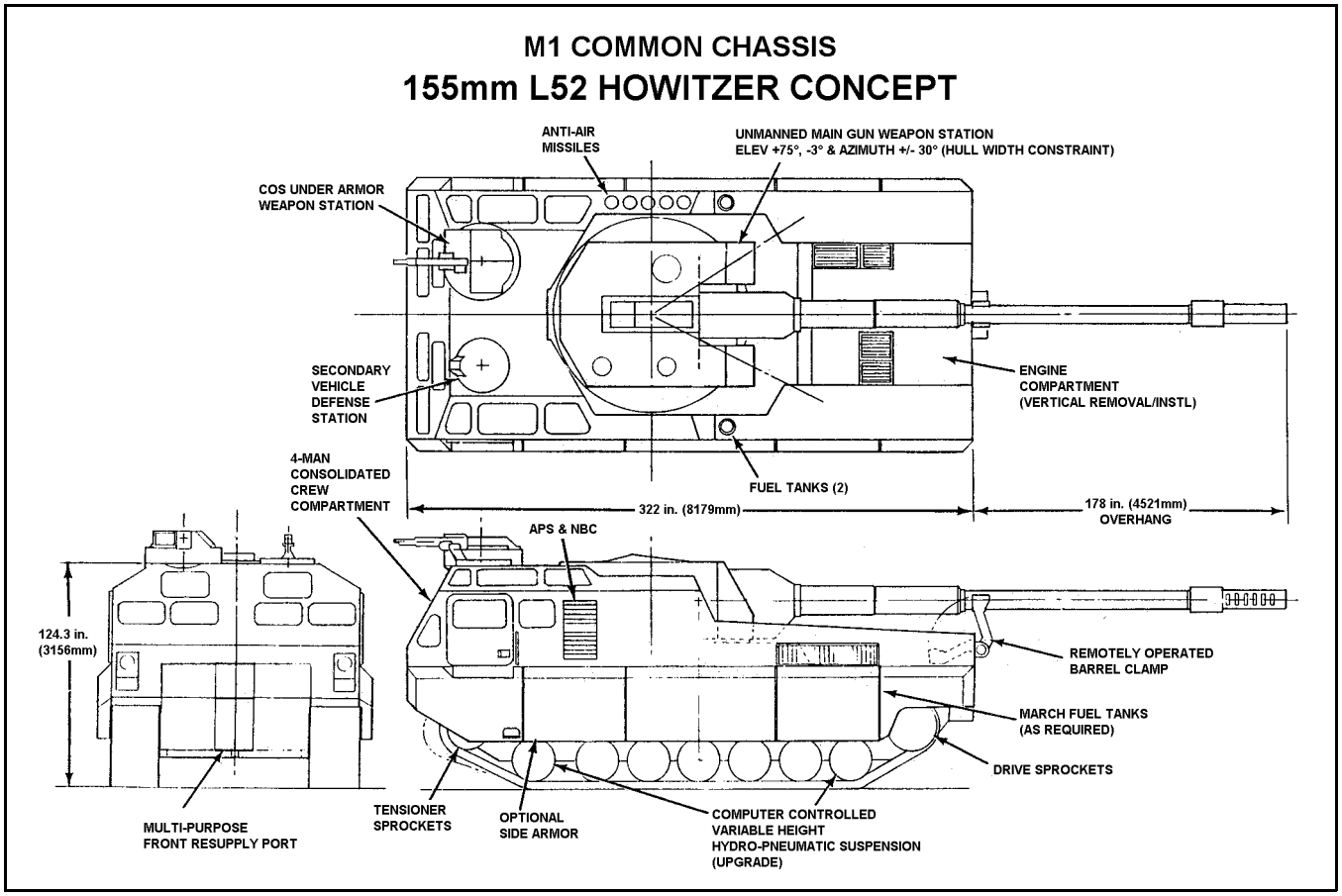


non, 52 calibers long, is currently installed in the German howitzer PzH2000. Effective range is 30km (unassisted)/40km (assisted) with growth potential. It can be upgraded with an integrated laser ignition system. Enhanced gun tube wear life is due to a chromium-plated barrel process.

- The "MACS" (Modular Artillery Charge System), XM231/XM232, is bar-coded, facilitates automation of propellant loading, handling, and storage. MACS provides increased tactical flexibility, improves gun performance, and is more cost-effective than standard conventional bag charges. It promotes faster action through improved logistics, is safer (more insensitive), autoloader compatible, non-toxic, lighter and cheaper, and environmentally safe. It requires lower operational and training costs, occupies less volume, and demands less transportation. MACS *does not* leave residue in the gun breech which can slow down the rate of fire. MACS is a low-risk, low-cost, viable, solid propellant backup and substitute to RLPG technology.
- Retains full operational and automatic replenishment capability under Nuclear, Biological and Chemical battlefield environments and sustainment through state-of-the-art resupply.
- The autoloader provides an increased rate of fire (burst rate: 3 rounds/9.2 seconds; sustained rate: 9 rounds/minute, thereafter), automation of ammunition loading, handling, and storing, and consequential reduction of manpower workload intensity.
- Autonomous Command and Control and Battle Management System provides for rapid firing reaction, independent tactical mission execution (self-location, self-computation of technical fire control, planning, embedded decision aid capability and fire support digital communications). Also provides target acquisition and prioritization, effective firepower on targets, and accurate damage assessments.
- The M1 modified chassis providing improved mobility, agility and maneuverability can keep up with the maneuver forces and provide optimum ballistic protection with ingrained 20-25 percent weight and combat-load growth potential.
- An extensive and highly-effective "survivability suite" includes the following sensors and subsystems: environmental control and life support; supplemental ballistic protection; detection avoidance materials (stealth); early warning; protection against directed energy and electromagnetic pulse; countermeasures; fire detection, prevention, and suppression; and highly potent defensive armament, equipment, and secondary weapons.
- Includes future Maintenance and Training Concepts (e.g. modularity, test-fix-test, embedded training and diagnostics and prognostics).

AFAS/M1 would fire 4 to 8 rounds in a Simultaneous Impact Mission (SIM) between 6-40 km. All rounds will impact within 4 seconds (first-to-last round). This requirement can be attained with an effective combination of a battle management system, fire control system, global positioning system (GPS) and an autoloader.

AFAS/M1 is required to perform survivability (250 to 750m) or tactical (4 km) moves after every mission to avoid enemy 'counter-battery' fire. To perform a fire mission, crew members *will not* be required to leave their protected and consolidated compartment. All operational activities will be remotely



executed, to include target identification and acquisition, ballistic computations, gun positioning and aiming, ammunition loading, and of course, firing.

Once the firing mission has been concluded, AFAS/M1 will move quickly to a new position to enhance its survivability and provide effective tactical flexibility.

AFAS/M1 will carry up to 80 fuzed (Multi-Option Fuze for Artillery-MOFA) and pre-coded rounds with corresponding 68 *XM231* and 178 *XM232*, stored in 41 magazine storage spaces (@ 6 MACS/space) for automated handling and loading. They are stored in two ready and accessible magazines located in the hull below the weapon station's bearing ring.

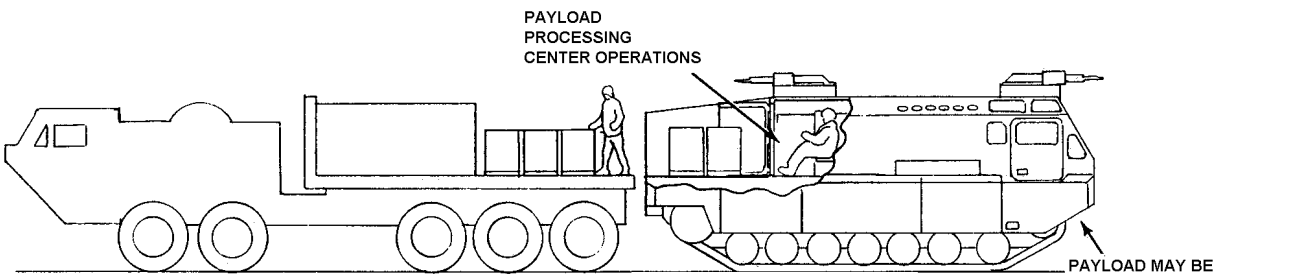
FARV/M1 will carry up to 180 (3 full complements of 60 rounds each) fuzed and pre-coded rounds with corresponding 153 *XM231* and 399 *XM232* in 92 storage spaces. They are stored in the primary transfer magazine, below the crew deck level, and in the secondary magazine above the crew level. Compartmentalized ammunition storage and "blow-off" panels will be provided in both vehicles to further enhance survivability.

Ammunition Handling System

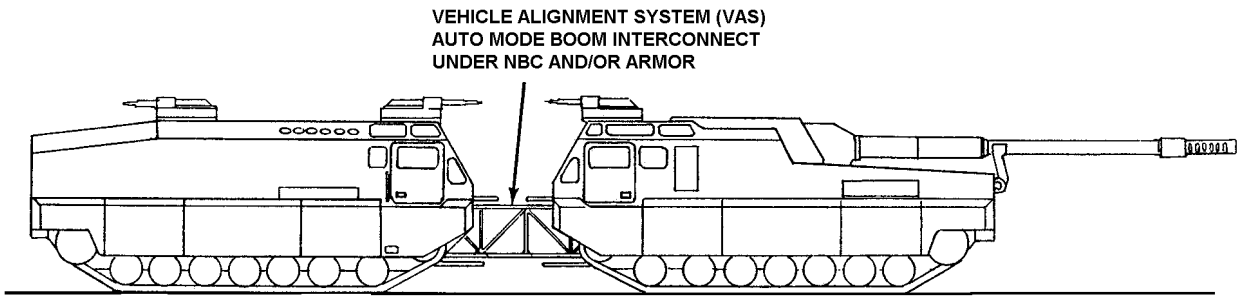
The autoloader will be compliant with the operational requirements to provide the rate of fire and ammunition handling safely and reliably. It will have the capability of determining ammunition type, lot, fuze, and weight. During resupply, the autoloader will verify the projectile/fuze combination. Throughout a firing mission, the autoloader will independently verify the projectile/fuze combination prior to ramming. There are a myriad of other beneficial features that an autoloader can provide that are not delineated here, and all requirements are attainable with proven technologies. The autoloader, though designed to fit a particular vehicle, includes generic characteristics that could be tailored to meet virtually any vehicle configuration. It will be capable of completely and automatically accepting ammunition from the FARV/M1 at a rate of 12 complete 155mm rounds per minute. The autoloader will also be capable of downloading 155mm ammunition and propellant (MACS) to FARV/M1 within 20 minutes, or to the ground within 30 minutes. Backup capabilities will be provided for manual upload and graceful degradation. The autoloader will encompass redundant actuators to increase reliability and functionality.

Consolidated Crew Compartment

AFAS/M1 will incorporate a consolidated, 4-man superstructure crew compartment. Chief of section and drivers (redundant controls) will be provided with 360-degree day/night visibility. Close-in vision will be within 10 feet of the vehicle due to the higher position of the crew compartment located at the front of the hull. It will also allow each crewman to directly view the remaining crewmen. There will be interior access and visibility between the crew and the weapon station. The crew will be entirely segregated and compartmentalized from the ammunition and the weapon station to increase survivability. The crew compartment will be adequately protected against top and direct attack, high-explosive fragmentation, small arms, and mines. Crew members will have provisions for rest, environmental control (including *NBC* protection), integral ration microwave heater, hygiene facility, and water stocks, all "built-in" and completely integrated into their consolidated compartment. Crew members will not be



HEMTT TO FARV/M1

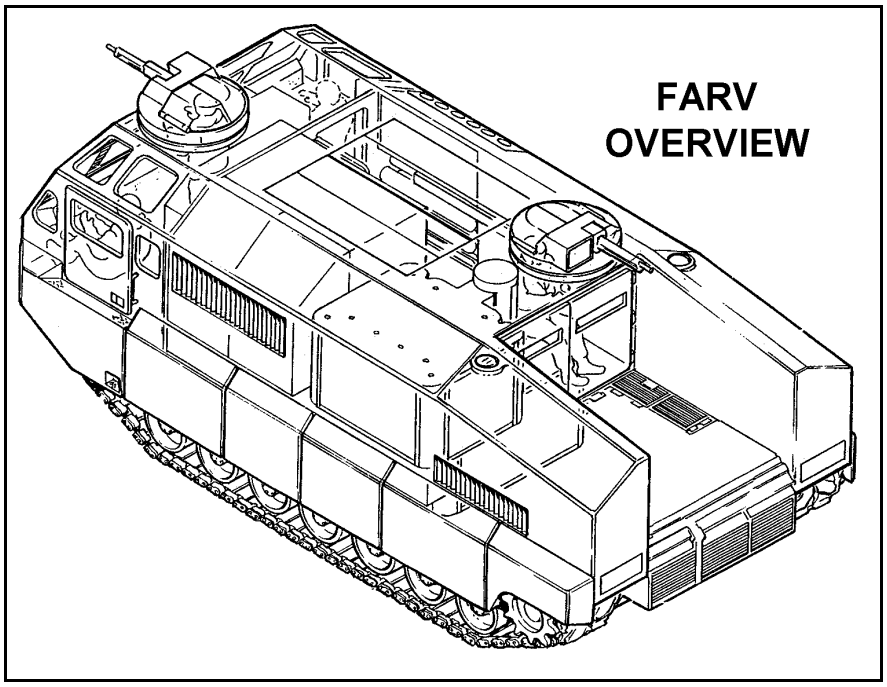


FARV/M1 TO AFAS/M1

required to leave their compartment to perform any operation short of an emergency/malfunction situation. The turretless, consolidated crew compartment simplifies installation and operation of environmental control, NBC and ballistic protection.

Performance Attributed to the M1 Chassis

AFAS/M1 must successfully keep up with the supported maneuver force. The M1 modified chassis (presently powered with a 1500 hp gas turbine) would grant the same level of *mobility* and *agility* as the M1 tank fleet. Self-propelled artillery capable of operating closer to main battle tanks will provide an unprecedented level of immediate support. AFAS/M1, as a minimum, would have a highway speed of 65 kph, and a sustained cross-country speed of 48 kph. This is readily achievable with M1 tanks weighing approximately 70 tons. If AFAS/FARV/M1's combat-loaded weight does not exceed 55 tons, its mobility and agility will surmount that of an M1 tank. M1 tanks will probably remain in active service until 2020-2025 before a new armored platform will be fielded. Implementation of a modified available tank chassis will substantially reduce development costs and technical risks, shorten the development cycle, greatly reduce the logistic burden and preserve the industrial base for production of M1 tanks and other armored vehicles. A common chassis concept for a *family* of armored vehicles is a valid approach and worth pursuing today more than ever before.



The M1 chassis is capable of mitigating the shock of firing and cross coun-

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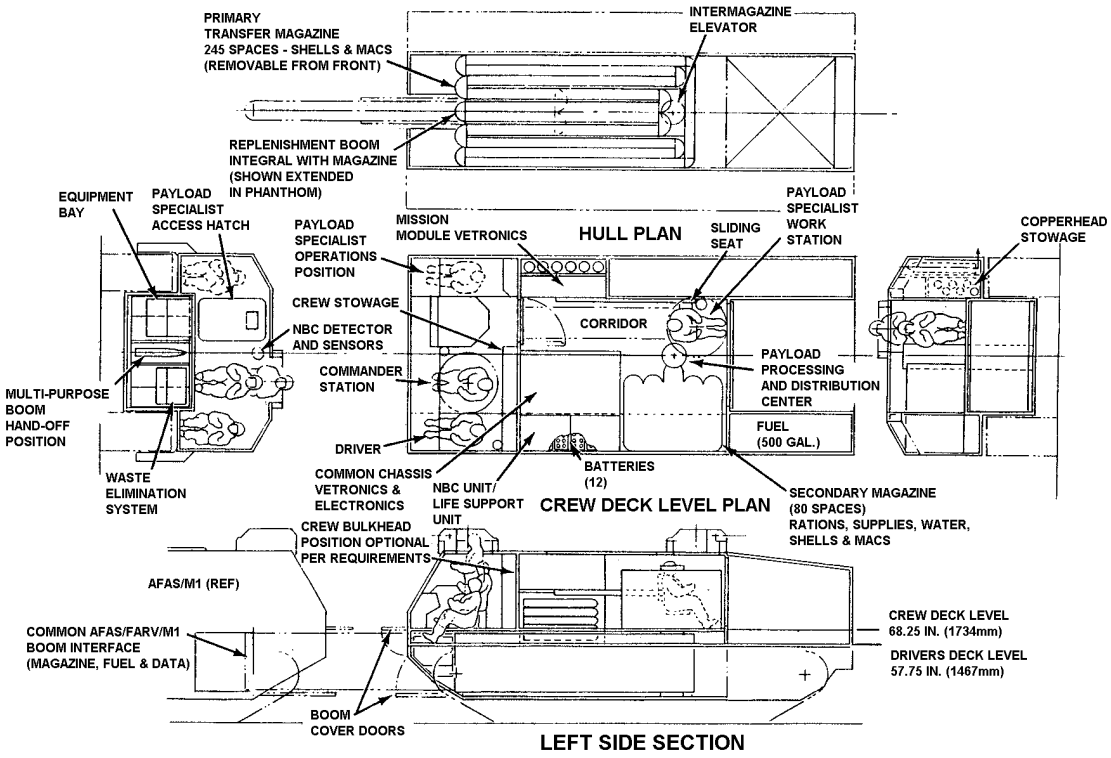
The Common Chassis Revisited - *Continued from Page 10*



try speeds due to its advanced torsion bar suspension system (Hydropneumatic suspension will be discussed later). AFAS/M1 would have a cruising range of at least 465 km, while that of the M1 tank is 440 km. To preserve fuel and extend engine life, AFAS/M1 will be equipped with an on-board Auxiliary Power System (APS).

Standardization, interoperability, and commonality between AFAS/FARV/M1 and with the M1 tank fleet, would be significantly enhanced due to the employment of a common chassis. Selection of the M1 chassis as the preferred alternative for the Crusader is further invigorated by the fact that two years after terminating the next-generation Armored System Modernization (ASM), Block-III Tank program, the U.S. Army decided to predicate its future ground armored combat strength on the M1 Abrams (M1A2 and "Tank 1080" programs).

The ASM program, if it had been successfully concluded, would have developed a "common chassis" for a new generation of combat vehicles.

Replenishment Operation

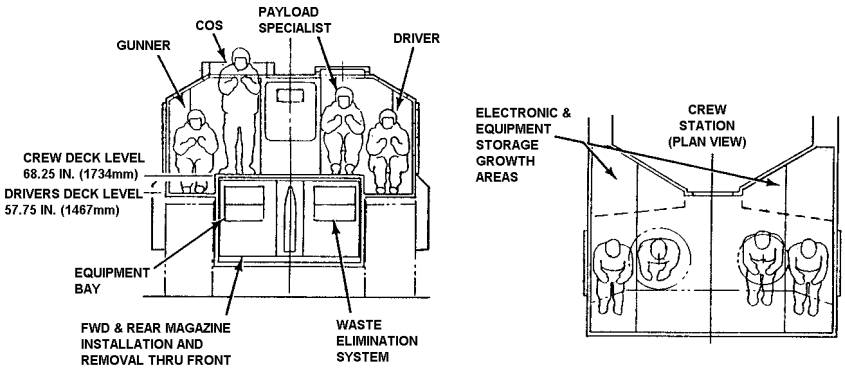
AFAS/M1's crew will remotely and concurrently conduct refueling, resupplying and 155mm ammunition replenishment without leaving their compartment or resorting to any manual operation. A preferable "resupply interface" for projectiles, propellants, fuel, food, and other supplies is at the front end of the vehicle. FARV/M1's resupply interface is also favorably located at the front-end of the vehicle if it is to implement a multi-purpose replenishing "boom." The frontal location of the crew compartments in both vehicles substantially enhances the viewing and monitoring of the replenishment operation, facilitating vehicle maneuvers for a quick connect. The transfer of food, water and small arms munitions, etc., will be performed via the main ammunition resupply path by using standard cylindrical containers that emulate the shell diameter and length. The rations will be transferred to the crew by the autoloader next to their double hatch access for subsequent pick-up and storage.

Hydropneumatic Suspension

A hydropneumatic suspension may be installed as an "add-on" system with only very minor changes made to the M1's chassis. This advanced suspension is currently under development by TACOM, Cadillac Gage, and Teledyne, and has gone through extensive and vigorous testing. The hydropneumatic suspension provides a high degree of tactical mobility and allows operation over all terrain and in all weather conditions. The revolutionary "in-arm" suspension system can save well over a ton in weight, as compared to the conventional torsion bar system, and will free valuable hull space under armor for ammunition storage. A variable-height, dynamic hydropneumatic suspension with active damping would be computer controlled (as in the MBT-70). It would simplify docking and connecting AFAS/M1 and FARV/M1 in the replenishment mode. The implementation of *Vehicle Alignment System Technology* (*VAST*), is in essence, an integration of available and mature computer, variable suspension, and mi-

crowave transmission technologies to permit a true "hands-off" adjustment operation. Under adverse conditions and varied terrain, the hydropneumatic suspension will permit replenishment with cumulative slopes of up to 10° resultant angle between vehicles in any direction (pitch and roll controlled by variable-height suspension, yaw controlled by steering). When installed in both mating vehicles, it will permit a relatively uncomplicated, less costly, and less articulated multi-purpose replenishment "boom" mechanism. The hydropneumatic suspension will also allow for hydrostatic lockup during firing to enhance chassis stabilization and consequently improve fire rate and accuracy.

CREW COMPARTMENT LOCATIONS

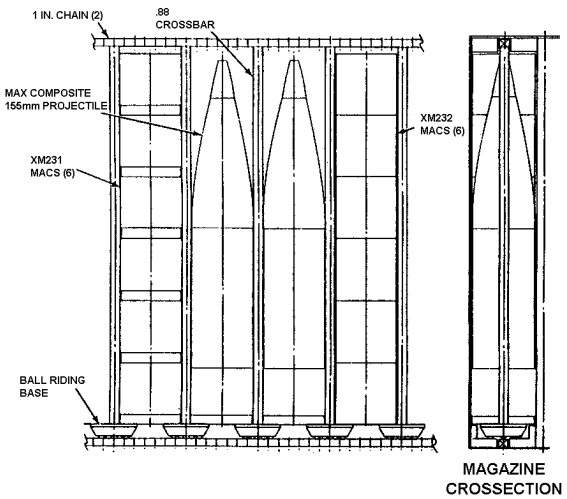


Concluding Remarks

This article is written with the aim of capturing the attention and imagination of the *ARMOR* reader and to trigger a creative thought process. There are lower-risk, more cost-effective alternatives for the Crusader that fully meet — and in some aspects exceed — AFAS operational requirements. With manpower, time, and budget constraints, the authors could not perform a full-scale detailed analysis and optimization of all aspects involved in undertaking such a tremendous endeavor. Nevertheless, in principle, the concepts presented here offer feasible alternatives that should be of interest to all parties in the defense community. Notwithstanding, two essential ingredients must be preserved to serve as the fundamental bedrock for Crusader evolution — The JBMOU 155mm L52 gun, and the MACS Charge System.

We believe the M1 common chassis concept has great merit, and that the practice of continued evolution of existing fielded systems will considerably abridge the prolonged design and development process typical to the acquisition of modern weapon systems. In times of declining defense budgets, affordability considerations must play a decisive role in major weapon systems procurement and acquisition, as well in fleet maintenance costs of existing systems. Furthermore, the potential sales of a particular weapon system internationally should be a paramount economic consideration in the development process. Foreign sales preserve the industrial base, keep production lines alive, and reduce the cost of procurement. An AFAS/FARV/M1 weapon system, as described herein, is more likely to be procured in substantial quantities by those foreign countries that operate the M1 tank and have the logistic infrastructure already in place. Any solution that excludes the RLPG has a greater likelihood of both technical and economic success.

155mm PROJECTILE / MACS CHAIN LADDER STORAGE CONCEPT



Western Design HOWDEN (WDH), a small defense company in Irvine, California, 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.

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