The Future Combat System (FCS)

A Technology Evolution Review and Feasibility Assessment

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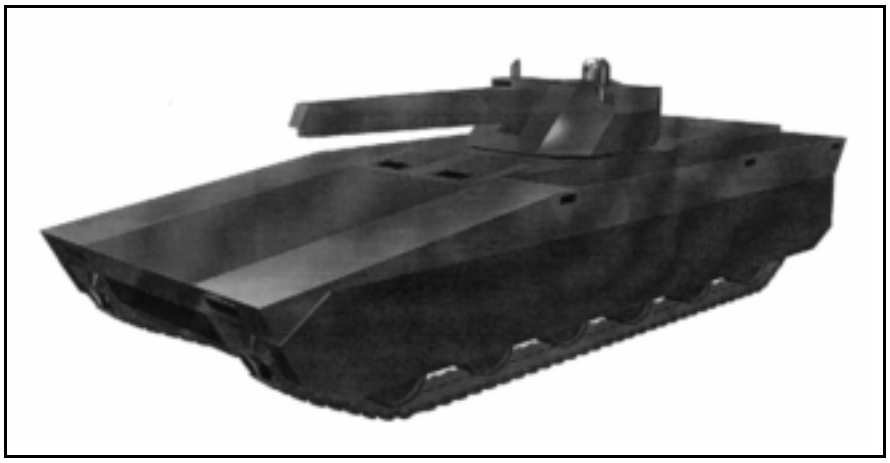
This is the first installment of a three-part article on an independent analysis and proposal for a future tank-like system. The second part will appear in the September-October issue. - Ed.



A computer-modeled sketch of the system being discussed.

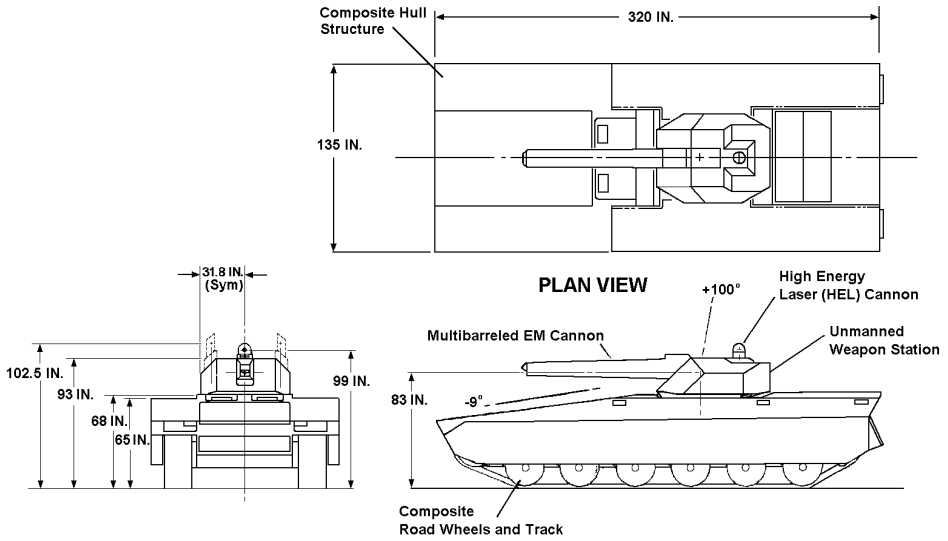
The Future Combat System (FCS) is the Army's most recent attempt to begin developing a new tank that is to be fielded in the 2010-2015 time frame. To understand its origins, one must examine the prevailing global political situation, and its effect on future deployment of the U.S. Army. The post-Cold War era has been distinguished by the downsizing of military power and ever-diminishing defense budgets for research, development, and acquisition of new weapon systems. Moreover, the counterterrorism program added unplanned budgetary and operational pressures, and its immediate funding led to an additional intensive cut of $680 million from research and development programs as a 'down-to-earth' practical approach to reducing total allocation of FY 97 defense spending.

Meanwhile, the U.S. Army has been currently undergoing a transition from a force permanently deployed all over the world into a global, consolidated, 'power-projection' force, primarily stationed in the U.S. In view of these changes and uncertainties, the conception of a novel tank has not been heretofore widely advocated. Instead, the Army has been focusing its efforts on upgrading programs to improve the M1 Abrams tank fleet[1] (e.g. M1A2/SEP, M1A2/P^{3}I, M1A3(?)...). Possible upgrades may include the high-pressure XM291 120mm tank gun, with more effective, advanced kinetic energy (KE) and chemical energy (CE) ammunition; an integrated dynamic defensive 'suit' (Active Protection System - APS); armor augmentation (Explosive Reactive Armor - ERA); digital appliqués; improved target acquisition; digital fire control system; and a driver night vision enhancement. A new turret incorporating a 140mm gun is not considered a viable option at this time. Continued modernization and upgrades are designed to preserve the M1 Abrams fleet's advantageous technological edge, operational superiority, and sustainability until a new generation tank is ready to be deployed.

Nevertheless, we've recently discerned a resurgence of interest in a novel tank, postulated by the authors to be fielded within at least 20 to 30 years into the next century, rather than within 15 to 20 years as commonly perceived feasible. General Dennis J. Reimer, U.S. Army Chief of Staff, has recently stated in an interview to Armed Forces Journal that by 2010, "The Army After Next," namely Army XXI, will be configured and equipped with M1A2 Abrams tanks.[2] General Reimer also commented that the Army has begun work with OSD's Net Assessment Group to portray what the future battlefield will look like in the 2020-2030 time frame. In a recent Ad-Hoc Study of Tank Modernization,[3] the Army Science Board (ASB) panel, headed by General Glenn K. Otis (USA, Ret.), concluded that no significant technological breakthroughs are expected prior to the year 2020. This distinguished panel of military and civilian experts has identified the following future major threats to U.S. Armored Forces: Line of Sight (LOS) Antitank Guided Missiles (ATGM) fired from tanks and helicopters; top-attack ATGMs; advanced KE rounds fired from large-caliber tank guns (120mm and up); extensively proliferated infantry antitank weapons; top-attack, artillery-fired, precision-guided antitank munitions with shaped charges or Explosively Formed Penetrator (EFP) warheads; significant advances in foreign tank armor (e.g. explosive reactive and active protection/defense systems) and, sophisticated (intelligent) mines. These findings lead to the conclusion that the 2020-2030 future battlefield environment's operational requirements could only be met — on equal terms — by the FCS. Consequently, it implies what the FCS's time frame of deployment may realistically be — beyond Army XXI!

The Future Combat System (FCS) is fundamentally a futuristic conceptual tank or weapon system, characterized by *unprecedented* operational capabilities.[3] It will incorporate state-of-the-art, leap-ahead technologies, matured and available for implementation 20-30$^+$ years from today. The Senate Armed

Future Combat System (FCS)
External Dimensions and Features

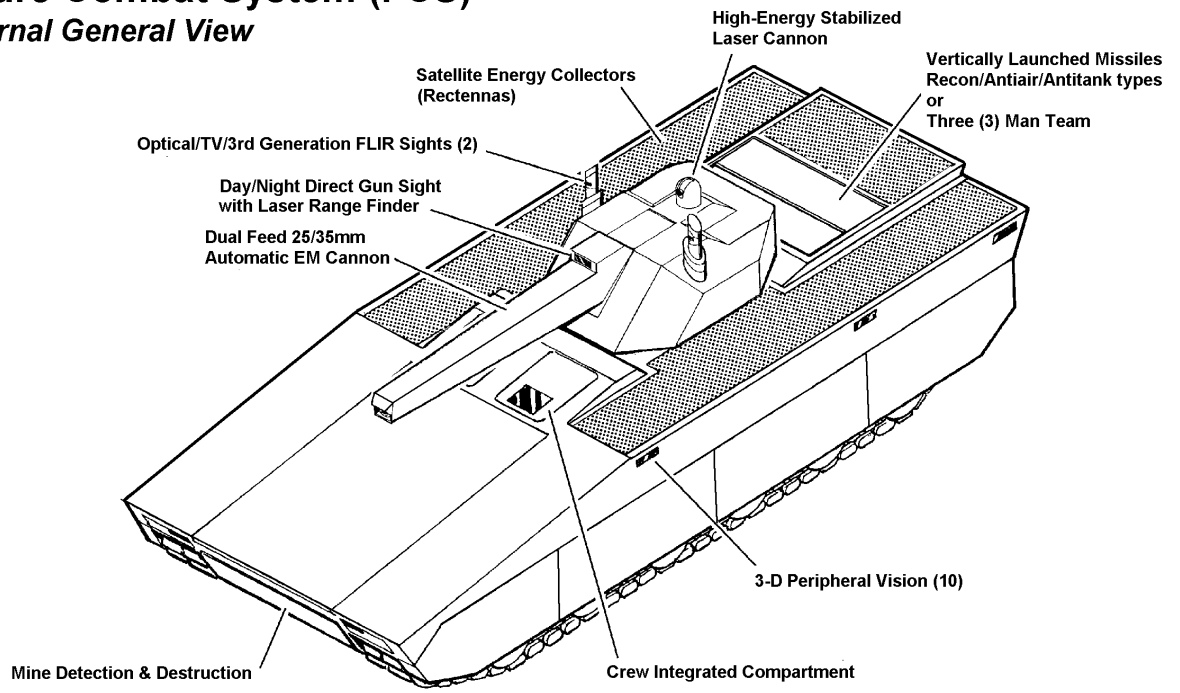


Services Committee and the Senate Defense Appropriations Subcommittee started the ball rolling when they recently authorized funds ($12 M) for a new program primarily designed to:[4] Identify requirements and assess future concepts as to what system or mix of systems will support the best operational weapon system for defeating the ever-evolving threats; develop conceptual approaches for imminent technologies that could be integrated into a future tank (or upgrades to the existing M1 Abrams fleet); and employ 'virtual prototyping' techniques [e.g. studies of computerized 3-D graphics and processes for emulation of engineering and manufacturing development (EMD)] for conceptualizing and subsequently fielding a *revolutionary* Future Main Battle Tank (FMBT) within 20 years or so.

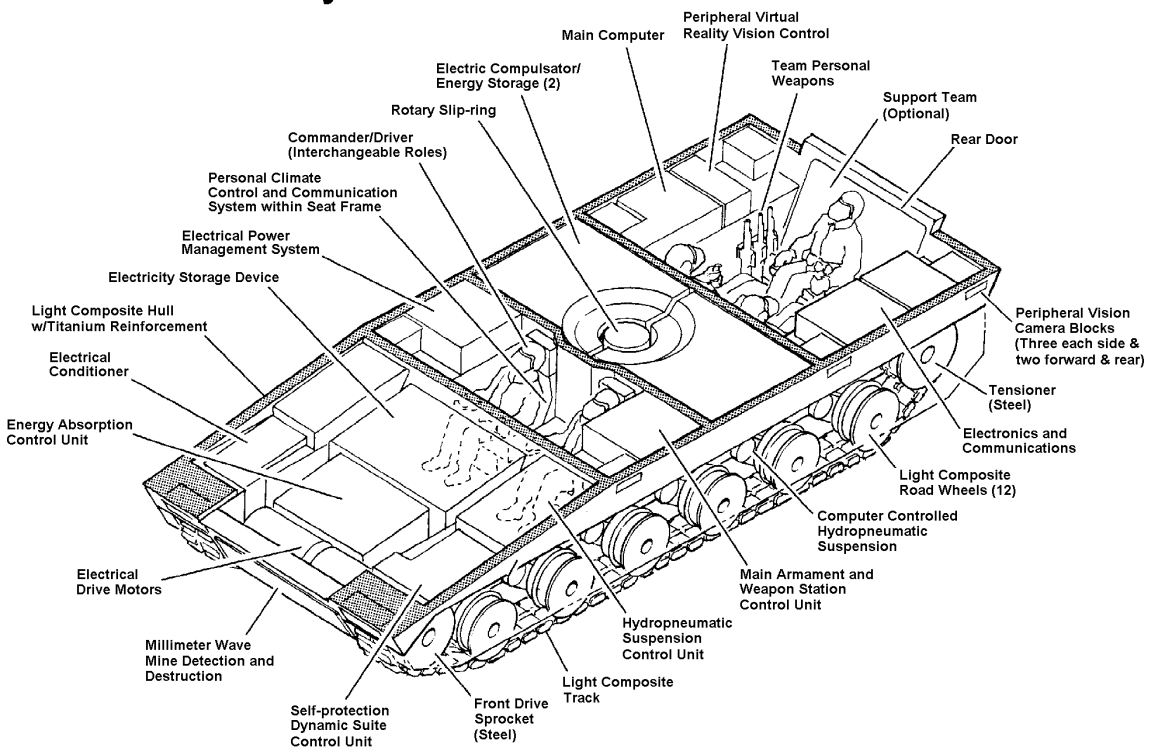
The Future Main Battle Tank (FMBT)

The evolution of the FCS should not be disassociated from that of its predecessor, the FMBT. On January 1993, the U.S. Armor Association and *ARMOR* magazine, in conjunction with the Directorate of Combat Developments at Fort Knox, Kentucky, conducted a conceptual tank design contest for the next-generation tank — known as the FMBT. The contest drew close attention and extensive response from all quarters of the defense community. The winning entry, submitted by Western Design Howden[5] (WDH), presupposed 2010-2015 as the time span for fielding.

Future Combat System (FCS)
External General View



FCS Detailed Layout



The FMBT was perceived as the successor to the M1 Abrams tank. It capitalized on a new and revolutionary tank design philosophy as a fully integrated, multipurpose weapon system. Considering lethality as the principal design driver, the design approach commenced with the selection of the main armament, continued with an unmanned, remotely operated weapon station, and concluded with the hull constructed around it. Consequently, the weapons station was located towards the rear of the hull, the three crew members were positioned abreast in a well-protected, consolidated compartment low in the center portion of the hull, and the power pack was placed at the front.

Compartmentalization and placement of the entire crew in the hull constituted a major enhancement to crew survivability and predominantly contributed to overall weight reduction.[6] The high-pressure 120mm XM291 gun, developed by TACOM-ARDEC/Benet Labs, was the main armament gun system of choice. The XM291 possesses the inherent lethality growth potential, affordability, and ability to defeat contemporary and future armor. It is about the same size and weight as the standard M256 120mm tank gun, yet possesses a 'built-in' growth capability to utilize higher pressure, future 120mm ammunition, can be adopted to electrothermal chemical (ETC) propulsion, and is internationally harmonized with the 140mm gun implementation, requiring solely a tube and ammunition exchange. It is considered by many as the most viable upgrade to the standard M256 gun. The XM291 gun is short-term, readily available, and represents a sound economical alternative to serve in the next 30 years and beyond, prior to maturation of a new and *revolutionary* main tank armament system. The FMBT was favorably received by the armor community because it epitomized the prudent utilization and integration of mature, state-of-the-art, and battle-proven technologies *currently* available.

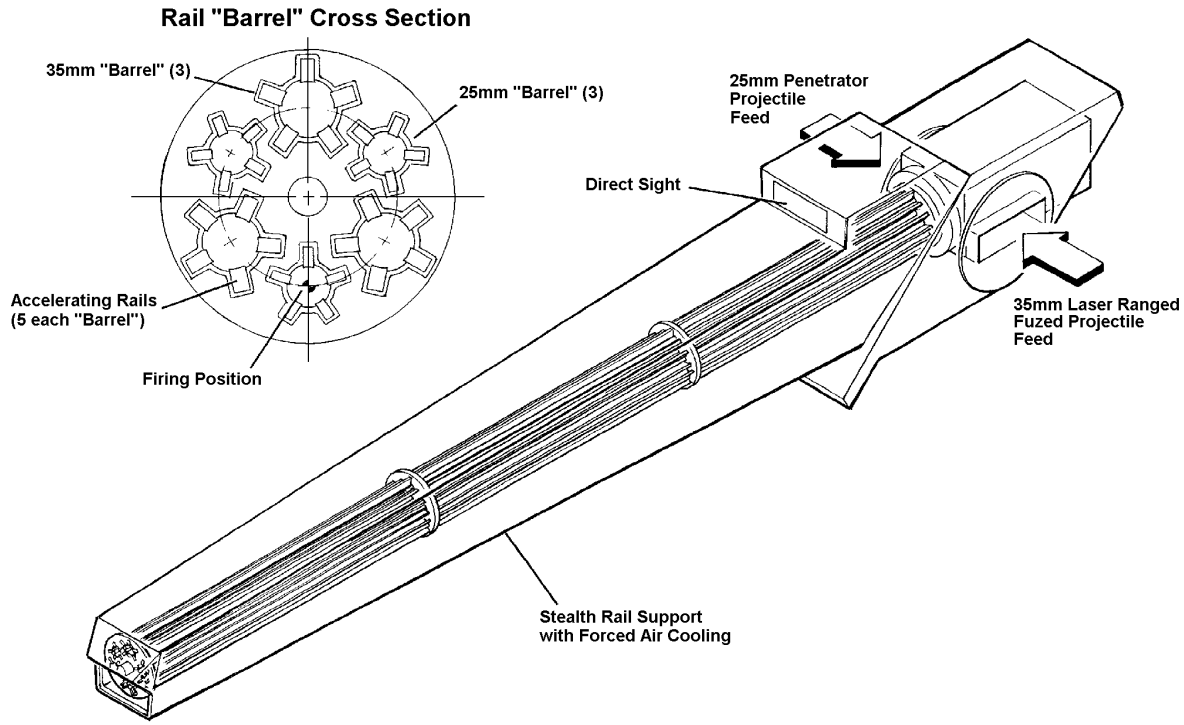
The Future Combat System (FCS)

On July 8th, 1996, Major General Lon Maggart, then commanding general of the U.S. Army's Armor Center at Fort Knox, Kentucky, introduced a novel concept of a "tank" identified as the *Future Combat System* (FCS). MG Maggart expressed his explicit viewpoint regarding the FCS while interviewing with the *Defense Daily* newsletter.[7] Our present analysis is based in part on that interview, considering that the Mission Need Statement (MNS) was not available. Additional insight into the FCS concept was subsequently provided at the American Defense Preparedness Association's Combat Vehicles Conference,[3] conducted at the U.S. Army Armor Center, Fort Knox, Kentucky, September 24-26, 1996.

The imaginary FCS is, in our *personal* conviction, a visionary successor to the conceptual FMBT, whereas the latter is the successor to the M1 Abrams series tank. Our governing assumption is that, in actuality, the FCS will be deployed in the 2020-2030 and not in the 2010-2015 time frame as currently presumed feasible.[3] Formidable technological breakthroughs are mandatory and prerequisite prior to committing immense funds and scarce technological resources to the development, acquisition, and fielding associated with the FCS. These may not be realized, nor sufficiently mature, to warrant their implementation within the 2010-2015 time frame, especially under continuous adverse budgetary restraints and ever-competing, oftentimes contradictory, operational requirements.

Nonetheless, the FCS concept has secured support of military leaders and captured $100 M in the Army's recent six-year budgetary plan. For the FCS, or any other future generation tank, to

Conceptual 25/35mm Electro-Magnetic Automatic Cannon



Concept for a dual-caliber electromagnetic railgun to be cooled by forced air circulation.

come to fruition, it *must* incorporate *revolutionary* technologies that demonstrate novel, highly-potent weapon systems and substantial reductions or savings in manpower, propulsion energy, consumption of consumables, sustained maintenance, reliance on logistic support, and overall combat weight.[8,9,10,11,12,13]

Presumably, it will be one of the last manned tanks produced in large numbers. Most likely thereafter, remotely-operated tanks will be introduced — much smaller, unmanned 'robotic' tanks introduced into the battlefield in decisive aggregates.[14,15,18]

Scope of This Article

The emergence of the revolutionary FCS concept triggered our imagination and persuaded us to conduct a rather limited technical literature research of information available in the public domain. The latter resulted in this article, after we anguished over the imponderable complexities associated with such a revolutionary design, portraying how we envision the FCS 20-30 years into the future. In consequence, we've determined to advance our conceptual FMBT one generation further to meet future battlefield operational requirements and leverage technologies available for implementation in the 2020-2030+ time frame. FMBT's underlying philosophy served as the bedrock for our proposed FCS. It bridges the gap in the evolutionary process between the advanced, yet conventional, M1 Abrams tank series and the imaginary, futuristic, nearly 'science-fiction' FCS. Whenever applicable, conceptual features have been adapted from the FMBT and further advanced to correspond to their likely evolutionary status at the time of implementation. Admittedly, it is a formidable task to accurately forecast technology evolution 20 or 30-plus years into the future. This has become particularly evident in the course of the last four decades, when *unprecedented* technological breakthroughs have become customary and more frequent. In view of this, we ask readers for patience as we look into our 'crystal ball' and occasionally let our imaginations go wild.

The FCS - Characteristics and Major Capabilities

The FCS will capitalize on the following major capabilities and attributes:

Lethality - FCS Armament Choices

● **Primary Armament System - Main Gun Armament Candidates:** The following are the potential prime candidates for the FCS's Main Armament System (MAS):

- Conventional solid propellant (SP) 120/140mm smoothbore guns
- Liquid propellant (LP)
- Electro-thermal chemical (ETC)
- Electromagnetic (EM)
- Antiarmor, antiair guided or 'fire-and-forget' type tactical missiles.

We will discuss the predicted evolution, technical feasibility, and applicability of these guns and missiles later on.

● **Secondary (I) Armament System - High-Energy, Direct-Projection Laser Gun:** The FCS will be equipped with a high-power, extremely accurate, fully-stabilized laser gun. The FCS is envisioned as an 'all-electric' vehicle, which facilitates a laser gun that could be used against a variety of close-in threats. Among them are helicopters, drones, ground 'soft' targets, infantry,

and — in self-defense mode — against incoming enemy missiles. High-power laser technology for armament applications has successfully advanced beyond its infancy and nowadays is well established in outer space and airborne applications. The FCS laser gun application will probably be a 'spin-off' of these developmental efforts. Incontestably, laser gun technology represents a tremendous step towards independence from logistic support. There is no need for frequent ammunition resupply since it will be 'firing' variable, high-energy short pulses (bursts) of converted electrical energy. During target acquisition, a low-energy laser beam will be pointed at the target to verify 'on-target' position and the corresponding effective range. Subsequently, the low-energy beam will be substituted with a short, high-energy pulse, ultimately yielding target destruction.

A case in point is the USAF's *High-Energy Chemical-Oxygen Airborne Laser* (ABL), currently being developed to destroy ballistic missiles early in their boost phase of flight, immediately following their launch phase. A full-power prototype baseline configuration laser module in the hundreds of kilowatts class has already been demonstrated to meet stringent performance requirements. Another notable program is the U.S.-Israeli *Tactical High-Energy Laser* (THEL), developed to engage and destroy incoming missiles. Though chemical laser technology is considered mature, a compact and transportable tactical laser weapon system, well integrated into a smaller mobile armored vehicle, remains to be demonstrated. Typical outstanding issues are integration of optics, energy pressurization system, radar, and command & control. To facilitate its development, the U.S. Army is already leveraging technology from the USAF's space-based laser program. Finally, the U.S. Army's fixed laser, based at the *High Energy Laser Systems Test Facility* (HELSTF) White Sands, N.M., and the *Los Alamos National Laboratory* (LANL) facility are both engaged in laser research for military applications. These developments and similar projects imply that future 'spin-off' versions, on a much smaller scale, could be implemented in various, armored ground-to-ground and ground-to-air offensive weapons and active self-defense applications. The high-power, direct line-of-sight (LOS) laser beam must have the ability to travel through the atmosphere at tactical operational ranges (10-15 km) without detrimental losses from beam spreading, divergence, dispersion, diffraction and scattering. Additionally, it must maintain its 'self-focus' characteristics and high-energy density, which are mandatory for achieving an effective target kill. Much has yet to be said about laser research and applicability, but, in the interest of time and space, this short overview will suffice.

● **Secondary (II) Armament System - Dual-Role Antiair/Antiarmor Missiles:** The FCS will be equipped with dual-role, 'fire-and-forget' antiair (40-50^{+} km extended range) beyond-line-of-sight (BLOS), and laser/TV (infrared, passive or active, 3rd generation) guided 'line-of-sight' and beyond (B/LOS) antiarmor (10-30^{+} km range) missiles. Compact *third* generation missiles, with multiple target capability, air-defense and antitank system (ADATS), robust lethality type missiles. Though still presumed to incur high cost per unit and inefficient at very close engagements, there will be no substitute for their accuracy and extremely high probability of hit and kill at short and extended tactical ranges. Their BLOS formidable tactical capability will remain second to none.

In addition to primarily assuming an offensive role, the FCS will also act as an armored *mobile* air defense (AD) system[16] for the combined arms team (CAT). By acquiring this capability, air defense will become fully integrated into the CAT to allow for its maximum effect and deployability. A network of four to six FCSs could prioritize and engage a number of aerial and point targets. This network, being an integral part of the digitized force, could either acquire and engage targets on its own, or convey critical information to other forces in the greater area. The FCS dispersed 'battle groups' (not large armored formations anymore) could be connected to higher-echelon defense and command centers for automatic response to saturation and time-compressed attacks. This need is reinforced by the reality that the Army is modifying its 50-year-old air defense doctrine, taking over responsibility for close air support (CAS). The Army will rely on its own means, such as deep attack helicopters (AH-64 Longbow Apache), advanced artillery systems (Crusader), and ultimately the FCS, rather than the customary U.S. Air Force dedicated close support aircraft.

● **Battle Management System**

The third-generation Battle Management System (BMS) includes a peripheral, multi-sensor-aided target acquisition and fire control system. It would be a day/night integrated system capable of automatically engaging and managing up to 15-20 active or passive targets simultaneously and autonomously. Automatic air/ground acquisition would be made through thermal imagery, millimeter-wave radar processing, and direct optical sights. It would include target recognition, identification, prioritization, and automatic tracking. Fire controls would incorporate main and secondary armament stabilization and support automatic loading. The system would offer full fire-on-the-move capability while engaging multiple targets. It would assume an active role within the tactical and regional digitized communication networks by providing critical battle awareness information and target data submission and acceptance. The FCS/BMS could be temporarily 'slaved' to other FCSs or to higher-echelon commands.

● **All-Around Vision, Transparent "Virtual Reality" Under Armor**

An all-around, 'virtual reality,' day/night, 360^{o} array of TV/thermal cameras and computer-processed vision would enable the crew to "see" through the armored walls of the crew compartment with helmet integrated displays. This would allow excellent "buttoned-up" visibility and alleviate motion sickness. The weapons could be fully slaved to each of the two crew members' helmets as tactical considerations and battle conditions dictate. The displays would make accessible all critical battle awareness, vehicle status, and intelligence information. Crew members would be able to see the faces of people they are communicating with and other pertinent pictured information on their personal displays.

Integrated Survivability

This lightweight (40-45 ton), all-terrain, all-weather, extended-operational capability (EOC), highly mobile armored vehicle would be significantly more versatile than the present M1 Abrams tank series and capable of missions *beyond* those traditionally performed by contemporary main battle tanks (MBT).

The vehicle would present a substantially reduced overall target signature

(heat, acoustic, magnetic and visual) by way of utilization of 'stealthy' materials and design contours. Equipped with an extensive signature management system (SMS - thermal, electromagnetic, acoustic), countermeasures, and a *False Target Generation* (FTG) active/passive decoy system, which could project and emulate an imaginary FCS signature to divert incoming homing missiles away from the real FCS.

A self-defense, dynamic 'hit-avoidance suit' (HAS) would automatically detect, prioritize, counter, and intercept enemy cruise missiles, helicopters, unmanned vehicles, high performance fixed-wing ground support aircraft, top-attack antitank munitions, homing artillery munitions like SADARM (Search and Destroy Armor), and other antitank threats.

There would be an automatic detection, alert, avoidance, and protection system for areas contaminated by weapons of mass destruction (WMD).

The vehicle would be equipped with advanced, 'add-on' modular passive and energetic/reactive armor modules that could be installed in accordance with the primary assigned mission.

Another system would integrate passive/active mine detection, avoidance, and possibly destruction (neutralization) while stationary, or preferably on-the-move.

Force-Projection Deployability

Reduced weight and a smaller silhouette would improve air, land, and sea transportability and deployability.

The FCS would play a key role as an active information node, fully integrated into digitized battlefield, tactical, and regional communication networks, providing combat, surveillance, and logistic information.

The vehicle would offer improved cross-country mobility, speed, and agility, and a greater range than the M1 series tank.

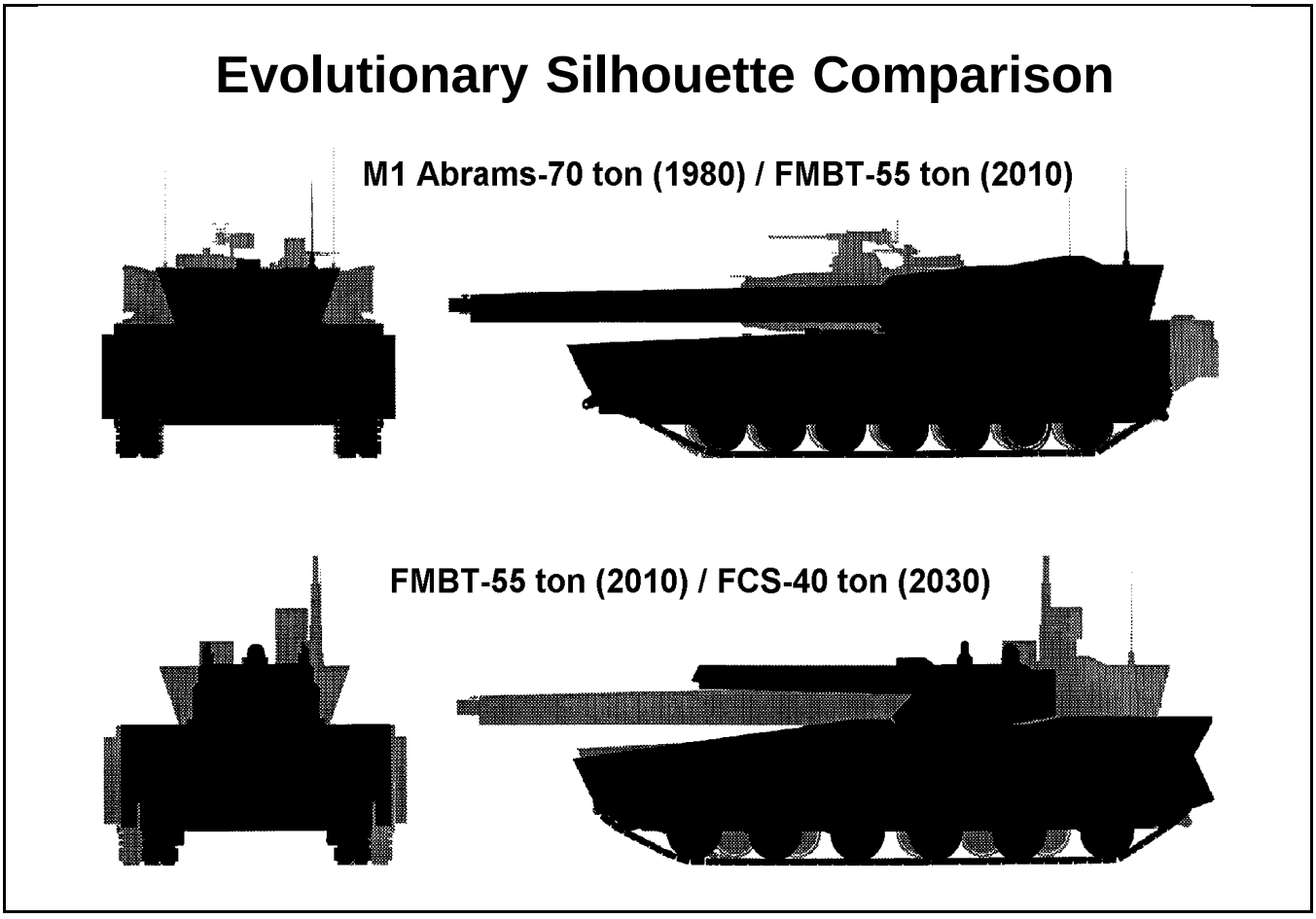
An autonomous system would provide day/night obstacle avoidance, 'Auto-Pilot' (AP) navigation/cruise and automatic formation maneuver.

Mobility and Agility

Unprecedented cross-country mobility and enhanced agility will be provided by an all-electric power train producing a variable 800-1200 Hp (@45 ton max. overall weight!). Computerized hydropneumatic 'dynamic' suspension will provide smooth and comfortable adjustable ride over all kinds of rough terrain. Maximum cross-country speed will be 100 KPH (63 MPH). This is extremely high and practically unattainable with limited performance, conventional torsion-bar or coil-spring suspensions. Nonetheless, it is attainable with a hydropneumatic suspension. Maximum flat-road cruising speed will exceed 120 KPH (75 MPH) at maximum power output.

Sustainability - Reduced Maintenance and Logistics

Powered by a new, high-efficiency power-pack and energy source, possibly an *alternative* energy source to conventional fossil fuels. The engine/power source facilitates the implementation of electromagnetic or elec-



trothermal-chemical guns that use electrical energy (EE) as their means, all or in part, for projectile propulsion.

We envision a significantly reduced reliance on conventional maintenance, resupply of rations, ammunition, fuel, and spare parts to achieve long-term, extended operational capability.

Compliance of major sub-systems with the above required capabilities and attributes will be discussed in the following sections.

Logistics Are the Key to the FCS

The M1 Abrams, though inarguably one of the most capable and potent tanks ever produced, must cease operations for refueling at least once every 8 hours under normal operational conditions. Its ammunition and other critical consumables could be readily depleted in a very short time during heavy combat. Like all contemporary modern tanks, the M1 requires a long and vulnerable logistic support "tail" that severely delimits its deployability and operability. In an era when power projection is critical, strong logistical dependency is not acceptable over the long run. The current goal is to reduce the logistic burden by at least 50%. Unfortunately, armored force maneuver and the intensity level of its attack are frequently limited by the capabilities of logistic support infrastructures, rather than the inherent ability of the tank itself. *(What's new?... Wasn't General Patton short of fuel while rapidly advancing in France? Or for that matter, Field Marshal Rommel in North Africa?).*

A modern fast-maneuvering army must reduce its reliance on restrictive logistic support systems while consuming fewer limited resources. On July 17, 1996, Major General Robert Scales, Deputy Chief of Staff for Doctrine at the Army's Training and Doctrine Command (TRADOC), expressed his conception in the *Defense Daily* newsletter,[17] that the Army's operational revolution relies upon effective utilization of better technologies and techniques to support ground forces. The key issue at hand is to be able to *"temporarily break from the logistics umbilical cord..."* restoring the rapid maneuvering of dispersed formations so essential to full exploitation of armor firepower, shock, and mobility. According to General Scales, the Army will be able to create a dominant Force XXI by employing alternative sources of energy for mobility and propulsion, while reducing the traditional restricting dependency on rations, ammunition, and spare parts. This same underlying philosophy has played a paramount role in the derivation of our FCS concept.

We'll deal with solutions to these problems in the second part of this three-part article.

***Note**: All information contained in this article was derived from open sources and the analysis of the authors.*

Notes

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[3]Proceedings, *1996 Combat Vehicles Conference*, American Defense Preparedness Association (ADPA), September 24-26, 1996, U.S. Army Armor Center Fort Knox, Kentucky.

[4]Special Report, *"Authorizers Put More Money Into Future Tank," INSIDE THE PENTAGON*, August 8, 1996, p.10.

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[15]Col. Killebrew, R.B., "The Army After Next - TRADOC's Crystal Ball Eyes the Service's Shape Beyond Force XXI," *Armed Forces Journal INTERNATIONAL*, October 1966, p. 36.

[16]Col. (IDF, Ret.) Dr. Sharoni, A. and Bacon, L., "Forward Area Air-Ground Defense-Do We Need A Dual-Role Hybrid Air-Ground Defense System for the Armored Forces?," *ARMOR*, July-August 1996, p. 15.

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[18]Evers, S., Briefing, Future Warfare, "Rise of the Robots," *Jane's Defence Weekly*, July 31, 1996, p. 19.

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. WDH has been involved among others in the Tank Test Bed, AC-130U Gunship, AH-64 Apache and Tank Compact Autoloader Programs.

Mr. Lawrence D. Bacon is the Director of Graphic Arts at WDH where, for the past 18 years, he has been responsible for creating numerous concepts for automatic ammunition handling, loading and storage systems.

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