The Future Scout And Cavalry System - (FSCS)

Technology Overview, Critical Program Issues, and Design Considerations

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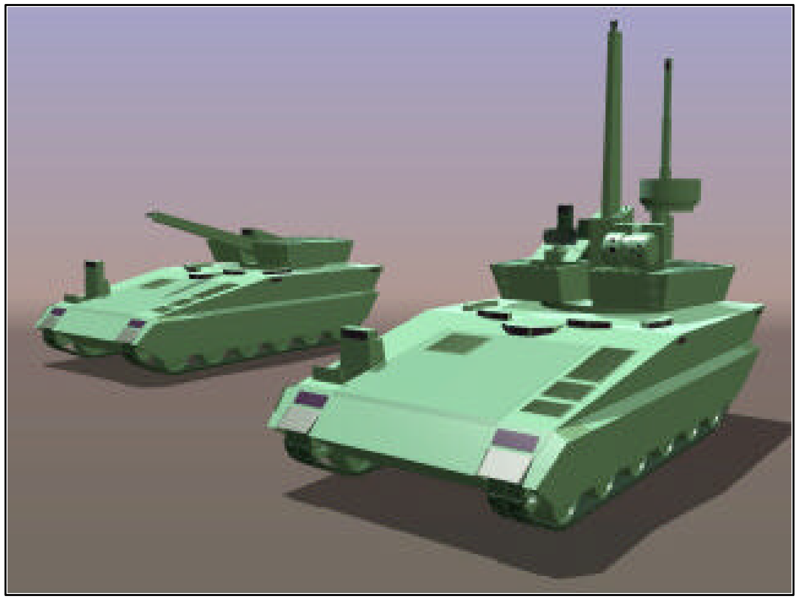
Editor's Note:

In past issues of ARMOR, the authors of this article have discussed and illustrated some fascinating combat vehicle concepts, including a future main battle tank design that won ARMOR's 1993 tank design contest.

Currently, Britain and the U.S. are collaborating on a joint design for a future scout and cavalry vehicle that would replace the HMMWV and Bradley in U.S. service.

Authors Sharoni and Bacon join the dialogue with this article, which – it must be stressed – is an independent, conceptual design, not to be confused with the U.S.-British Tracer/FSCS final concept.

But I think you will find their discussion of scout and cavalry requirements as interesting as the vehicle they have designed to meet these needs.



A Short Overview of the Ground Surveillance and Reconnaissance Role

Mechanized tactical surveillance and reconnaissance scout and cavalry vehicles have been the traditional 'eyes and ears,' serving the tactical commander and front combatant units since WWI. In past days, mainly due to immature or virtually nonexistent technologies, there was an acute insufficiency of long range, multiple-sensing capabilities. Consequently, these highly maneuverable and lightly protected mounted units were oftentimes assigned the ungrateful but critical role of serving as human 'bait.' When a potential enemy could not be detected, they had no choice but to attract enemy fire by deliberately exposing themselves at the front line. Once a well-concealed enemy force revealed its position, it lost the critical element of surprise. Consequently, tactical commanders were able to plan their tactics and respond with much higher probabilities of success, ostensibly avoiding catastrophic encounters with the enemy. Stringent operational requirements have been posted for a small and light vehicle featuring a low profile, increased agility, and improved mobility to enhance its survivability. These requirements led to various vehicle configurations that were inadequately protected — if at all — thereby suffering a highly disproportional casualty rate when exposed to hostile enemy fire.

The last three decades or so have been characterized by efforts of upgrading and modernizing old and new main battle tanks (e.g. M60A5/M1A2SEP) and medium/heavy armored personnel carriers (e.g. M113A3/M3 Bradley). These vehicles have been improved to enhance their firepower, mobility, and in particular, their survivability. Current scout vehicles in use by the U.S. Army that served well in their heyday were originally designed while maintaining their particular mission in mind. Nonetheless, they can no longer be regarded as clandestine and effectively operate in the electronically saturated, heavily *'sensorized,'* future battlefield environment without being easily detected and consequently destroyed.

According to Army sources, the M3 version of the Bradley armored fighting vehicle fundamentally lacks the rigorous stealthy characteristics considered mandatory for the FSCS. The High Mobility Multipurpose Wheeled Vehicle, HMMWV (XM1114) up-armored scout version, though with improved mobility, lacks adequate armor protection. The HMMWV is equipped with light weapons and has insufficient payload-carrying capacity for the required wide array of sensors and electronics. The latter are necessary to successfully meet the surveillance and reconnaissance needs of the future battlefield during the first quarter of the next century. Neither the HMMWV nor the Bradley was designed or optimized to perform scout and cavalry missions.

Arguably, scout and cavalry operations have been viewed in the past as secondary in importance to the combined armed forces' maneuvers. Existing infantry carrying platforms, produced to satisfy other land warfare functions, were converted into scout and cavalry vehicles. They were not customarily designed nor optimized to achieve their specific mission. Thus, inherently limiting compromises in firepower (primarily self-defense), survivability (armor protection, signature attenuation, detection sensing ability, etc.); mobility and agility had to be made. This situation has changed dramatically with the proliferation of high-tech weapon systems offered for sale today in the open market, and the availability of a wide array of matured 'sensing' technologies.

It is widely recognized that an army with superior tactical *situation awareness*, real-time intelligence gathering, fast information dissemination capabilities, and high potential firepower, will have the decisive edge and thus dominate the future battlefield. It will win the war in the shortest time possible, with minimum casualties and with lesser damage to its own military installations and industrial assets. The FSCS is designated by the U.S. Army to be one of the principal means by which it will substantially improve its tactical situation awareness. It will gain the critical, decisive, and competitive edge deemed crucial for quickly winning a modern war. It will play an essential role in the digitized battlefield by analyzing, sending, and receiving vital information that will dramatically enhance combat effectiveness and survival of front line combatant units.

FSCS/TRACER — A Joint Program Between the U.S. and U.K.

The U.S. Army began thinking about a new *Future Scout and Cavalry System* (FSCS) just a few years ago. The Armor Center's Directorate of Force Development at Fort Knox, Ky., has concluded that an FSCS was unequivocally essential for the ground forces to achieve superiority on the battlefield. The FSCS will achieve that with an *unprecedented* level of intelligence gathering, information dominance, real-time analysis, and effective dissemination of information.

The main thrust was launched when the U.S. Army ascertained that its scout and cavalry vehicle program resembled the one that had been launched by the British Army in a program known as TRACER *(Tactical Reconnaissance Armored Combat Equipment Requirement),* intended to replace the British Army's aging Scorpion family of light armored vehicles. The profound similarity of operational requirements between the FSCS and TRACER is the major rationale behind the U.S. Army initiative. On April 21, 1997, a joint requirement oversight council validated the service's mission need statement for the FSCS. Coupled with seemingly perfect timing (still), it has presented a unique window of opportunity for the U.S. and the U.K. armies to join forces and effectively merge the two individual programs. The agreement would substantially reduce overall Engineering Development Manufacturing (EDM) costs to the U.S. by splitting them with the U.K., and would cut production costs for both nations by leveraging economies of scale.

Consequentially, the U.S. and U.K. zealously embarked upon a collaborative venture to develop and produce a common FSCS/TRACER. On July 7, 1998, they signed a Memorandum of Understanding (MOU) that covers the program definition, production, and follow-on support. The MOU states that the FSCS/TRACER will fill a need for both sides to correct existing shortfalls in the current ground reconnaissance/counterreconnaissance capabilities on the battlefield and to fully implement new emerging military doctrines. Current long-range U.S. acquisition plans call for procurement of 1,700 FSCS systems, to begin fielding in the 2007-2008 time frame, while those of the U.K. call for 400 TRACERs. This combined production quantity is ostensibly sufficient to ensure industry economical return on its investment. The US/FSCS is targeted for fielding to all Army scout platoons, including division and regimental cavalry squadron scout platoons that are equipped with HMMWV/M1114 and M3/Bradley.

In order to facilitate the FSCS joint program, the U.S. Army has approved, for the first time, a *Fast Track Acquisition* (FTA) strategy for its Advanced Technology Demonstration/Project Definition (ATD/PD) cooperative phase. Other pertinent executive management guidelines for immediate implementation are: Use of the Army System Acquisition Review Council (ASARC) for follow-on milestone I/II decisions; approval of ATD/PD criteria at 50% signature reduction and 250% increase in target identification and acquisition range; and the execution of an affordability study to address unit manufacturing costs (UMC) prior to establishing requirements and requesting proposals for the subsequent Engineering and Manufacturing Development (EMD) phase. According to Army officials, the FTA strategy will shorten the development effort by roughly 4 years and save a total of $890 million by combining exploration, project definition, risk mitigation, and EMD phases. A unique U.S. feature of the FSCS program strategy is the elimination altogether of the traditional Demonstration/Validation (DEM/VAL) phase, thus allowing the program office to move straight into the EMD phase following the completion of ATD/PD phase. A formal Request For Proposal (RFP) was issued on July 7, 1998, immediately following the signing of the MOU. Two competing international consortia were to each receive a 42-month contract (scheduled for 12/98) to cover the development and production of an Advanced Technology Demonstrator (ATD). These competing ATDs will be completed at the close of 2001, 36 months after contract award. Thereafter, only one consortium will be downselected for the EMD phase.

Much has been written about the political nature and inherent mutual benefits of such unprecedented cooperation between the U.S. and the U.K. governments. To keep records straight, the U.K. voluntarily brought its program to a temporary halt, allowing the U.S. to organize and subsequently join forces with the U.K. in this ambitious program. Multinational defense programs of this nature, orchestrated between allied countries on political grounds, are known to be extremely intricate and fragile. They have their 'enemies' (opponents) from within and outside of their respective defense organizations. They also require that the two governments (and armies — at all working levels) be fully committed and work very closely to solve any problem. The participating governments must quickly abridge emerging differences and legal complications that may rise initially (e.g. signing the MOU), during the developmental and production phases. They must ensure program stability and enduring support. Experience has shown that participants must share developmental costs on an equal basis (50/50%) and thereafter, *individually* bear production costs in accordance with the base configuration and quantities each party plans to procure, while enjoying the savings of a combined production order.

Complicated contractual issues had to be resolved before the memorandum of understanding was signed. These included intellectual property rights, in the event that either party decides to prematurely end its participation in the development or prior to production; transfer of technology; cost sharing during the development and production phases; and future international sales to a third party by each participant. Another essential prerequisite is that both armies must be willing to exercise a philosophy of 'give-and-take' in order to establish the widest base possible for common operational requirements. A major threat to the rationale and stability of such a cooperative program could possibly arise if the U.S. versus U.K. unique requirements will govern and dominate over the common, rendering the developmental phase ineffective and subsequent production noneconomical. Following the removal of these obstacles, FSCS engineers must yet encounter extraordinary technical challenges. They must achieve the optimum middle grounds between highly sophisticated technology and escalating costs; reliability and utilization of fully integrated, customized versus 'off-the-shelf' Non-Development Items (NDI) modular systems.

Finally, the independent National Defense Panel (NDP), though not specifically recommending any program cancellations, has recently challenged the validity of the Army's legacy systems, such as the *Crusader* field artillery system and the *Comanche* scout/attack helicopter. This attempt further reemphasizes the vulnerability and fragility of new major weapon systems developments in withstanding the sharp teeth of military downsizing and critical budget cuts. Senators have been known to continuously urge Congress to look seriously at potential weapons cancellations to free funds for other high priority modernization programs that will better position the U.S. Army against modern and future threats. In this 'hostile' political ambience, any major new developmental program could become an inopportune victim of cancellation due to DOD's attempts to recover funds for investment in *revolutionary* technologies and other force-multiplier modernization priorities. Recently, we have been advised of the U.S. Army Armor Center efforts to terminate the M1A2 upgrade in support of the FSCS funding. This is a precarious situation, which may lead to a severe conflict within the service's elements themselves and industry, causing program instability. Furthermore, we have recently ascertained that the U.S. Army is considering an increase in the Crusader requirement from 824 to 1,378 systems, extending production by 5 years. Given overall finite and ever decreasing budgets for acquisition and procurement, this may lead to a shortage of funds available for FSCS future production.

Multinational Defense Joint Ventures — Critical Lessons for the FSCS

In reviewing similar multinational joint ventures, the MBT-70, an ambitious U.S.-German collaborative tank program during the late 1970s, comes to mind. The tank was technically superior to its contemporaries, but way ahead of its time. This collaborative program did not come to fruition because the two governments failed to abridge and conciliate their differing operational requirements and other pertinent funding, intellectual, developmental and production matters. In Europe, multinational attempts to cooperate on various defense programs suffered a similar ill fate. Germany developed the PzH 2000 and Britain the AS90 self-propelled howitzers after the multinational effort of Germany, Italy and the U.K. to develop the SP70 howitzer failed in the mid-1980s. The Howitzer Improvement Program (HIP/M109) during the late 1980s, which evolved into a joint venture between the U.S. Army and the Israeli Defense Forces (IDF), exemplifies the complexities of such endeavors. This program commenced with an extensive base of common requirements that served as a firm foundation and justification for such a joint venture. Unfortunately, as the program progressed, conflicting operational requirements, cost and domestic industrial issues had emerged, leading to an ever-growing increase in individual unique requirements while diminishing the common. Consequently, the joint program was ultimately terminated, and each country proceeded with its own efforts, culminating with their particular designs (The U.S. with the M109A6/PALADIN).

This brief, grim history of similar unsuccessful international endeavors is not intended to discourage, predict, or cast a shadow on the current collaboration. It does emphasize the *crucial* importance of true and full cooperation among political, military-operational, industrial functions, and other DOD procurement and acquisition entities deemed mandatory for program success.

In the authors' opinion, if the above critical lessons will be carefully analyzed and correctly implemented, the FSCS program is predestined for success. It possesses a unique blend of essential ingredients and prerequisites. Its timing is favorable; up-front funding for Project Definition and Advanced Technology Demonstration (PD/ATD) is available and supposedly in place; operational requirements are recognized, well established, and justified; sensor technology is maturing and available; and the FSCS could be successfully put to use in local or in large scale military conflicts. Last but not least, the cooperation between the U.S. and the U.K. governments could serve as a mutual 'insurance policy' for both armies, diminishing the likelihood of a premature political termination, avoiding the destiny of similar ill-fated defense programs. The FSCS philosophy complies with the U.S. Army's fresh line of thought in accomplishing a *"Full Spectrum Dominance"* in the near future. It embodies seeking *"Mental Agility"* by enhancing real-time information processing and situation awareness, in contrast to *"Physical Agility,"* which pertains to all other progressive conventional improvements and upgrades. The FSCS could successfully be deployed with a small strike force that will be more lethal and mobile than current units.

The FSCS — A Leader at the Forefront of Current Advanced Technology

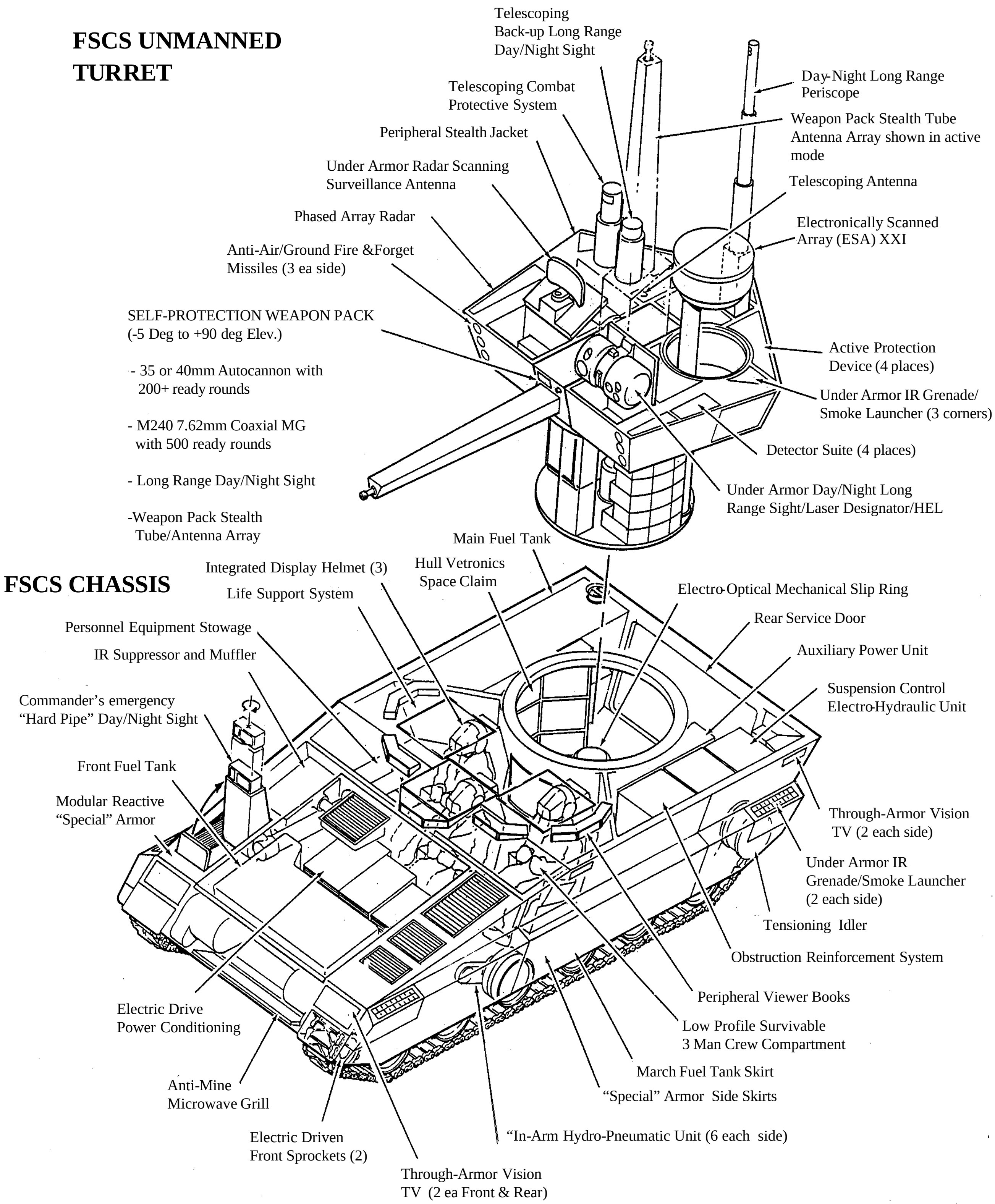
The FSCS is expected to serve well into the 21st century (2030) and will inarguably be the most advanced scout and cavalry customized armored vehicle ever produced. Most of the major operational requirements for such a vehicle seem to be forcefully endorsed by both armies. Positioned at the current forefront of technology, the FSCS will play a prominent role by serving as an *Advanced Technology Demonstrator (ATD)*. An advanced electronic sensors 'suite,' stealth, reduced crew, high-mobility, medium caliber armament, light weight, and enhanced survivability, will all point the way — technology wise — for other potentially subsequent developments, like the Future Infantry Vehicle (FIV) and further along, the Future Combat System (FCS). With the cancellation of the Crusader's Regenerative Liquid Propellant (RLP) main weapon system option, and with ever-growing reliance on *current* technology, the new field artillery system is not largely an ATD.

The FSCS will attempt to leverage numerous next-generation technology programs developed in the U.S., to include: The hunter sensor suite ATD; the multifunction staring suite ATD; the battlespace command and control ATD; the electric vehicle demonstrator; the driver's vision enhancer; the composite armor vehicle ATD; the advanced light armor technology; and the composite armored vehicle (CAV) ATD.

Overview of the FSCS Major Operational Requirements and Technology Feasibility Assessment

The following are the major Combat Operational Requirements that have been presented to the FSCS developers. These are fundamentally different than the requirements posed to conventional contemporary surveillance and reconnaissance vehicles. The profound difference is the *level* of sophistication and maturity of advanced sensing 'suites' and stealth technologies that will ensure successful implementation in the FSCS. The FSCS is required to 'push the envelope' of a wide spectrum of currently developed technologies. With its advanced sensor package; target identification, acquisition and designation capabilities; and long-range optics, it will provide real-time intelligence and enhanced situation awareness. These will be provided at an *unprecedented* level of speed, resolution, detail, and accuracy.

Future Scout and Cavalry System – The Authors' Concept

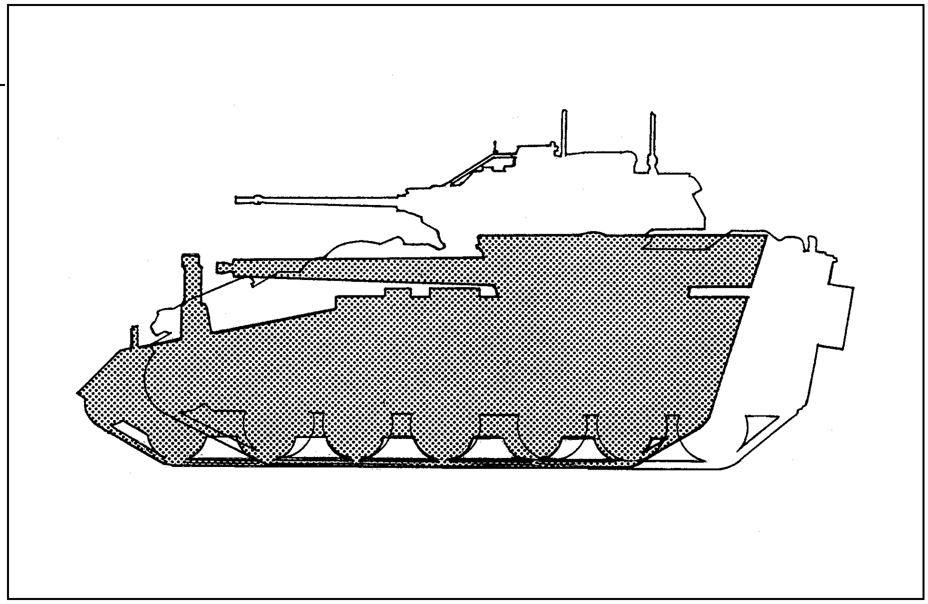


To ensure that the FSCS will survive to achieve its entire mission and ultimately return safely, it must be equipped with state-of-the-art *defensive* protection and weapon systems. These will dramatically enhance its survivability and provide independence from reliance on the forces it is designated to support, allowing it to independently operate close to enemy front lines.

(Ed. Note: Program officials in both the U.S. and the U.K. emphasize that this cooperative program is firmly grounded on operational requirements that are nearly identical for both armies).

• **Situation Awareness Sensors 'Suite'**: Situation awareness is the *paramount* role of the FSCS. It will possess multi-spectral band sensors at ground level and elevated positions (stationary surveillance and on-the-move viewing/monitoring) to detect and identify enemy forces at 10+ km with "Over-The-Hill" (OTH) operational capability in all weather conditions and during day/night. Rapidly advancing sensor technologies currently offer a multitude of detection and monitoring options, such as electro-optical, millimeter wave radar, acoustical, electromagnetic, and infrared. The FSCS will provide answers to the operational strategic level and lower echelon commanders who have ever-increasing information requirements.

• **Multi-Spectral Target Acquisition**: Day/night target acquisition, identification, prioritization and designation enhanced capabilities. The FSCS will be equipped with a new generation radar system, such as Northrop Grumman's *Electronically Scanned Array* (ESA) XXI. This radar is deemed highly effective in supporting FSCS's critical missions. The ESA XXI is based on the Longbow radar mounted atop the main rotor assembly of Boeing's AH-64 improved Apache attack helicopter. This radar combines the basic Longbow fire control system — which detects, classifies, prioritizes, and presents ground targets for the Apache crew — but in a lightweight configuration adapted to ground applications. The ESA XXI ground version uses a smaller, lower cost, and lighter weight antenna that was developed for use by the U.S. Army's next-generation reconnaissance helicopter, the Boeing/Sikorsky RAH-66 Comanche. The direct 'sensor-to-shooter' linkage will be enhanced by combining external information and intelligence gathering from other mobile sources so that the FSCS can integrate his own sensors with external information and intelligence to yield a complete 'picture' of the battlefield.

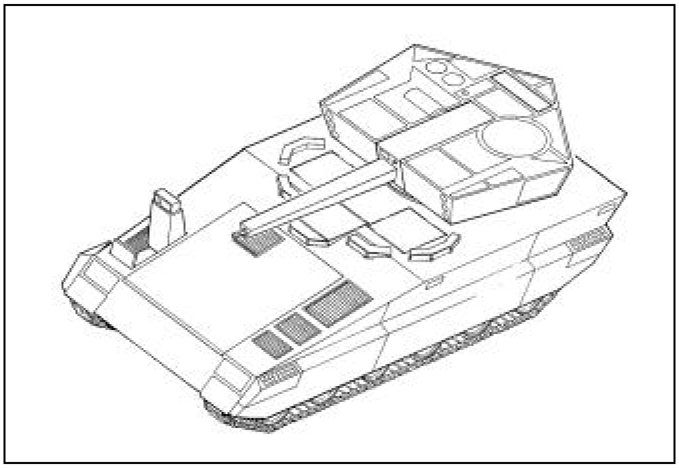


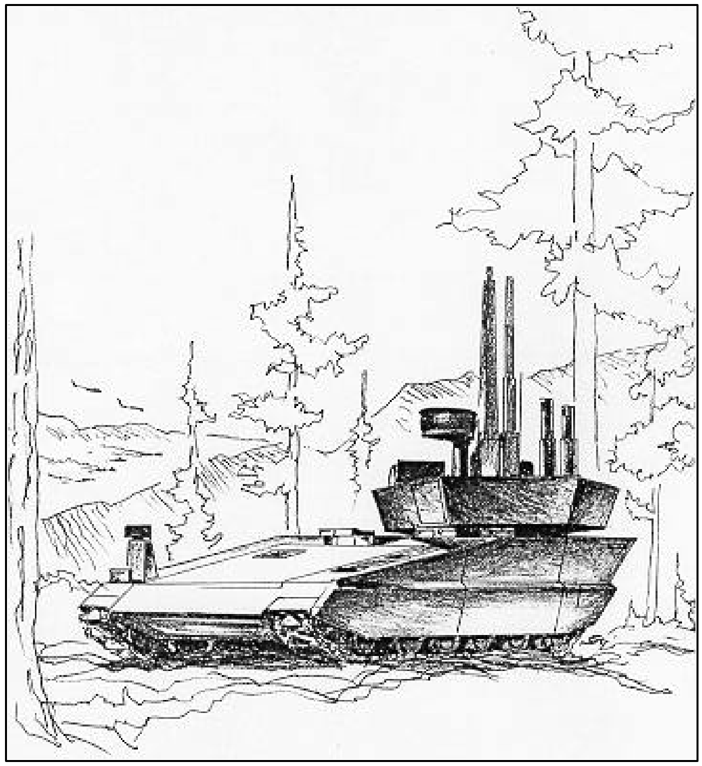
Silhouettes show relative sizes of the conceptual FSCS and the Bradley.

• **Main Defensive Armament:** Equipped with a medium caliber, automatic gun system (30-40mm), sufficient to defeat enemy APCs and lightly armored scout and cavalry vehicles. As connoted, the automatic gun will be used primarily in a *passive* self-defense role, and only as a last resort, when discovered and directly threatened by hostile enemy forces. The main armament will be employed against fixed-wing ground support aircraft, attack helicopters, tactical unmanned aerial vehicles (UAV), and a plethora of ground armored threats. The new Bushmaster III 35mm automatic gun is selected as a possible candidate because of its inherent advantageous characteristics: It is designed and made in the USA, near the end of development, and fires NATO standard 35mm ammunition. The Bushmaster III demonstrates high reliability, superior durability, exceptional accuracy, and safe operation under all firing conditions. This gun is an evolutionary upscaled design that incorporates all the battle-proven features of the 25mm M242 Bushmaster gun, with significant system commonality and low-risk, proven performance. The M242 is a widely acclaimed gun and serves as the primary armament on the Army's Bradley fighting vehicle. The Bushmaster III will be able to defeat the armored reconnaissance threat out into the year 2020 and beyond.

The Bushmaster III combines the cost-effectiveness and compactness of Chain Gun technology, design simplicity, external operation, positive round control, ease of maintenance, and constant velocity feed to enhance the reliability of the gun feed system. Fired cases are ejected forward so that handling and discarding spent cases is entirely eliminated. Longer dwelling after firing reduces gun gas buildup under armor. It is smaller and lighter, and is comprised of fewer parts than any other comparable 35mm gun available today. Bushmaster III capitalizes on the use of externally powered operation to separate gun mechanism motion from cartridge ballistics, allowing for a precisely timed and fully controllable operating cycle. A key feature assuring outstanding reliability is 100 percent 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, anti-armor and anti-air penetrating rounds currently being developed for the popular 35mm ammunition series to defeat present and future threats. The 35mm ammunition family is extensively used all over the world (30 countries) in various anti-armor and anti-air applications, so continuous development and performance enhancement are expected for many years to come. NATO standard 35mm ammunition is characterized by a very short time of flight, which ensures very flat trajectory and enhanced accuracy, resulting in high hit probability and extreme on-target effects. It has excellent armor piercing performance by use of a discarding sabot projectile and superior terminal ballistics. Storage, transportation, handling, and firing criteria are all in full compliance with the U.S. Army and NATO specifications. If Bushmaster III is ultimately selected, 35mm NATO ammunition will be produced under license in the U.S. The Bushmaster III could also operate with the newly developed Oerlikon Contraves





Conceptual vehicle is seen above in travel mode, and at right in-surveillance mode with sensor systems deployed. Main gun tube housing also contains antenna array and is raised to vertical when sensors are deployed.

Advanced Hit Efficiency And Destruction (AHEAD) anti-air/missile defense to keep abreast of the ever-escalating threat scenario. Last but not least, the Bushmaster III is capable of firing the 50mm *Supershot* ammunition, currently in development, which is substantially more potent than the 35mm standard ammunition. This is a strong argument in favor of this gun, indicating growth potential beyond the 35mm ammunition capacity.

There are possibly other viable candidates for the main armament, but in the interest of space, they will not be discussed herein. Any selected gun must exhibit similar characteristics to the Bushmaster III, or better. (Ed. Note: for discussions pertaining to gun selection, see *ARMOR* article "Forward Area Air-Ground Defense," Jul-Aug 96).

Bushmaster III major Specifications: Caliber: 35mm; Feed: single/dual; Peak recoil: 14,000 lb/ft; Total weight: 535 lb; Overall length: 158.1 inch; Rate of fire: Semi-automatic, 200 rpm (250 max.); Power required 3 Hp @ 28 Vdc; Clearing method (cook-off safe): Open bolt; Safety: Absolute hangfire protection; Case Ejection: forward.

• **Secondary Potential Armament System: High Energy Direct Projection Laser Gun for Self-Defense and Target Designation:** The FSCS will be equipped with a high-power, extremely accurate, fully stabilized laser gun. The FSCS is envisioned as an almost 'all-electric' vehicle, which facilitates use of a laser gun that could be used *defensively* against a variety of close-in threats. Among them are helicopters, drones, ground 'soft' targets, infantry, and incoming enemy missiles. High-power laser technology for armament applications has successfully advanced beyond its infancy and now well established in outer space and airborne applications. The FSCS laser gun application will probably be a near-term '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 (see *ARMOR* articles about the *Future Combat System* – FCS, J-A 97, S-O 97, and J-F 98).

Though chemical laser technology is considered mature, a compact and transportable tactical laser weapon system, well integrated into a smaller mobile armored vehicle such as the FSCS, remains to be demonstrated. Typical outstanding issues are integration of optics, energy pressurization system, radar, and command and control. Recent developments in high-power laser technology imply that future 'spin-off' Self Defense Initiative (SDI) exertions, on a much smaller scale, could be implemented in armored ground-to-ground and ground-to-air offensive weapons and active self-defense applications. A 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, severely damaging or temporarily disabling an enemy threat.

• **Battle Management System (BMS)**

The second generation Battle Management System (BMS) includes peripheral multisensor-aided Target and Fire control acquisition system, a day/night integrated system capable of automatically monitoring and tracking up to 8-10 active or passive targets simultaneously and autonomously. Automatic air/ground acquisition would come through thermal imagery, millimeter-wave radar processing, and direct optical sights. The system would include: target recognition, identification, prioritization, and automatic tracking with fire controls for both main (medium automatic gun) and secondary (laser) armament incorporating full stabilization and automatic loading. It would include fire-on-the-move capability while engaging multiple targets in self-defense. It would play a passive role within the tactical and regional digitized communication networks by providing critical battle awareness information and target data submission and acceptance. The FSCS/BMS could be temporarily 'slaved' to other FSCSs, air defense systems, or to higher echelon command and control centers.

• **Signature Management**: A Reduced Signature Management System (RSMS -

radar, acoustic, visual, infrared/thermal and magnetic) would enhance survivability.

• **Multi-Net Communications**: Capable of simultaneous voice, data, and imagery communications on multiple nets, and of collecting, sending, receiving, and integrating information from a variety of land, air and sea sources, including higher echelons, other services, and friendly forces. Intervehicular communications must be highly reliable and capable of operating flawlessly and continuously under all adverse conditions to facilitate internal communications and dissemination of information within the crew.

• **Mobility**: Must be greater than the supported armored forces, with potential speed of 60 mph. An amphibious capability is desired. The FSCS will be powered either by a conventional power pack, comprised of a highly efficient diesel engine coupled with a hydro-kinetic transmission, or a hybrid electro-mechanical power system (discussed separately).

• **Survivability**: Increased survivability against enemy scout vehicles via signature management reduction, enhanced agility and mobility, a "dynamic protection 'suite,' selective modular special armor, and NBC integrated protection.

• **Deployability and Force Projection**: Transportable by C-5, C-17, C-130, and C-141 aircraft.

• **Endurance**: Effective range of 400 miles, 72 hours continuous operation without resupply.

• **Hull/Turret Construction**: Advanced composites and metallic materials implemented as structural and ballistic elements to facilitate weight reduction and reduce radar and thermal signatures. Though not mandatory and a topic for a separate discussion, it is most likely that the FSCS will be equipped with a weapons/sensors station, which will resemble a rotating platform or superstructure. It will provide structural support for the main and secondary armaments, as well as for the vast array of multi-directional sensors, other electronics, and communications equipment. The conventional turret is not applicable here because that implies at least one crewman will be positioned there. In the authors' personal opinions, the multitude of electronic sensing and communications equipment, in addition to the main and secondary armaments, will not leave any extra room for an additional crewmember. If attempted, it will result in an undesirable increase of the FSCS's weight due to the need for additional ballistic protection, and consequently, the enlargement of its visible silhouette.

• **Modular Armor Protection:** The FSCS will be equipped with an advanced add-on modular armor kit ('package') that will be installed as required. This armor kit could be improved over time without requiring major changes to the hull and weapons/sensors station. It will also allow easier transportation of the vehicle without the armor kit, which could be transported separately. This system will protect against medium-caliber ammunition and rocket-propelled grenades.

Two or Three Men Operational Crew - Is It Feasible?

The vehicle would be manned by a crew of two, preferably three, to facilitate simultaneous mounted and dismounted surveillance operations. The option to carry a fourth crewman in the turret to extend the length of effective operational capability — though up front seems advantageous — will substantially reduce the electronic 'payload,' ultimately resembling the undesirable image of yet another personnel carrier. The FSCS must be smaller and lighter than the Bradley. Its crew ought to be less than the conventional four or more crewmembers in order to reduce the vehicle's protected and visible volume. Full automation, with consolidation and centralization of major functions performed by a conventional crew, will eventually lead to dramatic crew reduction. The major functions of commander, main armament operator, weapons/self-defense suite operator, data acquisition and processing operator, and driver/navigator, could be alternately assumed by each one of only three crewmembers. The adaptation of a reduced crew requires a departure from the underlined philosophy of conventional APC operation. The three-crew members could not and should not be expected to perform all routine functions presently assigned to conventional APC crews. It implies that logistics, maintenance operations, sentry duties and alike, should be *reduced* by virtue of highly advanced technologies and extended reliability. The FSCS self-defense systems should operate intelligently and independently; continuously watching, monitoring, and protecting while the crew is asleep, recuperating, or inoperable.

Alternative Energy Propulsion for Automotive Applications

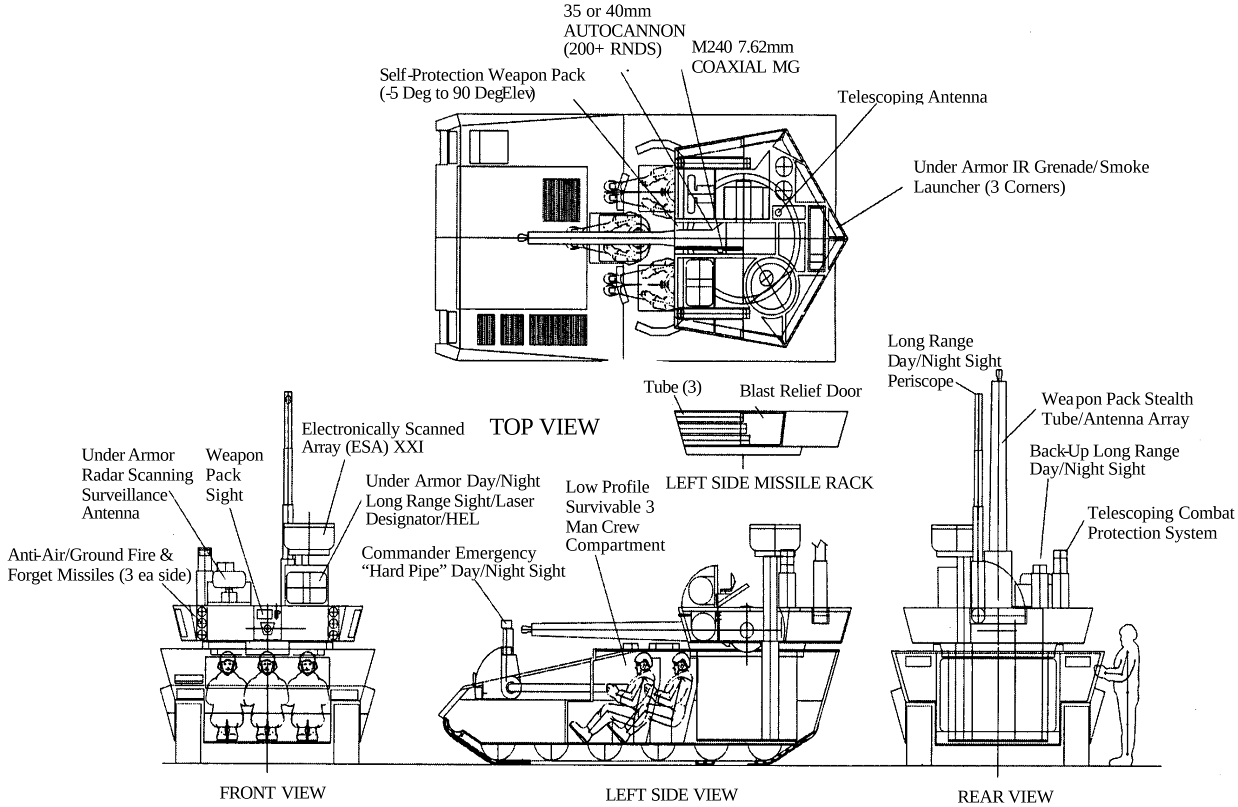
A predominant FSCS requirement is to significantly lessen the dependency on conventional fossil fuels, thus making the FSCS more independent and capable of operating over long periods without requiring periodic maintenance and logistical support. This requirement is difficult to satisfy and necessitates a departure from any conventional power source. As shown, the FSCS power pack is configured for a hybrid front-drive installation. Electro-mechanical propulsion for mobility applications is currently recognized as the wave of the future, let alone the fact that another major system is partially utilizing electrical energy for its operation.

• **Hybrid Electro-Mechanical Power System For Automotive Applications**

Defense Daily (12/11/96 p. 398) reported that DARPA is embarking upon a new venture to find a contractor team able to inexpensively develop and demonstrate the capabilities of a highly-effective, Hybrid Electro-Mechanical Power System (HEMPS) for generation and storage of electricity. HEMPS is intended for automotive applications as a prime-mover in advanced combat vehicles. In essence, it is comprised of a diesel engine or gas turbine driving a generator(s) to produce electrical energy for use and subsequent storage by the vehicle systems. DARPA intends to invest more than $40 M to develop and test the HEMPS over the coming few years. Competing teams will develop and demonstrate an integrated HEMPS for a 15-20 ton vehicle (e.g., FSCS).

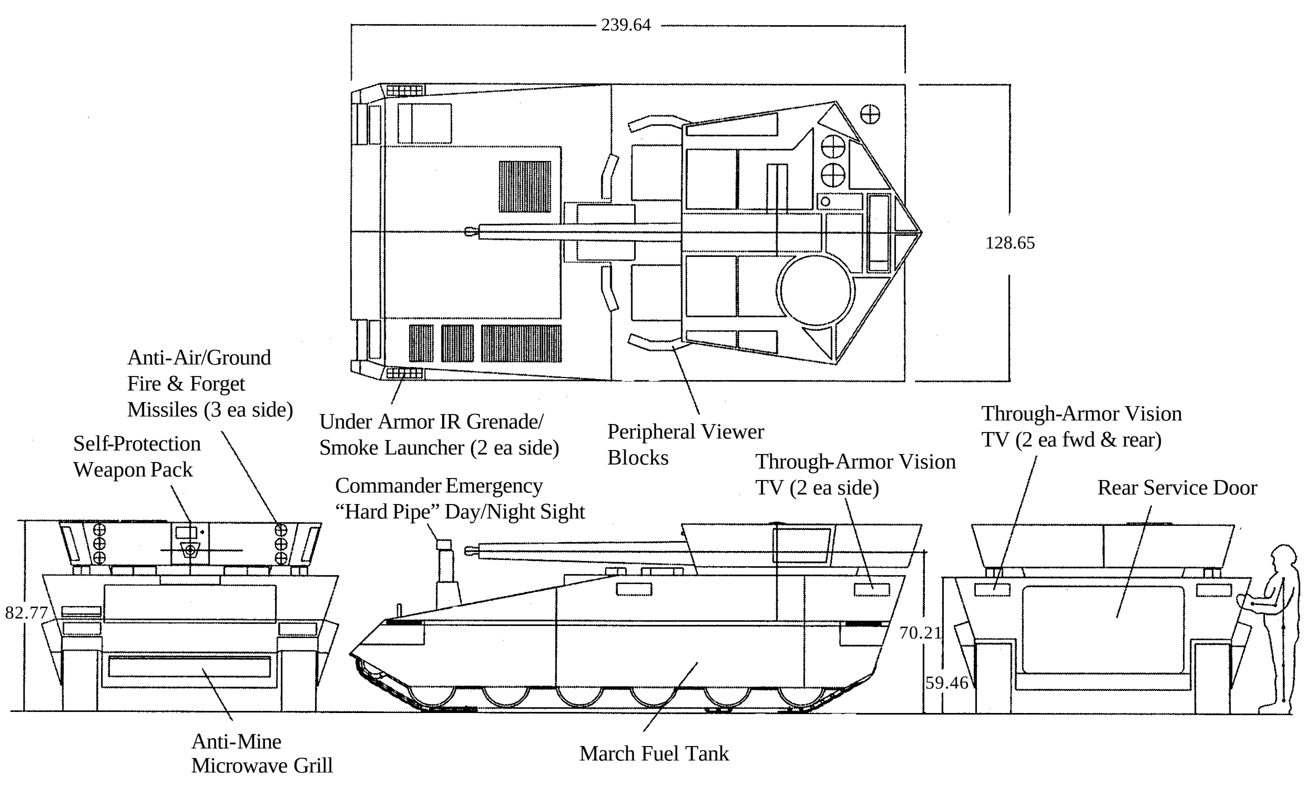
Granting industry the prerogative to develop its own designs without stringent directive from DARPA is a fine idea that has great merit and will pay handsome dividends in shorter schedules and overall reduced developmental costs. The HEMPS is in full accordance with the requirement for simplified and reduced logistics. Integrated HEMPS are more efficient and have improved performance compared to contemporary diesels or turbine-based power packs. They operate with less noise and with reduced thermal signature, thus improving survivability. It's problematical whether integrated HEMPS will be less costly to produce and deploy than contemporary diesel power packs. Attempting to capture the better of two worlds, HEMPS seems to be applicable to the lighter FSCS and alike as a near-term solution, and less for the longer-term, heavier FCS. HEMPS is still going to require diesel or turbine fuel for its operation, and now we would have a piston engine or a gas turbine in addition to a sophisticated electrical power generating system to worry about. This will be counterbalanced by higher reliability and fuel economy.

FSCS Concept Vehicle Details



FCS Concept Vehicle (Overall View)

(Sensing Devices Under Armor)



• **Circumferential Transparent "Virtual Reality" Under Armor Vision**

All-around, 'virtual reality' day/night 360° array of TV/Thermal cameras and computer processed vision enable the crew to "see" through the armored walls of the crew compartment with their helmet-integrated displays. It allows excellent "buttoned-up" visibility and alleviates motion sickness. The weapons could be fully slaved to each of the three-crew members as tactical considerations and battle conditions dictate. All critical battle awareness, vehicle status, and intelligence information is accessible to the crew on their helmet displays.

Integrated Survivability

• Lightweight (15-20 ton) all-terrain, all weather, extended-operational capability, highly mobile vehicle. More versatile than the present Bradley APC series and capable of missions *beyond* those traditionally performed by contemporary surveillance and reconnaissance scout and cavalry vehicles.

• Substantially reduced overall target signature (heat, acoustic, magnetic, and visual) via 'stealthy' materials and a contour design. 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.

• Equipped with a self-defense dynamic 'Hit-Avoidance Suite' (HAS) which automatically detects, prioritizes, counters, and intercepts enemy cruise missiles, helicopters, unmanned vehicles, high performance fixed wing ground support aircraft, top attack anti-tank munitions, artillery munitions (SADARM - Search and Destroy - Armor type), and other anti-tank threats.

• Automatic detection, alert, avoidance, and protection in areas contaminated by Weapons of Mass Destruction (WMD), and Nuclear-Biological-Chemical (NBC) protection capability.

• Integrated passive/active mine detection, avoidance while stationary or, preferably, on the move.

Force-Projection Deployability

• Improved air, land, and sea transportability and deployability by way of reduced overall weight/volume and a smaller silhouette.

• Play an essential role as an *active* information node, fully integrated into the digitized communication battlefield, tactical, and regional networks: combat, surveillance and logistic.

• Improved cross-country mobility, speed, and agility, and greater range than the Bradley APC.

• Autonomous day/night obstacle avoidance, 'Auto-Pilot' (AP) navigation/cruise and automatic formation maneuvers.

Enhanced Mobility

The FCS will be equipped with a highly efficient, electro-mechanical power train, which consumes substantially less energy than conventional prime movers to produce equivalent output. It could increase the operating range by up to 20% and more when compared to the fuel guzzling gas turbine engine. It has a much higher power density (HP/ft^3) and is much smaller in comparison to conventional diesel or gas turbine prime movers (up to 50% increased volumetric efficiency). Power electronics could be increased by 100%, which ultimately implies a smaller envelope of the FSCS. A composite 'band' track will reduce noise signature (30-50%) and increase life such that no maintenance is required during operational activity.

• *Unprecedented* cross-country mobility and enhanced agility will be provided by a Hybrid Electro-Mechanical Power System producing variable 600-700 Hp (@20 ton, 30-35 hp/ton). Computerized hydropneumatic 'dynamic' suspension will provide a smooth and comfortable adjustable ride over all kinds of rough terrain. Maximum cross-country speed will be 100 kph (63 mph). This is 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, highly efficient type of prime mover. An engine/power source that facilitates the implementation of electricity as a source of energy.

• Significantly reduced reliance on conventional maintenance, resupply of rations, ammunition, fuel, and spare parts to achieve extended operational capability.

Logistics Are Crucial To the FSCS

Like all contemporary modern APCs, the Bradley requires a long, vulnerable 'trail' of logistic support, which severely limits its deployability and operability. In the power projection era, strong logistical dependency is not acceptable. The current goal is to reduce the logistic burden by at least 50%! A modern, maneuvering army must reduce its reliance on restrictive logistic support systems while consuming fewer, limited resources. On July 17, 1996, Maj. Gen. Robert Scales, Deputy Chief of Staff for Doctrine at the Army's Training and Doctrine Command (TRADOC), expressed his conception that the Army's operational revolution relies upon effective utilization of better technologies and techniques to support ground forces. The key issue is to *"temporarily break from the logistics umbilical cord..."* restoring the rapid maneuvering of dispersed formations so essential to full exploitation of armor's firepower, shock, and mobility. According to Gen. 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 FSCS concept.

Tracked Versus Wheeled Suspension

Tracked suspension is by far the best system ever devised for ground automotive applications in terms of mobility, reliability, and durability. There is no evidence of any current or near future system that could match or outperform it. There are some voices arguing to equip the FSCS with a conventional wheeled system. No wheeled vehicle could catch up with armored formations when they move quickly to surprise and defeat the enemy. Tracked suspension will remain the best and only choice for armored vehicles on the Earth's random surface texture. Future improvements will include extended durability, maintenance-free operation, and substantial weight reduction. The FSCS will be equipped with a Hydropneumatic Active Suspension (HAS). HAS is a hydropneumatic tracked system that provides a high degree of tactical mobility through variable suspension height, which is dynamically computer controlled, and allows operation over all terrain types and in all weather

Continued on Page 49

FSCS (Continued from Page 17)

conditions. This greatly improves accuracy while firing on the move. HAS can save over a ton of weight compared to conventional torsion bar suspension systems, which contributes to the paramount overall goal reducing weight. Arguably, HAS is not as critical for the FSCS as it is for a much heavier vehicle (FCS?), but it will dramatically enhance the FSCS' ride quality speed, and thus warrants serious consideration. Critical for survivability, the HAS equipped FSCS's reduced silhouette will give it an important battlefield advantage when on silent watch or during other missions requiring minimum visual signature.

Implementation of Composites in the FSCS

To allow rapid deployability and facilitate transportability, weight reduction is one of the dominant and mandatory prerequisites imposed on the FSCS. To achieve meaningful weight savings, the crew must be repositioned in the hull (see FMBT/FCS) such that the overall protected envelope could be dramatically reduced. A possible way of complying with this requirement is to manufacture the hull and possibly the 'turret' out of composites with reinforcement of titanium or other light but strong metallic components to serve as a 'skeleton' for maintaining structure integrity. In essence, the issue is to achieve large-scale economical production while establishing the level of confidence in the ability of composites to be successfully applied in armor structural applications. To gain additional weight reduction, the tracks and road wheels must be made of composites, although they may also contain metallic components for reinforcement. Affordable composites technology could be demonstrated as a cost-effective alternative approach to manufacturing vehicle components. Applications may include road wheels, suspension components and track shoes, leading to significant weight reductions and increased durability. Composite materials utilized in the production of structural elements are lighter than steel and can improve a vehicle's fuel consumption, cross-country speed, operational range, and battlefield endurance.

A four-year contract to develop a lighter, more transportable composite armor vehicle was awarded to United Defense L.P. in 1994. The program is aimed at exploring the use of composite materials in structural applications to reduce weight, enhance vehicle survivability, and improve deployability. In order to reach applicability, there are still many practical problems that must be resolved associated with ballistic and structural integrity, non-destructive testing, signature reduction, producibility, and field reparability. The program is focused on developing a medium-size chassis (17-22 ton) for typical applications such as the FSCS. It is expected that as much as a 50% weight savings could be achieved in the future compared to a conventional steel structure. Composites technology will bring substantial reductions in size and weight of the high performance FSCS without sacrificing operational capabilities. Indisputably, lighter vehicles offer many advantages in the form of strategic deployability, tactical mobility, and sustainability.

The FSCS Scenario - A Major Digitized Battlefield Contributor

Operational requirements dictate that the FSCS should operate as a 'system' while functioning and communicating beyond the conventional, rather narrow, tactical level. The FSCS will be an active node on the battlefield-digitized network. This is a dramatic departure from the conventional way mechanized tactical surveillance and reconnaissance scout and cavalry vehicles have operated since their inception. The FSCS will assist the local commander and crews in obtaining real-time digitized information on the close-area battlefield. This information will be used by the local forces, but also will be conveyed to Greater Area War Management Centers. Vital information on enemy targets obtained from the FSCS, will be prioritized and fed back to tanks, artillery, infantry, and ground attack aircraft.

The FSCS will be an integral part of the digitized (computerized) battlefield network system and will serve as its "eyes and ears." Much has been recently written about the essence of battlefield digitization, so we will not elaborate any further here. The FSCS will have a *second*-generation vetronics system that will further advance digitized data control and distribution, electrical power generation and management, computer resources, and crew control and display processes. The vetronics system will accept a variety of inputs, while delivering outputs related to power system control, sensor control, communications, countermeasures, weapons control, artificial intelligence, training, maintenance, diagnostics, and prognostics. This architecture will provide the interface between the various functional modules, computer, and power resources.

Concluding Remarks

In preparing this article, we have come to realize that there are many similar attributes in the underlying philosophies among the FSCS as we envision it, the Future Combat System (FCS), and the Air Ground Defense System (AGDS) that we described in previous articles published in *ARMOR*. We ask for the reader's forbearance for the repetition of these similarities as outlined here. They were mentioned only where they helped in understanding the prevailing concept and the conceptual evolution of the FSCS. Like our Future Combat System (FCS) concept, the proposed particular configuration of the FSCS is not as important as the core idea behind its conception. A revolutionary sensing and monitoring 'suite,' greater lethality, reduced signature, extraordinary survivability, improved deployability, enhanced communications, mobility, endurance, and substantial reduction in logistic reliance are key to FSCS.

The FSCS is a very advanced mechanized tactical surveillance and reconnaissance scout and cavalry vehicle. With its extended information-gathering capabilities, it pushes the boundaries of technology currently available. It is almost an all-electric platform that uses electricity as a dominant energy source. Electricity is used to power its laser gun, main power train, and all other self-defense suites, sensors, communications, fire control systems and various auxiliaries. It is designed to be highly reliable by virtue of advanced technologies requiring only low-level, and in some cases, virtually no maintenance during operation. It will be closer to the logistician's 'dream war machine' than any other armored vehicle ever produced. The FSCS will influence armored warfare because it will provide essential real-time information. It is quintessential in allowing the combatant ground component to achieve information dominance on the 21st century battlefield.

The FSCS is categorically *not* a direct offensive weapon system and should not be envisioned, designed, or deployed as such. Its primary "weapon" is its sensor suite. Once detected and identified, it will be a prime target for enemy forces, particularly tank hunters and attack helicopters. The FSCS' main role, to the extent possible, is to perform its surveillance and reconnaissance missions while being entirely *transparent* to the enemy. This will dramatically increase its survivability and ability to fulfill its critical missions. Its predominant underlying operational philosophy should always remain: *'The FSCS's strength is in its stealth...'*

The FSCS, as capable as it promises to be, must compete for availability of funds for R&D like any other major development program. The fully justified requirement to support the existing M1 series tank fleet until a new tank becomes available, while preserving the industrial base for armor design and production, will limit the allocation of funds set aside for the FSCS. The FSCS's ultimate destiny, among other major development programs, was determined in the recent Army's Quadrennial Defense Review (QDR) that will dictate the Army's shape for the next 20-30 years. The proposed FSCS, with its powerful main armaments, alternative unique energy source to operate almost all systems, enhanced self-defense capabilities, digitized communications, computer networking ability, precision navigation and advanced aerial sensors, will be a paramount member of Army XXI and beyond. It has all the necessary ingredients to succeed.

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

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.

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[Editorial Note: A. Sharoni and L. Bacon have co-authored the following other articles in ARMOR: The U.S. Future Main Battle Tank (FMBT); Autoloaders For Future Tanks; The Common Chassis Revisited: Should the Next Howitzer Be Built on the M1 Chassis?; Forward Area Air-Ground Defense For The Armored Forces-Revisited; and The Future Combat System (FCS).]