The Crewing and Configuration of the Future Main Battle Tank

by Robin Fletcher

General Sheridan's letter, "A New Tank: Time to Begin," in the September-October 1994 issue of *ARMOR* is a timely reminder that we cannot go on forever modifying and adding to the basic M1 Abrams main battle tank (MBT) and that we ought to start now to give serious thought to what sort of vehicle we wish to create as our future MBT. It should certainly be lighter than the MBTs that we have at present and there has been considerable discussion, not only in *ARMOR*, on the desirability or otherwise of reducing the number of its crewmen from four men to only two in order to reduce the size of the vehicle and so allow it to be better protected.

Captain Mike Newell set the ball rolling with his article, "Survivability Is the Best Argument For a Two-Man Tank" in the March-April 1992 *ARMOR*, and correspondence continued to Matthew Kristoff's letter, "The Two-Man Tank — Time for a Reality Check," which was published in the September-October 1993 issue. General Sheridan now draws our attention to J.B. Gilvydis' article, "A Future U.S. Main Battle Tank for the Year 2010 — A New Vision," published in the May-June 1994 issue, in which, in addition to commenting on the further development of the various systems which make up an MBT, he also advocates the reduction of the FMBT's crew to only two men.

But strenuous opposition to such a reduction is voiced in two letters in the September-October 1994 issue, one entitled "The Four-Man Crew Works — Don't Fix It" and the other "The Two-Man Crew — A Step in the Wrong Direction." But does the choice lie only between a conventional four-man crew and one composed of only two crewmen? Might not a three-man crew have a great deal to offer?

The introduction of automatic loading into Russian MBTs in the 1970s, and more recently into those now being built in France and Japan, has allowed the human loader to be eliminated and opposition to this particular move has been voiced in only one of the letters published in *ARMOR*. Moreover, if we are to move on from the 120-mm tank gun to guns using even larger rounds of ammunition, a human loader may be unable to handle these longer and heavier rounds, and automatic loading will become quite essential.

Having eliminated the human loader, attention has then been directed — certainly by Mr. Gilvydis — at the gunner and the possibility of laying the gun automatically, and this additional responsibility has then been given to the tank commander over and above his normal vital duties of commanding his vehicle. This time, opposition to such a change has been universal, as witness Major Warford's letter, in which he writes: "While reality may dictate the replacement of a human loader with a reliable automatic device, the replacement of the gunner is another matter. What Mr. Gilvydis has failed to recognize is that the addition of the gunner's responsibilities to the demands of the tank commander does not replace the gunner; it replaces the tank commander. That seems like a high price to pay."

What may have been overlooked in the discussion thus far is that the driver may be able to take over some of the additional duties placed on the tank commander, just as the commander of a two-man tank should also be able to drive the vehicle, should that become necessary. For these two crewmen to be able to cooperate closely together in the operation of their vehicle, it will be essential for them to be seated together — preferably shoulder-to-shoulder — either down in the hull, as specified by Captain Newell and as shown in the illustration in Mr. Gilvydis' article, or even together in the turret. What would not be acceptable, principally for reasons of loss of morale, would be for the commander to be the sole lonely occupant of the turret while the driver remained down in the front of the hull.

Figure 1.

The French AMX-ELC of the 1960s.

Although the FMBT is most likely to be operated from fixed hull crew stations, it is still conceivable that two crewmen might handle it from crew stations in the turret. In fact, this latter arrangement was actually adopted by a French experimental antitank vehicle during the 1950s.[1] (Fig. 1) Its turret was locked at 12 o'clock while it was being driven by one of its two turret crewmen. All-round traverse was only restored when the vehicle had become stationary in a selected fire position. Using modern technology, the driver — or rather both crewmen who might

now both have driving controls — could have television screens mounted in front of them, with cameras on the front of the hull. It would then be possible for a crewman to drive the vehicle with its turret partially traversed while the other man searches for targets and then engages and destroys them himself. But since the motion experienced by the crewman driving the vehicle would not be in agreement with what he expected from watching his screen, he would not be able to drive at high speed while his companion fired on the move.

Although this arrangement could use existing technology for the construction and control of the turret, the frontal area of the vehicle would still remain undesirably large, and it would be preferable to seat the two crewmen together in fixed crew stations down in the hull which, by presenting a smaller frontal area, could be better protected.

Two-Man Operation But Three-man Crewing

The adoption of automatic loading in turreted MBTs today has reduced the number of men in the turret but still requires the presence of a third crewman in the front of the hull to drive the vehicle. This can be seen in vehicles produced in Russia, Poland, Slovakia, and now in France and Japan. The American CATTB experimental vehicle[2] follows this same formula, as does the XM8 Armored Gun System[3] now being readied for production.

But so far — apart from the Sleep Support System hurriedly supplied for DESERT SHIELD[4] — no attempt has been made to alter these vehicles' crewing arrangements so that they can keep going 24 hours a day for continuous periods. All three crewmen are on duty together, and all will become equally exhausted over time as described in detail in Captain Chaisson's article, "Rest for the Weary," also in the September-October 1994 *ARMOR*. If best use is to be made of night vision devices now provided for all members of the crew, some system must be found for allowing a crewman to rest and sleep in the vehicle during 24-hour-a-day operations so that it can keep going for many days on end.

Fortunately, the transfer of the MBT's two principal crewmen from the turret into fixed crew stations down in the hull provides the opportunity for them to drive the vehicle, relieving the hull front crewman of his driving duties and allowing him to rest in the rear of the vehicle before coming on duty. If these three crewmen then rotate through the two principal crew stations, the vehicle will be able to keep going for continuous periods.

This new crewing system will require that all three crewmen be trained to the same high standard in the operation of all systems in their vehicle, but it will also provide crewing continuity, which the "2 plus 2" system of crewing does not. This is because a crewman coming on duty, probably after a four-hour period of rest, could be briefed on the tactical situation by his companion in the other crew station, who would already have completed half of his eight-hour duty. The vehicle commander would also take his turn in the crew rest space so he could keep going for many days on end. While he rests, the next senior crew member would command. Only the most junior crew member would not be called upon to command the vehicle.

Retaining three crewmen and adopting a "two-man operation and three-man crewing" system will give the tank the extended endurance that automatically-loaded, turreted vehicles do not currently possess. In addition, gathering the complete operation of the vehicle into the hands of only two crewmen is likely to lead to an increase in its speed of reaction when it goes into action. This can be contrasted with the three — or even four — crewmen needed to operate an MBT today, all performing different functions in different crew stations and dependent on good teamwork for successful operation. As mentioned above, overloading the commander of the FMBT can be relieved by giving his companion part of his load and the capability to rapidly exchange duties in duplicate fixed hull crew stations. Overall, the relocation of the crewmen from the turret into the hull will provide this opportunity for the FMBT to be operated by only two men.

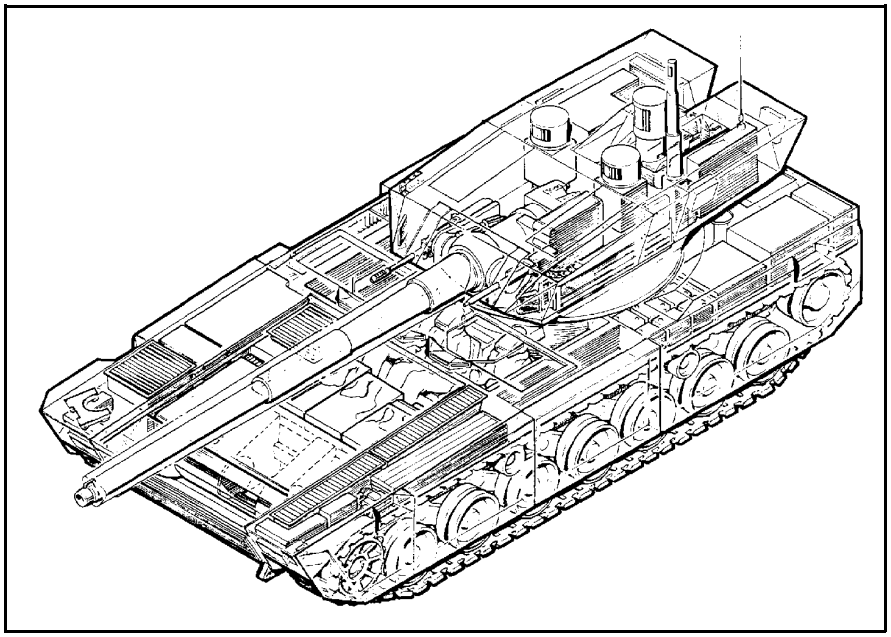

Figure 2. The Western Design winner of the 1993 Tank Design Contest envisioned three crew members sitting abreast in the hull.

If the above is accepted, and two-man operation provides such advantages, why does the Western Design winner of the Tank Design Contest,[5] (Figure 2) and also the Tank Test Bed vehicle,[6] which preceded it, both provide three crew stations abreast of one another in the hulls of these vehicles? Should it be assumed that the three crewmen would be designated as commander, gunner, and driver to operate as a team. Or, with driving and gunnery controls at all three stations, would the vehicle's endurance be extended with two-man operation while the third simply switches off his displays, disconnects his controls, and sleeps in his crew station? An advantage of this would be that no changing of places would be necessary,

because a crewman coming on duty after rest would simply switch on his displays and start work. An intriguing question then arises — whether or not the three crewmen would revert to being a team of a commander, gunner, and driver when action threatened. Or would two-man operation provide such an increased speed of operation that only two crewmen would handle all duties between them, while the third merely assisted when called upon to do so and kept watch to the rear of the vehicle?

It is possible to operate an automatically-loaded, turreted vehicle, such as the Russian T-72 or French Leclerc, while one crewman is absent but is not recommended because one man would then have to drive from the front of the hull while the other operated as a commander/gunner up in the turret. With the two men thus separated in different parts of the vehicle, it would be difficult to transfer part of the additional load from the commander to the driver down in the hull front. In the case of the FMBT, on the other hand, with two crewmen in fixed hull crew stations and a third man resting to their rear, the absence of this crewman would only affect the vehicle's endurance. So long as a replacement crewman could join the vehicle without too much delay, it could continue to operate at full efficiency, and his arrival would restore its ability to operate day after day. With the complete operation of the vehicle being handled by only two crewmen in duplicate fixed hull crew stations, it would even be possible for the vehicle to be maneuvered and fought by a single crewman in an emergency, though with greatly reduced efficiency.

Figure 3.
The Swedish S-Tank can be operated by only two crewmen at hull stations.

Two-man operation of an MBT has, of course, already been in use for many years in the fixed-gun Swedish "S" Tank (Figure 3), in which both men have driving and gun-laying controls in their fixed hull crew stations. This vehicle also carries a third crewman, seated to the rear of the other two, but he only watches over the operation of the automatic loader, drives when the vehicle is reversing, and keeps watch to the rear.

Front Engine, Rear Ammunition, and Rear Entrance

So far, the introduction of hull-seated crewmen has tended to place them in the front of the hull, more or less in the same position as that occupied by the driver of a conventionally-turreted vehicle. This was certainly the case with the Surrogate Research Vehicle and the Tank Test Bed, both of which were constrained by having to use hulls based on that of the Abrams MBT, and thus remained rear-engined.[7] However, the alternative front-engined hull layout is now receiving increased attention, principally because of the efforts of Teledyne Vehicle Systems in offering their Direct Fire Support Vehicle in the Armored Gun System contest[8] and their proposals for a heavier vehicle in the ASM Program having a similar front-engined layout.[9] Although these particular vehicles still have two crewmen traversing in low "pancake" turrets, they not only establish the employment of a front engine compartment but also make use of the rear of the hull to serve as stowage space for a large proportion of the ammunition. This configuration can be seen in the figure accompanying Frank Briglia's article in the July-August 1994 issue of *ARMOR* and in Jody Harmon's excellent illustration of such a vehicle on the front cover. Western Design's winning entry in the Tank Design Contest, which shows a full width front engine compartment combined with the stowage of reserve ammunition at the rear of the vehicle, has given added impetus to the changeover to a front-engined hull layout.

In the famous front-engined Israeli Merkava MBT, rear ammunition stowage is combined with a rear entrance and exit. Since the rounds are stowed in containers that can be removed from the vehicle whenever necessary, this space can accommodate tank crewmen who have been forced to abandon their vehicles, or, if thought to be appropriate, even infantrymen. Cadet Barrett's design, second place in the Tank Design Contest, includes a rear-hull escape door for added survivability.

If two crewmen are to operate the FMBT from fixed stations down in the hull, with a third crewman occupying a rest space behind them to extend the vehicle's endurance, the front engine compartment can extend across the full width of the vehicle and, in particular, the compartment's rear bulkhead can extend intact from one hull side plate to the other. Then, if a penetration should take place through the vehicle's frontal armor, there would be sufficient space for the debris to interact with the engine compartment components before being stopped by the rear armored bulkhead. Cooling air could be discharged at both sides of the vehicle, but might be discharged selectively on only one side when stationary in order to reduce its thermal signature. With direct driving vision being exercised from the top of the hull, a frontal roof slope of less than eight degrees might prove to be inadequate. This roof armor would have to be removable in order to allow power packs to be exchanged, and after being replaced, would have to be suitably secured to withstand heavy attack.

Rear ammunition stowage allows replenishment much more easily than if rounds have to be replaced in a carousel in the hull center, as in typical Russian vehicles. Moreover, should a penetration occur, rounds stowed at the rear of the vehicle can be vented upwards and rearwards in the same manner as those carried in the bustle of a turret. In addition, ammunition-handling systems already developed for installation in turret bustles should be transferable, at least in principle, to handle rounds in the rear of the hull. Rounds being supplied from a rear stowage magazine may either be moved internally through the hull crew space on their way to the breech or, alternatively, they may be moved externally without entering the crew space at all. Ideally, the breech of the gun would be located right at the rear of the vehicle, close to the ammunition magazine, which would not only

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reduce gun overhang at the front of the vehicle, but by employing external ammunition movement, would be much safer for the crew.

Tank soldiers have long admired Merkava's rear entrance and exit, recognizing that it would allow them to mount and dismount unobserved by the enemy and would provide an excellent alternative escape route. However, some form of passageway will have to be provided through the ammunition stowage space, from the crew space to the rear entrance, which immediately raises the specter of space being wasted. Although it would be possible to make use of this space to contain rounds of ammunition, which could be ejected to the rear of the vehicle in an emergency to allow the crew to escape, it seems more sensible to use it as a rest space for the third member of the crew so that his head would be close to the two crewmen operating the vehicle and his feet would be against the rear entrance.

Although increased survivability can be advanced as the principal reason for adopting a front-engined hull layout, this is certainly matched by the advantages to be gained from making the rear of the hull available for ammunition stowage. Should the introduction of a rear entrance and exit rank only third in the list of reasons for adopting a front-engined layout? With increased emphasis now on crew survivability, the introduction of a rear entrance has become of much greater importance. But whichever reason is advanced for adopting a front-engined FMBT configuration, it will be the movement of the crewmen down into the hull of the vehicle, and their consequent ability to drive their vehicle, that will confirm this change of hull layout.

Gun Traverse and Commander's "Top Vision"

With two crewmen operating the FMBT from fixed crew stations down in a front-engined hull, attention should now be focused on how its large tank gun should be mounted and how it should be traversed to engage flank targets. The simplest means of achieving this is, of course, to adopt the configuration used by the fixed gun Swedish "S" Tank, to turn the complete vehicle by the differential action of its tracks and to tip it back and forth in elevation and depression on its controllable suspension system. The breech of the gun would then be at the rear of the vehicle, close to the ammunition magazine, making it a simple matter to move rounds from magazine to breech because their relative positions would remain fixed.

But if independent traverse is considered essential for the rapid engagement of emergency targets to a flank, the "S" Tank configuration will be rejected and the gun may have to be carried either in an unmanned turret of reduced dimensions or on some form of overhead mounting. Rounds might then be supplied to the breech of the gun internally if in an unmanned turret, as has been suggested by Western Design, or externally if the gun is to be carried on an overhead mounting, although this latter system will present considerable problems as the rounds are raised one by one to the gun. Should the gun return to the 12 o'clock position after firing in order to simplify the reloading process, or should rounds be supplied to the gun in whatever direction it happens to be pointing, as was indeed the case in the Swedish UDES-19 design of the 1970s?[10]

If the gun is to be well protected in an unmanned turret, the presented frontal area of the vehicle and, therefore, its all-up weight, will still remain substantial. If, on the other hand, it is carried on a mounting above the hull, the size of target displayed to the enemy, particularly when engaging over a crest, will be much smaller, but the gun itself is likely to become more vulnerable. Moreover, with the gun carried well above and distinct from the hull of the vehicle, this latter form of mounting will be very prominent — as is apparent from the illustration on the front cover of the July-August 1994 *ARMOR* — and the FMBT will become very difficult to conceal on the battlefield.

But over and above the problems of remote reloading, an even more difficult problem will then arise — crew vision will still be exercised from the roof of the hull while the mounting will extend to well above that level. This will mean that when moving over rolling country, the unmanned turret or overhead mounting will come into the view of the enemy before our commander is in a position to see him. Our commander will then have lost what is usually described as his "top vision," which can be defined as the ability to see all round from the highest point of his vehicle. This is what he has become accustomed to when putting his head above the roof of a conventional manned turret or when he closes his hatch and uses the array of vision blocks or periscopes surrounding his turret cupola.

Although sighting vision can be obtained remotely from an unmanned turret or an overhead mounting and displayed on screens in front of the crewmen, it will be much more difficult both to obtain "top vision" remotely from the top of these mountings and also to display it at the crew stations down in the hull of the vehicle.[11] The commander could certainly traverse the restricted vision of some form of Commander's Independent Thermal Viewer (CITV) to look in any direction, but, while doing so, he would be unaware of enemy movement in other sectors surrounding his vehicle. And if an instrument could be devised with a broader field of vision, which might even be able to approach that of the human head, how would this scene be shown to the commander down in the hull of the vehicle unless he were surrounded by an array of screens?

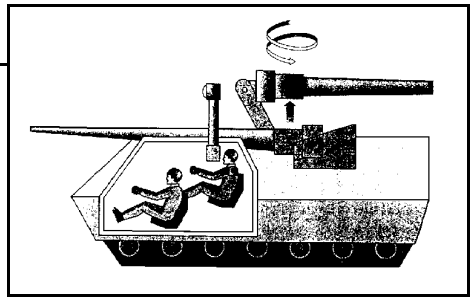
It may be that Helmet Mounted Display (HMD) will have to be adopted, as has been suggested by Western Design, so that crewmen can quickly and naturally turn their "top vision" to observe in any direction. Since crewmen cannot see through the sides of their vehicle, their Helmet Position Sensing Systems (HPSS) can be quite coarse, designed not so much to provide accuracy as to preserve orientation. Should a crewman identify a target and wish to go on to engage it himself, sighting vision from the gun mounting could be displayed in his helmet to allow accurate gun laying. Alternatively, if lack of resolution will not allow this, the crewmen would have to use his fixed display screen for fine laying and firing.

Although indirect "top vision" may thus be possible, it may not be wholly satisfactory and crewmen would, no doubt, be glad to return to direct vision from the hull roof when their vehicle was not in contact with the enemy. Moreover, the prominence of unmanned turrets and overhead mountings will put the FMBT at a tactical disadvantage, and crewmen will wish to have a low-profile vehicle, which would be

easily concealable. This might suggest that an overhead gun be lowered when not required for action, both to restore crew direct "top vision" and to remove its undoubted prominence, and that it only be raised above the level of hull top crew vision when traversed. Such a "lift-and-turn" mounting was actually proposed in Sweden in the 1970s in the form of their UDES-17 design, and it appears to embody the only means available — apart from the turret — of combining both gun traverse and direct "top vision" in one and the same vehicle. The conventional turret, of course, did this so effectively for very many years, but its large size and weight have become too much to tolerate, and it will have to be discontinued.

More recently the Board of Army Science and Technology of the National Research Council (U.S.), in their 1992 report "STAR 21: Strategic Technologies for the Army of the Twenty-First Century" have suggested a "concept for an extensible and rotatable gun mount on a direct fire armored vehicle (battle tank)," and provided illustrations of such a vehicle.[12] These show that the NRC vehicle would not carry its gun in a depression running the length of the hull center line when lowered, as it does in the UDES-17, but would carry it at one side of the vehicle above one of its tracks. Thus, the two crewmen would be able to sit shoulder-to-shoulder in their fixed hull crew stations in order to work together instead of being separated by the central cleft in the hull roof containing the gun barrel, as in the original Swedish proposal.

There appears to be no reason why an FMBT equipped with such a "lift-and-turn" mounting should not be handled like an "S" Tank while its gun remains lowered, forming a compact, well-protected, and easily-concealed configuration with crew "top vision" exercised directly from the hull top. The gun might then only be raised into its more prominent and more vulnerable position to engage emergency targets to a flank before being returned to the 12 o'clock position and lowered again to be reloaded, in effect, bringing the breech **to** the ammunition rather than moving rounds up to a raised breech. Also as an advantage, the gun could then be raised to engage targets over a crest, when the size of target exposed to enemy return fire would be small, the time of exposure would be minimal, and forward and rearward vehicle movement would not be necessary.



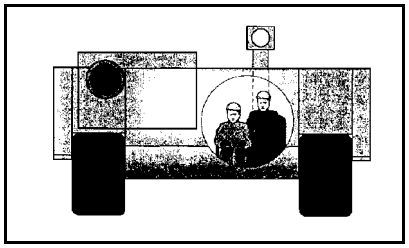


Figure 4. STAR 21 concept vehicle featured a "lift and turn" main gun.

Choice for the FMBT does not lie only between two-man and four-man crewing as three men have handled automatically-loaded, turreted MBTs satisfactorily for many years with two men up in the turret and a driver down in the hull. If the turret is going to be eliminated, because of its weight and size, and its crewmen moved to fixed hull crew stations, where both will be able to drive, the FMBT can be operated by only two crewmen while the third man can rest in the rear to extend its endurance in 24-hour-a-day continuous operations.

Relocation of two crewmen to fixed hull crew stations will also provide the opportunity of altering the MBT's configuration, placing the ammunition magazine at the rear of the vehicle and a full-width engine compartment at the front. If an entrance and escape door is provided at the rear of the hull, a passageway leading through the ammunition stowage area may serve as a rest space for the third member of the crew.

Arming the FMBT will then become a question of selecting the best method of combining gun traverse with commander's "top vision" — which the conventional turret has been able to do so effectively for so long. The Swedish "S" Tank and the overhead gun configuration each provide one of these features, but do so only by sacrificing the other. Moreover, while one is compact and easily concealed on the battlefield, the other is unduly prominent with its gun mounting above, and distinct from, the hull of the vehicle. Does the best answer lie in introducing a "lift-and-turn" mounting, as originally put forward in Sweden and more recently by the National Research Council? The FMBT could then be used like an "S" Tank until threatened from a flank, when it would raise its gun and then transverse it to engage its target.

Notes

[1]The AMX ELC described in *Les Vehicles Blindés Francais 1945-1977* by Pierre Touzin. Editions EPA 1978, pp. 45-50.

[2]"Combat Vehicle Test Bed to Play Key R and D Role" by George Taylor in *Army RD&A Bulletin*, March-April 1993, p. 30.

[3]"AGS Rollout" on the back cover of *ARMOR*, July-August 1994.

[4]"AMC-FAST: Lessons Learned in the Gulf" by Richard E. Franseen, in *Army RD&A Bulletin*, March-April 1992, p. 14.

[5]"We Have a Winner?" in *ARMOR*, July-August 1993, p. 6.

[6]*Technology of Tanks* by Richard Ogorkiewicz, ISBN 0-7106-0595-1, published by Jane's Information Group Ltd., 1991, p. 398.

[7]*Jane's Armour and Artillery, 1983-1984* by Christopher Foss, p. 103.

[8]*Jane's Armour and Artillery, 1990-1991* by Christopher Foss, p. 187.

[9]Teledyne Vehicle Systems representative speaking at Shephard Conferences 2d Armoured Warfare Conference in London in November 1994.

[10]*Jane's Armour and Artillery, 1983-1984* by Christopher Foss, pp. 52-53.

[11]"VERDI 2" by Rupert Pengelley in *International Defense Review*, 8/1994, p. 54.

[12]Board on Army Science and Technology of the National Research Council (US) in their report "STAR 21: Strategic Technologies for the Army of the Twenty-First Century" published by the National Academy Press in 1992, pp. 80-81.

Robin Fletcher was commissioned in the Westminster Dragoons in 1941 and later served in the Special Operations Executive and 2d Special Air Service Regiment. After the war, he attended the technical staff officer's course at Shrivenham, spent two years on tank design at Chobham, and returned to Shrivenham to lecture on tank armament. After leaving the service, he raised crops in Kenya and cattle in Ireland. His articles on armor have been published in *International Defense Review, Soldat und Technik, Military Technology,* and other journals.