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Theater Warfare, Movement, and Airpower

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HISTORICALLY, MOST MILITARY professionals have seen airpower as playing a permanently supporting role in theater warfare when the objective requires the defeat of an enemy army. Such a perspective may explain why Air Force officers are not selected to command forces with a regional responsibility. But now developments in surveillance and battle management technologies have dramatically increased airpower's capabilities against armies. Thanks to these developments, airpower has the potential in many situations to be the nation's main instrument for defeating an enemy army.

Warfare and Movement

To appreciate why developments in surveillance and battle management technologies, especially the joint surveillance target attack radar system (JSTARS), have the potential to give airpower a central role in the defeat of enemy armies, it is necessary to understand the importance of movement in land warfare. An examination of military history quickly reveals that movement is the soul of modern warfare.[1] The key role played by movement is apparent in the definition for logistics: "The science of planning and carrying out the movement and maintenance of forces."[2] The importance of movement, especially rapid movement, is also reflected in the words of successful military commanders and recognized military experts:

> Marches are war. . . . Aptitude for war is aptitude for movement. . . . Victory is to the armies which maneuver. (Napoléon)[3]

> Any slowing down of one's own operations tends to increase the speed of the enemy's. Since speed is one of the most important factors in motorized warfare, it is easy to see what effect this would have. (Erwin Rommel)[4]

> In small operations, as in large, speed is the essential element in success. (George S. Patton)[5]

> Let us organize movement; this is the crucial problem. (J. F. C. Fuller)[6]

> With a time advantage, numbers don't count. (Gen James H. Polk)[7]

> Movement is the essence of strategy. (Stephen Jones)[8]

Why Movement Is Important

Although many are aware of the importance of movement in warfare, there is less understanding of all the reasons why movement can produce immense military advantages.

Besides allowing a commander to gain the advantages of mass and position, movement is one of the main ways a commander degrades the accuracy of an opposing commander's information on the location and strength of his forces. When information on the location and size of an opposing force is inaccurate, it often creates the important advantage of surprise.

In his stimulating book *Race to the Swift*, the late British military theorist Richard E. Simpkin attempted to explain how it is possible to quantify the amount of surprise that can be created by rapid movement. He quantified surprise by measuring the time it takes a commander to make decisions *once* the opposing force's movement is disclosed. Simpkin assumed that movement would be "disclosed" when opposing forces crossed a frontier or seacoast.[9] Simpkin's analysis would have been even more revealing if he had measured the time it takes to "disclose" movement by breaking out the time that is required to collect data on the movement, process the data to produce reliable information on the opposing force's location and strength, and then disseminate the information to the commander and other war fighters. For a truly comprehensive treatment of movement's ability to create surprise, Simpkin should have also addressed the ability of commanders who do not possess exclusive use of the airspace to degrade or even defeat an opposing force's ability to collect and produce reliable information through the use of concealment and deception measures. For example, commanders have learned through experience that when they do not possess complete control of the air, moving their forces at night or in bad weather is one of the most effective methods for denying an opposing commander the ability to collect and produce reliable information.

As seen by the title of his book, Simpkin assigned great importance to rapid movement. According to him, there are two types of armies: those that fight to move (German, Israeli, and Soviet) and those that move to fight (US and British).[10] When armies fight to move, they tend to use rapid movements deep into the opposing force's territory to dislocate the opposing force's ability to conduct effective military operations. The use of movement to dislocate the opposition may explain why the German and Soviet armies assigned so much importance to the operational level of war and the maneuver of large forces over significant distances. In contrast, the US Army, which Simpkin believed tended to focus on moving in order to fight, assigned great importance to the tactical level of war, measuring success in terms of numbers of enemy killed. Although the US Army has begun emphasizing the operational level of war in its doctrine, it has yet to fully institutionalize the operational level of war. It still depends on models that use attrition to determine movement and force structure requirements! Further evidence is found in one officer's observations on "decisive maneuver" during the recent Army war-fighter experiment. He noted that

German convoy destroyed around a farmhouse in Normandy, 1944. German commanders believed that one of the most important contributions made by Allied airpower in World War II, especially in Normandy, was through its impact on the German army's daytime movement.

> accurate/timely situational awareness was always available and in sufficient detail to highlight opportunities when offensive action could have led to prompt victory. At no time did the brigade assault with unexpected, overwhelming maneuver to decisively overwhelm the enemy. For whatever reason, leaders did not demonstrate the capacity to recognize or seize these opportunities. Instead, attritional/high casualty warfare was always favored.[11]

More evidence of the importance of movement in warfare can be seen by the number of great victories in history that were characterized by the use of movement to create and then exploit the advantages of surprise, concentration, and position. These advantages often allowed the seemingly inferior force to win quickly and at an amazingly low cost. The impact of advances in technology on military doctrine, organization, and training was often related to how these advances enhanced or degraded, directly or indirectly, an army's ability to move. The motor vehicle is one of the advances in technology that enhanced movement, creating an immense impact on military doctrine, organization, and training. By freeing armies from the railhead, motor vehicles greatly enhanced army mobility.

Today, armies depend on motor vehicles for mobility, heavy firepower, armored protection, and supplies. Without its motor vehicles, an army would have to live off the land, making it extremely vulnerable if trapped in place. Without motor vehicles, an army would be limited to light weapons and would have no protection when maneuvering in the open. Dependence on vehicles explains why light infantry can effectively fight heavy forces only in complex terrain such as cities, mountains, and jungles. Although light forces in complex terrain can be costly to defeat in direct attack, the Pacific campaigns of World War II demonstrate that these forces can be bypassed and isolated by forces possessing superior mobility and firepower.

Movement and Intelligence

Given the central role vehicular movement plays in modern army operations, this movement has the potential to be the most important form of an opposing army's behavior for intelligence to assess. In fact, it is very difficult to identify significant military actions

that would *not* involve vehicular movement. Compared to vehicular movement, other forms of behavior such as signals and other electromagnetic emissions provide information that often gives only brief glimpses of an army's capabilities or possible intent. Worse, signals intelligence is often unreliable because of deception and concealment measures (e.g., the use of landlines and messengers). In contrast, movement defeats many camouflage, concealment, and deception (CCD) measures. Nature provides many excellent examples of how movement can destroy camouflage and concealment measures.

Despite movement's immense potential value as a source for intelligence, it has been extremely difficult for commanders to reliably and quickly reconstruct the movements of enemy forces using inputs from their surveillance and reconnaissance assets. Contributing to the problem was that until the invention of the aircraft, commanders had to depend on surface-based surveillance and reconnaissance with a field of view that was severely limited by terrain, foliage, darkness, and weather. Although aircraft provided the important advantages of elevation and speed, their value as a surveillance and reconnaissance platform continued to suffer from significant limitations. Besides the human eye, many of the sensors aircraft carried were handicapped by darkness or bad weather. Other sensors, like the synthetic aperture radar (SAR), which is not handicapped by darkness and weather, have a small field of view and cannot see movement. Adding to the problems with sensors mounted on aircraft (and satellites) have been the extensive amounts of time and resources required to process the data they collected to produce information. Plus there remained the problem of communicating this information to the war fighters.

Since movement made information on a unit's location perishable, even with airborne surveillance, the time required for processing and communication often made information on the location of opposing army units provided to commanders dangerously unreliable. As long as the opposing force remained mobile in World War II, Korea, and Vietnam, actual contact between friendly and opposing ground forces was often the most reliable way for an army commander to collect information on enemy ground forces. It was this need for contact between armies that explains B. H. Liddell Hart's "man-in-the-dark" theory of warfare. Liddell Hart compared warfare to two men fighting in a dark room using their extended hands to locate the other while protecting against a surprise attack. When one man found the other with his hand, he would grasp (fix) him and attempt to immobilize him while setting him up for a decisive blow.[12]

MTI Imagery Capability and Potential

But now the old paradigm is changing. JSTARS, with its high performance when operating in the moving target indicator (MTI) radar mode, has suddenly "turned on the light" for US forces. It is important to note here that while other systems may possess an MTI capability, all MTI-capable radars are definitely *not* the same! Thanks to its 24-foot-long antenna, high power, and various other design factors, JSTARS has demonstrated vastly superior performance in *all* of the areas that make it possible for its MTI imagery to be used to precisely track vehicles, even when they move very slowly.[13] Moreover, compared to other MTI-capable radars, JSTARS demonstrates far superior performance even when operating from a much greater standoff distance and while providing a much larger field of view. With JSTARS, US forces now possess the unprecedented ability to reliably detect, accurately locate, precisely track, and, if appropriate, target in real time almost all the unscreened vehicular movement of opposing forces occurring within an area exceeding 40,000 square kilometers, even if this movement takes place at night or during bad weather.

The value of this capability is enhanced because the MTI imagery of JSTARS is frequently updated, easy to quickly exploit, and widely

disseminated. Much of the ease with which MTI imagery can be exploited results from its display on board the E-8C aircraft on the high-resolution color graphic displays of the 18 operator workstations. Workstation operators can enhance their display by superimposing MTI imagery on a variety of digitally stored databases that show terrain features as well as other tactically significant information. The operators can replay the recorded MTI at selected speeds using time-compression and integration techniques to further enhance imagery exploitation. They can also superimpose MTI imagery on an SAR image and enhance the image by fusing it with information provided by off-board sources.

Adding to the value of this information is the fact that it is widely distributed to Army forces through an unlimited number of ground station modules (GSM) via an encrypted, highly jam-resistant surveillance control data link (SCDL). The SCDL also permits specified GSMs to uplink radar service requests. Thanks to this dissemination of JSTARS information, air and ground commanders can share the same real-time picture of friendly and opposing movement. Sharing a common picture makes it much easier for them to orchestrate their actions so as to create an immensely powerful joint force synergy.

But to fully realize the potential contribution of JSTARS, it is important that sufficient aircraft be available to provide continuous surveillance. Without continuous surveillance there will be gaps in the information on vehicular movement. These gaps will create uncertainties regarding the location of forces that moved when JSTARS was not present.

When JSTARS surveillance is continuous, it is possible to replay MTI imagery to further reduce uncertainties by tracing the movements of vehicles back in time. For example, if a vehicle was identified as a surface-to-surface missile (SSM) transporter erector launcher (TEL), replaying MTI imagery could make it possible to trace the TEL's movement back to its source, perhaps leading to the location of a previously unknown missile storage area. Once a storage area is found, replaying MTI imagery to follow the paths of other vehicles originating from that area could easily lead to the location of other dispersed and concealed TELs.

Besides continuous surveillance, fully exploiting JSTARS information on movement depends on developing appropriate exploitation tools. Most importantly, it requires changing the mind-set of those responsible for intelligence who have no experience working with MTI imagery. Since warfare, like football, is about movement, the military might want to study how coaches exploit video to better understand how to use the MTI imagery of JSTARS for intelligence purposes.

While this MTI imagery alone is an extremely valuable source of information, it can also be used to dramatically increase the value of other collection sources by cueing their employment. Using MTI imagery for cueing makes it possible for high-resolution, small field-of-view SAR, electro-optical (EO), and infrared (IR) sensors to collect information on unanticipated, fleeting events involving movement that otherwise would be uncovered. The advantage of such cueing was demonstrated during unmanned aerial vehicle (UAV) operations in the Army war-fighter experiment at the National Training Center. The MTI imagery of JSTARS can also be useful for validating information provided by other intelligence assets. For example, comparing its MTI imagery with other forms of information could be especially useful for detecting camouflage, concealment, and deception measures. Knowing where and how the enemy is attempting to hide or deceive would be extremely useful information.

Battle Management: The Primary Role of JSTARS

Despite the immense value of the information provided by its MTI imagery, viewing JSTARS as just another airborne sensor fails to recognize the system's immense potential for increasing overall joint war-fighting effec-

JSTARS launch. Rather than considering JSTARS to be an "upside down" AWACS, perhaps it would be easier to appreciate its immense joint interdiction battle management potential if viewed as a giant electronic airborne forward air controller (FAC) or killer scout.

tiveness through battle management. The importance of being able to see movement in real time is ultimately determined by whether this information can be used while the information is still fresh. As has been noted, one way information on the movement of enemy forces can be used is in the dynamic management of surveillance and reconnaissance assets. Such a use explains why JSTARS has immense potential as a "mother ship" for UAVs performing surveillance and reconnaissance. Cueing by JSTARS with its wide area view makes it much more likely UAVs will collect information on key events since movement is a part of almost all significant military activities. Similarly, cueing will make it easier to establish exploitation priorities, reducing the time it takes to provide information to the war fighters while possibly also reducing the resources that need to be devoted to exploitation.

However, the most dramatic use of JSTARS real-time information on movement is in the employment of combat forces. By exploiting the unprecedented surveillance *and* battle management capabilities of JSTARS, a joint force commander possesses the ability to conduct dynamic, asymmetric joint warfare. Dynamic, asymmetric joint warfare involves the creation and execution of interdiction and ground maneuver schemes that are designed to exploit the tremendous interdiction capabilities possessed by US forces, while ensuring the two different schemes complement and reinforce each other.

For example, ground maneuver schemes (which can ensure friendly ground forces avoid significant close contact by using JSTARS surveillance) could be designed to force the enemy to attempt moving large forces quickly, making them more vulnerable to US interdiction. The objective of the complementary schemes would be to create dynamic conditions that put the enemy at a tremendous disadvantage, while minimizing the risk for friendly forces. The ability of JSTARS to see movement in real time also makes joint warfare more dynamic by allowing a commander to detect and exploit the often fleeting opportunities that are created when the enemy attempts rapid, large-scale movements. Unfortunately, while the advantages of JSTARS information for ground maneuver appear to be well understood, Joint Publication 3-03, *Doctrine for Joint Interdiction Operations,* indicates that the asymmetrical

and revolutionary advantages for joint warfare from JSTARS-supported interdiction are not.[14]

Revolutionizing Joint Warfare through Interdiction

To understand why JSTARS-supported interdiction creates revolutionary advantages for joint warfare, it is necessary to understand that, before JSTARS, interdiction against mobile ground forces did not reduce the need for friendly ground forces to fight, often very costly, close operations where US personnel were in immediate contact with enemy ground forces. The need to fight close operations was directly related to the immense problems involved in detecting, locating, and effectively targeting the enemy's mobile ground forces with airpower and artillery before the enemy's forces could move into close proximity with friendly ground forces. But now the ability of JSTARS to detect, locate, track, and then precisely target enemy ground forces with airpower and long-range missiles while these forces are still far from the nearest friendly forces makes it possible to inflict devastating destruction even when the enemy attempts to move at night or during bad weather. In many situations, this destruction could be so devastating that there will either be no close operations or they will, as was the case during the battle at Al Khafji, pose relatively little risk for friendly ground forces.

Given the importance of movement to warfare, it is extremely important to recognize that the value of interdiction should not be judged solely in terms of the amount of destruction that is actually inflicted. Joint interdiction supported by JSTARS has immense and revolutionary joint warfare potential because the *threat of destruction* that is possible can have the extremely important functional effect of preventing an enemy army from conducting militarily significant movement, even at night or during bad weather. And when the initial interdiction attacks are sudden and intense, it is possible to achieve the desired functional effect relatively quickly and at low cost in terms of both lives and material resources.[15]

The ability of interdiction to influence an enemy army's movement through the threat of destruction is apparent from past experience. For example, although Allied airpower killed relatively few German tanks in Normandy, German army commanders like Field Marshal Erwin Rommel credited it with having an immense impact on their ability to fight effectively.[16] Rather than risking devastating destruction from air interdiction by attempting to move during the day, the Germans waited until darkness or bad weather removed the threat. As the following quotes make clear, German commanders believed that one of the most important contributions made by Allied airpower in World War II, especially in Normandy, was through its impact on the German army's daytime movement:

> The technically superior enemy fighter-bombers neutralized practically all traffic during the day. (Hans Speidel, Rommel's chief of staff)[17]

> This air supremacy manifested itself in mass air commitments in certain front sectors . . . and in the almost ever-present Allied fighter-bomber units to depths varying between 30 and 60 miles in the German rear, the frequency with which they were encountered decreasing with the increasing distance behind German lines . . . [as a result] tactical movements during daylight were impossible or could only be carried out at considerable costs in casualties, materiel losses, and loss of time. (Gen Wolfgang Pickert III, AA Artillery Corps commander)[18]

> On clear days, it was practically impossible to carry out any movement in the rearward areas. This could only be done on cloudy days or by night. (Col Willy Mantey)[19]

In explaining the impact of airpower performing interdiction on the Normandy campaign, the US Army's Twelfth Army Group states that "German commanders agree that a considerable part of the art of war consists of concentrating more forces at key points than the enemy. When mobility and maneuver are

lost, the loss of battles and campaigns follows."[20] If interdiction had this impact on battles and campaigns by preventing significant German movement during the day within 30 to 60 miles of friendly ground forces, imagine the impact on future battles and campaigns when interdiction makes significant movement within one hundred miles impossible even at night or during bad weather!

Allied interdiction influenced German movement in two ways: directly in attacks against mobile forces themselves in the form of armed reconnaissance and indirectly through attacks against lines of communications (LOC) infrastructure and fuel supplies. Just the threat of destruction from armed reconnaissance generally caused the Germans to limit movement to times when armed reconnaissance was not feasible because of darkness or bad weather. A German panzer corps commander in Italy explained the impact of airpower in this way:

> The enemy's mastery of the air space immediately behind the front under attack was a major source of worry to the defender, for it prevented all daylight movement, especially the bringing up of reserves. We were accustomed to making all necessary movements by night, but in the event of a real breakthrough this was not good enough. In a battle of movement a commander who can only make the tactically essential moves by night resembles a chess player who for three of his opponent's moves has the right to only one.[21]

It is also important to note that the threat from armed reconnaissance rapidly decreased with distance from friendly territory because of the range of fighter-bombers and the increasing size of the area the aircraft had to search for movement.

Allied armed reconnaissance proved to be very effective in Normandy at influencing German movement for a variety of reasons. The Allies could generate many sorties. Besides possessing a very large number of aircraft, the Allies quickly established many bases in close proximity to the enemy. The campaign was fought during the summer, when the hours of daylight were long and the weather generally good. Also contributing to the effectiveness of armed reconnaissance was the surprise achieved by the invasion's location, which required the Germans to move units quickly to Normandy. Once their ground units reached the Normandy area, the Germans were forced to shift these units around their defensive perimeter in attempts to contain Allied attacks.

Although it was very effective in Normandy, there are many reasons why Allied armed reconnaissance was also very inefficient. Performing a comprehensive target search of all the LOCs required a great many sorties. Limited range tended to restrict the depth of search to 30 to 60 miles in the German rear, so the frequency with which fighter-bombers were encountered decreased with the increasing distance behind the lines. The increased exposure that was required to perform a low-altitude search resulted in very high fighter-bomber losses to short-range air defenses. Attacks were frequently wasted on previously destroyed vehicles. The search for targets was limited to daylight and good weather. Finally, reliable, timely battle damage assessment (BDA) for attacks against mobile forces was extremely difficult and often impossible.

The ability of enemy armies in World War II, Korea, and Southeast Asia to exacerbate these inefficiencies does much to explain why armed reconnaissance was not always as effective as it was in Normandy. At the same time, the threat posed by air interdiction attacks explains why *all* of our foes (Germans, North Koreans, Chinese, North Vietnamese, and Iraqis) have quickly chosen to restrict the movement of their forces and supplies to periods of darkness and/or bad weather. They also increased the inefficiency of armed reconnaissance by deploying numerous decoys, moving cross-country rather than on roads, concentrating short-range air defenses along LOCs and around LOC nodes, preparing bypasses for LOC nodes, concentrating resources for rapid LOC repair, and using deception to conceal LOC repairs and bypasses.

Now, with the unprecedented capabilities of JSTARS, most if not all of the measures that successfully limited the effectiveness of interdiction attacks against mobile forces will no longer work. But the performance of effective joint interdiction against enemy mobile forces depends on more than just the ability of JSTARS to provide unprecedented surveillance. Effectiveness also requires exploiting its ability to perform lower-level interdiction battle management. The realities of theater communications availability and throughput, span of control, and the need for graceful degradation combine to explain why a platform with the sensor that can see and track enemy movers is also the ideal location for performing target/weapon pairing, providing target information to the shooter, conducting BDA, and determining the need for a reattack.

It is important to realize in this situation BDA should be functionally oriented, assessing whether the target continues to move. If the target does continue moving after an attack, it is important to know in what direction, at what strength, and at what speed. However, knowing immediately whether vehicles stop because they have been destroyed, exhausted their fuel supply, or have been abandoned by their crews is of secondary importance.

The joint force commander and his component commanders must remain responsible for the higher-level battle management activities, managing the planning and execution of warfare at the operational and tactical levels to include oversight of engagements. These commanders are the ones who determine a joint interdiction campaign's objectives, conceive concepts of operations for employing their forces to achieve those objectives, prepare plans to implement those concepts, assign resources to execute the plans, and oversee execution of the plans, to include dynamically modifying their plans and reassigning resources to ensure the crea-

The Highway of Death. With JSTARS, US forces now possess the unprecedented ability to reliably detect, accurately locate, precisely track, and, if appropriate, target in real time almost all the unscreened vehicular movement of opposing forces that is occurring within an area exceeding 40,000 square kilometers, even if this movement takes place at night or during bad weather.

tion and exploitation of powerful joint warfare synergies.

Further rationale for performing the engagement activities of joint interdiction battle management on board JSTARS can be found by comparing the differences between air-to-air and air-to-surface targeting. These differences explain why there is a huge difference between the airborne warning and control system (AWACS) and JSTARS. In air-to-air combat, AWACS is working with fighters that possess their own long-range sensor and employ air-to-air missiles (AAM) that also possess sensors for terminal homing. In this situation, AWACS does not always need to provide the same amount of targeting information (such as the number of vehicles, their spacing, speed, direction, and how the surrounding terrain may influence the attack) that would be needed for effective deep air-to-surface interdiction attacks. In contrast, no fighter or bomber can detect and track moving ground vehicles at anywhere near the same ranges that are possible in the targeting of other aircraft in air-to-air combat. In fact, often the only way the crews of most aircraft can find and target their munitions against ground vehicles is with their own eyesight, perhaps aided by short-range, narrow field-of-view night vision devices. Even then, unless the target is moving, they cannot tell if the target is real or dead or a decoy.

Rather than considering JSTARS to be "an upside down AWACS," perhaps it would be easier to appreciate its immense joint interdiction battle management potential if it was viewed as a giant electronic airborne forward air controller (FAC) or killer scout. Like Fast FACs, such as the F-100F Misty operating over the Ho Chi Minh Trail in Southeast Asia, JSTARS uses its sensor (but a multimode radar, rather than the pilot's vision) to find targets. Also like a FAC, once it finds a target, JSTARS can then provide appropriate targeting guidance (sensor-to-shooter information) to ensure an effective attack.

Despite the similarities, JSTARS is vastly superior to Fast FACs for a wide variety of reasons. The field-of-view radar of JSTARS is immensely larger than the field-of-view of a FAC's eyesight. Thanks to its radar, JSTARS stands off at a significant distance from the area it is watching, providing unobtrusive surveillance and greatly reducing its exposure to air defenses. With its radar, JSTARS surveillance is not degraded by darkness or weather as is the case with the FAC's eyesight. Unlike a FAC, JSTARS can provide far more persistent surveillance and battle management; with air refueling it has an endurance of 20 hours or more. Operators on board JSTARS work in an environment more conducive to their effectiveness (this includes access to databases and outside sources of information) than a Fast FAC maneuvering at low altitude (sweating, breathing hard, and pulling Gs), while attempting to watch the target area and study maps or photos. JSTARS operators are also less susceptible to degradations in their performance from fatigue because there is room to accommodate relief operators. The JSTARS workstation operator can instantly look at an area anywhere within the radar's very large field of vision, while a FAC has to expend the time (and fuel) it takes to fly the aircraft within visual range of the target area. Also, a FAC is limited to providing targeting in one area at a time, but JSTARS with its 18 onboard workstations can support many simultaneous attacks throughout the sensor's field of vision.

Large or Small AGS Platform?

Determining whether an airborne ground surveillance (AGS) system like JSTARS should be on a small (unmanned aerial vehicle or business jet) or large (707) platform requires consideration of a number of issues. One issue is whether the system is to be a "full spectrum" system or stovepiped for only one portion of the spectrum of conflict or only for surveillance, rather than surveillance *and* battle management. Generally, armed forces are sized primarily based on war-fighting considerations and, as has been explained, a large platform possesses far more potential to manage joint interdiction than a small platform.

When it is on a large platform, the same system can support operations across the spectrum and make a smooth transition from one type of task to another (indications and warning [I&W], crisis management, war fighting, and peacekeeping). A large platform also possesses the flexibility to quickly respond to out-of-area situations where surface forces either have not yet arrived or for a variety of reasons (political or threat) may not have been considered. Additionally, a large, manned platform can more easily incorporate and exploit new technologies than a platform with little or no extra internal volume or power. And if there is one system where the mission growth possibilities from advances in technology are barely understood, it is in AGS.

Conclusion: Back to the Past or Forward into the Future?

One of the most difficult challenges armed forces face is change.[22] When faced with new developments, armed forces have often exhibited the tendency to look to the past and not to the future as they made crucial force structure decisions. This tendency was particularly apparent in navies during and after World War II when plans were proposed within the US Navy and British Royal Navy to continue building battleships. As one naval aviator, Adm Arthur W. Radford (later chairman of the Joint Chiefs of Staff), asked in frustration, "Are we to have an air-sea Navy in the future, or is it to be in the immediate future the sea-air Navy of pre-Pearl Harbor days and ultimately no Navy at all?"[23]

Today many recognize the increasing parallels between warfare on land and warfare at sea.[24] For example, during World War II the Battle of the Coral Sea saw the first combat between fleets without the exchange of gunfire between surface ships. Aircraft had transitioned from merely finding the enemy and supporting surface ship gunfire to becoming the primary instrument for defeating an enemy fleet. The Battle of Al Khafji in the Gulf War approaches the Coral Sea as a key transition point in warfare on land. During this battle, Iraqi ground forces were attacked from the air, and a powerful offensive threat was defeated with almost no contact between opposing surface forces. And this occurred with two prototype JSTARS, little doctrine, and next to no training.[25]

Today the challenge facing the US military is determining whether they want to make the changes needed to fully exploit the immense potential of JSTARS. If they do, it is likely they will have to change how they fight (joint and service doctrine) and the role of the forces they use to fight, and these changes could also lead to significant changes in types of forces the United States fields.[26] The choice is brutally stark because the failure to move forward will mean US forces must continue to fight enemy armies the old way, putting large numbers of US personnel at risk in close operations.

Notes

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2. Joint Publication 1-02, *DOD Dictionary of Military and Associated Terms*, 12 January 1998.

3. Le Comte de Dervieu, quoted in J. F. C. Fuller, *The Conduct of War, 1789–1961: A Study of the Impact of the French, Industrial, and Russian Revolutions on War and Its Conduct* (New York: Minerva Press, 1968), 50.

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5. George S. Patton, quoted in Robert Debs Heinl Jr., *Dictionary of Military and Naval Quotations* (Annapolis, Md.: United States Naval Institute, 1966), 306.

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9. Richard E. Simpkin, *Race to the Swift: Thoughts on Twenty-First Century Warfare* (London: Brassey's Defence Publishers, 1985), 182–83.

10. Richard E. Simpkin, *Red Armour: An Examination of the Soviet Mobile Force Concept* (London: Brassey's Defence Publishers, 1984), 89.

11. James J. Grazioplene, ATXY, memorandum for leaders, subject: Army Warfighter Experiment, 25 May 1997.

12. Capt B. H. Liddell Hart, "The 'Man-in-the-Dark' Theory of Infantry Tactics and the 'Expanding Torrent' System of Attack," *Journal of the United Service Institution*, February 1921; and Lt Col Robert R. Leonhard, USA, "Shedding Light on the 'Man in the Dark,'" *Army* 47, no. 2 (February 1997): 40–48.

13. The ability to precisely track a moving vehicle depends on the moving target indicator (MTI) performance in *all* of the following areas:

- Minimum Detectable Velocity (MDV). MDV determines whether the majority of military traffic, which often moves very slowly, will be visible. To capture the majority of this traffic, a radar must have the ability to detect the lowest possible radial velocity. As a target's radial velocity approaches zero, the target will fall into the clutter or "blind zone." The clutter spread is a function of a radar's antenna real bandwidth. When a target is in clutter, traditional MTI radars can either detect the target or locate it, but not both. JSTARS uses a patented technique that allows slow-moving targets to be both located and detected, even at maximum ranges in this clutter region. In contrast, short antennas tend to have a high MDV and/or a large number of false alarms.
- Probability of Detection (PD). PD is the probability of detecting a given target at a given range any time the radar beam scans across it. PD is determined by factors that include range to the target, target radar cross section, system false-alarm rate, and characteristics of background noise in the returned radar signal (signal/noise ratio).
- Target Location Accuracy. Location accuracy is a function of platform self-location performance, radar-pointing accuracy, azimuth resolution, and range resolution. A long antenna or very short-wavelength can provide fine azimuth resolution. Range resolution is a function of radar pulse width, with shorter pulse widths providing higher resolution. Short antennas tend to have a large azimuth error, increasing with range to the target.
- Surveillance Time. This time equates to the frequency with which the radar beam revisits the target. Frequent revisits are vital for track continuity. When revisit intervals become too lengthy, tracking performance is greatly diminished because of the need to increase the "window" size to compensate for increased uncertainty regarding target location. Increasing the window size increases the probability that more than one radar return (from other targets within the window) or a return from a different target will be processed into the track file, corrupting the track's accuracy. Still other critical areas of performance are standoff and coverage area, which determine how many radars are needed to cover a given area and their exposure to defenses located in the target area.

14. Although the doctrine publication notes that "JSTARS not only enhances situational awareness, but C^4 capabilities as well," it provides little guidance on *how* JSTARS can dramatically change the conduct of joint interdiction. To provide this guidance, the doctrine should provide a discussion of functional or effects-based warfare, explaining that ultimately warfare is about changing human behavior. Too often joint and service doctrine ignore the role and use of fear, which is why so many military officers measure war-fighting effectiveness almost exclusively in terms of physical destruction. Yet fear of destruction is often an excellent way of influencing behavior, as in the case of mine warfare. Besides explaining effects-based warfare, the doctrine should explain the vital role that vehicular movement plays in army operations. After doing this, the doctrine would be ready to explain how the ability of JSTARS to detect, locate, track, and target vehicular movement allows the system to have an impact on interdiction that is very similar to the role Wild Weasels played in suppressing Iraqi radar-guided surface-to-air missiles (SAM) during the Gulf War. Joint Publication 3-03, *Doctrine for Joint Interdiction Operations*, 10 April 1997, III-4.

15. The coalition's suppression of enemy air defenses (SEAD) operation during the Gulf War provides an excellent example of the functional effect. The operation used a combination of surprise and intensity to quickly demonstrate to Iraqi SAM operators the dangers of allowing their radars to emit long enough to conduct an effective engagement. By successfully intimidating most Iraqi SAM operators, the coalition quickly achieved its objective of flying at medium altitudes without a high risk of being engaged by radar-guided SAMs. Thomas A. Keaney and Eliot A. Cohen, *Revolution in Warfare?: Air Power in the Persian Gulf* (Annapolis, Md.: Naval Institute Press, 1995), 202–4.

16. *The Rommel Papers*, 477, 491; and Ian Gooderson, "Allied Fighter-Bombers versus German Armour in North-West Europe 1944–1945: Myths and Realities," *Journal of Strategic Studies*, June 1991, 210–31.

17. "A German Evaluation of Air Interdiction in World War II: Saber Measures (Echo)," US Air Force Assistant Chief of Staff, Studies and Analysis, Washington, D.C., November 1970, 26.

18. Ibid., 28–29.

19. Ibid., 40.

20. Gen Omar N. Bradley and Air Effects Committee, Twelfth Army Group, *Effect of Air Power on Military Operations, Western Europe* (Wiesbaden, Germany: US Strategic Bombing Survey and Air Effects Committee, Twelfth Army Group, 15 July 1945), 181.

21. Fridolin von Senger und Etterlin, *Neither Fear Nor Hope: The Wartime Career of General Frido von Senger und Etterlin, Defender of Cassino* (New York: E. P. Dutton, 1964), 224.

22. See Barry R. Posen, *The Sources of Military Doctrine: France, Britain, and Germany between the World Wars* (Ithaca, N.Y.: Cornell University Press, 1984), 54–56, 277–78. Given the magnitude of the obstacles to change, Posen states that civilian "intervention is often responsible for the level of innovation and integration achieved in a given military doctrine."

23. Stephen Jurika Jr., ed., *From Pearl Harbor to Vietnam: The Memoirs of Admiral Arthur W. Radford* (Stanford, Calif.: Hoover Institution Press, 1980), 77.

24. The US Army's Field Artillery Center has published a concept called "Ascendency of Fires" that describes a potential trend in which "land warfare is becoming more like sea and air warfare . . . forces will fight at increasingly greater ranges in 'demassed formation.' In this setting, combat elements conducting superior information operations and employing state-of-the-art smart/brilliant munitions, robotic vehicles, and swarms of unmanned aerial vehicles can conceivably shape the battlefield and conduct decisive operations, possibly without coming in visual contact with each other." "New Field Artillery 'Roadmap' Espouses 'Ascendency of Fires' Concept," *Inside the Army* 9, no. 1 (6 January 1997): 6.

25. Lt Col John W. Holmes, *Operational Evaluation Command (OEC) Joint Surveillance Target Attack Radar System (Joint STARS), Operation Desert Storm (ODS) Summary Report* (Alexandria, Va.: US Army Operational Test and Evaluation Command, 10 October 1991), 4–7.

26. The National Defense Panel's review of the Quadrennial Defense Review (QDR) notes that "as new technologies mature, very different operational concepts will be feasible and that will lead to demands for quite different forces and equipment. As a result, the fairly conventional approaches used in the QDR's MTW [Major Theater War] assessments may not provide an optimal force structure." "National Defense Panel Sees No Link between QDR Reductions, Strategy," *Inside the Army* 9, no. 20 (19 May 1997): 25.