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"CONCEPTS AND TECHNOLOGIES FOR THE ARMY BEYOND 2010"

March 1999

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A study assessing the 2010-2025 timeframe and seeking technologies and enablers for Joint, Army and other Service operations with emphasis on Joint missions involving land combat. Specific areas of analysis include Mobility and Sustainment, Information Dominance, Platforms and Weapons and Investment Strategies. Study analyses suggest tapping commercial successes as private sector investment is strongly supporting improvements in many areas. However, to fully tap these developments the Army must begin participating in the design of future commercial systems. This study provides 9 major recommendations including: establishing an Investment Council, exploiting non-Army commercial capabilities, establishing a C4ISR testbed , and using FSCS vehicles as precursors for AA2010 platforms.

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Introduction

During November 1997, the Army Science Board (ASB) initiated a study dealing with Concepts and Technologies for the Future Army (Circa 2010) referred to as the Army After 2010 (AA2010), interchangeably called the Army After Next (AAN). Substantial effort was already underway to modernize the near term Army (Army XXI) by leveraging information technology.

The activities of the Study consisted of monthly two-day plenary meetings starting in November 1997 and ending in July 1998, along with one or two-day meetings each month by various Panels. The Panels addressed a variety of topics – air lift, sea lift, containerization and modularity, weapon platforms and systems, lethality, C^4ISR and situation awareness systems (SAS) capabilities, joint force support, training and education, dismounted combat and modernization strategy. Experts drawn from Government, academe and industry assisted the Panels.

The study was completed with an Executive Briefing and Report Writing Session at the Beckman Center on the campus of the University of California in Irvine. This effort produced this Executive Summary and an Executive Summary Briefing consisting of 51 viewgraphs. Its Background and Context are treated in a short six chart section. The majority of the assessment is contained in the sections labeled a) Mobility and Sustainment, b) Information Dominance, c) Platforms and Weapons and d) Investment Strategy and Recommendations.

Terms of Reference

A Terms of Reference (TOR) for this ASB study was prepared and the study staffed in the early fall of 1997. The TOR was finalized at the November meeting of the ASB Study Group. During the first Plenary Meeting a video teleconference was employed to bring the Study Group and its Sponsors together. The TOR directs the Study Group to review Joint, Army and other Service Concepts and give emphasis to Joint missions involving land combat. It is for these that technologies and enablers were sought. In the same context, we assessed the Army's modernization and technology planning.

Background and Context

With regard to concepts and missions for the future, the largest Joint missions involve generating, projecting, protecting and sustaining the Joint forces. Unlike combat operations where there are clearly defined responsibilities and unity of command, these larger Joint activities are spatially, command and means segmented. They are multi-Service, employ commercial capabilities and are supported by host nation means in-theater.

Threats and Concepts

Substantial effort has been made to estimate circumstances that would represent future challenges to US national security. Such effort provides a consensus that future threats will be different from those of the past. They will also encompass a greater spectrum of threats and will require a broader range of U.S. capabilities.

In the past, preparations were made to produce threat offsets in the competition with the Soviet Union. Marginal superiority was sought in areas understood to be critical. Forward basing, theater prepositioning and reinforcement provided hedges. All other threat circumstances were judged to be lesser included cases and required little or no special treatment.

Possibly the most insightful characterization of the future threats has been to establish the idea that there is no single overriding and central threat. Preparing for one, assuming all others to be included cases, is a poor starting point. In addition, attention has been justifiably given to asymmetric threats.

In this period of both uncertainty and preparedness, the JCS and Services have embarked on future force planning. Joint Vision 2010 (JV2010) is the overlying vision for the future. It posits dominance in all phases of future operations, particularly in the critical domains of power projection, sustainment, force protection, engagement and maneuver. These built on a base of high quality leaders and soldiers and superb training, should both enhance deterrence and produce much more continuingly favorable engagement and ultimately campaign circumstances than in the past.

The Services have embraced this vision in their "flagship" efforts such as AA2010 (AAN). Shaping subordinate processes and programs is now underway. Thus, the Army's (and other Services) research, development and acquisition leaders as well as those which support joint activities (such as TRANSCOM) have engaged in the search for means and technologies to underwrite the six central capabilities which comprise JV2010.

The Army is now, as it has always been, an Army in transition. The current Army of Excellence (AOE) is being modernized by exploiting information technology. An example of this is the "Applique Internet" and its follow-on "Tactical Internet." Over the next ten years, the Army will modernize its units with information systems that will reduce, but not totally eliminate, today's stovepipe systems. It will also provide battlefield information to platforms and dismounted soldier teams which should enable unprecedented situation awareness. Exploiting these circumstances will require substantial advances in training, in various simulation domains and education, particularly distance learning in units.

AOE transitions to Army XXI through information exploitation, the addition of new platforms and systems, and improvements to existing – sometimes called legacy – platforms, weapons and systems. In a parallel effort described correctly as a campaign, AA2010 comes into being with successive generations of "Battle Forces" – experimental, developmental and fielded. Battle Forces are mechanized/motorized units which are rapidly strategically deployed by air. Their platforms – primary and supporting – are also moved operationally and tactically by air when desired or feasible. Ground mobility will be improved with respect to current platforms and forces. Sustainment and endurance improvements sought are an order of magnitude greater than achievable today. The traditional terms – light, heavy – are blurred and probably not relevant to the Battle Forces. Improvements which are needed to realize desired Battle Force performance levels will in many cases provide great benefits to Army XXI.

It is not possible to precisely quantify performance improvements at this time. However, it is possible to estimate what makes a difference. Today, a well prepositioned Brigade can be manned, generated and in position in five days. A Battle Force unit projected from the CONUS might accomplish the same in two days or possibly less. Thus, the Battle Force design goals are best described as improvements of factors of 2 to 3 or more over current forces in each of the domains of deployability, survivability, lethality, sustainability and operational-tactical mobility. Taken in combination, along with drastically reduced manpower and equipment in-theater footprints, appropriate combinations of AA2010 Battle Forces and Army XXI elements could provide the equivalent of an AOE Corps combat capability – air deployable worldwide – sustained by air until the arrival of prepositioned and sealift-deployed follow-on forces within two weeks or less.

Mobility and Sustainment

Unit lift requirements are described for two purposes (chart 10 from the Executive Summary Briefing). The first is comparative relative to available military air lift fleet capabilities. The second has to do with continuing sustainment. A regional CINC has very difficult choices to make in setting priorities for rapid air lift DoD assets. Deploying an F-16 air wing and a protecting Patriot battalion exceeds today's one-time air lift capabilities. Future weight reductions will improve these specific circumstances but will not change the fundamentals.

Battle Force elements and units must be made as robust and as light as possible for similar reasons. Sustainment by air runs afoul of the same limitations. Volume considerations are equally important. These limitations could reduce deployable combat power before weight limits are reached.

All the Services – Army, Marines and Air Force – which require airlift for rapid power projection have heavy and bulky equipment and have substantial resupply requirements. The Army's 70 ton tanks (also used by the Marines) are the "bumper sticker" perception example of the heavy force but the facts are otherwise.

TRANSCOM's future strategic fleet structure will be 246 aircraft including 120 C-17s (which are really optimized for intra-theater purpose with much shorter takeoff and landing circumstances). Cargo throughput capability is approximately 50 million ton miles per day, including the Civil Reserve Air Fleet (CRAF). It is important to note today that CRAF represents a substantial portion of the required strategic airlift capability.

In the future, CRAF could be the dominant lift component, providing the Army with a non-organic air lift fleet of traditional and non-traditional CRAF platforms. This will save the DoD the expense of expanding its strategic lift fleet and allows the C-17 to be freed for intra-theater lift to augment the C-130 fleet. This dramatically expands theater capabilities because of the 80 ton C-17 payload and its shorter landing and takeoff requirements. Chart 12 addresses this possibility and addresses sea lift as well.

Mobility and Sustainment

UNIT LIFT REQUIREMENTS

UNIT	MANNING	PRIMARY PLATFORMS	TONNAGE OF OVERALL UNIT	DAILY FUEL & AMMO TONNAGE
Air Wing	5000	72	7000	1300
AEF Air Wing (estimate)	2500	72	4000	1300
Patriot BN	651	81	15000	100
AOE MLRS BN	132	27	2400	260
AOE ARTY BN	663	24	3300	220
MAGTF (estimate)	2711	150	15000	600
AOE BDE	5000	400	25000	800
AAN Battle Force (estimate)	6000	1400	13000	300

DoD C-5 and C-17 fleet have

- ***4,000 NM unrefueled lift capacity***
- ***17,000 ton one-time lift***

INSUFFICIENT FOR ANY POSTULATED JOINT EARLY ENTRY FORCE DEPLOYMENT

Concepts and Technologies for the Army Beyond 2010

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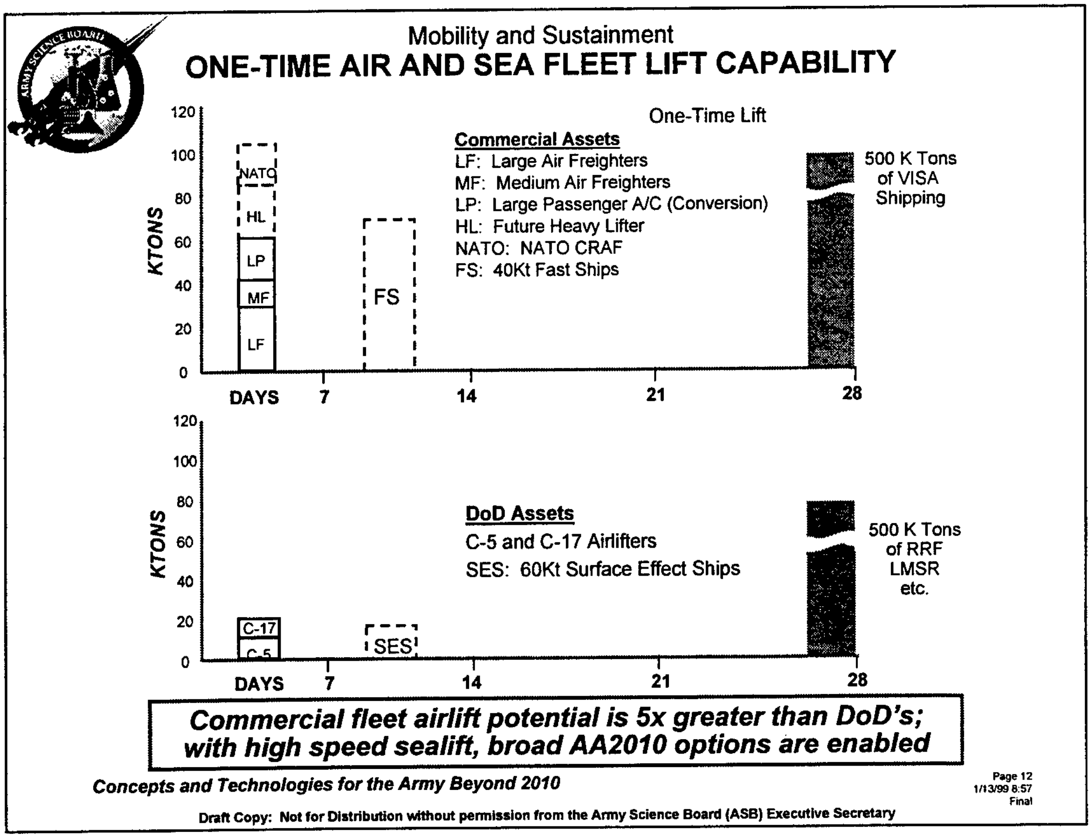
It is worth noting that TRANSCOM's future planning shows no growth in CRAF capabilities. This is indeed strange because projections by several sources show commercial fleet growth rates of 7% per year. Explorations of this disconnect suggest that TRANSCOM has received no requirement for additional CRAF support.

An analytic construct of one-time fleet lift potential (in kilotons) is used to portray the relative contributions of various elements of a future mix of strategic lift means. For illustrative purposes, a deployable range of 8000 nautical miles is assumed. It shows that commercial assets, conservatively estimated, dominate DoD assets (chart 12).

TRANSCOM air deployment potential using C-5 and C-17 aircraft is slightly less than 20,000 tons delivered in 2-3 days at 8000 nautical miles. A small DoD fleet of 60 knot, 2000 tons payload surface effect ships could deliver the same tonnage in 8-12 days (cost = $4-5B). Commercial airlift is projected to this time frame at growth rates of 7%. Assuming CRAF III and 50% U.S. ownership of the worldwide fleet, it is seen that an assumed commercial capability substantially exceeds that of DoD. In addition to U.S. traditional commercial CRAF assets, there are additive possibilities with a NATO CRAF initiative and the stimulation and adaptation of commercial heavy airlifters such as a proposed commercial aerolifter and a future blended wing body. Rapid sea lift provided by 40 knot commercial ships and 60-knot surface effect ships will provide quick follow-up to forces initially deployed by air.



The Army should modify its Army XXI equipment where feasible and affordable, and design its improvements and the Battle Forces to meet the door and floor loading constraints of traditional CRAF. These are now becoming known in the Army requirements and development community. The Army should also be a pro-active CRAF supporter and expand these fleets by changing policies, practices and marketing approaches.

Proper exploitation and stimulation could provide circumstances for air insertion of Battle Forces in one to two days and Army XXI brigades in ten to twelve days by seas. Stimulation and adaptation of a commercial aerolifter class platform could provide airfield and port free operations with the incorporation of defense features such as VTOL or a hover-winching capability.

Battle Forces are currently envisioned as having 3-D mobility (near vertical air insertion and extraction of the Battle Force from unprepared sites). The largest load could be a 15-ton combat vehicle. Airlift missions might be flown to operationally significant distances (up to 1,000 km radius) by rotorcraft or more traditional aircraft.

A RAND study to evaluate the dual use potential of a National Transport Rotorcraft concluded that there was only a niche market for large (8 ton payload) rotorcraft. The result is that DoD investment will be required to create a large (15 ton payload) V/STOL transport.

2-D and 2-1/2-D mobility implies drive-in/drive-out and fly-in/drive-out respectively. Various forms of airdrop, including low-altitude parachute extraction, could be used for 2-1/2-D insertion. This would allow the use of conventional military airlift assets such as the C-17 instead of development of a new military V/STOL transport.

There are three general cases which must be considered in assessing needs for operational-tactical lift which would underwrite full 3-D, 2-1/2-D and 2-D mobility. These are: a) administrative entry, b) disrupted entry and c) opposed entry. Strategic lift by military or CRAF means apply to all cases. The circumstances for operational-tactical lift and AA2010 vary substantially. Understanding the tradeoffs and the most robust solutions deserve a substantial inquiry well beyond ASB resources. The AA2010 analysis to date falls short of a development and acquisition case.

Lift alone does not assure rapid deployment. The entire non-unified DoD process must be optimized. The commercial world has moved beyond DoD in total transportation systems and processes. The FedEx X-Box air/land container system is an excellent example. It fits into the current air/land transportation system; it is light enough for efficient air transport; and it includes a modular X-Pad that can be moved by forklift. This is just part of the total system including asset tracking, automated cargo handling and ground crew training.

DoD should consider taking advantage of the entire system. This means requiring that new military equipment be designed to take advantage of the commercial transportation system. It should be containerized and modular, as appropriate. It must fit into commercial airfreight aircraft. And, it must be compatible with commercial asset tracking and automated handling systems.

The commercial transportation system integrates processes, facilities, equipment and trained people. DoD should consider encouraging CRAF operators to employ members of the Reserves, who could be called up as a unit, together with their air and ground equipment.

In the design of the Battle Forces, the Army should plan to employ both DoD and commercial lift means as well as commercial processes to include modularization and containerization. Experts and expertise from the commercial sectors should be part of the AA2010 design effort.

Information Dominance

Information dominance has been identified as a crucial integrating and enabling capability for the Battle Force. Many technologies that can contribute to gaining information dominance have been identified by the study panel and those deemed most critical are enumerated in the following paragraphs.

Battlefield visualization provides operational context for evaluation, interpretation and swift decision making. The lack of archived terrain data and the inability to rapidly collect terrain data has inhibited current situational awareness systems and developing battlefield visualization capabilities. The Battle Force must have ready access to a rich terrain data set that is updated to meeting changing mission needs.

Battle Forces will be able to utilize the synthetic environments with terrain data in support monitoring of battle, course of action (COA) development and analysis, and mission rehearsal. DARPA's Discover II program offers major contributions with its MTI and SAR capabilities. Tasking and reporting in real and near real time at the battalion level must be maintained as features. Its DTED 5 performance is critical for mapping.

Hyperspectral imagery will be very important to provide fine ground terrain and featured interpretation. These inputs will be further exploited in operational assessment (e.g., mobility, Course of Action, etc.)

To accommodate faster OPTEMPO by the Battle Force, the timelines for the military decision making process and for engagements will be compressed. C^4ISR systems for situational awareness and sensor-to-shooter links must likewise accommodate these compressed timelines. Although embedded C^4ISR systems will have the primary purpose of supporting warfighting, soldiers of the Battle Force must also be able to use them to support learning, experimentation, planning and training. This will require new functionality to be added to the C^4ISR systems.

The OPTEMPO of the Battle Force will demand that command and control (C^2) activities are done while traveling in ground vehicles or aircraft. As contrasted with the past, the Army must focus advances and modernization at the battalion level. This constitutes a true challenge for C^4ISR systems that must be enhanced to support C^2 on-the-move. The Battle Force will fight along side Army units using legacy C^4ISR systems and Joint and combined forces. The C^4ISR systems used by the Battle Force must be interoperable with those systems used by others. Communications for the Battle Force must be assured. Leveraging satellite and fiber optic services and technologies must be part of the solution because this sector outspends the DoD by a factor of 30 or more and modernizes three to four times faster.

The ASB conducted a 1997 summer study on "Battlefield Visualization." That study concluded that warfighter understanding of a battle's progress and alternative courses of action are enhanced by using computer graphic renderings of battle activities. Recommendations from that study are re-emphasized here, as they are important for Battle Force situational awareness. Terrain data at DTED level 5 is crucial for computer graphic renderings of the battle but the Army does not now have adequate archives nor the ability to rapidly obtain the necessary data.

Commercial communications could and should play an important role. In the area of terrestrial fiber, there are several companies (such as Qwest, AT&T, Sprint, MCI Worldcom, etc.) that are laying large capacity fiber backbones in CONUS. The GTE Qwest backbone, for example, spans 92 metropolitan areas and has a capacity of almost 5 terabits/sec. (Assuming the size of this briefing is 2MB, this is enough capacity to send almost 2.5M copies across the CONUS in one second).

In global fiber telecommunications, the situation is similar. Many companies (such as AT&T, Global Crossing, Ltd., etc.) are laying transoceanic fiber. Transatlantic traffic is growing at a rate of 80% per year, and all bulk capacity is sold out for the foreseeable future. Fiber technology is robust in growth potential, as the theoretical bandwidth limits are extremely high (on the order of 100 terabits/sec per dark fiber strand); with the current limitations being the switching speeds. Continents such as Africa and South America are being ringed with fiber.

The global telecommunications market also includes satellite telecommunications. Most market projections predict that global satellite telecommunications will grow extremely rapidly, enough to capture at least 10% of the total global telecommunications market. Although satellites have some disadvantages they are extremely attractive in the "last mile" applications, which are likely to be of high importance to AA2010 operations. Despite being limited in overall capacity (in the 10s of gigabits/second in aggregate bandwidth) and older technology (due to the 5-10 year lag in launch times), they allow point-to-point communications without the need to lay fiber or "dig ditches." Hence, the projected growth.

Market forecasts in these business areas show no sign of slowing investment in the foreseeable future. It is the ASB's judgement that commercial communications should be the preferred means between higher (Brigade and above) echelons and should be a redundant capability for Battalion operations.

Current and possibly future links (terrestrial and space-based) are individually vulnerable to a modest variety of weaknesses and exploitation modes. The Army working with DoD should provide partnering which eliminates these and results in a robust network of networks.

DARPA has several ongoing command and control programs – Command Post of the Future for higher command echelons and Small Unit Operations (SUO) Situation Awareness System (SUO-SAS) for battalion through team operations. It is contemplating a mobile tactical operations center (TOC) for high OPTEMPO continuous battalion and brigade operations. This development would pursue the capabilities needed for Command and Control on the Move (C2OTM) with innovations such as stabilized displays.

All three developments are important to the Army and should be fully exploited by the Army with senior attention to program management and future funding.

The Battle Force design architecture is one that is intended to produce highly integrated overall force and platform capabilities, which have strong interdependencies. Capabilities for engagement and protection are dependent upon information dominance and the ability to reach out and lethally engage before being engaged.

There is good news relative to CTC-like training, distance learning (DL), mission rehearsal and After Action Reviews (AARs). This set of methodologies, processes and capabilities set the Army apart from all other armies in the world. The current digitization program with a mode expansion provides all of these for circumstances as different as asynchronous Distance Learning to instrumented force training at home stations.

Bringing together concepts, organization and technologies for robust C^4ISR in the battalion environment is a formidable challenge. However the Army has had a similar but smaller challenge with digitization.

The Army should expand the multimode man- and hardware-in-the-loop CECOM simulation and evaluation used so successfully for both definition and design of digitization's hardware and software. This should then be ported into SIMNET to provide a learning, training and experimentation basis for the troops. Expansion of this "test bed" and adoption of DDRE's Sensor Web concepts (for sensor systems and networks) will provide the Army the means to achieve C^4ISR and SAS performance needed for Battle Force operations.

Platforms and Weapons

The effectiveness of the contemplated AA2010 Battle Force will be strongly dependent on a number of interlinking factors. Some of these considerations include overall force composition (platforms, weapons, personnel); the availability of current situation awareness information; the capabilities and reliability of local and wide area communications networks; the ability to generate timely, accurate, extended range and highly lethal firepower. Additional factors include linkages to supporting Joint fires; individual platform and overall force survivability; and the ability to execute sustained operations for several days without external ammunition resupply or vehicle refueling. The force concept is based on the ability to execute fast-paced, sustained operations using a fleet of lightweight, highly mobile and agile ground vehicles, supported by VTOL attack and transport aircraft and robotic ground and air platforms.

The survivability of these platforms, particularly ground systems, poses a significant challenge, especially in urban environments. Achieving individual platform survivability will require the effective integration of a number of vehicle design features and critical subsystems, including active protection system (APS), capabilities against highly lethal KE and CE threats, signature management (RF and IR), and advanced EW and other defensive countermeasure systems.

Overall force survivability will be enhanced through the combined synergistic benefits of cooperative engagement and long-range fires, including the timely delivery of munitions from loitering platforms. Dominant force lethality will be realized via a weapons mix that includes high-performance KE and CE munitions, in conjunction with new directed energy systems (HPM and lasers).

Missiles and precision guided mortar/smart munitions (PGMs) technologies will continue to advance in every area, particularly in the seeker and propulsion areas. PGMs with lock-on-after-launch (LOAL) capability should be available for imaging infrared, ladar and dual mode/multi-sensor type seekers – essentially automatic target recognition (ATR) capability for narrow field of view PGMs.

The exploitation of controllable thrust propulsion technology provides an opportunity for mission tailoring the thrust profile for a wide variety of target situations with a potentially large increase in effective range. For example, missiles in the 100 pound range may have effective ranges from 1-200 km against a wide variety of targets and with the option for loitering and cooperative engagements.

Similar improvements in warheads and guidance and control (G&C) are expected. G&C options should include "aim-point-selection" (for maximum lethality), mission tailorable trajectories and data links for man-in-the-loop (MITL) and "sensor to munitions" updates to target intercept while the munitions are in flight.

There are two potential breakthrough areas. I^2R Focal Plane Arrays have become significantly more capable over the last two decades. The number of individual pixels in modern missile/munitions seekers are at least 64 times larger than seekers in development in the early 1980s. Comparable improvements in ladar and millimeter wave seekers can be expected. Integrated multi-spectral sensors/processing technologies like acoustics or special signal processing should be an option for this time frame. The need for increased range and precision "beyond-line-of-sight" engagement will demand many of these advanced technologies and capabilities.

The AA2010 force will have a robust array of offensive and defensive options, each contributing to overall force lethality and survivability. The insertion of robotic vehicles, both ground and air versions, will provide an unprecedented ability to see, track and attack the enemy with high precision and at significant stand-off ranges. Unmanned ground vehicles and unattended sensors will provide an ability to exploit advanced, long range precision guided munitions throughout the battlespace. Robotics will also benefit Army XXI to the same degree.

Unmanned air vehicles will complement these reconnaissance, surveillance and target acquisition (RSTA) capabilities to include rapid, dynamic battle damage assessment (BDA). In the 2015-2020 time frame, cooperative engagement capabilities should be available to allow near real-time sensor-to-munitions links with in-flight updates to target intercept until the seeker/sensor can achieve lock-on or impact occurs. Long range weapons (~200 km) in the 100 pounds weight class should be available to include loitering capability for 5 to 20 minutes. This new class of munitions should be able to provide rapid engagements time lines (seconds versus minutes of latency). The combination of these unmanned systems and smart/brilliant munitions should provide the overall force major advantages in survivability including dramatically reduced manned system losses.

Future active protection systems (APS) can provide a very robust capability to defeat most precision or ballistic threats to smaller and less detectable vehicles. Active countermeasures suites will provide broad spectrum protection. However, other force level technologies/capabilities (such as situation awareness and information operations) will significantly enhance unit/force survivability.

The Army is investigating a comprehensive array of very capable PGM technologies. These PGM capabilities will be an important factor in designing future forces that are easier to deploy and sustain, have overmatching lethality and engagement ranges to provide flexibility in both OPTEMPO and agility. The challenge is to determine the best balance or blend of technologies given substantially reduced resources and the high R&D cost of getting PGM programs into production. The DARPA Advanced Fire Support System (AFSS), commonly referred to as "munitions-in-a-box," may provide exciting new opportunities for PGMs for many different types of missions. The concept may provide a valuable opportunity for developing a consolidation or neck-down strategy for AA2010 PGMs. Given expected resource constraints, only a few different PGMs types would seem to be reasonable. The process to determine (through analysis and experimentation) which types are best for this application may be helpful in defining the consolidation process.

The DARPA AFSS program includes consideration of a new missile, one that could have both multi-role capabilities and be designed for conventional platforms. If the missile exploits variable thrust propulsion and optional wing-type lift technology, engagement capabilities beyond 200 km could be realized. An overall consolidation strategy should also consider selected upgrade of other high value PGMs to provide the AA2010 force a wide range of lethality options. A holistic approach to force lethality is needed to promote overall efficiency and warfighting capability.

The Army has launched a Future Scout and Cavalry system program. This will be closely followed by a Strike Force vehicle family initiative which is a precursor for Battle Force platform developments. It is recommended that SARDA employ these programs as "testbeds" in the broad sense for components and sub-systems that are critical for the future. Some may require emulation. Others may have live but not fully mature representations.

Candidates include hybrid electric drive (which might also be a precursor for fuel cell employment) applied to manned and unmanned platforms as well as for signature management. The Army must make some major innovations in platform crew size, tasking and the use of robotics to achieve the air-mech capabilities desired. Commercial industry could and should supply the hybrid electric capability and technology and save substantial time and money for the Army.

Similarly, currently planned improvement programs (Crusader, MLRS, etc.) should be considered as vehicles to examine improvements that could provide major advantages to Army XXI and Critical Technologies for conceptual Battle Forces. These initiatives would include redirecting EM launcher work to providing medium caliber and artillery capabilities, extended range and loitering rounds as well as technical needs to support cooperative engagement to reduce or eliminate latency. In the course of exploiting electric launchers, the Army should consider initiatives that could enhance the realization of non-traditional laser and high powered microwave devices.

Dramatic improvements and unparalleled flexibility would attend the successful upgrading of both Crusader and its rounds. Crusader has the power and volume to employ near-term electromagnetic launch components that are volume and energy/power diversity limited (the reason for the concerns about EM possibilities are main tank armament). With these and a flexible sabot-rail combination, it could launch payloads ranging from 50 kg (approximately the weight of the current 155 mm round) to 500 kg at the same muzzle energy of 10 MJ. The rounds heavier than 50 kg would be non-ballistic and fly to and loiter at their targets.

Such improvements would provide major enhancements (3x to 5x) for the overall Joint force in terms of combat effectiveness (measured in tons of lethality delivered to the enemy) per ton of sustainment relative to today's means.

The Army's program to enhance the capability for dismounted combat operations are also critical for the current and future force. The major technical challenge has been, is and will always be the weight carried by the infantrymen. Today, the technology-dominated approach has not met this challenge.

The ASB suggests two possible directions for a broader solution to this problem. The first is in the organizational and operational (O&O) concept. It should be broadened from "soldier as a system" to "soldier team as a system" because soldiers train and operate in teams not as individuals. This is not just an editorial nuance and it goes to the heart of solving the weight problem. As an example, the team members could each carry an element of a team corporate radio which as a corporate radio has the required maximum performance. Each soldier would carry his smaller, lighter part of the corporate radio which would have adequate but limited performance characteristics.

Similarly, the teams should have a vehicle to carry the major (and heavy) elements of the team's kit. The vehicle could also provide the recharging capability for the many batteries needed. The team vehicle will probably be paid for many times over just in the savings from batteries.

Investment Strategy

The current (FY 98) Army Modernization Plan addresses improvements in terms of the Investment Categories and Patterns of Operation for the near, mid and far term. At best, such a methodology would account for contributions of an initiative (e.g. M1A2 upgrades, Crusader development, Land Warrior, etc.) to Patterns of Operation or to tradeoffs among them. The surface interpretation (which the documentation creates) suggests it is a sorting with loose holistic ties to Patterns of Operations or implied force capabilities. The Plan, while very informative, does not provide a sense of absolute or relative priorities or the sense of overall integration so critical to Army operations. It is similar to such plans for air and naval forces which are platform based and whose numerical entity scale is hundreds to thousands smaller than those of the Army.

The Investment Strategy does not reflect possible contributions from commercial and non-Army government programs, means, processes and technologies. It does not reflect the significance of projecting the force, as an example, and tradeoffs that relate to this crucial force capability. It does not reflect the inherent tradeoffs between information dominance and protecting the force which is important to Army XXI but is at the core of the design of AA2010.

The Science and Technology priorities for AA2010 show these same fundamental shortfalls. In the case of AA2010, positive interdependencies are at the heart of achieving the desired force capabilities. In the case of both the investment and S&T strategies, the Army is being limited by its bottom-up and stovepipe mechanisms. Integration is the key to the future. It must be part of the Strategy for Investment.

Central Recommendation

The first and central recommendation put forward in this report identifies a series of on-going commercial and non-Army DoD developments whose exploitation could materially benefit the Army. An Investment Council is recommended as a means to select and focus attention on all or a subset deemed to be most adaptable and affordable. An example of the issues that might be addressed are shown in chart 42. This approach would also provide a means to communicate to at least the Army, OSD and the Congress its priorities and its ability to leverage developments outside the Army. While it could be described as "OPM", using other people's money, it is substantially broader and more sophisticated than this simple description implies.

Recommendation

SCIENCE AND TECHNOLOGY INVESTMENT STRATEGY *EXAMPLES*

Gain early access to participate in and influence programs which could affordably underwrite substantial capability improvements in AOE, Army XXI and AA2010 through

- Major *COMMERCIAL* investments being made in
  - Expanding air transport (passenger and freight)
  - Providing innovative heavy and outsize cargo air lift
  - Providing innovative fast sea lift
  - Establishing seamless, synchronized, high throughput intermodal means and processes
  - Transitioning automotive propulsion to hybrid electric power
  - Providing a capability explosion in worldwide access and high bandwidth fiber and space-based communication networks
  - Providing expanded space surveillance and mapping
- Major *GOVERNMENT, NON-ARMY* investments to demonstrate
  - Near-staring space-based MTI - SAR Tactical RSTA (DARPA + NRO + AF)
  - Survivable C2 on-the-move (DARPA)
  - Organic, high resolution battalion SAS (DARPA + DDRE)
  - A near-revolutionary C-130 replacement (AF+ industry)
  - JSTARS

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As an example, the Army could employ both traditional and innovative forms of commercial air lift and sea lift. This strategy could be extended to include the employment of Reserve Component forces to generate, receive and sustain the forces and project power rapidly and affordably and in the most modern forms possible. In doing so, it is partnering with and leveraging the continuing strength and world class performance of the US economy. The benefits internal to the Army include building on commercial strengths while increasing the Army's currently strained investments and modernization rate. Similarly, the Army can derive economies of scale from non-Army DoD developments (e.g. DARPA).

Related Recommendations

High level interactions are needed between senior Army leaders and senior leaders from the industry. The purpose is threefold:

1. Understand where both traditional and innovative capability growth is going and gain a seat at the table in continuing discussions.
2. Formulate and execute programs within the Army to adopt, support and encourage favorable developments (not necessarily limited to technologies but including means, integrated capabilities and processes).
3. Understanding and acting on additional possibilities in these sectors particularly, on one hand, where Allies and friendly nations could be beneficially involved and, on the other, where US government action and influence can be brought to bear in addition to funding.

Derivative Recommendations

1. Within the Army, CG TRADOC and CG FORSCOM, assisted by CG AMC, should undertake a program to substantially improve modularity and containerization in all its forms and achieve higher throughput, confident logistic support and reduce choke points and concentrations which might attract enemy measures with unconventional and conventional weapons and weapons of mass destruction – nuclear, biological and chemical.
2. The Army should formulate its expanded CRAF, Visa and APOE/APOD needs to meet CINC requirements and JV2010 needs for the future. It should engage OSD, JCS, TRANSCOM and DLA in these developments.
3. The Army should employ the digitization capabilities to support CTC-like home station training, distance learning, mission planning and rehearsal and after action reviews.
4. The Army should, in conjunction with OSD, undertake a program to leverage commercial communications in survivable and enduring networks and at the same time exploit commercial and non-U.S. space surveillance capabilities.
5. The Army should employ the Future Scout and Cavalry System and the Strike Force initiative as test beds to bring along important technological innovations such as:
   - Hybrid electric drive
   - Directed energy and high power microwave weapons
   - Advanced active defenses
   - DARPA "rockets in a box" program

- Signature management
- Robotic vehicles
- Modularity and containerization for all phases of deployment and sustainment.

6. The Army should change the organizational and operational (O&O) concept for the soldier as a system (land warrior) to the soldier team as a system and alter priorities and RDA accordingly.
7. The Army should prototype and experiment with individually and in combination.
   - An EM version of Crusader (as a P^3I initiative) with a multicaliber launch capability
   - Loitering rounds for a variety of purposes
     - Close combat
     - "Rockets in a box"
     - Long range "artillery"
   - Cooperative engagement execution

Concepts and Technologies for the Army Beyond 2010

Army Science Board Summer Study Briefing

ASB 1998 SUMMER STUDY
CONCEPTS AND TECHNOLOGIES
FOR THE ARMY BEYOND 2010 (AA2010)

- ASB searched for and found significant means, processes and technologies in commercial non-Army Federal and Army sectors to underwrite both Army XXI and AA 2010 concepts and achieve their affordable realization

- Examples of Above are:
  - Mobility means: commercial airlift and sealift
  - Power Projection and Sustainment } { Commercial Modularity, Containerization Information Systems, use of Reserve Forces
  - Commercial Terrestrial and Space Information Networks
  - Commercial / Non-US Surveillance Capabilities
  - Alliance participation in the above
  - DARPA and Air Force Surveillance and C2 Systems

- Central Recommendation is for Army Leadership to add top-down direction to tap into commercial and Federal Non-Army potential. This will improve the Army development process which is both bottom-up and rarely able to foster such initiatives.

ASB 1998 SUMMER STUDY CONCEPTS AND TECHNOLOGIES FOR THE ARMY AFTER 2010 (AA2010)

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  - Mr. Robert Dodd, HQ TRADOC

AGENDA

- **Study Background and Context**
- **Mobility and Sustainment**
- **Information Dominance**
- **Platforms and Weapons**
- **Investment Strategy**
- **Recommendations**

Study and Study Panel

During November 1997, the Army Science Board (ASB) initiated a study dealing with Concepts and Technologies for the future Army, circa 2020, which is referred to as the Army After 2010 and is interchangably also called Army After Next. Substantial effort was already underway to modernize the near term Army, Army XXI, by leveraging information technology.

A large group of ASB members, Government Advisors and Staff Assistants undertook the effort. Study Panel activities consisted of monthly two-day plenary meetings starting in November 1997 and ending in July 1998 along with one or two day Panel meetings each month. The Panels addressed a variety of topics -- airlift, sealift, containerization and modularity, weapons platforms and systems, lethality, C4ISR and SAS capabilities, joint force support, training and education, dismounted combat and modernization strategy. Additional experts drawn from Government, academe and industry assisted the Panels on an ad hoc basis.

The study was completed with an Executive Briefing and Report Writing session at the Beckman Center on the campus of the University of California at Irvine. The major portions of the Executive Summary Briefing are listed on the Agenda chart (chart 2). A major heading appears individually on each chart to identify its relationship to the Agenda and with that of the overall Executive Summary. This construct also eliminates the need for a repetitive use of an Agenda chart in moving from one section to another.

Agenda

The Background and Context are treated in a short six chart section. The majority of the assessment is contained in the sections labeled: a) Mobility and Sustainment; b) Information Dominance; c) Platforms and Weapons; and d) Investment Strategy (charts 9 through 40). Recommendations follow (charts 41 through 51).

Background

TERMS OF REFERENCE (TOR)

- **Survey Joint and Service concepts**
- **Examine missions emphasizing land combat**
- **Identify technology/capability drivers and enablers**
- **Review/comment on Army Science & Technology Strategy**
- **Suggest an investment strategy**

Background

SPONSORS' EMPHASIS

- **Identify means and technologies to**
  - Control land, people, and resources at higher space-to-force ratios
  - Conduct simultaneous, non-echelon operations
  - Provide mobility including intermodal transfer
  - Achieve force efficiencies and affordability
  - Improve survivability for soldiers and units
  - Enhance lethality in all forms (including non-KE/CE)
  - Improve training for both Active and Reserve components
  - Maintain a general purpose force

Continuing attention in the assessment was given to control of land, people and resources -- the raison-d'etre for land forces. Other approaches raised issues not topically needed or appropriate.

Study Terms of Reference

A Terms of Reference (TOR) was prepared and the study was staffed in the early fall of 1997. The TOR was finalized at the November meeting of the ASB Study Group. During this first Plenary Meeting, a video teleconference was employed to bring the Study Group and its Sponsors together. In that session, the TOR was discussed in detail. There was unanimous agreement on the meaning of the TOR topics and related matters for emphasis defined by the study sponsors.

The TOR (reproduced in Appendix A) directs the Study Group to review Joint Army and other Service Concepts and give emphasis to Joint missions involving land combat. It is for these that technologies and enablers were sought. In the same context, the Army's modernization and technology planning was assessed.

Sponsor's Emphasis

With regard to concepts and missions for the future, the largest Joint missions are those requiring presence in all cases and combat in some cases. These involve generating, projecting and sustaining the Joint force. Unlike combat operations where there are clearly defined responsibilities and unity of command, these largest joint activities are spatially command and means segmented.

As will be seen (and quantified in chart 10) for the many basic units of a national Joint force, generation and deployment is a complex process involving intermodal management from fort or base to base or foxhole. It is multi-Service and employs commercial capabilities and support by host nation means in-theater.

Focusing the study only on Joint combat missions would miss dealing with the urgencies and challenges of projecting and sustaining the Joint force.

Context

THE EVOLVING THREAT

- **Potential regional/global conflict-causing circumstances**
  - Projected third world population growth in urban settings and in conditions of poverty and insufficient resources
  - Disagreement over national boundaries, control of resources and ethnic/tribal/political tensions
- **The Symmetric Threat**
  - Peer with global objectives and reach (none now - possibly Russia or China in future)
  - Major regional powers and/or coalitions with significant traditional forces
  - Lesser regional powers with modest forces
- **The Asymmetric Threat**
  - Use of WMD
  - Ballistic and cruise missiles
  - Capable RSTA systems
  - Multipurpose UAV fleets
  - Information warfare
  - Underground facilities
  - Submarines and sea mines
  - National and transnational terrorism

Concepts and Technologies for the Army Beyond 2010

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Context

CONCEPTS/CAPABILITIES SUMMARY

- Joint Vision 2010
- Army After 2010
- Operational Maneuver From the Sea and Extended Littoral Battle
- Air Expeditionary Force
- Generally integrated Service RDA planning
- In addition, the ASB reviewed
  - Inputs from DARPA, DSWA, ACTDs, and ATDs
  - Studies by the National Defense Panel and the Service Advisory Boards (ASB, AFSAB, NSB, etc.)
- All propose capability enhancements to
  - Deploy rapidly
  - Sustain confidently
  - Maintain survivability
  - Be information dominant
  - Engage precisely
  - Maneuver decisively

Concepts and Technologies for the Army Beyond 2010

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The Evolving Threat

The global security environment in the first quarter of the next century will see increasing challenges to US interests, greater multi-polarity, less cohesive & sustainable alliances, and probably, new concepts and weapons for conducting warfare.

The worldwide "drive for self-determination" will probably lead to more nation states rather than fewer. However, this also means greater turbulence and instability leading to a number of conflicts across a broad spectrum. Food insecurity, urbanization, and "youth bulges" will hasten the picture of states in the "developing world". Economically, "two worlds" will emerge: interdependent market economics and those states struggling to keep up while attempting to shelter their people from international, particularly western, influences.

Powerful economic blocks may lead to "peer competitors" to the U.S. as well as the more "visible" threats of a surging China and Russia. An alliance of these two nations would seem to present the greatest near-term threat possibility. While these so-called symmetric challenges to the US are most evident, other states will certainly take more indirect or asymmetric approaches to deal with the U.S.

Substantial effort has been made to estimate circumstances which would represent future challenges to U.S. national security, including those situations where US security guarantees and the interests of the friendly nations might be involved. (chart 5) The best that can be said for all efforts is that they provide a consensus that future threats will be different from those of the past. They will also encompass a greater spectrum of threats and will require a broader range of U.S. capabilities.

In the past, preparations were made to produce threat offsets in the competition with the Soviet Union. Marginal superiority was sought in areas understood to be critical. Forward basing, theater prepositioning and reinforcement provided hedges. All other threat circumstance were judged to be included cases and required little or no special treatment.

Possibly the most insightful characterization of the future threat(s) has been to establish the idea that there is no single overriding and central threat. Preparing for one assuming all others to be included cases is a poor starting point. In addition, attention has been justifiably given to asymmetric threats.

Concepts / Capabilities Summary

In this period of both uncertainty and preparedness, the JCS and Services have embarked on future force planning. The central theme is Joint Vision 2010 which posits dominance in all phases of future operations, particularly in the critical domains of power projection, sustainment, force protection, engagement and maneuver. These built on a base of quality people and superb training, should both enhance deterrence and produce much more continuingly favorable engagement and ultimately campaign circumstances than in the past.

The Services have embraced this vision to foster conceptual innovation seen in their "flagship" efforts such as AA2010 (AAN). Shaping subordinate processes and programs is now underway. Thus the Army's (and other Service's) research developments and acquisition communities as well as those which support joint activities (such as TRANSCOM) have engaged in the search for means and technologies to underwrite the six central capabilities (chart 6).

Context

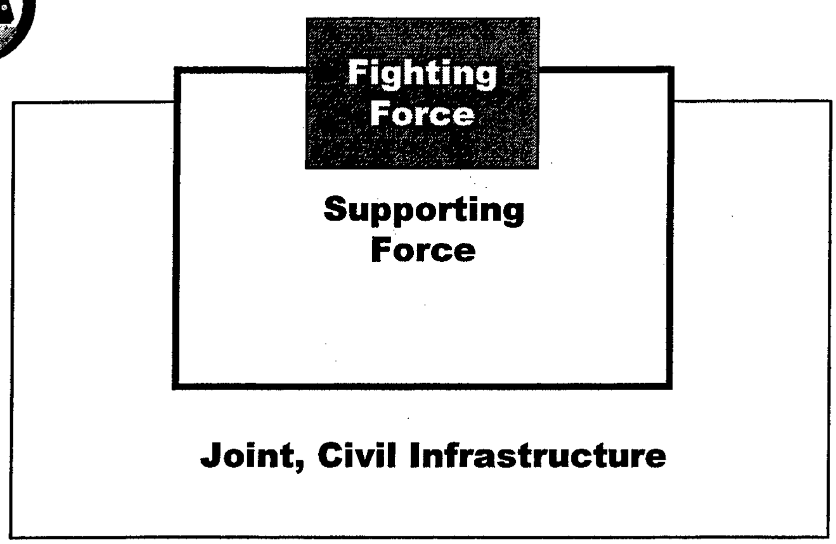
ARMY FORCE-STRUCTURE TRANSITION PLAN

1998	Army of Excellence (AOE)
2001	AOE + Beginning of Army XXI and experimental "Battle Forces"
2010	Army XXI + Comanche, Crusader, P3Is + developmental Battle Forces
2020-2025*	Army After 2010 = Army XXI + combined arms, heavy/light, "air-mech" *Battle Forces* strategically deployable worldwide

*** AA2010 Based in CONUS + Forward Presence +Prepositioned Equipment and Supplies**

Context

FUTURE FORCE



Compared with AOE counterpart, at least 3x more mobile, 3x more effective, yet needs only 1/3 in-theater support

The Army Force Structure Transition Plan

The Army is now, as it has always been, an Army in transition. The current Army of Excellence (AOE) is being modernized by exploiting information technology. An example of this is "Applique Internet" and its follow on "Tactical Internet." Over the next ten years, the Army will modernize its units with information systems that will reduce, but not totally eliminate, today's stovepiped systems. It will as well provide battlefield information to platforms and dismounted soldier teams which should enable unprecedented situation awareness. Exploiting these circumstances will require substantial advances in training in various simulation domains along with education, particularly distance learning in units.

AOE transitions to Army XXI through information exploitation, the addition of new platforms and systems and improvements to existing -- sometimes called legacy -- platforms, weapons and systems. In a parallel effort, described correctly as a campaign, AA 2010 comes into being with successive experimental, developmental and fielded generations of Battle Forces. Battle Forces are mechanized/motorized units which are strategically deployed by air. Their platforms -- primary and supporting -- are also moved operationally and tactically by air when desired or feasible. Ground mobility will be improved with respect to current platforms and forces. Sustainment and endurance improvements sought are an order of magnitude greater than achievable today. The traditional terms -- light, heavy -- are blurred and probably not relevant to the Battle Forces. Improvements which are needed to realize desired Battle Force performance levels will in many cases provide great benefits to Army XXI.

The Future Force

It is not possible to confidently quantify performance improvements at this time. However, it is possible to estimate what makes a difference. Today a prepositioned Brigade can be manned, generated and in position in 5 days. A Battle Force unit projected from the CONUS might accomplish the same in 2 days or possibly less. Thus the Battle Force design goals are best described as improvements in factors of 2 to 3 over current forces in each of the critical domains of deployability, lethality, sustainability and operational-tactical mobility. Taken in combination along with drastically reduced manpower and equipment in-theater footprints, appropriate combinations of AA2010 Battle Forces and Army XXI units could provide the equivalent of AOE Corps combat capability, air deployable worldwide in 72 hours with sustainment by air until the arrival of prepositioned and decisive sealift deployable follow-on forces within two weeks or less. Coupled with the benefits of the revolution in Military Logistics, the sustaining and supporting Army plays its role.

STUDY SOUGHT ENABLERS OUTSIDE ARMY

We focused on means, technologies, and processes judged to be most important

- **Strategic mobility means and technologies investigated**
  - Military airlift
  - Commercial airlift (CRAF)
  - Commercial heavy airlift (possible future CRAF)
  - Commercial fast sealift (possible future CRAF-like)
- **Operational-tactical means and technologies**
  - Military airlift only (no commercial dual-use possibilities)

C-130	C-130 Replacement	Thrust Vector Lifters
C-17	Tilt-Rotor	CH-47 Modernized

- **Processes and their contributing elements**
  - Commercial, high-throughput, seamless (UPS, FED EX-like) systems
  - Customer-friendly modularity
  - Standardized containerization
  - Information systems
  - People and automated materiel handling equipment (MHE)

UNIT LIFT REQUIREMENTS

UNIT	MANNING	PRIMARY PLATFORMS	TONNAGE OF OVERALL UNIT	DAILY FUEL & AMMO TONNAGE
Air Wing	5000	72	7000	1300
AEF Air Wing (estimate)	2500	72	4000	1300
Patriot BN	651	81	15000	100
AOE MLRS BTRY	132	9	2400	260
AOE ARTY BN	663	24	3300	220
MAGTF (estimate)	2711	150	15000	600
AOE BDE	5000	400	25000	800
AAN Battle Force (estimate)	6000	1400	13000	300

DoD C-5 and C-17 fleet have

- ***4,000 NM unrefueled lift capacity***
- ***17,000 ton one-time lift***

INSUFFICIENT FOR ANY POSTULATED JOINT EARLY ENTRY FORCE DEPLOYMENT

The Study Sought Enablers Outside the Army

The ASB chose to look first outside the Army and DoD for solutions. The study addresses those technologies and processes which enhance most greatly the strategic mobility and logistical flexibility. The air and sea improvements should be integrated to the commercial world with attention to the proper mix which best supports the warfighter. As a result of budgetary constraints the Army must involve itself in the long-range planning of commercial airlift and sealift developments such that requirements can easily be met through add-on features. The capability should be coupled with greater logistical control and delivery timing to the battle force. The essential part of this is to logically match containerization of logistical packages to warfighter requirements, to monitor package flow by high-speed ubiquitous information systems, and to execute package movement on the battlefield using more automated Materiel Handling Equipment (MHE). These improvements must compliment theater prepositioned or afloat war reserves and stockage of equipment and supply classes. The use of modern and faster delivery means with overall management control means will result in better-timed logistics to a high paced battle force.

Unit Lift Requirements

Unit lift requirements are described in Chart 11 for two purposes. The first is comparative relative to available military airlift fleet capabilities. The second has to do with continuing sustainment. A regional CINC has very difficult choices to make in setting priorities for rapid airlift with DoD assets. Deploying an F-16 air wing and an austere protecting Patriot battalion exceeds today's DoD airlift capabilities. Future weight reductions will make this feasible and will provide a capacity for resupply.

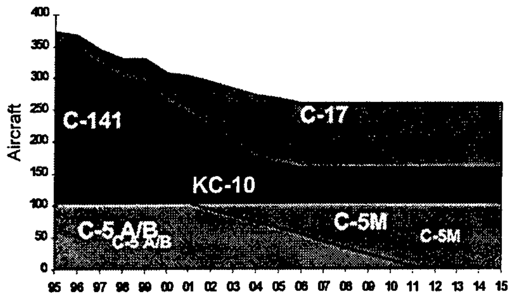
Battle forces elements and units must be made as robust and as light as possible for similar reasons. Sustainment by air runs afoul of the same limitations. Volume considerations are equally important, these limitations could reduce deployable combat power before weight limits are reached.

Army, Marines and Air Force -- All the Services which could require airlift for rapid power projection have heavy and bulky equipment and have substantial resupply requirements. The Army's 70 ton tanks (also used by the Marines) are the "bumper sticker" perception of the heavy force but the facts are otherwise. All DoD combat and support elements are heavy and bulky.

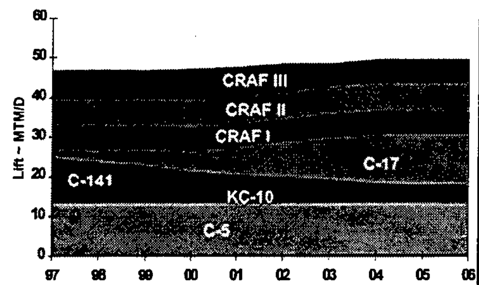
Mobility and Sustainment

AIR MOBILITY MASTER PLAN

Future Military Strategic Airlift Force Structure



Strategic Airlift Throughput

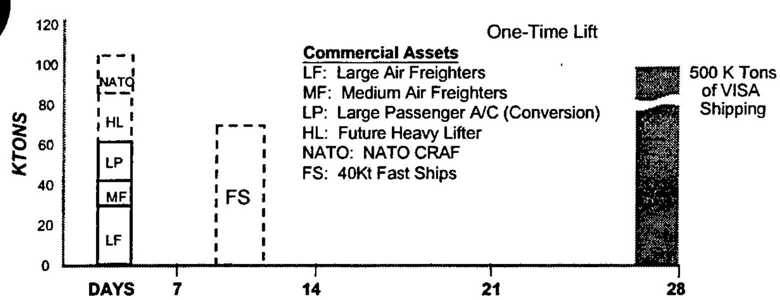


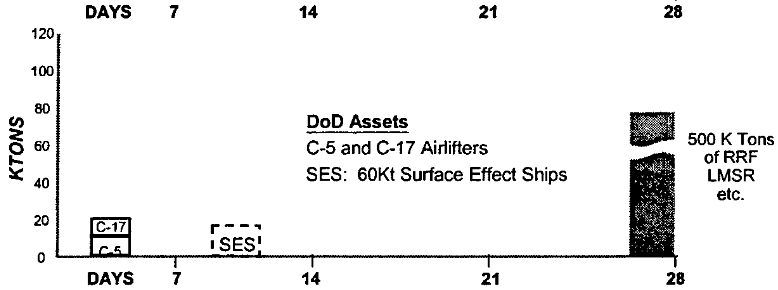
- **TRANSCOM long term planning calls for no new strategic or tactical cargo aircraft**
- **Use of Civil Reserve Air Fleet (CRAF) is *mandated* in current deployment planning**

Air Mobility Master Plan shows that CRAF is a critical strategic lift component

Mobility and Sustainment

ONE-TIME AIR AND SEA FLEET LIFT CAPABILITY





Commercial fleet airlift potential is 5x greater than DoD's; with high speed sealift, broad AA2010 options are enabled

Air Mobility Master Plan

TRANSCOM's air deployment concept for the near future is depicted in two ways. The chart on the left shows the military strategic cargo aircraft available to the U.S. Air Force from the present day through 2015. While the C141 is phased out, the C-17 is procured through FY2006 to provide an equivalent lift capability. In the same timeframe, C-5A/B transports will be converted to the more capable C-5M configuration.

Cargo lift capability expressed as millions of ton miles per day, MTM/D is shown in the chart on the right. In addition to the lift capacities of the military fleet, the Civil Reserve Air Fleet, CRAF, is displayed. The commitments of the American commercial cargo aircraft vary as CRAF stages I through III are called into service. It is important to note that this civil fleet represents a substantial portion of the required strategic air lift capability.

The most important point to be made is that the DoD fleet shows no growth, the civilian fleets from which CRAF is drawn are doubling every decade. TRANSCOM reports that there are no Army requirements for extended CRAF.

One-Time Air and Sea Lift Capability

This chart illustrates the cargo carrying capabilities of commercial and military vehicles. Airlift and sealift are both displayed. For illustrative purposes, a deployment range of 4000 miles is assumed. The chart represents the situation in the 2015 time frame.

The USAF's rapid air deployment capability using C-5 and C-17 aircraft is slightly less than 20,000 tons. This is much less than the capability of large commercial aircraft of today's operational configurations supplemented by future heavy lifters carrying up to 500 ton payloads.

Rapid sea lift provided by 40 knot commercial shops and 60 knot surface effect ships will provide quick follow up to forces initially deployed by air.

Beyond the early entry phases of operations, the great cargo capacity of conventional sea lift will provide the bulk of material necessary to sustain our forces.

Commercial lift dominates compared to military lift. The Army should exploit, stimulate and adapt its designs for future forces to the limitation of commercial means and have both fleets at its disposal.

In the future, CRAF could be the dominant lift component which provides the Army with a non-organic air lift fleet of traditional and non-traditional CRAF platforms. This will save the DoD the expense of expanding its strategic lift fleet and allows the C-17 to be freed for intra-theater lift, augmenting the C-130 fleet and dramatically expanding theater capabilities because of the 80 ton C-17 payload.

TRANSCOM air deployment potential using C-5 and C-17 aircraft is slightly less than 20,000 tons delivered in 2 to 3 days at 8,000 nautical miles. An assumed DoD fleet of 60 knot 2,000 ton payload surface ships could deliver about the same tonnage in 8 to 12 days (cost= $ 4-5 B). Commercial airlift is projected to the time frame growth rates of 7 percent. Assuming CRAF III and partial U.S. ownership of the worldwide fleet, it is seen that commercial capabilities substantially exceed DoD's. In addition to U.S. commercial assets there are additive possibilities with a NATO CRAF initiative and the stimulation and adaptation of commercial heavy airlifters. Rapid sealift provided by 40 knot commercial ships and 50-knot surface effect ships will provide quick follow-up to forces initially deployed by air. Beyond the early entry phases of operations, the great cargo capacity of conventional sealift will provide the bulk of material necessary to sustain our forces.

The Army should modify its Army XXI equipment and design its improvements and the Battle Forces to meet the door and floor loading constraints of traditional CRAF. These are not now well known, as understood in the Army requirements and development community. The Army should also be a proactive CRAF supporter and expand these fleets by changing policies, practices and marketing approaches.

Proper exploitation and simulation could provide circumstances for insertion of Battle Forces in 1 to 2 days and Army XXI brigades in 10 to 12 days.

Mobility and Sustainment

COMMERCIAL FREIGHTERS ARE AN EMERGING OPPORTUNITY

- **World large freighter fleet will quadruple**

1995 →	2015
1219 Freighters	2261 Freighters
(224 Large)	(884 Large)

- **Advanced passenger and cargo aircraft are entering design stage**

Up to 1 million lb cargo capacity

Proprietary

BLENDED WING-BODY | **HEAVY PAYLOAD AIRLIFTER**

- **The opportunity to leverage the commercial airlift fleet requires**
  - DoD engagement and stimulation
  - Early and continuing Army involvement with developers and their customers
  - Cooperatively developed changes or appliques
  - Changes in Army platforms, etc., to accommodate constraints to meet airline needs

Future air freight fleet capabilities offer strategic capabilities to transport Battle Forces and selected Army elements and sustainment

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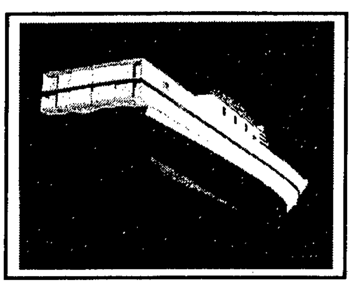
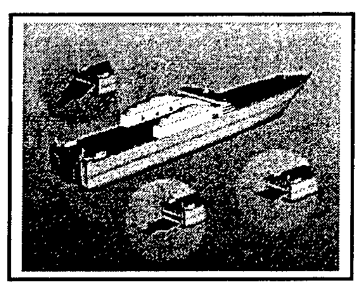
Mobility and Sustainment

COMMERCIAL FASTSHIPS FOR FOLLOW-ON FORCES

- **Emerging Commercial Technologies**
  - 40kt performance (nearly sea-state independent)
  - Design is optimized for rapid RO-RO or container load/unload
  - Important DoD/Army features yet to be considered
  - DoD (Army) action needed now





A small commercial "FASTSHIP" CRAF-like fleet of seven vessels could lift and deliver two AOE brigades 8000nm in 10 to 12 days along with two weeks of sustainment

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Commercial Freighters are an Emerging Opportunity

This chart illustrates the growing capabilities of the commercial air cargo fleet. In the 20 year period from 1995 to 2015 the number of commercial aircraft dedicated to carrying freight will almost double. It is important to note, however that the size of the large 747 size cargo lifters will quadruple. These are the aircraft of major interest for strategic military deployment.

The major U.S. aircraft manufacturers, Boeing and Lockheed Martin, are currently conducting design studies for the next generation of large airfreighters. Their commercial airline customers have indicated the need for carrying loads of up to 1,000,000 pounds. This results in a capability to rapidly deploy a large number of Army assets – both troops and equipment. Since these design efforts are in response to commercial interests, it is imperative that military need be recognized in the design stage.

Commercial Fastships for Follow-On Forces

Investment in a commercial Fast Ship, CRAF-like fleet is essential to assure logistical dominance. A target of seven vessels with 40 kt performance and near sea-state independent performance could provide support to two AOE Brigades. This is a proven concept which will meet the 8,000 nautical miles in a 10-12 day transit time with some internally incorporated force sustainment capability. Sea docking, speed of movement over the sea and loading and unloading are common interests in terms of power projection for the Army and profitability for industry. In the future/near-term the Army must seek such beneficial working and partnering arrangements that returns a better investment for any near and future partner. The intent should always be to seek maximum commercial logistical capability with the least military modification. The fast ship concept is technically and commercially viable and venture capital should be sought to make the Fast Ship CRAF thinking more certain.

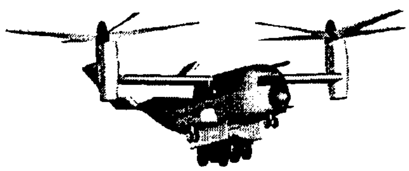
The chart summarizes the stages through which FastShip Atlantic has passed. Before construction is allowed structural design certification - is the vessel seaworthy - needs to be gained. A panel of experts - 270 - from Carderock reviewed all technologies and endorsed this concept. MARAD has review and certified.

The port directors of Cherbourg and Philadelphia have committed to make infrastructure based on the FastShip homeporting at these locations. Title XI financing will be used. The business case is solid. These ships will be operation by 2003. The Army should fold in its requirements to planning requirements and invest in planning.

Mobility and Sustainment

TACTICAL AND OPERATIONAL MOBILITY SOLUTIONS

- **No commercial counterpart found**
  - Near vertical insertion/extraction missions, will require DOD unique design and a major investment in new technology and systems
  - Means to be considered should include:
    - Rotorcraft: Modernized CH-47D, Adv Helicopter, Adv Tilt-Rotor, ...
    - V/STOL: Adv Tilt-Wing, Vectored Thruster, ...
    - Conventional: C-17, C-130J
    - Concept tradeoffs should be considered

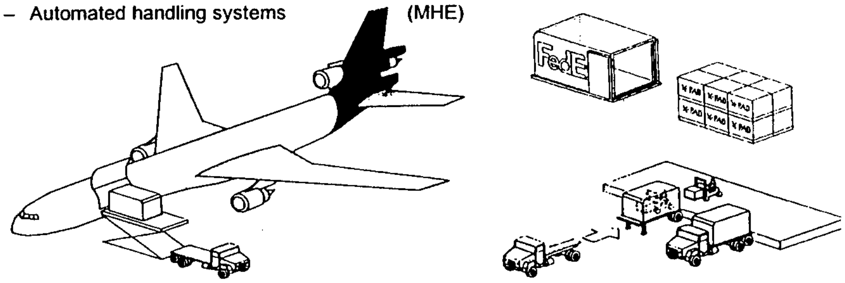


Operational-tactical airlift for beyond C-130/C-17 Battle Force mobility will require major DoD investment

Mobility and Sustainment

EXPLOITING COMMERCIAL PROCESSES

- A broad range of commercial transportation advances are planned or in process
  - Containers (air/land/sea)
  - Asset tracking systems
  - Automated handling systems
  - Customer-friendly modularity
  - Handling crews and materiel handling equipment (MHE)



- Army has exploited these processes
  - MLRS is designed and implemented with the same concept of target-six pack modularity, automated handling and small crews

Battle Force design must emphasize both modularity and containerization
Reserve components could provide handling crews and MHE

Tactical and Operational Mobility Solutions

3-D mobility implies air insertion and extraction of the Battle Force from unprepared sites. A representative load is a 15-ton combat vehicle. Airlift missions are flown to operationally significant distances (up to 1,000 km radius) at low altitude for survivability. An Army Hot Day (4,000 ft./95° F) design point is required to ensure 95% probability of near vertical operation, world-wide.

These requirements result in very large and expensive aircraft. Commercial aircraft in this size class are designed to use long runways and to cruise at optimum (high) altitude. Airports located at high altitudes with a hot climate have long runways to compensate. A RAND study to evaluate the dual use potential of a National Transport Rotorcraft concluded that there was only a niche market for large (8 ton payload) rotorcraft. The result is that DoD investment will be required to create a large (15 ton payload) V/STOL transport.

2-D and 2½-D mobility implies drive-in/drive-out and fly-in/drive-out respectively. Various forms of airdrop, including low-altitude parachute extraction, could be used for 2½-D insertion. This would allow the use of conventional military airlift assets such as the C-17 instead of development of a new military V/STOL transport.

There are three general cases which must be considered in assessing needs for operational-tactical lift which would underwrite full 3D, 2½D and 2D mobility. These are: a) administrative entry, b) disrupted entry and c) opposed entry. Strategic lift by military or CRAF means apply to all cases. The circumstances for operational-tactical lift and AA 2010 mobility vary substantially. Understanding the tradeoffs and most robust solutions deserves a substantial inquiry well beyond ASB resources or beyond that due in AAN design studies.

The Army and Air Force should fully exploit the C-17 in its designed-for theater role before looking to new developments. Exploiting CRAF airfreight enables this.

Exploiting Commercial Processes

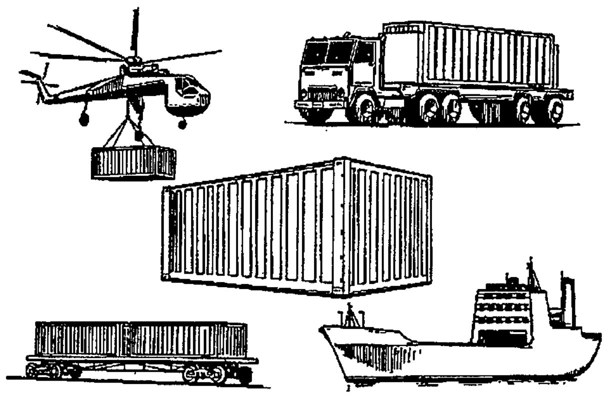
DoD has long been a leader in modularity and containerization but its application has been random. MLRS is an example. MLRS is modularized in that one pack of six missiles has an accuracy-lethality product adequate to deal with almost 90% of the spectrum of battlefield targets. The launcher carries two six-packs. These are/can be containerized. Size and weight dictate automated handling with deliberate and system wide application. The commercial world has moved beyond DoD in total transportation systems and processes. The FedEx X-Box air/land container system is an excellent example. It fits into the current air/land transportation system; it is light enough for efficient air transport and it includes a modular X-Pad that can be moved by forklift. This is just part of a total system including asset tracking, automated cargo handling and ground crew training.

DoD should consider taking advantage of the entire system. This means requiring that new military equipment be designed to take advantage of the commercial transportation system. It should be containerized and modular, as appropriate. It must fit into commercial airfreight aircraft. In addition it must be compatible with commercial asset tracking and automated handling systems.

The commercial transportation system consists of both equipment and trained people. DoD should consider encouraging CRAF operators to employ members of the Reserves, who could be called up as a unit, together with their air and ground equipment.

Mobility and Sustainment

THE ARMY LED THE WAY



Department of Defense
Project Master Plan
1972

Mobility and Sustainment

SUMMARY

- Commercial air and sea strategic mobility should be
  - -- Exploited -- Stimulated -- Adapted

  for Battle Force and some legacy components of AA2010
- There are important near, mid, and far-term possibilities to be explored; all need immediate attention
- Improving Battle Force and legacy system deployability dictates that
  - The force design team should include commercial sector expertise
  - Experimentation at the platform, unit and force levels should be undertaken
  - Modularity and containerization should be emphasized
  - DoD (Army) related information systems should at least interoperate with, if not be part of, commercial systems
  - Reserve forces should be considered for efficient manning and MHE
- Finding the best scenario-insensitive operational-tactical lift solution should be given high priority

The Army Led the Way

This chart is a reproduction of the cover of the 1972 DoD Master Plan for Containerization. The Army led this study and materially assisted the commercial sectors affected by those innovations. It is suggested that the Army again lead the DoD in advancing modularity and containerization for its legacy and Battle Forces to improve throughput performance confidence. It should also extend containerization and modularity to other military sectors such as battlefield medical care and warehousing, as examples and exploit commercial sector processes, information management and command control.

Mobility and Sustainment Summary

This chart summarizes the most important points which have been developed in the mobility and sustainment sectors of this overall report. To re-emphasize points already made, the Army should: 1) proactively recognize commercial air and sea capabilities in the design of future forces and the improvement of its legacy forces; 2) exploit the full potential of the C-17 before recommending a new theater aircraft; 3) seek theater lift modernization beyond the C-17 that is affordable and provides air-mech capabilities.

The panel found that there were widespread opportunities for utilization of commercial transportation technologies, particularly for DOD air and sealift needs. Pending or in process developments will benefit both the AAN Battle Force and the other components of AA2010.

An interactive process in which the Army and DOD engage constructively with industry and others involved in commercial logistics and transportation is the best way for the Army to proceed. Opportunities will be lost if the Army does not become more actively engaged immediately. Commercial technologies and systems can be exploited directly in some cases, stimulated to meet Army needs in others, and require Army adaptation of civilian transportation constraints in others.

The opportunities range from immediate opportunities to affect ship and aircraft design to long range opportunities to exploit commercially developed automatic handling equipment and information systems.

Army systems currently in the concept stage may have to be constrained by commercial carrier size and load carrying capability. These possibilities should be explored now before decisions by the Army or in industry foreclose options.

A number of steps such as those enumerated on the chart can be taken now to enable mobility improvements for both the AAN and the current and near term force.
One critical need that our study highlighted that will not be met by a foreseeable commercial development, even in part, is the possible requirement for a new heavy lift tactical transport aircraft. This applies to both vertical and short take off and landing concepts. The Army needs to determine the criticality of this need and do the necessary trade-off of cost versus capability options over a wide range of operationally interesting scenarios in order to determine the best tactical lift solution and in order to support any requirement for a major new DOD program in this area.

Information Dominance

REQUIREMENTS

- The study concluded that the critical technologies for the Battle Force must provide
  - A rich terrain and operational context for evaluation, interpretation and swift decision making
  - C4ISR, situation awareness and sensor-to-shooter information on very compressed timelines
  - The ability to confidently learn, experiment, plan, train and fight with one embedded system
  - Survivable command and control on the move
  - The ability to successfully train and operate with legacy units of both Active and Reserve components and with Joint and Combined forces
  - Commercial communications to support the above through redundancy and diversity

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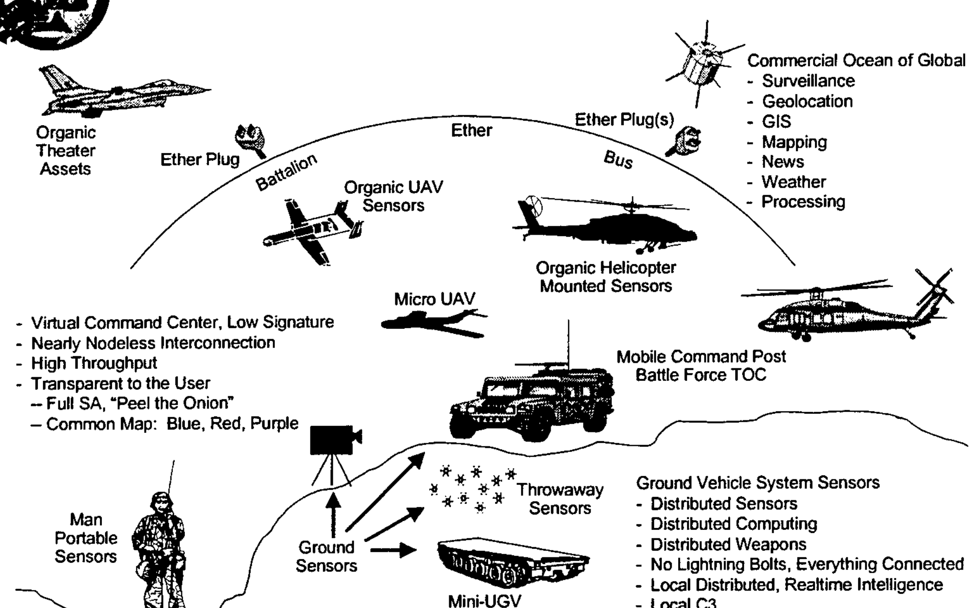
Information Dominance

SAS FOR THE BATTLE FORCE: WHAT IT SHOULD BE



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Information Dominance Requirements

Information dominance has been identified as the crucial integrating and enabling capability for the Battle Force. Many technologies and capabilities that can contribute to gaining information dominance have been identified by the study panel and discussed before.

Battlefield visualization provides operational context for evaluation, interpretation and swift decision making. The lack of archived terrain data and the inability to rapidly collect terrain data has inhibited current situational awareness systems and developing battlefield visualization capabilities. The Battle Force must have ready access to a rich terrain data set that is updated to meeting changing mission needs.

To accommodate faster optempo by the Battle Force, the timelines for the military decision making process and for engagements will be compressed. C4ISR systems for situational awareness and sensor-to-shooter links must likewise accommodate these compressed timelines. Although embedded C4ISR systems will have the primary purpose of supporting warfighting, soldiers of the Battle Force must also be able to use them to support learning, experimentation, planning and training. This will require new functionality to be added to the C4ISR systems.

The tempo of the Battle Force will demand that command and control (C2) activities are done while traveling in ground vehicles or helicopters. C4ISR systems must be enhanced to support C2 on-the-move. The Battle Force will fight alongside Army units equipped with legacy C4ISR systems and Joint and combined forces. The C4ISR systems used by the Battle Force must be interoperable with those systems used by others.

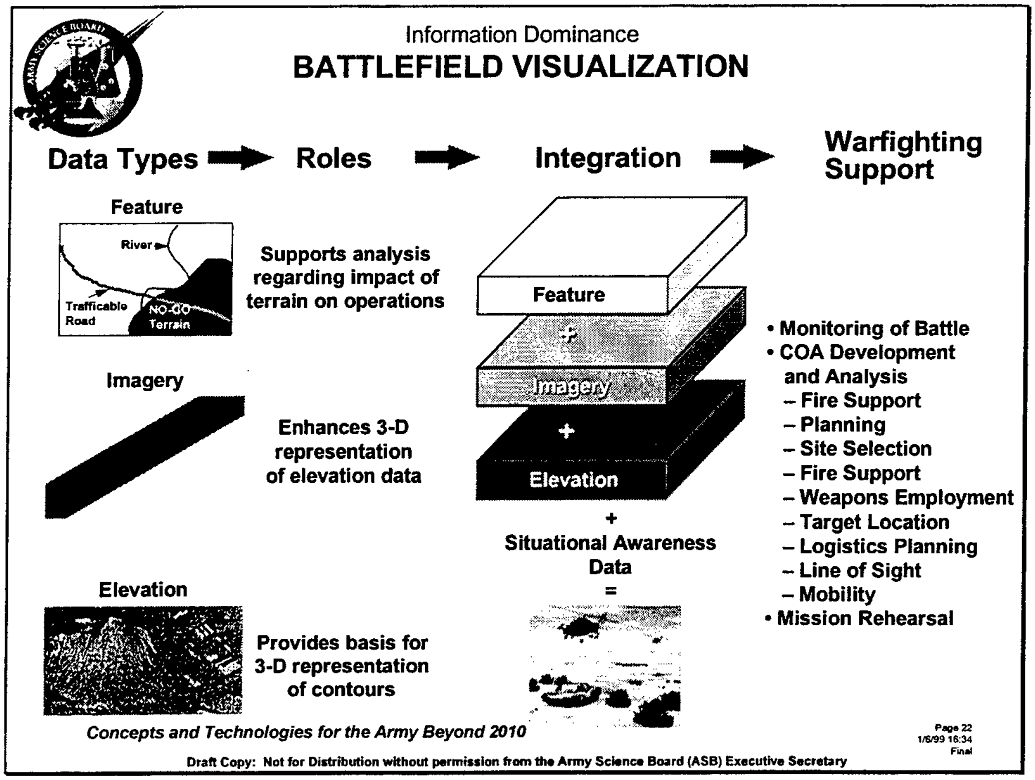
Communications for the Battle Force must be assured. Leveraging the enormous investment in various forms of commercial communications should be part of providing robust capabilities for the Battle and legacy forces.

SAS for the Battle Force

The Battle Force, including its Units, Elements and their smaller components must be served by both organic, higher echelon, other Theater and national collection and assessment capabilities which are pictorially shown. Today battalions, companies, platoon squads and teams get their situational awareness from their limited organic means and from higher levels of command.

In the future, Battle Force and legacy forces will have organic on-board and off-board sensors to collect and report events in the full variety of domains -- acoustic, seismic, electromagnetic and active radar operating in traditional and non-traditional frequency ranges. External information will become available through the Army's tactical internet.

The Army must find an approach to address and solve the challenges and problems resident in dramatically expanding battalion capabilities. This in itself will constitute a major change in Army priorities that in the past have focused improvement in brigade and above.


Information Dominance
BATTLEFIELD VISUALIZATION
Data Types
Roles
Integration
Warfighting Support
Feature
River
Trafficable Road
NO-GO Terrain
Supports analysis regarding impact of terrain on operations
Imagery
Enhances 3-D representation of elevation data
Elevation
Provides basis for 3-D representation of contours
Feature
+
Imagery
+
Elevation
+
Situational Awareness Data
=
• Monitoring of Battle
• COA Development and Analysis
– Fire Support
– Planning
– Site Selection
– Fire Support
– Weapons Employment
– Target Location
– Logistics Planning
– Line of Sight
– Mobility
• Mission Rehearsal
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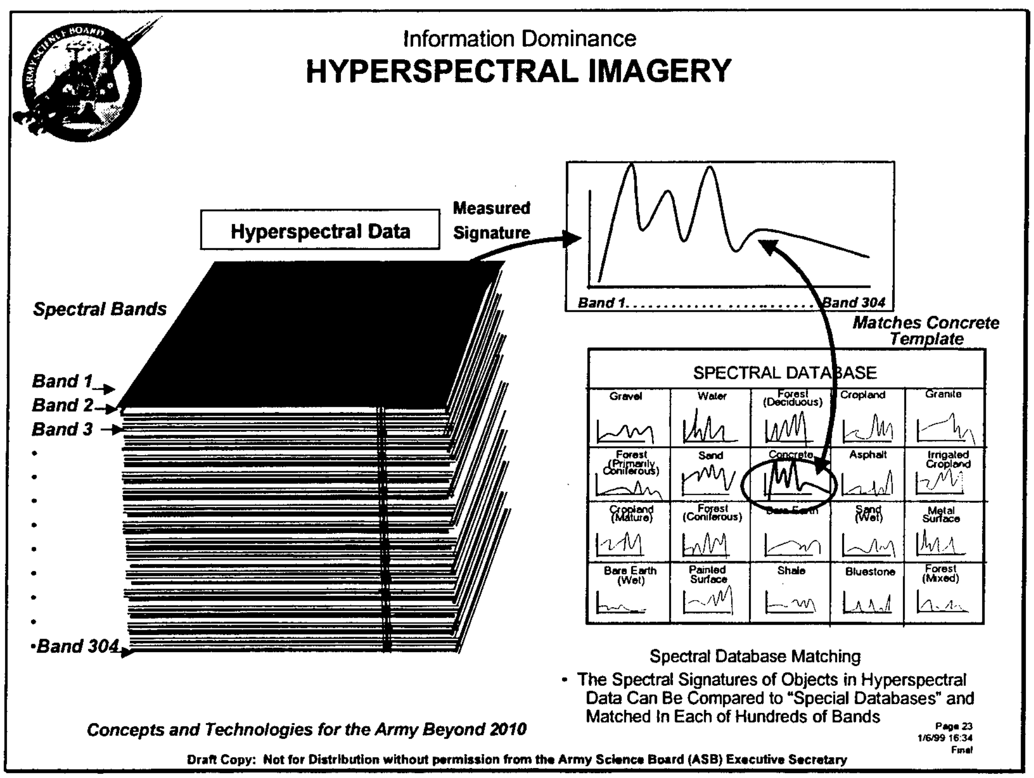
Information Dominance
HYPERSPECTRAL IMAGERY
Hyperspectral Data
Measured Signature
Spectral Bands
Band 1
Band 2
Band 3
•Band 304
Band 1
Band 304
Matches Concrete Template
SPECTRAL DATABASE
Gravel
Water
Forest (Deciduous)
Cropland
Granite
Forest (Primarily Coniferous)
Sand
Concrete
Asphalt
Irrigated Cropland
Cropland (Mature)
Forest (Coniferous)
Bare Earth
Sand (Wet)
Metal Surface
Bare Earth (Wet)
Painted Surface
Shale
Bluestone
Forest (Mixed)
Spectral Database Matching
• The Spectral Signatures of Objects in Hyperspectral Data Can Be Compared to "Special Databases" and Matched In Each of Hundreds of Bands
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Battlefield Visualization

The ASB conducted a 1997 Summer Study on "Battlefield Visualization". That study concluded that warfighter understanding of the battle's progress and alternative courses of action are enhanced by using computer graphic renderings of battle activities. Recommendations from that study are re-emphasized here, as they are important for Battle Force situational awareness.

Terrain data is crucial for computer graphic renderings of the battle but the Army does not have adequate archives nor the ability to rapidly obtain the necessary data. The optempo and early entry mission for the Battle Force make the need for terrain data even more crucial than for Army XXI units.

As shown in chart 21, three types of terrain data are necessary for battlefield visualization: elevation, imagery and feature data. Each data type has a specific role. The three types of data are integrated to contribute to the rendering. With situational awareness data, a two or three-dimensional depiction of battle activity can be presented to warfighters. Battlefield visualization actually has time as a fourth dimension that emphasizes the progress of past activities or unfolding of alternative courses of action. Battle Forces will be able to utilize the synthetic environments with terrain data supporting monitoring of battle, course of action (COA) development and analysis tools, and mission rehearsal.

It will not be possible to archive and manage all of the terrain data warfighters will ever need. The Earth is too large to collect and archive all types of terrain data at the high resolutions that will be desired. As peacetime construction and war changes the face of the Earth, updates to terrain database will be necessary. As a result, the Army must have on-demand access to capabilities for collecting, processing, integrating and storing terrain data for Battle Force areas of interest.

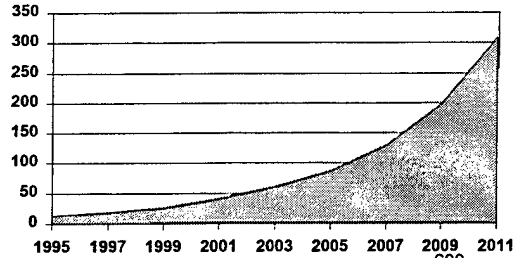
Commercial capabilities can meet many terrain data collection requirements. Commanders must have online access to commercial terrain databases and the authority to order new collections for contingencies. NIMA and other services will have satellite-based (e.g. Discoverer II) and UAV based collection capabilities that can collect terrain data. Discoverer II must be able to directly support battalion operations with its MTI and SAR capabilities. Non-Army government capabilities will provide faster response and higher resolution than commercial firms. To ensure its timely response to critical mission requirements, the Army will need collection capabilities of its own. For small unit operations, very high-resolution terrain data will be needed that may best be acquired with ground vehicles (rather than overhead assets).

Hyperspectral Imagery

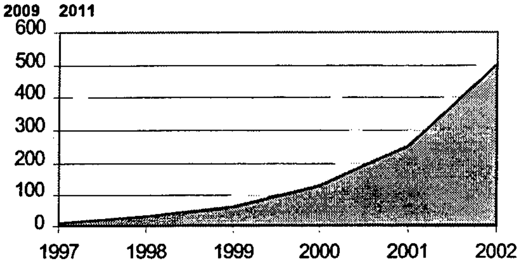
Hyperspectral imagery will be very important to provide fine ground terrain and feature interpretation. These inputs will be further exploited in operational assessment (e.g., mobility, Course of Action, etc. Hyperspectral analysis can provide the means to understand the nature of the "terrain." Successive "looks" can highlight changes. In many cases, but not all, it should be possible to intuit the nature and cause of the change. The remainder of the cases will require either vehicles or distributed ground based sensors to provide the information.

Information Dominance

TRENDS IN COMMERCIAL COMMUNICATIONS



Commercial satellite market forecast in billions ($)

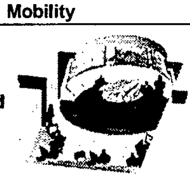
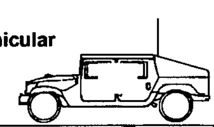


Fiber optic market forecast in billions ($)

Army DoD needs to be involved and influence the outcome

Information Dominance

DARPA CONCEPTS IN C2

	Echelon	Capacity	Mobility
Command Post of the Future	Joint TF	High	Limited 
Mobile TOC	Battalion	Limited	Vehicular 
Small Unit Operations (SUO) Situational Awareness System	Squad	More Limited	Foot 

Army must leverage DARPA command and control developments

Trends in Commercial Communications

DoD was once the world leader in communications means and technologies. It was also a major investor and user. This circumstance set no longer applies. Commercial sources now globalized are the big investors and innovators.

Today there are several companies (such as Qwest, AT&T, Sprint, Worldcom, MCI, etc.) that are laying large capacity fiber backbones in CONUS. The GTE Qwest backbone, for example, spans 92 metropolitan areas and has a capacity of almost 5 terabits/sec. (Assuming the size of this briefing is 2MB, this is enough capacity to send almost 2.5M copies across the CONUS in one second!). In global fiber telecomm, the situation is similar.

Many companies such as AT&T, Global Crossing Ltd., etc., are laying transoceanic fiber. Transatlantic traffic is growing at a rate of 80% per year, and all bulk capacity is sold out for the foreseeable future. Fiber technology is robust in growth potential, as the theoretical bandwidth limits are extremely high (on the order of 100 terabits/sec per dark fiber strand); with the current limitations being the switching speeds. Total investment approaches $100B/year.

The global telecomm market extends well beyond terrestrial fiber-based infrastructure, to satellite telecommunications. Most market projections predict that global satellite telecomm will grow rapidly, enough to capture at least 10% of the total global telecomm market. This is in the range of hundreds of billions of dollars. Although satellites have many technological disadvantages they are extremely attractive in the "last mile" applications, which are likely to be of high importance to AAN operations.

Despite being limited in overall capacity (in the 10s of gigabits/second in aggregate bandwidth) and older technology (due to the 5-10 year lag in launch times), they allow point-to-point communications without the need to lay fiber or "dig ditches". Hence the projected growth.

Market forecasts in these business areas show no sign of slowing investment in the foreseeable future. It is the ASB's judgement that commercial communications should be the preferred means between higher (Brigade and above) echelons and should be a redundant capability for Battalion operations.

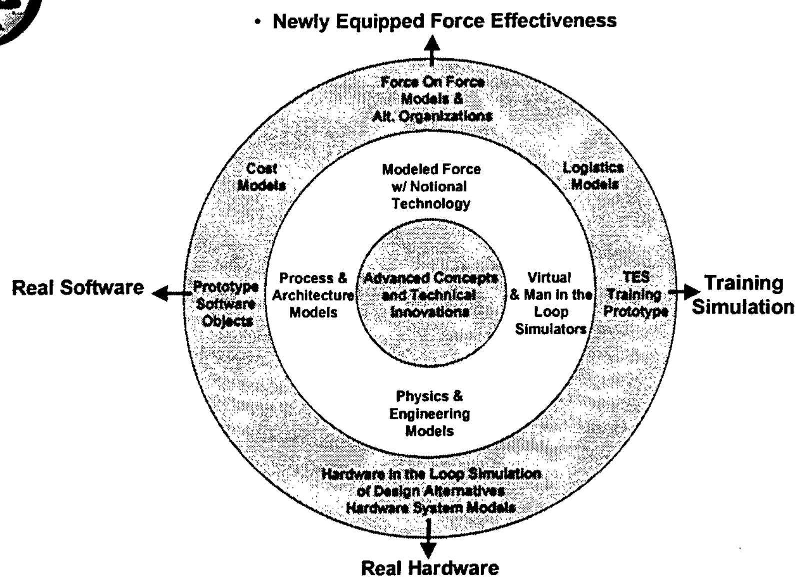
Current and future networks (terrestrial and space-based) are individually vulnerable to a modest variety of weaknesses and exploitation modes. The Army working with DoD should provide partnering which eliminates these and results in a robust network of networks, as it has in the past.

DARPA Concepts in C2

DARPA has two ongoing C2 programs -- Command Post of the Future for higher command echelons and Small Unit Operations (SUO) Situation Awareness System (SUO-SAS) for battalion through team operations. It is contemplating a mobile tactical operations center (TOC) for high optempo continuous battalion and brigade operations. This development would reach for the capabilities needed for Command and Control on the Move (C2OTM) with innovations such as user stabilized displays. All three developments are important to the Army and should be fully exploited by the Army with senior attention, program management and future funding.

Information Dominance

LEARNING THROUGH EXPERIMENTATION



System Of Systems Integration testbed is a must

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Information Dominance

FINDINGS

- The Battle Force concept employs Information Dominance and indirect fires as a surrogate for Rolled Homogeneous Armor
- Commercial communications and surveillance capabilities are receiving massive investments and can be exploited
- DARPA programs for Discoverer II, Small Unit Operations Situation Awareness System and Mobile TOC are important to the Army but have limited Army interest and support
- The digitization program could readily be enhanced to support CTC-like TES, DL, mission rehearsal and AARs
- A sophisticated testbed is the *only* way to understand, develop and successfully test such a complex system of systems as the AA2010 C4ISR and SAS capabilities. CECOM's digitization testbed, its SIMNET coupling and DDR&E's Web concept could be joined to start the spiral development, experimentation and test process

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Learning Through Experimentation

Success in information dominance in the AA2010 will depend heavily on the seamless interoperability of many complex C4ISR systems. Inasmuch as interoperability requirements are loosely levied on system developers, there are no mandates within the RDA community requiring demonstration of functionality and interoperability within the total Army force. Further, the Army has no integrated simulation environment that would facilitate such demonstrations.

A System of Systems Integration testbed would provide such a development and test environment. Advanced concepts and innovative applications of emerging technologies could be examined in the context of the total force structure to examine holistic value added prior to bending metal. The Army is in a position to leverage much of the simulation work done in preparation for TFXXI (AWE Focused Dispatch, FBC2B SIMNET training, the Digital Integration Laboratory and the Central Technical Support Facility). These enablers will provide the foundation for integrating physics and engineering models as well as process and architecture models with Constructive, Virtual and Live simulations of the existing and notional force structure.

Exercising prototype hardware and software in-the-loop simulations with man-in-the-loop simulators immersed in force-on-force scenarios will demonstrate the value added of advanced concepts and technical innovations in the context of the total fighting force. This environment will also provide the basis for a Tactical Engagement Simulation for development of collective training concepts and capabilities.

The Army has the largest information and force integration challenge when compared with the other services. Its size:

Army = 1000 x Navy
Army = 100 x Air Force
Army = 10 x Marines

The Army must therefore lead DoD in advanced architectures and integration methods relative to combat and support information reporting.

Relative to developments for both the Battle Forces and improvements to Army XXI, the Army requires a continuing testbed to evaluate possible improvements in four domains -- concepts, technology, software and operations. Fortunately, a smaller version of what is now needed was developed by CECOM for the digitization initiative. It combined the various simulation modes -- live, virtual and constructive -- with hardware in the loop and ultimately porting with SIMNET.

This last feature provided troops with the means to experiment with and learn the ways in which digitization would change and improve operations.

The Army needs larger and more sophisticated versions of the CECOM test bed to make hardware and software choices and find integration solutions for networks of sensors, platforms and weapons as well as support and suppliers. It should include the DDRE Sensor Web initiative where from the outset sensors are envisioned as parts of networks and employed at that level. The idea itself is revolutionary, at least within the Army. Large numbers of sensors (or sometimes sensor systems) have been fielded each within its own concept of operation and management for tasking, thus creating smaller stovepipes within larger ones in the C4ISR domain. AA2010 needs a very different network-driven user-directed C4ISR system.

Information Dominance Findings

The Battle Force design architecture employs integration to achieve greater overall force and platform capabilities. At the same time this creates interdependencies. Capabilities for engagement and protection are dependent upon information dominance along with the ability to reach out and lethally engage before being engaged. Passive protection is augmented with other capabilities along with active protection.

In this same vein, information sources, advanced processing, context formation and knowledge derivation are strongly dependent on developments outside the Army. In this case, as in the command post situation, DARPA development should be adopted and exploited by the Army. Discoverer II, a SAR-GMTI constellation which will provide high resolution DTED-5 mapping, wide area surveillance and focused imaging, provides unique capabilities which must be made part of Army future developments. The same is true for commercial communications and surveillance.

There is also good news relative to CTC-like training at home stations, mission rehearsal and After Action Reviews (AARs). This confederation of methodologies, processes and capabilities set the Army apart from all other armies in the world. The current digitization strategy with a modest expansion provides all of these capabilities and will transform and intellectually integrate education, training and preparation for and conduct of operations.

Platforms and Weapons

REQUIREMENTS

Key Battle Force Capabilities

- Highly lethal striking power - indirect and direct
- Highly survivable with limited passive armor
- Sustainment independent for 5 to 10 days
- Primarily beyond line of sight (BLOS) engagements
- Attack immediately upon targeting - low weapon latency

Approach

- Assessed technological options/opportunities
- Used a "holistic" total force adaptation
- Suggested innovations not currently considered
- Added Soldier as a System observations

Platforms and Weapons

LETHALITY - KE/CE WEAPONS

- **Continuing advances in traditional KE/CE weapons will provide a high level of lethality for AA2010 forces**
  - Individual weapons, crew-served weapons, direct and indirect fire systems, weapons deployed on both ground and air platforms
  - High-performance missiles (KE/SC/EFP warheads)
  - Extended range munitions (e.g., TERM), controlled trajectories
  - New gun technologies: ETC, EM
- **Lethality benefits will accrue from technology advances in many areas**
  - Sensors and signal/data processing
  - Guidance and control
  - Command and control
  - Propulsion
  - Warhead design and air bursting small arms munitions
- **PGMs will provide major deployability/survivability/sustainability benefits to AA2010 forces**
- **Emerging new concepts may lead to significant additional lethal capabilities (e.g., DARPA AFSS program – "Munitions in a Box")**

Platforms and Weapons: Requirements

The concept for Battle Force operations envisions a rapid deployment from CONUS and insertion into a theater to oppose enemy attempts to both generate and position forces and to conduct decisive operations, if required. Just as critical is the ability to extract the Battle Force and reinsert it where desired. It must also operate without additional external sustainment during these periods of high operational tempo. Thus certain key capability requirements emerge: a) high and efficient lethality; b) high sustainability within the weight and volume constraints which allow full air mobility supported maneuver; c) robust organic unit sustainment independence; d) majority of engagements beyond line of sight; and e) low latency for all engagements.

The ASB approach to assess S&T progress and address additional innovations used traditional assessment techniques focusing on each of these major capabilities. A formal integration across the set was not attempted nor were tradeoffs addressed. Appendix K dealing with platforms and weapons attempts a viewing of the integration trade space in one of its displays. Much of the AA2010 design effort to date has been focused on mounted forces although it is recognized that combined arms operations conducted by the Battle Force will have elements of dismounted combat. Thus the Land Warrior (Soldier as a System program) is addressed as a contributor. An additional point is worth mentioning. The logic of the air-mech concept and the weight and energy challenge for the dismounted team all suggest the need for a team support vehicle of some kind. AA2010 design studies have not yet identified this solution.

Lethality

Lethality advances for the Battle Force (and also Army XXI) show promise in the traditional kinetic and chemical energy domains (KE/CE). The Army modernization S&T activities have promising candidates for substantial evolutionary improvement along with a few revolutionary possibilities.

The Army-DARPA Advanced Fire Support System (AFSS) -- sometimes called Rocket/Munitions in a Box -- is an excellent initiative which addresses and solves not only the immediate fire support problem but also, through modularity and containerization, simplifies handling (possibly through the use of a standard aircraft cargo container) and reduces manpower footprint and overhead. It is a stroke of operational and tactical genius.

Many, if not all, of the benefits in lethality are enabled because of advances in sensors and information management along with advances in the classic supporting technologies needed for extreme low cost per kill precision guided munitions.

Platforms and Weapons

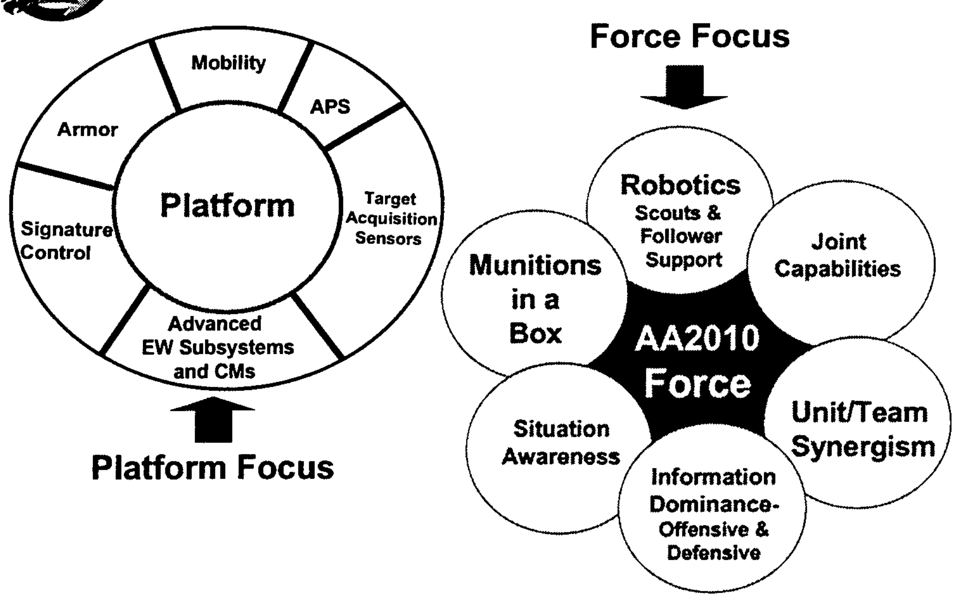
LETHALITY - NON KE/CE WEAPONS

- **HPM Weapons**
  - Provide advanced EW capabilities to upset/degrade/burnout critical electronic components in many types of military systems
  - Significant potential utility against missile guidance systems, radar and FC systems, R/S systems, computers, communications assets, aircraft...
  - Vehicle-mounted weapons of effective ranges of up to 10km or more could be available in the next 10-20 years
- **Laser Weapons**
  - Potential targets: helicopters, UAVs, ATGMs, ATG missiles, cruise missiles
  - Solid-state laser technology could enable useful capabilities in compact, truck/HMMWV-mounted system within the next two decades
  - Problems include range and weather limitations, system complexity/size/cost
  - Established defensive capability will provide growth potential for other missions
- **Non-Lethal Weapons (NLW)**
  - Offer new capabilities for crowd control, localization or dispersal of non-combatants, area denial, and disablement/neutralization of vehicles, facilities and equipment
  - Current RDT&E thrusts: acoustics, entanglements, riot control agents, kinetic technologies, vehicle stoppers
  - Provide new options for CINCs and field commanders conducting MOUT operations under stringent rules of engagement

Weaponization of emerging/maturing technologies could enable exciting new capabilities for AA2010 Battle Forces

Platforms and Weapons

CHANGING SURVIVABILITY STRATEGY



Lethality -- Non-KE/CE Weapons

Continuing research for alternatives to KE and CE lethality mechanisms has yielded initial and promising results at the less-than-lethal prototype state for high power microwave, laser and non- and less-than- lethal mechanisms. Two major sets of issues still inhibit moving forward in development and fielding. The first involves operational concepts and utility, the second is concerned with rules of engagement. There are also technical issues; especially at the subsystem and integration levels of detail.

Both high power microwave and high power laser weapons offer exciting possibilities in multi-mission lethality/effects, including the possibility for "deep magazines" / large number of stowed kills / engagements with associated payoff in reduced sustainment needs. At lower power levels these technologies may be attractive for use in smaller platforms attacking more vulnerable target sets (e.g. cruise missile defense and counter Unmanned Air Vehicles). Another interesting area is "non-lethal" weapons/effects. This rapidly developing class of "non-lethal" weapons also offers many possibilities for missions where lethal means are unacceptable or inefficient. These technologies show promise for engagement/disruption of combatants and for use in missions involving civilian riots and environments where lethal options pose unacceptable risk to friendly/allied troops or non-combatants. They may also provide effective capability for area denial and enemy operations disruption in ways not feasible with lethal means.

The ASB finds that there is substantial promise for such alternate lethality means not least of which is in operations in urban settings. A continuing effort is warranted.

Changing Survivability Strategy

On the other side of the coin, the AA2010 force design studies have developed a multifaceted approach to survivability which includes a "system of systems" or total force trade assessments (to include platforms) as contrasted with the traditional "platform alone" focus of the past. The major difference lies in tradeoffs in crew size, protected volume and levels of passive protection. Much work remains to be done to realize the desired levels of strategic and theater air-mech mobility along with adequate survivability, lethality and endurance. One of the most promising new dimensions for improvement is in the area of robotics. While these are currently thought of in the context of Battle Force design, when successful, these unmanned systems/capabilities would expand the control and engagement space of Army XXI units as well.

Force survivability involves complex trades between several technology and capability areas. Survivability can be considered from two distinct perspectives – platform survivability and the capability of the overall force to avoid or minimize the impact of enemy attack. Example platform/system survivability features are shown on the left side of the chart. AA2020 will exploit a balance of these emerging advanced survivability technologies including active protection, signature control, electronic countermeasures, platform mobility and lightweight armor protection. The ability of the platform to dominate an engagement while avoiding detection (e.g. exploit beyond-line-of-sight (BLOS) weapons) will also play a major role in survivability. Survivability of the force will often include many complementary capabilities that provide substantial synergism to the force. Tactically integrating these capabilities can provide overmatching agility and freedom to maneuver. The ability to dominate battle space and control optempo will deny the enemy the option to execute his battle plan – posturing the enemy forces for defeat. For example, robotic (air or ground) vehicles in a scout role operating in conjunction with manned platforms and unmanned weapons follower vehicle, can facilitate precise BLOS kills at extended ranges, thus reducing manned platform exposure to threats. Joint capabilities, situation awareness, information dominance and teamwork are all major factors in force survivability.

Platforms and Weapons

THE MIX IS CRITICAL

- **Rocket-delivered PGMs** (e.g., MLRS MSTAR) – able to defeat most high-value ground targets at ranges up to 200 - 350 km
- **Medium/long range missiles** – capable of killing armored targets and helicopters at ranges of up to 200 km (optional 10-15 min loiter)
- **Air defense missiles** – effective against high-performance fixed-wing aircraft, cruise missiles, UAVs, and helicopters in clutter
- **Advanced compact/hypervelocity KE missiles** – for direct LOS engagement of hard targets at ranges up to 5 - 10 km
- **Vehicle-mounted medium caliber guns**
- **Individual and crew-served weapons** – with both conventional and air-bursting projectiles
- **Advanced EW weapons (HPM), laser and non-lethal weapons**

Maximum force effectiveness achieved by mixing different munitions on air and ground platforms

Reachout Joint fires shape the initial battlespace and provide continuing long-range support

Platforms and Weapons

LOW LATENCY IS NEEDED

- Non ballistic rounds and weapons
  - May be expendable or reusable carriers
  - "Soft" launched (not impulsively launched)
  - Deploy lifting surfaces, fly and are powered
  - Are navigated on arbitrary flight paths to the target area
  - Can transition to a lower speed loitering mode
  - Can be called in and approach target to optimize munitions effectiveness
- Loiter and cooperative engagement
- Extensive field training and experimentation data show that small scale engagements (segments of larger battle) involve durations of a few to approximately fifteen minutes
- Loiter with in-flight targeting, providing immediate fire in 5 to 10 seconds, would dramatically improve synchronization and virtually eliminate latency
- First order assessments suggest that loitering of 5 to 20 minutes is possible with AFSS follow-on and Crusader P3I respectively
- Cooperative engagement is the process that brings sensor/shooter (launcher) together

Latency degrades synchronization of longer range fires. Non-ballistic rounds and weapons could eliminate latency using cooperative engagement processes

The Mix is Critical

The previously described advancements in lethality are being matched with delivery systems. The mix currently under consideration expands engagement area by orders of magnitude and provides for a mix of lethality mechanisms. This latter part has both a deterrent and combat advantage. Engaging enemy forces, mounted or dismounted, on the ground or in the air at extended distances imposes risks to all phases of his operation not just the closure with our forces. Enemy platform and countermeasure designers are also forced to find protective measures from all attack and defeat geometries (top, front, rear, side) along with both high energy KE and CE lethal mechanisms. In a sense, such a strategy provides little or no space to hide and many ways to die when engaged.

Latency

In the midst of all this good news lies a challenge that arises along with critical and engagement space expansion. It is technical and command and control induced latency (or engagement timeline delays). The Army, as well as the other Services, must deal with targets of possibly changing location and/or altering vulnerability conditions/aspects. Thus target detection and the decision to engage are often separated in both time and space.

Along with other initiatives to deal with this problem (e.g. hypervelocity missiles) the ASB recommends that the Army explore and employ the benefits of loitering munitions and cooperative engagement processes. Currently, long range direct fire and indirect fire are mostly accomplished with impulsively launched (gun) weapons or short term boosted weapons (e.g. MLRS rockets). Trajectories are deterministic and to some greater or lesser extent useful to localize the launcher, leading to the need for protection and get-away mobility.

Non-ballistic rounds with a loitering capability eliminate or complicate the backtracking and provide, in a limited way, fire close at hand in the sky, possibly five to ten seconds away. Latency could be nearly eliminated but the cooperative engagement doctrine, tactics and procedures also need development and testing to achieve robust results.

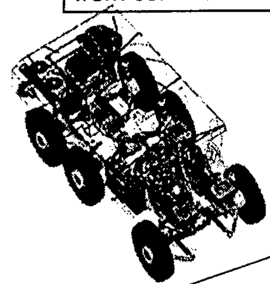
Appendix M examines a Gulf War engagement and an NTC warfighting experiment to address the issue of desired loiter time. The results (not expanded here in detail) suggest that 5 to 20 minutes of loiter coupled with 5 to 10 seconds engagement delay would make dramatic changes in local battle outcome.

The ASB suggests exploring such possibilities in both domains of concept and technology.

Platforms and Weapons

SUSTAINMENT EFFICIENCIES

Hybrid electric drive available from commercial developments

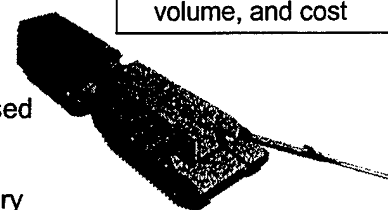


Numerous advantages

- Fuel efficiency
- Low weight
- Low signatures
- Dash power
- Simplicity

EM Launch

- DoD unique, high risk
- Payoff: reduced weight, volume, and cost



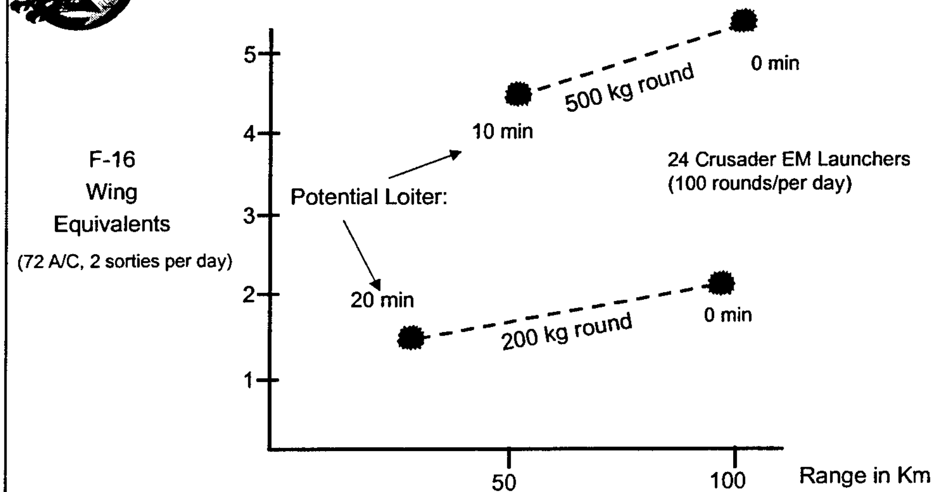
Ongoing R&D effort

- Major challenges remain in pulsed power, launch physics, lethality
- Most promising applications – medium caliber guns and artillery

Force efficiency/sustainment: requires high fuel efficiency and increased stowed kills

Platforms and Weapons

EM LAUNCH OF LOITERING ROUND COMPARED TO F16 WING



Possible improvements in destructive potential for equal sustainment levels of 1300 tons/day of fuel and ordnance

Sustainment Efficiencies

Achieving the necessary sustainment efficiencies to support the Battle Force concept and improve the total Army's ability to conduct all operations will require a mix of advances. Some of these can capitalize on developments in commercial technologies while others are DOD or Army unique. This chart discusses an example of each.

Today's combat vehicles utilize mechanical drive systems that are mature technologies with minimal potential for improvement. Since they were developed specifically for the Army's combat vehicles, the systems are typically expensive to procure and to maintain. Hybrid electric power and propulsion systems have potential as enabling technologies for future combat vehicles. When compared to a state of the art mechanical drive, hybrid systems offer a 50% improvement in fuel economy, excellent acceleration and braking capability, reduced thermal and acoustic signatures. They will also provide robust electrical power for weapons, communication systems, sensor suites and other electric power users. Hybrid electric systems also enable design flexibility in that components can be placed where convenient and connected with wires rather than shafts and gears.

There is a major international effort to develop hybrid electric propulsion for automobiles, medium and heavy-duty trucks and busses, trains, and ships. The Army can leverage these efforts in order to provide affordable components for future combat vehicles but will have to tailor the components and systems for its applications. For instance, hybrid drives will enable the Army to use commercial high performance diesel engines that are being developed for sport utility vehicles to power a 15 ton combat vehicle. The reason we can use these small, efficient engines in a 15 ton combat vehicle, is that energy storage components such as flywheels and batteries, which are also being developed commercially, provide the extreme power needed by a combat vehicle. The Army should also leverage ongoing programs at DARPA, such as the Combat Hybrid Power System and the hybrid electric Reconnaissance, Surveillance and Targeting Vehicle, to provide a foundation for their future programs. They should also integrate the pulse power development efforts ongoing in the EM and ETC gun programs with the hybrid power system work to provide an overall system solution. Using existing validated analytical models of hybrid power and propulsion systems coupled with virtual prototyping of combat vehicles, the Army can perform needed tradeoffs of vehicle size, fuel efficiency, mobility, weapon systems and survivability. These can then be used to guide the development of propulsion technologies, (i.e. wheels, tracks and suspensions) lethality systems, (i.e. guns, DEWs and missiles) and survivability systems, (i.e. active defense and low observable) as required for future lightweight, fuel efficient, lethal, survivable combat vehicles.

EM Launch of Loitering Round Compared to F-16 Wing

DoD and the Army have been conducting research on electromagnetic launch for many years. While some important progress has been made there are a number of major challenges remaining.

The payoff to a successful EM launch program would be high, particularly for the artillery and medium caliber gun applications. A tank application is technologically very stressing because of the smaller number of firings expected of a tank and because the packaging constraints would be more severe.

The technology for EM launch is, unfortunately, DOD unique. Although it remains high risk because of needed breakthroughs in the areas mentioned on the chart it is also potentially high payoff, and the panel believes a continued research program focused on the critical issues is warranted.

Efficiency in all aspects of operations and performance of platforms and weapons is crucial to the success of the Battle Force. Lighter vehicles which are air-movable will consume less fuel. Further efficiencies are possible with hybrid electric drive and ultimately fuel cells. In the next two to three decades the civilian economy will transition to hybrid electric drive and also reap other fuel economy and handling, traction and ride improvements because of the availability of on-board electric power at high levels.

At the same time, trucks will move to more payload efficient forms. The current fleets have payloads by weight of 30% of gross weight. Improved construction and materials will move this to the 50% to 60% range, thereby doubling the carrying and driver -- new efficiency. An example, Singapore defense forces have adopted a transport vehicle called the Flyer which has such properties. It has additional advantages, the capability to stack one vehicle on another and be air transportable on both military and commercial air freighters.

Application to Fire Support

As an example of what could be, the ASB posited a set of improvements to Crusader. Those advances included hybrid drive, possibly a wheeled vehicle, electromagnetic launch capabilities for a range of calibers and non-ballistic rounds.

Dramatic improvements and unparalleled flexibility would attend the successful upgrading of such a Crusader and its rounds. Crusader has the power and volume to employ near-term electromagnetic launch components that are volume and energy/power diversity limited (the reason for the concerns about EM possibilities as main tank armament). With these and a flexible sabot-rail combination, it could launch payloads ranging from 50 kg (approximately the weight of the current 155 mm round) to 500 kg at a muzzle energy of 10 MJ.

Range and effectiveness results are shown for guided non-ballistic rounds. In the case shown, the munition/lethality choice is the Air Force Tactical Munition Dispense (TMD) with CBU-87 characteristics. A 30-m CEP is nicely matched to such bomblets and area targets. If Crusader was so improved and supplied at the F-16 overall wing sustainment rate, within its zone of influence (25 km to 100 km from a launcher) it has the effectiveness of several wings of today's F-16 flying two sorties per day. This is not intended to diminish the F-16 because its range alone offers other advantages. The comparison is made to show the possible advances in providing 24 hr./day on call fires.

Platforms and Weapons

THE SOLDIER

- Soldier as a System Program focus is the soldier and hardware/software enhancements to his survivability and effectiveness
- Key program, but O&O focus is too narrow
  - Soldiers bond, train and fight as teams, small units, etc.
  - A team or small unit focus would rapidly surface weight carrying and energy needs on a scale which would lead to no-backpack solutions
  - Means to control space would take on a different form (as an example, the small unit could be a distributed sensor system)
- Miniaturization of many possibly useful services and capabilities are either opportunities to add more weight or lost opportunities. The benefit of another 10 lbs of widgets to soldier or small unit is poorly understood and the weight carried climbs.
- The Army leads the DoD and the world in distributed live, virtual and constructive TES to understand how to beneficially integrate men, doctrine and platforms through objective assessment
- The Army has very limited (possibly primitive) means for such purposes to bring technology and the soldier or small unit together. Changing the focus to small unit and having objective assessment is needed.

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Platforms and Weapons

FINDINGS

- Tradeoff of ground vehicle weight for air transportability and tactical mobility requires new approaches for achieving platform survivability (e,g., signature management, APS)
- Advanced weapons (KE/CE/DEW/NL) expected to be available for fielding with AA2010 Battle Forces could provide dominant overall force lethality against many types of targets
- Battle force survivability and lethality will be enhanced by implementing beyond LOS and SAS-enabled cooperative engagement capabilities
- Adding loitering capabilities to selected missile systems will facilitate cooperative engagement and increase overall force lethality and optempo by eliminating latency effects
- Use of robotic ground and air vehicles for reconnaissance, responsive precision fires, and suppression will provide critical new survivability and lethality benefits, including timely BDA capabilities
- Ability of Battle Forces to conduct sustained operations for several days without external refueling or ammo resupply could be enhanced by adoption of vehicle hybrid electric drive and medium-caliber EM guns
- Soldier as a System program misdirected to individual soldier; strong team/small unit focus needed
- Substantial simulation/experimentation/testing needed to validate AA2010 Battle Force concepts; FSCS program and Strike Force activities provide potential test beds

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The Soldier

The Army has now and in the design of its future forces a high priority requirement to make substantial improvements for its dismounted soldier teams. It has an ongoing program which has many promising technology thrusts. These, we believe, would be much more valuable in a circumstance where the O and O concept was expanded from the individual soldier to the team. The major "enemy" in improvements is adding weight to an already heavily overloaded soldier.

With a team concept, the teams corporate capability is what is sought. A corporate radio strategy would lead to much lighter radios and batteries while still allowing team communications performance.

To some extent the efforts thus far have not had the intellectual basis for dismounted combat that applies in the instrumented circumstances which mounted forces have prepared for over two decades. In addition to an Operational and Organizational (O&O) comparison, the Army should raise the TES support for dismounted operations to match that of the mounted force.

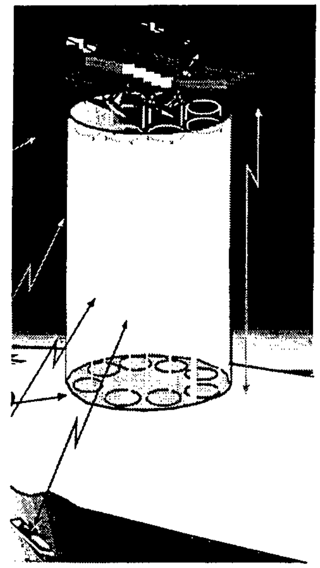
Platforms and Weapons Findings

The summary of findings is shown on the facing page. There is little need to repeat these as they have been advanced in some detail in this briefing format and in greater detail in Appendices K, L and M. The Army's design efforts for its future force has opened some revolutionary areas for exploration. The ASB suggestions are made to add to the list of such possibilities.

Investment Strategy

AAN TECHNOLOGY SHORT LIST

- Hybrid Power Systems
- Logistics Efficiencies (fuel efficiency, ultra-reliability, weight reduction)
- Human Engineering/Cognitive Engineering
- Signature Control (including counters)
- Protection Schemes for Land Systems (including active protection)
- Advanced Materials
- Affordable Precision and Alternate Lethality Means
- Alternative Propellants
- Nonlethal Capabilities
- Biological and Chemical Protection, Antidotes, and Vaccines



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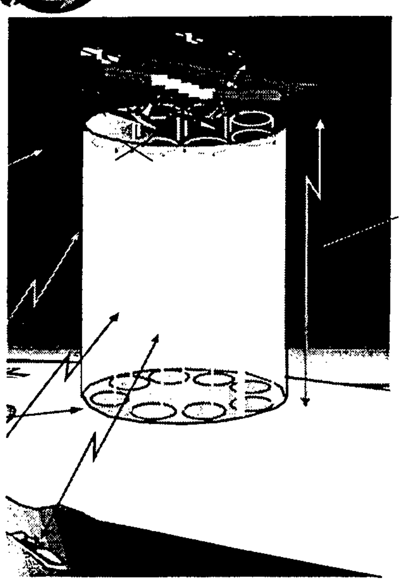
Investment Strategy

AAN SYSTEMS SHORT LIST



- Situational Awareness
- Global Maneuver Platforms
- Advanced Airframe
  - Heavy Lift/Tactical Utility Lift
- Future Fighting Ground Craft
- Autonomous and Semiautonomous Unmanned Systems (air, ground, sensors)
- Advanced Fire Support Systems
- "Living Internet" with Mobile Non-Line-of-Sight Communications
- Assured Intelligence, Surveillance, and Reconnaissance
- Soldier As a System

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AAN Technology Short List

As part of the AAN effort, integrated idea teams were formed. These brought together operational and technical experts from within and outside the Army (to include developers).

As the operational characteristics of the air-mech Battle Force emerged, needs for technical improvements were formulated in a pseudo-requirements-like process. Army and industry experts addressed these requirements by postulating future developments based upon improvement trends in areas such as materials, propulsion, armament, protection, weapons, vehicles and information systems.

The process involved iterating operational and technical possibilities until a convergence was developed. From this convergence, needed science and technology advances were described. These when integrated were prioritized. The so-called Short List of AAN S&T priorities thus emerged.

Because the process was holistic in character, much of the effort had to be based on assumed success in integration across categories of improvements. Of necessity the interdependence between categories was understood intellectually and internally coupled. There was, however, no formal effort made to address integration and interdependence.

A complete summary of the items on the short list can be found in the Army's Science and Technology Master plan.

The AAN Systems Short List focuses on major force assets; some highlight Battle Force requirements.

- Situational Awareness. Processing and display systems to create/present an integrated picture of friendly; enemy, and environmental knowledge. Adaptable templates, filters, and displays, tailored to individual and situation. Provides battle command/decision aids; planning tools; platform training and rehearsal by platform to support distributed, enroute, and remote training, planning, and operations.
- Global Maneuver Platforms. Rapidly deploy sizeable landpower forces to theater; increase speed, weight, and volume with ultra-heavy airlift and high-speed sealift (75-100 kts). Leverage commercial lift; emphasize modularity and containerization; enable logistical throughput. Strategic maneuver enabled with platforms that bypass lodgments (airfields and seaports).
- Advanced Airframe. Enable operational and tactical maneuver through vertical envelopment with VTOL and super-STOL airframes able to rapidly load/unload, lift at least 15 tons internally, fly minimum of 1000-km combat radius at 300 kts or more. Emphasize survivability and fuel efficiency.
- Future Fighting Ground Craft. Highly mobile, lightweight armored platform (15 tons or less) with BLOS precision lethality (up to 50 km). Common chassis and components shared among family of vehicles. Reduced crew supported by crew aids, able to oversee multiple robotic companions. Optimized mix of mobility, lethality, and survivability (against multiple KE for latter). Operate for days without resupply.
- Autonomous and Semiautonomous Unmanned Systems. Force, platform, and dismount enabler for protection, RISTA, comms, fires, and logistics. Reduce exposure of manned systems and extend force presence beyond manned platforms, to include distributed unattended sensors. Full regime of air and ground platforms, including microsystems; support MOUT/complex terrain. Reduced size and cost.
- Advanced Fire Support Systems. Manned and unmanned air and ground platforms; multi-functional systems able to mix munitions. Includes containerized unattended modules and loitering platforms/ munitions to reduce latency. Balance of reachout and organic, PGM and area effect; support cooperative engagement/effects management; extended range (up to 200 km organic); minimize logistics burden, uses modular and containerized logistics; support MOUT/complex terrain.
- "Living Internet" with Mobile NLOS Comms. Uninterrupted and reliable movement and storage of information. Design on diversity, GIE, plug-in modularity, dispersed and highly mobile operations, self-healing and graceful degradation, microsystem connectivity, functional in MOUT/complex terrain.
- Assured ISR. Front-end processing, sensor-to-user direct links, MOUT/complex terrain.

Soldier as a System. Focus on enabling the small team and dismounts, reduce/offset loads (50 lbs or less on soldier), individual power, operations in urban/complex terrain.

Investment Strategy

ARMY MODERNIZATION PLAN

Investment Categories	Patterns of Operation	Plan Time Frame
Information Dominance	Information Dominance	Near-term: FY98-03
Overmatch	Shape the Battlespace	Mid-term: FY04-10
Essential R&D/Leap-ahead	Decisive Operations	Far-term: FY11-20
Recapitalization	Project the Force	
Contributing Capabilities	Protect the Force	
Infrastructure	Sustain the Force	

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Investment Strategy

FINDINGS

- **Investment strategy overall**
  - Does not address the significance to the Army of commercial and non-Army programs, means, processes and technologies
  - Implies that the Army system development and acquisition process which is heavily bottom-up is appropriate for the full spectrum of possibilities
- **S&T focus for AA2010**
  - S&T priorities are set on a compartmented stovepipe basis coupled with holistic assessment and logic
  - The designs of the battle force, its component platforms and weapons are inextricably coupled with the development and exploitation of deployment/sustainment technologies and information dominance technologies

There is little manifestation of interdependence

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Army Modernization Plan

The current (FY '98) Army Modernization Plan addresses needed improvements in terms of the Investment Categories and Patterns of Operation for the near, mid and far term. At best, such a methodology would account for contributions of an initiative (e.g. MIA2 upgrades, Crusader development, Land Warrior, etc.) to Patterns of operation or to tradeoffs among them. The surface interpretation (which the documentation creates) suggest it is a sorting with loose holistic ties to Patterns of Operations or implied force capabilities. The Plan, while very informative, does not provide a sense of absolute or relative priorities or the sense of overall integration so critical to Army operations. It is similar to such plans for air and naval forces which are platform based and whose operations are on a scale of hundreds to thousands of entity integration smaller than those of the Army.

Investment Strategy Findings

The Investment Strategy does not reflect possible contributions from commercial and non-Army government programs, means, processes and technologies. It does not reflect the significance of projecting the force, as an example, and tradeoffs that relate to this crucial force capability. It does not reflect the inherent tradeoffs between information dominance and protecting the force which is important to Army XXI but is at the core of the design of AA2010.

The Science and Technology priorities for AA 2010 show these same fundamental shortfalls. In the case of AA2010, positive interdependencies are at the heart of achieving desired force capabilities. In the case of both the Investment and S&T strategies, the Army is being limited by its bottom-up and stove-pipe mechanisms. Integration is the key to the future. The Strategy for Investment should be based on a combined top-down and bottom-up approach. This is absolutely necessary if the Army is to get the full benefit of investments made outside the Army as well as large-scale cross-stovepipe innovations within the Army. The S&T strategy should be this embracing.

Recommendation

SCIENCE AND TECHNOLOGY INVESTMENT STRATEGY

- **Organize an Investment Council at the Army's highest levels to provide leadership for the Army through**
  - Direction on integrated Army assessments of new strategic options
  - Strategic Guidance on Investments (S&T and other) to the Army
  - Decisions on non-Army investments to leverage or advocate
  - Top-down direction on resource allocation within the Army
- Council function is to make broad strategic investment decisions including reliance on commercial and non-Army developments
- **Sec Army and CSA establish and organize council**
- Organize and start functioning by 1 Oct 1998

Payoff: Use of Other People's Money (OPM) where possible and focusing of Army resources on the fighting Army

Recommendation

SCIENCE AND TECHNOLOGY INVESTMENT STRATEGY *EXAMPLES*

Gain early access to participate in and influence programs which could affordably underwrite substantial capability improvements in AOE, Army XXI and AA2010 through

- Major *COMMERCIAL* investments being made in
  - Expanding air transport (passenger and freight)
  - Providing innovative heavy and outsize cargo air lift
  - Providing innovative fast sea lift
  - Establishing seamless, synchronized, high throughput intermodal means and processes
  - Transitioning automotive propulsion to hybrid electric power
  - Providing a capability explosion in worldwide access and high bandwidth fiber and space-based communication networks
  - Providing expanded space surveillance and mapping
- Major *GOVERNMENT, NON-ARMY* investments to demonstrate
  - Near-staring space-based MTI - SAR Tactical RSTA (DARPA + NRO + AF)
  - Survivable C2 on-the-move (DARPA)
  - Organic, high resolution battalion SAS (DARPA + DDRE)
  - A near-revolutionary C-130 replacement (AF+ industry)
  - JSTARS

Science and Technology Investment Strategy

There isn't anything as certain as uncertainty in the politico-military future, but the United States can act with assurance that its businesses will overmatch competition worldwide in the information sciences and in the technology to support swift dependable transportation of people and merchandise. As we have reported, in our interaction with representatives of firms that are in the forefront of these developments, we learned that they are genuinely supportive of being utilized in a national emergency. ***However, each stressed the importance of involvement by the Department of Defense very early in his program, if not at the outset.*** Uniformly, they pointed out that if the Army had an interest in using their materiel or services, the time to express that interest was before the firm began bending metal -- when the Army as a potential user might factor favorably in the decision of prospective investors, and when "national defense features" could be incorporated into the enterprise at least cost and highest tolerability for commercial use.

Civil aviation is the salient case in point, with the potential of providing by 2015, under an arrangement like today's Civil Air Reserve Fleet (CRAF) aircraft capable of lifting five times the tonnage of the military fleet then expected to be available, with higher availability rates and greater range. In a reversal of the pattern of the past century, the extraordinarily large aircraft now on the design board are intended to meet commercial demands. But these aircraft when built will be apt for carrying heavy and outsize military cargoes, and some may even be capable of landing on short, austere fields, or of vertical descent.

Comparable developments are underway vis-a-vis ship hulls and propulsion: container carriers with a speed in heavy seas in excess of 40 knots seem practicable.

As exciting as these new carriers may be, even more useful for military purposes is the hardware and software being devised to ensure fast reliable transit from point of manufacture to point of sale. These will enable minimizing warehousing and handling as the products move from one mode of transportation to another.

In addition, of course, the backbone of these capabilities is the ability to move vast amounts of information; extending pervasive and assured communications to whoever needs it, wherever they may be worldwide. Given the reach, power and sustainment these developments promise, leaders of today's Army would be irresponsible were they to fail to act to identify those of particular promise and dedicate whatever manpower and money may be necessary to use them. This will: 1) give the Army a strong voice in providing "national defense features," and 2) enable Army execution of swift decisive maneuver for projection. Such action entails seeking out and cultivating new supporters -- the Army as the primary protagonist for CRAF is a case in point. Nevertheless, if the Army leadership from top-down acts judiciously as we recommend, the Army after 2010 will be stronger than any in our history.

We recommend that the Secretary and Chief of Staff of the Army form an Investment Council to set priorities and provide advocacy for these programs which benefit the Army using the investments of others. This recommendation suggests that the Army add a top-down component to its future force planning and modernization effort. One might ask "why?"

The Army's "system" is a bottom-up one. The scope of individual activities is too small to support global initiatives of the kind suggested. Thus Army planning at the bottom employs only Army assets and resources and rarely looks outside.

Recommendation

MOBILITY AND SUSTAINMENT

- **Exploit non-Army capabilities and programs**
  - Gain early access to influence programs that could provide substantial improvements in the capability of AOE, Army XXI, and AA2010 through major ***commercial*** investments being made in:
    - Expanding air transport (passenger and freight); developing cargo aircraft capable of lifting heavy and outsize cargo; and building fast, reliable transoceanic container ships
    - Installing seamless, synchronized, high throughput intermodal transport means; and transitioning automotive propulsion to hybrid-electric power
  - Exploiting commercial communications networks, and space-based cargo tracking
- **AAE and CG, TRADOC as directed by Investment Council**

Payoff: Leverage large investments of OPM

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Recommendations

MOBILITY AND SUSTAINMENT

- **Experiments and ACTD'S "FedEXing" the force**
  - Conduct exercises involving ***commercial*** support that dramatically:
    - Improve the use of CRAF and CRAF-like civil transport
    - Restructure for force projection via modularity and containerization
    - Adapt civil methods for materiel handling and throughput optimization
  - Organize civil transport teams as Reserve Component units (airport loading/unloading, advanced stevedoring, asset visibility teams)
  - Explore with OSD extending CRAF-like programs to amplify contingency airlift and sealift with commercial planes and ships of coalition partners
- **CG, TRADOC and CG, FORSCOM as directed by Investment Council**

Payoff: Robust force projection capabilities

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Mobility and Sustainment Recommendations

The earlier portions of this report have provided estimates from a variety of sources concerning the likely growth in global commercial transportation and high confidence-high-throughput cargo systems. This recommendation suggests that the Investment Council select those non-Army capabilities for high level attention and related efforts within the Army.

High level attention by the Army Acquisition Executive and CG TRADOC should be undertaken with the most senior people in those companies so involved. The purpose is threefold. It is:

1) Understand where both traditional and innovative capability growth is going and gain a seat at the table in continuing discussions.

2) Formulate and execute programs within the Army to adopt support and encourage favorable developments (not necessarily limited to technologies but including means, integrated capabilities and processes).

3) Understanding and acting on additional possibilities in these sectors, particularly on one hand where Allies and friendly nations could be beneficially involved and on the other where US government action and influence can be brought to bear in addition to funding.

Within the Army, CG TRADOC and CG FORSCOM, assisted by CG AMC, should undertake a program to make a substantial improvement in modularity and containerization in all its forms. This will enable higher throughput, confident logistic support and reduced choke points and concentration which might attract enemy measures with unconventional and conventional weapons and weapons of mass destruction -- nuclear, biological and chemical.

Recommendation

INFORMATION DOMINANCE

- **Stand up a C4ISR system of systems integration testbed to evaluate and develop requirements for Battle Force C4ISR and SAS capabilities**
  - Use simulations/emulations of emerging technology
  - Use CECOM's Digital Integration Laboratory, its coupling to SIMNET and DDR&E Web concept as a start
- **ASA(RDA) draft plan 1 October 98**
- **PEO C3S lead integration of testbed capabilities and concepts into digitization programs thus enabling a Tactical Engagement System (TES) training capability**

Payoff: Totally integrated Battle Force C4ISR capability with embedded collective training

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Recommendation

INFORMATION DOMINANCE

- **Develop a plan to leverage civil sector and non-Army command, control and communications, and surveillance capability**
  - Commercial and civil sector space and terrestrial communications
    - AAE and DISC4 task force, draft plan by 1 October 98
  - Civil and non-Army surveillance
    - DCSINT draft plan by 1 October 98
  - Integrate DARPA technology investment for Army C4ISR programs
- **ASA(RDA) draft plan to transition DARPA technology into Army development programs by Jan 99**
- **ASA(RDA)/VCSA provide technical and management staff to support DARPA programs**

Payoff: AA2010 C4ISR advances financed in large part with Other People's Money

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Information Dominance Recommendations

The Army, the other Services and DARPA have a plethora of sensor related fusion programs intended to advance the future capability to be information dominant. The Army will assuredly construct networks of sensors to support fast paced, continuous battalion operations. Architecture and integration -- human and machine -- will dictate the effectiveness and robustness of possible network solutions. The Army should start now to develop the necessary test bed and tools to do this. The initiative outlined in the recommendation above suggests the ASA(RDA) draft a plan to start this activity.

As a complimentary action the PEO C3S should lead the effort to integrate the testbed with the digitization program. Included in this effort should be the capability to provide distributed training, mission planning and rehearsal and after action reviews.

To leverage major commercial investments in:

1) Communications,

2) Non-U.S. surveillance and

3) DARPA investments in C4ISR useful to the Army,

... the ASA(RDA) should draft a plan with tasking assuring these benefits for the Army. In addition, the Army should intensify efforts to staff the programs which grow from these initiatives to assure their continuing capabilities to meet Army needs.

Recommendation

PLATFORMS AND WEAPONS

- **Use the Future Scout and Cavalry System (FSCS) vehicles and the Strike Force family of vehicles as precursors for AA2010 Battle Force platforms**
  - Leverage commercial advances in hybrid electric power
  - Pursue development of advanced robotic ground and air vehicles
  - Investigate powering of various future weapons (DEW/EM)
  - Intensify critical vehicle survivability RDT&E efforts involving signature management and active protection
- **SARDA** – initiate in early FY99

Payoff: Early assessment of major technology challenges critical to Battle Force vehicle survivability and sustainment

Recommendation

PLATFORMS AND WEAPONS

- **Exploit technology advances in missiles and smart munitions to provide long-range, beyond line-of-sight, loitering, and cooperative engagement capabilities**
- Redirect EM Launcher S&T efforts to medium caliber gun and artillery applications
- Support continuing RDT&E efforts for a wide range of advanced weapons technologies: KE/CE/DEW/NL
- **SARDA** – initiate in early FY99

Payoff: Enhanced beyond-line-of-sight precision engagement capabilities and overall force lethality

Recommendation

PLATFORMS AND WEAPONS

- **Redirect the Soldier as a System program to emphasize soldier team / small unit capabilities**
  - Develop capabilities that enable dismounted units to conduct instrumented tactical engagement simulations (TES) to support R&D, training, operations rehearsal, and post-combat AARs
  - Assess potential utility of *organic* sensors to assure close-in (~ 1 km range) situational awareness (e.g., electric UAV, acoustic arrays, miniature robotic helicopters)
- **CG, TRADOC and AAE (all), PEOC3 (TES)**
  - Develop plan by January 1999
  - Implement NLT 1 October 1999

Payoff: Advanced capabilities for dismounted soldiers for Army XXI and AA2010 Battle Forces

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Platforms and Weapons Recommendations

The Army has launched a Future Scout Cavalry system program. This will be closely followed by a Strike Force vehicle family initiative which is a precursor for Battle Force developments. It is recommended that SARDA employ these programs as "testing vehicles" in the broad sense for components and sub-systems which critical for the future. Some may require emulation. Others may have live but not fully mature representation.

Candidates include hybrid electric power (which might also be a precursor for fuel cell employment) applied to manned and robotic platforms as well as signature management. Active protection, particularly that which would defeat KE penetrators, is crucial. Robotic investigations should be accomplished to benefit Battle Force and AA XXI units and platforms. Electric powering should be made available to future possibilities for future laser and high power microwave applications as well as EM launchers.

Similarly, currently planned improvement programs, (Crusader, MLRS, etc.) should be considered as vehicles to examine improvements which could provide major advantages to Army XXI and Battle Forces. These initiatives would include redirecting EM launcher work toward medium caliber and artillery capabilities, extended range and loitering rounds should be explored along with cooperative engagement to reduce or eliminate latency. These initiatives should be directed by SARDA.

The current Soldier as a System or Land Warrior program should have a broader operational and organizational basis to reflect the needs of unites engaged in combined arms operations which involve dismounted teams. CG TRADOC and the Army Acquisition Executive should jointly drive this change.

In addition, the needs for fully instrumented tactical engagement simulation should be met by PEO C3 to bring dismounted training and experimentation up to the standards established for mounted forces.

It is recommended that SARDA lead the first two efforts recommended above. They involve, on one hand, seeking development successes inside and outside the Army to provide the building blocks for the realization of the combat vehicle families needed to underwrite the air-mechanized concepts for the Battle Force of the future Army. On the other hand, they focus on weapons needed by both direct combat vehicles and those that are used for fire support. Implicit in both developments is the need for new concepts for use such as loitering and cooperative engagements.

Improving circumstances for dismounted combat requires re-examining and, we believe, exploring the operational and organizational concept for the related technology program. It is recommended that TRADOC provide a soldier team concept to be underwritten. The next step is to provide a tactical engagement simulation improvement to understand the possibilities offered in particular technology solutions. With these in mind it is believed that a much more effective and lighter weight suite of "things" will be available to revolutionize the dismounted combat force for the future Army.

Recommendation

SCIENCE AND TECHNOLOGY INVESTMENT STRATEGY

- **Organize an Investment Council at the Army's highest levels to provide leadership for the Army through**
  - Direction on integrated Army assessments of new strategic options
  - Strategic Guidance on Investments (S&T and other) to the Army
  - Decisions on non-Army investments to leverage or advocate
  - Top-down direction on resource allocation within the Army
- Council function is to make broad strategic investment decisions including reliance on commercial and non-Army developments
- **Sec Army and CSA establish and organize council**
- Organize and start functioning by 1 Oct 1998

Payoff: Use of Other People's Money (OPM) where possible and focusing of Army resources on the fighting Army

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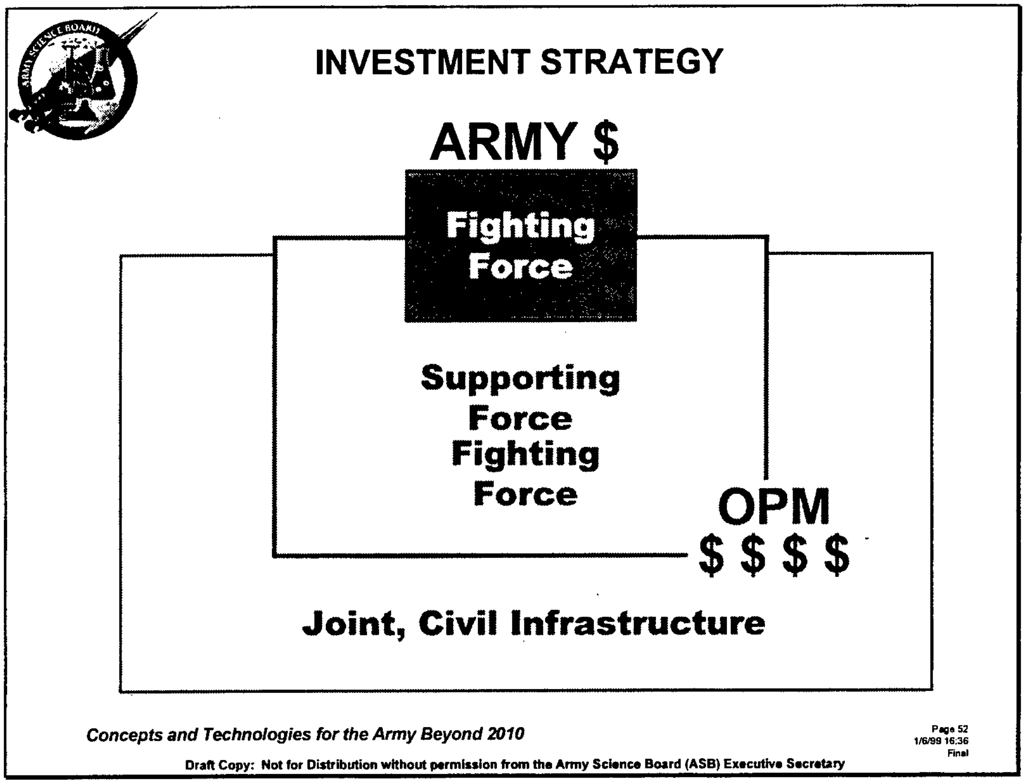

Investment Strategy

The first recommendation put forward in this report identifies a series of on-going commercial and non-Army DoD developments whose exploitation could materially benefit the Army. An investment council was recommended as a means to select and focus attention on all or a subset deemed to be the most adaptable and affordable. This approach would also provide a means to communicate to at least the Army, OSD and the Congress its priorities and its ability to leverage developments outside the Army. While it could be described as using other people's money, it is substantially broader and more sophisticated than this simple description implies.

As an example, the Army could employ as a sophisticated multifaceted adoption of both traditional and innovative forms of airlift and sealift and the employment of Reserve Component forces to generate, receive and sustain forces to project power rapidly and affordably. In doing so, it is partnering with and leveraging the continuing strength and world class components of the US and world economies. The relationship between the Army and these world class commercial activities has some familiar partnering aspects similar to those with industry. The remainder, though, is different. The Army might be an early investor or it could be a facilitator with other branches of the Government. Regardless of the differences, the financial leverage is very substantial.

The Army Science Board was asked to suggest an Investment Strategy as part of its terms of reference. Earlier versions of this report have focused attention on beneficial contributions which could be leveraged by the Army in both the commercial and non-Army defense domains.

It has also been stated that accessing such cost effective benefits is too difficult for participants with limited scope of action and even narrower authority which is a characteristic of a bottom-up requirements development process.

The ASB therefore recommends a two part investment strategy. The first part is the equipment now in place (a bottom-up component). The other is directed from the top. It is expected to use "other people's money" and its employment will force changes in both choices and priorities which "bubble-up" from the bottom up sectors. Properly balanced, the future Army, including its legacy components, will be more effective and affordable.

APPENDIX A

TERMS OF REFERENCE

DEPARTMENT OF THE ARMY
OFFICE OF THE ASSISTANT SECRETARY
RESEARCH DEVELOPMENT AND ACQUISITION
103 ARMY PENTAGON
WASHINGTON DC 20310-0103

REPLY TO
ATTENTION OF

8 DEC 1997

Dr. Michael S. Frankel
Chair, Army Science Board
103 Army Pentagon
Washington, DC 20310-0103

Dear Dr. Frankel:

I request that you conduct an Army Science Board (ASB) Summer Study on "Concepts and Technology for the Army Beyond 2010." The study should address, as a minimum, the Terms of Reference (TOR) described below. The ASB members appointed should consider the TOR only as guidelines and may include in their discussions related issues deemed important or suggested by the sponsors. Modifications to the TOR must be coordinated with the ASB Office.

Background.

a. Assessing the future and crafting an associated vision of future Army requirements demands a process that anticipates the nature of warfare in the next century as well as the evolution of US national security requirements. In addition, the process should consider visions and concepts for joint and combined operations, and the expected technological capabilities that can support these requirements. For that purpose, the Army After Next (AAN) is conducting broad studies of future warfare to frame issues vital to the development of the Army and to provide those issues to the senior Army leadership in a format suitable for integration into the Concept Based Requirements Systems and the TRADOC Requirements Determination process. To ensure a comprehensive and holistic perspective focused on the year 2025, the approach is organized around four broad research areas: the geostrategic setting, the evolution of military art, human and organizational issues, and technology trends. It is this latter area to which this study broadly addresses itself.

b. The Army's leadership must soon determine how to apportion research and development resources among a host of competing technological alternatives. Also, it must determine how much of the Army to modernize along current lines before superseding Army XXI (the "programmed force" falling largely within the influence of the Program Objective Memorandum (POM) covering the next 5-to-7 year period) systems with new technologies and significantly different operational and organizational concepts, thereby creating the "potential force" which is described by (1) the AAN project; (2) the concepts development process (see TRADOC Pam 525-5); (3) the TRADOC Requirements Determination process which includes an experimental process through the Battle Labs; and (4) S&T programs such as AAN 6.2 STO Enhancement Program, ACTD, ATD, ACT II and other such advanced concept and technology projects.

c. Planning for the distant future tends to concern capabilities and possibilities—the *how* rather than the *who* or *what*. While pragmatic near-term planners try to improve existing systems, longer term visionaries can deal in theory and emerging capabilities in a more abstract fashion. The challenge is linking the two without allowing the present to consume the future, or the vision to become intellectually sterile. The Battle Lab Integration, Technology and Concepts programs and the AAN program are primarily focused on treating the potential force. Here the focus shifts from improvement of fielded capabilities to long term research and development programs; and from current and programmed force structures to as-yet-unspecified capabilities associated with the emerging vision and concepts of future warfare.

d. The Battle Lab Integration, Technology and Concepts program and the AAN program are the primary link to other DOD agencies engaged in long term development—for example, Defense Advanced Research Projects Agency projects and various Defense Science Board studies. Some of these efforts frequently push the outer bounds of practicality. Moreover, because the potential force is generally not hostage to the POM, it represents the most promising opportunity for true integration with sister Service concepts, such as the Air Force's ultra-high-altitude UAV and the Army's lead of the DARPA Small Unit Operations project.

Terms of Reference.

a. Receive briefings on concepts that include, but are not limited to, Small Unit Operations (the subject of last year's DSB Summer Study on "Tactics and Technology for 21st Century Military Superiority"), "USAF Expeditionary Forces" (AFSAB Summer Study 1997), "Future of the Navy" (National Academy of Sciences and Engineering) and Extended Littoral Battlespace (ONR ACTD). Also receive briefings on (1) the geostrategic environment and possible threats in that timeframe; (2) the developing concept to be published in TRADOC Pam 525-5; (3) the results of the Army Warfighting Experiments (AWE) and, (4) possible AAN concepts of operations and the lessons learned from the AAN wargames.

b. Identify joint missions, with an emphasis on land combat, that integrate the concepts/visions with those identified above and AAN.

c. Identify technology drivers and enablers for the Army beyond 2010 and the identified joint mission concepts. Identify and place particular emphasis on those emerging technologies that are robust in that they support a variety of emerging concepts of operations and that require maturing or are inadequately funded. Comment on the adequacy and direction of military and private-sector research and development activities and investment strategies in advancing and achieving AAN goals and objectives. The technologies should support: rapid and decisive force insertion and extraction, survivability and force protection, command, control, and communications (C^3--on the move and at extended ranges), strategic maneuver, precision strike, precision engagement, sensors to detect and localize targets, real-time situational awareness at all echelons, and effective logistical combat services.

d. Review and comment on the Army's present Science and Technology strategy in support of the Army Experimentation Plan and the AAN. Comment on cooperative S&T opportunities with DARPA, the other Services, NASA and the National Laboratories. Indicate how US industry can be involved.

e. Develop a technology exploitation and overall investment strategy (not just S&T) for the Army to move toward and realize advanced concepts and capabilities out to about 2025.

Study Support. Cosponsors of this study are LTG Paul J. Kern, Military Deputy to the Assistant Secretary of the Army (Research, Development and Acquisition); LTG Thomas N. Burnette, Deputy Chief of Staff for Operations and Plans; LTG John N. Abrams, Deputy Commanding General, TRADOC; and LTG Dennis L. Benchoff, Deputy Commanding General, AMC. The Study Cognizant Deputies are Dr. A. Fenner Milton, Deputy Assistant Secretary for Research and Technology; BG Robert St. Onge, Deputy Director for Strategy, Plans and Policy, ODCSOPS; MG Robert T. Clark, TRADOC Deputy Chief of Staff for Combat Developments and BG Edward Buckley, TRADOC Deputy Chief of Staff for Doctrine; MG John Caldwell, DCS(RDA), AMC. The primary staff assistant is Dr. John Parmentola, OASA(RDA). Other staff assistants are LTC John Medve, ODCSOPS; COL James F. Bald, Jr., AMC; LTC Henry Franke, TRADOC; Dr. Bert Smith, ODCSINT; Mr. Mike Hendricks, ODCSLOG; Mr. Roy Cooper, OASA(RDA).

Schedule. The study panel will initiate the study immediately and conclude its effort at the report writing session to be conducted 13-23 July 1998 at the Beckman Center on the campus of the University of California, Irvine. As a first step, the study co-chairs will submit a study plan to the sponsors and the Executive Secretary outlining the study approach and schedule. Conclusion of this study group will result in a final report to the sponsors in December 1998.

Special Provisions. It is not anticipated that this inquiry will go into any "particular matters" within the meaning of Section 208, Title 18, of the United States Code.

Sincerely,

Kenneth J. Oscar
Acting Assistant Secretary of the Army
(Research, Development and Acquisition)

APPENDIX B

PARTICIPANTS LIST

PARTICIPANTS LIST

ARMY SCIENCE BOARD SUMMER STUDY

CONCEPTS AND TECHNOLOGIES FOR THE ARMY AFTER 2010

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The Potomac Foundation

LTG Paul Funk (USA, Ret.)
Vice President for Mideast Operations
General Dynamics Land Systems

GEN Paul Gorman (USA, Ret.)

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Mr. William P. Brown
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Mr. Bruce Deal
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Mr. Bran Ferren
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Mr. Frank Kendall
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Cognizant Deputy

Dr. A. Fenner Milton
Deputy Assistant Secretary for Research and Technology

APPENDIX C

ACRONYMS

Acronyms

AA2010	Army After 2010
AAC	Army Acquisition Corps
AAE	Army Acquisition Executive
AAN	Army After Next
AARs	After Action Reviews
ABCS	Army Battle Command SystemS
ACAT	Acquisition Category
ACTD	Advanced Concept Technology Demonstration
ADO	Army Digitization Office
AEF	Air Expeditionary Force
AF	Air Force
AFSAB	Air Force Scientific Advisory Board
AFSS	Advanced Fire Support System
AGCCS	Army Global Command and Control System
AI	Artificial Intelligence
AMC	Army Materiel Command
AMCOM	Aviation and Missile Command
AOE	Army of Excellence
AOE ARTY BN	Army of Excellence Artillery Battalion
AOE BDE	Army of Excellence Brigade
AOE MLRS BN	Army of Excellence Multiple Launch Rocket System Battalion
APS	Active Protection System
ARDEC	Army Research, Development, and Engineering Center
ARL	Army Research Laboratory
ARTY	Artillery
ASA(RDA)	Assistant Secretary of the Army for Research Development and Acquisition [Note: Logistics responsibilities were transferred to ASA(RDA) in early 1999; title changed to "Assistant Secretary of the Army for Acquisition Logistics and Technology" -- ASA(ALT)]
ASB	Army Science Board
ASTMP	Army Science and Technology Master Plan
ASTWG	Army Science and Technology Working Group
ATD	Advanced Technology Demonstration
ATG	
ATGM	Anti-Tank Guided Missile
ATR	Automated Target Recognition
AWE	Advanced Warfighting Experiment
B2C2	Battalion and Below Command and Control
BAT	Brilliant Anti-Tank
BCIS	Battlefield Combat Identification System
BDA	Battle Damage Assessment
BDE	Brigade

BITS	Battlefield Information Transmission System
BLOS	Beyond Line of Sight
BN	Battalion
C2	Command and Control
C2E	Command Center Element
C2SID	Command and Control System Integration Directorate
C2T2	Commercial Communications Technology Testbed
C2V	Command and Control Vehicle
C2W	Command and Control Warfare
C3	Command, Control and Communications
C3I	Command, Control, Communications and Intelligence
C3IEW	Command, Control, Communications Intelligence and Electronic Warfare
C4	Command, Control, Communications and Computers
C4I	Command, Control, Communications, Computers and Intelligence
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance
CC&D	Camouflage, Concealment and Deception
CE	Chemical Energy
CECOM	Army Communication-Electronics Command
CINC	Commander-in-Chief
CKEM	Compact Kinetic Energy Missiles
CM	Countermeasures
COA	Course of Action
COTS	Commercial Off-The-Shelf
CRAF	Civil Reserve Air Fleet
CTC	Combat Training Center
DAMO-SS	Deputy Chief of Staff for Operations and Plans -
DARPA	Defense Advanced Research Projects Agency
DAS	Director of Army Staff
DAS(R&T)	Deputy Assistant Secretary for Research and Technology
DBBL	Dismounted Battlespace Battle Lab
DCS(RDA)	Deputy Chief of Staff Research Development and Acquisition
DCSD	Deputy Chief of Staff Combat Development
DCSDOC	Deputy Chief of Staff Doctrine
DCSINT	Deputy Chief of Staff Intelligence
DCSLOG	Deputy Chief of Staff Logistics
DCSOPS	Deputy Chief of Staff Operations
DDR&E	Director, Defense Research and Engineering
DEW	Directed Energy Weapons
DISA	Defense Information Systems Agency
DISC4	Director, Information Systems, Command, Control, Communications and Computers
DL	Distance Learning

DMSO	Defense Modeling and Simulation Office
DPG	Defense Planning Guide
DS	
DSWA	Defense Special Weapons Agency
DTAP	Defense Technology Area Plan
DTO	Defense Technology Objective
DUSA-OR	Deputy Undersecretary of the Army - Operations Research
EAD	Echelon Above Division
ECOM	Electro-Optical Countermeasure
EFOGM	Enhanced Fiber-Optic Guided Missile
EFP	Explosively Formed Penetrator
EM	Electro-Mechanical
EO/IR	Electro-Optical/Infrared
ERA	Extended Range Artillery
ERCEC	Edgewood Research, Development and Engineering Center
ETC	Electro-Thermal Chemical
EW	Electronic Warfare
FBC2	Force XXI Battle Command Brigade and Below
FC	Fire Control
FCS	Fire Control Systems; Future Combat System
FED EX	Federal Express
FOG-M	Fiber-Optic Guided Missile
FSCS	Future Scout and Cavalry System
FSV	Future Scout Vehicle
GCCS	Global Command and Control
GIS	Global Information System
GPS	Global Positioning System
HMMWV	High Mobility Multi-purpose Wheeled Vehicle
HNS	Host Nation Support
HPM	High Power Microwave
HQAMC	Headquarters of the Army Materiel Command
I2R	Imaging Infrared
IFSAR	Interferometric Synthetic Aperture Radar
IO	Information Operations
IR&D	Independent Research and Development
ISC/R	Individual Soldier's Computer/Radio
IWS	Individual Warfighter System
JSTARS	Joint Surveillance Target Attack Radar System
KE/CE	Kinetic Energy / Chemical Energy

KEM	Kinetic Energy Missile
LADAR	Laser Radar
LCLO	Low Cost Low Observable
LCMS	Laser Counter Measures System
LCPK	Low Cost Precision Kill
LIDAR	Light Detection and Ranging
LMSR	Large Medium Speed Roll-on/roll-off
LOS	Line of Sight
LOTS	Logistics Over-the-Shore
LRIP	Low Rate Initial Production
LTL	Less-than-Lethal
LW	Land Warrior
M&S	Modeling and Simulation
MAGTF	Marine Air-Ground Task Force
MANPRINT	Manpower and Personnel Integration
MAVS	Micro-Autonomous Vehicles
MEM	Micro-Electro-Mechanics
MEMS	Micro Electric Mechanical System
MEP	Mobile Electric Power; Mission Equipment Package
METT-T	Mission, Enemy, Troops, Terrain, Time
MHE	Materiel Handling Equipment
MILDEP	Military Deputy
MLRS	Multiple Launch Rocket System
MMUAV	Multi-Mission Unmanned Air Vehicle
MOUT	Military Operations in Urban Terrain
MRDEC	Missile Research, Development and Engineering Center
MSTAR	Smart Tactical Rocket
MTI	Moving Target Indicator
MTI-SAR	Moving Target Indicator - Synthetic Aperture Radar
MW	Mounted Warrior
NL	Non-Lethal
NLT	No Later Than
NLW	Non-Lethal Weapons
NMD	National Missile Defense
NRDEC	Natick Research, Development and Engineering Center
NRAC	Naval Research Advisory Committee
NVESD	Night-Vision/Electronic Sensors Directorate
O&O	Operational and Organizational
OOTW	Operations Other Than War
OPM	Other People's Money
ORD	Operational Requirements Document
OSD	Office of the Secretary of Defense

P3I	Preplanned Product Improvement
PAC-3	Patriot Advanced Capability-3
PEO	Program Executive Office (Officer)
PEO/3C	Program Executive Officer for Command, Control and Communications
PGM	Precision Guided Munitions
PGMM	Precision Guided Mortar Munitions
POS/NAV	Position/Navigation
R/S	Reconnaissance/Surveillance
RDA	Research Development and Acquisition
RDT&E	Research Development Testing and Evaluation
RFPI	Rapid Force Projection Initiative
RHA	Rolled Homogenous Armor
RORO	Roll-on Roll-off
RRF	Rapid Reaction Forces
RSTA	Reconnaissance Surveillance, Target Acquisition
S&T	Science and Technology
SA	Situation Awareness
SADARM	Sense and Destroy Armor
SAR	Synthetic Aperture Radar
SARDA	Office of the Assistant Secretary of the Army (Research Development and Acquisition) -- now revised, see ASA(RDA)
SAS	Situation Awareness System
SBIR	Small Business Innovation Research
SES	Surface Effect Ships
SIGINT	Signal Intelligence
SIMNET	Simulation Network
SINCGARS	Single Channel Ground and Airborne Radio System
SIPE	Soldier Integrated Protective Ensemble
SRO	Strategic Research Objective
SSCOM	Soldier Systems Command
SSTOL	Super Short Take-Off & Landing
STI	Stationary Target Indicator
STO	Science and Technology Objective
STOW-E	Synthetic Theater of War-Europe
SUO	Small Unit Operations
SUOSAS	Small Unit Operations Situation Awareness System
SUSOPS	Sustained Operations
SWA	South West Asia
T&E	Test and Evaluation
TAAD	Theater Area Air Defense
TACOM	Tank Automotive and Armaments Command
TAP	Technology Area Plan

TARA	Technology Area Review and Assessment
TARDEC	Tank Automotive Research, Development and Engineering Center
TENCAP	Tactical Exploitation of National Capabilities (program)
TERM	Tank Extended Range Munition
TES	Tactical Engagement System; Tactical Engagement Simulation
TF	Task Force
THAAD	Theater High Altitude Defense System
TOC	Tactical Operations Center
TOR	Terms of Reference
TOW	Tube-Launched, Optically Tracked, Wire Command-Linked Guided
TRADOC	Training and Doctrine Command
TRANSCOM	Tansportation Command
TWG	Technology Working Group
TWS	Thermal Weapon Sight
UAV	Unmanned Aerial Vehicles
UGV	Unmanned Ground Vehicles
UHF	Ultra-High Frequency
UPS	United Parcel Service
UWB	Ultra-Wide Band
UXO	Unexploded Ordinance
V/STOL	Vertical or Short Take-off and Landing
VCSA	Vice Chief of Staff of the Army
VISA	Voluntary Intermodal Shipping Agreement
VSAT	Very Small Aperture Terminal
WIN	Warfighter Information Network
WMD	Weapons of Mass Destruction
WRAP	Warfighting Rapid Acquisition Program

APPENDIX D

PREPARING FOR WAR IN THE 21ST CENTURY

PREPARING FOR WAR IN THE 21st CENTURY
by
Lieutenant General Paul Van Riper, USMC
and
Major General Robert Scales, USA

As we write this article, the United States government has embarked on a major reassessment of current and future military requirements. Given the lead-time involved in making any significant change in the nation's defense posture, the results of this review are likely to influence American military capabilities well into the next century. All the more reason to insist that any such reexamination of America's military requirements should reflect a clear understanding of the likely character of future war. Thus we are troubled by recent claims that technological supremacy will allow the United States in the future to abjure the use of ground combat forces in favor of delivering advanced precision weaponry from platforms remote from conflict areas.

This is not the first time we have been lured by promises of high-tech, bloodless victory. In the early 1950s similar promises produced the New Look, a strategy proposing to rely on strategic nuclear weapons as an alternative to conventional warfare. Describing the origins of the New Look, one observer noted "the American yearning for some simple, single solution to all the bothersome and frustrating complexities of living in a world of perennial conflict."[1] Then, as today, optimists insisted that technological change had rendered conventional warfare obsolete. Events in Southeast Asia and elsewhere soon disabused them, but the resulting damage to conventional military capabilities persisted long after the United States had abandoned the New Look.

What overconfidence in nuclear weapons produced then, overconfidence in the microchip threatens to reproduce today. Recurring proposals to substitute advanced technology for conventional military capabilities reflect a peculiarly American faith in science's ability to engineer simple solutions to complex human problems. They also gratify both economic and political interests. That remains true even though the practical military impact of technological supremacy over the past half-century has been equivocal at best. Such supremacy could not prevent Holland's defeat in Indonesia, France's defeats in Indochina and Algeria, America's defeat in Vietnam, the Soviet Union's defeat in Afghanistan, or Russia's more recent defeat in Chechnya. All these episodes confirm that technological superiority does not automatically guarantee victory on the battlefield, still less at the negotiating table.

Nonetheless, belief in the possibility of a technological "fix" for the challenges of war has shown astonishing persistence. In addition to its impact on force postures, it has significantly affected even how Americans define military success. That influence peaked during Vietnam, in which reliance on body counts and other quantitative "indicators" virtually replaced strategic reasoning. And while defeat in Vietnam temporarily discredited such mechanistic thinking, some still insist that a technological solution for war is "out there somewhere," if only we could discover it.

In an important sense, therefore, U.S. military policy remains imprisoned in an unresolved dialectic between history and technology, between those for whom the past is prologue and those for whom it is irrelevant. Today's debate about the preferred structure of American military forces thus in the end is a debate about the future of war itself. The debate goes far beyond which weapons to buy or whether to favor this or that capability. At its heart, rarely considered and even less often articulated, are fundamentally incompatible views about the nature of war and about what conditions produce victory and defeat -- indeed, how one should define these concepts -- and ultimately, about the purpose for which we maintain military forces in the first place.

For those placing unbridled faith in technology, war is a predictable, if disorderly, phenomenon, defeat a matter of simple cost/benefit analysis, and the effectiveness of any military capability a finite calculus of targets destroyed and casualties inflicted. History paints a very different picture. Real war is an inherently uncertain enterprise in which chance, friction, and the limitations of the human mind under stress profoundly limit our ability to predict outcomes; in which defeat, to have any meaning, must be inflicted above all in the *minds* of the defeated; and in which the ultimate purpose of military power is to assure that a trial at arms, should it occur, delivers an unambiguous political verdict.

Such a view of war does not discount the importance of technology. But it recognizes that technology is only one of many influences on the conduct and outcome of military operations, an influence mediated by the nature, scope, and locale of the conflict, the character and objectives of the combatants, the attitudes of local, domestic, and international publics, and above all, the political issues in dispute. Acknowledging war's inherent unpredictability, it abjures over-reliance on any single capability, seeks maximum force versatility, and requires that military operations conform to the peculiar conditions and demands of the conflict itself.

America's military forces in the twenty-first century must exploit every advantage our technological genius can supply. But as we will argue in this article, the central ingredients of military victory or defeat will continue to reflect the enduring nature of war at least as much as the transient means used to prosecute it. And in the end, America's next war, like those which have preceded it, almost certainly will be won -- or lost -- on land.

From a geopolitical perspective, the world in which that war might erupt may be indefinite, but it is not indecipherable. On the contrary, it promises to look much like that of the late nineteenth century. As in that era, the principal engines of economic progress will continue to be the wealthy nations of Western Europe, North America, and the Asian rim. Political relations among these First World nations are, if anything, more stable than those which prevailed among the major powers after the Congress of Vienna, which inaugurated modern history's longest period of sustained great power peace. Healthy democracies, economic interdependence, cultural affinities, and the shared memory of two appalling world wars have created a community of interest that makes war among the developed democracies nearly unthinkable.

Unlike the major powers for 130 years after Napoleon, however, today's developed nations do not dominate the remainder of the world. Instead, they confront both developing states -- some of which, like Russia, balance precariously between aspirations to join the developed world and the threat of political, economic, and demographic collapse -- and Third World societies mired in economic and demographic misery. Nations in both groups tend to organize on different principles and operate on different premises from those of the developed democracies, and it is in relations within and among them that future military challenges are most likely to arise.

While some developing nations are poised economically to enter the developed world, neither political freedom nor respect for law, two of history's most reliable inhibitors of aggression, necessarily have accompanied their economic growth. Some, like China, continue to pursue irredentist claims against the territory of their neighbors. Others like Iran assert religious suzerainty over entire regions. All seek access to the raw resources that fuel development. And most continue to see war as a legitimate way of achieving their objectives. For many of these states, acquiring territory remains a basic impulse, for prestige if no other reason. Armed aggression may not be their only or even their preferred means. But especially among states with authoritarian governments, the conquest of land remains a legitimate ambition, and given their own economic and strategic interests, the developed democracies cannot remain unaffected.

In the meantime, vast portions of the world are economically either inert or retrogressing. While the proximate causes may be violent, venal, or otherwise misguided governments, the fundamental problems are structural. Many Third World societies remain economically dependent on subsistence agriculture and simple mineral extraction. In the meantime, the introduction of modern medicine has only accelerated a demographic explosion straining both their economic and political arrangements.

Among these societies, war tends to revert to its most primitive character. Driven by ethnic or tribal rivalries -- themselves often a function of differential population growth -- civil warfare will fester. Populous states will launch calculated invasions of less-crowded neighbors. Hordes of refugees will spill across borders provoking violence. And while war in the Third World may be waged with relatively unsophisticated forces, it frequently will drag on beyond any apparent strategic purpose, in part because it is aimed deliberately at depopulation. Finally, as recent events in Rwanda, Burundi, and Zaire illustrate, it often will manifest war's worst excesses -- intentional starvation, extreme brutality, and mass slaughter.

In these unhappy struggles, the developed democracies typically will seek reasons *not* to intervene. But as we have seen already, media-generated public revulsion may compel intervention. The visual horrors of genocide may be intolerable. Humanitarian efforts may backfire, as they did in Somalia. Or the collapse of Third World societies, whether through internal dynamics or external invasion, may threaten to destabilize an economically vital region to the point where nonintervention is imprudent.

Finally, we will continue to confront military challenges from non-governmental groups which fall neatly into none of these categories, but whose military capabilities and political, ideological, or economic objectives make them impervious to restraint by the civil police power. Such groups are far from a historical novelty, but their potential access to sophisticated military technology is unprecedented. They will remain among the most difficult military problems confronting us.

* * * * * * * * *

While the military challenges outlined in this appraisal vary in origin, kind, and degree of threat to U.S. interests, all have one thing in common: in each case strategic success will ultimately require the direct control of land, people, and resources. In confrontations with developing states, war is likely to be about the control of territory. In Third World episodes, it is likely to be about the control of populations. And suppressing terrorist and other non-governmental challengers will require depriving them of political, psychological, and material support.

In none of these cases is technology alone likely to be decisive, and in many cases the very nature of the contest will restrict its use. Notwithstanding, some visionaries insist that emerging technologies will utterly transform the nature of war, permitting the defeat of future adversaries from a distance with no need to risk precious lives in the maelstrom of land combat. Such predictions ignore both war's inherent uncertainty and what we have learned about military victory and defeat in our own time.

Soldiers and marines intuitively recognize the limits of prediction, and increasingly, even physical scientists share that recognition. From quantum physics to meteorology, science has become aware that "nonlinear" interactions pervade the natural world. We call such interactions "chaotic," and where they predominate, confident prediction is impossible. If that is true even of the apparent regularities of nature, how much more true must it be of war? As Clausewitz noted long ago, "No other human activity is so continuously or universally bound up with chance."[2] Indeed, Clausewitz remains relevant today largely because his work is "suffused with the understanding that every war is inherently a nonlinear phenomenon, the conduct of which changes its character in ways that cannot be analytically predicted."[3]

Recognizing that, observers as far back as Thucydides have insisted that war can be perceived accurately only through the lens of history. To be useful, military theory must be grounded in the known realities of the past, not because the past repeats itself in specific ways, but rather because it reveals aspects of war which are timeless.

One such enduring feature is the invariable subordination of war to politics. "War is not a mere act of policy," Clausewitz asserted, "but a true political instrument, a continuation of political activity by other means... War should never be thought of as something autonomous, but always as an instrument of policy."[4] In one way or another, political considerations always condition military operations. Allied commanders rediscovered that enduring reality at the very outset of the Gulf War air campaign, when two bombs aimed at a secret police communications bunker in the heart of Baghdad destroyed not only the bunker, but also 200-odd civilians sheltering inside it. Political reaction to CNN's telecast the following morning resulted in the abrupt curtailment of all attacks on the downtown Baghdad area.[5] In the process, it also removed any possibility of destroying the political infrastructure of Saddam Hussein's tyrannical régime.

As this incident confirmed, war in practice is hostage to political concerns that routinely preclude the unconstrained employment of military means. Such concerns tend to be highly situational, hence unpredictable. For that reason alone, the mere possession of advanced technology is no guarantee of its practical utility.

The second and most pervasive of war's enduring characteristics is what Clausewitz called "friction." "Everything in war is very simple," he observed, "but the simplest thing is difficult. The difficulties accumulate and end by producing a kind of friction that is inconceivable unless one has experienced war"[6] In battle, danger, confusion, fear, fatigue, and discomfort combine with a hostile physical environment to curtail the effective performance of both men and machines. Moreover, as battlefields enlarge, formations disperse, and operations accelerate, these stresses increase, even as familiar sources of physical and psychological support -- proximity to other units, lulls in activity, and the comfort of known ground -- continue to evaporate. Hence the laboratory at best is an imperfect predictor of battlefield effectiveness; and even where the employment of advanced technology is politically unconstrained, it is far from a military panacea.

The stresses of baffle, finally, merely are compounded for leaders, who must make crucial decisions with little time for reflection and in a welter of typically ambiguous information. "In the dreadful presence of suffering and danger," Clausewitz reminds us, "emotion can easily overwhelm intellectual conviction, and in this psychological fog it is...hard to form clear and complete insights."[7] Hence the profound danger of claims like those of certain Washington consultants who recently asserted, "What the [Military Technical Revolution] promises, more than precision attacks and laser beams, is...to imbue the information loop with near-perfect clarity..."[8]

Such arguments verge on the theological, having neither scientific nor historical foundation. On the contrary, as one observer has noted, "Much of the particular information which any individual possesses can be used only to the extent to which he himself can use it in his own decisions. Nobody can communicate to another all he knows, because much of the information he can make use of, he himself will elicit only in the process of making plans of action."[9] Similarly in war, there simply are too many critical pieces of information inaccessible to sensors and beyond the power of computers. In an information-rich environment in which what matters remains buried in noise, individuals at every level are limited in both what they can absorb and what they can pass along. And the more oppressed by danger and fatigue, the more vulnerable they become to both inadvertent misunderstanding and deliberate deception.

It is above all the interactive -- indeed, antagonistic -- quality of war that makes it unpredictable. "War is not waged against an abstract enemy," Clausewitz points out, "but against a real one"[10] America's adversaries in the next century will have options no matter what our technological advantages. Political limitation, friction, and fog are not artifacts of history, but rather conditions imbedded in the very fabric of war. To suppose that technology could eliminate them from the battlefield thus flies in the face of the natural world *as it is.*

Instead, twenty-five hundred years of history confirm that ambiguity, miscalculation, incompetence, and above all chance will continue to dominate the conduct of war. In the end, the incalculables of determination, morale, fighting skill, and leadership far more than technology will determine who wins and who loses.

****

Acknowledging war's inherent uncertainty by no means argues for ignoring technology. On the contrary, advanced information and munitions technologies already have had a significant influence on Army and Marine Corps doctrine. Some believe they may radically alter the relationship between maneuver and firepower, just as the tank and airplane did from 1918 to 1939. And every modern armed force must cope with increasing battlefield transparency, munitions lethality, information overload, and logistical vulnerability.

Our objection is not to technology itself but rather to claims that it will permit the achievement of victory by distant punishment alone, with no need to exert direct and continuing influence over the land, people, and resources which are war's ultimate stakes. In addition to what history reveals about the inherent nature of war, our own military experience in this century argues the contrary.

That experience repeatedly has confirmed that distant punishments unexploited by the physical domination of ground is a wasting asset. From Verdun to Cassino, the Iron Triangle to Al Busayyah, firepower along, even delivered on a massive scale, has rarely proved capable of ejecting determined troops from the ground they occupy. Even massive bombing in the Gulf War, for all its destructive and demoralizing effect on the Iraqi Army, could not by itself induce that army's withdrawal from Kuwait.

What is true of firepower delivered against troops in the field may be even truer of firepower delivered directly against an opponent's civil infrastructure. In fact, the evidence suggests that such efforts readily backfire, particularly when directed against opponents whose leaders can manipulate their publics' interpretation of events. We also must be concerned with the reactions of our own citizens as they watch modern weapons impacting among apparently defenseless populations. A problem likely to intensify as the developing states, the most probable loci of future high-intensity conflict, continue to urbanize.

Some argue that the increased precision of emerging munitions will limit collateral damage, making less likely both psychological stiffening on an enemy's part and psychological revulsion on our own. But precision means one thing applied to military forces in the field, quite another applied to heavily populated urban areas. Indeed, fear of media reaction to the scenes of carnage even among military targets along Kuwait's "Highway of Death" in part explains the Bush administration's decision to end hostilities in the Gulf War after 100 hours, though all the objectives of the ground offensive had yet to be achieved. [11]

There certainly have been a few cases in which the limited use of distant firepower alone produced strategic results. Air attacks against Libya in 1986, for example, seem effectively to have diminished Muamar Gaddafi's eagerness to openly challenge the United States. In such cases, in which objectives are limited or merely demonstrative, distant punishment may well curb hostile behavior. But it is unlikely in any permanent way to resolve the underlying issue, as the history of the 1965-68 air campaign against North Vietnam underlines. Rather, every such application of distant firepower risks the embarrassing possibility that the recipient simply will ignore the attack, forcing the attacker to choose between escalation or impotence.

In short, over-reliance on distant punishment ignores the psychology of an opponent's will to resist. There is an enormous difference between enduring distant attack, which however unpleasant must eventually end, and enduring the physical presence of a conquering army with all of its political and sociological implications. We should not lose sight of the difference between a Kuwait liberated by ground forces and an Iraq still truculent and combative, however ravaged by air attack.

The fundamental limitation of distant punishment is that it commits without resolving. Notwithstanding, its ease of use and apparent low risk make it deceptively attractive in cases where U.S. strategic interests are limited or ambiguous. Some even have urged redesigning American military forces specifically for intervention in such cases.[12] Such proposals are a gilt-edged invitation to back into war, and ignore everything we have learned so painfully over the past half-century about the incremental use of force.

* * * * * * * * * *

If resolution and durability are among the most important and irreplaceable contributions of land forces to victory in war and deterrence in peace, they are by no means the only ones. In the geopolitical environment forecast earlier, strategic success will place a premium on military versatility. Even the United States cannot afford to maintain capabilities tailored discretely to every potential military challenge, nor will any single capability accommodate all such challenges. Instead, American military forces must be capable of rapid adaptation to a broad and constantly varying range of strategic tasks and conditions.

Ground forces remain the indispensable foundation of that strategic versatility. Air and naval capabilities complement but can never replace the ability to deploy ground forces tailored to the peculiar conditions and objectives of a given conflict. To say that in no way deprecates their importance. No American commander today would consider launching ground combat operations without command of the air and space, nor littoral operations without command of the sea. Moreover, as the United States continues to shift from a forward deployed to an expeditionary force posture, dependence on both aerospace and naval capabilities will increase merely to insure ground forces reach the theater of operations rapidly and safely. Hence to insist that future U.S. military operations will inherently be joint is not just rhetoric but rather frank acknowledgment of strategic and operational imperatives. But only in unusual conditions will air, sea, or space operations alone produce decisive strategic results. In almost every circumstance, the effective integration of all components -- land, sea, air, and space -- will be required.

Moreover, U.S. military forces exist to deter as well as fight. Even after a half century of practice, our understanding of the dynamics of deterrence remains imperfect, but we have learned that a key requirement is making a deterrent threat credible. One of the central arguments for relying upon the threat of distant punishment is that its presumed low risk enhances that credibility. As we have seen, however, situations in which distant punishment alone is likely to be effective are precisely those in which the issues in dispute are least fundamental. The greater the stakes, the less likely that distant attack alone will produce a favorable strategic result. It follows that the greater the stakes, the less likely that the threat of such attack alone will deter.

Instead, reconciling credibility with effectiveness requires operational seamlessness. Deterrence is most likely to succeed when complementary capabilities reinforce each other, and when all contribute in a credible way to the assurance of victory should deterrence fail. That emerging precision attack systems promise to more effectively kill people and break things is not at issue. The challenge will be to translate those essentially tactical effects into strategic results. And the principal mechanism of that translation will remain an unrivaled land combat capability.

There is one additional reason why emerging technologies must be designed to enhance rather than replace land power. Whether to deter or fight, the U.S. probably will confront future adversaries as a member of an alliance. We have nearly a century of experience with alliances. And if one lesson can be drawn from that experience, it is that presence on the ground is an irreducible bonafide of alliance commitment, especially for the nation claiming leadership of that alliance.

Central to alliance commitment is the requirement to share risk. Thus, Sir Basil Liddell Hart's effort in the 1930's to restrict the continental role of British ground forces not only diminished deterrence, but also led to doctrinal and material stagnation for which the British paid a heavy price when deterrence failed.[13] More recently, repeated U.S. efforts to "rationalize" America's NATO contributions by substituting air for ground forces in return for greater European ground force contributions invariably foundered over the principle of shared risk.

The reality is that ground combat forces represent the strongest evidence of alliance commitment. That, and the fact that their deployment alone conveys an intention to remain engaged for the duration, makes them the irreplaceable adhesive of any military coalition.

* * * * * * * *

Any sustained period of peace challenges military institutions. It requires holding on to the immutable and terrifying realities of war in a climate of peacetime pursuits and ease, because only by an understanding of what war has been can we hope to glimpse what it will be. To prepare for the future, we must keep our grip on the past.

America's performance in its first battles rarely has been impressive.[14] The Gulf War broke the mold. For once, America took the field with a team that was ready to play. And the result was the shortest, most successful, and in American lives least expensive, military campaign in modem history.

But the military forces which won that war had been built to fight another, and in that fact there is a stern warning for today's planners. In an uncertain world, we dare not base force requirements on preconceived assumptions about whom we might fight in the next century or how. Instead, American military forces must be able to fight and win on any battlefield, under any conditions, and with whatever means the nature of the contest requires. And to do that, America will need robust, well-equipped, and sustainable land combat capabilities as far ahead as we can foresee.

Innovative application of emerging technology will enhance those capabilities. But in the end, war is a contest of human wills, not machines, in which means must be subordinated to ends if the results are to justify the costs. In the world we confront, those ends are likely to be more complicated, and the circumstances in which they must be pursued less predictable, than ever before in our history. A military posture that evades rather than accommodates that reality is doomed to expensive irrelevance.

ENDNOTES

[1] Warner R. Schilling, et al., *Strategy, Politics, and Defense Budgets* (New York, 1962), p. 386.

[2] Carl von Clausewitz, *On War*, edited and translated by Michael Howard and Peter Paret (Princeton, 1976), p. 83.

[3] Alan Beyerchen, "Clausewitz, Nonlinearity, and the Unpredictability of War," *International Security,* Winter 1992/1993, p. 61.

[4] Clausewitz, *On War*, pp. 87-88.

[5] Williamson Murray, *Air War in the Persian Gulf* (Baltimore, MD, 1995), pp. 190-192.

[6] Clausewitz, *On War*, p. 119.

[7] Clausewitz, *On War*, p. 108.

[8] Michael I. Mazarr, et al., "The Military Technical Revolution: A Structural framework," Center for Strategic and International Studies, March 1993, p. 38.

[9] Friedrich Von Hayek, *The Fatal Conceit: The Errors of Socialism,* in W.W. Bartley III, ed., *The Collected Works of F.A. Hayek,* Vol. 1 (Chicago, 1988), p. 7.

[10] Clausewitz, *On War*, p. 161.

[11] Col. (Ret.) Richard M. Swain, "Reflections on The Revisionist Critique," *Army,* August 1996, p. 28.

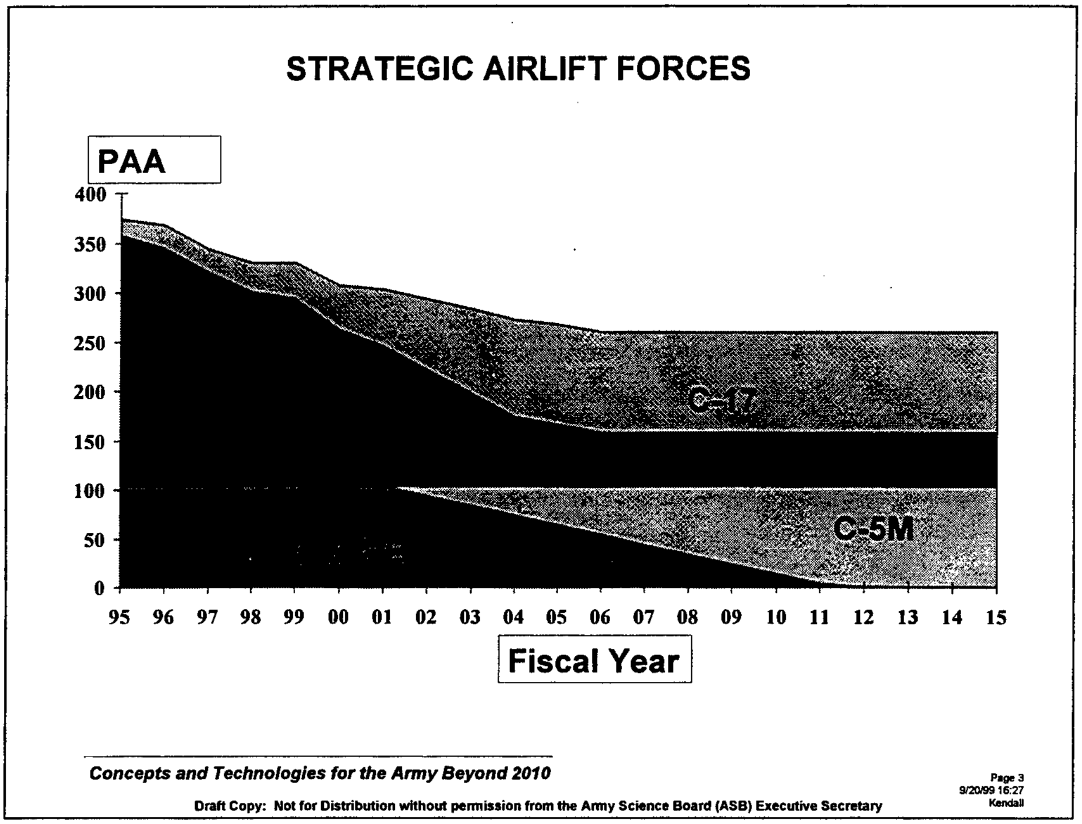
[12] Edward N. Luttwak, "A Post-Heroic Military Policy," *Foreign Affairs,* July/August 1996.

[13] Williamson Murray, *The Change in the European Balance of Power, 1938-1939* (Princeton, New Jersey: Princeton University press, 1984), pp. 86-91.

[14] Charles E. Heller and William A. Stoffi, *America's First Battles, 1776-1965* (Lawrence, KA, 1986)

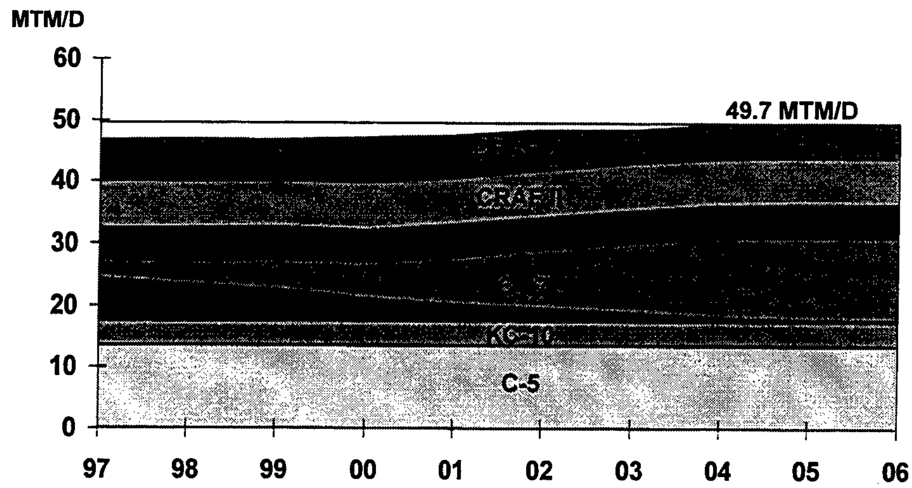
APPENDIX E

AIRLIFT



TRANSCOM's air deployment concept for the near future is depicted in two ways. The chart on the left shows the military strategic cargo aircraft available to the U.S. Air Force from the present day through 2015. While the C-141 is phased out, the C-17 is procured through 2006 to provide an equivalent lift capability. In the same timeframe, C-5A/B transports will be converted into more capable C-5M configuration.

STRATEGIC AIRLIFT CARGO CAPACITY



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Illustrated here is the TRANSCOM cargo deployment capability intended to reach fifty million ton-miles per day in 2006. It is composed of a baseline lift capacity of the large, Airforce owned C-5's, C-141's, C-17's and KC-10's supplemented by Civil Reserve Air Fleet capabilities of traditional passenger and freight aircraft owned by participating airlines. It is worth noting that there is no anticipated growth in TRANSCOM or its CRAF component even though commercial capacity is projected to double each decade.

A major change in Air Force capability results from the retirement of the C-141 and a gradual buildup of the C-17 fleet to a total of 120 aircraft.

CIVIL RESERVE AIR FLEET (CRAF)

- Provides commercial augmentation for DoD military airlift
- Consists of commercial air carriers that voluntarily commit aircraft to support airlift requirements that exceed the capabilities of Air Force organic aircraft
- Contributes significantly to DoD total airlift capability
  - 93% passenger   35% cargo

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The Civil Reserve Air Fleet, CRAF, has been established to provide surge capabilities in times of national emergencies. The commitments of the American commercial cargo aircraft vary as CRAF stages I through III are called into service. It is important note that this civil fleet represents a substantial portion of the required strategic airlift capability. CRAF III requires 60% of freighter commitments as an example.

MILITARY LIMITATIONS OF CURRENT CRAF FLEET

PASSENGER AIRCRAFT

- No significant limitations

CARGO AIRCRAFT

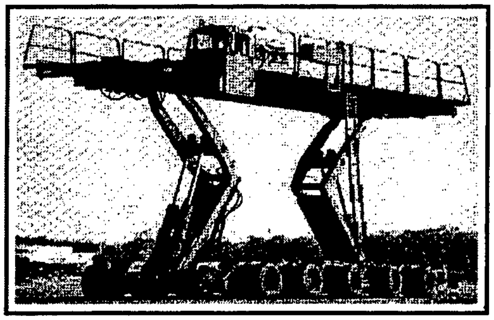
- Floor strength
- Cargo hold cross section
- Size/location of cargo doors
- Container configurations

Today's civil aircraft fleet has adequate capability for rapidly deploying large numbers of personnel. However, because of the size and weight of much military equipment, commercial airplanes have significant cargo carrying limitations. The items noted present difficulties when attempting to carry military loads such as large, heavy vehicles. However, the TRANSCOM and FedEx loading guides clearly show how a 10T M113 can be loaded or a 747 freighter and a 7.5 ton palletized load can be placed on a DC-10 freighter.

MATERIAL HANDLING EQUIPMENT

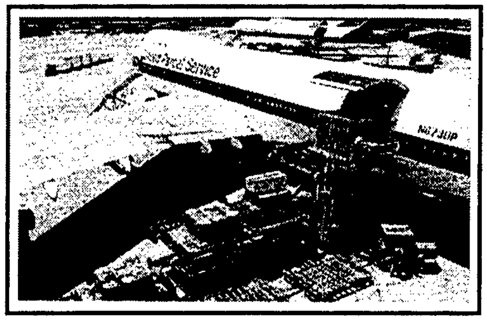
MILITARY

TUNNER AIRCRAFT LOADER



- Six Pallets / 60,000 Lbs
- Interfaces with all cargo aircraft
- Air transportable4 -- C-141, C-5, and C-17

COMMERCIAL



- Side loading
- Bulk cargoes

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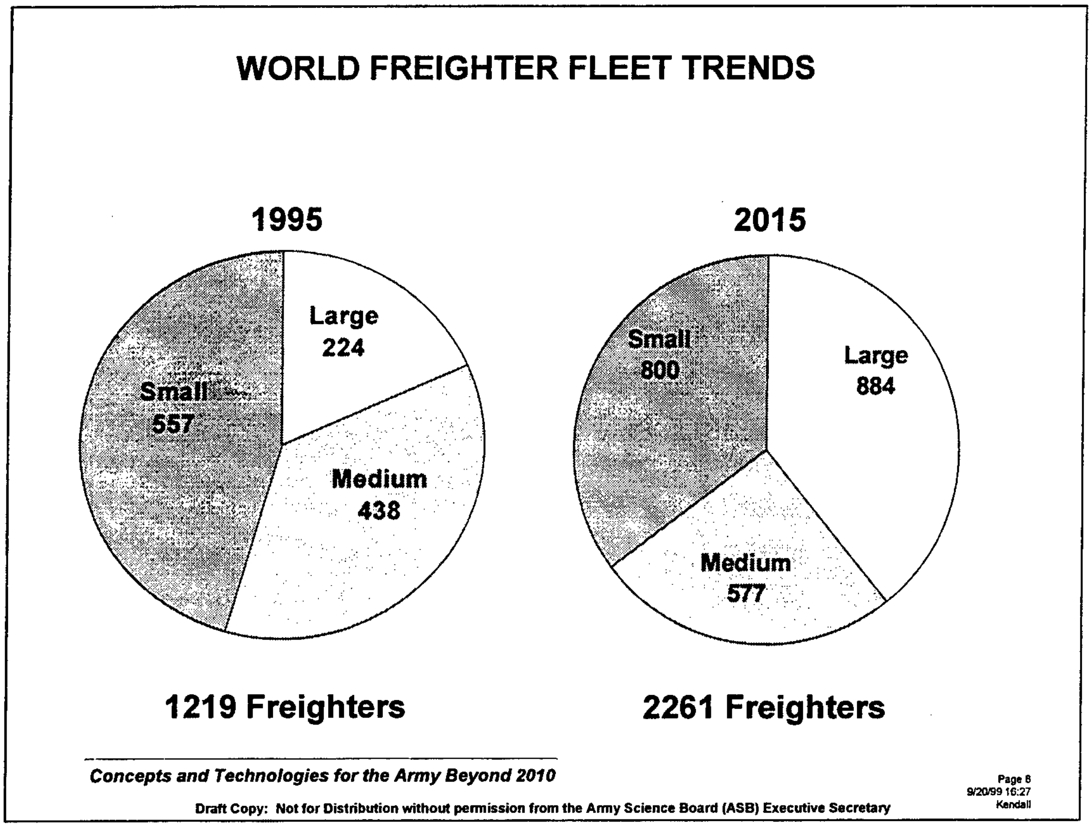
TRANSCOM has made materiel handling equipment its #2 priority for acquisition (#1 is C-17). This applies for both military and CRAF fleet operations. Such equipment and crews along with air traffic control applications could be the highest priority for initial insertion to maximize throughput and force buildup.

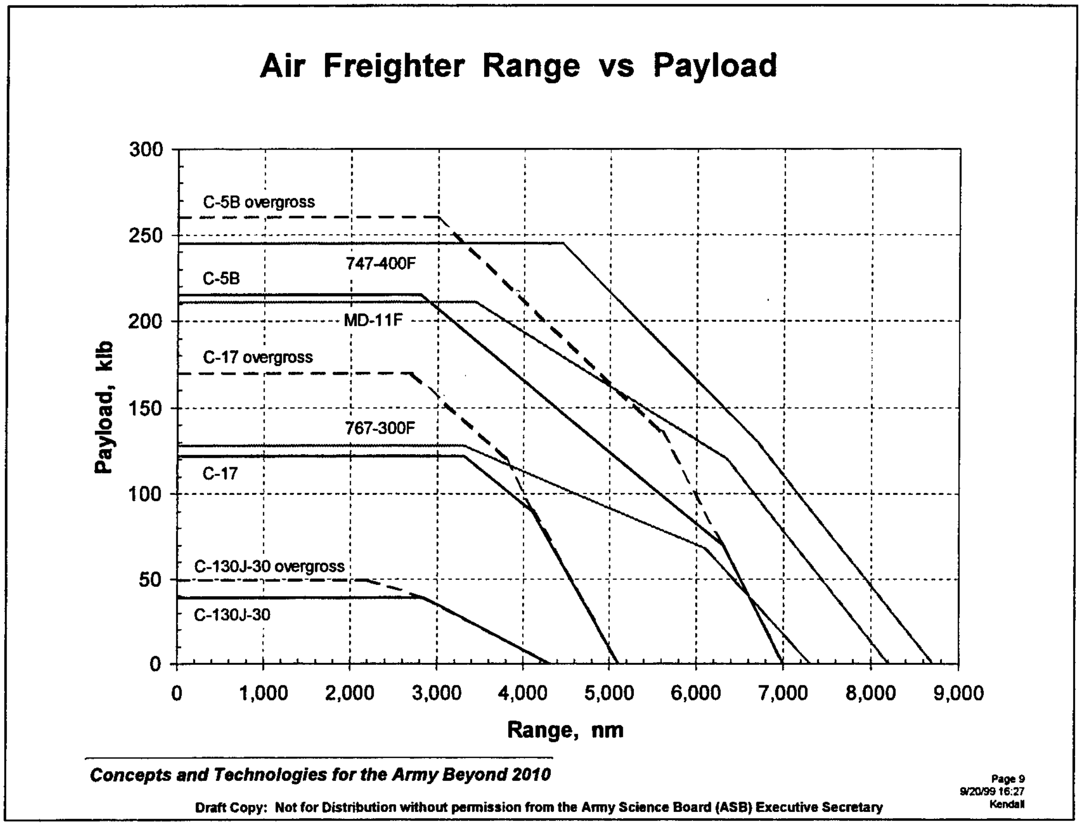
Reserve forces could play an important role in this aspect of power projection.



The rapid growth in commercial air cargo business is even greater than passenger business. This charge illustrates the anticipated need for air freighters by 2015. This represents a doubling of this sector in the commercial marketplace.

It is important to note that the greatest growth is anticipated in the large size freighter category -- a quadrupling in numbers of aircraft. This represents a substantial increase in rapid world-wide deployability.

It is important to note, however, that even though the numbers of large commercial air freighters will grow rapidly, their military capabilities are limited.



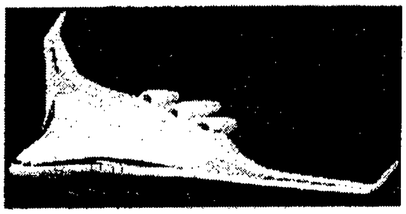
Commercial air freighters are optimized for very efficient, long-range operations from large civil airports using commercial material handling equipment. Military cargo aircraft are required to operate from smaller airfields with shorter and less strong runways plus very limited ramp space. In addition, military cargo aircraft are designed to carry both outsized and very concentrated loads (e.g., combat vehicles). These requirements add weight and compromise aerodynamic efficiency.

The bottom line is that commercial air freighters are more efficient than military cargo aircraft, when large airports and suitable material handling equipment are available. Thus the Civil Reserve Air Fleet (CRAF) air freight capability for strategic mobility is substantial and there is a strong incentive to design military equipment to be CRAF transportable. It is also essential to continue the Air Mobility Command program to procure military material handling equipment that can also work with commercial air freighters.

MATERI~1

ADVANCED CARGO LIFTERS

COMMERCIAL CONFIGURATIONS



BLENDED WING-BODY

Up to 1 million lb cargo capacity

Proprietary

HEAVY PAYLOAD AIRLIFTER

MILITARY REQUIREMENTS MUST BE INCORPORATED

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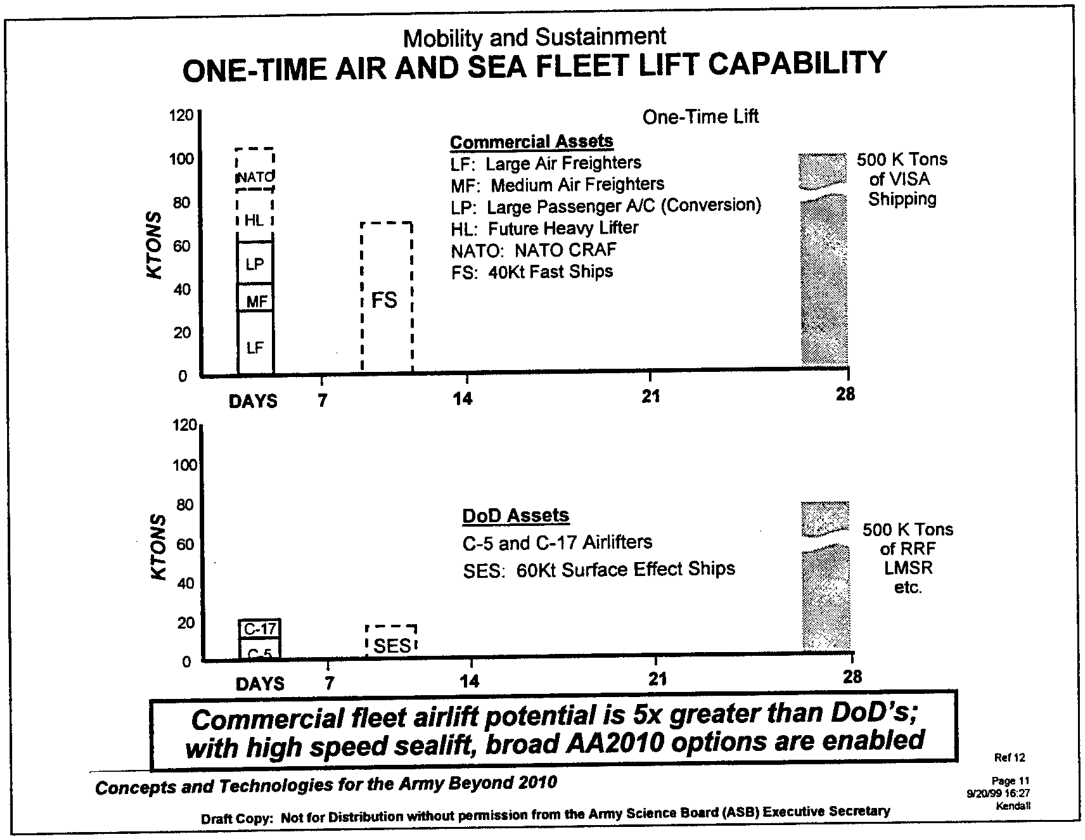
ADVANCED CARGO LIFTERS

Several concepts for improving the worldwide distribution of passengers and cargo are under study by aircraft manufacturers for commercial purposes. They might include the Boeing Blended Wing Body (BWB) and a proprietary Lockheed-Martin heavy lifter. Illustrated here are notional designs that can deliver large quantities of cargo (up to 1 million pounds) at global ranges.

A 17-foot mockup of the aerodynamically efficient blended wing body concept has been flown and other proprietary configurations are being evaluated.

The next large cargo aircraft and tanker will spring from a commercial need. It is important that military requirements be reflected in the initial design. Extensive coordination must occur during the conceptual phase so that these aircraft can be available during military emergencies. The Army must be a major participant in the DoD's efforts to track and influence such developments. It has not done this in the past.

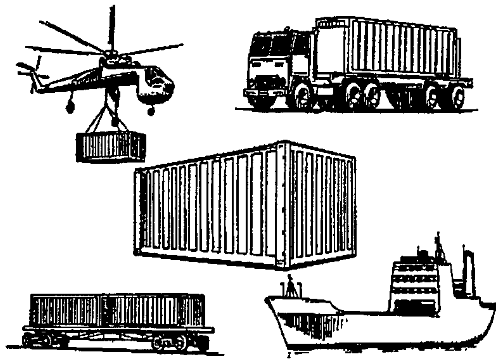


One technique or construct to asses the value of transportation platforms is to characterize the lift potential of the fleets of similar assets. Such a representation will provide insights into the relative value of individual fleets but without additional information this does not immediately translate into throughput or power projection details. The display above provides a measure of value in a display of fleet lift potential and the time at which a particular fleet could deliver its lift potential to a substantial distance (for example 6,000nm to 9,000nm).

Two clear cut conclusions flow from the portrayal of expected military air and sea strategic lift platform fleets versus the probable time of their effective action. (this display explains information for ships derived from the sealift appendix).

It is seen that commercial assets dominate DoD assets in fleet lift potential in comparable time domains. This is the first conclusion. The second is that both asset fleets are equally important for Army power projection <u>and</u> that the Army's vehicle and packaging designs for AA2010 <u>must</u> take into account commercial constaints.

Past Experimental Use of ISO Containers by the Army



1972

Aviation Intermediate Maintenance Shop Sets ISO Containerization Program

The Army has been using containers for decades, but few efforts have been made to design expressly for containerization

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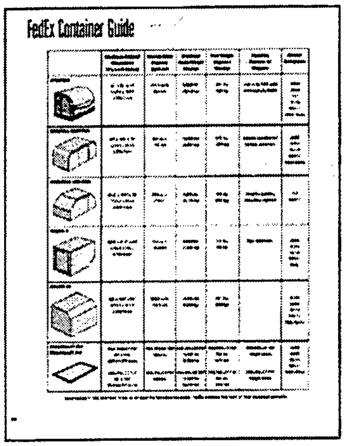
- The Army has briefed the Task Force on two previously successful attempts to improve mobility by adoption of containerized concepts.

- The first was the aviation maintenance community program to place intermediate maintenance shops ISO containers. This program is successfully improving the mobility and utility of selected intermediate maintenance shops. This program has not, however, dramatically reduced the footprint of the organizations involved because they are so vehicle intensive.

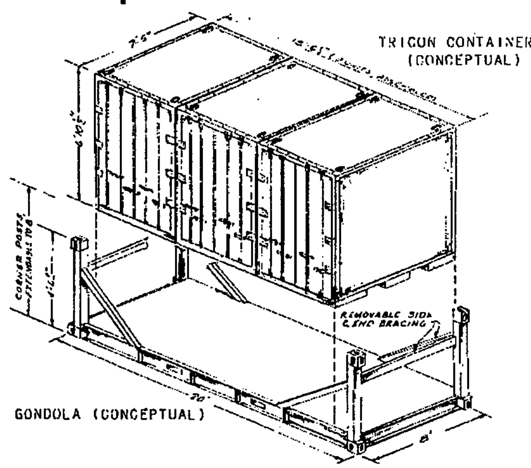
- The second was experimental “operating room in a box” program currently being tested and considered for implementation. This rapid prototype demonstrated how a design driven from the outset by mobility imperatives and ambitious packaging goals can succeed.

- Other targets for containerization have been identified, but not on a broad scale.

Containerization: An Opportunity for Mobility Enhancement Based on Commercial Developments



Standard containers used by FEDEX



A proposed air/land/sea ISO container design

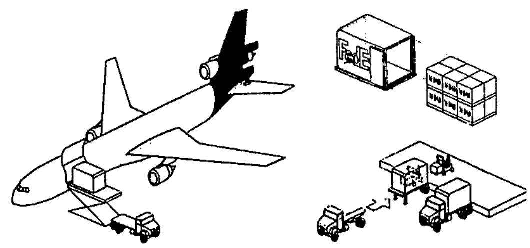
Use of standard commercial containers is wide spread and increasing

- The widespread use of standardized containers provides an opportunity for future forces to be more efficiently deployed and configured for use with minimal preparation upon arrival in theater. Although the Army has used standard ISO containers on a limited basis, the potential for increased used, particular given a new future force design, is significant.

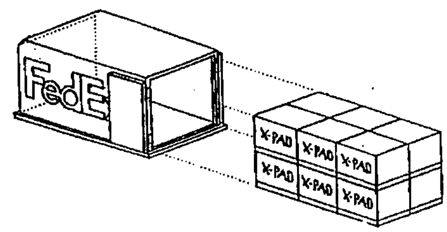
- The commercial transportation community is moving increasingly to standardized containers for inter-modal transportation. Both the Army and DoD need to become involved in these commercial developments to insure their future needs are met. Concurrently AAN concepts and designs need to be structured to take advantage of this opportunity from the outset.

- The MLRS design already demonstrated how the Army could field a modular and partially containerized system (except for its vehicles). The efficiency gained gives the Army fire support that is twice as manpower efficient as howitzer units for equal dispensed lethality.

Commercial Container Developments Are Proceeding



FedEx has introduced X-Box to provide seamless, efficient air/land transport



With a flexible multi-purpose design

- The task force was briefed on a number of concepts for commercial transport aircraft development programs designed to accommodate current ISO size sea/land container volumes and weights.

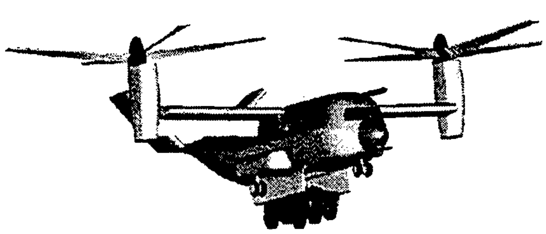
- In addition the panel learned that Federal Express has just introduced its own design for a common air/land family of containers into commercial use. These containers are part of a commercial "mobility system" that integrates air and land vehicles, containers, handling systems and information management systems together.

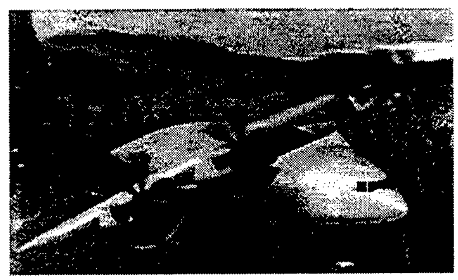
- The panel believes that commercial incentives will soon dictate similar developments of an air/land/sea ISO container system with high, if not full commonality

- The panel has concluded that a commercially derived air/land/sea container based mobility system could be produced and integrated into the planning for AAN.

Operational-Tactical Airlift for 3-D Battle Force Mobility will Require DOD Investment

- **3-D mobility, near vertical insertion/extraction missions, will require DOD unique design and a major investment in new technology and systems**
- **Means to be considered should include**
  - Rotorcraft: Modernized CH-47D, Adv Helicopter, Adv Tilt-Rotor, ...
  - V/STOL: Adv Tilt-Wing, Vectored Thruster, ...
  - Conventional: C-17, C-130J
- **Concept tradeoffs of 2-D and 2½-D should be considered**





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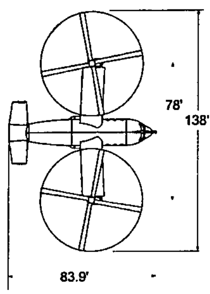
3-D mobility for the Battle Force implies near vertical air insertion and extraction of the Battle Force from unprepared sites. The largest load is a 15 ton combat vehicle. Airlift missions are flown to operationally significant distances (up to 1,000 km radius) at low altitude for survivability. An Army Hot Day (4,000 ft / 95° F) design point is required to ensure 95% probability of near vertical operation, world-wide.

These requirements result in a very large and expensive aircraft. Commercial aircraft in this size class are designed to use long runways and to cruise at optimum (high) altitude. Airports located at high altitude with a hot climate have long runways to compensate. The result is that the commercial aircraft are much more efficient (lower direct operating cost). A RAND study to evaluate the dual use potential of a National Transport Rotorcraft concluded that there was only a niche market for large (8 ton payload) rotorcraft. The result is that DOD investment will be required to create a large (15 ton payload) V/STOL transport (see rotorcraft above). Another alternative would be to develop a super-STOL which could operate from road segments or improvised fields (see SSTOL above).

2-D and 2½-D mobility imply drive-in/drive-out and fly-in/drive-out respectively. Various forms of air drop, including low-altitude parachute extraction, could be used for 2½-D insertion. This would allow the use of conventional military airlift assets instead of development of a new military V/STOL transport.

AA2010 Tactical Airlift Requirements are not Commercially Interesting

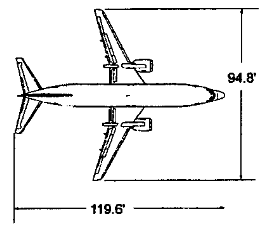
- AA2010 Tactical Airlift Requirements are very Specialized
  - Near-vertical insertion/extraction of 15 ton combat vehicles from unprepared sites
  - Long-range airlift missions at low altitude (2,000 km on the deck)
  - World-wide operation with 95% probability (4,000 ft / 95° F)
- Commercial Aircraft are Supported by Airports (Runways, Terminals)
  - Concrete (paved runway) is cheaper than V/STOL
  - Cruise at optimum altitude (airplanes like to fly high)
  - Long runways as required (e.g. Denver)



Cruise Altitude / Ambient Temperature
P = Payload, tons R = Range, km
T = Max Thrust, lb V = Best Range Speed, kt
MPG = Miles (statute) per Gallon

Adv Rotorcraft
4,000 ft / 95° F
P = 15, R = 2,000
T = 105,000, V = 260
MPG = 0.68

Best Altitude / Std Day
P = 20, R = 4,800
T = 130,000, V = 300
MPG = 0.87



737-400
Best Altitude / Std Day
P = 20, R = 3,870
T = 44,000, V = 424
MPG = 0.53

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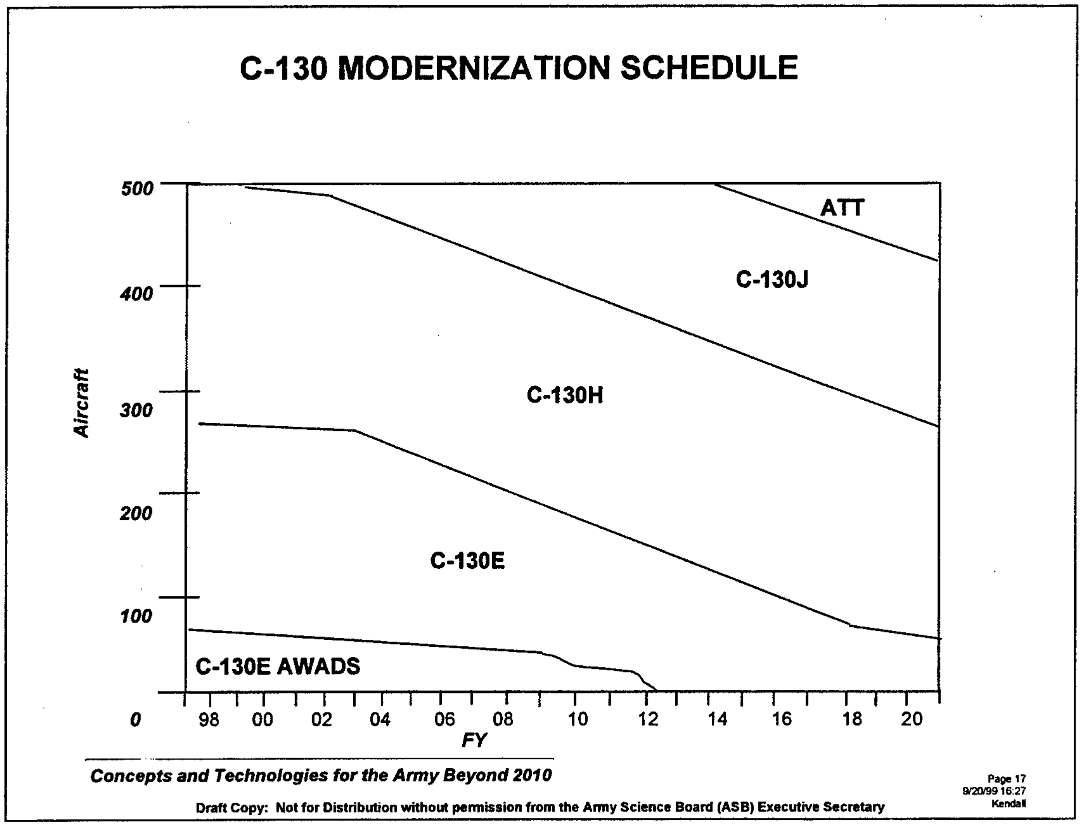
AA2010 tactical airlift requirements are based on near vertical insertion/extraction of the Battle Force from unprepared sites. The largest load is a 15 ton combat vehicle. This implies a large transport aircraft with Vertical/Short Take-Off and Landing (V/STOL) capability. Large commercial transports use concrete (long paved runways) instead of V/STOL, because it is the least expensive way to serve a limited number of high traffic locations.

Airlift missions are flown to operationally significant distances (up to 1,000 km radius) at low altitude for survivability. An Army Hot Day (4,000 ft / 95° F) design point is required to ensure 95% probability of near vertical operation, world-wide. These requirements result in a very large and expensive aircraft. An advanced rotorcraft designed for long range missions at low altitude with VTOL capability at 4,000 ft / 95° F conditions can carry 1/3 more payload 2.4 times as far, faster and more economically under best altitude / standard day conditions.

A current production commercial transport is smaller and requires substantially less thrust for take-off. It trades some fuel efficiency for greater productivity (payload times speed) compared to a very advanced technology rotorcraft operating under the same conditions. Since productivity drives operating cost per ton mile, this does not motivate commercial development of a new transport rotorcraft.



The Air Mobility Master Plan envisions the continued use of the C-130 series of cargo aircraft for the foreseeable future. As the C-130E is phased out it will be replaced by the more productive3 C-130J. The C-130J program calls for its use by Britain's Royal Air Force as well as the USAF.

Although the C-130 is not considered a "strategic" aircraft, it provides proven delivery capabilities in the intra theater deployment role. The Panel does not believe the AA2010 design activity has "_______" for a particular solution and needs to do so. The follow-on to the C-130 or a new helo or both will be expensive.

APPENDIX F

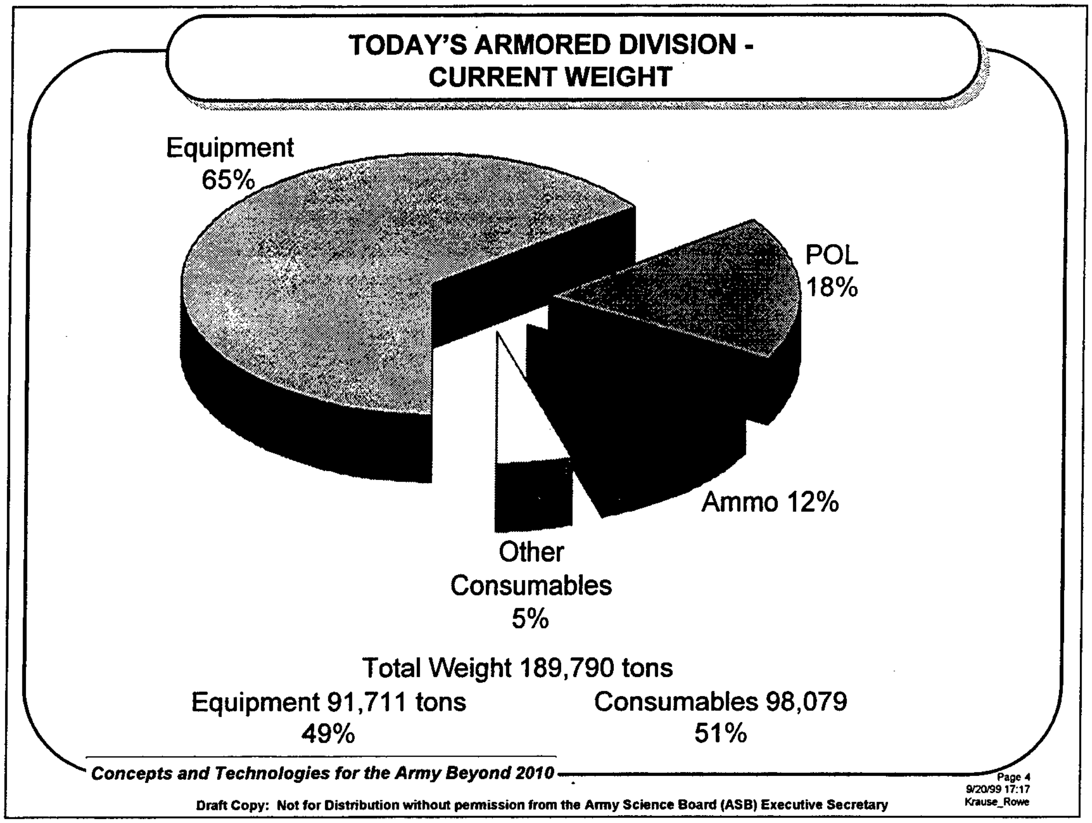
SEALIFT

Appendix F -- Sealift

Deploy Rapidly - Sustain Smartly - Control Confidently

Dr. Michael Krause, Dr. Joseph Rowe, MG Dan Brown, Mark Okonski,
MG(R) Robert Ruth, Anthony J. Braddock, William Crowder, LTC Joseph McVeigh
MAJ Joe Gerard, Michael Hendricks, Deborah Pollard

18 July 1998



This annex is a report on deploy, control and sustain observations, findings and recommendations for the "Concepts and Technology for Army After 2010" panel.

The intent of this report is to summarize what we have considered, evaluated and seen; then to formulate observations findings and recommendations.

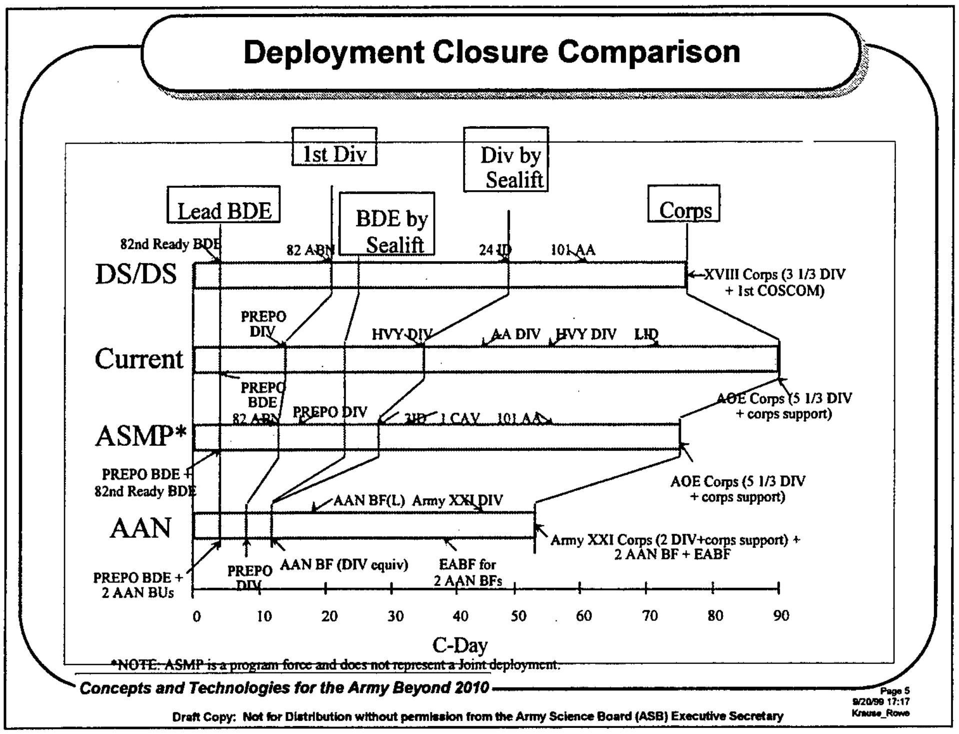
For the Army to be relevant it must be able to get there fast. Once there, the force must be sustained smartly and confidently. Control must be assured.

This is the weight of a current armored division. For the future we need to examine the weight reduction target for Force XXI and AA2010 units. Force size and weight either add or subtract time required for deployment. What are the Army's objectives for weight reduction?

Our base line question is how to deploy faster? We are convinced that land forces must be capable of getting to the operational area - get to the fight - about two to three times faster than now. We thought through the timelines of the movement of land forces for Operation Desert Shield and Gulf. Ultimately about 75 days for Light Corps to be deployed. This must be shortened to 75 days for a full corps, 30 days for a division and 120 hours for a 'composite' heavy/light brigade.

This will demand acting faster in alert, loading from fort to port, then loading at port, transit, then unload at port of debarkation and manning of the force for battle.

Commercial industry if beginning to look at the entire scenario of faster, more efficient material delivery of goods, with predictability. This is not only the change of speed by ship, but equally important is the power projection platform and agile ports.



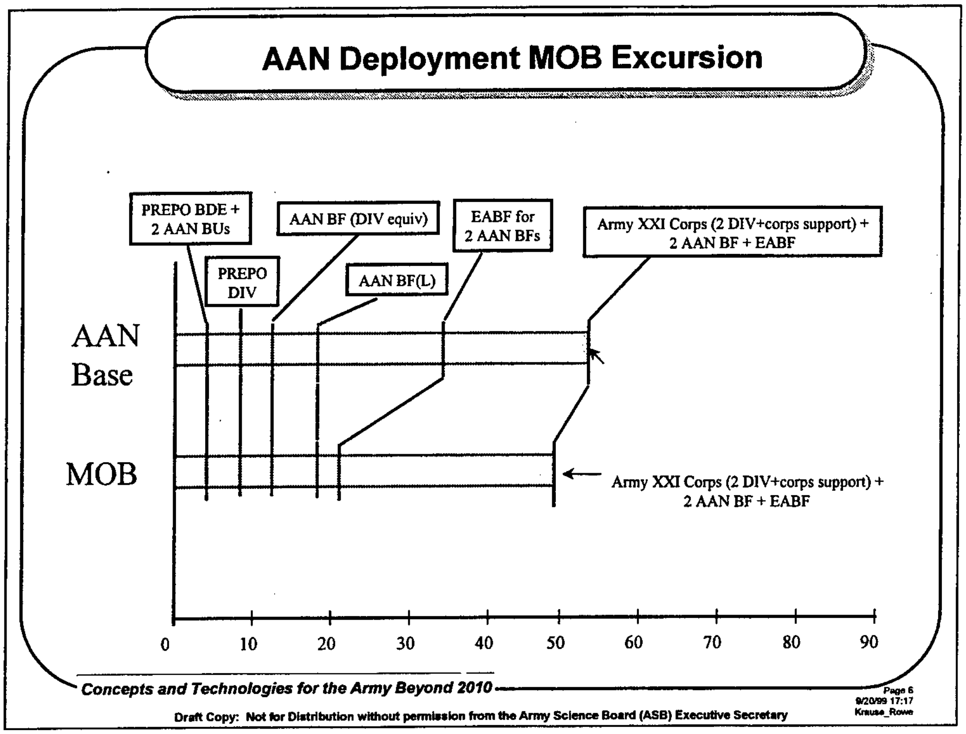
General Assumptions: 8700 nm (to SWA). Army part of a Joint flow including sustainment (except ASMP). No Flexible Deterrent Options (FDOs) for early positioning of strategic lift exercised. PREPO at 100% fill. Benign entry. CINC prioritizes early entry Army forces. HNS support for strategic lift refueling. CRAF and RRF activated (CRAF I on C+0, CRAF II on C+15 except for ASMP where CRAF II activated on C+0). ACR arrivals not listed. Military airlift assets are in accordance with USAF Airlift Master Plan.

Current Assumptions: 3 PREPO BDEs (afloat and ashore) available. Only 4 LMSRs available for Army (initially carrying afloat PREPO).

ASMP Assumptions: Programmatic force. 3 PREPO BDEs (afloat and ashore) used for timeline; 4th BDE set afloat is programmed. No joint requirement or sustainment adjudication for strategic lift. No MOG constraints. 19 LMSRs available. No sustainment flow. CRAF II available on C+0.

Future Assumptions: 3 PREPO BDEs (afloat and ashore) available for CINC. 75 Ultra Large Airlifters available (25 as part of CRAF I, 50 as part of CRAF II). 12 High Speed Sealift part of the commercial fleet. AAN BFs and support similar to that played in the AAN Spring Wargame 98. Echelons above Battle Force for the 2 AAN BF is notional and in development.

Key observations: Note the AAN + Force XXI force gets there in 5 days with BDE and 12 days with division. The time is not reduced by the same ratio for the remainder of the corps. SEV and fast ship and aircraft improvements need to alter this timeline. In short, action is required now, to shorten deployment time.



Description of the MOB excursion:

On C+0, five MOB sections (ready for transit) leave Diego Garcia and begin a 2204 nm trip to 30 nm off of Masqat, Oman.

Given a speed of 12 knots and assembly time, the MOB is ready for flight operations on C+10.

From C+10 to C+12, cargo handling personnel are ferried to the MOB from Oman.

From C+13 to C+21, 6 HSS vessels (returning from Ad Dammam after off-loading an Air-Mech BF on C+12) ferry the 120,000 ston EABF to Ad Dammam (a distance of 550nm) and use the MOB for refueling while loading.

Estimated time benefits are a 15 Day improvement to AAN BF support (EABF) closure and an overall 7 day decrease in total force closure.

We do not see value added by the MOB at this stage - cost of $5.5 billion should be applied to building faster ships.

THIS CHART IS INCLUDED TO SHOW THAT WE HAVE CONSIDERED THE MOBILE OFFSHORE BASE. WE DO NOT FEEL THE INVESTMENT OF $5.5 BILLION IS VALID

Mobility - Sustainment - Control

- AA2010 Mobility Requirements significantly exceed current and projected DOD capabilities in all areas.
- Airlift to support AA2010 strategic lift needs to be based largely on commercial developments and CRAF like programs with a small DOD planning investment now.
- Airlift to support AA2010 tactical insertion/extraction missions will require DOD unique designs and major DOD investment in new technology and systems. Several alternative concepts appear feasible.
- Commercial sealift development can support rapid deployment of a composite brigade for a small near term investment.
- A holistic total mobility and logistics system that relies heavily on commercial developments in containerization, automated material handling, and efficient asset tracking/management should be pursued faster.
- Enhance the Revolution in Military Logistics by linking and leveraging industry's 'best in class' automation technology, 'best business practices' to shorten technology insertion timelines and processes, and basic, fundamental organizational re-structuring.

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We need to look at commercialization in terms of system advancements, not troop replacement. Commercialization is also not always available, nor will it be unless the Army adopts a more commercial view.

Observations - Outline

- What is the Problem?
  - Background - no consideration of threat
  - Time Line
- Speed and control are important
  - From Vendor and Unit to Port
  - From Port to Port
  - From Port to Fight
- Define the mission - "Our mission is to rapidly deploy combat ready and sustaining forces prepared to fight and win"
- Saving time with
  - Containers
  - Modular Organizations - include Reserve/Industry
  - MHE units
  - Asset visibility and control
  - Less handling
  - Intransit speed

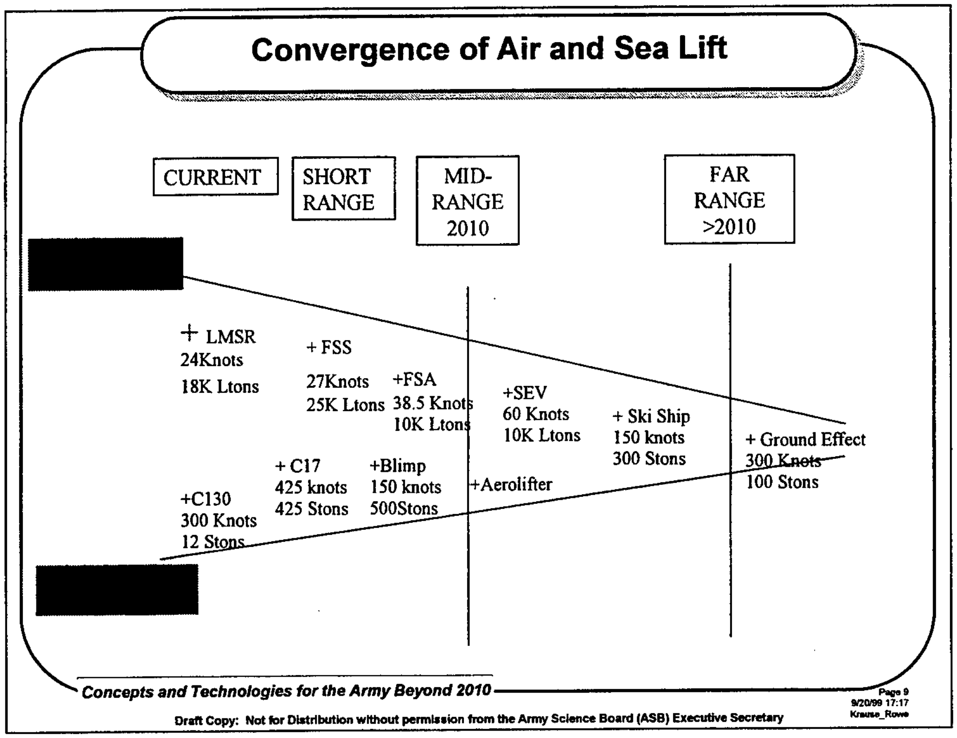
The portion contains an outline of our observations. First what is the problem? It centers on forces, time, speed, and space.

Our time line will show the need for cutting time to gain speed in all facets of the deployment and sustainment process. Essential consideration must be given to getting units and their sustainment materiel to the port, handled as little as possible, using every facet of intermodal shipping; there upon to load at air and sea ports, and then transit as rapidly as possible with visibility and control, to be off loaded and ready to fight.

Hence our ASB mission is to find all methodologies and technologies and ways of doing business which cuts down this time and reacts to the flow efficiency at the tactical (logistical) level of effort.

Our mission is to deploy rapidly for the Army to maintain relevance.

Also listed are several methods which save time during the get to and from the port.



The inherent challenge of strategic lift is one of combining the large payload of sealift with the speed of airlift. Technological advances in new hull forms, waterjet propulsion, light weight structural composite materials, 'marinenized' aircraft engines and harnessing a variety of psychical lifts all combine to bring air lift and sea lift closer together.

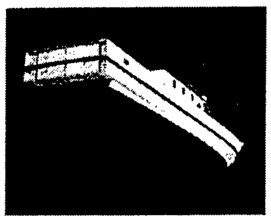
The ultimate end state is either a ship that moves like a plane or a plane that carries like a ship. Psychically, this could result in a ship barely touching the water or a plane harnessing the "ground effect" air cushion by barely flying above the sea. The result is the same, the capability to deliver a militarily substantial cargo in a matter of hours or days vice days or weeks.

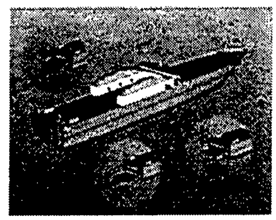
In the year 2025, a Wing-In-Ground vessel could carry three or four 15 ton land combat vehicles directly into the combat zone. A ten vessel squadron could deliver a Task Force size element in one lift and insert it directly into the desired area.

This far term objective is not reachable without substantial research, development and testing. In the near and mid term, technologies are feasible that substantially reduce the deployment time of heavy or composite forces.

Deploy Faster Short Range - Best Case FASTSHIP

- Structural design review certification completed
- Carderock review supports technical feasibility
- US Dept of Transportation Maritime Administration review and approval
- Home Port Director's evaluation - infrastructure changes being planned
- Financial impact of Title XI 85% financing 25 yrs
- Business Plan imbeds National Features - ramp, austere port unload - cost $10m/ship
- Capable of transporting heavy battalion 8700 nm in less than 10 days
- Technically feasible, commercially viable, venture capital required





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This summarizes the stages through which FastShip Atlantic has passed.

Before construction is allowed structural design certification - is the vessel seaworthy - needs to be gained.

A panel of 270 experts from Carderock reviewed all technologies and endorsed this concept.

MARAD review and certified.

The port directors of Cherbourg and Philadelphia have committed to make infrastructure based on the FastShip homeporting at these locations.

Title XI financing will be used.

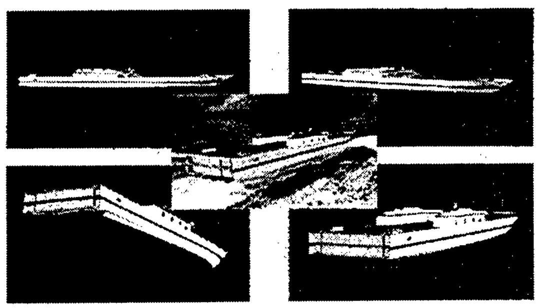
The business case is solid.

Technically feasible, commercially viable, venture capital obtained - these ships will be operation by 2003.

Fold in Army requirements to planning requirements. Invest in planning.

Findings- Deploy Rapidly
Short Range - FastShip Atlantic

- **Short -range - next 5 years**
  - Carderock Report validates technical feasibility of commercial transport at 40 knots in sea state 7 (25m waves) 15,000 tons 10,000 nm
  - FastShip Atlantic will be commercially viable at 40 knots payload of about 10,000 tons
  - Characteristics: Water jet propulsion system - intermodal connectivity at home port - not weather dependent - austere port unloading
  - Four Fastships to be built by 2003 Forecasted construction date April 99
- **There is no Army investment at this date**



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FastShip Atlantic is a fast ship which received technical endorsement from the Carderock naval organization. The ship design - dynamic air cushion - propulsion system and engine are technically feasible. The design certification - permission to construct - is considered state of the art doable. The ship is commercially viable and financially sound.

The ship will have speed of an average of forty knots in any sea state. This is part of its commercial advantage of reliability. The middle market of high value goods which need to have scheduled arrival times measured in days - four days to cross the Atlantic - from port of Cherbourg to port of Philadelphia - with loading and unloading timed at four hours at embarkation and debarkation.

National Defense Features include a different ramp for austere port off-loading plus deck height changes and deck reinforcement.

Four ships will be built by 2003.

Bottom line is these ships will be built for the commercial market - with or without US Army requirements. We need to imbed AA 2010 requirements in the design stage before ships are in construction. Construction is planned for Litton-Ingalls shipyards beginning in April 1999. The Army needs to invest in this commercial FastShip.

Observations - Outline

- Decrease time - increase speed of deployment
  - Short Range - 5 years
    - Best Case - Fast Ship Atlantic (FSA)
  - Mid-Range - 10 Years
    - Best Case - Surface Effect Vessel
  - Long Range - Beyond 10 years after 2010
    - Ski and Wing-In- Ground Effect vessel
    - Best case - theoretical work, simulation and model, and pilot test facility

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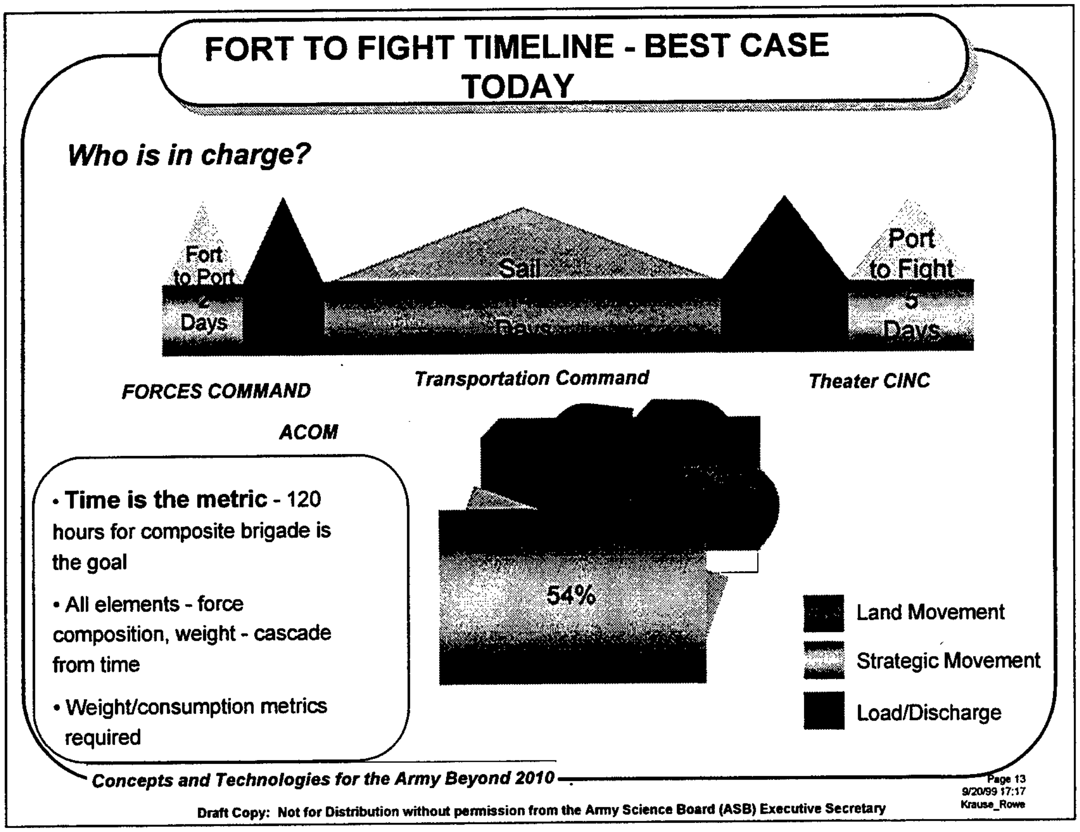
Decreasing time in deployment in transit through a "Sealift Revolution". Short, mid, long ranger are defined as five, ten, and beyond years. Best cases are highlighted as FastShip Atlantic (40 knots) commercial ship; yet to be developed Surface Effect Vessel (80 knots) and the theoretical work required to look at revolutionary technology such as ski and wing-in-ground effect technology and required testing facilities. This is clearly a time saver, but must be in tandem with improved off-load capability.



Time is a critical element. The metric is 120 hours (5 days) for a composite brigade to SWA.

Who is in charge? Time for deployment must be controlled. Right now the pieces of the time line are owned by three different CINC's. Forces Command owns the getting to the port and the load-out, Transportation Command owns the port-to-port piece and the Theater CINC owns the off-load and to the fight piece.

Time must be measured in each element of the deployment. From a force sustainment perspective, if ammunition can be reduced with usage of smart munitions - reducing weight and cube to be transported and distributed - it must not be arbitrarily changed. Hence the question of whose in charge?

If anyone along the present path changed the basic load for a unit, time of deployment will be affected.

There is a cascading effect of time - forces - and space. Logistically, if there are increases in force support - in fuel and ammo - it will affect the time for deployment.

Hence goals - objectives - metrics - must be set.

Observations - Outline

- Control assuredly
  - Army Total Asset Visibility
  - Intransit Visibility
  - Commercial integration
  - Commercial communications
- Sustain Smartly
  - Link asset visibility with commercial capability and control
  - Automation - 'Best in Class' commercial utilization
  - Technology insertion - spiral development - speed up the process
  - Organizational change - en route to a Logistics Command - First step Army Force Sustainment Command - DA 100-XX implementation plan

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Control is essential in deployment and sustainment. The basics are available through Army Total Asset Visibility. Intransit Visibility is provided through Global Transportation Network. What is essential is commercial integration into the visibility through open networks. Commercial communication means should be considered.

There are three serious impediments to functioning sustainment smartly:

Automation - follow commercial standards and kill legacy efforts.

Technology insertion - require a Cooper & Lybrand study

Organizational change - Reorganize AMC for improved sustainment

These will be discussed in detail.

Key Theme - Sustain & Control

- Link asset visibility with commercial capability and control
- Improve technology insertion process time lines
- Link tactical logistics data and information automation flow
- Establish Army Force Sustainment Command as step toward Logistics Command

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There are four major areas:

1. Our Army is doing well in asset visibility. What is needed is linkage of Army asset visibility with commercial visibility. Next the ability to control assets is an issue. This means that while we know where our stuff is, we are not enabled like commercial industry to control the assets as yet. We need to link systems with them.

2. Technology insertion to date takes in the best case five to seven years. This is too long. This includes just buying commercially available stuff and getting it in the hands of soldiers. Just too long!

3. There is no electronic seamless linkage for logistics data flow at the tactical level.

4. Organizational change is required for realization of the Revolution in Military Logistics. The first step is the implementation of the Army Forces Sustainment Command as a step towards an overall Logistics Command. This will enhance joint operations and combined operations. The mission of the AFSC would be to control all aspects of sustainment - wholesale and retail - in support of the warfighting CINC. The future LOG Command will be an organizational structure for DOD sustainment and deployment. The model is the existing Transportation Command.

Neither deployment nor sustainment has an overall command in charge. Yes the TRANSCOM and the AMC are the designated hitters for these functions but they are not in charge. Organizational change begins with this step.

Findings - Sustain & Control

Technology Insertion

- Army lacks ability to rapidly insert technology
  - In many cases technology is outdated before it can be fielded across the Army
  - WRAP gets selected systems/system upgrades "in the cue" faster, but not enough
- What could be done
  - Spiral development (with adequate funding)
  - Make "Modernization Thru Spares" a Program, not just a Process --- Provide funding
  - Increase OSCR funding levels
  - Develop/adopt requirements determination and resource allocation methodologies

Reducing Log Demand for the Legacy Fleet

- How heavy is the legacy fleet?
  - Armored Div - 102,052 Short Tons
  - Mechanized Div - 100,839 Short Tons

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1) Technology Insertion - The Army lacks the ability to rapidly insert technology into its weapon systems and processes. Current process takes too long; in many cases the technology is outdated before it can be inserted across the force. The Warfighter Rapid Acquisition Program gets selected items "in the cue" a little faster, but not enough. (For example, WRAP is how Army began to get MTS capabilities procured). While spiral development is good, if Army doesn't have mechanisms to procure, rapid or spiral development doesn't mean much. Therefore, believe that this is an area where you could recommend more aggressive funding in processes such as Modernization Through Spares (which currently has no $$ attached to it) or increased funding for Operations and Support Cost Reduction (some level of funding, but usually not a lot.) Further suggest that Army develop/adopt a requirements determination and resource allocation methodologies.

2) Reducing Logistics Demand for the Legacy Fleet Beyond 2010 (AAN timeframe), current estimates are that the Army of Excellence and Army XXI units/equipment will comprise 80% or the force. During the Spring 98 AAN Wargame, the U.S. Army couldn't close combat forces in a timely enough manner. In the outbrief, LTG (R) Russo indicated that the Army needs to reduce its weight and fuel consumption by a factor of 2.

Our current weaponry is heavy and consumes large amounts of fuel. For the most part, it requires robust maintenance capability to keep it operationally ready. Many of our front line weaponry is

Not equipped with the embedded diagnostics that would facilitate rapid fault isolation/identification.

Findings - Sustain & Control

- Containers -
  - Intermodal connectivity is now recognized as essential, commercial interface is a must
  - Strategic configured loads are being implemented
  - Modularized ammunition shipments
  - Use of racks
  - Use air boxes - Fed Ex example
  - Purchase of Army containers
  - Visibility through RF tags, Worldwide Ports systems
- Army Total Asset of Visibility provides excellent visibility of Army assets across the board.
- Asset visibility of commercial assets as not integrated with TAV. They should be linked.
- Commercial industry exercises control of assets. The same type of control should be imbedded in the Army TAV.

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The Army has some 28,000 containers. Most are 20 footers. Containers should also be bought for the airlift. Commercial air containers are 8x8x13. These need to be used throughout.

Containers need to be thought of as modularized units which can be self-sustaining. For example, containers should contain the items needed by the soldier, including ammunition, fuel and vehicles used by smallest unit.

Commercial containers formed a revolution in intermodal traffic. The Army needs to think through everything in light of standardized container sizes. There is progress in strategic configured loads and in modularized units, but these need further development.

Ammunition is being racked and modularized.

The visibility of where containers are, what is in the container, are enhanced through the Radio Frequency tags. These are being used in Bosnia-Herzegovina with great success. Next step is toward normative usage. Once normal visibility and control is attained then a number of movement control units and level of headquarters can be reduced.

The Worldwide Port System - a part of the Global Transportation Network - is used to track freight. This system is cumbersome, but needs to be tied to the commercial systems, particularly the Sabre system in commercial use.

Findings - Sustain & Control

Organizational

- There is a need for logistics organizational structural change. Draft DA Pamphlet 100-XX organizes the Army Force Sustainment Command (AFSC). A written implementation plan brings forth the main features of the re-structured command. The AFSC basically adopts a seamless view of logistics integration wholesale with retail.
- The AFSC is a necessary first step toward a more functional approach to logistics and foreshadows the creation of a specified Logistics Command embracing all aspects logistics support to forces in the field.

Linkage

- Tactical logistics information and data communications and automation is planned, but not funded. Other systems must be examined to add logistical modules.
- The digitized force does not have integrated operational and logistical interface.
- The logistics automation legacy systems are being integrated into the Army Global Combat Support System (AGCSS). This system of system will function through a multiplicity of gateways and software 'wrap around integrating the existing logistics systems. The timeline for full AGCSS is 8 years out. When fully operational it will use obsolete and old technology. Commercial system of systems approaches are required.

Who is in charge of logistics?

The Army needs a logistics commander who is able to bring together corporate leaders.

To meet future productive efficiency, AMC must be redesigned to provided and accommodate the sustainment and control needs of the war-fighting forces. Clearly, oversight is needed. What could be done:

- Direct modernization resources to reduce weight, fuel consumption, and imbed diagnostics/prognostics - include ECU/data buses in FTV
- To include alternative propulsion systems, alternative fuels
- Make "Modernization Thru Spares" a Program, not just a Process ---
- Provide funding
- Increase OSCR funding levels
- Develop/adopt requirements determination and resource allocation methodologies
- Predict, or prognostiat, the ability of combat equipment to conduct the mission

Too many 'stovepipe systems will not/ do not blend with the modern "precision" warfight.

METRICS

Targets - 1/2 weight reduction in fuel and ammo

Establish goal - be as good as FedEx and UPS

Tie everything to high performance.

Findings - Sustain & Control

Reducing Log Demand for the Legacy Fleet (Cont'd)

- How much fuel does the legacy fleet consume?
  - M1 Main Battle Tank uses 3 gal of fuel to go 1 mile
  - PLS has an operating range of approximately 300 miles
  - In ODS, a Heavy AOE Div consumed at least 500,000 gal in an attack
  - In Bosnia, BDE+ is consuming101,700 gal/day
- What Combat commander needs to be able to :
  - Maneuver in an unencumbered manner
  - Predict, or prognostic, the ability of combat equipment to conduct the mission
- What could be done:
  - Direct modernization resources to reduce weight, fuel consumption, and imbed diagnostics/prognostics - include ECU/data buses in FTV
    - To include alternative propulsion systems, alternative fuels
    - Make "Modernization Thru Spares" a Program, not just a Process --- Provide funding
    - Increase OSCR funding levels
    - Develop/adopt requirements determination and resource allocation methodologies

Findings - Sustain & Control

- The imperative is to reduce the logistics requirements in fuel consumption and ammunition. Metrics need to be established for key consumption reductions.
- There is linkage between deploy faster and sustain smarter in a number of areas:
  - To cut time in deployment more effective sustainment must include containerization, use of FedEx type airlift boxes and modularized organizations. Lessen the amount of handling. Improved sustainment will allow the reduction in time for load and un-load.
  - Use of commercial automated handling equipment
  - Reduced logistics footprint
- Technology insertion from commercial industry examples reduce logistics requirements. Army application includes reduction in spares.
- Visibility of assets (ATAV) is well developed; yet commercial connectivity should be accomplished.
- Automated logistical data and information linkage at tactical level is required.
- Organizational re-structuring of the Army Force Sustainment Command (AFSC) is well developed.
- Enhancement of the Revolution in Military Logistics can be accomplished by linking and leveraging industry's 'best in class' automation technology, 'best business practices' to shorten technology insertion timelines and processes, and basic, fundamental organizational re-structuring.

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Key is to cut consumption, establish metrics toward that end.

Key toward the accomplishment of the Revolution in Military Logistics are the above.

Bottom line is adopt from industry or hire industry as much as feasible, in visibility and control, build linkages and reduce consumption.

Recommendations - Sustain & Control

- Size future vehicles and weapons platforms to take advantage of commercial transportation door/ramp/deck sizes
- Insure existing family of tactical vehicles fits into commercial lift
- Direct utilization of imbedded sensors and electronic control unit/data bus in weapons platforms and transport vehicles
- Maximize use of containers & boxes (FedEx example) in sustainment
- Organize modular units in reserves from industry
- Organize MHE units
- Simulate the deployment and sustainment needs using realistic scenarios

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These are specific recommendations for improved sustainment and control.

APPENDIX G

SITUATIONAL AWARENESS

SITUATIONAL AWARENESS

PREPARED FOR THE U.S. ARMY RESEARCH INSTITUTE, FORT BENNING, GEORGIA
BY GENERAL PAUL F. GORMAN, U.S. ARMY (RETIRED)
18 November 1998

Abstract Operational training requirements for future infantry teams must be derived from mission essential task lists that encompass the entire range of military situations from mid-intensity combat in urban environments to peace keeping and peace enforcement. The first requirement for situational awareness is team cohesion under fire. The second is mission orientation, the ability to act consistent with the commander's intent, and to adjust rapidly to new circumstance.

sit-u-a-tion ***n.*** **1.** Manner in which a thing is place in relation to its surroundings; location; position **2.** a place; locality **3.** position or condition with regard to circumstances **4.** *a)* the combination of circumstances at any given time *b)* a difficult or critical state of affairs *c)* any significant combination of circumstances developing in the course of a novel, play, etc. *d)* Psychol. The objective conditions, environment, stimuli, etc. immediately affecting and individual **5.** A position of employment.

sit-u-a-tional ***adj.*** **1:** of or resulting from a situation **2:** altered to fit a specific situation

aware ***adj.*** **1.** Orig., on one's guard, vigilant 2. Knowing or realizing; conscious; informed – **a-wareness** ***n.***

WEBSTER'S NEW WORLD DICTIONARY, 1972

Situation: Awareness for What Purpose? Operation training requirements for future infantry teams ought to procees from a thorough understanding of environments in which these must be prepared to operate. Mission essential task lists (METL) for training can them be derived from that understanding.

Two pitfalls obtrude: the first is propensity to relate future situations solely to infantry's canonical combat mission -- "to close with and to destroy the enemy by means of fire and maneuver, or to repel his attack by fire, close combat and counterattack." The second, a corollary of the first, is presumption that training for Operations Other Than War (OOTW) is a less demanding undertaking, often entailing operational training requirements inconsistent with maintaining infantry's warrior ethic.

Concerning the first fallacy, infantry requirements for situation awareness have for decades transcended its functions in close combat. In November 1971, William E. DePuy, then a Lieutenant General and Assistant Vice Chief of Staff of the Army, lectured at the Infantry School on "The Future of Infantry." DePuy cited statistics that showed that enemy casualties caused by the basic infantry weapon had been declining for centuries, and that the percentage of infantry effort devoted to finding the enemy, as opposed to fighting him, had been rising over the same period. He averred that technology was changing the infantry mission as dramatically as that of other arms. Then he shocked students and members of the faculty by pointing out that, while the infantry's own statement of its mission had remained unchanged since 1941 ["to close with and destroy..."], in practice its mission in Europe had been "to move the Artillery Forward Observer to the next hill." It should be noted that General George Patton, who headed the board of officers convened for an after action review in 1945, concluded that U.S. artillery had "won the war," and almost certainly would have agreed with DePuy's characterization of the infantry's role.

Infantry is demonstrably the most versatile arm of our Army. The main advantage of infantry over other elements of our armed forces is discrimination. Human eyes, and human minds examining any situation on the ground can best judge when that situation requires lethal force, and most surely how to apply that force with minimum unintended side effects.

Would that all young infantrymen could be mentored as was I by General Harold K. Johnson. When he was Deputy Chief of Staff for Operations, he taught me a most memorable lesson about operational training requirements. One day in the spring of 1963 I entered his office with a dozen other majors of the Army Staff to brief him on certain matters pertaining to the war in Southeast Asia. I had been sitting on a board considering adoption of the 5.65mm rifle, and was surprised to find that the General had the weapon on his desk. He handed it to me and told me to explain to the others the purpose of such a weapon. I started with the mission of the infantry "to close with and destroy..." He cut me short and handed the rifle to another officer. The latter reworded my statement, only to lose the weapon to his neighbor. One by one, we tried all sorts of variants on the rifle as an instrument for killing, capturing or disabling an enemy, but the General kept expressing displeasure, and moving the weapon to the next man. Finally he made this point:

> Gentlemen, modern wars are not interneccine wars in which the killing of the enemy is the object. The destruction of the enemy in modern war, and indeed, modern war itself, are means to obtain that object of the belligerent which lies beyond the war. The soldier shoots his rifle so that his comrade can advance, and by so moving, rifleman by rifleman, our army asserts control over enemy territory and enemy people. This rifle, and any one of our other weapons, is a means to the end of control.
>
> You should know that I have been quoting from General Orders 100 and that appraisal is as valid at this moment as when the War Department published that order in April 1863.

I would extrapolate from General Johnson's lesson that infantry is the arm of choice when the objective of any operation is the imposition of U.S. control -- as was the case in Panama, Haiti, and Kuwait, and as it would be were our forces to be sent into a Kosovo-like situation. I believe firmly that infantry's situational awareness must draw upon the full prowess of our intelligence community. Moreover, it constitutes one of the more daunting challenges for our technologists, for over the past century changes in warfare have dramatically raised requirements for infantry's situational awareness. Between 1860 and 1990, per infantry unit of about 600 men, area controlled has increased by 3 orders of magnitude, firepower by 2.5 orders of magnitude, and dispersion (lower density) by 1 order of magnitude. In the future, small infantry teams, their situational awareness enhanced by oncoming technology, will be able to exert decisive control over even larger areas.

Situation awareness for close combat should be regarded as a subset of that for control. Let those who suppose that peacekeeping and peace enforcement detracts from the warrior ethic remember that control in any situation is better assured when hostiles, neutrals, and allies alike are convinced that U.S. infantry can resort to deadly force in an instant, and can do so with telling effect and with minimum collateral damage.

Awareness: of what? Many who have glibly addressed requirements for situational awareness have failed to appreciate that there are profound differences in those requirements among the four armed services. For instance, it is important to understand that simple awareness of the location and status of our own forces is far more problematic on the land than on the sea or in the air.

The following table compares typical forces under command of a three-star flag officer of each service. The array, left to right, compares relative ease of gaining and maintaining situational awareness. "Moveable subordinate entities" are numbers of ships, flights of aircraft, armored fighting vehicles, or dismounted elements that maneuver responsive to a single leader; these spread by orders of magnitude across the four services. The problem is most complex in an Army corps. For the reasons depicted on the chart, keeping track of where these entities are, and orchestrating what they are doing, is significantly more difficult than it is in the other services. In the current Army, situational awareness depends upon an extensive, hierarchical command and control apparatus:

	USN	**USAF**	**USMC**	**USA**
	^ ^ ^	^ ^ ^	^ ^ ^	^ ^ ^
Moveable Subordinate Entities	10^1-10^2	10^2-10^3	10^3-10^4	10^4-10^5
Rank of Subordinate Leaders	Highest	———	———▶	Lowest
Communications with Subordinates	Best	———	———▶	Worst
Information re Subordinates	Precise	———	———▶	Vague
Tactical Flexibility	Greatest	———	———▶	Least
Command Principle	Centralize	———	———▶	Decentralize

Within a force operating amid the uncertainties and clutter of the surface of the earth, the greatest contribution of improved situational awareness would be to lend purpose and cohesion to its disparate elements as they seek to act on the intent of commanders.

The challenge is greatest for those who fight on foot, where each soldier is dependent on his own physical and spiritual resources, buttressed neither by vehicles, large guns nor other impediments. The masterpiece on the infantry problems remains S.L.A. Marshal, who in his classic Men Against Fire (1947) posited "combat isolation" as a fundamental dysfunctional phenomenon. During training, the Army's ancient forms of regimentation convey a sense of a huge, overpowering, interactive organism capable of advancing inexorably through whatever hostile resistance it may encounter. This misleads the infantry soldier, leaving him unprepared for the day when his will and his courage may determine whether the Army will move at all. The nearer the soldier approches battle, the stronger his misapprehension becomes. Activity of aircraft, ships, guns, and other units creates in him the expectation of overpowering strength and renders the awsome loneliness and emptiness of the battlefield the more debilitating:

> ...The distant sounds of battle... are impersonal... they produce no dispersion in the force right around him... The unit enters upon the battlefield and moves across ground within range of the enemy's small arms. The enemy fires. The transition of the moment is wholly abnormal. He had expected to see action. He sees nothing. There is nothing to be seen. The fire comes out of nowhere. He knows that it is fire because the sounds are unmistakable. But that is all he knows for certain... The men scatter as the fire breaks around. When they go to ground, most of them are lost to the sight of each other. Those who can still be seen are for the most part strangely silent. They are shocked by the mystery of their situation. Here is surprise of a kind which no one had taught them to guard against. The design of the enemy has little to do with it; it is the nature of battle which catches them unaware. Where are their targets? How does one engage an enemy who does not seem to be present? How long will it be until the forces opposite begin to expose themselves and and one's own forces will rally around the tactical ideas which training had taught them and would prove useful?... There is none present to tell this rifleman and his comrades that this is normal and that only his personal reaction to it may change with tim. He may go on and on through repeated engagements and never know a situation that is more tangible. In essence it's against this very situation that his unit must find the means to rally if it is to scceed in battle... The enemy fire builds up. Its aim becomes truer. The men spread further from each other, moving individually to whatever cover is nearest or affords the best protection. A few of them fire their pieces. At first they do so timidly... Others do nothing... Such response as the men make to the enemy fire tends mainly to produce greater separation in the elements of the company, thereby intensifying the feeling of isolation and insecurity in its individuals....
>
> One must come to rest on Clausewitz gloomy warning that: "In war the novice is only met by pitch black night." On beyond that are to be read the words: "It is of first importance that the soldier, high or low, should not have to encounter in war things which, seen for the first time, set him in terror or perplexity."
>
> That is the desired goal -- to shed such a strong light in training that it will dispel much of the darkness of battle's night. We have the word of the nineteenth's great military thinker that it can be done. It remains a hope for those of us who weigh the military problems of the new age...

Marshal wrote before the advent of TRAINFIRE and Tactical Engagement Simulation. In a note for the 1961 edition of Men Against Fire he lauded the former and there is every reason to believe that had he lived to see training exercises like those at the National Training Center, he would have approved heartily. But with "digitization" it now appears possible to develop in training a wholly new mental construct of battle for each infantry team, and to provide its members with reliable counters to combat isolation. Situational Awareness must, first and foremost, weld together infantry teams with assured information as to where each soldier is relative to his leader, and to his fellows of the team.

Within that fraction of U.S. Army mounted units that is undergoing "digitization," situation awareness is embodied in a graphic depiction on a screen in each combat vehicle that presents the situation dynamically as an overlay upon a conventional, two-dimension map. The problem of how to present comparable information to infantry under fire remains unsolved.

The current approach of "Land Warrior" that relies on a heads-up display and in-the-ear audio seems quite inapt for the circumstance depicted by Marshall -- close encounter with a deadly enemy -- especially when the desired response includes sensing the location of friend and foe, firing a weapon and purposeful movement.

I have advocated a display mouted on the weapon support forearm simply because that area is naturally within the scan of a firing soldier. A simple plot of relative position of self, leader, and team members thereon would do much to evoke a coherent team response.

I have before me a Land Warrior Functionality Design Document approved by the TRADOC Systems Manager, *inter alia*. It describes a communications/computer system that will provide a wide range of information to each infantryman. Indeed, Land Warrior's stated purpose is to amplify individual performance:

> To improve the fightability of each dismounted soldier in the Army infantry platoon by integrating him into the evolving digital battlefield. Improved soldier fightability includes enhancements to lethality, command and control, survivability, mobility and sustainment capabilities.

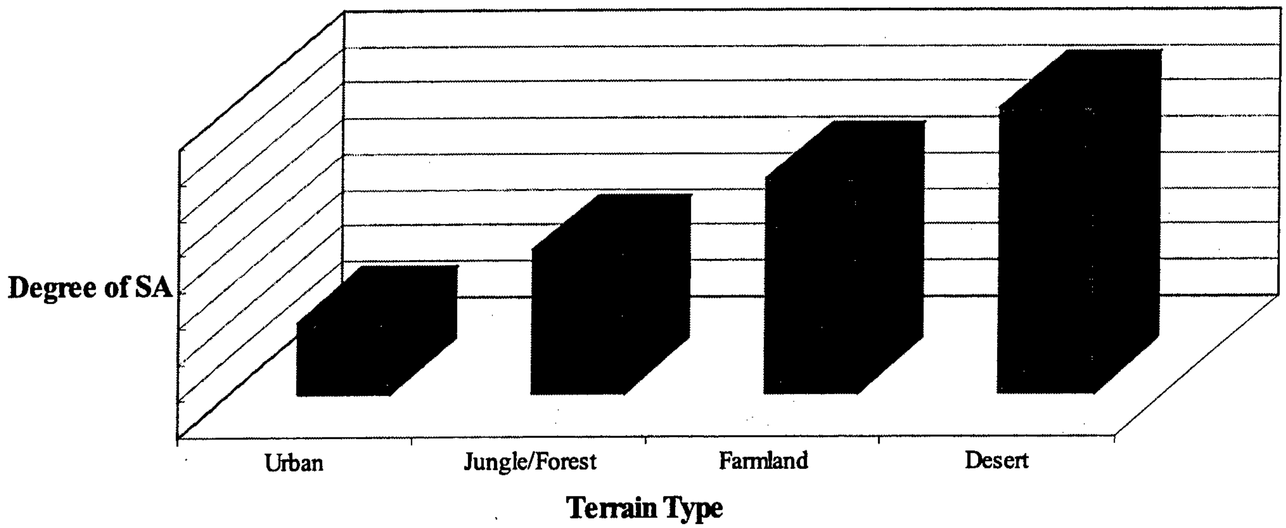
Embedded in the Land Warrior computer are the system operations manual and eight field manuals. There are elegant provisions for preparing and for transmitting formatted messages and orders (warning, operations, or fragment), for navigating (including map displays), and even for video scene capture and transmission. But the document is silent on how Land Warrior should function for situational awareness in a firefight. I believe that some of the documentation and process functionality might usefully be traded for the latter form of "fightability."

Of course leaders of infantry units require access to the same digitized system of command, control, communications and intelligence as their mounted counterparts. In fact, their need for powerful, speedy computers with large facile storage is far greater. Paradoxical as it may seem, dismounted infantry, commonly regarded as the most primitive form of modern force, demands more of "digitization" than do mounted forces. A moment's reflection will suffice to remind that a fold in the ground that would be inconsequential to an armored fighting vehicle or a helicopter might constitute cover or concealment for an infantry unit. For example, while the Army's stated requirement for digital terrain elevation data to support strategic and operational maneuver is one elevation posting per 30 square meters (DTED 2), its requirement for tactical maneuver is one elevation posting per 1 square meter (DTED5) -- 900 times more elements of data to record the accidents of the ground. To this elevation precision there must be added even more complex data on vegetation and the works of man where these affect observation, fields of fire, cover and concealment. Moreover, while a situation can be satisfactorily portrayed for mounted troops by showing vehicles, dismounted infantry requires plotting individual persons -- again multiplying the number of entities that must be managed.

Land Warrior is supposed to facilitate situational awareness for dismounted leaders from battalion down to squad. The limitations of its display, radio, and power supply suggest that a supplemental interface with the Army Battle Command System (ABCS, the "digitized" system) will be necessary to take full advantage of ABCS. For this reason I have proposed a backpack version, as sketched. In April 1999 ABCS will issue for mounted battalions a set of UNIX-based laptops; one of those compueters and associated communications might well be modified for dismounted operations.

The following chart makes the point that situational awareness is relatively disadvantaged in environments that limit observations and fields of fire, and provide ample cover and concealment.

Situational Awareness



Cover and concealment detract from situational awareness not only because they make it harder to locate the enemy, but also because they have the effect of "fractionalizing" -- divinding friendly forces intouncoordinated parts. Men Against Fire has a chapter headed "The Multiples of Information" that describes "informational strength" and "weapon strength" as "the complementary halves of moral strength." In Marshall's view, American infantry were stronger with weapons than they were with information, and he held that "information is the soul of morale in combat and the balancing force in successful tactics."

> In combat almost nothing has the appearance of juncture and of hanging together. Viewed from above, an attack would appear not unlike the disparate movements of a colony of water bugs. The first effect of fire is to dissolve all appearance of order. This is a most shocking surprise to troops who are experiencing combat for the first time. They cannot anticipate the speed with which their own forces become fractionalized or the extent to which the fractions will become physically divorced from each other as the movement is extended and enemy resistance stiffens.
>
> During Normandy fighting there was much emphasis on the ill effect of the bocage country in compelling a rapid breakdown of the smaller tactical units, thus compounding the difficulties of control. But this was no new problem in tactics. The main difference was that the hedgerows and their effect was very visible to the naked eye. It was easy to see what was happening and why.
>
> But a comparable effect is produced in almost any terrain which can serve infantry forces, including most desert country. It is not the accident of ground which produces the effect but the simple fact that man must take advantage of the accident to survive. Hous-to-house fighting in a town or city (and regardless of what the book says, this is always a catch-as-catch-can kind of business) will split a company apart more quickly than any other kind of action. The hedgerows notwithstanding, in Normandy it was relatively easier for forces to maintain contact among their own elements than in campaigns occurring at the same time in the Central Pacific where troops were advancing across flat, palm-covered islands.

The remedy to "fractionalization" is information: situational awareness. Marshall pointed out that the Army did relatively well with information flowing rearward, but was abjectly clumsy with passing information laterally to the glanks. Arbitrariness and inertia played a role, but few leaders understood that the passing of lateral information at platoon, company, and battalion level is frequently essential for carrying out the commander's intent. Commanders at the lower levels were all too often neglectful of the principle that they were not only a channel of information but also a distribution point.

Perhaps the greatest advantage that will accrue to infantry teams with advanced situational awareness is the ability to adapt to unforeseen circumstance. One of the key bridgeheads over the Merdest River in Normandy was occupied by four successive small American infantry units, who, unaware of the strategic importance of the position, moved on to other missions they deemed more important. Eventually, a major attack had to be launched to seize the bridgehead. I have personally interviewed veterans of the 10th Armored Division, the original occupiers of Bastogne, who were entirely ignorant that they had moved onto center stage in the unfolding drama of the battle of the bulge, and behaved as had been their wont in routine attacks across France. Fifty years ago changes in strategic and operational circumstance were communicated by happenstance; with tomorrow's situation awareness, such communications ought to be assured for any commander.

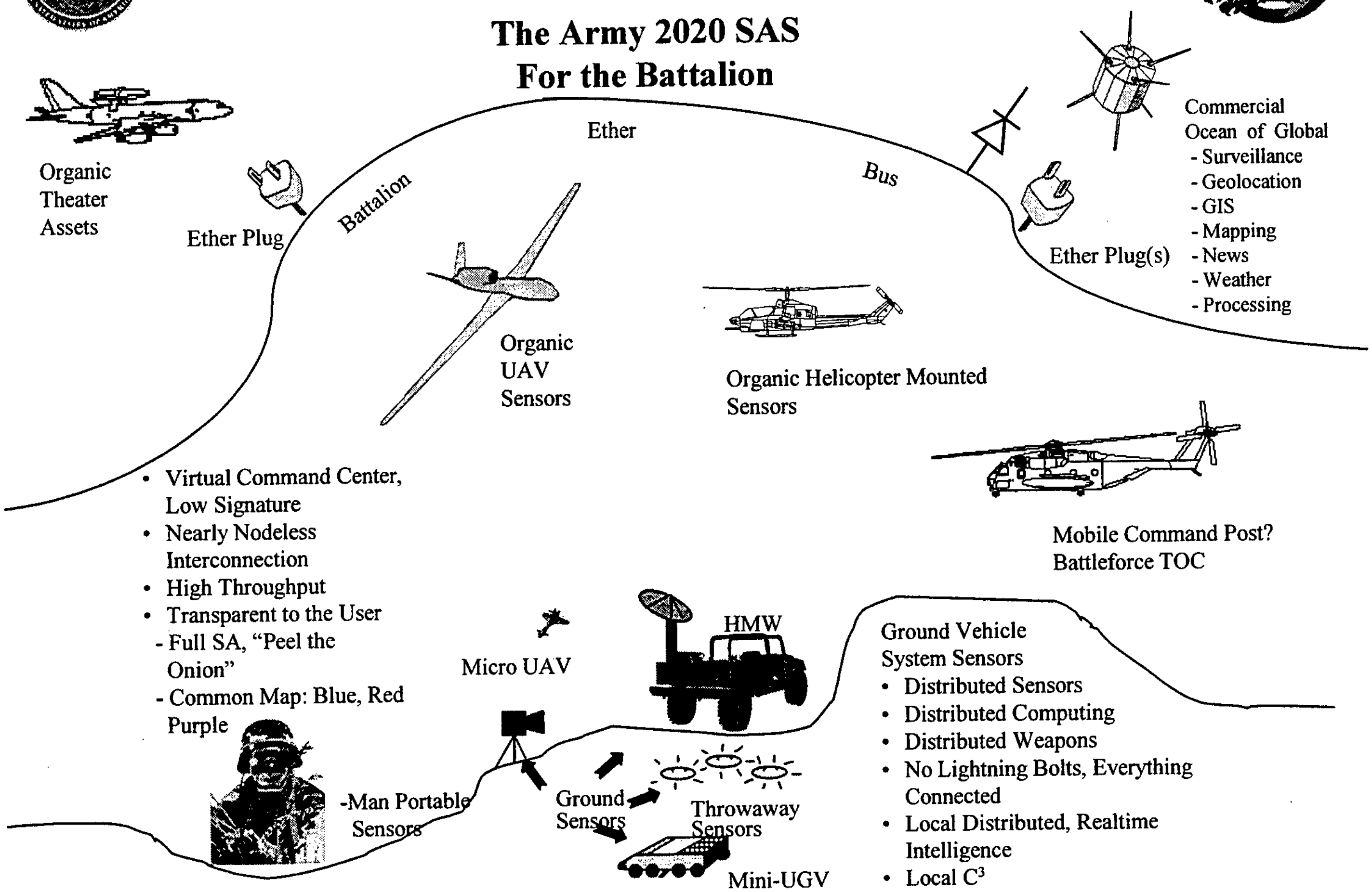
Lower echelons will inevitably see any situation with different eyes, and with different brains from that of their higher commander, and there will be rich tactical, operational and strategic rewards for an army able to refocus to realign its missions to meet un-provided-for situations. Warfare of widened deployments and increased dispersion, with frequent shock use of troops dropped suddenly upon decisive targets entails combat in which initially there will be little contact among friendly units, and situation awareness will vary widely among them. Hence mission orientation will come to have many times its previous importance in operational training.

> The need for a clearer concept of [the principle of the objective]... is not greater than the need for junior commanders who will take a keen interest in the larger affairs of war and for higher commanders who make it a practice to get down their troops. More appropriate to what we will know in the future to what we have experienced in the past is that old truth: It is not always possible to lead from behind. -- S.L.A. Marshall, Men Against Fire

APPENDIX H

SENSOR WEB

Vision 2020: (*Army2020*)



Twenty years from now, assuming the current growth in technology, it is possible to foresee a battalion held together by a web that integrates sensors, weapons, weather, and in a hemisphere of information. This infosphere will surround the battalion commander with software tools that help him manage his assets in an intuitive and natural way.

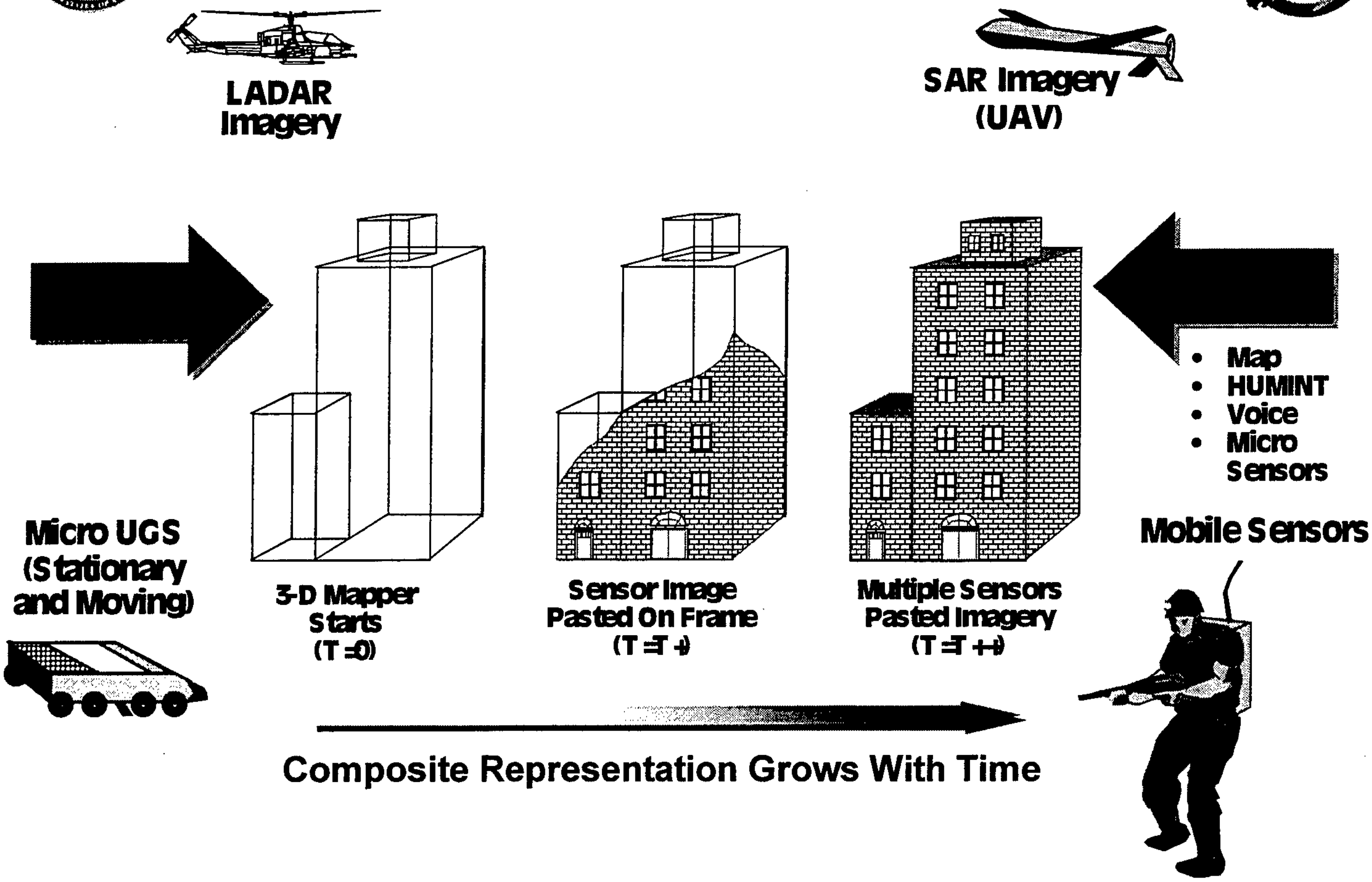
The illustration above divides the world into that space outside the "Battalion ether bus" and everything else. Since everything is on the web, the usual use of lightning bolts to connote connectivity have been omitted. Everything is connected, from the smallest disposable, distributed ground sensors to spaceborne surveillance.

The advantage will fall to force that can make the best use of all information and support operations with a variety of weapons. Organic sensors, as well as opportunistic use of existing commercial sensors may prove to be preferable to a purely military system.

The Tactical Operations Center (TOC) will be where the commander is, not vice versa. Command on the move, with a small staff will help assure rapid insertion of the fighting force. Intelligence, image analysis, advisory functions, and data mining may be done remotely (even in CONUS) and will be augmented by embedded intelligent agents.

Planning and advice will be delivered "before" real time to provide commanders with scored options and probable outcomes prior to use. His experience and judgement will help him to quickly pick the best option, or even pick his own course of action, naturally, quickly.

Image Web



Sensors will be omnipresent; most will be cheap or even throw away. For example, it is possible to imagine up to four CCD TV cameras mounted on a soldier's helmet.

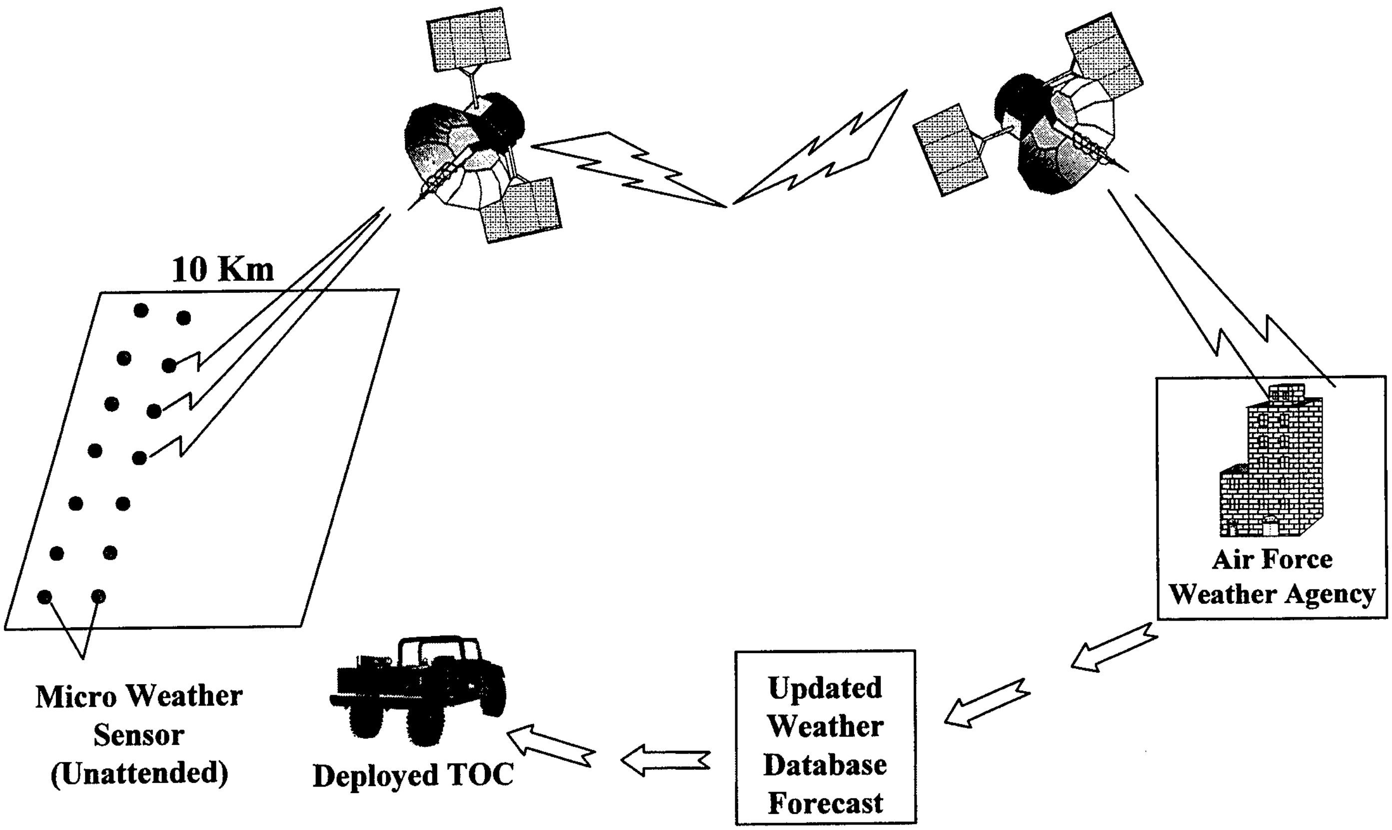
The hemisphere surrounding the battalion can be filled with imagery that is spatially and temporarily registered, and "posted" on a wire frame, 3-D representation of each object.

As time goes by, the percentage of the hemisphere seen by at least one sensor will increase to provide growing understanding and resolution.

The Commander will navigate through a synthetic almost cartoon-like representation of the imagery and information.

Imagine a volumetric image where the viewpoint is arbitrary and selectable, where each object has layers of accessible information, and where the default representative is a cartoon that provides an intuitive caricature of the object, its status, identity and function.

Weather Web Concept



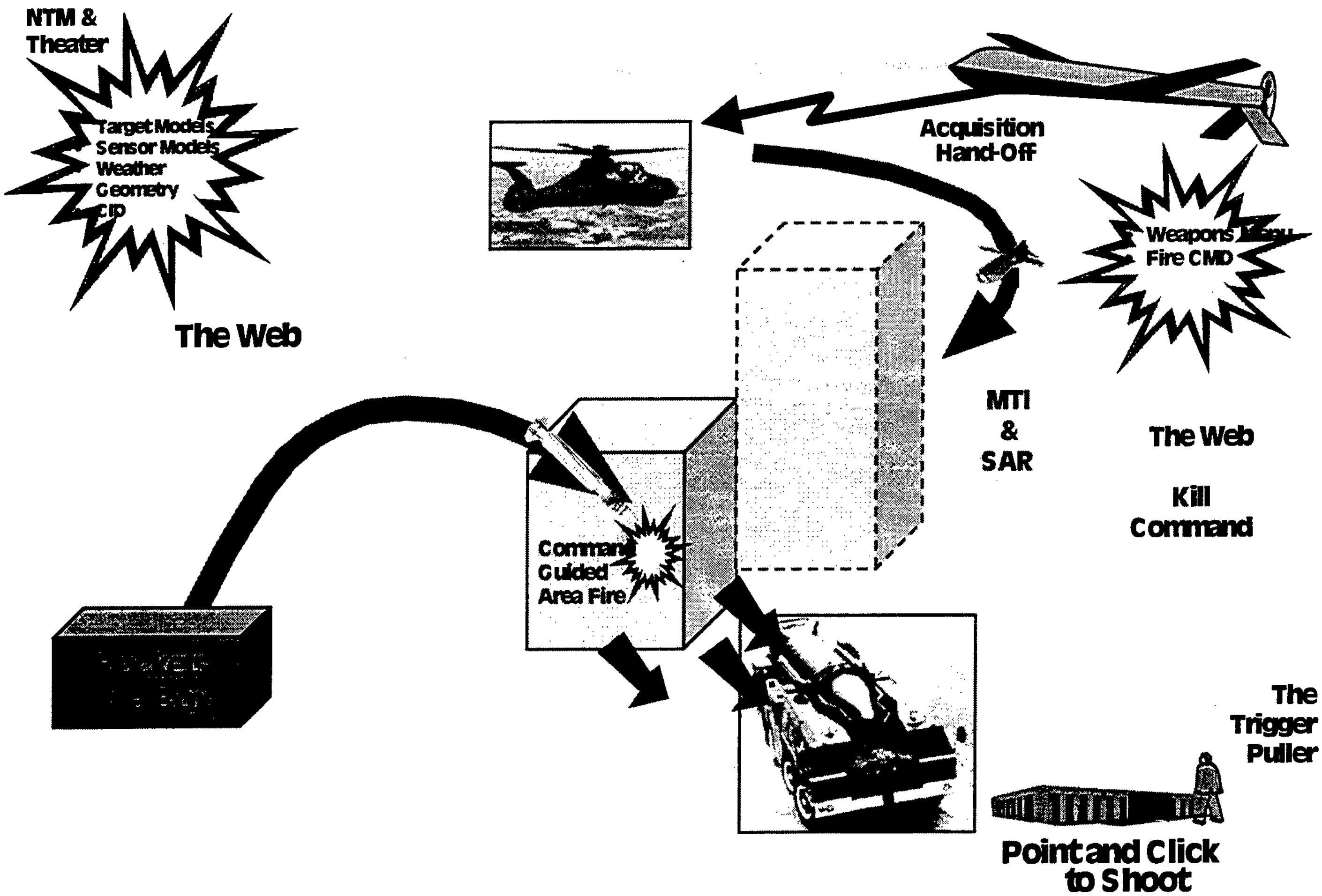
A variety of small, distributed weather sensors will provide the ability to measure microweather in the Battalion.

Affordable, disposable sensors the size of a digital watch can provide local measurement in loosely distributed arrays and greatly enhance the knowledge of special, localized information, not detected by the sensors.

For example, a small pocket of ground fog, or unfrozen ground, may prove useful to the commander in gaining advantage over the enemy.

The distribution patterns of sensors will vary depending on prior understanding of weather variability, time of year, etc. All these factors will be included in predictive tools integrated with the overall Battalion situation awareness system.

Weapons Web



The integration of planning, resource management, sensors, and combat identification will enable the networking of weapons on the battalion web.

Any authorized combatant will be able to use Battalion weapons to engage targets.

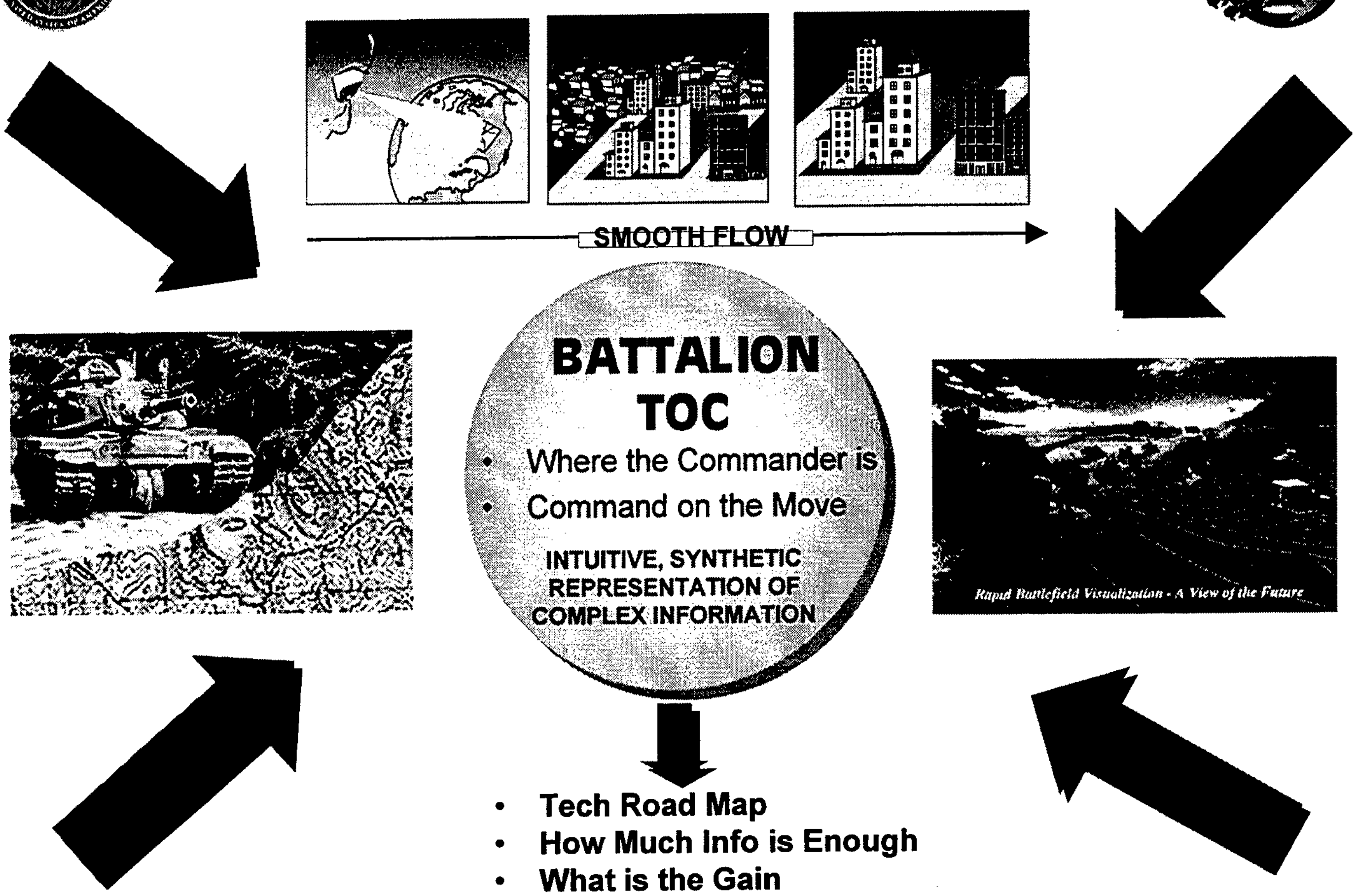
The web of weapons will incorporate all prioritization and management functions so that the trigger puller need only point and click to mass fires, both remote and local, in sight or behind the scenes, in the air or on the ground.

Combat identification may take on a more substantial meaning because the web will track hundreds, even thousands of objects. Since the position of all friendly units will be known, permission to fire on such a position could be denied automatically.

Remote and local sensors may be commanded to service targets for the full range of targeting functions, including command to impact. The full integration of weapons in the web will provide new options for the use of area fire and precision weapons, as well as smart and guided weapons.

Feasibility of target defeat will be assessed by embedded planning tools, providing the trigger puller of commander options on weather to fire or not.

Simulation Testbed



- **Tech Road Map**
- **How Much Info is Enough**
- **What is the Gain**
- **Training**

The value of exquisite information for the battalion Level is best assessed through simulation.

The design philosophy for such a simulation is to include function and capability that exceed current military doctrine so as to hopefully more closely approximate what could be available in the AAV timeframe.

Computer game designers and the commercial graphics arts community should be engaged to work with the best in government and create intuitively informative representations of information, means of initiating actions, and tools for obtaining advice.

As with the gaming community, serious representations will be available: god's eye view; map view; 3-D ground level view; and blends of these. The user should be able to "navigate" through this infosphere using joystick-like tools. Actions should be "point and click" or by use of the "five button".

The simulation, in over reaching current doctrine, will expose long poles for future developments.

It's an evolutionary tool that can grow from prototypes to a fully integrated package that blends command, control, training, and predictive planning in a single package.

The Four Testbeds Attributes and Barriers

Image Web: A hemisphere of imagery surrounding the Battalion Commander

Weather Web: Battlespace Weather on a very fine scale (10-100 meter) integrated into decision aids

Weapon Web: A hemisphere of lethality available to the Battalion and Combatants

Information & Simulation Web: A hemisphere of Information wrapped around the Battalion and tuned to its needs.

Image Web would provide a variable resolution volume of imagery with variable refresh times from staring to much longer, as needed. Any view angle can be supported. Barriers to its implementation include image registration from diverse sensors at diverse view angles, obscuration, moving objects, geospatial and object registration.

Weather Web would provide high resolution weather for use in predicting microweather. Barriers include modification of models to incorporate microweather, and integration of such knowledge into decision aids.

Weapons Web will put command, control, and guidance on the battalion Internet.

The Information Web and Simulation provides a complete, flexible source of information, training and planning. It integrates a variety of software modules and agents. The biggest challenge here is the development of smart software agents and decision aids that operate "sooner" than real time.

Battalion Sensorweb
A Testbed Approach

- **The Critical Path Must be Found**
- **4 "Testbed" Projects will Demonstrate Capability and Isolate Long Poles.**
- **Image Web**
- **Weather Web**
- **Weapon Web**
- **Simulation or Info Web**
- **These Testbeds are Decoupled Initially. Ultimately they Merge to the Operational System**

To implement the vision of Sensorweb, the three webs will be integrated to form the operational system: Image Web, Weather Web and Weapons Web.

Each of these webs has a critical path that will indicate the investments needed for fielding. A testbed can be designed for each that addresses those issues early on and decouples its risk from the others.

The R&D community can establish a team to design each testbed, a set of objectives and the schedule to moving job is done.

Image Web creates a volumetric image around the battalion, viewable from any angle, and annotated with all sources of information.

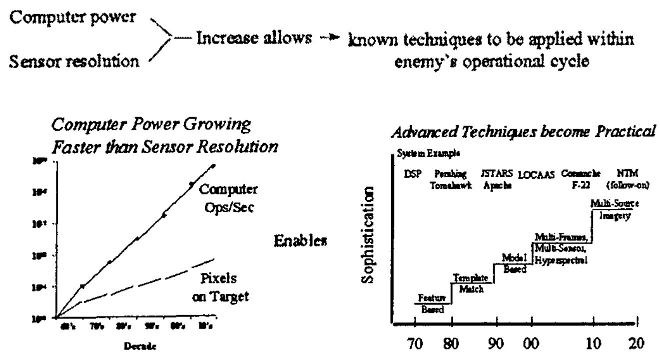
Weather Web integrates distributed , disposable sensors with other weather assets to model and predict weather with the resolution needed for the scenario at hand.

Weapons Web puts command, control, and guidance on the battalion internet.

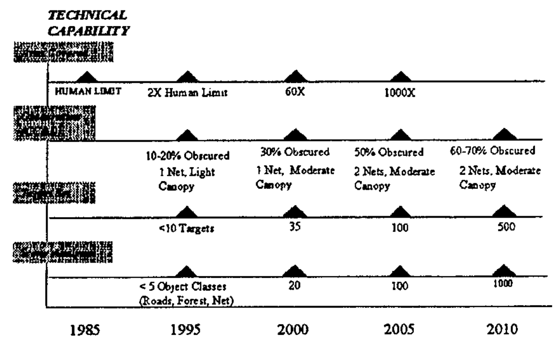
Info Web is the volume of information, i.e. sphere of information (infosphere) surrounding the battalion commander and his forces. It is the integrating mechanism for using and controlling the first three webs and other battalion assets.

The integration of the pieces enables network centric warfare. The testbed approach permits decomposition of the development into manageable groups of related technologies and function.

Key Enabling Technologies



Goals



Automatic Target Recognition (ATR) will play an essential role in Sensorweb.

The phenomenal growth of computer technology out-paces the impressive improvements in sensors. Although the resolution and sensitivity of sensors have been improving dramatically, the computer power to deal with the pixels has growth even faster.

This favorable situation is allowing developers of ATR systems to use increasingly powerful techniques. Improved sensor capability, coupled with such techniques as neural networks and model based recognition algorithms will allow future ATR's to handle more targets over larger areas, even though they may be obscured.

More sophisticated functions, such as knowing what a non-target is and identifying terrain and foliage characteristics will also be enabled.

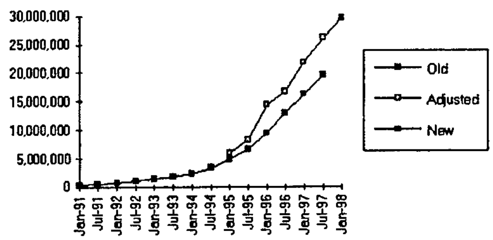
APPENDIX I

COMMUNICATIONS AND INFORMATION SYSTEMS

Commercial Drivers: The Internet

- **Explosive growth of the internet drives commercial development of global and personal communications technology**
- **Internet statistics (as of Jan.'98).**
  - **29,670,000 Internet hosts, and doubling every year.**
  - **~96 million users.**
  - **8,201,511 *.com hostnames.**
    - **> 11,606 *.com names added every day.**

Internet Domain Survey Host Count



Source: Network Wizards, www.nw.com

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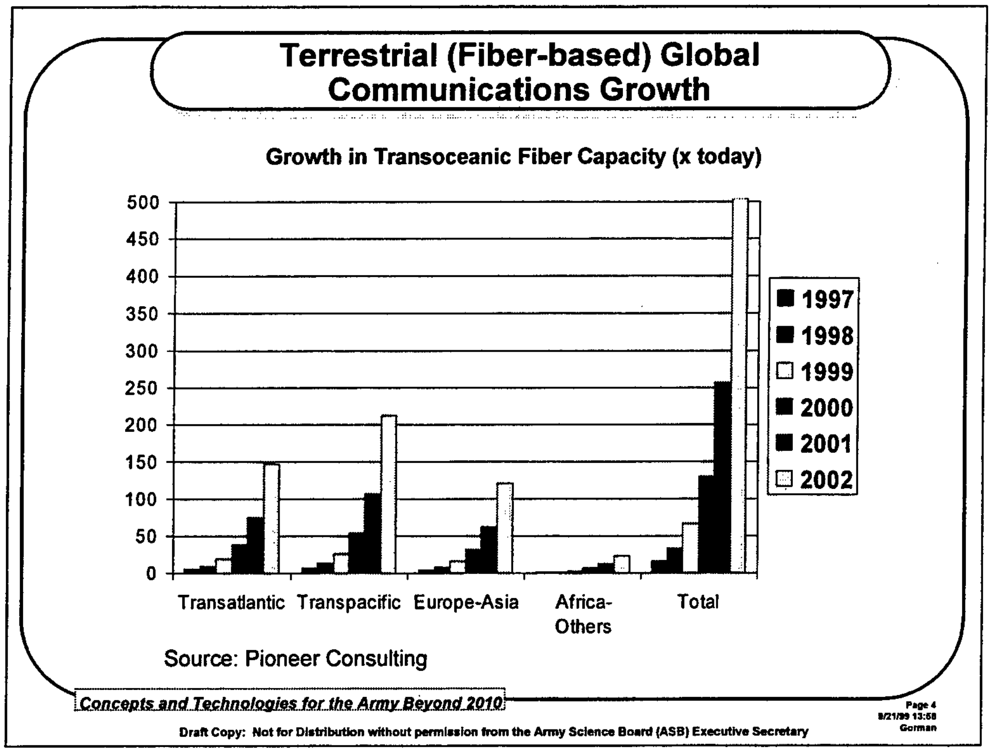
The Internet is growing at an enormous rate, roughly doubling in size each year for the past 8 years. The amount of Internet traffic is growing at roughly %400 each year, compared to %10 growth for voice communications. At this rate, the total volume of Internet communications will exceed voice by 2001. During the calendar year 1997, the number of Internet hosts increased by nearly 15M, to a total of 29.7M. Most of this growth is in the commercial sector with an average of over 11K new commercial (*.com) Internet domain names registered each day.

This incredible growth is fueling the development of new communications technologies and deployment of high-bandwidth infrastructure in the areas of terrestrial wideband (fiber-based) communications, global satellite (wide and narrow band) communications, and personal wireless communications. The question is, will these commercial developments satisfy the needs for the AAN?

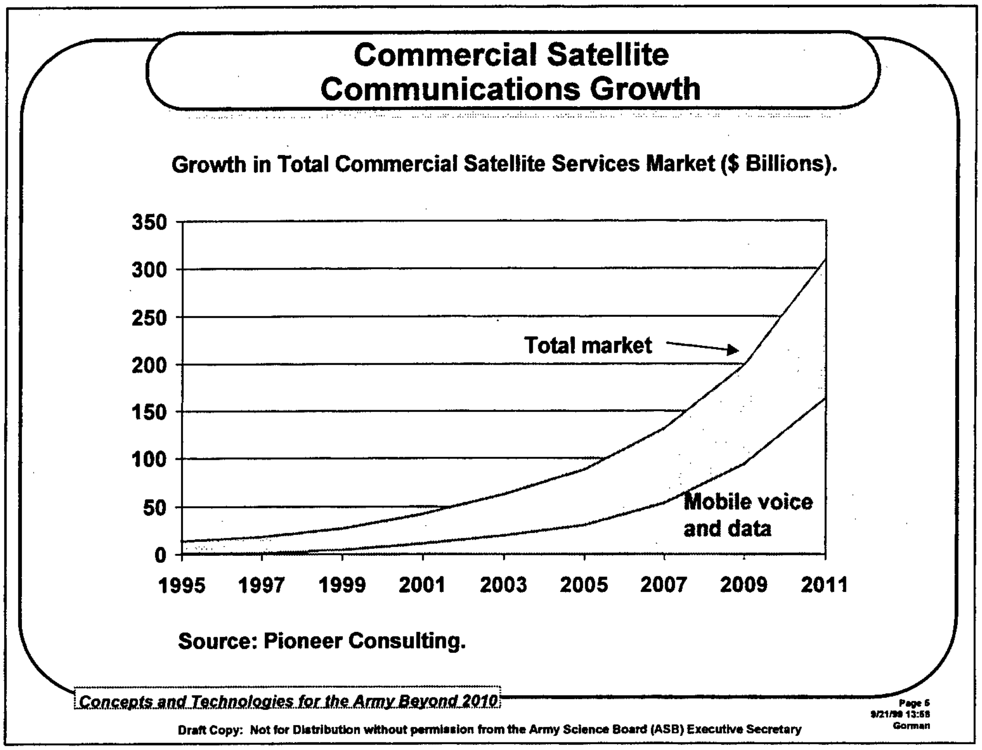
Communications technology is the basic infrastructure for all envisioned AAN strike force activities, including logistics, and strategic and tactical operations. It relates directly to the technologies for Battlefield Visualization, Situational Awareness and Space Technologies.



One of the most basic requirements for AAN communications is secure and reliable global reach. It is clear that the growth of the Internet is causing a huge amount of effort to be put into reliable and secure global high-speed digital communications infrastructure, both in terrestrial fiber-based and cellular systems, and in space-based systems.

In the area of terrestrial fiber, there are several companies (such as Qwest, AT&T, Sprint, Worldcom, MCI, etc.) that are laying large capacity fiber backbones in CONUS. The GTE/Qwest backbone, for example, spans 92 metropolitan areas and has a capacity of almost 5 terabits/second. (Assuming the size of this briefing is 2MB, this is enough capacity to send almost 2.5M copies across the CONUS in one second!) In global fiber telecomm, the situation is similar. Many companies, (such as At&T, Global Crossing Ltd., etc.) are laying transoceanic fiber. Transatlantic traffic is growing at a rate of 80%/year, and all bulk capacity is sold out for the foreseeable future. Fiber technology is robust in growing potential, as the theoretical bandwidth limits are extremely high (on the order of 100 Terabits/sec per dark fiber strand), with the current limitations being the switching speeds.

This chart shows the growth in capacity in global fiber telecommunications, relative to 1997 capacity. It shows an overall 500-fold increase in global fiber capacity by the year 2002.



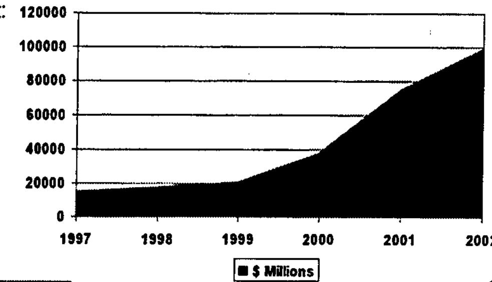
The global telecomm market extends well beyond terrestrial fiber-based infrastructure to satellite telecommunications. Most market projections predict that global satellite telecomm will grow rapidly, enough to capture 10% of the total global telecomm market. The chart above shows this to be in the range of hundreds of billions of dollars.

Although satellites have many technological disadvantages, they are extremely attractive in the "last mile" applications, which are likely to be of high importance to AAN operations. Despite limited overall capacity (in the tens of gigabits/second in aggregate bandwidth) and older technology (due to the 5-10 year lag in launch times), they allow point-to-point communications without the need to lay fiber or "dig ditches". Hence the projected growth.

There will be many types of global satellite communications, ranging from narrow band voice services to broadband digital and direct broadcast services.

Wireless Personal Communications Growth

- Marketing features
  - Three most important selling features: Bandwidth, bandwidth and more bandwidth
  - Secondary: Size, battery life and cost
- Large market allows exploitation of economies of scale
  - ~3M cell phones produced each month
  - ~500K digital data radios each month
- Cycle time and production learning curve are carefully managed
  - Products are designed for reuse, internal upgrade
- Technology is moving towards support of wireless internet access
  - Growth of wireless Internet market:



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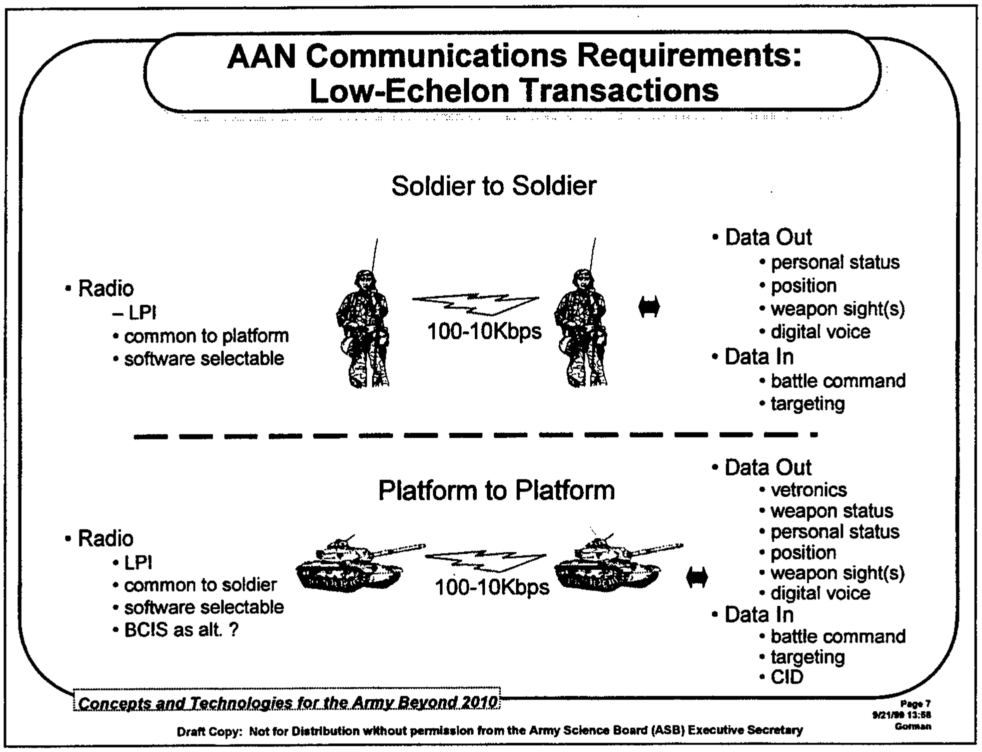
Personal wireless communications is a huge growth market. The commercial sector is moving especially quickly here, with intense drivers for the exploitation of economies of scale and careful management of product cycles. A single company might produce more than 3M cellular telephones per month. According to an NRC report, over 500K digital mobile radio sets are manufactured commercially each month. It seems clear that such economies of scale must also be exploited for AAN.

The rapid pace of change in technology translates into rapid changes in base infrastructure (e.g. CDMA vs. GSM) and the features expected by the consumer. As a result, the industry has to develop processes which allow them to manage product cycle times and production learning curves. Products are designed with the intention to reuse parts of previous designs and manufacturing processes. Ofentimes, an additional investment is made to allow for easier internal upgrades, thereby reducing the cost of future products. It is imperative that the Army be able to exploit these advances in product lifecycle management.

The market for mobile digital communications is also exploding, with the major part of this being in support of mobile internet access. The chart above shows the projected growth in this market, which is projected to reach the $ 100M mark by 2002.

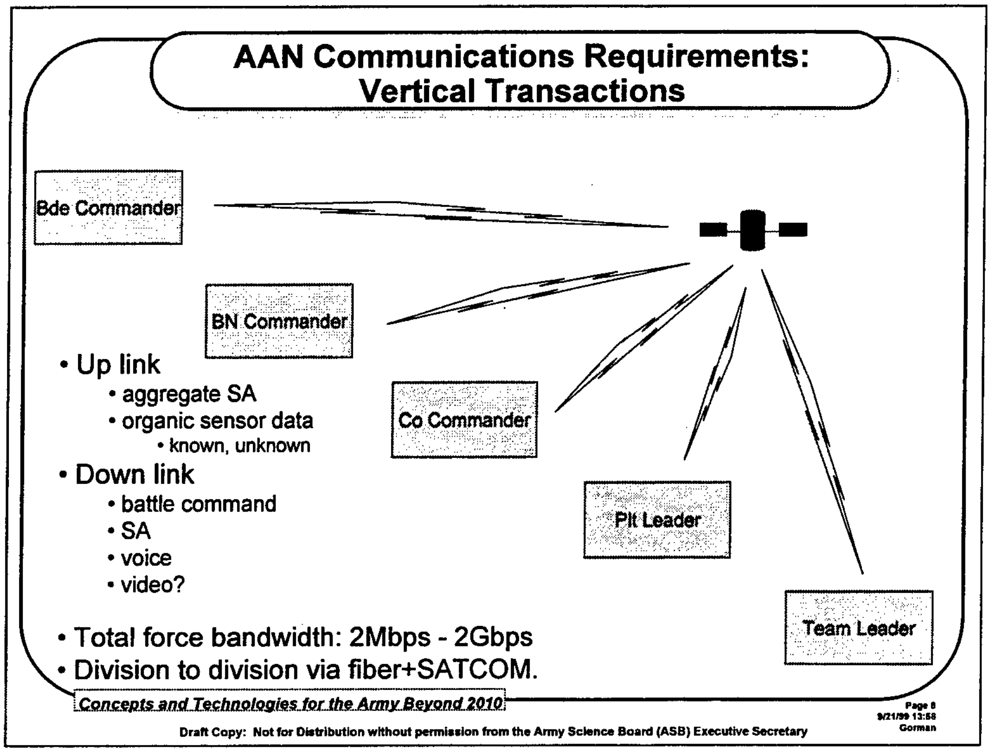


At the lowest level, intra-squad communications, it is likely that the Army will need its own unique voice/data radio with application in common, perhaps, with the USMC.

The individual combatant becomes a hunter-killer platform capable of providing a rich source of information to peers and higher command. Weapon sight imaging, coupled with precision range finding and self location will provide real-time accurate targeting data. Personal status monitoring will provide real-time readiness indicators for commanders and planners as well as prioritizing casualties for triage. All of this data will need to be communicated off the individual combatant to peers and higher command (squad leader). The through-put capacity requirement of such a radio is not clear. Simply moving the data can be done within 56kbps however the overhead associated with net management and security will likely increase this number.

Likewise, individual wheeled and tracked vehicles will need a similar capability, however, they will have additional throughput capacity requirements associated with vetronics, weapon status and combat identification.

In all cases, signature management and link integrity will be key. Squads and individuals will be inserted into denied space requiring low probability of detection and intercept.



For the Army After 2010 light strike force, it is anticipated that the battle force will have to rely on commercial satellite communications prior to the arrival of the Warfighter Information Network. Communications among peer echelons and inter-echelon will have to utilize space-based assets, handsets and small terminals to accommodate mobility requirements and the terrain. Commercial satellite based Personal Communications Systems (PCS) such as Iridium II or a similar commercial venture might fulfill this requirement. However, the Army's universal handset development which integrates the capability of many commercial waveforms in a single handset would provide a more robust capability.

There are, however, limitations in the current commercial initiatives with respect to survivability and utilization of the commercial spectrum during hostilities.

For echelons that would for the most part be stationary (division and above), terrestrial and trans-oceanic fiber will provide the requisite connectivity and serve as a high bandwidth injection point into the theater.

Potential SATCOM Show-Stoppers

- **Commercial ventures may not provide COTS communications technology to meet all AA2010 needs**
- **Survivability.**
  - **Robustness in the face of jamming and denial-of-service attacks**
  - **Requirement for low probability of intercept/detection**
  - **End-to-end security, including tamper proof devices**
- **Use of commercial satellite frequencies for "battle command" during hostilities**
  - **May violate international treaties.**

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The Army and DOD have unique requirements regarding secure SATCOM communications for military operations. These requirements far exceed those imposed by commercial SATCOM carriers. Given the cost associated with SATCOM system developments, it is likely that the Army and DOD may have to buy their required features as additions to commercial developments and deployments.

Specifically, the unique features that a commercial venture would likely not design into their systems are features necessary for robust operation in the face of hostile RF attack. Further, there is little need for a commercial concern to design a SATCOM system for low probability of detection and low probability of intercept. Most commercial ventures will implement some level of security features, especially with the growing market supporting electronic commerce. It is unlikely, however, that these security features will be adequate to meet Army and DOD requirements.

The use of commercial transponder frequencies for battle command during hostilities is prohibited. To date, the commercial spectrum has been used for the most part for planning and training operations.

Possible Risk Mitigation for Commercial SATCOM

- **Negotiate military transponder frequencies into commercial developments**
  - **Lease military frequencies back to commercial carriers during peacetime operations**
    - **possibly offset limitations in Army R&D resources**
  - **"federalize" military frequencies during conflict**
  - **stand up the communications equivalent of "CRAF"**

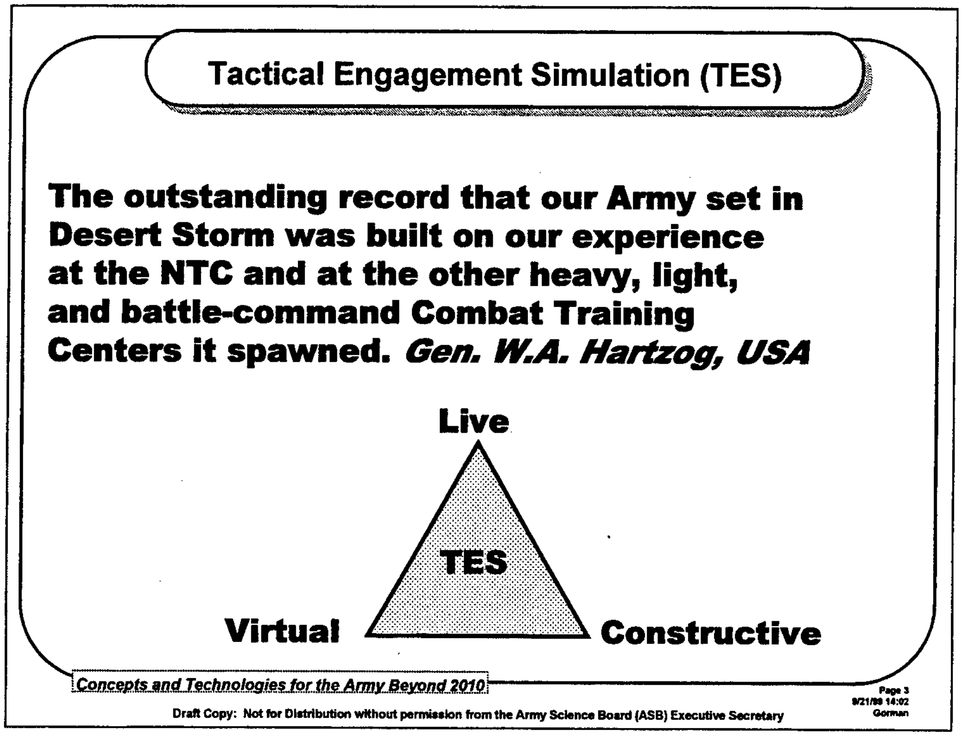
With Army and DOD budgets on a declining slope, it is clear that the Army does not have a strong financial position to develop, deploy and maintain its own dedicated space-based communications infrastructure to meet emerging information exchange requirements. What is less clear is whether or not the Army has adequate R&D resources to even buy the required unique features for Army applications to piggy-back on commercial ventures (case in point; Iridium). DOD does, however, have other tangible resources that may enable a favorable negotiating position to leverage a "seat at the table" for commercial (with DOD features) deployments. The military spectrum, for example, is such a resource.

The concept of using the military spectrum as a negotiating lever with commercial satellite vendors has several attractive features. First, the commercial sector is going to run out of physical bandwidth capacity and demand for wireless voice and data services increases. The industry can not buy more spectrum, there isn't any. Further, there are international moratoriums on the use of commercial transponder frequencies for battle command during hostilities. Offering military spectrum to commercial carriers for peacetime operations could provide the leverage needed to position the Army and DOD to get commercial concerns to absorb the cost of additional transponder (space vehicle) and earth terminal features to accommodate military frequencies. These frequencies could then be leased back to commercial carriers for peacetime operations and the "federalized" as needed during hostilities.

Agreements between DOD (likely DISC4 and/or DISA) and the commercial carriers for utilization would be similar to those used for the Civilian Reserve Air Fleet (CRAF).

APPENDIX J

TACTICAL ENGAGEMENT SIMULATION



After World War II, German generals among U.S. POW were asked to compare the fighting doctrine of the allied armies. There was agreement among the Germans that U.S. doctrine was clearly superior, but, as one spokesman put it, "While the Soviets almost always followed their doctrine slavishly, and the British usually enacted theirs, Americans rarely, if ever, behaved as if they knew what their doctrine was." When TRADOC came into being in 1973, General DePuy, its first commander, set out so to train the Army that its doctrine was consensus on how to fight.

The present commander of TRADOC has stated that "No single training reform since World War II has had so profound an impact on the readiness of...fighting battalions. [The NTC] introduced to Army units an unprecedented combat realism under rigorous, spartan field conditions by staging force-on-force mock battle through laser-simulated fire and near-real-time location, communications, and casualty assessment instrumentation." (Foreword in Chapman, A.W. The National Training Center Matures 1985-1993. Military History Office, USATRADOC. Fort Monroe, VA, 1997.)

But it was the combination of TES with after action reviews that translated experiential learning into doctrinal consensus. AARs "were arguably the major single influence on the revolution in training...By 1993, the AAR process was firmly in place throughout the Army as an evaluation tool...The NTC observer controllers [O/Cs] conducted AARs at platoon, company, and battalion task force levels...Data — both objective, computer-gathered information and subjective field observations gathered by video cameras and the O/Cs— were fed to the operations center to be analyzed, even as the battle continued.... Within fours hours [after battle, O/Cs]received, via microwave, edited video tapes and computer graphics [and] tapes of radio communications...The O/Cs went through the operations with the task force leaders and explained what was done right or wrong according to doctrine. Leaders...could analyze the results of their actions and develop approaches to improvements before the next battle." (Chapman, 218-220)

Buying the Past: Stand-Alone Systems

- **MILES dates from 1972; NTC from 1976; CCTT(SIMNET+) dates from 1983**
- **CTC-like instrumentation, LOS wpn emulators, two-dimensional AARs are @$700 m in planned spending FY98-05:**
  - **— $400+ million for MILES replacement**
  - **— $200+ million for NTC instrumentation**
  - **— $50+ million for JRTC instrumentation**
  - **— $70+ million: instrumenting Home Sta.**
- **Virtual Sim (CCTC) FY98-05> $700 million**
- **" Investment in Yesteryear: ~$1.5 billion**

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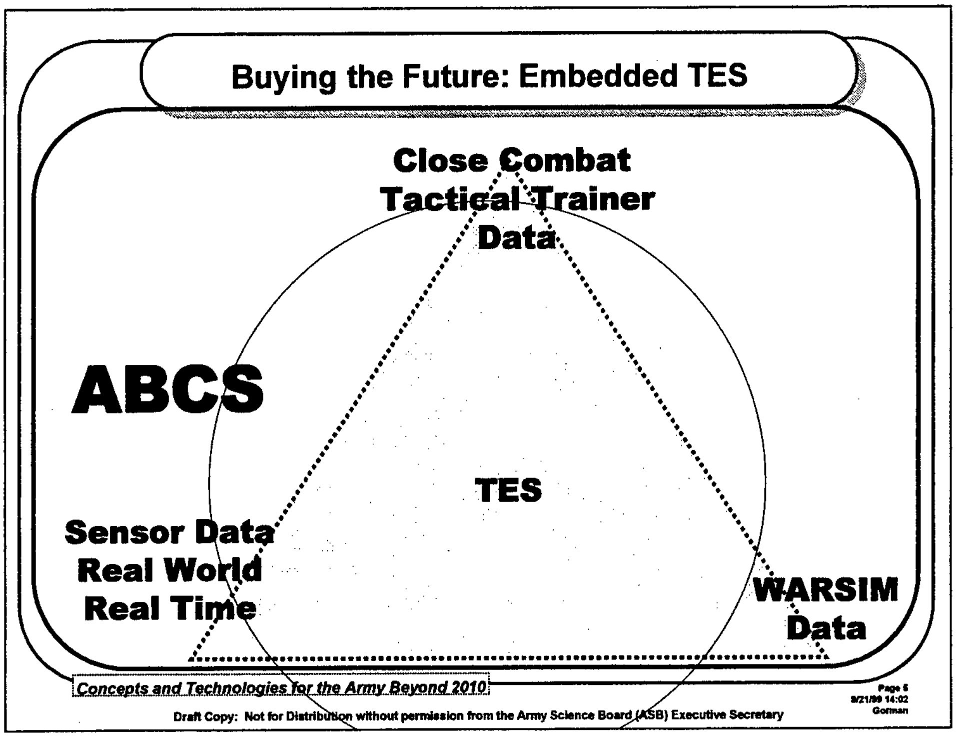
The information age permits the next commander of TRADOC to move TES to a new plateau of effectiveness:

LIVE

VIRTUAL TES **CONSTRUCTIVE**

Inter-connections among the three types of TES have been technically demonstrated, but are rarely exploited for training purposes. Rather, development of each of three types continues more or less independently, constraining the multi-echelon training advocated in Field Manual 25-100. E.g., the new CCTT facility at Fort Hood — where the Army's first digital division (FDD) is being fielded — utilizes terrain data from the NTC, not home station, and can not yet be coupled with the digitized Army Battle Command System (ABCS). Hence, battalions of the FDD can not use CTTT to learn how to use ABCS [it is germane that the $PEOC^3$ has identified performance of battalion TOCs as a major shortfall].

All TES instrumentation systems for which funding is contemplated are designed to **function independent of ABCS**. Yet, particularly if oncoming ABCS sensors, precise digital terrain data, laser range-finders and designators coupled into targeting functions, and battlefield identification systems are taken into account, such **instrumentation appears to be not only redundant, but also dysfunctional**: the principal teaching power of TES is the AAR, and since the AAR can and should be used in combat no less than in training, the means to capture and present data on combat actions ought to be as adroit as that for TES employed for training or operational rehearsals. **Habituation to the AAR ought to be a compelling reason for integrating TES capabilities into ABCS**. And avoiding the expenditures cited above ought to compensate for requisite software development, and lead to significant long-term OMA savings.



One AMC general stated that what is needed today is "a research effort to build OneSAF and WARSIM into future TOCs and C3 systems, for analysis, testing and training...we also see the potential synergy with the Joint Tactical Radio program (JTR)...because essentially it is a computer with RF output. Program needs an integration concept for fighting among joint/combined forces using the system…We should imbed simulation into TOCs vice external adaptations. ...If you consider this --and the idea that the Army wants to embed training and simulation into weapon systems platforms --and the TOC is a platform managed by PM TOC-- why aren't we moving to embrace this in WARSIM? This seems particularly important given ... wartime C3, mission rehearsal, etc --and the potential for sharing hardware costs with C3 systems (same hardware in TOCs for operations and simulation). Is this a simulation "rice bowl" issue? Is this a user partition between the TRADOC simulation and C3 community that has us building separate functionality?"

The Army Times recently attributed to the commander of the NTC the view that crimped funds have forced units to drop their highest level of home station training down a notch, from battalion to company. The result is that some units find the learning curve at the NTC to be so steep they can barely begin to climb it. He singled out the areas of battle command, communication and sustainment as those where the lack of collective training at home station was most keenly felt at the NTC.

The Army has proved that simulation can train battle command, communications, and sustainment. If there is a "rice bowl" issue obtruding, the new commander of TRADOC ought to knock heads together. **What is required is a determined rearrangement of funds and developmental priorities, led by TRADOC, so that over the next five years the Army can field TES support integral with fighting battalion's wartime C4ISR.**

Recommendations

- **Revamp the ABCS so that it can enable users to employ seamless TES for training or operational rehearsals, or to conduct AARs in combat**

- **Reallocate planned Army funding for stand-alone TES support (wpn sim, range inst, CCTT, WARSIM) to fold all three forms of TES into ABCS**

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Gorman

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The foregoing proposals above are not new. A paper published seven years ago ("The Future of Tactical Engagement Simulation," Proceedings of the 1991Summer Computer Simulation Conference, The Society for Computer Simulation. Pages 1181-1186.) held that airborne sensors could record actual air and ground vehicles engaged in live TES within a relatively small area and that these could be combined situationally by ABCS with friendly forces on the flank generated from the Armor School at Fort Knox, and with OPFOR reserves generated by a constructive model at Fort Huachuca, to fit into a corps exercise under the Battle Command Training Program at Fort Leavenworth.

What is <u>new</u> about the proposals is (1) the urgency of the issue they address, given the Army's narrowing fiscal options, and (2) the technology that can now support real-time interaction among the three forms of TES within ABCS.

Nonetheless, the proposals set forth are unlikely to succeed absent a strong top-down thrust. The CSA has heretofore vocally supported embedding simulation into Army systems; he should now direct: (1) the commander of TRADOC to revise the ABCS Operational Requirements Documents (ORD) as necessary, and to task appropriately his subordinates, especially the Commander of the Army Training Support Command (ATSC); (2) the PEOC^3 to incorporate TES into the ABCS to enable any commander from battalion or higher to use his wartime C^4ISR for seamless TES; (3) the Commander of the Army Materiel Command to task his subordinates to lend all possible support, especially the Commander, Simulations, Training and Instrumentation Command (STRICOM).

APPENDIX K

AA2010 PLATFORMS AND WEAPONS

AA2010 Battle Force Platforms and Weapons

- **Basic force concept —**
  - Lightweight, highly mobile ground combat and support vehicles
  - Advanced attack VTOL aircraft and advanced VTOL/SSTOL lift aircraft
  - Unmanned ground and air vehicles
  - Timely situation awareness information
  - Precision long-range fires and highly lethal weapons
  - Sustained operations without ammo resupply and refueling for several days
- **Trade-off of ground vehicle weight for air transportability and tactical mobility/agility demands alternative means for achieving platform and force survivability**
  - Reduced vehicle size and vulnerable area
  - Vehicle signature management
  - Platform mobility and agility
  - Active self protection
  - Advanced EW and CM subsystems
  - Beyond LOS and cooperative engagement capabilities

Compensate for Reduced Passive Armor

- **Array of advanced weapon systems expected to be available for fielding with AA2010 Battle Forces could provide dominant overall force lethality against a wide variety of targets**

Concepts and Technologies for the Army Beyond 2010

The effectiveness of contemplated AA2010 Battle Forces will be strongly dependent on a number of interlinking factors. Some of these factors include the overall force composition (platforms, weapons, personnel); the availability of current situation awareness information; the capabilities and reliability of local and wide area communications links; and the ability to generate timely, accurate, and highly lethal firepower at extended ranges. Others include supporting Joint fires; individual platform and overall force survivability; and the ability to execute sustained operations for several days without external ammo resupply or vehicle refueling. The force concept is based on the ability to execute fast-paced, sustained operations using a fleet of lightweight, highly mobile and agile ground vehicles, supported by VTOL attack aircraft and robotic ground and air platforms. The survivability of these platforms, particularly ground systems, poses a significant challenge, particularly in urban environments. Achieving individual platform survivability will require the effective integration of a number of vehicle design features and critical subsystems, including active protection system (APS) capabilities against highly lethal KE and CE threats, signature management (RF and IR), and advanced EW and other defensive countermeasure systems. Overall force survivability will be enhanced through the combined synergistic benefits of cooperative engagement and long-range fires, including the timely delivery of munitions from loitering platforms. Dominant force lethality will be realized via a weapons mix that includes high-performance KE and CE munitions, in conjunction with new directed energy systems (HPM and lasers).

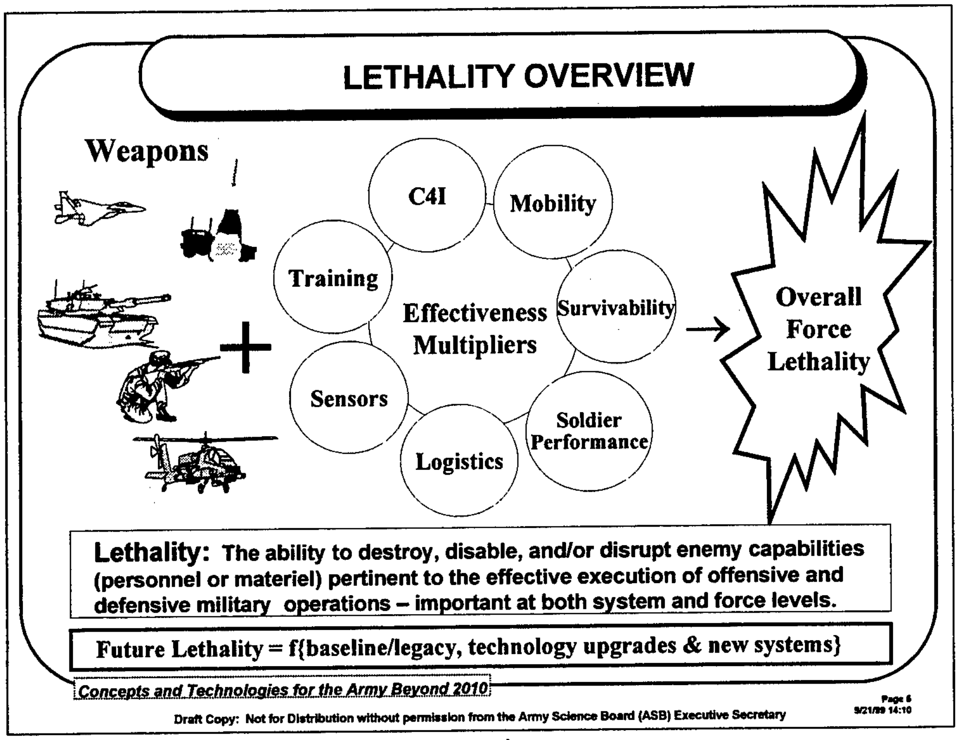
Platform/Force Survivability Options

Use of robotic vehicles and active protection systems will significantly enhance vehicle/force survivability —

- **Robotic ground vehicles**
  - Execute critical reconnaissance missions (including MOUT)
  - Serve as fire support companions (fighting in tandem with manned fighting vehicles)
  - Provide convoy/lines-of-communications security
  - Optional platform for advanced EW weapons (HPM)
- **Robotic air vehicles**
  - Provide long-range (BLOS) reconnaissance/surveillance
  - Provide long-range communications connectivity
  - Capable of EW and lethal munitions delivery
- **Vehicle Active Protection Systems (APS)**
  - Systems capable of providing protection against ATGMs, RPGs, and similar weapons already demonstrated
  - APS capable of defeating tank-fired KE munitions: ongoing research
  - Limited effectiveness against attacks at short range and high-rate-of-fire medium caliber weapons

AA2010 forces will have a robust array of offensive and defensive options, each contributing to overall force lethality and survivability. The insertion of both ground and air robotic vehicles will provide an unprecedented ability to see, track, and attack the enemy with high precision and at significant stand-off ranges. Unmanned air/ground vehicles and unattended sensors/munitions will greatly enhance Army capabilities for exploiting advanced, long-range, precision guided munitions throughout the battlespace. Unmanned air vehicles will complement high-altitude and space reconnaissance, surveillance, and target acquisition (RSTA) capabilities, including rapid and accurate battle damage assessment (BDA). The combination of these technologies should provide major advantages critical to overall force survivability, dramatically reducing human casualties as well as losses of manned equipment. The use of unmanned assets to defeat enemy targets at long ranges will contribute significantly to manned platform survivability by minimizing or eliminating detection of the usual signatures associated with firing platform-mounted weapons. This vulnerability will only be experienced when firing at shorter ranges as required for self-protection and surprise engagements.

Future active protection systems (APS) under development may soon be capable of defeating a variety of precision munitions and large-caliber ballistic threats. Active countermeasure suites will provide additional broad-spectrum protection. Force-level capabilities such as situation awareness and information dominance are also key contributors to system/force survivability.



Beyond 2010, achieving a high level of lethality will continue to be a complex and challenging problem, driven by the need for timely synchronized precision fires to support widely dispersed forces operating at high operational tempo. Two distinct perspectives on lethality are important — one based on the capabilities of individual weapon systems/munitions, the other reflecting an overall force effectiveness that includes many other factors.

Individual weapon system lethality is strongly dependent on the ability of the weapon platform to detect, track, and engage individual or multiple targets and specific missile/munitions and/or delivery system characteristics. Key features include sensors and signal/data processing, guidance and control systems, command and control links, propulsion systems, and warhead/fuse performance. Overall force lethality derives from the cumulative and synergistic effects of all of the various weapon systems deployed, as well as on other key force capabilities that serve as effectiveness multipliers, as illustrated in the chart. Continuing technology advances in many areas can be expected to enhance lethality from both perspectives.

The overall synergism of deployed weapons is critical — they must present the enemy with a wide variety of "ways to die." Lethality overmatches with respect to range, engagement timelines, and volume/precision of fires, either direct or indirect, must be enhanced for AA2010 forces. Complementary mission-enabling capabilities from joint fires and the effective use of non-lethal weapons must be exploited to the fullest extent possible.

KE/CE Weapons and Warhead Technology

KE Weapon Lethality Enhancements
- Advances in gun-launched projectiles:
  - Penetrator materials and design
  - Pre-cursor designs to defeat ERA
  - Advanced penetrator concepts
- Hypervelocity missiles/rockets
  - LOSAT: overmatch kill capability
  - CKEM: candidate KE weapon for lighter vehicles
- Extended-range, precision delivery

CE Warhead Lethality Enhancements
- Shaped charge technology
  - Liner materials and geometry
  - Multi-stage, multi-purpose designs
- EFP warheads
  - Materials/design improvements
  - Improved geometric control
  - Longer standoff devices
- Advanced explosives
- Improved computational design tools

EM Gun Technology
- Numerous potential advantages: range, lethality, accuracy, firing signature, reduced ammo weight/volume, etc.
- R/D challenges: pulsed power sources, hypervelocity launch, lethality
- Program motivation: tank main armament
- Potential AA2010 utility: medium-caliber guns, artillery

ETC Gun Technology
- Alternative electric gun concept
- Significant progress achieved in R/D, enabled in part by developments in fast-core propellant technology
- Current focus: electro-thermal ignition (ETI), with low electrical energy input
- Payoffs: increased velocity, range, accuracy, weapon system efficiency

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Continuing advances in weapons technology will help to ensure the fighting effectiveness of AA2010 combat forces. Significant advances are being made on many fronts. Lethality enhancements involving kinetic energy (KE) kill mechanisms are being achieved through improvements in materials and projectile design concepts (e.g., the use of precursors effective against both current and future ERA systems and segmented penetrators), as well as through the development of advanced missile systems for delivering heavy metal long rods at very high velocities. Productive ongoing efforts to increase weapons system accuracy and range will enable effective engagement of enemy forces under both line-of-sight (LOS) and non-LOS conditions. For chemical energy (CE) warheads, noteworthy lethality enhancements are being achieved for both shaped charges and explosively formed projectiles (EFPs). Increased standoff and greater control of individual projectile characteristics, including the ability to design multi-function warheads, will make future EFP weapons highly effective against a variety of targets.

Progress is also being made in the development of advanced gun systems. Although significant technical challenges must still be overcome before large-caliber electromagnetic (EM) guns might be deployed for main tank armament, the technology may find utility within the next two decades for medium-caliber guns on lightweight combat vehicles. Electrothermochemical (ETC) or ETI technology may also provide important new opportunities for upgrading the performance of future gun systems for AA2010.

Directed Energy Weapons

- **Offer significant potential for enhancing lethality of future forces**
- **Two most important types: HPM, lasers**

HPM weapons

- Upset/degrade/burnout critical electronic components in military systems
- Potential targets: missile G/C systems, radar and FC systems, R/S systems, communications assets, aircraft
- Instantaneous engagements, deep magazines

Laser Weapons

- Longer term DEW option: requires major advances in solid-state laser technology to reduce system complexity, size, and cost
- Critical operational issues: range, laser/target coupling, all-weather utility
- Potential targets for defensive weapons: helicopters, UAVs, ATGMs, air-to-ground missiles, cruise missiles
- Need to continue development for both offensive and defensive use to avoid technological surprise

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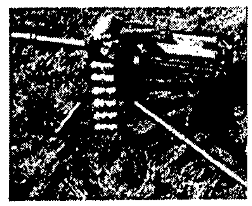
The weaponization potential of directed energy technologies, including high-energy lasers and high power microwaves (HPM), has been been the focus of significant DoD research and development activity for more than two decades. They remain under intensive investigation for their great potential in both offensive and defensive roles. Directed energy weapons offer a number of exciting potential advantages compared to more conventional munitions, including near instantaneous engagement timelines, increased stowed kills (deep magazines), adjustable power levels/effects, and unprecedented accuracy. There are a number of critical challenges to their development and operational utility, however, including high power requirements; system efficiency, complexity, and cost; concerns regarding fratricide; effectiveness against "hard" targets; and inherent limitations with respect to range and effectiveness under adverse weather conditions and in the presence of common battlefield obscurants.

Certain directed energy technologies investigated to date have shown significant potential as weapons able to to degrade and destroy the controlling electronic systems and subsystems—including various sensors—that are critical to the performance of many types of military equipment. They have also been shown to be effective in defeating a wide range of "soft" or thin-skinned targets such as cruise missiles, helicopters, and UAVs. It is highly likely that DEW systems will play a significant role in future AA2010 combat operations.

Non-Lethal Weapons

- **Offer new capabilities for conducting operation others than war (OOTW)**
- **Joint Army/USMC RDT&E program thrusts —**
  - **Acoustics:** systems to deter, disorient, disable, and incapacitate individuals individuals and deny access to designated areas
  - **Entanglements:** systems that deter, detain, disable, deny/inhibit access to to individuals and vehicles
  - **Kinetics:** direct-fire, low hazard, non-shrapnel producing munitions and systems that produce less-than-lethal trauma upon impact
  - **Riot Control Agents:** Systems that confuse, stop, neutralize, disable, disorient, distract, disperse, or isolate groups of people or potential threats over various terrain and under a range of environmental conditions
  - **Vehicle Stoppers:** Mechanical and directed energy systems that incapacitate vehicles
- **Representative system: Vortex Ring Gun**
  - Integrates concussion, flash, chemical, impact and possibly infrasonic methods for crowd control into a single vortex ring delivery system
  - Approach: PIP kit for 40mm MK19 machine gun
  - Payoff: significant non-lethal knock-down or incapacitation capabilities at up to 50 meters range



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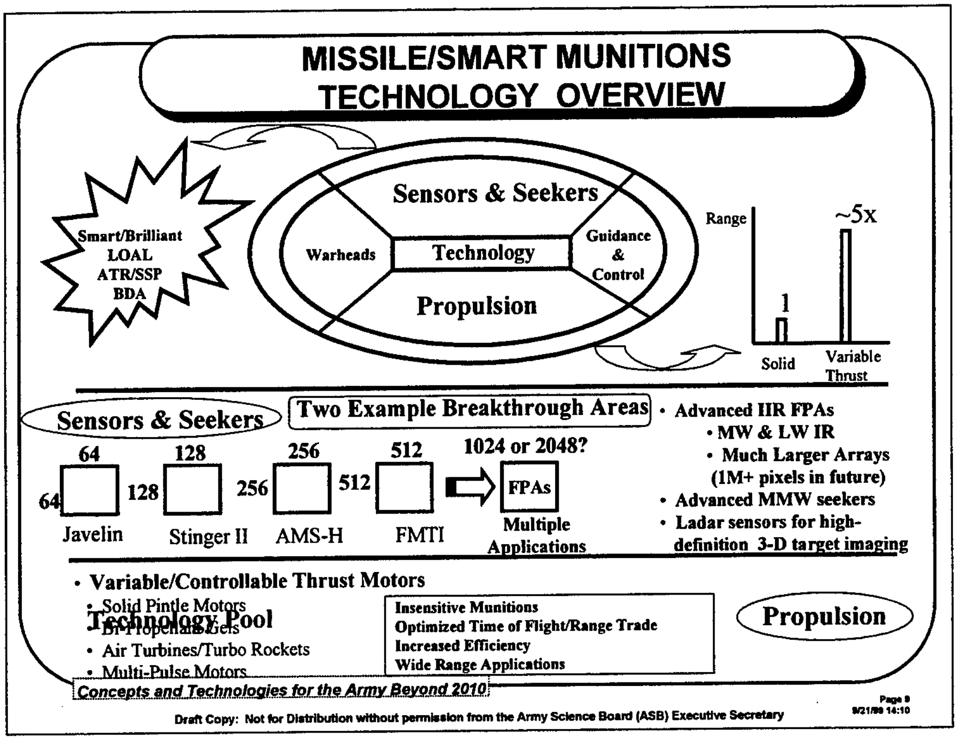
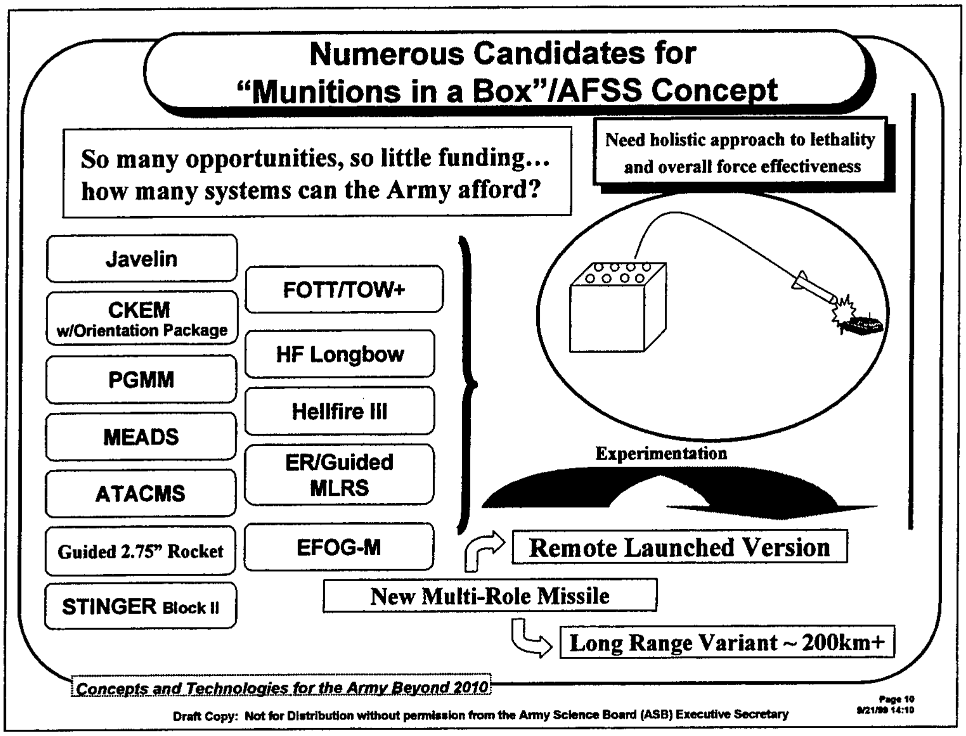
The importance and potential utility of non-lethal weapons in certain future military operations have been recognized at the highest levels of government. In June 1994, President Clinton directed the Secretary of Defense "...to *accelerate efforts to field non-chemical, non-lethal alternatives to Riot Control Agents for use in situations where combatants and noncombatants are intermingled.*" In response, a variety of non-lethal technologies have been developed to provide viable "less-than-lethal" options to military commanders in the field. The ability to employ a suitable mix of lethal and non-lethal means for achieving mission objectives offers advantages from both military and political perspectives.

The increasing concentration of world populations in large urban centers increases the likelihood that future military operations will be conducted in areas inhabited by large numbers of civilians. As a consequence, such operations will often be conducted under complex rules of engagement and humanitarian constraints. Recent deployment of U.S. forces to Somalia, Haiti, and Bosnia have demonstrated the fundamental operational need for non-lethal weapons (NLW), which can enable mission objectives to be met without unnecessary deadly confrontation. Such weapons can both minimize casualties and limit collateral damage to infrastructure and equipment while simultaneously denying propaganda opportunities to our adversaries. Important uses of NLW include crowd control, personnel incapacitation, area denial, vehicle disablement, the clearing of buildings and structures.



Missiles and precision guided mortar/smart munitions (PGMs) technologies will continue to advance in many areas, particularly in the seeker and propulsion areas. PGMs with lock-on-after-launch (LOAL) capability should be available for imaging infrared, ladar and dual-mode/multi-sensor type seekers—essentially automatic target recognition (ATR) capability for narrow fields of view. The exploitation of controllable thrust propulsion technology provides an opportunity for mission tailoring the thrust profile for a a wide variety of target situations with a potentially large increase in effective range. For example, missiles in the 100-pound range may have effective ranges from 1-200 km against a wide variety of targets, with optional capabilities for loitering and cooperative engagement. Similar improvements in warheads and guidance and control (G&C) are expected. G&C options should include "aim-point-selection" (for maximum lethality), mission tailorable trajectories, and data links for man-in-the-loop (MITL) and "sensor to munitions" updates to target intercept while the munitions is in flight.

The capabilities of I^2R Focal Plane Arrays have increased greatly over the last two decades. The number of individual pixels in modern missile/munitions seekers are at least 64 times greater than seekers in development in the early 1980s. Similar improvements in ladar and and millimeter wave seekers can be expected. Integrated multi-spectral sensors/processing technologies such as acoustics or special signal processing should be an option for this time frame. The need for increased range and precision "beyond-line-of-sight" engagement demands continued development of many of these advanced technologies.



Accelerated development and fielding of advanced PGM capabilities is critical to the rapid deployment and effective sustainment of future forces having overmatching range and accuracy, lethality, and heightened operational flexibility with respect to both optempo and agility. In response to this need, the Army is currently investigating a wide variety of advanced technologies relevant to the performance of PGMs. Identifying the most promising technologies to pursue given R&D resource constraints and the high costs of getting PGM programs into production, however, remains a major challenge. A technology consolidation or "neck-down" strategy is needed to help ensure that resources are properly allocated to the most promising approaches.

The DARPA Advanced Fire Support System (AFSS) program, widely referred to as the "munitions in a box" concept, is focused on the development of advanced PGMs for many different types of missions. Results of experimental and analytical program efforts to define key performance characteristics and to develop the critical enabling technologies could support the formulation of invaluable guidelines for developing PGM technologies and systems in general. A new missile is being considered in the program, one that might have both multi-role missions and also be suitable for deployment on conventional platforms. Design modifications that exploit variable thrust propulsion and optional wing-type lift technology could enable engagement ranges beyond 200 km. The optimal combination of technologies for achieving such varied capabilities could provide significant insights applicable to the adoption of a more holistic approach to PGM design and effectiveness.

APPENDIX L

FIRE SUPPORT

FIRE SUPPORT FOR THE BATTLE FORCE

Fire support for the Battle Forces comes from a variety of organic, supporting and joint sources. This Annex addresses first the organic source and then proceeds to supporting and joint sources.

Organic Means

For the Battle Force the organic sources of fire support are a) the Advanced Fire Support System (AFSS) and b) an MLRS-like (Multiple Launch Rocket System) capability. In both cases, the missiles are guided, although many performance details are still in the process of definition and design. The starting point for both AFSS and BF MLRS has been current inventory systems. Thus, shaped charge, forged fragments and bomblet lethality mechanisms are also the starting points on the design. Trajectories are ballistic. The major difference lies in the ranges of these weapons. The starting point systems have short ranges and expanding these does not involve significant risk

BATTLE FORCE ENHANCEMENTS FOR CRUSADER

The current plan for Crusader development should be viewed as a broad improvement that has been decades in formulation. Its howitzer, automated support, targeting, command control, mobility and protections combine to bring about an almost quantum leap in traditionally implemented tube artillery. It has no known peer either in planning, design or in being.

When one addresses the subject of Crusader improvements, they should not be marginal. This Appendix suggests that there could be dramatic improvements that derive from two sources – the nature of Battle Force air-mode operations and the possibilities resident in the combination of electromagnetic launch means and non-ballistic rounds. The first section of this Appendix will focus principally on electromagnetic launch; the next on the underlying rationale for the design of non-ballistic rounds. The concepts employ non-traditional capability mixes to achieve spatial control and very high space to force motion.

Electromagnetic launchers (EML) employ the forces arising from the cross product of a current and a spatially coherent magnetic field. The projectile to be launched rides in a sabot-like device which makes contact with rails. Very high current (drawn from a storage peaking and switching mechanism) is injected into the rail-sabot-projectile, which is accelerated along the rails to the desired speed. Were the rail just a traditional gun, its spatial orientation and the energy imparted to the projectile would determine its ballistic performance. The innovation suggested here is that the launcher imparts a reasonable speed to the projectile and an on-board propulsion system either sustains or increases the speed. Navigation and controls determine the flight path.

What does EML add to Crusader? The answer is caliber independence and efficiency. When these are coupled with rear ballistic (powered flight) projectiles dramatically different performance emerges.

The current 155mm projectile (46kg) can be accelerated to speeds of 660m/sec and achieve a muzzle energy of about 10MJ. This would also be true if the rails were set further apart so that one could accommodate projectiles ten times heavier. These heavier projectiles would approximate the lethality of the Air Force TMD (Tactical Munition Dispenser) CBU-87. Crusader could launch these at speeds of 200m/sec. Propulsion, airframe, fuel, guidance and control could be accommodated conservatively in about 200kg leaving 300kg for payload.

The current Army R&D program has focussed its total attention on EML for tanks. The objective is to achieve improved penetration of armor at higher speeds at energies of 20 to 39 MJ. The energy and power density of related EML components is thus driven to greater launch on one hand and constrained by the limited volume under armor in a tank.

These same objectives are not required for artillery or for that matter for smaller caliber gun equivalents. Artillery at 10MJ meets conventional round needs and opens up the possibility of caliber independence and the use of non-ballistic rounds. The volume available in Crusader lessens the EML power and energy density constraints. The Army could employ one of several EML mechanizations to achieve the 10MJ per launch goal. Firing-rate (and therefore recharge rate and energy supply demands) can be traded off against projectile weight and payload.

There are also other efficiencies and cost savings. The cost of conventional propellant is approximately $250 for 10MJ of muzzle energy. The cost of diesel fuel to achieve the same muzzle energy is about $0.50 using conservative efficiencies for the EML and fossil fueled elements of the system. Were the Army to shift all its artillery to EML, there is a propellant savings of $80M/year. Without counting the savings in unneeded infrastructure and the cost of environmentally eliminating waste propellant (possibly as much as half of that manufactured).

MLRS ENHANCEMENTS

The Army is moving ahead with a program to improve the accuracy of MLRS. There is no doubt that this is a wise choice. At the same time the Army should consider range improvements or combined range payload improvements which could be derived for MLRS implemented as a cruise missile.

Once again, MLRS requires a substantial weight fraction devoted to propellant – fuel plus oxidizer. MLRS could achieve the Treaty imposed limits of 500km as a cruise missile. At shorter ranges it could have a larger payload.

MLRS as a cruise missile could employ the many lessons learned and the technologies that the other Services have developed. The Army need not use expensive guidance or propulsion because of the conventional nature of such an MLRS variant.

With its current payload and low risk appliques for lift, propulsion, control and guidance, a current MLRS could slip to a range of 300 km (low risk) to 450 km (medium risk). An MLRS battalion could provide long-range fire support to cover the operation of widely dispersed Battle Forces or their Elements.

NON-BALLISTIC FLIGHT AND LOITERING

An innovation set recommended to be considered for Army XXI and AA2010 is to design all missiles with a capability to fly to the target area and loiter. A number of advantages result from this innovation although along with it comes a lengthening of flight time -- possibly by as much as of a factor of two or slightly more. The advantages are discussed at this point. The disadvantages are discussed next.

Efficient non-ballistic missiles fly to their target area as might a UAV, or manned aircraft might fly to a station or orbit. When ordered or programmed to do so, it delivers ordnance to the target. The transit and loitering capabilities are provided by lifting surfaces which are deployed after launch and a variable or dual thrust engine which uses a fossil fuel (JP-8, diesel, etc.). There are several efficiency advantages open which are a) the weight of fuel needed is much smaller and less expensive than rocket propellant; b) it's volume is also much less; c) lifted bodies simply get more miles per gallon than ballistic bodies, and as a result have greater range.

Loitering provides additional technical advantages. From loitering locations, delivery trajectories can be employed to optimize the performance of terminal seekers and guidance and to deliver munitions and lethality with greater effect than in general with ballistic trajectories.

The principal advantage of loiter is an enhancing and enabling synchronization in engagements. The seeming disadvantage of lengthened flight could be fully offset by synchronization improvements. Small engagements in gulf war combat and live (NTC) settings show significant operational value for loiter duration of a few to at most twenty minutes (see Appendix M). AFSS and MLRS-like missiles can achieve these if they fly efficiently at high but subsonic speeds (200-250m/sec) and can loiter at lower speeds (50-100m/sec). Large EM Crusader payload can perform similarly.

The challenges for the Army lie mostly in the concepts and doctrine changes to exploit loiter advantages operationally through cooperative engagement. The major technical problems lie in the affordability domain.

NON-BALLISTIC ROUNDS

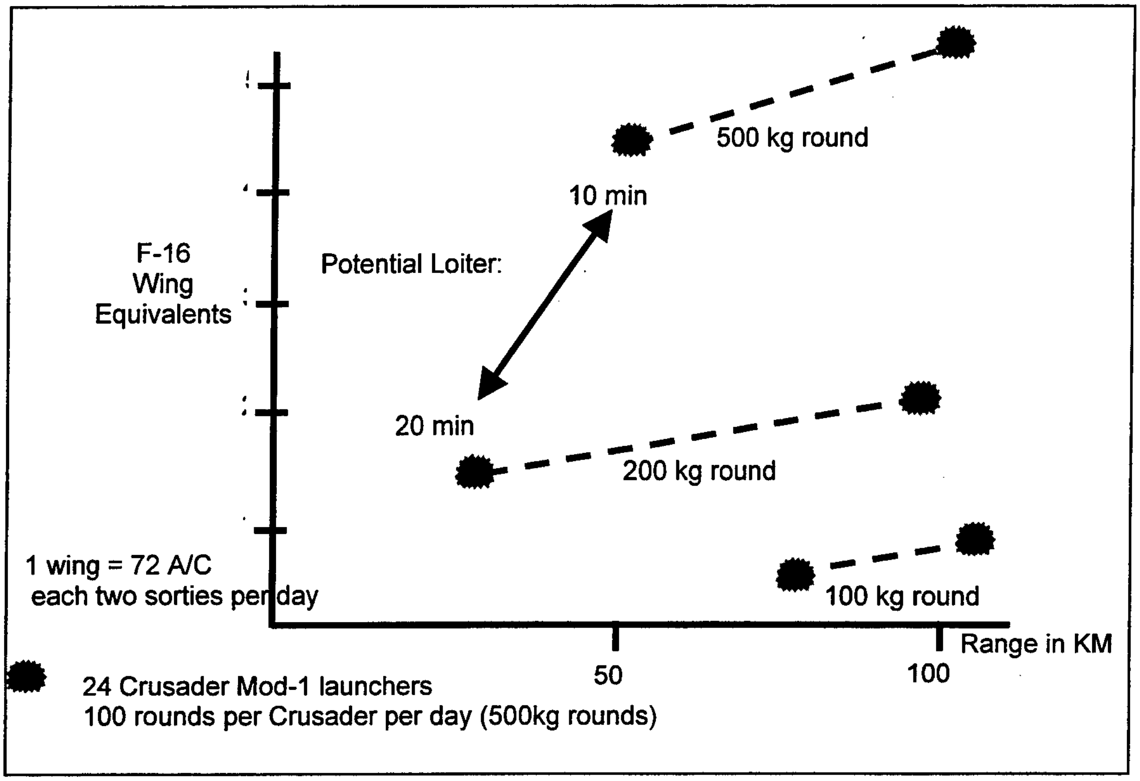


Figure 1

Designing, building, fielding and employing non-ballistic rounds is not a simple matter. Having said that, it is possible to employ surrogates to understand likely performance and define technical challenges. Non-ballistic rounds are very similar to UAVs (Unmanned Aerial Vehicles). Some UAVs that have been designed, tested and nearly fielded can be used for lethal suppression of various soft and medium hard targets such as command control area and air defense vehicles. Some UAVs have been and are used as targets, others have been and are used for sensor platforms.

UAVs fall into three broad classes – low, medium and high speed. All required endurance (which translates into range and loiter time). All have some vulnerabilities. Some are impulsively launched requiring fairly rigid structures, others take off and land like manned aircraft and are, therefore, soft-launched. A reasonable surrogate in some respects for non-ballistic rounds is the Northrop-Grumman BMQ-74C. It is canister housed, shipped and launched as a target for Navy air warfare training purposes. It flies for up to several hours (depending on its programmed flight profile) at high subsonic speeds. The canister is approximately 14 inches in diameter, the body is about 12 inches in diameter. Wings, stowed parallel to the body, swing into position and lock there after the body achieves a predetermined flight speed.

One may estimate non-ballistic round performance from its weight fraction characteristics.

Structure propulsion, avionics and controls	45%
Fuel (to fly 2500km at 250m/sec)	45%
Payload	10%

Payload can be traded for fuel. At 100km range with no loiter time or 50km with 20 minutes of loiter, payload moves to 50%. A 500kg EML Crusader round would carry a CBU 87 payload of 250kg, which is about 80% of the TMD payload. Range payload tradeoffs could yield ranges up to 300km with 75kg payloads.

This is not a bad start for design and technologies that are 20 years old. The Army and industry should be able to close the payload gap and produce an affordable package. In that regard the BMQ-74C is not a good model because it is designed to fall into the sea at the end of its mission, be recovered and then rehabilitated to fly again. At one time not long ago the BMQ-74C cost $70,000 in a canister and was returned rehabilitated for $20,000. Non-ballistic rounds need only short lives and should cost much less or they should be reusable in some way that does not hinder either the Battle Force or Army XXI units.

Battle Force Elements have areas of influence of 50 to 100km and may be separated by distances of a few hundred to one thousand kilometers. A modest number of Crusaders (3 to 6) could provide important overwatch functions, particularly in cases where an air or sea port was to be held and protected. Such forces would be 24 hours/day, all weather responsive and be massable because of range.

NON-ORGANIC AND JOINT FIRE SUPPORT

Supporting fires derived from non-organic but Army sources and joint forces have a common set of characteristics. The examples chosen are for joint support are the F-16 and DD21. They are comparable in delivering similar lethal payloads for purposes of this discussion. The payloads are area munitions which employ as their basic lethality element a grenade or grenade-like munition which on detonation creates a volume of high speed (~2km/sec) fragments ranging in size from 2 grains to 90 grains. In general, the heavier fragments have greater penetrating and damaging power but their area density is lower.

The F-16 is selected as an example of a joint Air Force fire support means. A wing (72 aircraft) has about 4,500 people and weighs about 7000 tons with all of its equipment. Later versions are expected to have 2000-2500 people and weigh about 4000 tons. The heaviest vehicle weighs about 10 tons (empty). The aircraft, which weigh about 8 tons, are not considered in this discussion since they self-deploy.

The DD-21 now in the design phase will probably displace 9000 tons, have a crew of about 200 sailors and carry about 400 missiles in total, including those for air defense and land attack. It may also have and extended range gun.

A comparable-lethality Crusader battalion (before the Army XXI reductions) had 24 self-propelled guns, about 600 people and weighed about 3300 tons. A similar MLRS battalion with 27 launchers and 132 people weighed 2400 tons.

The fuel and payload considerations for each of the alternate systems are based on what are felt to be reasonable rates – basic loads and wing sorties.

For two wing sorties per day, F-16s deliver 172,000 kg of CBUN and require 890,496kg of fuel for unrefueled missions at near maximum range of 800km. Daily resupply is 1,149,776kg or about 1300 tons/day without considering other classes of supply.

Crusader, delivering 3 basic load per day provides 115,000kg of bomblets with smaller fragments. Its total ammunition and fuel supply is 238,720kg/day or 260 tons/day, assuming maximum ground movement. Similar quantities for MLRS are 178,304kg of bomblets/day for a total weight of 387,932kg/day or about 430 tons/day.

Adjusting all to a common value – that of the F-16 – makes the comparable resupply quantities the following:

F-16 daily resupply – 1300 tons/day
MLRS daily resupply – 570 tons/day
Crusader daily resupply – 390 tons/day

In a preceding section of this Appendix, we examined other technologies to implement MLRS and Crusader which will measurably reduce these quantities. The Air Force is considering moving to much smaller bombs because improved accuracy provides the same lethality with less weight. This will not change the trends shown, since bomblets are used to attack area targets and unitary weapons are used to attack point targets.

The DD-21 cannot be comparably included since it is provisioned at a land base, takes its firepower to sea, expends it and returns to reload. It does not reload at sea.

APPENDIX M

THE MILITARY WORTH OF LOITERING

Boosted, Non-Ballistic Missiles [BN-BM]: The Military Worth of Loitering

Simulation Center,
Institute for Defense Analyses
for the
Army Science Board
Summer Study 1998

Task: Examine engagements in modern combat to gain insights into the utility of boosted non-ballistic missiles, and to ascertain requirements for loitering time

Executive Summary, Page 2

At the request of Dr. Braddock and Generals Funk and Gorman, co-chairs of the Army Science Board panel examining the Army after 2010, IDA's Simulation Center undertook to study two sets of data embodied in simulations of close combat: the virtual simulation **The Battle of 73 Easting**, and records of live tactical engagement simulation, **Operational Test VISualization (OTVIS) Playback of Selected Task Force XXI Missions — March 1967**. The study's purpose was as stated on the chart.

"73 Easting" is the product of a DARPA project initiated at the request of General Gordon Sullivan, then VCSA. General Sullivan was aware, from the book America's First Battles, 1776-1965, that among "first battles" of all previous wars the only decisive victory had been won by the 2d Cavalry in 1846. Intrigued by reports that the 2d Cavalry had fought and won the "first battle" against the Iraqis, he ordered teams to begin collecting data for DARPA in Iraq, within hours of the engagement, from all available sources, establishing minute-by-minute the positions and sequential actions of the U.S. and Iraqi antagonists. DARPA, employing SIMNET SAFOR, then used these data to drive icons within a synthetic battle environment. The result was a vivid, four-dimension representation (latitude, longitude, altitude, and time) of the battle that accurately depicts the actual behavior of combatants on both sides. Analysts can now examine the battle by roaming within that virtual simulation at will, adopting any point of view they wish, and running in real time, fast-forward, or back.

OTVIS is a product of the US Army TRADOC Analysis Center — WSMR, that presents a series of "movies" showing, by successive frames derived from NTC instrumentation, key engagements during the Advanced Warfighting Experiment involving the Task Force XXI brigade. Again, the data, derived from live tactical engagement simulation, accurately depicts the positions of forces of both protagonists at specified times.

Executive Summary

- Direct fire fights among AFV are usually of short duration: 15 minutes or less.
- Formations of AFV on the move present dense target arrays that usually persist for less than ten minutes.
- A non-ballistic missile with loiter time of up to 15 minutes would be useful for the following:
  - — Extending the control of US AFV (range, lethality) by exploiting sights, laser range finders, and BCIS
  - — Covering to the front or flank of AFV on the move
  - — Synchronizing maneuver with direct and indirect fires
  - — Foreclosing having to disclose position by muzzle flash
  - — Engaging transient targets identified by collaborative sensors

Artillery that depends on ballistic projectiles, being inherently heavy and vulnerable, is usually held to the rear by land combatants, and its *modus operandi* necessitates elaborate communications and procedures to nominate targets and to coordinate their engagement. Requests for fire being passed rearward consume some eight minutes at each echelon involved. As information technology flows into the force, its ability to prosecute even transient targets improves. Yet ballistic projectiles, whether shells or missiles, have difficulty in hitting moving targets, or in providing close support to swiftly maneuvering friendly forces. Cruise missiles able to dwell for a period over a target seem more apt for the information age, and more advantageous for future battlefields.

Moreover, in looking ahead to the period post 2010, the ASB anticipates both much more powerful sensors, and much tighter sensor to shooter linkages. Hence, several concepts being explored by the Tactical Technology Office of the Defense Advanced Research Projects Agency seemed highly relevant to the ASB study. These include several sensor and sensor control programs that provide for enhanced situational awareness, and, importantly, the Advanced Fire Support System that enables a very short time-span from sensing a target, to deciding to destroy it, to delivering the lethal munition.

The U.S. Army's "digitization" has thus far improved information flow for conventionally structured and armed units. This study assumes advanced sensor systems and fire support organic to the battalion echelon, directly under the control of the battalion commander.

The study tested the hypothesis on the following page, and concluded that non-ballistic, boost-launched missiles would benefit synchronization and heighten lethality for the reasons cited on the chart, and that ability for such missiles to loiter over a target area for up to fifteen minutes would suffice.

Hypothesis: Loitering BN-BM can provide enhanced synchronization and increased lethality

Test with two experiments:

1. Inject BN-BM into **Battle of 73 Easting** (pages 5-11)
   - Virtual simulation of engagements of 2d ACR vs. Iraq's Tawakalna Guards Division
   - Assume BN-BM weapons carried in lieu of 4.2 inch mortars

2. "Equip" TF XXI with C4ISR/BN-BM ca. 2010 (pages 12-30)
   - Employ **OTVIS screen-capture** from Mar, '97 Force XXI AWE
   - Assume availability of developing sensor/shooter systems in DARPA's Tactical Technology Office

By using both the data from actual combat as captured by the virtual simulation **The Battle of 73 Easting**, and the data from live TES captured by the **OTVIS Playback of TF XXI AWE**, the Simulation Center tested the hypothesis shown in the two experiments described.

Note that in both experiments, data from the past was used to establish an analytical framework for evaluating sensors and weapons that will not be available for another decade. The expected outcomes were insights into the military worth of the postulated materiel, not its definitive evaluation.

Note also that this report displays only frames from the imagery that supported the analyses, whereas the analysts viewed these data in motion, and in both cases were able to control the speed of display, to change scale at will, and to record times, to measure ranges and velocity of movement, and to observe the result of firing events.

Finally, the engagements described by the two simulations were categorically different: The Battle of 73 Easting was an actual battle that lasted only some three hours. It was fought in conditions of poor visibility on a generally featureless flat desert. In contrast, the simulated engagements of the TF XXI AWE took place over a period of ten days at Fort Irwin, California, in the high Mojave Desert, mainly in the daytime, with visibility impaired only by accidents of terrain.

Assumptions re BN-BM:

— Range >20 km
— Flight profile:
  --Climb to ~3 km
  --Glide/fly to target vicinity
  --Loiter for 5-15 minutes
  --Can be targeted to geo-spot
  --Can also seek, discriminate
  --Attacks on detection, or on command
— Lethality > current 155mm cargo round
— Deployed per AFSS schema

This report was prepared under the direction of L. Neale Cosby, Director of the Simulation Center, by R.E. Clover, assisted by Major H.R. McMaster, U.S. Army, of the Army's National Training Center, and Generals Funk and Gorman, USA (Retired).

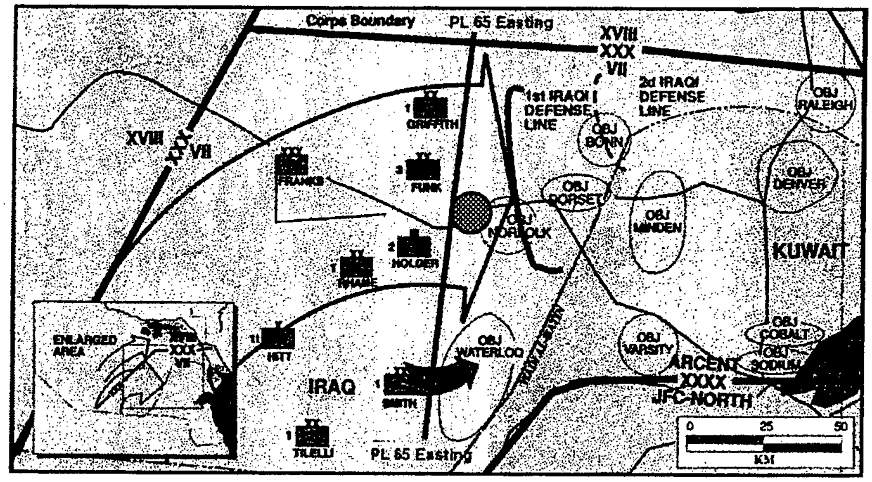
The Simulation Center's task was to examine the military worth of a hypothetical weapon system proposed by DARPA for the Army after 2010, referred to as the Advanced Fire-Support System (AFSS). AFSS could employ boosted, non-ballistic missiles (BN-BM), characteristics of which are stated on the chart.

The AFSS posits deploying small, cheap cruise missiles in a box, or container, that functions robotically on command from a radio transmission. Hence, an AFSS fire unit could be positioned from the air by parachute, LAPSE, or helo, or by ground vehicle, and could be assigned to a specific tactical commander, launching its missiles when and to where he decides. Moreover, BN-BM once aloft could seek vehicular targets autonomously, and deliver lethal sub-munitions accurately thereon either of its own volition, or on command.

The broad purpose of the Simulation Center's analysis was to explore the potential of a munition that could loiter over an expected engagement area to facilitate the tactical commander's exploitation of multiple sensors for identifying targets, and his synchronization of BN-BM strikes thereon with other fires and maneuver elements. The Center was specifically requested to ascertain from a study of both data sets how much missile loiter would be useful, given the time duration of force-on-force engagements, or the persistence of lucrative target sets.

Experiment 1

The Battle of 73 Easting, 26 February 1991

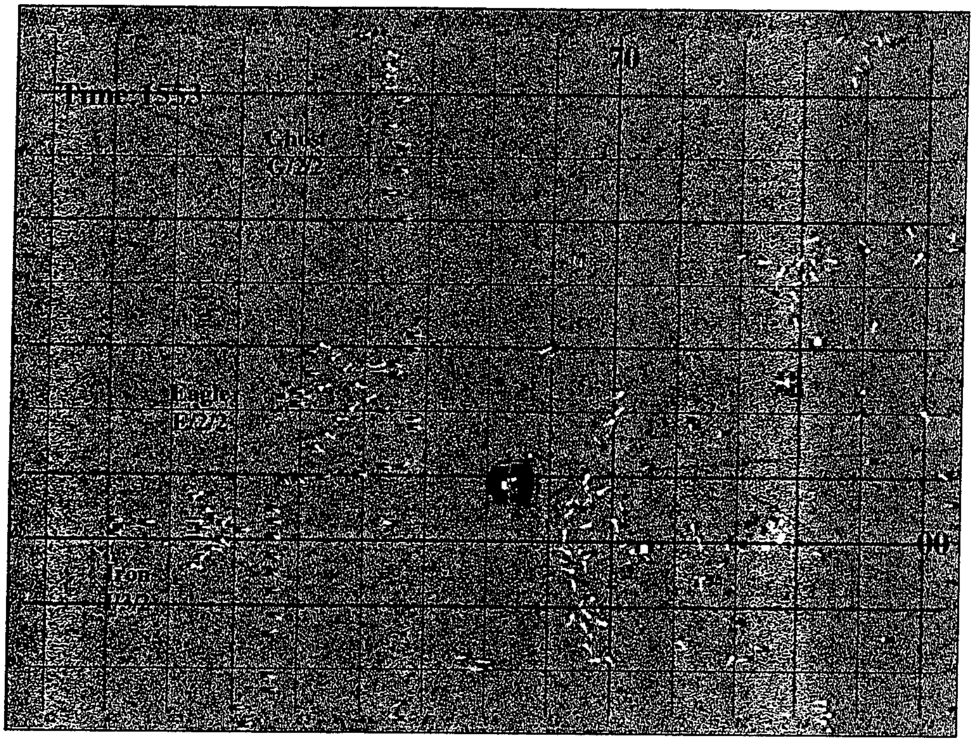


● 2d Squadron, 2d Armored Cavalry *versus*
18th Mechanized Brigade, Tawakalna Division, Republican Guards

On the third day of DESERT STORM, VII Corps (LtG. Franks) had penetrated deep into Iraq, and had shifted from a northerly direction of advance to an eastward thrust to engage and defeat divisions of Iraq's elite Republican Guards. The latter, equipped with late-model Soviet armored fighting vehicles, were arrayed across the VII Corps axis of advance, in the positions shown as Objectives Norfolk, Dorset and Bonn, screening Iraq's withdrawal from Kuwait. The 2d Armored Cavalry Regiment (Col. Holder) was on the Corp's right (south) flank, instructed as follows: "If the enemy is moving, the regiment destroys the advance guard battalions and establishes the situation. If the enemy is stationary, the regiment fixes the enemy, finds his flank and assists in getting the divisions into the fight." Behind the 2d ACR was the 1st Infantry Division (Mechanized) (MG Rahme), racing to pass through the 2d ACR to form on line with the 3d Armored Division (MG Funk) and the 1st Armored Division (MG Griffith).

At 1525, passing 65 Easting* (Phase Line Tangerine), the 2d ACR had its 2d Squadron on the north, its 3d in the center, and its 1st in the south. Most of the cavalrymen sensed that the enemy was near. A sandstorm was blowing under a low overcast, often reducing visibility to less than 1000 meters. There was neither air support nor aerial scouts. An order was passed to the lead elements to advance to 70 Easting, and to wait there for further instructions.

**In lieu of maps, the cavalrymen were navigating with GPS and a numbered grid of one-kilometer squares, the north-south lines of which were referred to as "(number) Easting."*

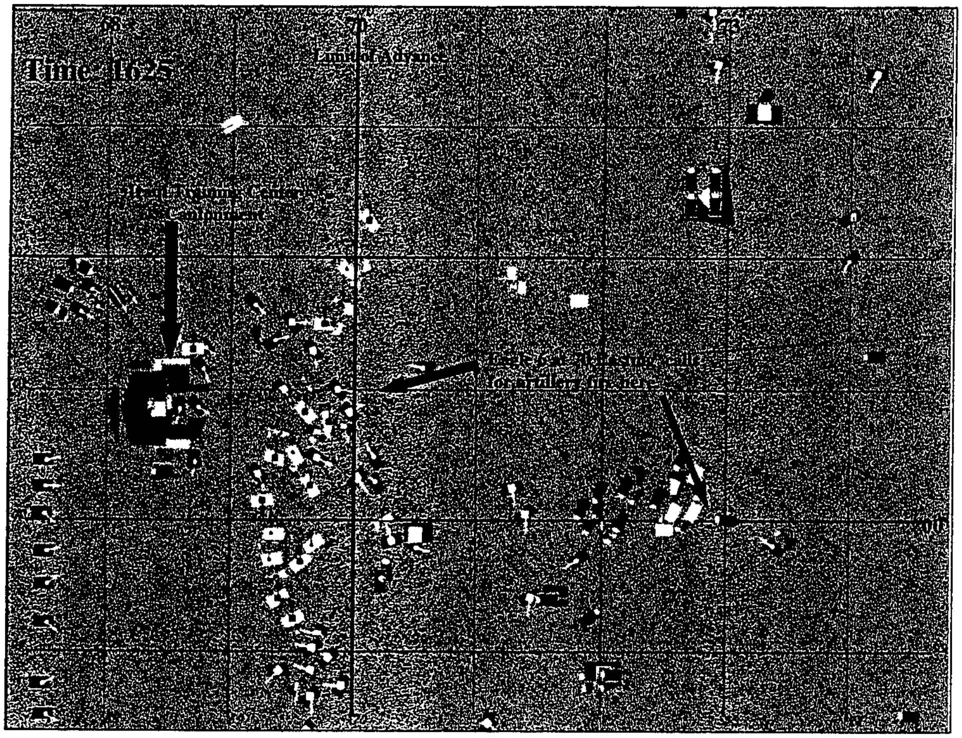


At 1553, among the most advanced elements of VII Corps were Ghost and Eagle Troops of the 2d Squadron, 2d Cavalry, moving abreast at 25-30 miles per hour, approaching 67 Easting. Iron Troop of the Third Squadron was to their southwest, nearing 65 Easting. Eagle's scouts (in Bradley AFV) on the troop's southern flank were echeloned back to maintain visual contact with Iron.

The diagram is a plan-view screen-capture, one output from DARPA's virtual simulation, generated from data collected on the ground immediately after the action, and supplemented by imagery and extensive interviews. The plan-view was chosen for this experiment because it provides an birds-eye view of friendly and enemy positions, records time, and facilitates changing the scale and speed of the action. The solid blue and red icons —scaled x50 the size of an actual vehicle— mark the positions of AFV; a tank bears a white dot and line to indicate the azimuth of its gun, while an infantry fighting vehicle bears a lesser white line. (In subsequent frames, whitened icons identify vehicles that have been hit and destroyed). The red polygons show Iraqi buildings or other structures, such as tents.

Minutes later, lead Bradleys of Eagle Troop came under fire from automatic weapons positioned in the building complex shown in the center of the screen (between 68 and 69 Easting). Eagle had driven into the Iraqi armor training center.

CPT McMaster, commanding Eagle Troop, decided to hit the enemy buildings hard and to bypass the complex to the north. He brought all 9 of his M-1 tanks on line and gave a command that fired a volley of nine 120mm HEAT rounds into the complex, effectively suppressing the enemy there.

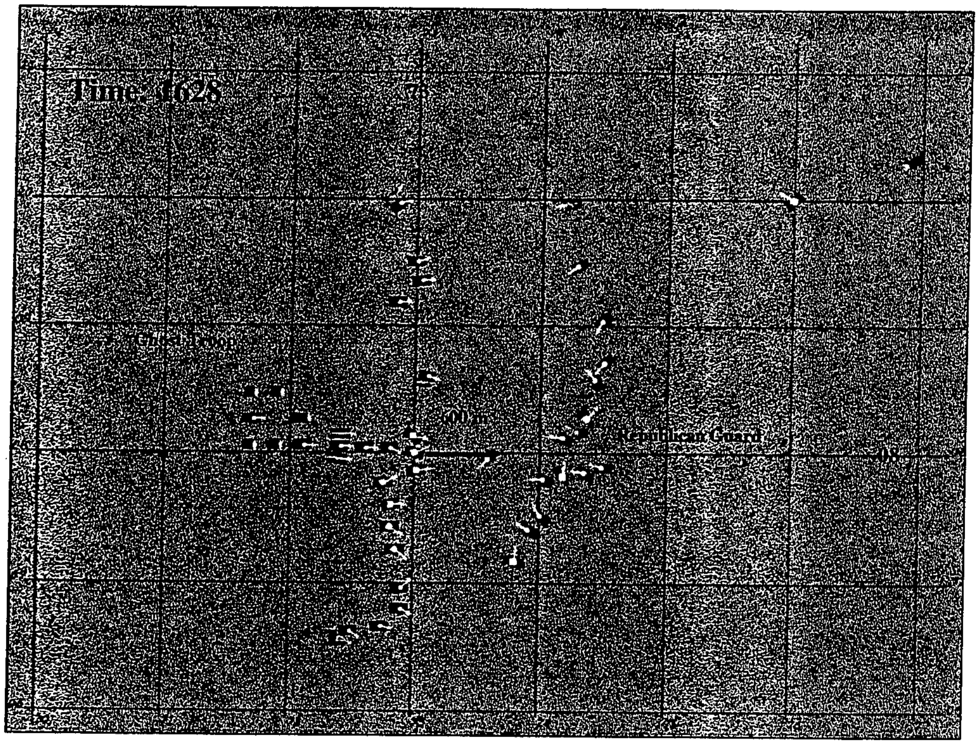


As Eagle swung past the buildings the troop encountered to its front some 30 T-72 tanks and a dozen BMP in revetted positions, interconnected by infantry-manned trenches. Without hesitation, McMaster opened fire and attacked southeasterly, knifing through the enemy defense.

Captain McMaster had struck into the flank of the 18th Mechanized Brigade of the Tawakalna Division. Expecting the Americans to advance up the roads to the Training Center, the enemy had oriented to the southwest. Further, his tankers had set their sights at the standard Soviet battle range, 1800 meters. Eagle's vehicle commanders opened at ranges as great as 2400 meters, consistently engaged first, and used their thermal sights and laser range finders for precision gunnery. Moreover, the Iraqis presumed that gun flashes they detected were from stationary tanks, whereas the Americans were shooting on the move aided by gun stabilization. Many Iraqis tried to shoot back, but their fire was wildly inaccurate. By 1625, as the diagram shows, all T-72s in range were flaming, and Iraqis were surrendering. The Iraqi commander later reported that over the preceding five weeks he had lost only 2 of 39 tanks to air attacks, but that in less than 6 minutes, Eagle troop had annihilated his entire command.

However, McMaster's aggressive attack had crossed into the path of the Iron Troop. Moreover, Eagle could see a much larger enemy force just out of range to the east. The Squadron Commander directed that Eagle turn northeast. McMaster complied, but at 1625, to cover his right flank, he requested artillery fires at "grid 730005." There ensued a classic example of the fog of war (tape-recorded as it happened): the Fire Support Officer, apparently believing that Eagle troop was still short of 70 Easting, the Limit of Advance, responded "Roger, grid 7005." This exchange was repeated twice more. McMaster, fearing that the artillery would shoot into Eagle at "grid 7005," called "Cease Fire!" and moved to the northeast without supporting fires, traveling for 10 to 15 minutes vulnerable to a counterattack from the flank.

Here was a situation where loitering, AFV-killing missiles could have served to secure the exposed flank of the troop on the move, and to confuse and to inflict losses on enemy forces that had been located, but were beyond range of direct fire.



Meanwhile, at about the time that McMaster was on 70 Easting calling for artillery fire, Ghost Troop had advanced to 73 Easting. As depicted here, they had closed to within 600-1000 meters of an enemy defensive position. Due to poor visibility, neither side had detected the other, and neither had fired a shot.

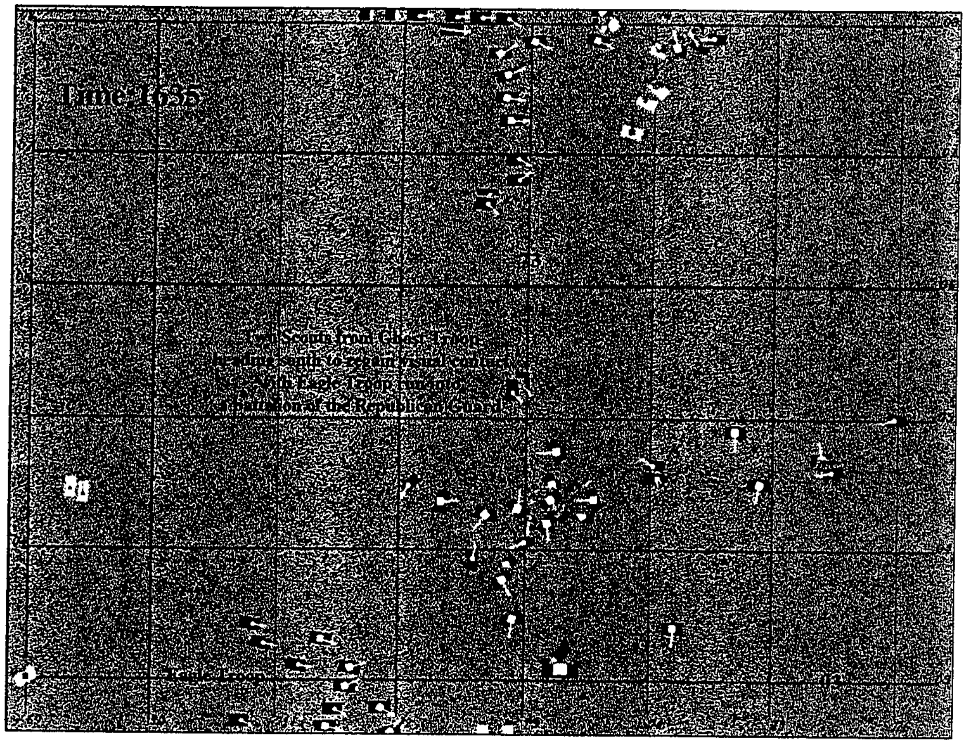
However, thanks to Ghost Troop's thermal sights, its soldiers spotted their quarry first, detecting as "hot spots" the very tops of T-72 turrets visible over the sand berms which the Iraqi's had thrown up around their vehicles.

Ghost Troop opened fire. The Iraqis returned fire, aiming at the Americans' gun flashes.

The US 120mm SABOT rounds punched through the sand berms, through the T-72 armor, into the rear engine compartment, and in many instances blew the engines completely out the backside of the tanks. The most violent part of the battle lasted only five to ten minutes, although it took almost 30 minutes to locate and to kill the last Iraqi tank.

Ghost troop emerged from the fight intact.

Had Ghost Troop been equipped with loitering missiles, they could have used them as "scouts", seeking out and attacking the enemy from above without requiring Ghost to reveal its position by firing, and searching out beyond the range of direct fire weapons to insure against a lurking counterattack force.

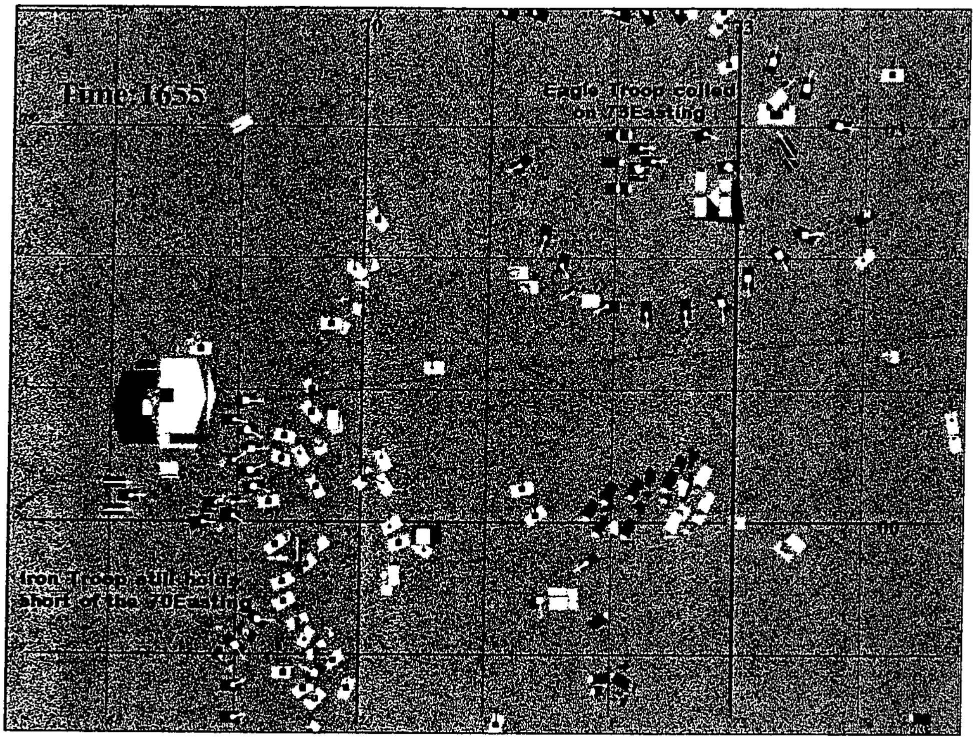


In the meantime, another threat emerged to the immediate south of Ghost Troop. Ghost had detailed two of its scout vehicles to maintain physical contact with Eagle, but these has been delayed by an enemy minefield, and lost sight of both Eagle and Ghost. When the the firing between Ghost and the Iraqis flared to their front, the two vehicles moved rapidly to join the fray, only to be ordered back south to reestablish liaison with Eagle.

However, when the two scouts from Ghost Troop turned south, they encountered a large armored force in defensive positions. Initially they were unable to tell whether it was friend or foe, or to estimate its size. They knew with certainty only that they were outnumbered. Cautiously they inched forward. As they closed to within 400-500 meters, they were able to ascertain that they had stumbled upon a fairly large concentration of enemy armored vehicles.

The two scout vehicles "hunkered down," and succeeded in raising Eagle on the radio to inform them that there was a large enemy force to their north, separating Eagle and Ghost. For the next 30 minutes, they coordinated with Eagle Troop as it turned northeast. When Eagle opened fire, the Ghost scouts fired TOW missiles into the enemy, and pulled back toward Ghost. Within 30 minutes, the entire Iraqi force between Eagle and Ghost was in flames, and again Eagle emerged from the engagement unscathed.

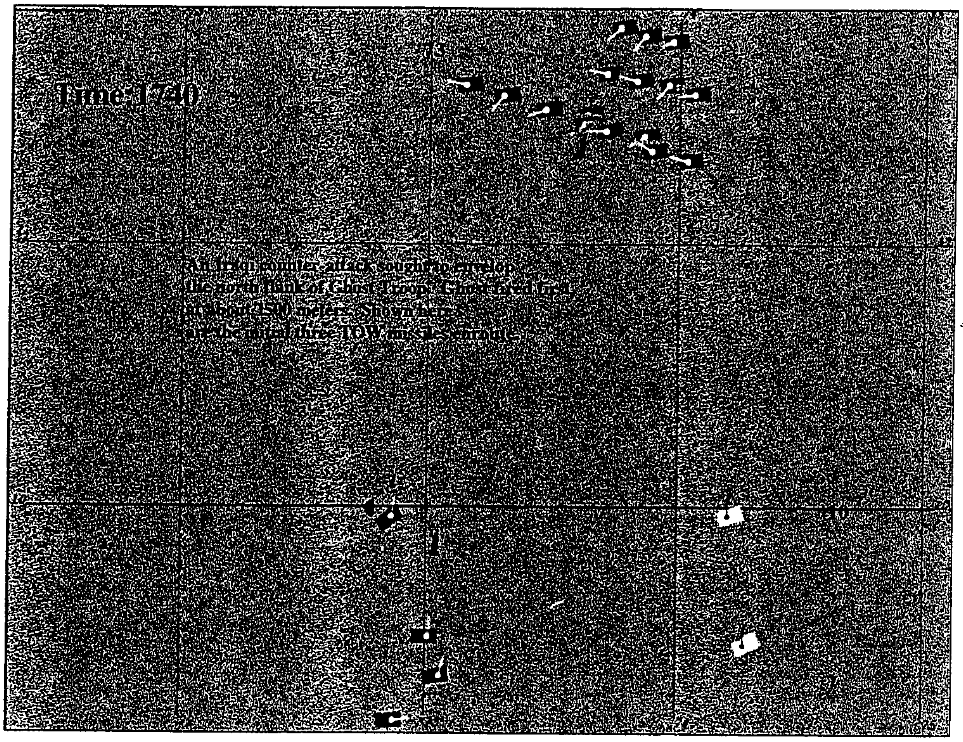
The implications for loitering missiles are clear: (1) they would have been a genuine force multiplier, transforming the two Ghost scout AFV into a force capable of engaging and defeating a larger enemy force without revealing position; (2) reliable "blue" situational awareness would have enabled the scouts to collaborate with Eagle, designating precise targets for missile strikes synchronized with maneuver into the enemy defenses.



At 1655, Eagle Troop had 73 Easting and had "circled-up" vicinity 730030 to assess the situation. Visibility was still very poor. Captain McMaster anxiously called each platoon, and learned that they had made it this far with no casualties. He was concerned that some of the Iraqi infantry which the troop had bypassed might hit them from behind. He was aware that Ghost had successfully engaged to his north, and he was reassured that, acting on reports from the Ghost scouts, his troop had eliminated the enemy battalion between the two troops. But he was troubled by the fact that Eagle had lost visual contact with Iron, which had been hotly engaged some six kilometers to the southwest of his lead platoon. Overhearing 2d Squadron ordering Iron to move eastward, McMaster directed Eagle to monitor Iron Troop's radio net to ensure that Iron did not mistake Eagle for the enemy.

As McMaster was estimating the situation, his tanks and Bradleys fired several enemy tanks, personnel carriers, and trucks beyond the 74 grid line. Violent explosions followed, indicating a fuel and ammunition resupply point, and suggesting that Eagle had penetrated into the enemy's rear. The enemy force to the south, vicinity 730005 Easting, that Captain McMaster had sought to attack with artillery could still be seen positioned across Iron's axis of advance.

Here was another situation where loitering missiles could have been used to advantage, both by Eagle to extend its control eastward, and by Iron to attack the enemy force out of range to its front. Collaborative engagement would have been possible, with Eagle pin-pointing enemy vehicles to be attacked and destroyed by missiles launched by Iron.



Later, just before dark, the enemy attempted to attack around Ghost's north flank. Enemy tanks and BMP's weaved among the endless array of dirt mounds which comprised the enemy defenses. As shown above, the Republican Guard elements had closed to about 1500 meters (the sand storm continued to have a serious detrimental effect on long range observation) before they were detected and engaged.

Thanks to thermal sights, even with the blowing sand, our forces still had a significant advantage over the Iraqis. Shown here is the opening salvo from Ghost Troop, three TOW missiles flying into the enemy formation.

In a sharp 10-minute engagement amid swirling sand, 5 Bradley scouts and 1 Abrams tank from Ghost troop destroyed 16 Iraqi BMPs, and suppressed enemy infantry that dismounted from the BMPs to assault toward Ghost. By 1750 firing had ceased, and Iraqis began surrendering. Ghost had no casualties.

Had 2d Squadron been equipped with loitering missiles, it could have massed fires from all its troops to meet the threat to Ghost, using the Ghost flank vehicles to target the enemy's forward elements, and searching to the east with the missiles for any following echelons.

Experiment 2

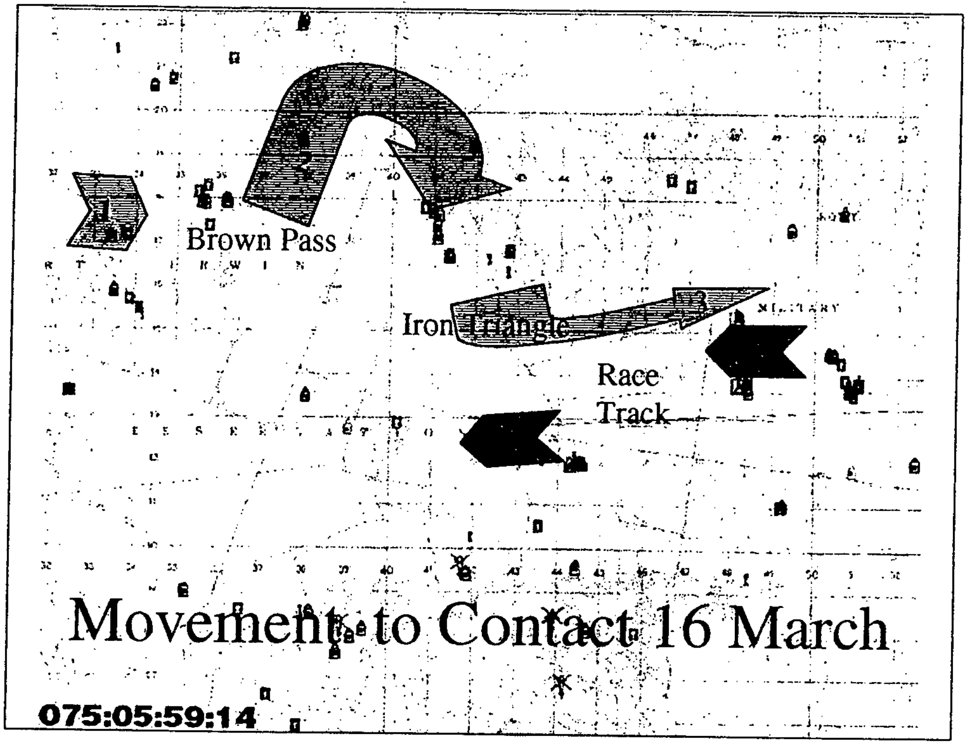
Task Force XXI AWE 16-26 March 1997

Among the records used to evaluate the Advanced Warfighting Experiment conducted with Task Force XXI, the first "digitized" brigade of the 4th Infantry Division (Mechanized) at the National Training Center were serial screen captures of the displays from NTC instrumentation, published in CD ROM format by TRAC. Two sequences were used to test the hypothesis that "loitering BN-BM can provide enhanced synchronization and increased lethality:" the meeting engagement of 16 March, and the OPFOR attack of 20 March.

In this analysis, BFOR has available not only AFSS, but also four developing sensor systems: (1) Discoverer II, a LEO constellation of satellites bearing MTI tasked by and displayed to battalion commanders; (2) strewn, linked UGS (SLUGS); (3) robotic observation post (ROP) capable of ATR and target designation; and (4) porteed micro aerial vehicles (P-MAV), missile-delivered to potential targets.

The terrain at the NTC is well illustrated on this picto-map: rugged mountains jutting out of the high Mojave Desert dominating deeply eroded valleys, countless defiles that constrain the movement of mounted forces, and observation, fields of fire, cover and concealment that vary from one of the 1 kilometer grid squares shown to the next. The arrow on the map is 20 kilometers in length, the assumed range of the loitering missiles of AFSS.

The Blue Forces (BFOR) were contending with a new command and control system, operating under the scrutiny of a large contingent of evaluators, coping with numerous visiting dignitaries. Moreover, they were conducting operations against the best trained unit of the U.S. Army, the NTC OPFOR, who knew well how to exploit the terrain at Fort Irwin, and to pose a formidable and continuous challenge.

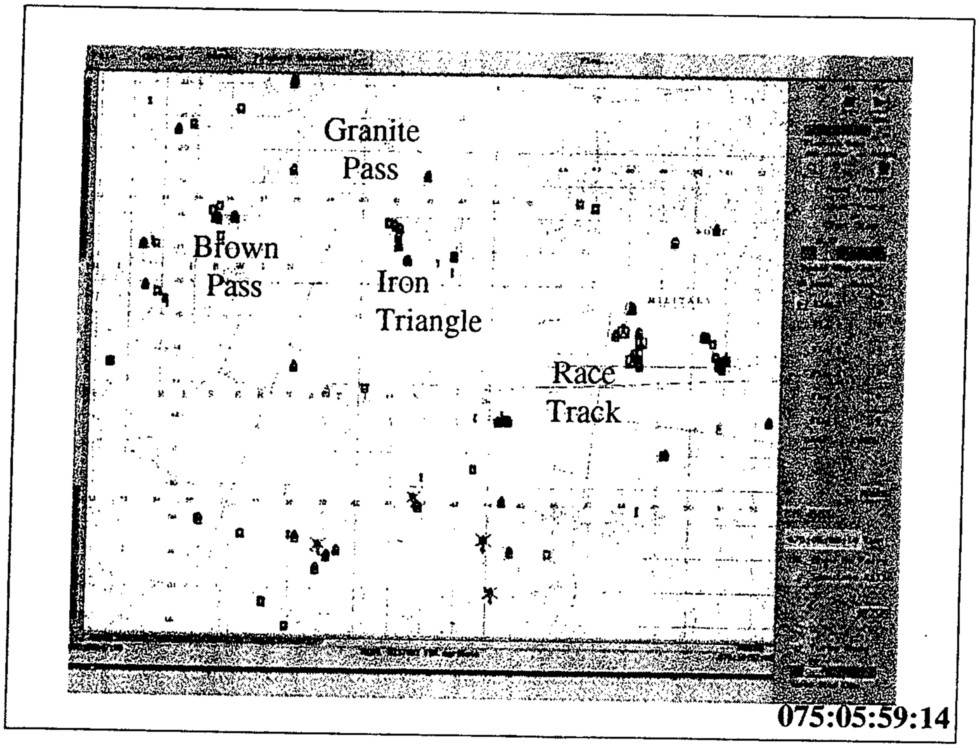


The date is March 16 (Day 075), and the time is 05:59 in the morning. Reconnaissance elements from both sides have been active throughout the night, and are poised to attack at 0600.

The bulk of Blue Force (BFOR) is off the map on the right (east); the main body of Opposing Force (OPFOR) is off the map to the left (west). Both have received orders to attack at 0600, and a meeting engagement on the ground displayed is imminent. The situation depicted shows the disposition of reconnaissance elements from both sides just prior to attacks by both sides. Blue icons show undamaged AFV of BFOR; when a BFOR AFV is hit, it turns purple. OPFOR AFV are shown in red; when an OPFOR AFV is hit it turns yellow.

The BFOR commander's plan is to advance westward with two battalion Task Forces echeloned to the right up the valley over the RACE TRACK [blue arrows 1 and 2]. The lead Task Force is to seize high ground north and south of IRON TRIANGLE, and the following TF will then attack to destroy remaining OPFOR.

OPFOR has prepared four options, the choice among them to be determined when the BFOR plan becomes clear. One of these, Plan FORK is shown: if BFOR attacks up the valley over RACE TRACK, OPFOR Advance Guard is to exit Brown Pass [red arrow 1], hook northeast [red arrow 2] to control IRON TRIANGLE, and to facilitate the passage of the regiment proper in an attack along the north edge of the valley [red arrow 3].



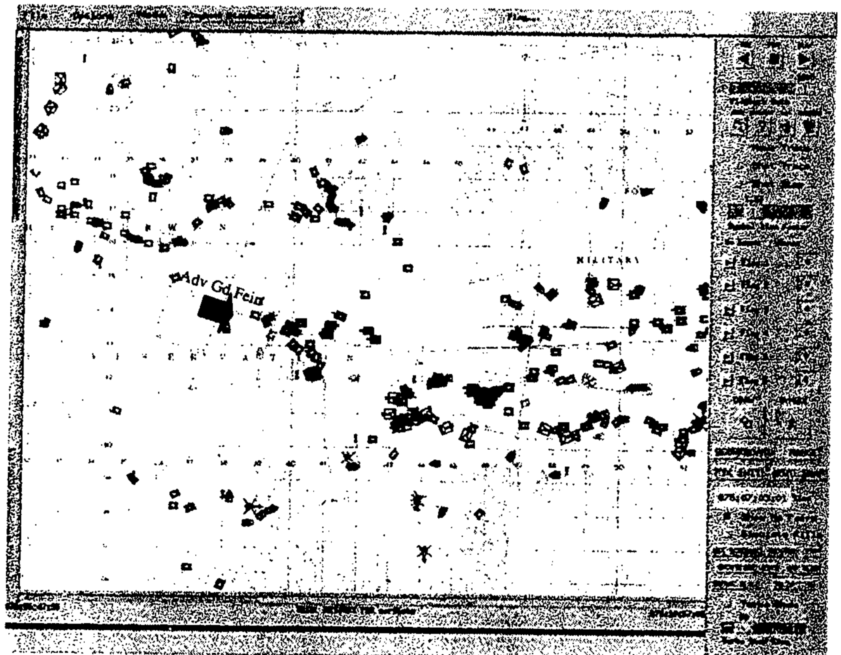
This is the display used by for the analyses. On the right are various controls and a timer. In the meeting engagement sequence, the data are presented in frames about 30 seconds apart, and these can be displayed one by one, or as a "movie" in real time, fast forward, or reverse.

This screen depicts the situation just before 0600, when each side commenced its attack. Scouts from both sides have been positioned to overlook BROWN PASS on the western entrance to the valley.

Note that OPFOR has inserted observers (OP) onto the high ground overlooking the IRON TRIANGLE from the south.

Note also that BFOR has posted a security element northwest of IRON TRIANGLE, designed to preclude OPFOR reconnaissance elements from seizing that critical terrain.

At 0545 OPFOR fired a persistent nerve agent south and east of RACE TRACK; BFOR has not yet reacted.



075:07:03:01

An hour has past since the inception of the two attacks. BFOR advanced with two task forces in echelon right, and within 45 minutes the lead TF had occupied IRON TRIANGLE and the high ground to its north and south. The rate of advance was about 15 mph (0.4 kilometers per minute). The lead task force sent a team north of IRON TRIANGLE, and the TF (-) occupied high ground to the south.

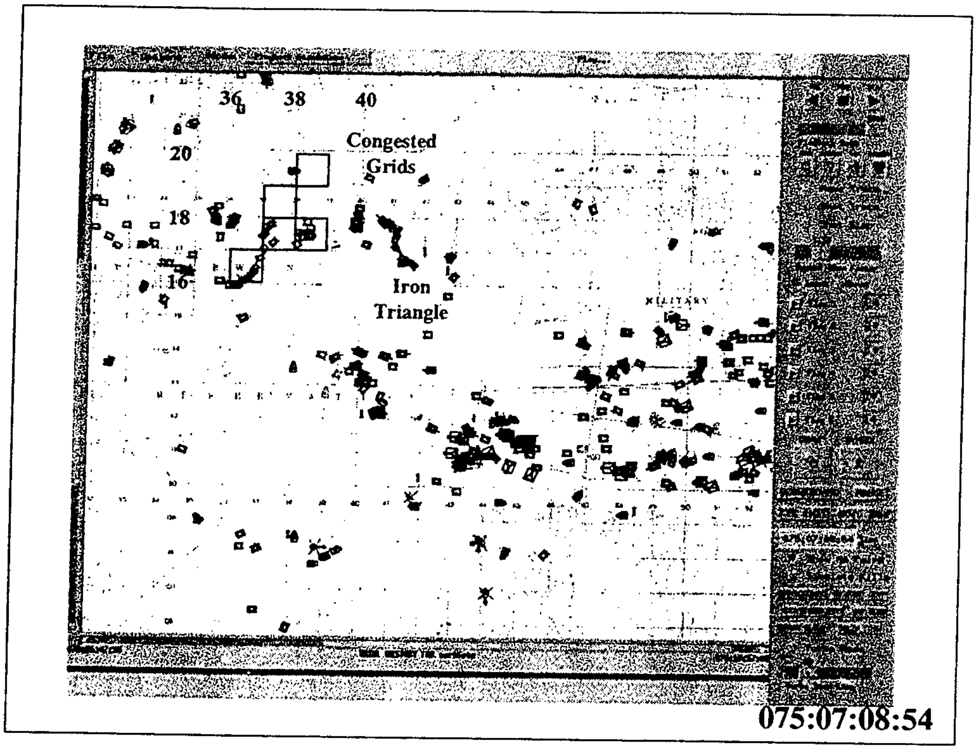
However, the following BFOR TF had difficulty in pinpointing the location of the persistent nerve agent vicinity RACE TRACK, and was both slowed and disorganized.

OPFOR exacerbated the resultant confusion by firing two volleys of FASCAM to extend the obstacle northward, and three lines of non-persistent chemical agents to the southeast of the obstacle so that the northeasterly breeze would drift the gas over forces struggling with the obstacle.

The OPFOR commander ordered his forces to execute option FORK. The screen portrays his Advance Guard entering the valley from vicinity BROWN PASS on the west. The foremost team of the Advance Guard made a diversionary attack on the BFOR elements south of IRON TRANGLE, while the remainder headed northeast per plan.

BFOR sought to deny BROWN PASS with a FASCAM volley, but OPFOR quickly moved south of the obstacle via an alternate route (BROWN CUT).

BROWN PASS and its environs might have been better defended by positioning SLUGS or ROP in the defiles, and using returns from these to cue FASCAM and loitering missiles of AFSS.

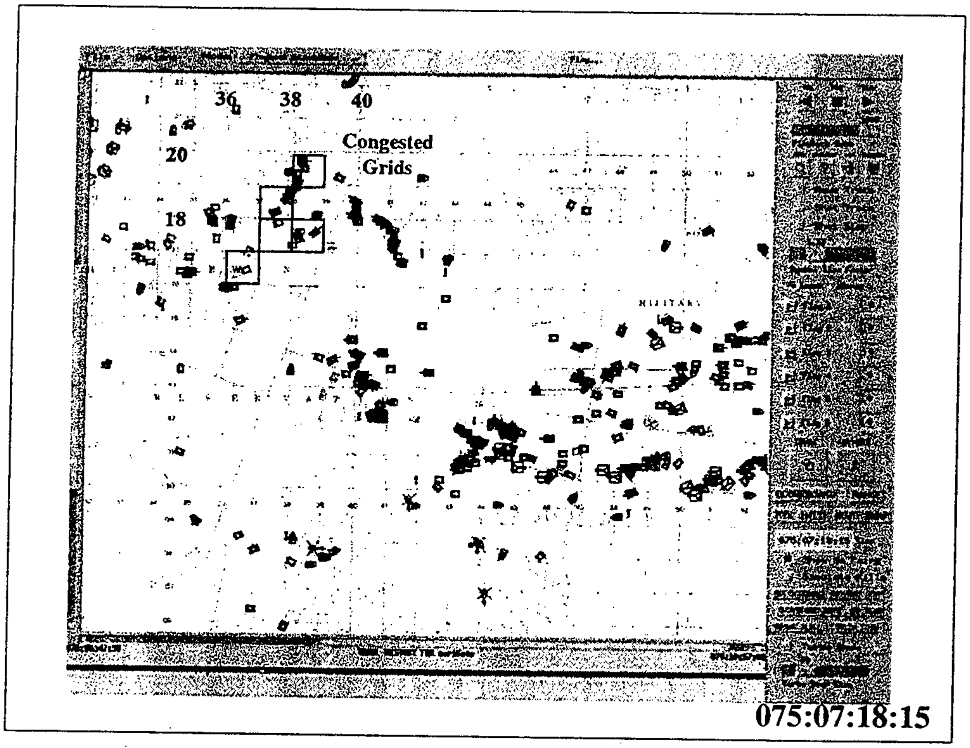


The OPFOR Advance Guard moved briskly, at about 30-35 mph (1 kilometer per minute). At grid 3817, OPFOR encountered a stout BFOR defense. As units in combat jockeyed for position, the OPFOR column jammed up. The OPFOR Advance Guard commander ordered his elements to move northeasterly toward the mouth of GRANITE PASS to envelop the BFOR defenders.

The screen shows several grid squares useful for assessing the locus and persistence of the target sets engendered by congestion, which was defined loosely as ten or more AFV per 1 square km. E.g., grid squares 3616 and 3817 at the time shown.

The next several screens will show how the situation developed in ten minute intervals.

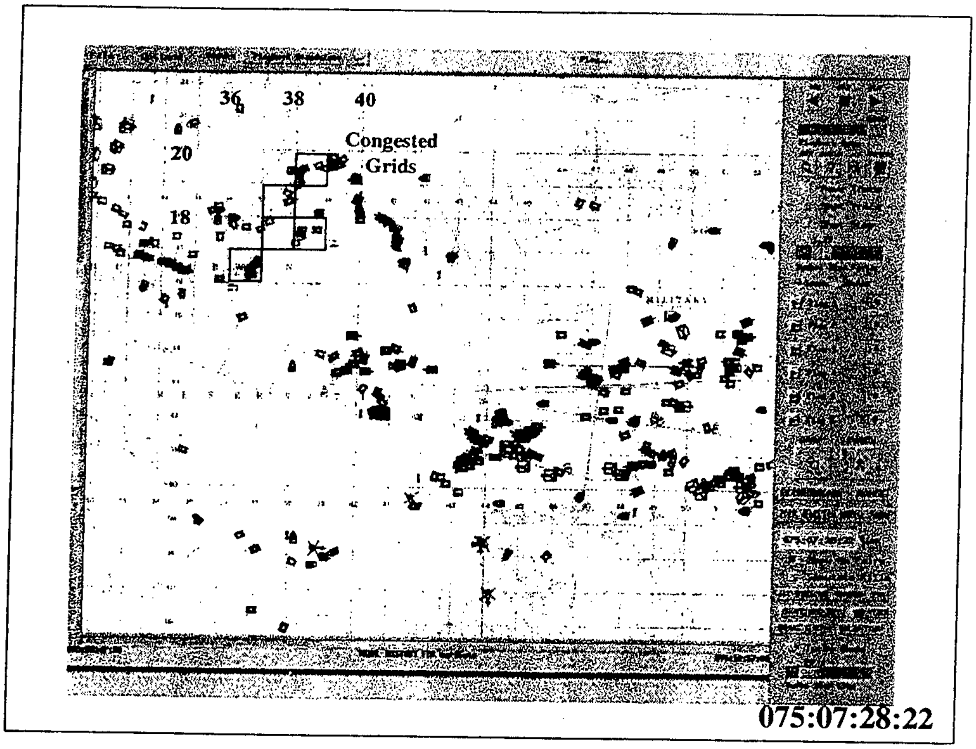
The BFOR defense could have been more effective had loitering missiles been used to extend the range of the tank and BFVs. For targets within sight, but out of range, the defenders might have used their laser range finders to pinpoint targets for the missiles.



Ten minutes later the OPFOR flanking maneuver is well underway, and the lucrative target sets have moved to grids 3718 and 3819.

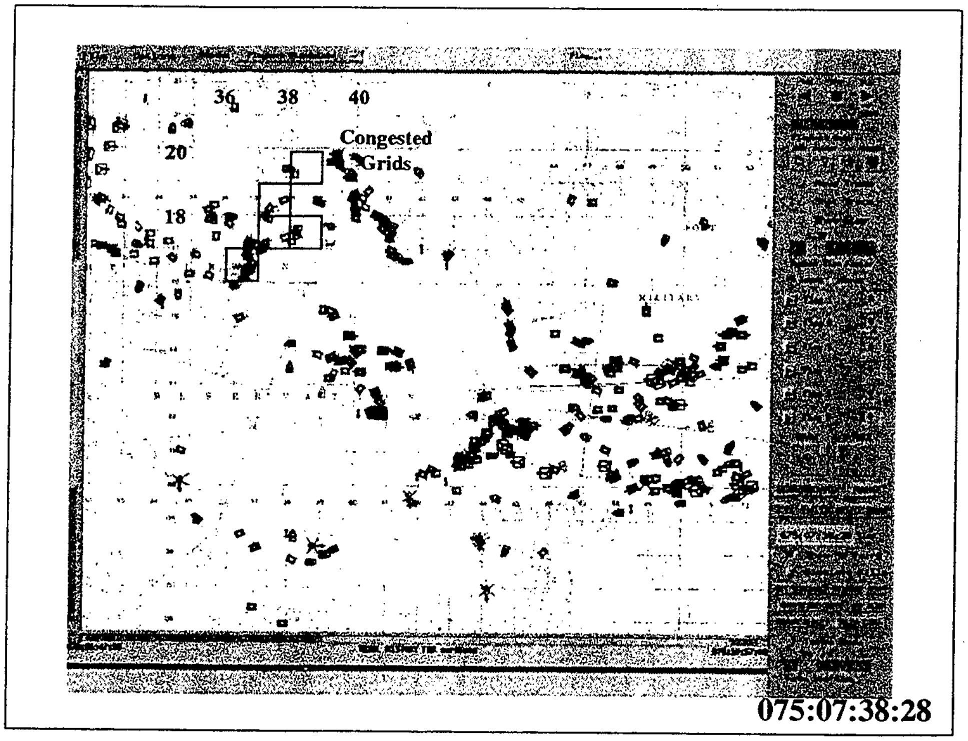
In the meantime, OPFOR was staging a series of demonstrations across the BFOR front, including an ostensible move to attack the BFOR from the south. In reality, however, the OPFOR main body was pressing at top speed toward BROWN CUT.

The obstacles around RACE TRACK continued to delay and to confuse the BFOR reserves.



Here the OPFOR Advance Guard has fixed the north flank of BFOR, and the lead elements of the main body have begun to arrive on the scene.

Loitering missiles on call of the BLUFOR armor team commander in the north could have extended the reach of his defense, enabled engagement without position-disclosing muzzle flash and blast, and exacted a heavy toll for the enemy's massing his armor on the flank.



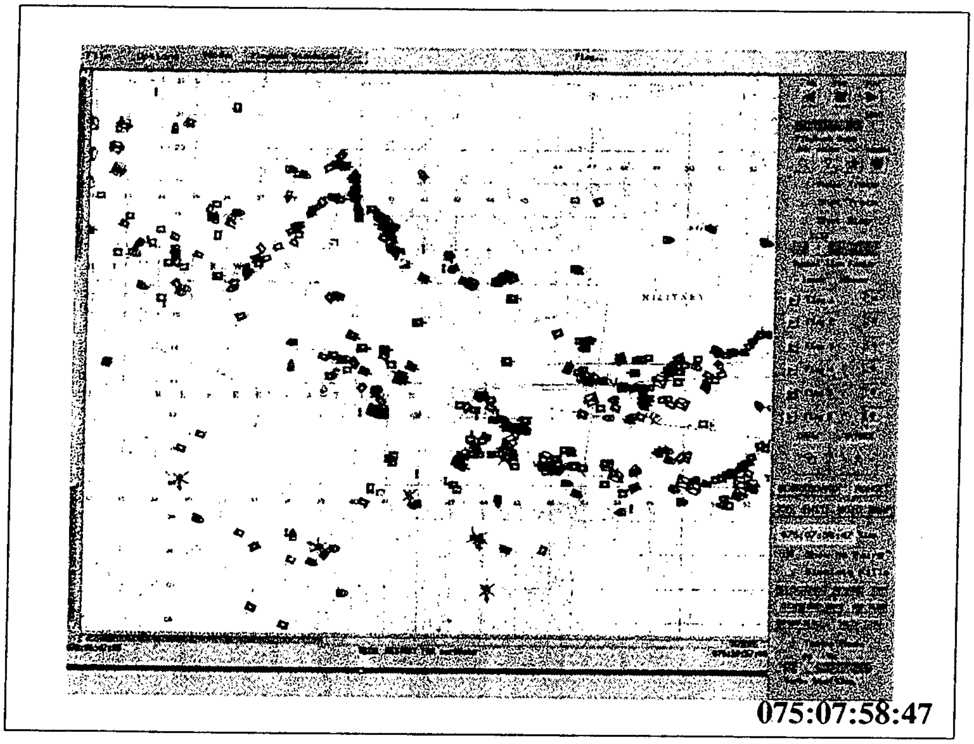
The Advance Guard, now attacking southeasterly toward IRON TRIANGLE, has begun to roll up the BFOR flank. Arriving OPFOR units have joined the attack, and more are coming.

This, and the foregoing three charts, 7:08, 7:18, 7:28 present an interesting tactical narrative of 30 minutes of engagement by the northernmost BFOR TF. Dense target arrays had been presented, but these were usually of short duration:

Grid Square	Start	End	Persistence
3616	**7:09**	**7:14**	**5 minutes**
3616	**7:24**	**7:38**	**14 minutes**
3717	**7:13**	**7:19**	**4 minutes**
3817	**7:09**	**7:19**	**10 minutes**
3718	**7:12**	**7:19**	**7 minutes**
3819	**7:14**	**7:35**	**21 minutes**

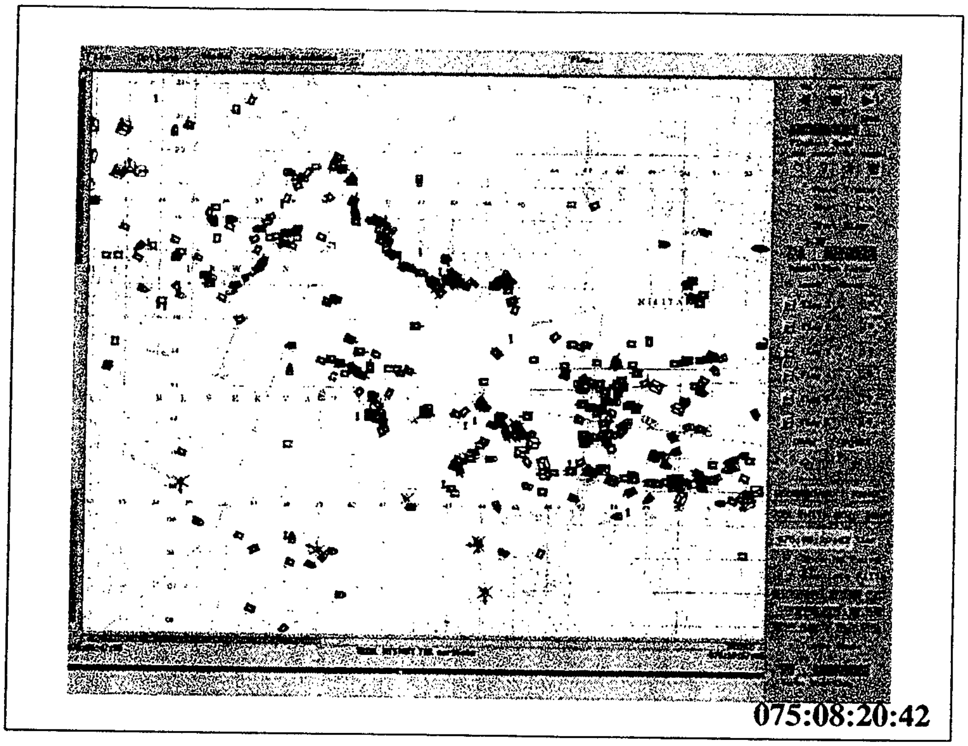
Of the grid squares examined, 3616 had the greatest potential for targeting, for all elements of the Advance Guard and the follow-on forces passed through that single square. In the entire engagement, ten or more OPFOR AFV were in that square for the times shown, plus 40 minutes from 7:49 through 8:29 as the main body passed: an hour in all.

Planning for and control of advanced sensors will be a difficult an art as today's fires and maneuver. Careful terrain analysis could have led BFOR to position MOP at key defiles such as 3626 and 3819, conjoined with SLUGS, and supplemented as the sensor fields became active with P-MAV. Such sensors arrays could have detected the target sets of the table in locus and time.



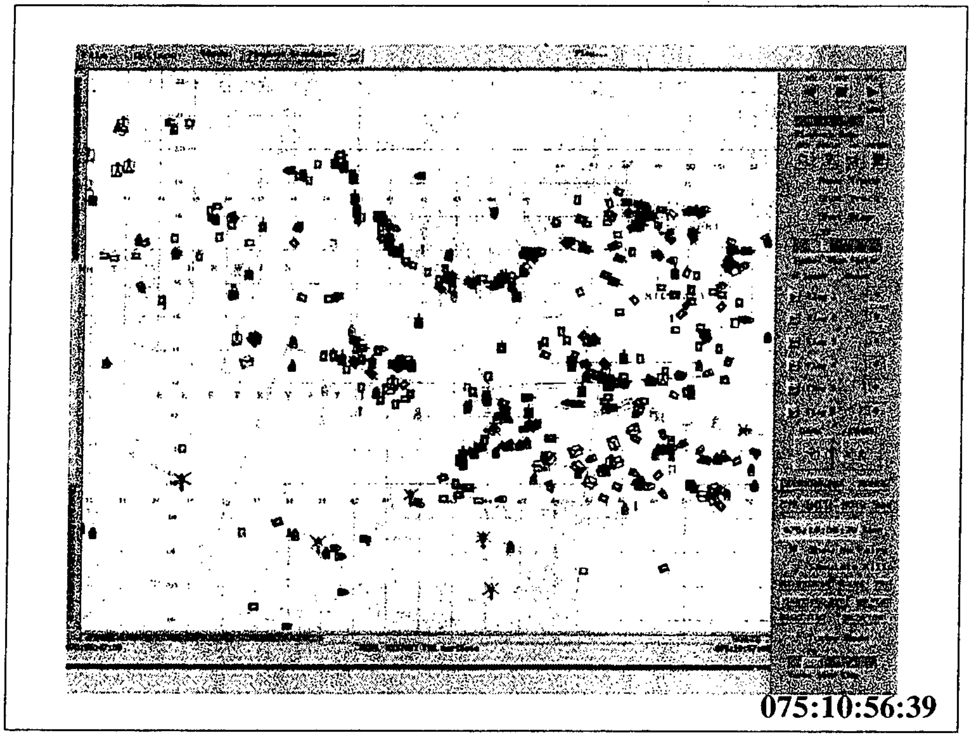
About an hour has past since the OPFOR Advance Guard engaged the BFOR north flank. The BFOR elements north of IRON TRANGLE have been largely destroyed, and OPFOR is pressing its advantage.

BFOR has begun to reinforce a position on the valley wall northwest of RACE TRACK.

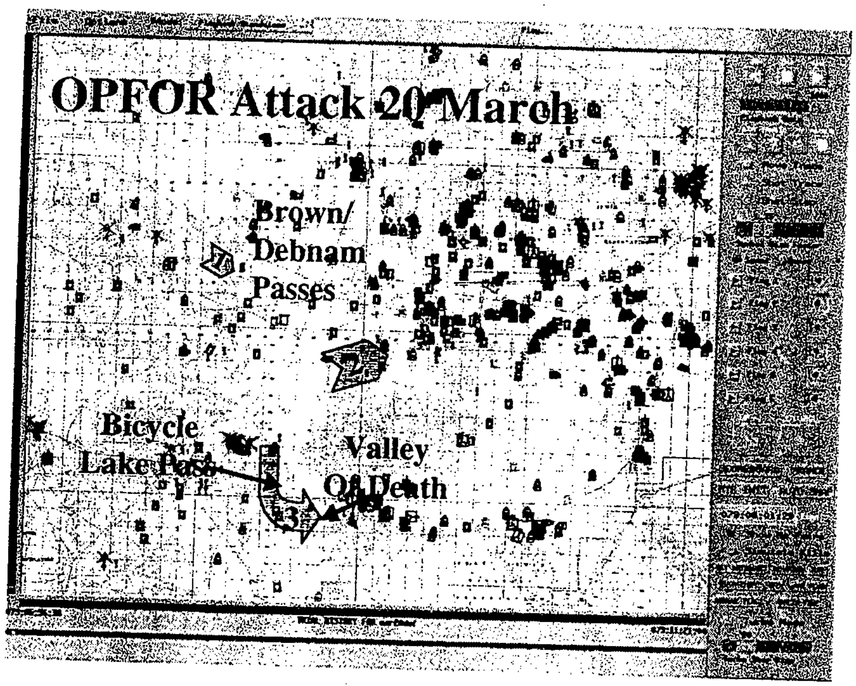


OPFOR has penetrated beyond IRON TRIANGLE, but has been stopped by the BFOR defense, again causing the OPFOR column to close up, and presenting dense AFV arrays. OPFOR clearly has the mass to punch through the defenders, albeit at a price. Only by massing fires can BFOR deny the OPFOR its objective.

In this instance, as in the previous case of the defense northwest of IRON TRIANGLE, the BFOR commander at the scene — the battle captain — ought to have had an opportunity to prepare the battlefield by setting up sensor arrays, and have been furnished sufficient AFSS fire units to enable him to find and to destroy the lead OPFOR attackers, with access to additional AFSS assets on request to inflict a decisive defeat. It is imperative that the commander have direct control of both the sensors and his supporting fires so that he has the means maintain full situational awareness no matter what the OPFOR attackers may choose to do, and so that he can respond immediately as targets are presented.



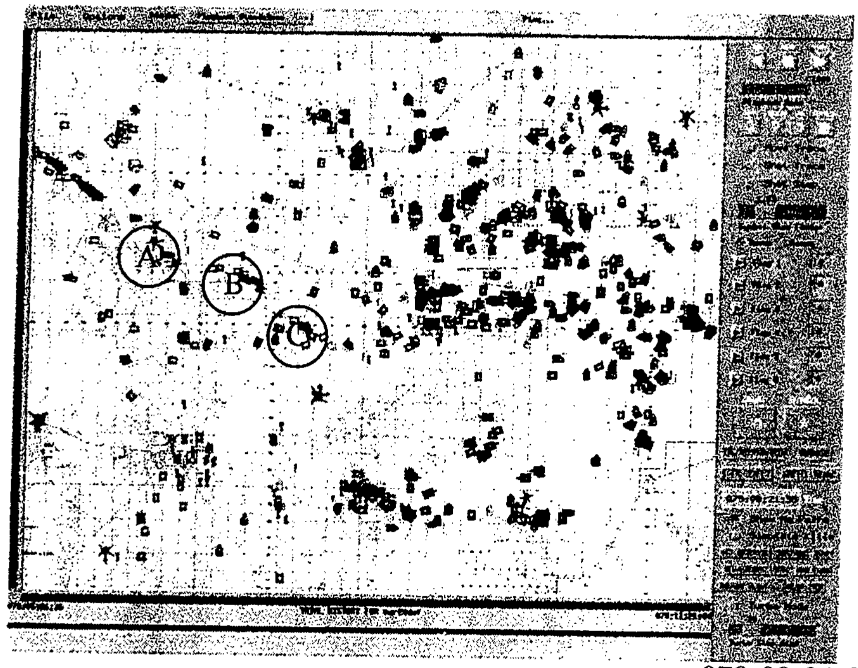
This is the situation at the end of the engagement. OPFOR has broken through the BFOR defenses, and is in a position to deliver fires or to maneuver throughout the BFOR rear. BFOR started the engagement with 54 tanks and 52 Bradleys; it has 5 tanks and 19 Bradleys still operating. OPFOR started with 44 tanks and 107 BMP; it has 26 tanks and 38 BMP remaining.



On 20 March, BFOR had been provided with 48 tanks, 46 Bradleys, and a contingent of light infantry, and assigned the mission of defending the sector shown — largely the ground over which it had operated on 16 March. The BFOR commander had organized the terrain under three task forces, one assigned to emplace and to defend obstacles in the Valley of Death, and two task forces in the north tasked to defend the valley vicinity IRON TRIANGLE and RACE TRACK.

OPFOR, as the numerous purple icons marking destroyed BFOR vehicles indicate, had been probing the BFOR position from the air and on the ground. The OPFOR commander, whose had twice the number of tanks and three times as many IFV at his disposal, had prepared several attack options, but in the light of what his reconnaissance had shown concerning BFOR dispositions, decided to launch the attack diagrammed. His plan called for his Advance Guard to pass through the Brown/ Debnam Passes into the valley in front of the BFOR position [red arrow 1], then to deliver a diversionary attack into the BFOR center [red arrow 2]. The OPFOR main attack, however, was to strike through Bicycle Lake Pass and the Valley of Death [red arrow three], and thence into the BFOR left rear.

In the narrative below, the reader is asked to imagine that the action took place on March 20, 2012, and that the postulated advanced sensors and AFSS were figured directly in the battle.

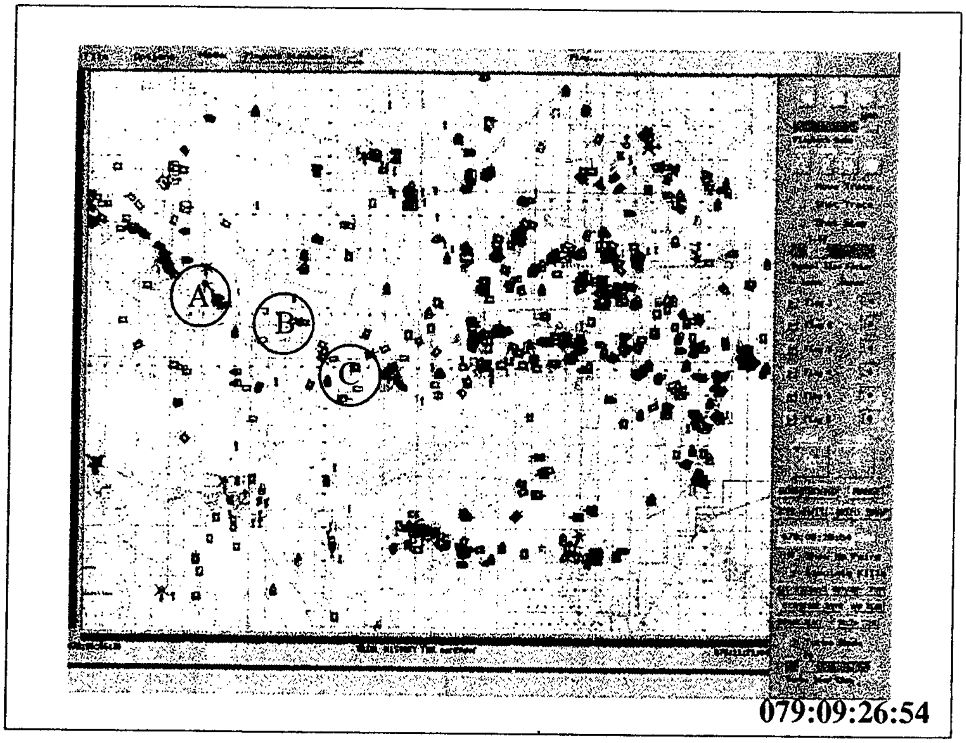


Throughout the early morning of 20 March, OPFOR conducted a series of demonstrations and hit and run attacks across the BFOR front. In front of the center Task Force, these activities were particularly intense, causing that Task Force commander to request Discoverer II coverage of the Brown/Debnam Passes.

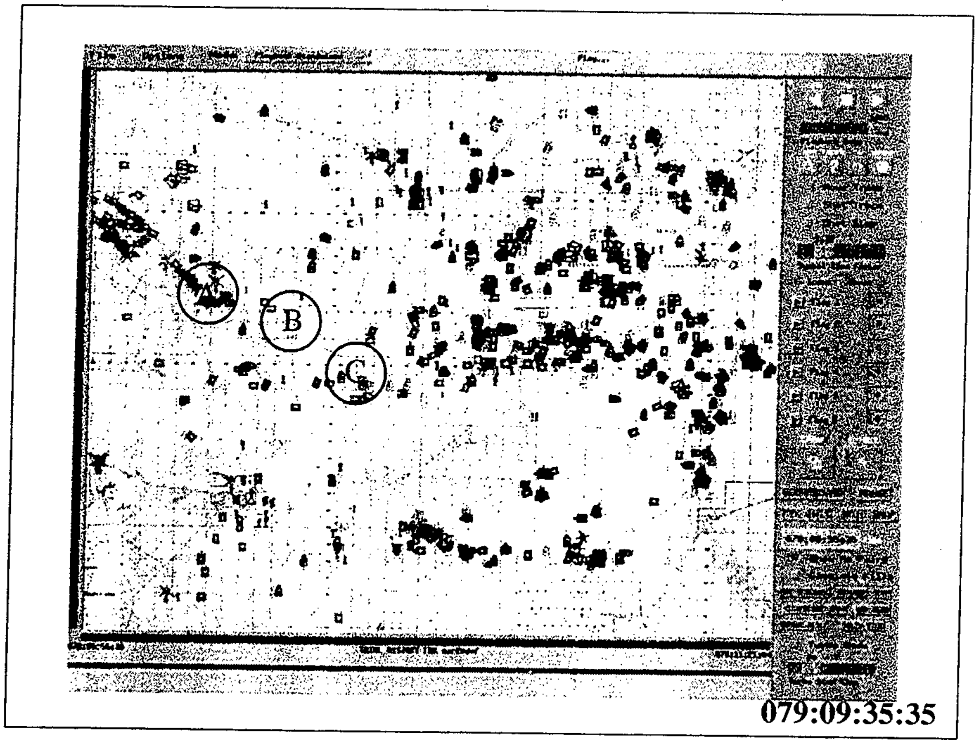
Around 0845, the OPFOR Advance Guard began its passage of defiles leading into center sector, and the Discoverer II MTI reported the movement. At 0900 the center Task Force commander laid down three sensor fields, shown above as A, B, and C, each with a coverage about four kilometers in diameter, to supplement the Discoverer II coverage.

At the time shown, indications were that the OPFOR had committed at least two company-sized OPFOR units, moving at high speed, to an attack on the center Task Force.

Broad area MTI coverage can focus the emplacement of more discriminate sensor fields, and taken together these can produce precise targeting information for AFSS missiles. With the information shown, two sets of ten missiles could be launched, flown to circle over B and C, and then committed to serial attacks missile by missile, every thirty seconds, separated from one another only by an interval necessary for a subsequent missile to confirm that it was locked on a target. The seekers on the missiles acted to confirm and to extend the coverage of the sensors.

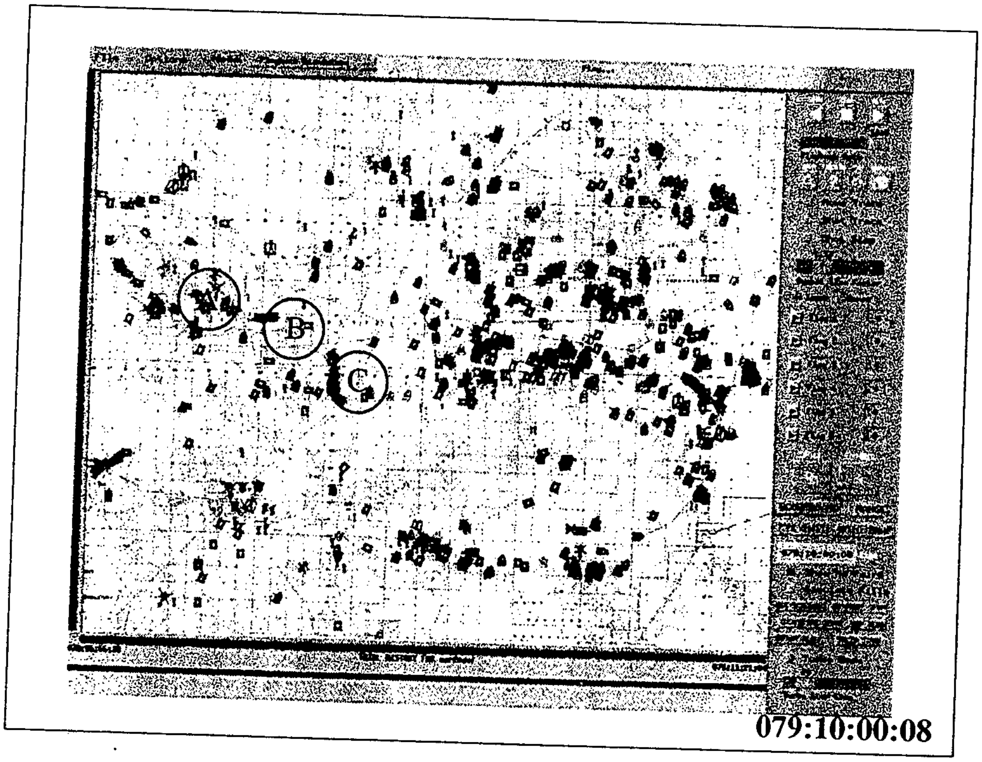


Five minutes later no AFV could be detected moving within A, B, or C, but there was clearly an attack on the center Task Force underway.

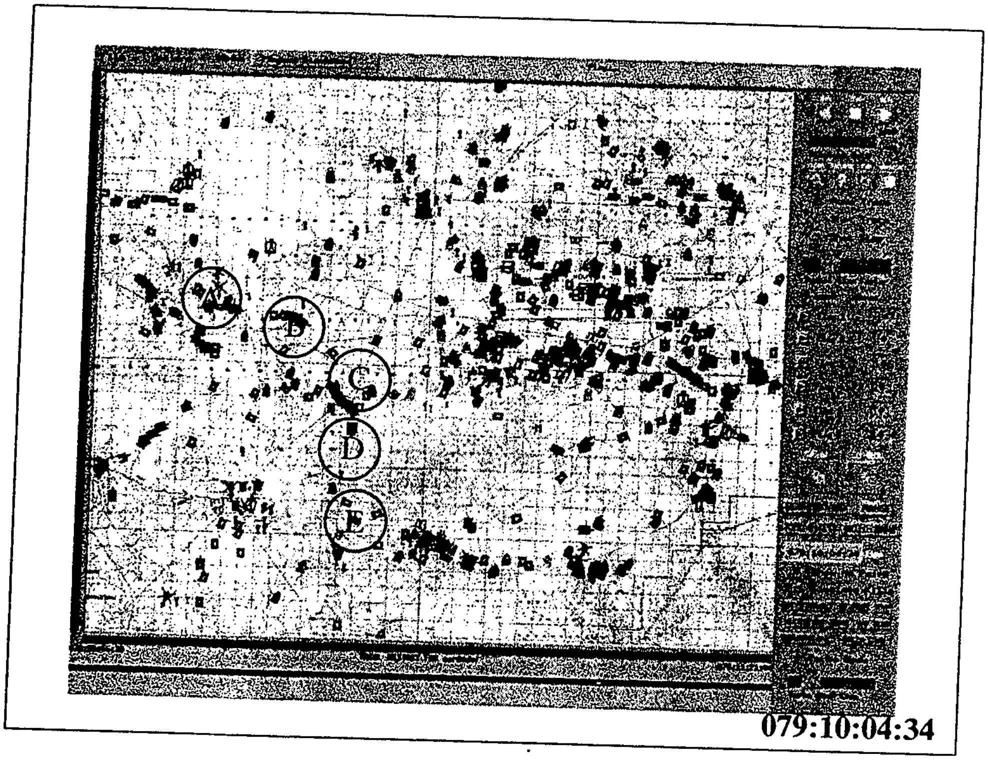


At his time A reactivated, and the center Task Force reported what appears to be an OPFOR effort to envelop their south flank.

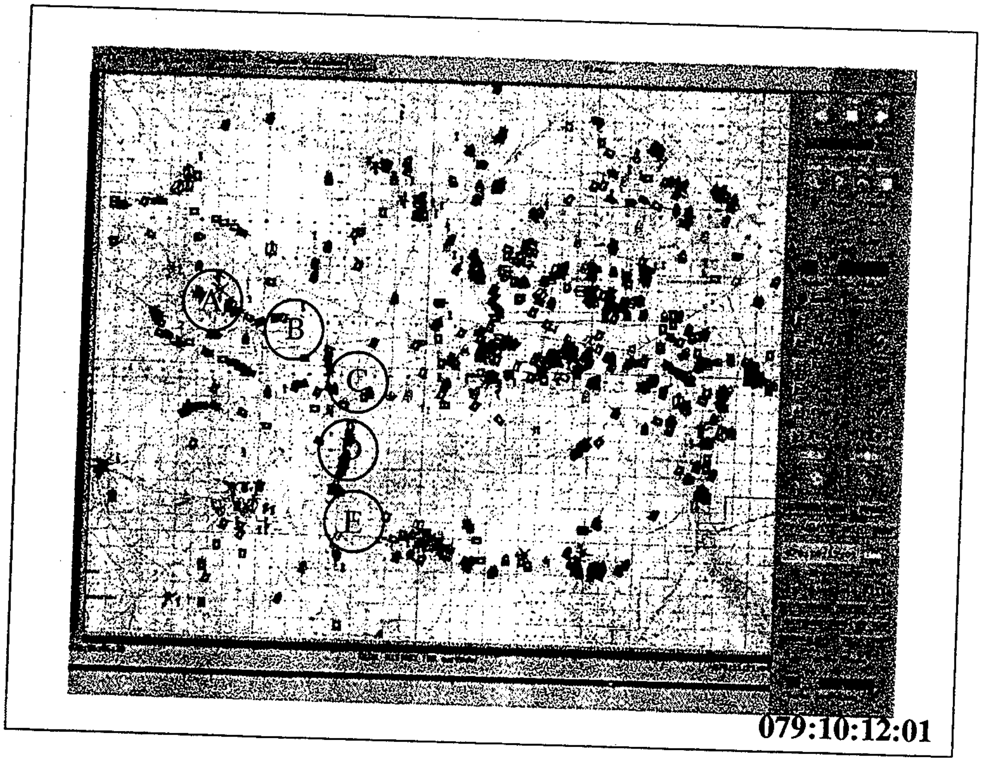
Another AFSS strike was called for A, and attack helicopters summoned to support the south flank company team.



At 1000 all three sensor fields were reporting target, but C was reporting southward, vice eastward movement, causing the BFOR commander to direct the emplacement of additional sensor fields between the center and south task forces.

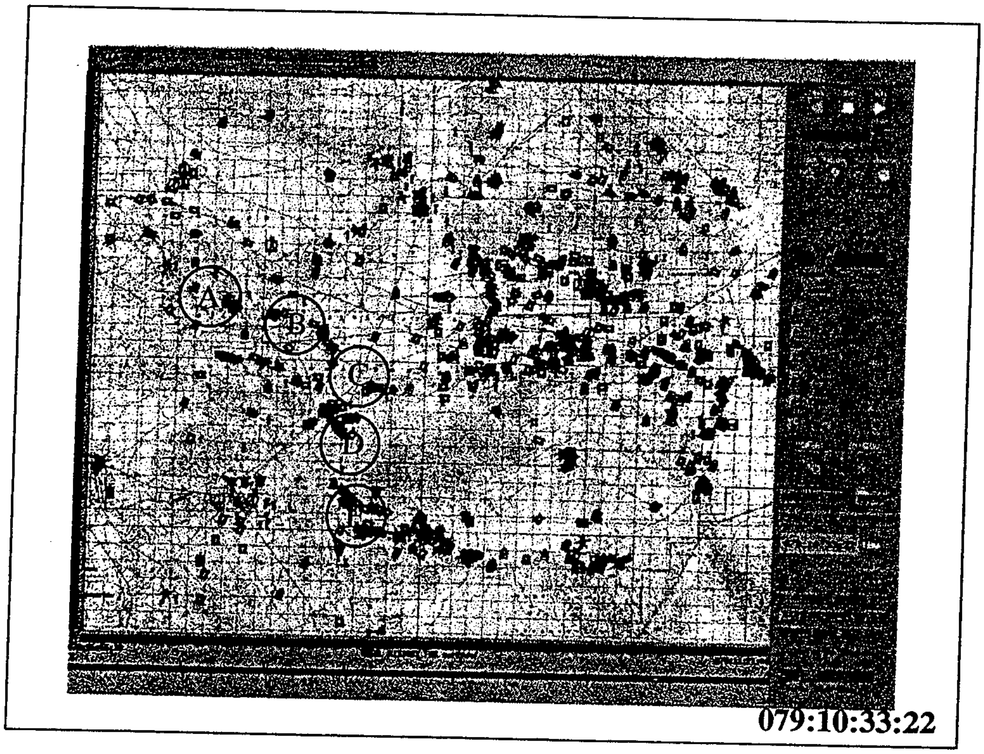


Four minutes later the additional sensor fields, D and E, were in place, and confirming that OPFOR AFV were moving rapidly down the road toward Bicycle Pass.



An AFSS strike was launched for D at 10:10, and at 10:14, ten missiles, delivered in rapid succession, struck into the OPFOR column.

By 10:18 it had become clear that OPFOR elements are converging on E, (Bicycle Pass), and another AFSS strike was launched on OPFOR in that area.



At 10:33 additional AFSS strikes of ten missiles each were fired at B, D, and E respectively.

To summarize the firings of 10-missile salvos:

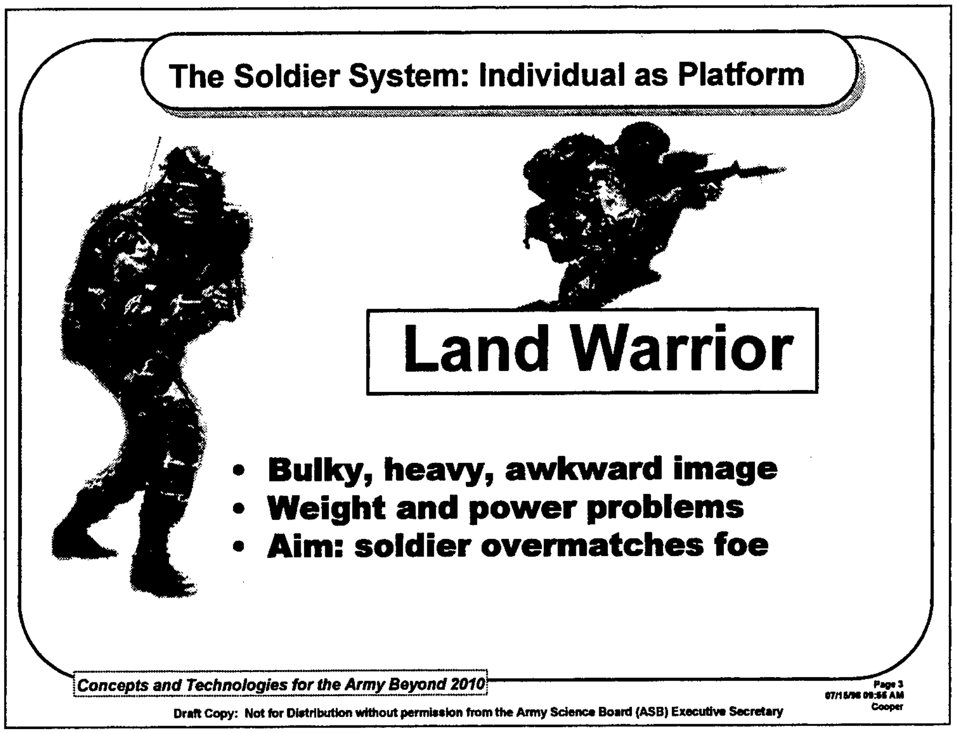
Area	TOT
A	0936
B	0922, 1033
C	0922
D	1010, 1033
E	1021, 1033

A total of 80 AFV-killing missiles were delivered, flown to precisely located targets, and attacked by diving from above with terminal guidance. Assuming 90% effectiveness, the AFSS eliminated 72 OPFOR AFV.

In the actual event, the OPFOR attack of the TF XXI AWE, the OPFOR had a total of 224 AFV — 63 tanks and 161 BMP. Around 1100 on 20 March 1997 the OPFOR succeeded in crashing through the BFOR defenses in the Valley of Death, and turning the BFOR southern flank. But that OPFOR success proceeded from his massing his direct fire power, and his accepting 64% attrition: OPFOR emerged from the fight with only 70 AFV. Had he lost 72 AFV forward of the BFOR defensive positions from AFSS strikes, as per above, even before he massed to make the main attack, there can be little doubt that the outcome would have been quite different.

APPENDIX N

THE LAND WARRIOR PROGRAM



SARDA published Weapon Systems, United States Army 1998. Page 123 states that: "The Land Warrior (LW) system will provide significant improvement in soldier lethality, survivability, battle command, mobility, sustainment, and training/mission rehearsal. The systems approach will optimize and integrate these capabilities, without adding to the soldier's combat load… The LW program in currently in the engineering and manufacturing development (EMD) phase, and progressing well according to very aggressive cost, schedule, and performance goals… critical design review (CDR) [was held] in September 1997. First unit equipped is scheduled for 4QFY00…The CDR established the final design for the system before it goes into soldier testing for 15 months… A low-rate production decision is planned for January 1999, with full production to begin in 2000 for 34,000 LW sets. LW Force XXI science and technology advancements will be included as block upgrades…"

Start of the 15-month soldier test has been delayed at least one year, until spring 1999. But the slowdown appears unlikely to resolve two drawbacks that have obtruded since the program began: weight and power.

The LW system is presently heavier than its design weight, and poses significant problems of battery consumption. But even so, it does not yet integrate all the capabilities cited by SARDA: e.g., the 49 pound Javelin shoulder fired anti-armor system, or capabilities for conducting tactical engagement simulations without a weighty MILES-like strap-on.

The Soldier's Load — National Mobility

- **Roman legionary marched with 40-60 lb.**
- **S.L.A.Marshal: combat load <80% training load, and training load ~ 33% body weight**
- **FM 21-18(1990) set combat load @ 40 lb. Further, for each 10 lb. carried in excess:**
  - **— Distance traveled in a 6-hour approach march would be reduced by 2 km**
  - **— Time for obstacle course slower by 15%**
- **Tired soldiers fighting on foot are less lethal, less survivable, less responsive**
- **Load redistribution, transport could help**

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Gibbon commented that the combat load carried by the Roman legionary "would oppress the delicacy of the modern soldier." But each 8-man section (*contubernium*, the mess/tent group) shared a mule to carry their leather tent, grindstones and extra clothing. The company or century usually had two-wheeled carts to haul winecasks, heavy weapons, fortification and siege gear.

LW will be issued to light infantry and airborne units almost completely dependent on manpower to move within the zone of battle. There was an incident during DESERT STORM when a battalion conducted an airmobile assault some 300 km deep within Iraqi-held territory, and after landing, marched 3-5 km to the Euphrates River, individual soldiers carrying over 200 lbs. each.

The Army lacks well-grounded models of dismounted soldiers in combat; the Deputy Under Secretary of the Army for Operations Research has often criticized LW for its lack of analytical underpinnings. Data to build sound models of individual behavior in combat is assuredly lacking; the Army, in closing its Combat Development Experimental Command, scrapped its best source of reliable data. However, empirical data on soldier performance under load is extensive, and is related to distance traveled and exertions performed as a function of carried weight. (E.g., Field Manual 21-18. Foot Marches. Washington, Department of the Army, 1990. C. Marshal, Brig. Gen. S.L.A. The Soldiers Load and the Mobility of the Nation. Washington, The Combat Press, 1950. It should be noted that FM 21-18 is not among the 9 manuals in hypertext on the LM computer.)

Moreover, the Dismounted Battlespace Battle Laboratory at Fort Benning now has prototypes of virtual simulators that -- with proper tasking and funding -- may be capable of supporting the iterative experiments, and might be developed as part of his LW training subsystem.

Load redistribution, a light vehicle, or a robotic mule might help.

Land Warrior: Impending Crisis

"Army leadership must emphasize the importance of reducing energy demand to achieve energy sufficiency for future dismounted soldiers. Meeting near- and far-term needs will require major changes in Army thinking. Paradigm shifts in energy strategy, system design, and use of commercial technology are absolutely essential to avert a crisis.[emphasis added] The new paradigms must be translated into top-down initiatives..."

Energy-Efficient Technologies for the Dismounted Soldier (NRC, 1997, p.166)

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There have been three studies by the National Research Council that directly addressed the Army's approach to developing technology that would enable dismounted American combatants to "overmatch" any enemy, currently named ***Land Warrior***:

STAR 21: Strategic Technologies for the Army of the 21st Century (NRC, 1992, p.63): "The Army already has a Soldier-as-a-System Initiative... this program appears to focus primarily on a particular equipment design... By contrast, the ... STAR Panels view integrated support for the soldier as more broadly applicable to soldiers with a variety of missions and not tied to particular equipment architecture... [a] configurable "support system" for a given soldier with a particular mission or task to perform..."

Tactical Display for Soldiers: Human Factors Considerations (NRC, 1997, pp. 184-185)

"RECOMMENDATION 1: The Army should [compare] the positive and negative performance implications of the monocular helmet-mounted display with alternative technologies. One fruitful approach would be to [issue] promising technologies to experimental groups, and compare performance.

RECOMMENDATION 2: If..digital data partly occludes the soldier's view... then handheld or wrist mounted displays should be considered ... to reduce the likelihood of negatively affecting the soldier's local situation awareness.

Energy-Efficient Technologies for the Dismounted Soldier (NRC, 1997, pp. 165-170) " The power requirements of the Land Warrior system will limit the effectiveness of dismounted soldiers... The Army should support development of mission-specific software for dismounted soldier systems. General-purpose software is wasteful and not energy efficient... Wireless transmission will dominate energy demand.... The Army should refine its requirements to the minimum necessary to meet battlefield needs..."

Example: the Battery Crisis

- **Light Infantry Battalion 1998 (no LW):**
  - **— 975 end items use 15 types of batteries**
  - **— Requires 1433 batteries to power-up, initial cost: $22,238**
  - **— In one week's continuous operations, consumes 4519 batteries: $75,765**
- **Light Infantry Bn of future (with 398 LW)**
  - **— 2405 end items, 19 types of batteries**
  - **— Requires 4795 to power-up; w/some rechargeables, initial cost: $1,477,661**
  - **— Week-long operation consumes 13,991 batteries: amortized cost $90,533**

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The data present are from draft contractor's survey, date 2 January 1998, of a battalion of the 10th Mountain Division. The basic data have been certified by the 10th Mountain Division for TO&E correctness, and by CECOM RDEC for accuracy of figures on batteries. LW basis of issue was then 198 per battalion, 152 "leader ensembles" (SINCGARS radios) and 246 "soldier ensembles" (peer-to-peer radio).

Several less expensive alternatives to the fielding depicted above were examined. Increasing the basis of issue for LW by 61 (more extensively replacing legacy systems with one-time batteries) was shown to reduce overall battery costs. But the re-chargeable batteries and re-chargers require new capital investment.

Whatever those batteries might provide in terms of increased combat effectiveness, they have a most serious, potentially disqualifying down-side: far more significant than the battery cost is the burden they would impose on operations and resupply within the battalion -- some 2000 daily battery transactions, with all that entails in terms of carrying parties and disrupted operations while the unit literally re-energizes itself.

What seems to be indicated by the foregoing is a determined effort to

(1) reverse the proliferation of type of batteries;

(2) substitute wherever feasible rechargeable batteries, and provide fueled energy sources for recharging;

(3) adopt and enforce strict energy management within LW

Needed Paradigm Shifts(1)

Paradigm	As Is	Should Be
Energy Strategy	Focus on supply	Tailor demand to function
System Design	One LW; usual tactical MOE	Job-specific; energy-efficiency
Use of Commerce	Buy lagging technology	Close-coupled to best on market

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Energy Strategy: "The Army Acquisition Executive should make energy efficiency a priority consideration in evaluating contractor performance… the Army [1] should support the development and use of low power software… [2] should use dedicated electronic circuits… Application Specific Integrated Circuit (ASIC) technology can achieve the efficiencies of custom circuits and hardware and still be cost-effective… [3] establish and enforce standards of awareness and discipline for energy consumption…"

System Design: "The Army should [1] refine its requirement for high resolution images and video communications to the minimum necessary… [2]minimize wireless data transmissions by reducing the time required to convey a given amount of information…[3] adapt the hierarchical network architecture of cellular phones to create a virtual "peer-to-peer" network [to] improve the distribution of computational resources… [4] modify and synchronize operational doctrine to minimize soldier transmissions … [5] exploit energy saving communications protocols [like those] used to alert radio receivers to incoming data in pagers and cellular phones… [6] study alternatives for the military network design to optimize power consumption. For example… commercial low-orbit satellites and unmanned aerial vehicles as relatively energy efficient alternatives that may also provide high bandwidth…

Use of Commercial Technology: "Subsystems in the Land Warrior system… will be obsolete compared with available consumer electronics by the time the system is fielded. Military radios that meet the strict definition of commercial off-the-shelf equipment in most cases are not built into the same energy efficiency standards as consumer electronics… Army procurement strategy should include provisions for keeping pace with advances in the semiconductor industry [and for] specifying low power performance criteria in its solicitations."

Needed Paradigm Shifts(2)

Paradigm	As Is	Should Be
Light Forces	Designed for early entry	One element of battle force
Light Infantry	Vehicle poor; heavy loads	Air-Mech like rest of battle force
Land Warrior	Enhance each combatant	Technology for teamwork

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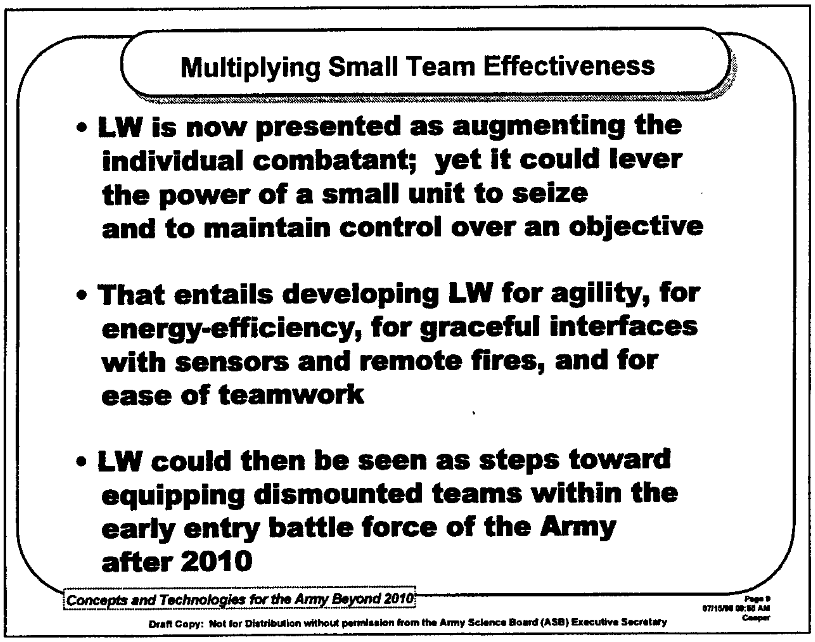
Army divisions are now characterized as "heavy"-- armor or mechanized divisions -- or "light" -- airborne, airmobile or light infantry divisions. Useful for the past, these terms obscure the future. LW has turned the historic term "light infantry" on its head. Today American "heavy infantry" -- mechanized "dismounts" deploying from the Bradley IFV -- carry a combat load lighter than that of their counterparts in a battalion of airborne or light infantry. Indeed, the heaviest load is that carried by the dismounted combatant of the light infantry battalion. Options for providing energy for LW in the form of rechargeable batteries are wider in mechanized battalions because of organic vehicles and available power than they are in units of airborne or light infantry.

It is time for the Army to empower light infantry <u>units</u>, and to equip and train these to operate as an integral part of air-mechanized formations. At little cost the Army could issue vehicles to carry light infantry impedimenta, and to recharge batteries. The vehicles could be man-powered (Machine Gun Cart, NVA logistical bicycle] or powered [ATVs or air-transportable stacking "dune buggies"]. Units could be issued means to acquire or to move power forward [civil power scavenging devices; air dropped, missile delivered, man-packed or robot-carried energy packs or light generators]. Radio designs for team use could employ a distributed architecture, ganging individual soldier transmitters for long-range. And small dismounted units could be configured as sonic sensor arrays, with a remote site integrating and interpreting the data from each soldier.

The LW scheme for energy distribution might be specifically related to dismounted team structure and function, so that, by a dictated power budget within each individual's LW equipment, more responsible members of the team would be allocated more power [RHIP].



The paradigm shift called for by the NRC's Electric Power Panel ought to include understanding LW not as a system for enhancing individual combatants, but as enabling technology for tactical teams. Within these small sub-units, soldiers perform different functions, and have, therefore, different needs for C4ISR, and thus for electrical energy. Infantry exists to provide human eyes, ears and minds for controlling land and people. Human sensory input on a given environment, interpreted by minds undistracted by irrelevant audio-visual information, is the payoff for sending infantrymen into places of high hazard. Yet not all soldiers need look and listen; not all need to read a map and navigate; not all need to collaborate in planning fires and maneuver. Some soldiers on each team could be dedicated to furnishing energy for overmatching situational awareness, precision fires, and dominant maneuver.

The LW program since its inception has consisted of periods of intensive component prototyping, followed by field tests that found the "system" wanting, but recognized in certain components capabilities worth developing. Thus the Soldier Integrated Protected Ensemble (SIPE) was tested in 1992 and relegated to further R&D. Some 32 months later a revised system, then billed as the 21st Century Land Warrior (21 CLW), was field-tested, and again returned for further development. The parts of the system that fared best were the weapon and sighting gear, and the navigational subsystem. Weight and energy remained problems to be resolved. By that time, LW had become prospective equipment for Force XXI.

What has been missing is a means to conduct continuous iterative experiments with soldiers to examine alternative approaches to component size, weight, and interface with the wearer, and to conduct excursions into different ways of sharing the overall combat load, and guaranteeing electrical power within a small unit. The Dismounted Battle Space Battle Laboratory should be funded to conduct such spiral development.

Recommendations

- **Even were some components of LW to perform well in troop testing, Army should defer Milestone III decision pending:**
  - **— Coherent, iterative experimentation**
  - **— Drastic reduction in combat load**
  - **— A cost-effective power system**
- **Convert LW into team technology by:**
  - **— Organic sensors for close-in awareness**
  - **— Micro-PGM w/ lethal/non-lethal options**
  - **— Direct control over loitering missiles for suppression or destruction**
  - **— Embedded TES**

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Three panels of the National Research Council and this panel of the Army Science Board have expressed misgivings about LW. As observed by STAR in 1992, the thrust of LW seems a "rush to judgement" on a particular set of materiel, rather than evolutionary engineering of an effective system for dismounted combat. Production of expensive, overweight, energy-inefficient gear for the individual combatant optimized around his weapon seems inconsistent with the "shared battlespace" or "infosphere" of the information age, and with the spiral development underway for other elements of Force XXI. Hence, we recommend further development with emphasis on teamwork.

Clearly the Army must adopt stringent weight and energy budgets for individual combatants, and ruthlessly enforce these. In so doing, it can preserve required functionality by restructuring small units along the lines advocated by recent studies on small unit operations by the Defense Science Board. The LW program can be transformed into technology for teamwork by exploiting DARPA's SUO program and the proposed DDR&E "web" testbeds:

(1) Incorporating into each small unit overhead sensor platforms (UAV, tethered electric AV, robotic mini-helos), suites of UGS and small vehicles as power supplies.

(2) Exploiting acoustic technology by deploying sonic sensors forward (e.g. on all soldiers and vehicles) but fusing and interpreting rearward.

(3) Enabling the team to control directly missiles fired from remote locations, capable of loitering overhead, and of self-targeting or synchronized strike.

(4) Embedding capabilities for live, virtual, and constructive simulation for training and operations rehearsal.

(5) Simulating for usability engineering: repetitive tests of form, fit and function.

APPENDIX O

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