Small Unit Operations: Technology for Tactical Teamwork *2017 - 2027*

Presentation of:
General Paul F. Gorman,
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Preface from I/ITSEC Report

In early December, 1997, General Paul F. Gorman (USA, Retired) delivered a keynote presentation at the annual Interservice / Industry Training Systems and Education Conference (I/ITSEC 97) in Orlando, Florida. This address, “Small Unit Operations: Technology for Tactical Teamwork, 2017 - 2027” was a watershed event in which the General unified constraints, requirements, and advanced technologies to provide a clear description of an achievable, efficient, and lethal combat component for the “Army After Next” force.

The presentation begins with a review of requirements for future systems development as expressed by J. S. Gansler, Undersecretary of Defense (Acquisition and Technology), and then shows that these imply the need for two fundamental changes in the established model of ground warfare force composition and development. First, future combat units and operations centers should be more widely dispersed and much smaller with “decreased presence but increased effect.” Secondly, the systems development processes that will ultimately produce this warfighting machinery will require new experimental methods that incorporate “usability engineering” as well as advanced simulation, both early and often.

Small unit operations provide an example of employing these tenets to combine developmental as well as matured technologies, producing a different kind of fighting force. Configurable fire support systems for dedicated firepower, micro air vehicles for surveillance, distributed operations centers for survivable command and control, and new decision support software to provide information dominance and battlefield awareness can be available to highly mobile teams that could form the basis for the Army After Next. These capabilities are explained and then developed as an example that compares their operations to those of their counterparts as envisioned for Force XXI, equipped according to the current POM.

General Gorman’s vision thus resolves the apparent contradictions between the pragmatic constraints on what can be achieved with the functional requirements of what must be achieved. Moreover, his vision is realized through examples that depend only on currently available or in-development capabilities that do not require major “breakthrough” discoveries prior to useful application. To date, there have been numerous requests that we both share and more fully explain his vision.

Small Unit Operations:

Technology for Tactical Teamwork, 2017 - 2027

I am going to talk about the future, but you should regard the years I cite — twenty to thirty years hence— as placeholders. Some of the systems I shall describe may not appear in the force until that period, but much can be done in the near-term to insure that such capabilities will materialize.

There is broad acceptance that the disappearance of the canonical "threat" necessitates a revision in how the nation prepares for its future security, but there is profound disagreement about how to proceed. The darkness of uncertainty has descended upon the Pentagon, and there is need there for <u>education</u> – using that term as its root suggests, to mean leading out of that darkness. We must learn how to progress from where we are, to where we ought to be, with maximum efficiency and minimum risk.

This presentation proposes experiments for selecting technologies appropriate for structuring and training significantly more efficient US land forces, forces that can deal with a broad range of threats, from weapons of mass destruction to terrorism, and that can perform missions of political and humanitarian urgency as well.

I advocate besides large, grand slam exercises for providing insights into future forces, that there be conducted small, iterative, focused analyses, employing the most advanced forms of conflict simulation available.

New Defense Needs

from J.S Gansler's *Defense Conversion* (MIT,1995)

- **Rapid response, with extended holding power for force projection onto foreign lands**
- **Lightweight, high firepower, minimally manned, survivable forces**
- **Relentless combat capabilities — 24 hours per day, days on end**
- **War-fighting simulations for research and development, test and evaluation, training, and operational rehearsal**

The newly appointed Undersecretary of Defense (Acquisition and Technology) calls for a **"Revolution in Business Affairs"** [including acquisition reform, conversion of DoD "tail" to "teeth," focused logistics, enhancement of the acquisition workforce, and civil/military integration in the defense industrial base]. But he has also strongly advocated acquisition of revolutionary war-fighting capabilities [Ref. 1]:

"1. Near-term achievement of an **integrated, secure, and "smart" command, control, communications, intelligence, surveillance, and reconnaissance (C3ISR**) infrastructure -- on a multi-service basis and encompassing both our strategic and tactical needs. This is the critical element of an effective 21st century warfighting capability and the backbone of the Revolution in Military Affairs. It is the key to our strategy of "information dominance".

2. Development and deployment of **long-range, all-weather, low-cost, precise, and "smart" weapons**. This will allow us to achieve maximum firepower on targets (either fixed or mobile) from air, land, or sea with minimum loss of life; and it will allow us to take full advantage of the advanced C3ISR systems (for example, by providing continuous targeting (including in-flight) from remote platforms).

3. **Achievement of rapid force projection and global reach of our military capability. With the uncertainty over where our forces will be required, and the need for extremely rapid response to a crisis anywhere in the world, this capability -- when combined with the first two elements (described above) -- will provide the U.S. with overwhelming military superiority.**

4. Development and deployment of **credible deterrents and, if necessary, military defense against projected, less "traditional," early 21st century threats** -- such as biological, chemical, and nuclear weapons, urban combat, information warfare, and large numbers of low-cost ballistic and cruise missiles....

5. Achieving **interoperability with our Allies** -- an essential requirement for coalition warfare...."

Assessment of Germany's Future
1928-1968
Oberstlt i.G. Ulrich von Schärfsteblick

Years Projected	End Year	Strategic Posture
5	1933	Depression, government by madmen
15	1943	Empire: Atlantic to Urals, Arctic to Africa
20	1948	Desolation and division, abject poverty
40	1968	Mainstay of Europe's economy and defense

No small part of the problem Jacques Gansler faces in the Pentagon is the mental habits of decades of strategic certainty, and near-total dependence on specific threat scenarios, such as "ability to meet two near-simultaneous regional contingencies." A senior German officer of NATO once told me the following parable about the perils of politico-military certainty. It centered on a particularly brilliant young officer of the *Generalstab*, Ulrich von Schärfsteblick, who, in 1928, was directed to prepare an estimate of the political and economic position of Germany five, fifteen, twenty and forty years in the future to serve as the basis for strategic plans and research and development. Von Schärfsteblick's study led to a briefing that began with his asserting that five years thence, in 1933, Germany would be in the grips of a worldwide depression, and would be ruled by a certifiable maniac intent on eradicating the Jewish people.

Stunned, his superiors asked whether this portended military disaster for the country. Not so, said the staff officer, because in fifteen years, in 1943, a Third German Empire would extend from the Volga to the French coast, from the Norwegian Arctic to the African desert. Would Germany then go on to dominate the world, he was asked. No, replied von Schärfsteblick, because in 1948 Germany would be divided among the Bolsheviks and the western democracies, its cities in ruins, and its industrial production only 10 percent of that in 1928. Would this mean the end of German military power?
No, replied von Schärfsteblick, because he estimated that in forty years time, in 1968, the German armed forces would be the largest in Central Europe, and would have a robust war industry in the Rhineland, where workers of unprecedented affluence would divide their time between automated machine tools and little black boxes where they would watch a man on the moon.

Von Schärfsteblick's carmine stripes were promptly ripped from his uniform, and he was quietly transferred to a padded cell.

TRENDS IN LAND WARFARE
1860-1990
per battalion (~ 600) engaged

★ **FIREPOWER** (per unit) **increased** by 2.5 orders of magnitude
★ **DISPERSION** (lower density) **increased** by 1 order of magnitude
★ **AREA CONTROLLED increased** by 3 orders of magnitude
★ **TEETH / TAIL RATIO declined** by 3 orders of magnitude

Over next two decades, technology is likely to leverage:
- **Strategic deployment at intercontinental distances** ↑
- **Enhanced situational awareness** ↑
- **More precise munitions, longer range delivery** ↑
- **More agile means of maneuver** ↑
- **Assured, efficient logistics** ↑

This is not to say that it is impossible to anticipate some aspects of the future. Here is a conjectural update of a chart first generated for the CJCS around 1983. The historical data points include Federal forces in the Civil war, the American Expeditionary Force (AEF) in France, U.S. Eighth Army units in Korea *ca*. 1952, and the U.S. Seventh Army in the Federal Republic of Germany, *ca.* 1980. Weapons of mass destruction (WMD) were not considered.

During the last half of the Nineteenth Century and throughout the twentieth century, technology has led to increased <u>firepower</u> [as measured in throw-weight]– machine guns, improved bursting munitions, etc. That induced greater <u>dispersion</u> [as measured in numbers of personnel deployed per unit of area]. At the same time, technology-boosted command/coordination and mobility means – telephone, radio, fax, TV, high-capacity fixed and rotary wing aircraft – enabling increased <u>control</u> [as measured in area dominated]. While these changes were being effected, fighters, as a percent of the force overall, decreased steadily. Looking ahead into the first decades of the next century, it seems reasonable to anticipate that:

> **Improved targeting and precision munitions** will cause at least <u>one order of magnitud</u>e gain in **firepower**, i.e., effective throw-weight.
>
> **Dispersion** for **force protection** will increase by at least <u>one order of magnitude</u>, especially if WMD are threatened or in use.
>
> **Control** per unit of force, driven by **further gains in mobility and C3ISR**, will nonetheless increase by <u>one order of magnitude</u>.
>
> **Teeth/tail ratio** is more difficult to project , but logisticians have not yet been tasked to design support for a minimal-presence force. Total asset visibility, just in time delivery, and maintenance on need ought to enable a dramatic reversal of the trend toward burgeoning numbers of support troops.

Small Unit Operations: **Decreased <u>Presence</u>, but Increased <u>Effect</u>**
• Use <u>utility for force projection</u> as prime MOE **• Prepare for broad range of adversaries, hence:** **— Smaller, lighter, more agile air and land forces** **— More versatile, faster maritime forces** **• Develop ordnance for precise, continuous close support** **• Create effective C3ISR infrastructure for SUO** **— Extend combatant team awareness:** **- Team-controlled robots overhead and on surface** **- Tagged MTI auto-posted to team-level displays** **- High-definition depiction of environment** **— Connect sensors to deciders to shooters** **— Exploit commercial communications** **• Devise "just-in-time" logistics** **• Telemedicine for combat casualty care**

All of these anticipated trends lead to a single logical outcome: operations by smaller units. The following observations pertain:

•The survival of small forces will depend on information: ability to find targets reliably and precisely, and to summon firepower before the enemy can act.

• Fighting in urban, jungle, and mountainous terrain will entail precisely applied firepower (e.g., Aachen, Khe Sanh) available twenty-four hours per day.

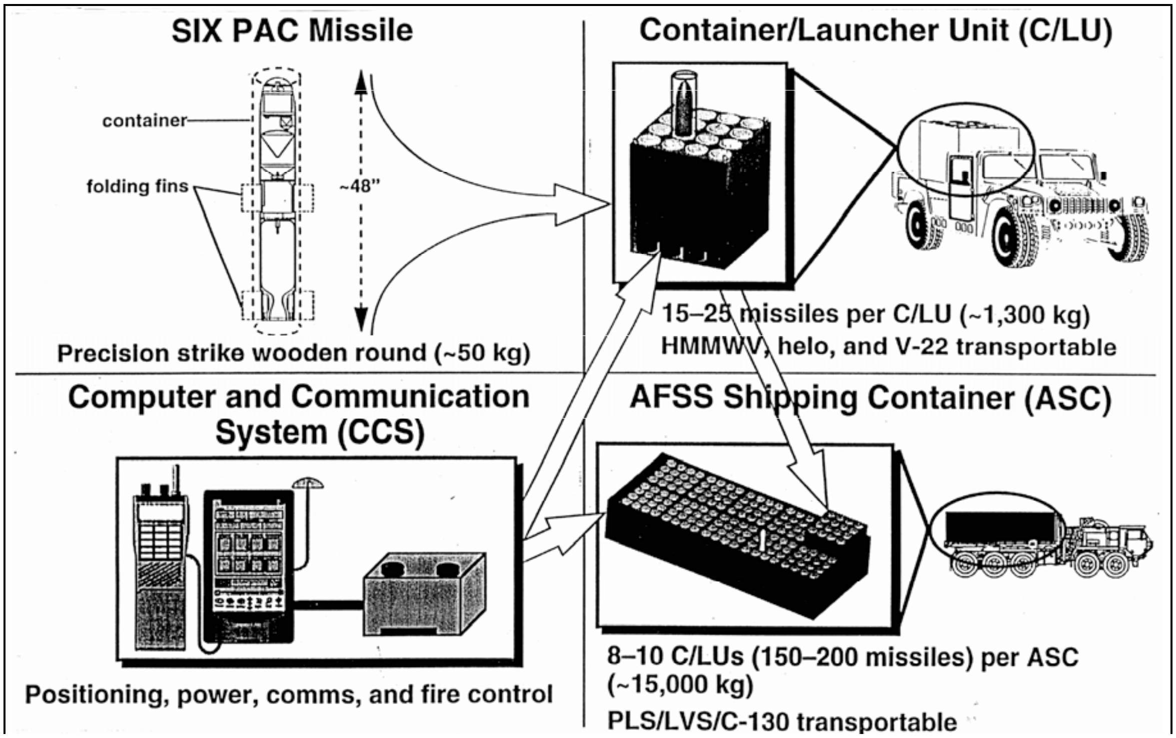
• Synchronization and IFF require human control of fires, but do not dictate a "center" in a physical sense; a "command post" is <u>not</u> a place [Ref. 2].

• The overall size of presence will be determined less by combatants on the ground than by their logistics. The two major logistics burdens have been imprecise munitions and vehicular fuel. Both must be ameliorated.

• The services have been using telemedicine largely as a publicity gimmick. It's time to get serious about developments for combat casualty care.

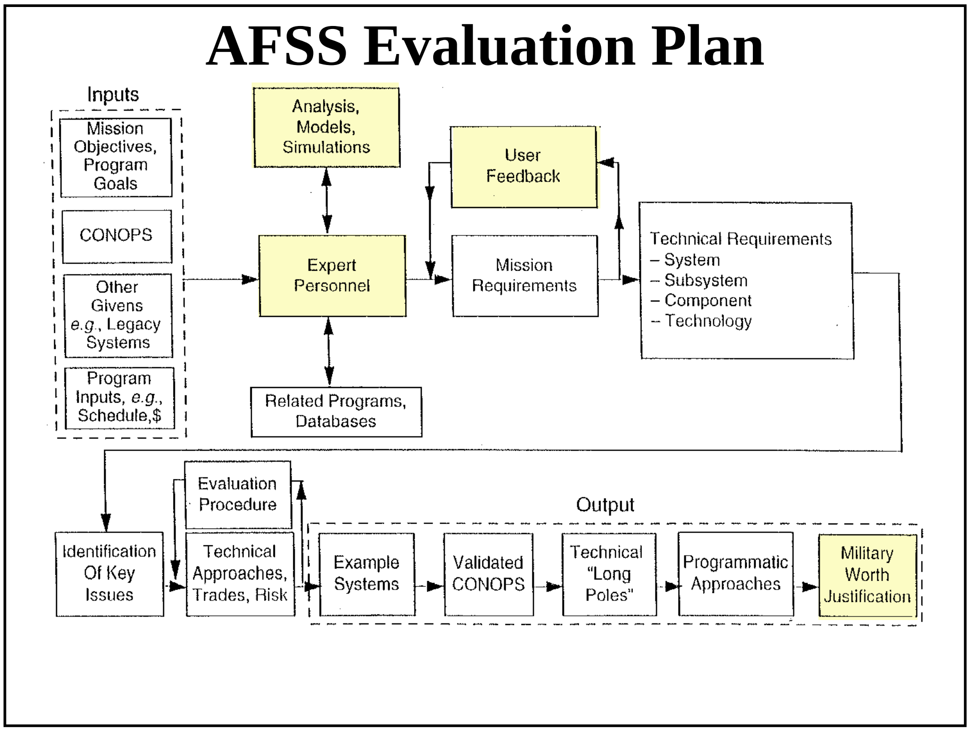
• As SOF experience teaches, only tailored, well-rehearsed teams can confidently take on larger opponents. **The paraphernalia for teams, their composition in terms of skills and leadership, and the method, means, and timing of their training all require technology interventions**.

There follows an example of a technology intervention now underway. It is sponsored by the Defense Advanced Research Projects Agency (DARPA) to develop an advanced system of fire support for Small Unit Operations (SUO).



The Advanced Fire Support System (AFSS) is a joint effort shared by DARPA and the US Army Missile Command (MICOM). The goals of the Advanced Fire Support System program are to develop and demonstrate a novel weapon system concept that will feature increases in both deployability and capability while reducing cost. While these goals do seem neither novel nor imaginative, proposed methods to obtain them are.

AFSS is incorporates a containerized system design that allows both logistic efficiency and a measure of platform independence, thus heightening its capability for rapid, configuration-appropriate deployment. As illustrated, it has designed-in flexibility as containers can be employed individually or as groups, the configuration determined by mission needs. Thus, AFSS provides a capability increase, permitting low-burden, responsive firepower that can be adapted to existing force structures and is further consistent with unmanned deployments. Finally, AFSS should be incorporated into the force at reduced cost, both for initial procurement and over its maintenance life cycle. AFSS is, in reality, a modular, scalable family of systems, all constructed from the same component parts.



The AFSS program extends from 1997 through 2002, culminating in low-rate production of a number of missiles plus containers.

The evaluation plan for AFSS is accepted practice. However, four aspects deserve comment in the context of Jacques Gansler's call for better acquisition practices:

(1) AFSS is a truly revolutionary concept for American land forces. To replace guns at the outset of the 21st Century, after a century of winning wars with guns, is as counter-cultural as abandoning the horse on the eve of World War II. I doubt if many "experts" on "artillery in a box" will readily be located.

(2) For the same reason, unprejudiced "users" will be hard to find. Indeed, most artillerymen are likely to find the concept of AFSS abhorrent.

(3) The depiction of the "Expert Personnel" interacting with "Analysis, Models, and Simulations" leads this commentator to suspect that the analytical methodologies of yesteryear are being brought to bear.

(4) In a time of tightly constrained Research, Development, and Acquisition budgets, **military worth justification** ought to be among the **first** evaluative steps. It clearly should not be the final judgment; rather this concept should permeate the entire evaluation process.

Beware of Experts

"What, sir, would you make a ship sail against the wind and currents by lighting a bonfire under her deck? I pray you excuse me. I have no time to listen to such nonsense."
Napoleon to Robert Fulton, 1800

"I have not the smallest molecule of faith in aerial navigation other than ballooning" **William Thomson, Lord Kelvin, 1870**

"We must not be misled to our own detriment to assume that the untried machine can replace the proved and tried horse."
Major General John K. Herr, 1938

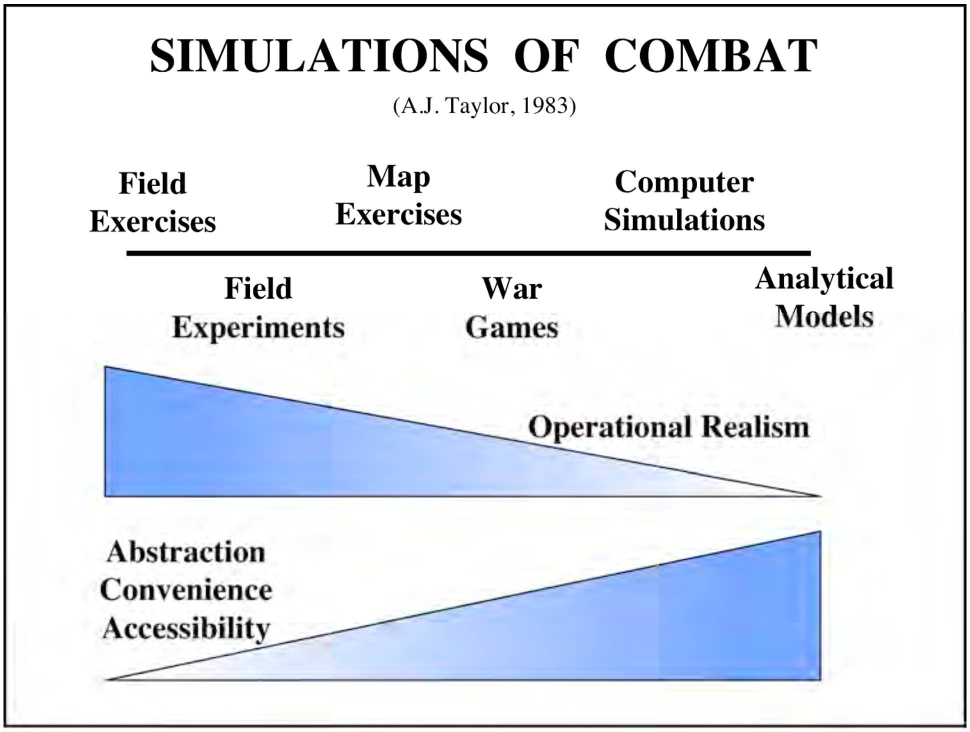
"This is the biggest fool thing we have ever done....The [atomic] bomb will never go off, and I speak as an expert in explosives."
Admiral William Leahy to President Truman, 1945

Perspicacity is not a prerogative of arrogated, appointed, or elected office. This applies to military genius or preeminent physicist alike. Most generals and admirals in the Pentagon, and the civilian leaders they advise, are mentally predisposed to the position of the Chief of Cavalry in 1938: *the horse plainly ain't broke, so why fix it?*

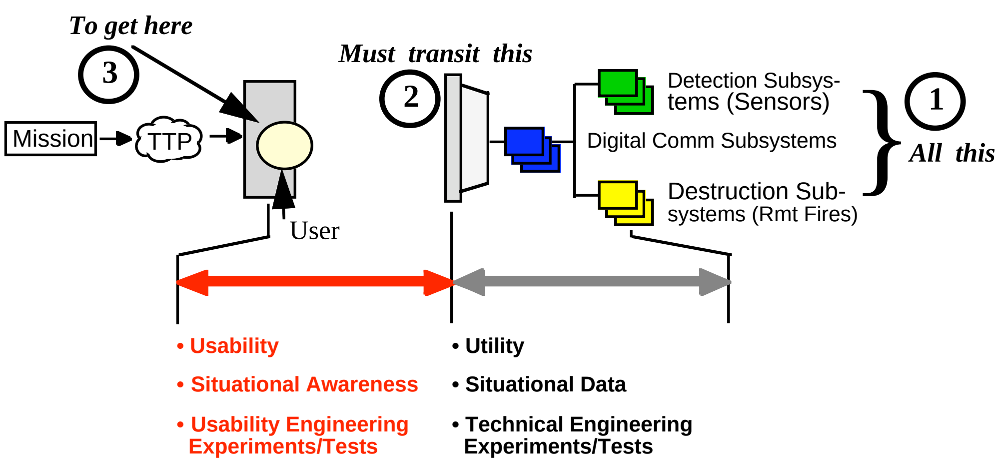
Incidentally, here the German experience is illuminating. Because WWI had taught that cavalry doesn't weigh heavily on the scales of modern war, the framers of the Versailles Treaty allowed the German Army to maintain a significantly large horse-based force structure in the 1920s and 1930s. As a consequence, the bulk of the German Army remained dependent upon equine transport throughout World War II. The American prophet cited above, General John Herr, Chief of Cavalry, was more correct than most suppose.

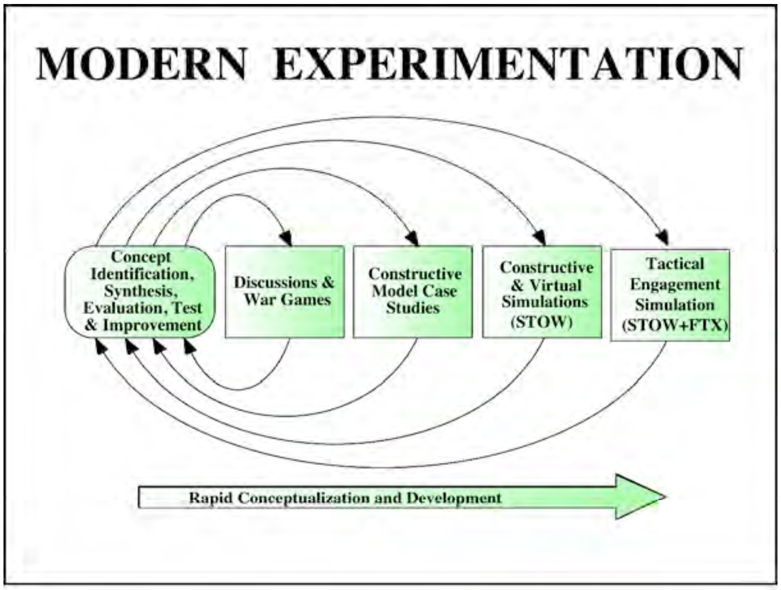
But Herr's argument in the U.S tended towards an all-or-none solution, whereas in Germany, Guderian's experiments with mechanization led to admixtures of highly-mechanized and animal-drawn formations that proved capable of conquering more territory than any army since Ghengis Khan's. In any event, it is historical fact that U.S. Army experiments in the 1930s and early 1940s – chiefly the Louisiana Maneuvers – impelled extensive mechanization, but not necessarily optimal mechanization, while German experiments led to functionally differentiated forces. These included adroit combinations of relatively static, minimally mechanized infantry/antitank battle groups and highly mechanized tank groups that time and again enabled the German army to fight and win outnumbered.

The German army's skill with experimentation was demonstrably superior to that of their American competition, and our ineptitude led to learning-while-fighting that was dreadfully expensive in terms of casualties. We need a better way to assess military worth.



All program managers feel a compulsion to make room in their planning for recourse to models and simulations, but what they are invariably offered, and usually buy, are the proved and tried horses depicted above. Reading Gansler's book [Ref. 3] and his most recent speeches has lead me to predict that acquisition reform may soon encompass a broader range of models and simulations, and richer forms of analyses, designed to explore relative military worth before the first steps are taken to build a new item of materiel. Not the least of the imperatives of information dominance are to master the means for transmitting the results of adroit collectors and facile processors to the space between the ears of a decision maker. Engineering **usability** is crucial: a system alone cannot achieve situational awareness, that is the province of the user.





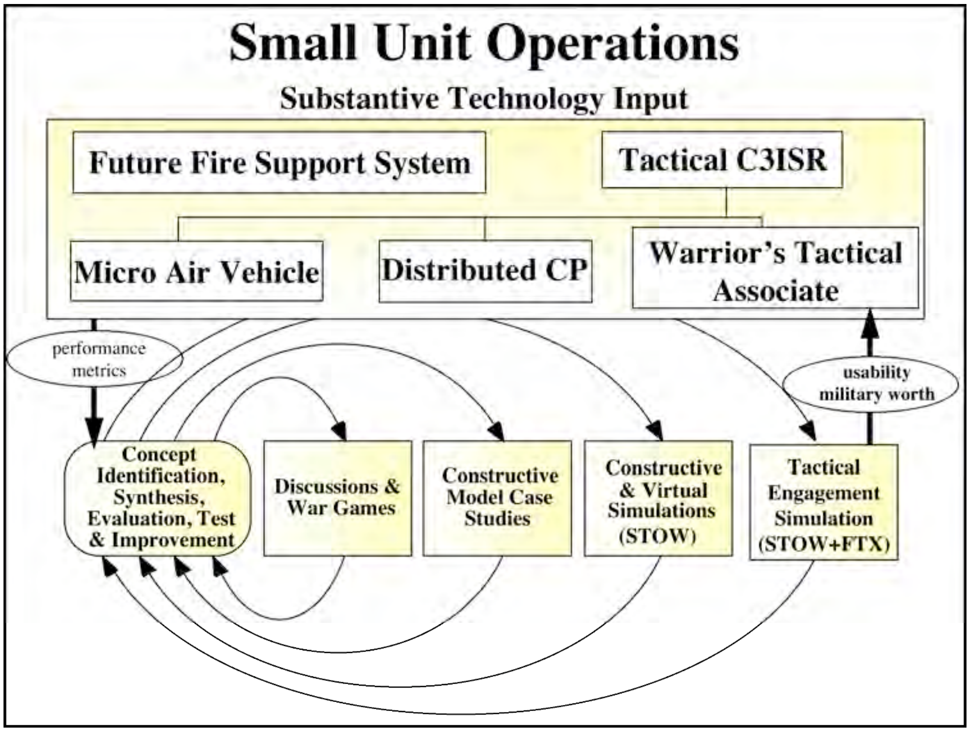
Here is a better paradigm for experimentation with 21st Century weapon systems, force structure, and doctrine. This audience [Training, Simulation, and Education] will recognize immediately that it employs methods and means that have proven themselves in military training and operational rehearsal over the past thirty years, and in that sense is hardly revolutionary.

What will be revolutionary is their adoption as serious decisional tools by those who allocate resources, manage system development, and test and evaluate oncoming materiel.

This evolutionary procedure, moreover, lends itself to engineering usability into the system as it proceeds through iterative experimentation, as advocated, *inter alia*, by Thomas K. Landauer [Ref. 4] and Jakob Nielsen [Ref. 5].

The concept seeks to conduct constructive and virtual experiments <u>before</u> any undertaking in the field. While live experiments will be required at some point, usually they provide insights into only one configuration of a system. Virtual and constructive trials can narrow choices among design options, and improve usability before going to the field.
As importantly, it is a methodology that enables commercial enterprises to present proposals to the Department of Defense [the opposite of what commonly occurs] with some confidence that proprietary information can be protected, and that the military worth of a commercial product or process can be assessed with minimal hazard to competitive advantage in the marketplace.

In short, this iterative examination, as a precursor to commitment of DoD funds for development, is a neat fit with Gansler's announced concepts. Let me now offer some specifics, drawing upon prospective systems for Small Unit Operations.



There is a plethora of unresolved issues about "small units" – their size, equipment, operational tempo, manning and training. But many such issues probably can not be convincingly addressed within the experimentation paradigm until after it is clear how small units shall exert military influence upon conflict outcome, or exert control in situations short of conflict. Hence for this discussion, I have focused on the proposed systems identified in the upper box which, in effect, would give the small unit its clout.

We have already discussed AFSS, development of which is already underway. Clearly, the ability to tailor this system to mission needs admits favorable employment opportunity for small unit applications. The terminology "Future Fire Support System" adds to AFSS another conceptual missile system, to be discussed with the chart following.

"Tactical C3ISR" (command, control, communications, intelligence, surveillance, and reconnaissance) includes advanced radios being worked on within DARPA under its SUO program. Shown here are three conceptual adjuncts that would lend themselves to experimentation; each of these– the Micro AV, overhead sensors organic to the small unit; distributed command post architecture for higher headquarters; and the WTA, the small unit commander's situational awareness display – will also be described and discussed in turn.

Future Fire Support System

for Small Unit Operations

• All land force fire support systems may be categorized as:

— Impulse launched, ballistic (**IB**) E.g, howitzers, guns

— Boost launched, ballistic (**BB**) E.g., rockets, "dumb" bombs

— Boost launched, guided (**BG**) E.g. TOW, Javelin, AFSS

• Weapons of the latter class are clearly more compatible with information age warfare, able to exploit enhanced C3ISR, and hence precise and discriminate.

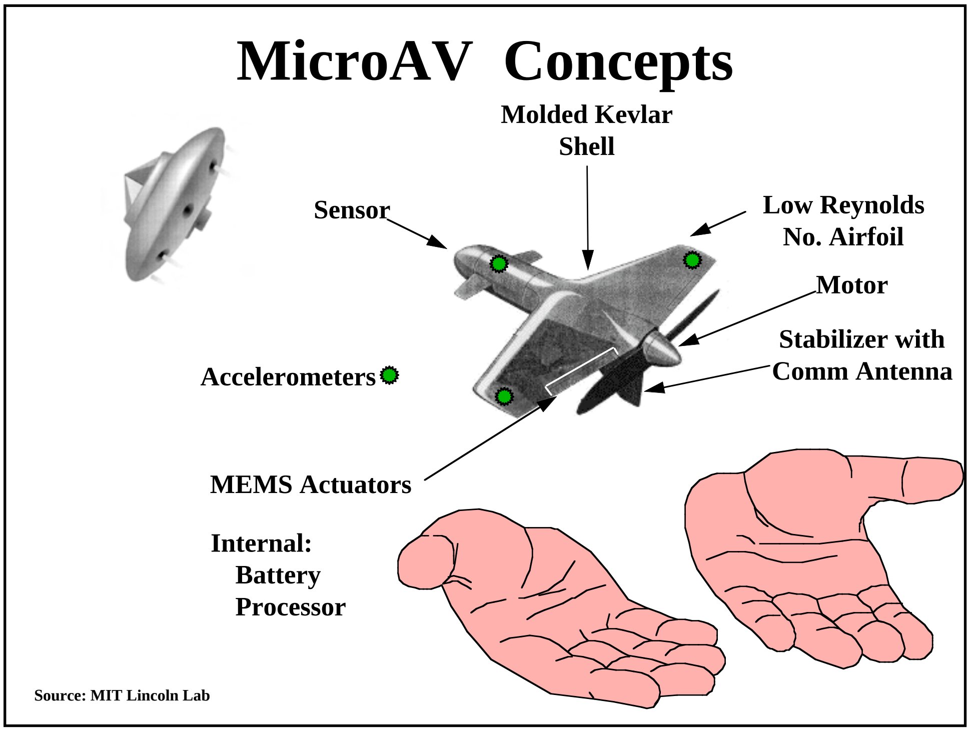
• Fire support for SUO ought to include AFSS, but in addition to its small warheads (10s of kg), should make continuously available larger, optimum-fragmentation weapons (100s of kg).

• **Experiments can be conducted with AFSS plus a proposed electromagnetic BG design delivering USAF CBU munitions.**

Parameters for the Advanced Fire Support System are generally known, a containerized system built around a $25000 missile about four feet in length and 7 inches in diameter, weighing 45 kg, delivering a 11kg warhead at ranges up to 15 kilometers. Analyses point to improvements in kill potential of 2 to 6 times over conventional fire support weapons. But these analyses have not shed any light on the implications of AFSS for strategic deployability, intra-theater mobility, interface with legacy CS (combat support) and CAS (close air support) systems, or force structure, let alone C3ISR. Hence, AFSS is ripe for experimentation.

However, another futuristic fire support concept has surfaced, one calculated to take advantage of the millions of dollars invested to date in electromagnetic (EM) propulsion, and in optimally fragmented munitions. EM research has been centered on relatively low-mass tank-killing projectiles launched at very high velocity (exploiting mV^2). The proposal would take advantage of what is known about EM propulsion to boost aloft a high mass, guided missile, weighing 100 to 500 kg, at launch velocities roughly one-tenth that of the anti-tank projectiles. The warheads would contain cluster bomblets.

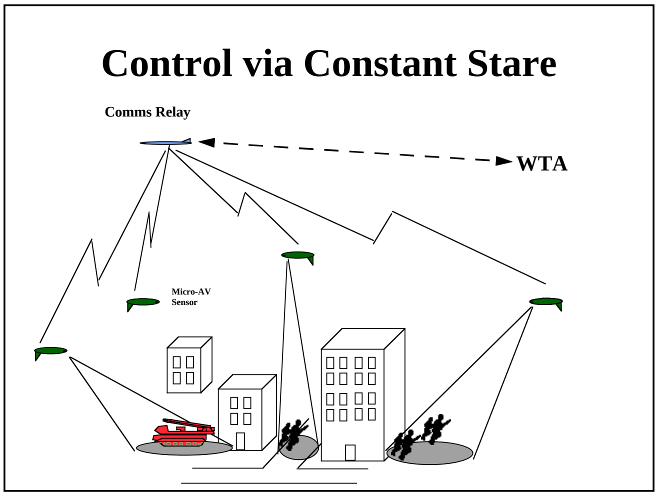
The Future Fire Support System for SUO would then rely on AFSS for direct support, and on the proposed EM BG system for general support.

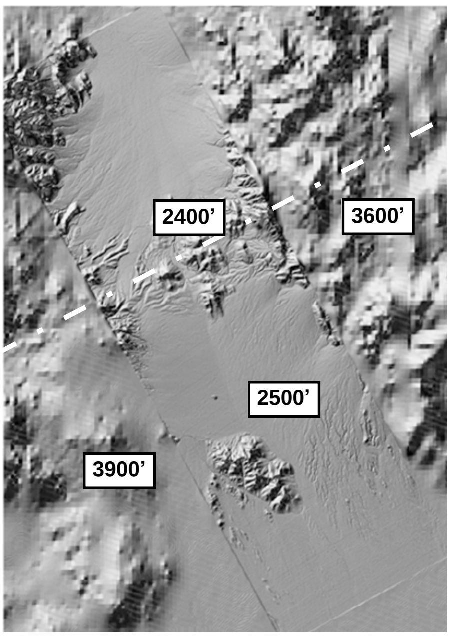


DARPA's Tactical Technology Office (TTO) now has a program to develop Micro Aerial Vehicles (MAV). This form of UAV, because of size and weight, may be especially useful for SUO. Many technologies must be integrated in a successful MAV. The small size requires new actuation mechanisms (e.g., MEMS) to achieve controllable flight. The sensors will need either very accurate orientation information, or the computational power to process jittery images. Depending on the type of information to be sent to the commander, and how distant the MAV is from a base station, the communications bandwidth and power are critical elements in MAV development. Finally, if MAVs are plentiful (and maybe not always recovered), inexpensive MAVs will depend on new manufacturing and component integration techniques.

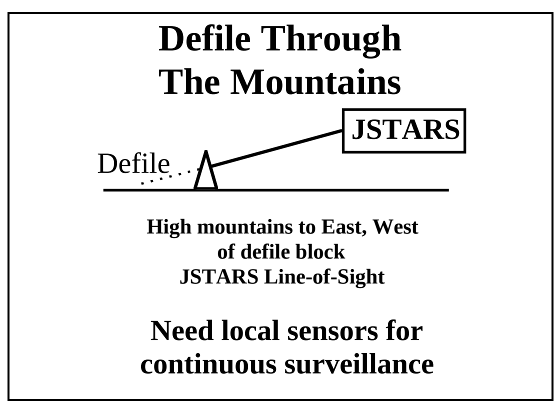
Operational characteristics assumed achievable for these vehicles are as follows:

Portability	**MAV, Base Station transportable by single individual**
Air Speed	**< 25 meters/second [m/s]**
Ceiling	**< 5000 ft.**
Range	**Limited by communications to 10 km**
Endurance	**~ 1 hour**
Weather	**Wind speeds < 10 m/s, no precipitation**
Payload	**Visible, IR, Acoustic, etc. Sensor 5-25 g; Power .3 - 3 W**
Navigation	**Base station tracking with line-of-sight; Autonomous navigation given small GPS**



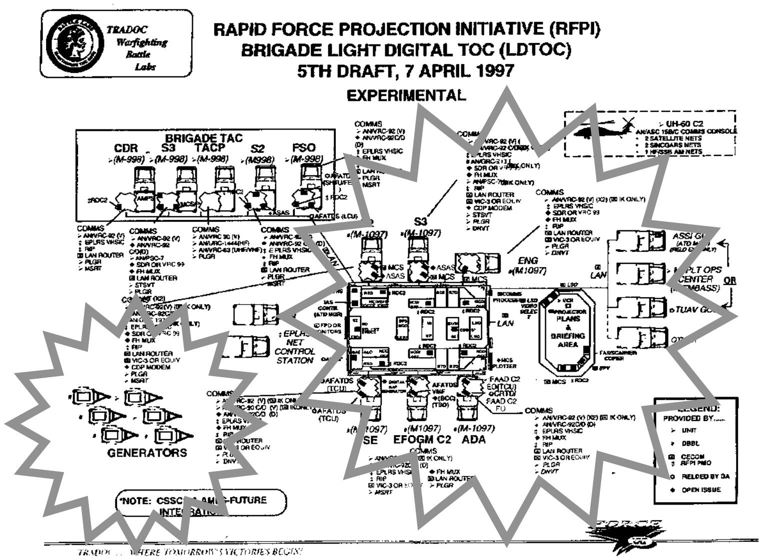


At present, almost all unmanned aerial vehicles fly point-to-point missions, collecting information on a large amount of terrain that they overfly. But there is another concept of UAVs: orbit over an area of special interest so that continuous surveillance is maintained. Data from this “constant stare” could then be processed using change detection techniques, automatically alerting the user to activity in the area of interest, and facilitating its identification. Micro Air Vehicles may be particularly well suited for such missions. In the cartoon above, an urban scene is depicted, and a swarm of MAV’s has been posted to observe the comings and goings about specific buildings. But a similar swarm of MAV’s might be used to observe defiles between mountains, as well as streets between buildings. It is thus that we will use them in the forthcoming experimental scenario.



The schematics to the right and above make the point that inexpensive MAV’s are not redundant to existing, more capable surveillance assets. JSTARS, even with a 9 second revisit time, might not be able to see into a defile if it is at a modest standoff distance. This would likely be the case, given that only a small force, insufficient in size to compete for and command dedicated JSTARS support, had been assigned responsibility for the defile. Hence, other sensors will be needed to conduct supplementary, continuous surveillance for situational awareness. Micro Air Vehicles could perform such a mission.

The Case for Distributed C3ISR



Neck Out for Decapitation

Modern wireless communications can readily provide broadband connectivity among elements of a Tactical Operations Center (TOC) that will enable their efficient functioning while dispersed over distances of several kilometers. In fact, exploitation of U.S. commercial, satellite-based PCS could enable dispersion at a savings over what we seem to be prepared to pay for TOC. Dispersal makes command nodes hard to identify, difficult to target, and significantly more mobile. In short, far more robust. Further, in enabling dispersal of the headquarters of larger units, land forces will acquire capabilities for ensuring connectivity with dispersed small units engaged in operations.

Air and naval forces are compelled by the nature of their environments to use **Operation Centers**. The Army and USMC need not, and should not, build **TOC**.

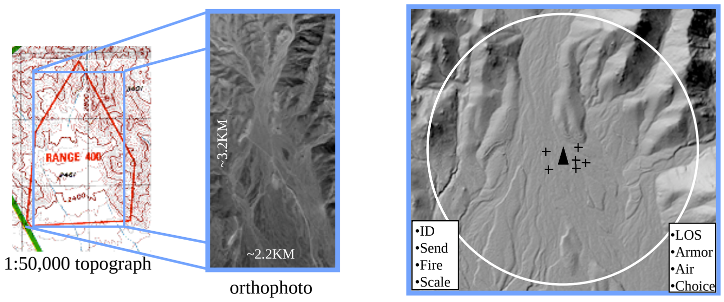
The alternative is well within reach in terms of technology, and tests have already established that there is no penalty for adopting distributed command and control architectures. To the contrary, field experiments have long since demonstrated that, qualitatively and quantitatively, information flow both internal to the command post, and to its higher, lateral, and lower associates **increases** [Ref. 2].

The experimental rubric heretofore described could readily take on the task of validating the previous findings, and of updating the enabling technology. In doing so, the experiments could provide definition to the concept, now explicit in DARPA's SUO program, called the Warrior's Tactical Associate, which is intended to serve as the small unit's interface with the C3ISR system of the expeditionary force. Let's look at one proposal for the WTA.

Situational awareness, or better yet, situational understanding entails collecting and presenting information crucial for tactical decision. That is difficult enough for forces operating in a homogeneous environment like aerospace, or the sea, but extraordinarily challenging when the arena of combat is the surface of the land, with all the complexities associated with works of man thereon. Moreover, small land force units cannot expect to have available elaborate display devices and extensive processing power. Hence, the search for a Warrior's Tactical Associate (WTA) to connect the small unit into the C3ISR system.

Terrain Representation and Analysis

Towards the Warrior's Tactical Associate



Conventional Paper Map
Locus via Grid Relief
from Elevation Contours

Relational Polar Plot Locus
via Azimuth and Range
3D Digital Elevation Model

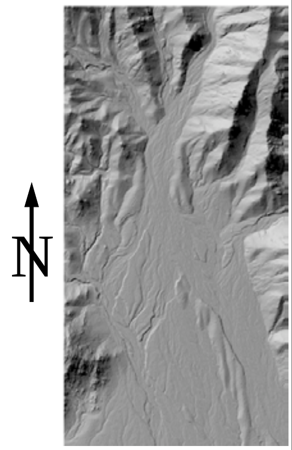
At the moment, the display with the highest information density and greatest usability available for small unit operations is the conventional paper map, represented above on the left. During the Defense Science Board (DSB) Summer Study of 1996, Larry Lynn, Director of DARPA, challenged participants to devise a better way to process and present the wealth of data that could be collected germane to operational decisions by a small unit leader. IDA has been experimenting with software to support a WTA.

In the center is an aerial photograph that matches the paper map, presenting relief better, but eliding geo-reference and other data. On the right is a candidate WTA, which displays with icons the tactical situation on a shaded-relief rendering of a high-definition digital elevation model (DEM) of the terrain, derived from photogrammetry, that records the elevation of every square meter (Digital Terrain Elevation Data Level 5, or DTED 5). Software is available to permit an experiment with the hypothetical WTA, which can automatically report locations in any of several coordinate systems (latitude/longitude, Universal Transverse Mercator grid, etc.), display ideographs representing cultural detail or activity of tactical interest, and respond to touch or oral commands from the user. The leader is always shown at display-center by the dark triangle, the apex of which reflects actual orientation. If the map is displaced, or reoriented, the display changes accordingly. The circle is about 1km in radius, but can be scaled, or zoomed, from radius 300m to radius 30,000m. The display is directly linked to a fire command channel so that the user can "point and click" to engage displayed targets.

Automated Terrain Analysis

A Hybrid Expert System for the WTA

- **Range 400, 29 Palms CA in shaded relief , based on a digital elevation model (DEM) of 1 meter horizontal resolution**
- **The range supports USMC live fire training for an infantry company**
- **Experiment showed that a WTA could aid a small unit leader in selecting routes for maneuver or positions for defense, placing observers or sensors, and planning fires**

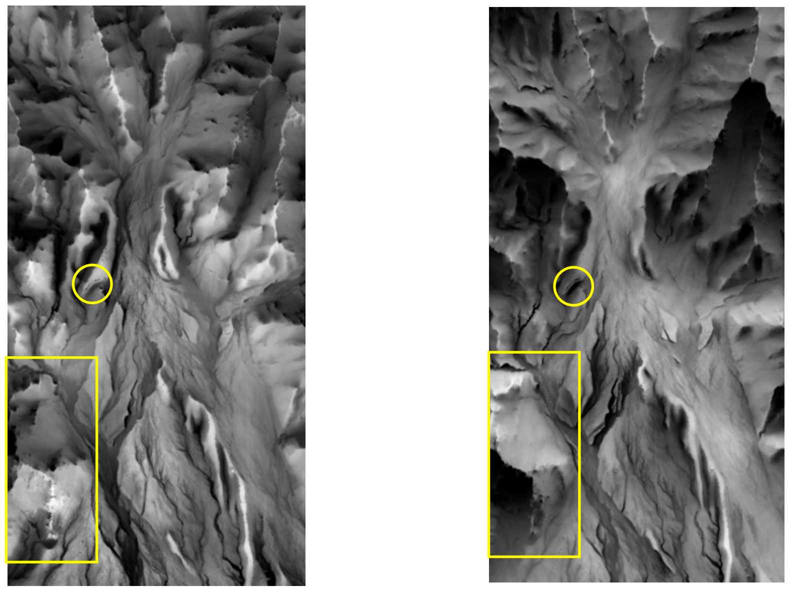


But the proposed WTA is more than just an aide for current operations: it is a planning tool. A software program initiated by researchers at the Artificial Intelligence Office, USMA, and further developed at the Simulation Center, Institute for Defense Analyses (IDA), enables it to analyze digital terrain data. To evaluate the validity – or expertness – of the software, the authors conducted an experiment to predict where Marine tactical instructors would elect to defend, and where Marine company commanders would choose to attack in an often-repeated field training exercise [Ref. 6].

At Range 400, USMC infantry companies are given the mission of attacking defensive positions of an OPFOR platoon somewhere in the valley shown. The attacking company usually advances northward from an assembly area just south of the mouth of the valley, through an extensive wash/wadi system that cuts through through the valley floor. Neither the issue topographic map nor aerial photos can present much information about that system, and of course, the Marines have no WTA available. Typically, a company will place a machine gun overwatch position on the small promontory in the southwest corner of the area.

In the IDA experiment, the computer program –acting on its own, without human assistance– analyzed elements of the digital terrain data for inter-visibility and vehicular-going information. It then successfully demonstrated that a WTA equipped with such an expert system could provide a detailed "reconnaissance" without any human setting eyes on the terrain until the operation were in progress. The computer program examined the terrain from the perspective of both an attacker and a defender, found optimal locations for the OPFOR squad-sized defensive positions, identified covered and concealed approaches for the Marine attackers, and flagged key terrain for aircraft and anti-aircraft employment.

Observation, Fields of Fire, Cover, Concealment



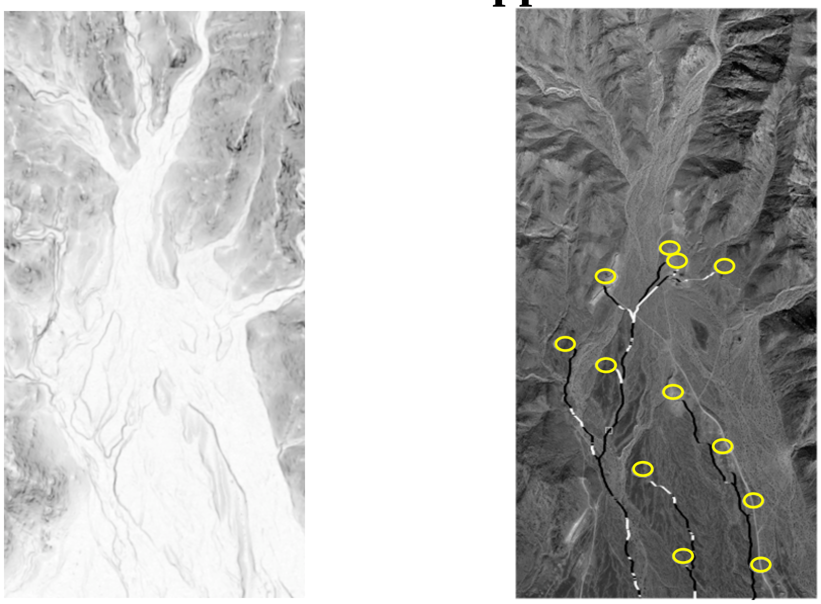
Defender's View **Attacker's View**

This is an elegant digital line-of-sight (LOS) analysis, comparable to contour-coloring topographic maps: computer-generated images generated by calculating LOS from each point on the earth's surface. The WTA user designates a direction and a range of interest (e.g., 600m). The examples show on the left the way the defender wants to see the terrain, highlighting those places with better observation and fields of fire towards the south, the expected origin of attacking forces. On the right, is a similar view for the attacker, but calculated to support an advance towards the north. In both depictions, more advantageous areas, those offering superior observation and clear fields of fire, appear whiter; less advantageous areas appear darker. To see the difference, look at the hill mass near the southwest corner of the display (yellow boxes). For the north-facing attacker, this elevation is near black in the south and white in the north; the opposite is true with the other view. Hence, this terrain appears as critical terrain at first glance.

Note how these depictions dramatize the wash/wadi systems. Their existence cannot be gleaned from study of the conventional topographic map, and requires an expert eye to discern from an aerial photograph. On the WTA, these gouges in the earth show up as darkly colored veins. Any person in one of these cuts would confront walls nearly vertical, sometimes fifteen feet high.

A "covered and concealed route identification" algorithm can plot routes that maximize use of the dark areas from any point *x* to point *y*. The user of the WTA can allow the program autonomously to compute a set of desired plots, or can examine any of these displays himself, and direct the WTA analyses at will. The computer can also be instructed to report anomalous features, such as the defensive trench dug to dominate one avenue of approach (yellow circle).

Selecting Defensive Positions and Avenues of Approach



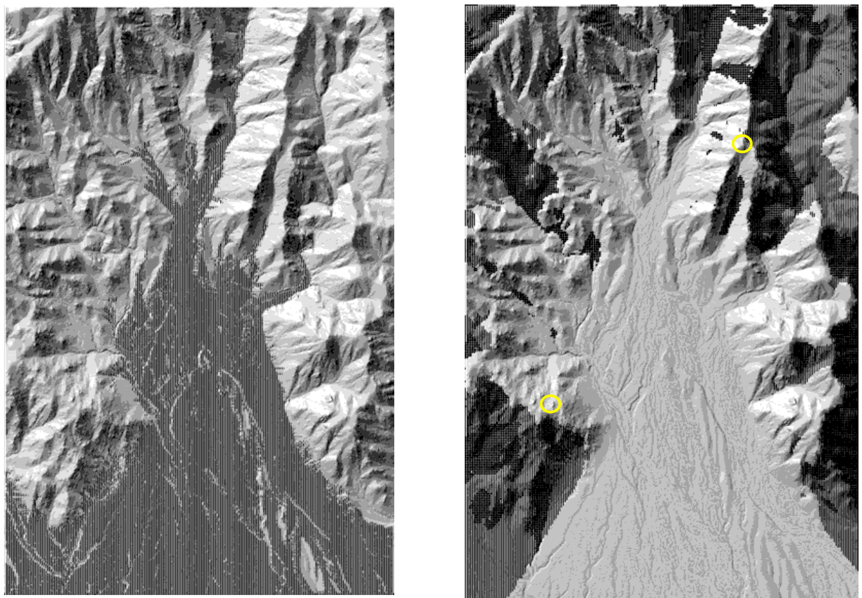
On the left, the WTA displays the result of examining small locales about each point in the DEM to characterize the total amount of elevation change within the locale. Areas that have high local elevation change are depicted as darker. Flat areas (i.e., those with very small amounts of local elevation change) are shown as whiter. Thus, the lighter areas represent areas where grazing fire is possible, and the gray or black areas represent dead space. This sort of analysis would also be useful in selecting landing zones for helicopters, or drop zones for parachute operations.

On the right, yellow ellipses are possible defensive positions selected by the WTA after examining the area for observation and grazing fire. The WTA has also plotted, in black for each position, covered and concealed routes of approach for troops afoot (the white segments alert the user where the route would be uncovered).

For the OPFOR defender, the WTA can now proceed to select, based on troops available, mutual support among positions, and any other criteria the user may insert, the best combination of positions to defend.

For the attacker, this analysis is instructive for specifying where C3ISR ought to look to detect OPFOR defenses, planning fires or concealing smoke, and selecting route(s) of advance.

Going Maps

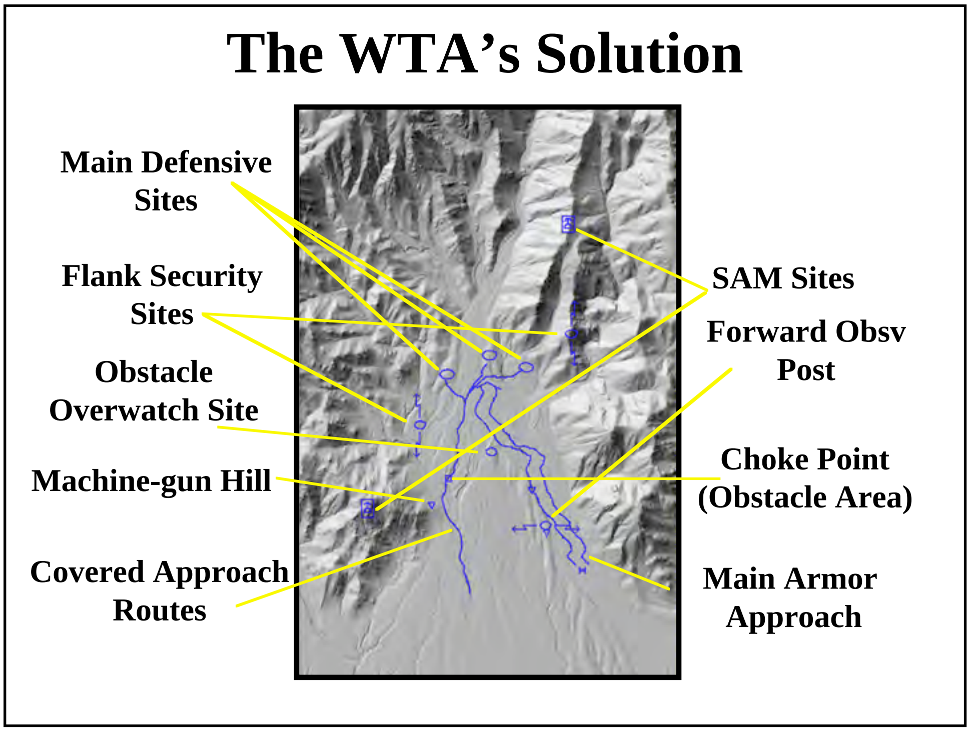


AFV **Helos, NOE**

On the left, the WTA, with dark vertical lines, shows the user where armored fighting vehicles can maneuver in the valley. The user can specify the "going" criteria, but the default, or usual setting, used here, reports terrain with forward slope less that 60^{o} and side slope less than 45^{o}, with at least 19 inches of ground clearance. The wash systems ("see-through" lines in the dark shading) constitute obstacles.

On the right, the WTA has performed an analysis based on input from the user that shoulder-fired surface-to-air missiles (SAM) are available. First the WTA assumed that a SAM would be sited at each of the three best defensive positions on the valley floor (as shown in the following illustrations). The shaded areas shown lack of SAM coverage against threat aircraft flying nape of the earth (NOE), 10 meters above the terrain or higher. Then the WTA sited two SAM's on high ground (yellow circles) to extend coverage; the double hatch shows remaining masked area.

The analyses would enable the defender to emplace SAMs and supplementary sensors, and the attacker to plan suppressive fires to support helicopters.



In the IDA experiment, the WTA analyses identified all components of an operations plan shown for a defender or an attacker, without any human intervention. The WTA findings were compared with sites and routes actually chosen by Marines over the past several years at Range 400, 29 Palms.

The computer solution aligned well with choices made by Marines. The center and western WTA proposed defensive sites are within 25 meters of the actual OPFOR positions. Covered approach routes agree well with those selected by the attackers.
One critical terrain feature identified by the WTA is known to Marines as "Machine-Gun Hill", where the attacking forces have usually emplaced one or more M-60s for supporting fires during their advance. The computer-identified armor route is truly the only trafficable path open to armor movement in the valley. The "choke point" is a constricted portion of one concealed route through the wash system that lends itself to overwatched terrain reinforcement by the defender.

OPFOR uses the WTA-selected obstacle overwatch site as forward defensive position. OPFOR has not employed obstacles for terrain reinforcement, or used SAM, and the attackers have used neither armor nor helicopters.

Note well that this WTA could readily be employed for training as well as operational rehearsal, and, with a constructive simulation like JANUS, could be used for analyses of different courses of action, modifications of force structure, or the introduction of new weaponry.

Other Experimental Results

- **U.S. Army has formally stated requirements for DEM:**
  - **— DTED 2 (30m) to support deployment planning**
  - **— DTED 5 (1m) to support Force XXI**
- **IDA experiments cited have shown that, for WTA-like applications:**
  - **— DTED 4 (3m) produces acceptable results**
  - **— Data base size at DTED 4 is 11% that of DTED 5**
  - **— Processing time at DTED 4 is correspondingly reduced**
- **WTA-like algorithms for identifying tactically significant terrain can facilitate DIS by expending the "polygon budget" on rendering at high definition only terrain likely to figure in tactical outcomes**

These are potentially important findings:

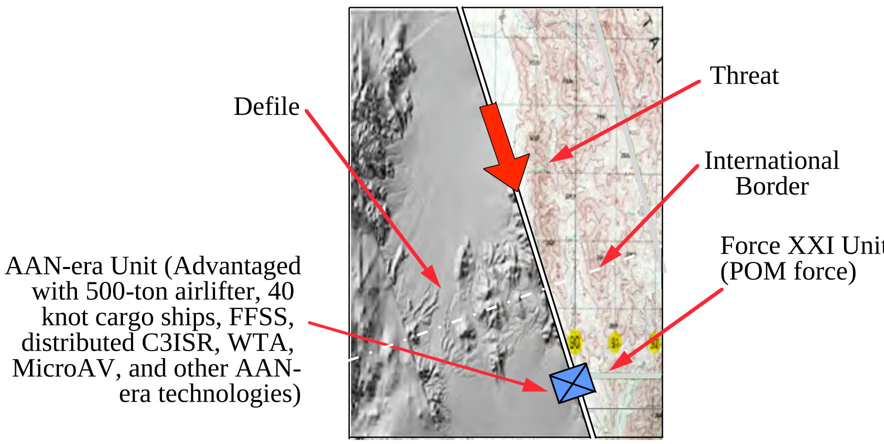
Situational awareness for SUO on land can not be provided absent a reliable digital model of the terrestrial surface: slopes, soil, vegetation and road characteristics, plus obstacles, bridges , buildings, fences, and other works of man.

Obtaining the digital elevation data is the main shortfall. Techniques involving interferometric synthetic aperture radar (IFSAR) are promising, but such devices are few in number, mounted on air-breathing aircraft, and therefore questionably capable of extensive mapping in remote areas of the world. A space-based mapping system, employing hyperspectral sensors and advanced rendering algorithms, is needed as a matter of urgency. Even with such technology, the difference between a large scale mapping effort aimed at extensive DTED 5 coverage will be very costly and time consuming.

Accepting DTED 4 coverage, as suggested by the IDA experiment, could save the government $millions –file size and processing time are proportionate to cost, and the leverage is 9:1. Revising that requirement would substantially assist the US in closing a major gap between its present force posture and readiness for the information age.

There will continue to be a need for 1m imagery in limited areas for such purposes as target definition and post-strike assessment, but the DEM is the principal driver in data collection. Distributed Interactive Simulation (DIS) and the Synthetic Theater of War (STOW) will be advanced to the degree progress is made on digital mapping. This community ought to follow the digital mapping issue closely, and support high priority for funding a gap-closing undertaking.

Scenario for a Future-oriented Experiment Comparing Force XXI and AAN Units



Now follows a scenario for a future-oriented experiment, in which a Force XXI unit will be compared with an AAN-era small unit performing the same mission, on the same terrain.

US land forces have been alerted for action overseas. One US unit is tasked to block a key defile at the border of Country X, to foreclose use of said defile for aggression by Country Y. The latter is capable of mounting an offensive with forces ranging from heavy armor formations to light infantry units, guerrillas, and terrorists. Y is rapidly massing forces opposite the defile, and there is political urgency on early arrival. The force commanded by Y will rapidly overwhelm any defensive posture that X could establish in isolation. At alert, there are no US forces in the theater and rapid deployment is a key. A central part of the mission is to avoid using firepower indiscriminately, and to cooperate with forces of Country X and of other allies.

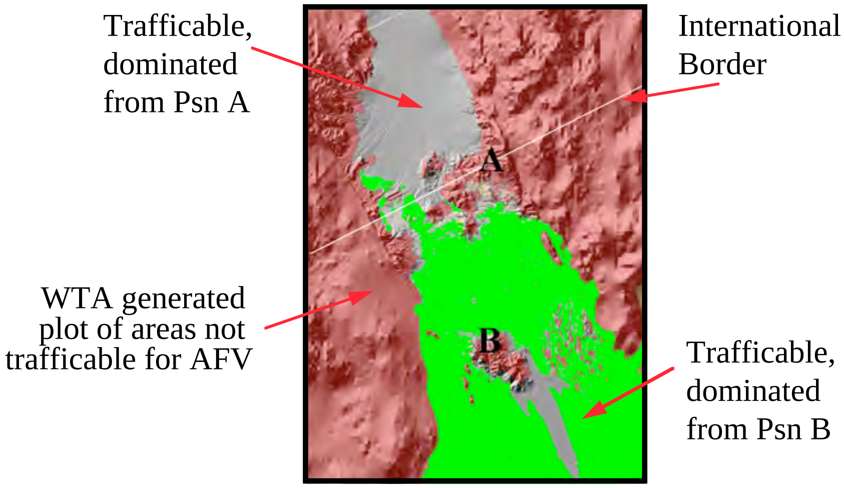
Comparisons will be drawn between the two US units from fort to foxhole, with MOE from deployability and sustainability to combat effectiveness.

The scenario starts at H-24. H hour is initial occupation by the US force of fighting position(s) from which to control the defile.

I will illustrate the experiment with examples of the conceptual equipment issued to the AAN unit. We will not attempt to describe what the Force XXI counterpart is working with, but you should understand that the experiment would permit the Force XXI unit to use any material in the current Program Operating Memorandum plus Extended Planning Annex.

H-24 WTA Analysis of Courses of Action

(22 hours prior to arrival in theater)



Planning would commence with a WTA display something like that shown, aiding a decision of where to go and what to do.

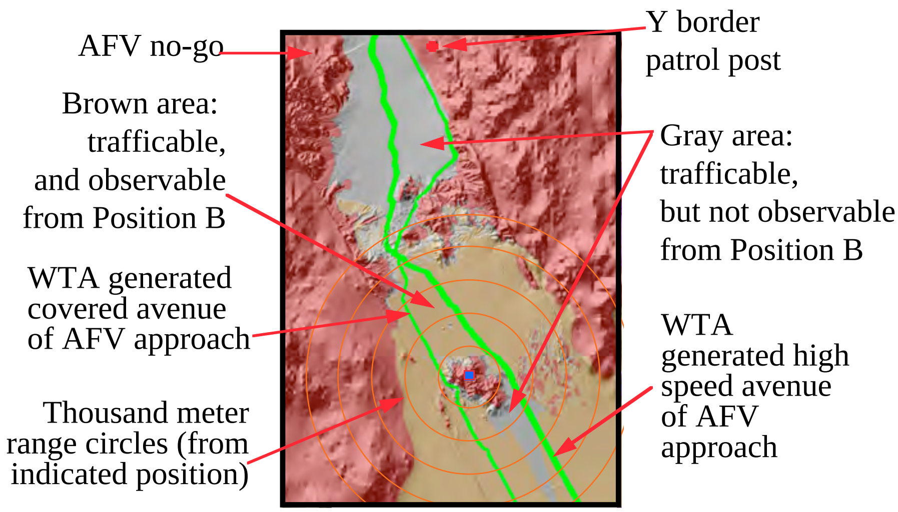
There are two terrain compartments, comprising a corridor hemmed in by untrafficable mountainous terrain all along its eastern and western flanks. The two compartments are neatly separated at the international border by a line of hills and cuts, traversed by a narrow pass. The northern compartment slopes upward to the pass, the southern compartment downward away from the pass. The WTA plots ground not trafficable for armor, shown by a reddish tint on the display, considering armored fighting vehicle (AFV) slope limitations (front and side), and ground clearance requirements.
The WTA flags two positions, labeled A and B, which, were both occupied, would provide virtually 100% observation over the entire corridor for 10km north and south of the pass at the border.

The WTA, on command of the user, depicts observation and fields of fire for various weapons from A and B, and analyzes terrain in the vicinity of each in detail. For instance, analysis of A shows that the position providing the best observation is virtually inaccessible to armored forces, and is, in any event, across the border in Country Y. Several “next best” choices for A were then examined, but all had drawbacks.

The commander elects to occupy Position B, from which he can detect and react to any transgression of the border by Y (direct coverage from B shown by the green tint). He plans to cover the northern compartment with sensors and fires – in concept, a rear-slope defense of the defile.

H-12 WTA Avenues of Approach

(10 hours prior to arrival in theater)



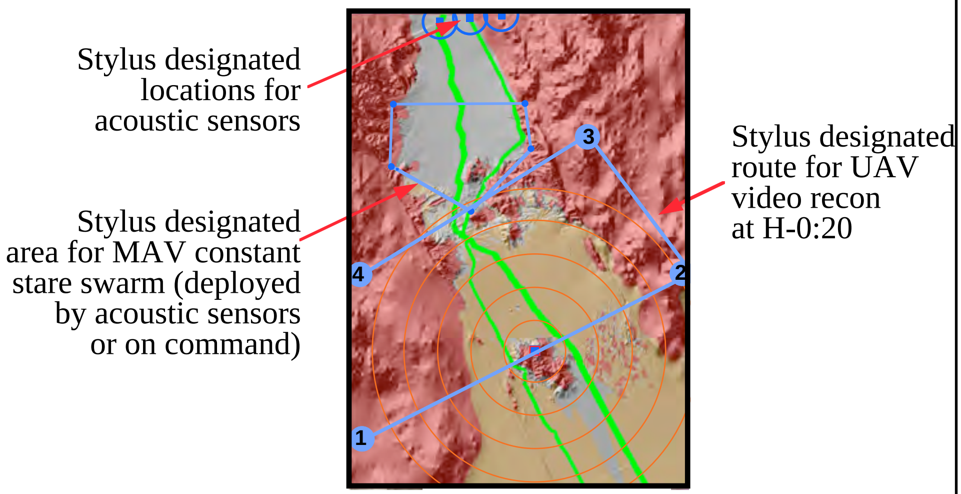
Position B, about 5km south of the pass at the border, sits on high ground astride the corridor. The WTA provides an analysis of possible armor avenues of approach. Two seemed particularly probable: the high speed avenue emerged from a search of the DEM for the shortest path that was most free of AFV no-go terrain over a path width of 150m (about a platoon on line). As may be seen, the high-speed approach comes down the center of the northern compartment directly for the pass, then skirts Position B to the east, moving between the hill mass and the wash-wadi system along a narrow channel of go terrain.

The WTA then calculated a longer and slower, but a more tactically sound, better covered avenue of approach. In its search for this path, it used LOS (visibility) data, seeking minimal observability, as well as AFV trafficability. Minimum acceptable path width was decreased to 75 meters, and further exceptions were made at specific points where a column formation would be necessitated to remain under cover. The covered approach hugs the east side of the northern compartment, snakes laterally across to the pass, then passes west of Position B.

The pass is definitely a choke point for movement of AFV. Were there any military activity in the corridor known to theater level intelligence, it would be plotted on the WTA in real time. Note the placement of a border patrol post in the northeast part of corridor.

H-4:30 WTA Transmits Leader’s R&S Plan

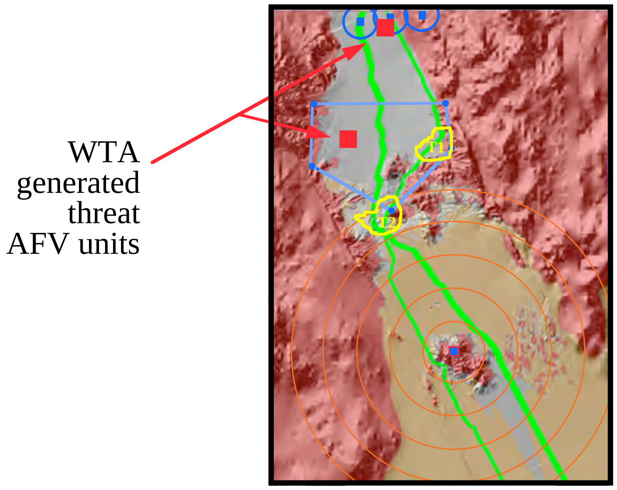
(2.5 hours prior to arrival in theater)



The unit’s reconnaissance and surveillance (R&S) plan would be entered directly on the WTA, and portions requiring action by higher headquarters, automatically submitted as a request (for example, the UAV plan). Approval would be transmitted via the same means.

<u>H-4 thru H-3:30</u> WTA Rehearses Sensors & Fires

(Completed 1 hour prior to arrival in theater)



Within the first hour after receipt of its order, and while still in route, the AAN-era unit would begin its rehearsals in concert with its higher headquarters and its sensor and fire support systems.

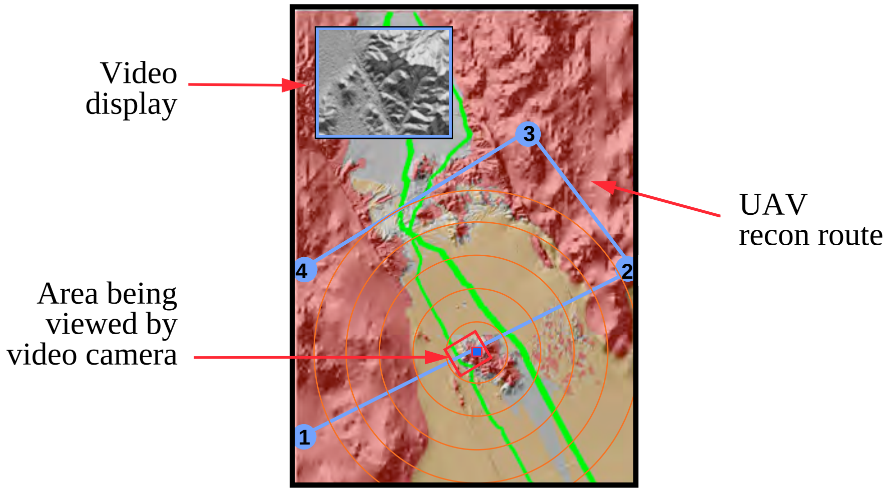
In addition to the sensor plan for the northern terrain compartment, the team leader has designated two "target areas," T1 and T2, for which he allocates weapons, and otherwise expedites delivery of fire in the event that targets appear.

Much of the rehearsal is concerned with taking advantage of the loiter capability inherent in the Future Fire Support System.

The culmination of the rehearsal postulates determined assault on the pass by AFV, exercising the unit in calling for EM BG fires.

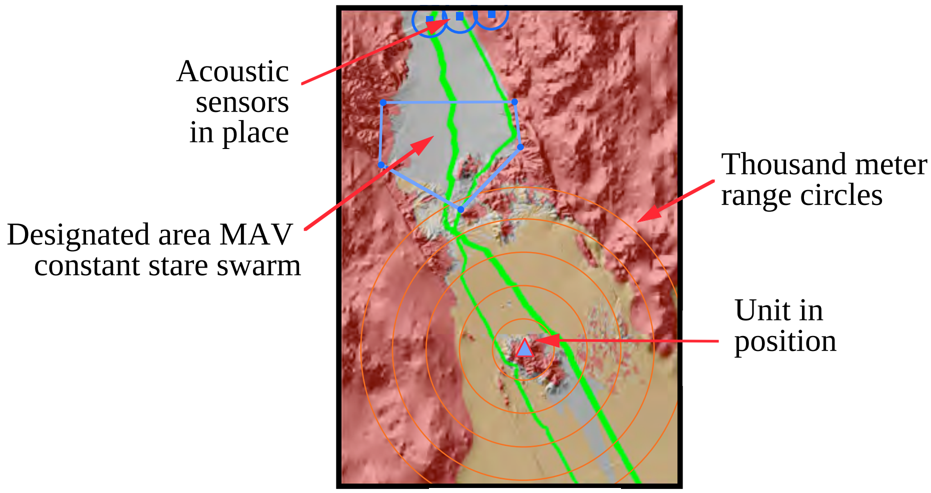
H-0:20 UAV Video Recon Begins

(Video transmitted to SU leader enroute)



At about 20 minutes prior to insertion onto Position B, the small unit leader would begin receiving a video feed from a UAV-mounted video sensor to verify that his landing zone (LZ), defensive positions, and the immediate area were clear of potential opposition.

H Hour Small Unit Rehearsed, in Position, and Ready to Fight

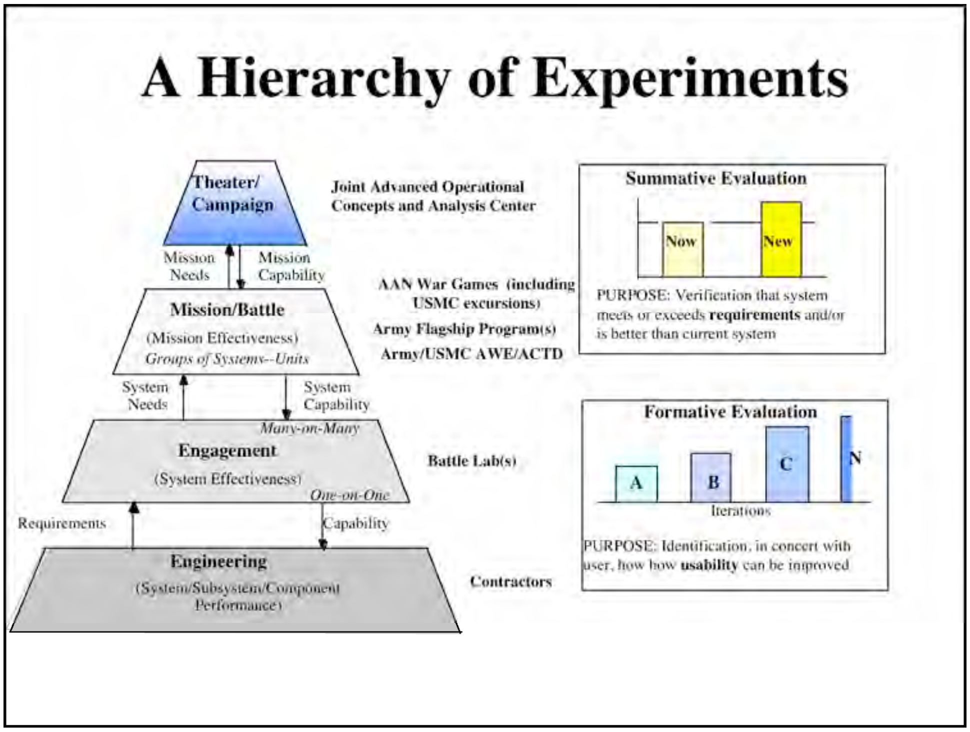


The scenario then continues with various threats being presented. Experimental probes might include:

- Attack by armed helicopters
- Attack by a mounted reconnaissance unit
- Infiltration of dismounted infantry units to seize high ground on both sides of the pass
- Attack by a tank/mechanized infantry brigade

This scenario is, of course, a deck stacked against the Force XXI unit and its supporting elements, who would probably (1) find it significantly harder to deploy rapidly; (2) be handicapped for lack of real-time intelligence; (3) be drawn onto the high ground overlooking the northern terrain compartment so as to exploit its direct fire weapons; and (4) require substantially more logistic support. Nonetheless, exercise of this scenario would shed light on the real combat capability of Small Unit Operations, and conceivably would lead to more cogent requirements for technological, doctrinal, and training developments.

Finally, this community should note that the WTA itself is nothing more nor less than a superb training device, and an embedded device at that.



Until the recent change in our military posture vis-à-vis the former Soviet Union there was little need for experimenting above engineering level as the anticipated characteristics of engagements, battles, and campaigns remained largely unchanged for over four decades.

Now that we are in an era of substantive, simultaneous change at all levels, e.g., Vision 2010 at the Theater/Campaign level and Army After Next at the Mission/Battle level, it is imperative that experimentation be bolder and broader. The tendency of late has been to conduct very large experiments – the Advanced Warfighting Experiments to point. But the technological novelties and uncertainties of the information age –especially as they pertain to the usability of computers and displays – should urge focus on the engagements from one-on-one up to somewhere slightly below many-on-many: small, iterative experiments, designed to clarify what tasks technology is to perform, and how well it must perform those tasks before time and funds are spent on constructing prototypes. These experiments can involve constructive or virtual models of the system, or live exercises with system emulators in place of the objective materiel.

Systems with a high level of interaction with the system's users –such as inherently the case in Small Unit Operations – should be supported with Formative as well as Summative experiments. These are particularly important for key C3ISR nodes, such as the Warrior's Tactical Associate.

References

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