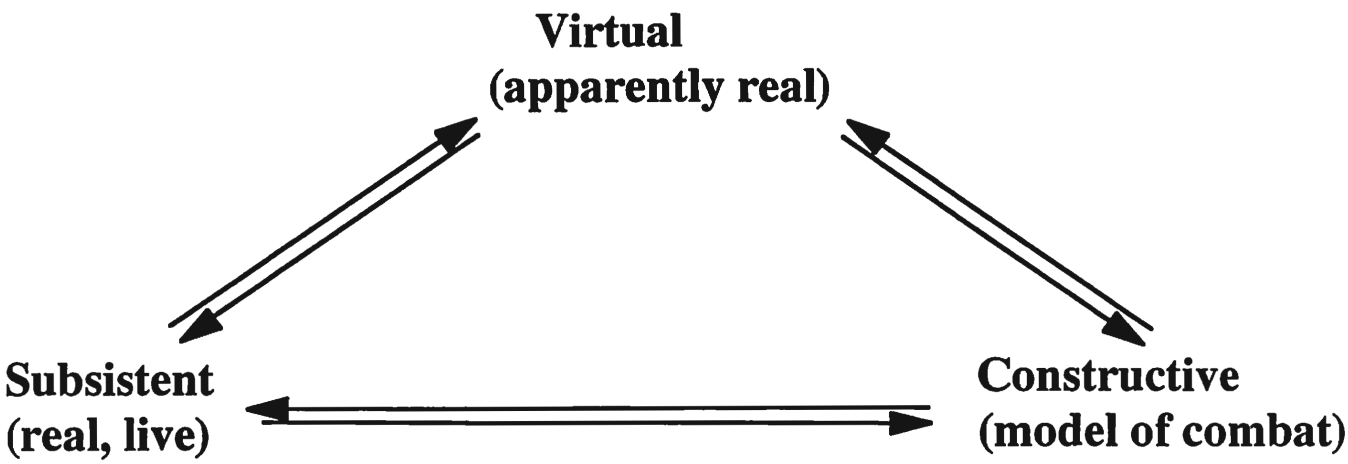
VISION



Presentation
at
Dismounted Battle Space Battle Laboratory
Fort Benning, Georgia
15 February 1994

General Paul F. Gorman
U.S. Army (Retired)

VISION DBSBL FEB 94

M&S for the Dismounted Combatant

21st Century Land Warrior

- **Digitizes dismounted combat**
- **Improves lethality & protection**
- **Reduces weight and bulk**
- **Is affordable, integrated, yet modular**
- **Comprised of five major subsystems:**
  - **Integrated Headgear Subsystem (IHS)**
  - **Individual Soldier's Computer/Radio (ISC/R)**
  - **Weapon Interface Subsystem (WIS)**
  - **Microclimatic Conditioning (MCC)**
  - **Objective Individual Combat Weapon (OICW)**

  Not <u>all</u> capabilities in use at <u>all</u> times by <u>all</u> combatants
- **Is compatible with current weapons**

2/7/94 1

The 21st Century Land Warrior Top Level Demonstration — 21CLW TLD — under DoD Science and Technology Thrust 5 has two foci: (1) to provide situation awareness, and (2) to provide near real time automated targeting via personal warrior communications linked via a data network and sensors to the dismounted Army Infantry, dismounted Marines, and Special Operations Forces. This should provide better integration of dismounted personnel into the total force, increase their dispersion while increasing their effective control over their surroundings, and providing them superior lethality and survivability.

The 21 CLW TLD seeks to leverage the industrial/commercial telecommunications and microelectronics explosion making lightweight, man-portable communications, data-networking, and sensor modules feasible and affordable. The program assumes that the technology has reached a state of maturity that a low to moderate risk developmental demonstration can be undertaken.

21 CLW builds upon the Soldier Integrated Protective Ensemble (SIPE) ATD (FY90-93). The technologies included in SIPE were shown to provide major improvements in individual and collective performance at night, in an obscured environment, and in a chemical environment by enhanced lethality, command and control, and survivability. However, SIPE was deficient in form and fit, if not in function, particularly:

> ...the constant and intense pain caused by the helmet/visor combination, and the weight of the equipment housed in the load bearing pack. Although the test soldiers tried to focus on the capabilities of the equipment, eventually their physical discomfort became unavoidable and overriding. Much of the potential benefit was lost due to their inability to devote full attention to the tasks at hand. The effects were cumulative over time; the impact was greater as the demonstration progressed. Integration of the equipment caused more problems than did any parts in isolation; it magnified problems and masked positive aspects. This was partially due to the physical discomfort generated by the prototype equipment and fit and partially due to the constraints forced on soldier behaviors by the equipment.... [ARI Research Report 1640, 6/93]

M&S for the Dismounted Combatant

Charge from OSARD

Generation II Soldier System Advanced Technology Demonstration

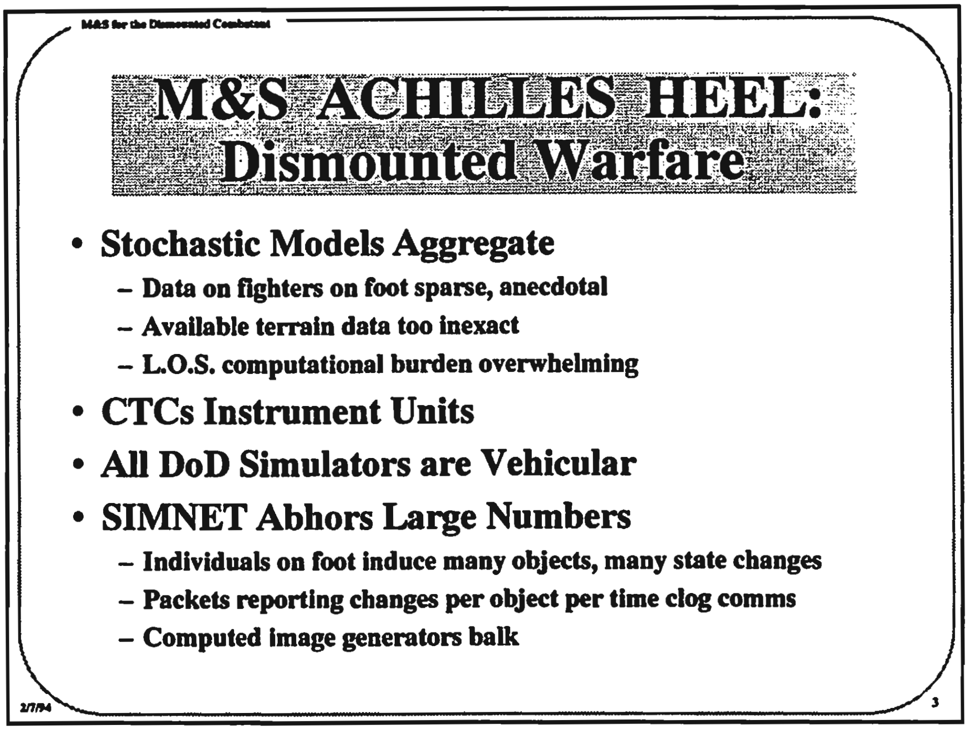
- **Plan Military Worth Analyses**
  - Show decisive advantage over current systems
  - Illuminate implications for doctrine, force structure, training
  - Be complete by FY 97
- **Provide Tools for ATDs**
  - 1996: Interim ATD with prototypes
    - » Capability of digital network(s)
    - » Form, fit, and function
  - 1998: Culminating ATD: light infantry platoon STX/FTX
  - Transition to minimal Engr Development P6.3b, 6.4

2/7/94 2

Mr. George Singley, Deputy Assistant Secretary of the Army for Research and Development, and the Army's Science and Technology Executive, requested a "second opinion" on how to go about conducting an analysis of the 21 CLW materiel that would establish its overall military worth. Mr. Singley asked three tough questions:

> Would that equipment be sufficiently advantageous to warrant a decision to assume the risks and costs of developing and fielding it?
>
> If it is effective, how would it affect the way the Army does business in the battlefield? [Does it mean depopulating the zone of close combat — fewer soldiers at risk? How does it affect doctrine and training?]
>
> How could the analyses be conducted so that informed decisions can be taken by the end of Fiscal Year 1996?

He also stressed that the Army needed to find a set of tools for conducting analyses that would insure meeting the tight timelines for an Interim ATD in 1996, and a Culminating ATD in 1998.



This audience does not need to be persuaded that dismounted combatants contribute importantly to force readiness: control of a foreign land and its people is assured for the United States only when the boots of American infantrymen and Marines stomp its soil; SOF teams, scouts, forward observers, snipers, combat engineers, medics, suppliers and maintainers...all are a vital part of combined arms teamwork.

> Strategically, dismounted combatants have recently been central in operations other than war, in which casualties, even a casualty, becomes a heavy burden on the President, and an MIA becomes a bargaining chip for our enemy. The U.S. needs higher mission assurance, and lower vulnerability for dismounted soldiers and Marines.
>
> In service resource management, our leaders face tough decisions concerning a promising, but expensive, R&D program called "21st Century Land Warrior" (21 CLW), which seems to offer dismounted combatants that increased efficiency and protection.

Nor is it necessary at a TRADOC Battle Laboratory to suggest that existing models and simulations of dismounted combatants are inadequate. Our armed forces, like the great Greek warrior, need only look footward to spot a weakness.

Allow me to stipulate, then, this chart as a point of departure for considering the future of the Dismounted Warfighting Battle Laboratory. I shall present an illustrated lecture, punctuated by brief examples of potentially useful technology.

M&S for the Dismounted Combatant

PARFOX VII

The Need for Reliable Data on Dismounted Combat

- **Soldiers prefer open foxholes**
  - **Engage at greater range, kill enemy before he closes**
  - **More rank, experience= stronger preference**
- **But data showed:**
  - **<u>No</u> difference in opening ranges**
  - **Parapeted hole kills 2X open holes, wins 2X open holes**
  - **Each shot at open hole 3X effect on parapeted hole**
- **Doctrine: teamwork & firepower**
  - **Two up, one back succeeded 25%of trials**
  - **One up, two back succeeded 87% of trials**

2/7/94 4

Modelers and trainers ought to be the strongest advocate of range instrumentation; regrettably, they have often been among its detractors. Modelers prize Subject Matter Experts as sources of data, and trainers are wont to assert that they need no instrumentation beyond their eyeballs and ears. Brigadier General S.L.A. Marshall amply documented that humans, even those most likely to be "subject matter experts," are not always a reliable source of information on close combat. Any well instrumented range can quantify such fallibility. One example, mentioned by Walt Hollis, is CDEC Experiment FC 033, the Evaluation of the Frontal Parapet Foxhole, conducted in 1976, tests known as PARFOX VII. There were 72 valid trials in this test, each involving some thirty soldiers, eight defending, the others attacking, on a well instrumented range. The defenders occupied one of three types of foxholes, (1) an Army standard foxhole permitting all around observation and fields of fire, (2) a foxhole built with a parapet across its front that confined the defender to observing and shooting at angles across the front of adjacent positions, and (3) a compromise between these that had an interrupted frontal parapet. The majority of soldiers participating expressed a strong preference for the open foxhole: they testified that during the trials they could see the enemy better, begin engaging him at a greater range, and thus defeat him with fire before he closed.

Range data on actual performance, however, told a very different story. There was little evident difference in opening ranges, and in any event, defenders behind parapets proved to be more than twice as lethal on the attackers as those in the open foxholes. Attackers of open foxholes succeeded more than twice as often as attackers of parapeted foxholes; each shot at an open foxhole measured three times more effective (hit or suppression) than a shot at a parapeted hole. Doctrinally correct infantry attacks, as then taught at the Infantry School (two squads up and one back), penetrated the defenses only 25% of the time; unconventional tactics (two back and one up) penetrated 87% of the time. There were powerful implications from PARFOX VII that could not have been elicited without objective data, derived from instrumentation, on what actually happened; field manuals, SME, and the constructive models of the day were confounded.

EQUIPARTITION OF MISFORTUNE

- **Rank does not intimidate hardware.**
- **The incidence of failure during a demo is directly proportional to the square of the size of the crowd multiplied by the rank of the senior observing official.**

Augustine's Laws XXVII

Technical Approaches:
- **Terrain data for combat afoot**
- **Secure, broad-band comms**
- **I-Port mechanisms**
- **Instrumented combatants**

Illus 1: 73 Easting + I-Port

Illus 2: Terrain for dismounted combat

Illus 3: Virtual TES for foot fighters

Illus 4: PSM, Infoscope: S
V △ C

1 Jan 94: Nothing you will see existed

M&S for the Dismounted Combatant

Advanced Research Projects Agency
Defense Mapping Agency
Defense Models and Simulation Office
GDE Systems, Inc.
Institute for Defense Analyses
InterDigital Communications Corporation
Kaiser Electro-Optics, Inc.
Loral Corporation
Sarcos Research Corporation
Silicon Graphics, Inc.
Technology Systems, Inc.
University of Pennsylvania, Department of Computer Science
University of Utah, Center for Engineering Design
U.S. Army Research Laboratory, HRED
U.S. Army STRICOM
U.S. Army Topographic Engineering Center
U.S. Marine Corps
U.S. Naval Postgraduate School

2/9/94 6

Government/Industry Team

The decision to begin planning for this illustrated lecture was taken on 15 September 1993 by Mr. George Singley. His office arranged for its funding.

Funds reached contractors beginning in December, 1993, but work on the devices and displays did not begin until the first week in January, 1994.

The impresarios were Jim L. Madden, of Sarcos Research Corporation and Farid Mamaghani of STRICOM.

We wish we had sufficient time to integrate the USMC Tactical Team Engagement Engagement Simulator (TTES) into this lecture. We are indeed grateful to the Marine Corps for sending it to the Laboratory so that it could be demonstrated for conferees.

You will all have an opportunity to examine the equipment you will see in operation. After lunch today there will be a series of seminars on the underlying technology, and plans for its further development by the Dismounted Warfighting Battle Laboratory.

M&S for the Dismounted Combatant

VISION

The Dismounted Battle Space Battle Laboratory:

- **Moves out on 21 CLW military worth analyses:**
  - **Supports TRAC in upgrading JANUS 4.0, CASTFOREM**
  - **Designs, conducts, analyzes constructive, virtual and subsistent (real) simulations**
- **Takes the point in digitizing dismounted combat**
- **Leads development of new BDS-D components:**
  - **Broadband communications for distributed simulation**
  - **Distributed processing system *LEGION***
  - **Object differentiated, DMA-sourced terrain data bases**
  - **I-PORT**
  - **PSM, & PSM-instrumented TES**
  - **INFOSCOPE**
- **Helps field unstoppable Infantry, Marines, SOF**

2/7/94 7

My vision is that this Battle Laboratory shall lead an attack on a broad front, from S&T across RDT&E, through training and ops rehearsal, near-term and far-term, to:

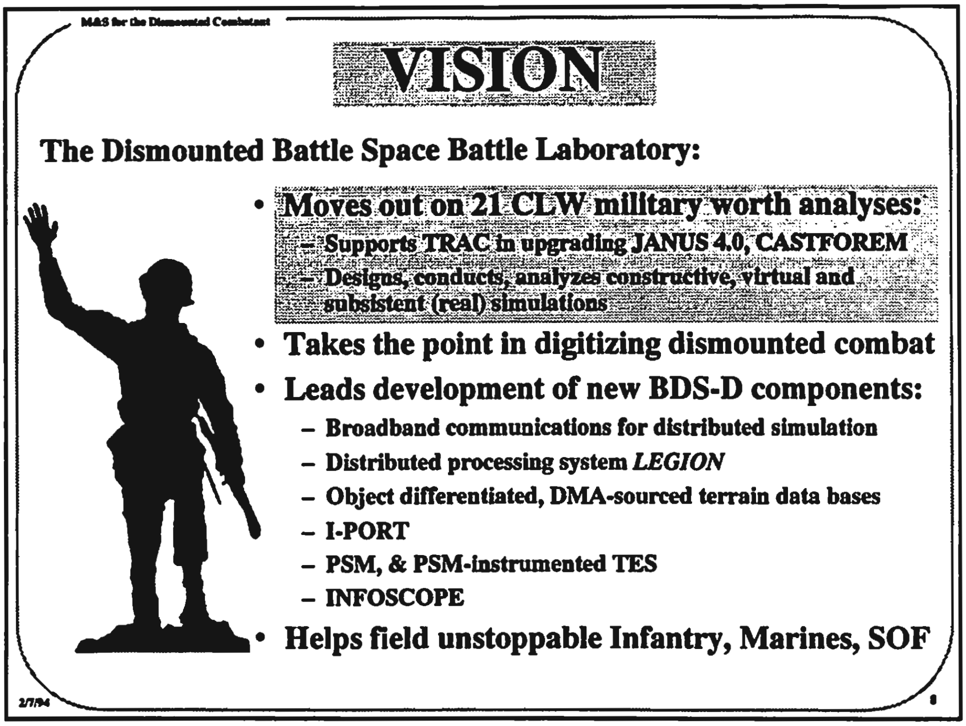
A. Conceive, and catalyze development of requisite materiel, training techniques, and tactics — with and for Commandant, USMC, and USCINCSOC — to produce the mightiest foot fighters the world has ever known.

B. Complete military worth analyses for 21st Century Land Warrior NLT end FY1996.

C. Enable full time participation by infantrymen at Benning in the training activities of the Virtual Brigade at Fort Knox, and, ultimately, virtual units anywhere.

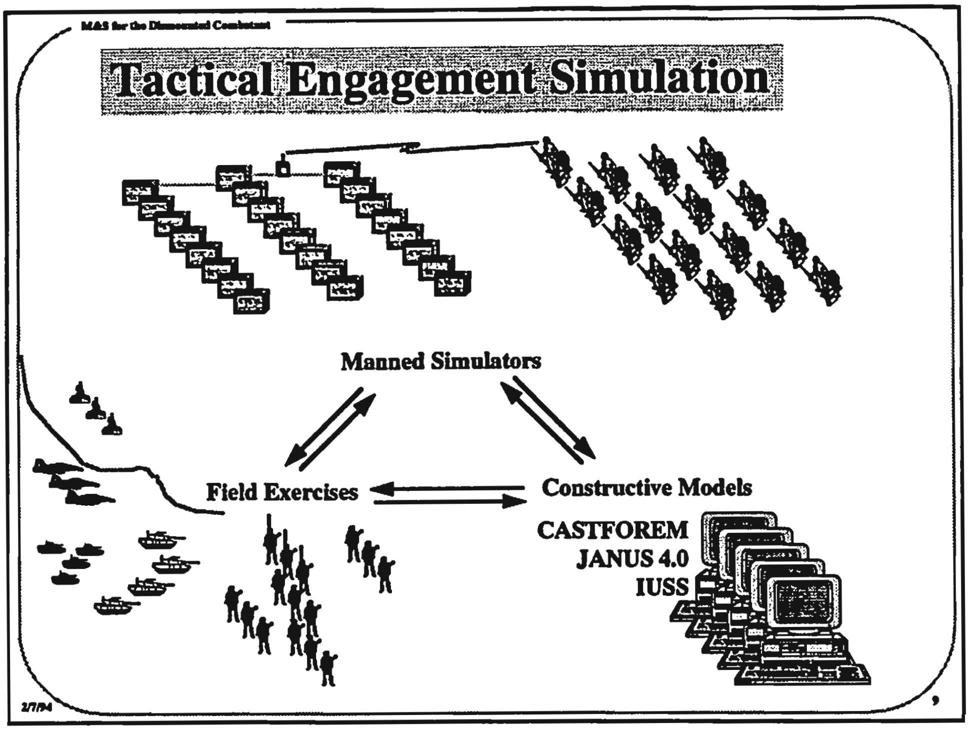
C. Provide test sites for maturing new analytical, evaluative, and training tools within the framework of the Battlefield Distributed Simulation-Developmental, and the Combined Arms Tactical training System.

Each of the topics listed will be discussed in turn, punctuated with illustrations of new tools this Battle Laboratory could use to translate vision into future victories.



Just two weeks ago, this Laboratory hosted a meeting on a Model and Simulation Plan for the 21 CLW program. In that meeting, it is fair to say that the emphasis was plainly on constructive models — principally TRAC's CASTFOREM and JANUS, and Natick's IUSS. These will plainly be needed.

However, to upgrade those models with precise data from actual human performances, and to inquire into issues of form and fit of the materiel, the plan must be broadened as shown on the accompanying chart.

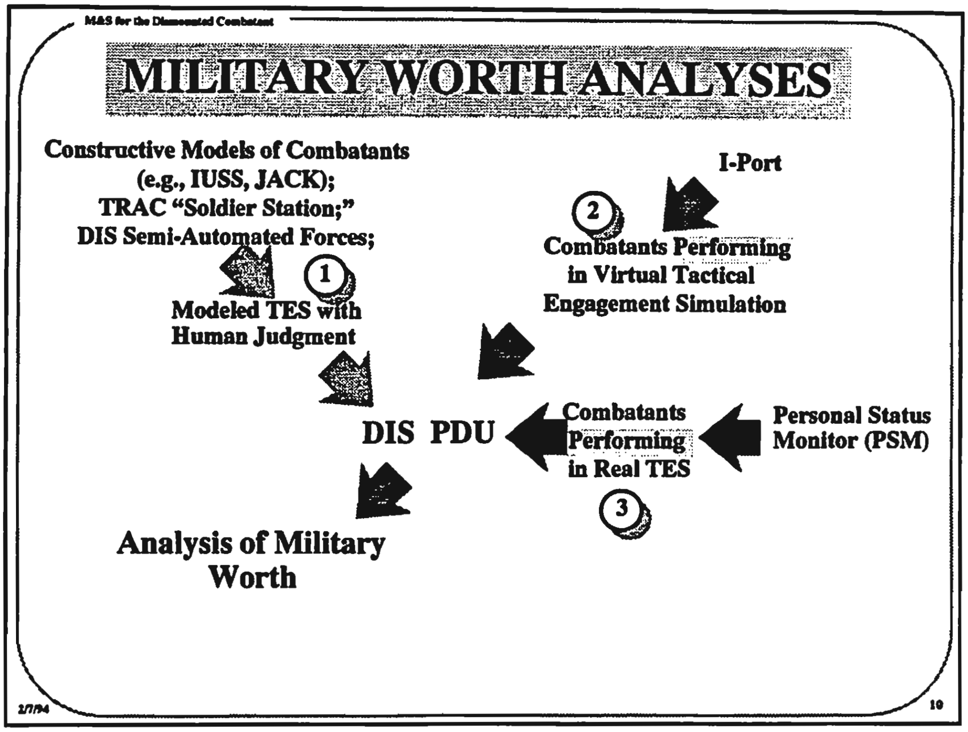


None of the winds of change blow more forcefully than the tempest propelling information technology, at the vortex of which are advanced computers, and the *Global Grid*: telecommunications enabling computers to network among themselves, exchanging enormous amounts of data over great distances, at very high speeds. Commercial products and services provide most of the impetus. Factor of ten improvements in both price and performance have been occurring every two to five years, and the prospects are for accelerating improvements.

But the DoD is a beneficiary . For instance, just ten years ago we drew a distinct difference between "simulations," — meaning mathematical constructs or models of war — and "simulators" — motion platforms like those imposed on aviators in pursuit of flight qualifications. Information technology has blurred such distinctions forever. DoD now recognizes the three forms of simulation shown, each form of Tactical Engagement Simulation (TES) enabling force-on-force combat.

Conceptually, all three forms of simulation can interact one with another, because all draw upon computers to generate audio-visual stimuli, to record and control relative position and motion, and otherwise to assist human understanding. All three also draw upon communications to enable computers to update each other concerning changes of state of objects under management, and to exploit common referential data, such as details of a place, a portion of the earth's surface, or the airspace above it. Such distributed, interactive simulations constitute a powerful mechanism for cost-effective RDT&E, training, and operational rehearsal. The U.S. lead in relevant technology has already figured in assuring U.S. military superiority over potential antagonists, and it is a lead we ought to maintain.

While small scale experiments with the concept have been promising, and larger scale proofs of principle are planned — e.g., by ARPA and USAREUR in November '94 — there has as yet been little effort to exploit the *Global Grid* to the advantage of all three forms of simulation depicted. And Fort Benning was not even on the Defense Simulation Internet until last month!



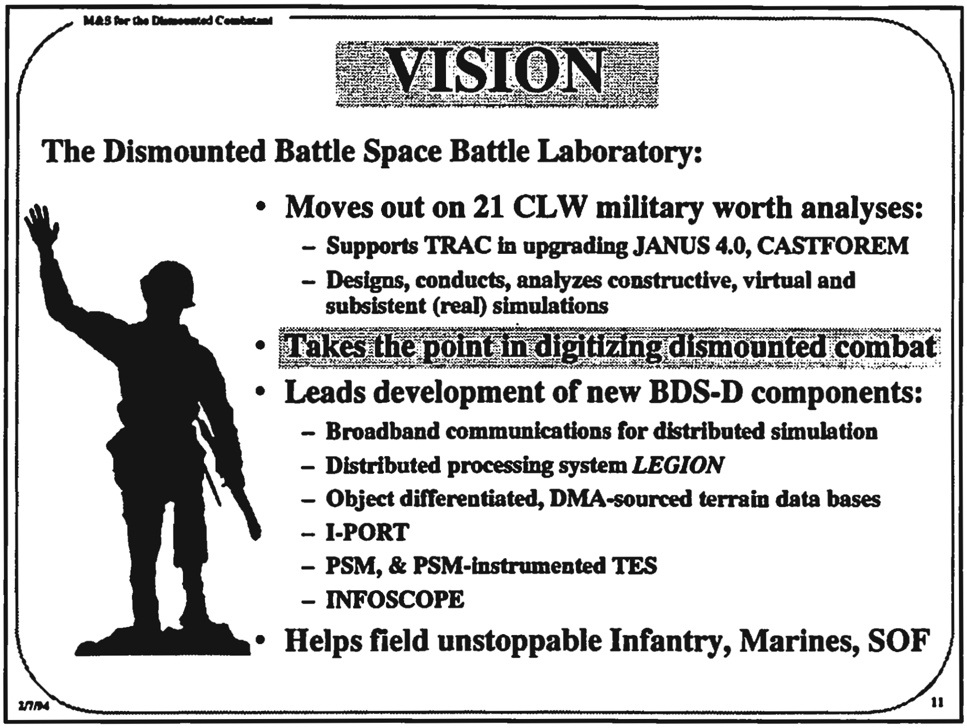
The approach diagrammed differs from that currently embraced by the 21 CLW M&S Plan in four important respects:

- It focuses on performance vice depiction; experience with the predecessor SIPE equipment proved that while the technology brought to bear promised substantial upgrades in combat capability for individual combatants, the SIPE equipment demonstrated was intolerably uncomfortable. Form, fit, and function at the man-machine interface are issues that deserve as rigorous analyses as lethality and survivability. The approach shown enable such analyses.

- It lends itself to on-going Verification and Validation: dismounted combat at the level of the individual soldier is not a region well known to stochastic modelers, if only because little reliable data is available. The approach shown should provide rich digital data readily converted for use in stochastic models.

- This approach justifies technological upgrades to all three forms of TES, and therefore promises improvements in RDT&E, training, and operational rehearsal.

- It admits of developing, evaluating, and training in the context of combined arms battle.

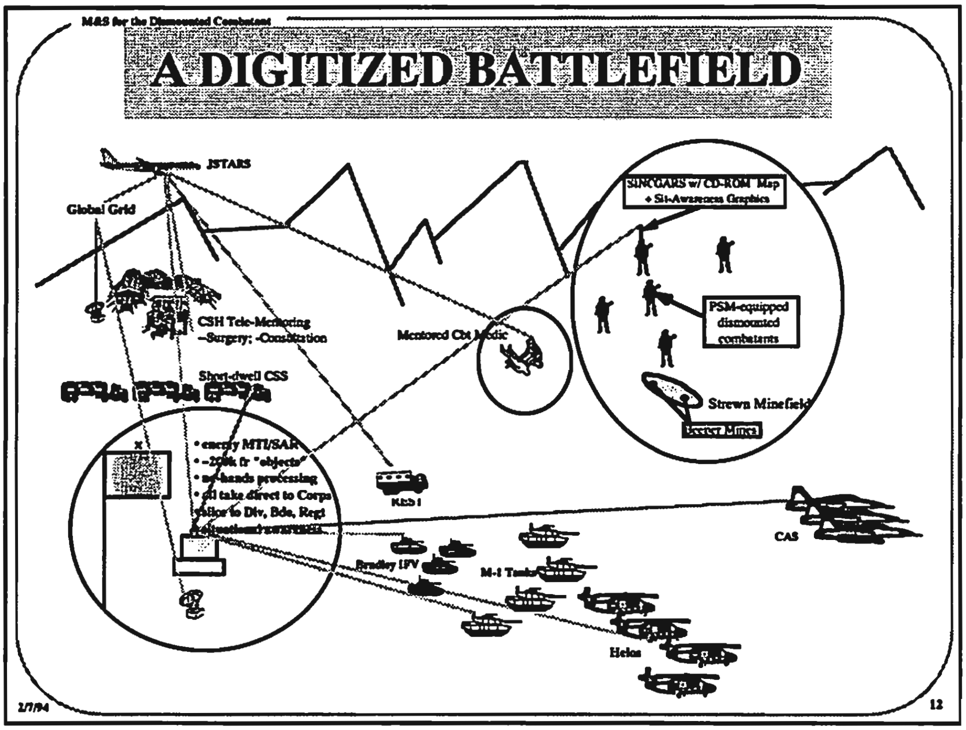


The 21st Century Land Warrior program was conceived, in part, as a framework for technology interventions aimed at extending battlefield digitization to every individual fighting on foot.

Digitizing the battlefield means more than a data bus/display suite for one model of the Abrams tank. It implies devising and adopting the means to move information in digital forms freely about the battlefield, whether that information originates in the National Capital Region or in the foxhole of the foremost foot-soldier, and whether that information is needed for decisions by a general or by a frontline private.

Moving information to or from a vehicle is relatively easy: power and weight issues are less formidable , and screens or helmet mounted displays are relatively simple to implement. Every step toward digitizing dismounted combatants will entail technological risk. Every step will involve resolving issues at the man-machine interface. Every step will demand scrupulous regard for tolerable weight, bulk, and thermal equilibrium.

This will be pathfinding of a high order, well worthy of George Marshall's school!



Dismounted combatants can improve their effectiveness when equipped with Personal Communications Systems, tied into Personal Communications Networks (PCN) able to boost situational awareness:

- Reports to higher, and intelligence from higher
- Position finding and navigation
- IFF, position of friendly units and fires, orders and synchronization
- Telemedical monitoring, mentoring, surgery, consulting and casualty management

The DDR&E panel on Global Surveillance and Communications has urged the armed services to equip weapon systems with the Interservice Data Modem, and issue KG 95 and *Key Agile* encryption devices. Legacy radios, such as SINCGARS and MSE can remain in use. What would be added is high-capacity, high-speed conduits to forward command posts, and spread spectrum, PCS/PCN extensions forward to individual combatants and combat vehicle crews.

Note that digitization, properly applied, embraces the **combined arms**, and interservice and inter-allied cooperation. None can afford to wait for combat to learn how to exploit the power of digitization. Preferably, each service would **train as they intend to fight: digitized**, and they would **use a digitized system for research, development, test and evaluation, training, and operational rehearsal,** at least compatible with, and as often as feasible identical to, that they would use in war.

M&S for the Dismounted Combatant

CONGRESSIONAL BACKING

"The Committee is very supportive of efforts by the Army to use simulation to accelerate force development activities, to enhance quality of training, and to provide significant improvements to training while conserving resources....The Committee commends the Army for its action to digitize the battlefield...among combat, combat support, and combat service support assets down to the individual soldier"

Report of the Senate Appropriations Committee on DoD Appropriations, Fiscal Year 1994, October 4, 1993

2/7/94 13

"As the Defense budget is reduced, DOD must continue to expand the role of modeling and simulation to sustain credible, effective operational capabilities...

"The Committee recommends providing [for the Virtual Brigade Program] $15,000,000 in fiscal year 1993 to perform the front end analysis , develop the training strategy, expand and modify existing simulation facilities at Fort Knox, and validate simulators configurable as combat, combat support, and combat service support platforms for the virtual battlefield environment. Fort Knox should assess alternative approaches to developing configurable simulators and select the most effective approach ...

"The Committee commends the Army for its action to digitize the battlefield... **The Army will thus attain a tempo of operations that consistently overmatches that of the enemy and offers the potential to significantly reduce fratricide through common situational awareness...**The Army has a goal of fielding a digital brigade by 1996 and a digital division a few years later..."

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  - **INFOSCOPE**
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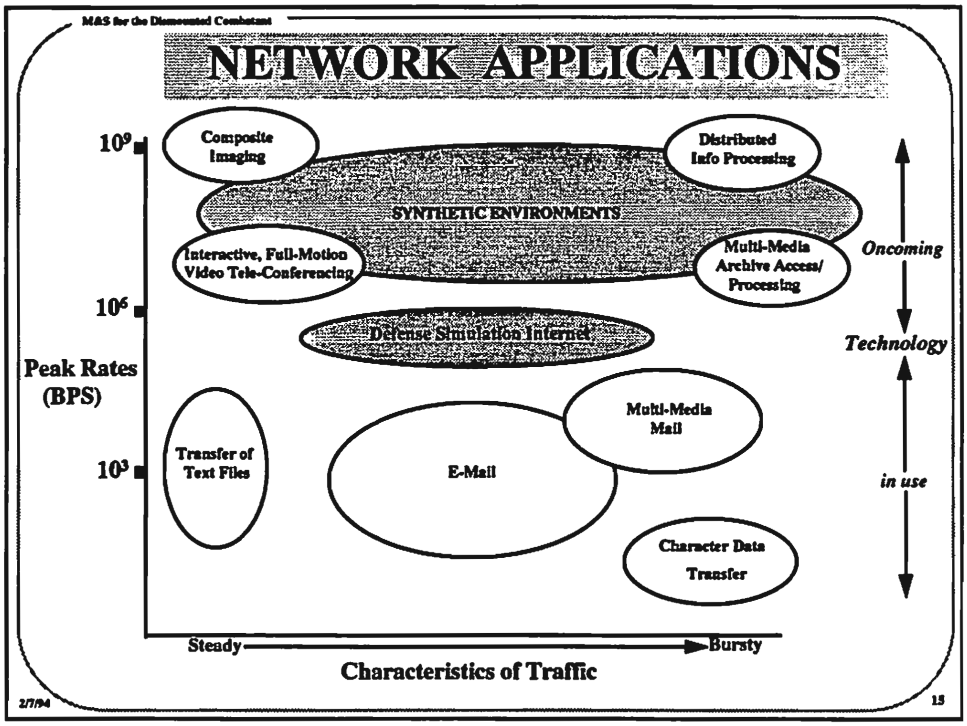
2/7/94 14

Most of us understand that we live in an era in which advantageous changes in computer power, size, and cost are occurring with bewildering celerity. But relatively few appreciate that within the past three years another revolution in technology has become evident, one that may prove to be of prime importance for military purposes: ever-more communications bandwidth is becoming available at increasingly attractive prices, and human interfaces with communications are ever more mobile and facile.

TRADOC could employ today's broad-band communications, terrestrial and undersea fiber optic cable, networked with satellites, to establish a "virtual battle laboratory" encompassing all the combined arms, and Fort Benning could lead the way!



The telecommunications industry, sensing the profound implications of that "bandwidth revolution," has moved to adopt industry-wide protocols for information transmission and switching. For long-haul transmissions, these are referred to as SONET/ATM (Synchronous Optical Networking-AsynchronousTransfer Mode switching), promise to meet the industry's requirement for low-cost, high-capacity interoperability, and end-to-end networking/dissemination capability. For local area networking, these are referred to as PCS/PCN — Personal Communication Systems/Networks.

"Synthetic environments" — the sort of scalable, advanced distributed simulations described by CSA at the Louisiana Maneuvers Symposium in Orlando on 25 May 1993— require very swift, robust, extraordinarily versatile communications. Speaking to the industrial leaders present, CSA remarked that: *What you need to know [about equipping the force] is that we will use simulation techniques throughout the Army's acquisition process. We will determine needs in large-scale, simulation-supported exercises that allow us to consider alternative solutions that meet the needs. We will use drawings, diagrams, and 3-dimensional models generated by computers, put them into constructive or virtual reality environments, and compare alternatives both technically and tactically. The most promising technologies will be tested by real soldiers, first in reconfigurable crew stations, then in full-scale simulators....*

The concomitant of such simulation-supported exercises is bandwidth in the range of MegaBitsPerSecond vice the KiloBitsPerSecond in general use today.

M&S for the Dismounted Combatant

COMMUNICATIONS:
Some Comparisons

Device/Protocol	Speed Bits/Sec	No. Tele.	SID/Min.*	Transmit *Encyl. Britannica*
SINCGARS(tactical radio)	16 kbps	1/3	2	2.5 days
Digital telephone (DS-0)	56 kbps	1	6	18 hours
Standard Leased Line (DS-1)	1.5 Mbps	30	170	38 min
High Capacity Leased Line(DS-3)	45 Mbps	800	5,000	1.5 min
SONET/ATM° STS-1	52 Mbps	900	6,000	1 min
SONET/ATM STS-3	155 Mbps	2,700	18,000	20 sec
SONET/ATM STS-12	622 Mbps	11,000	70,000	6 sec
SONET/ATM STS-48	2.5 Gbps	45,000	280,000	< 2 sec
SONET/ATM STS-192	10 Gbps	190,000	1,000,000	<0.5 sec

° synchronous transport via synchronous optical network with asynchronous transfer mode switching

* Secondary image dissemination 1000 pixels x 1000 pixels

2/7/94 16

This chart lists terms that describe circuits of the Global Grid, and compares their speed. The column listing "No. Tele." uses one industry-standard digital telephone connection as the unit of measure. "SID/Min" is a measure used by the U.S. intelligence community as a figure of merit for comparing capability for imagery dissemination; one SID is an image 1000 by 1000 pixels.

Most communities in the United States are already serviced by DS-3 fiber-optic cable, but the ATM switches and the terminal equipment to exploit high capacity transmissions has yet to be installed. Estimates on availability vary, but most companies expect to see applications increasing in 1995 and thereafter.

Recently, the Directors of the Advanced Research Projects Agency and the Defense Information Systems Agency formed a Joint Program Office to pursue adapting emerging telecommunications technology for military purposes. One immediate initiative of this office will be to upgrade the current Defense Simulation Network. Howard Frank of ARPA, who heads the office, has agreed that linking Forts Benning, Knox, Rucker and Leavenworth will be accorded priority. By early 1996, Dr. Frank expects to have these sites able to use DS-3 45Mbps information streams. When the telecommunication companies are prepared to offer SONET/ATM services, the upgrades can on from there.

M&S for the Dismounted Combatant

WIRELESS TELEPHONY

Efficiencies Compared

Protocol	Users/MHz
AMPS: current analog cellular	2.24
NAMPS: new analog cellular	6.72
TDMA: standard digital time division multiple access	18.0
GSM: European standard digital	5.0
N-CDMA: digital narrow-band code division multiple access	22.4
B-CDMA: broad-band CDMA	73.0

2/7/94 17

Commercial digital telephony is beginning to appear both as Personal Communications Systems (PCS), and as Personal Communications Networks (PCN), aspects of the Global Grid that will provide two-way interaction between a vehicle, or an individual on the move, and any other user of the Grid. PCS/PCN seems particularly important for this Battle Laboratory

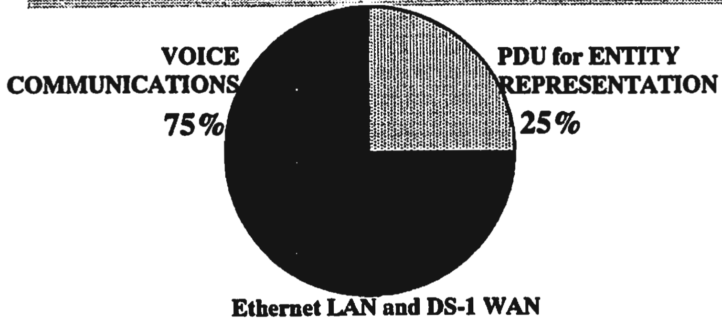
PCS was illustrated last June at Fort Gordon during the LAM FTX of the USAR 18th Field Hospital. Digital shirt pocket telephones, using TDMA, furnished voice communications. To demonstrate applications of B-CDMA, doctors of the same hospital were linked wirelessly with front-line medics, transmitting digital video, digital voice, and digital medical data from the point of casualty.

Both protocols employ multiplexing of digital packets, and therefore make notably efficient use of each increment of usable frequencies. B-CDMA however, has a clear advantage.

B-CDMA, in use here today, is a digital telephone technology so difficult to intercept, and so non-interfering that the FCC has approved its use anywhere without a license. To compare it with SINCGARS transmissions at a top speed of 16kpbs, the B-CDMA transmitters we are using here today can send video at 128 kbps; higher speeds are possible with different equipment.

M&S for the Dismounted Combatant

DIS WITH MANY OBJECTS



- **Throughput must increase**
- **Must minimize latency in visible; but can tolerate audible lags**
- **Hence, solution for future is:**

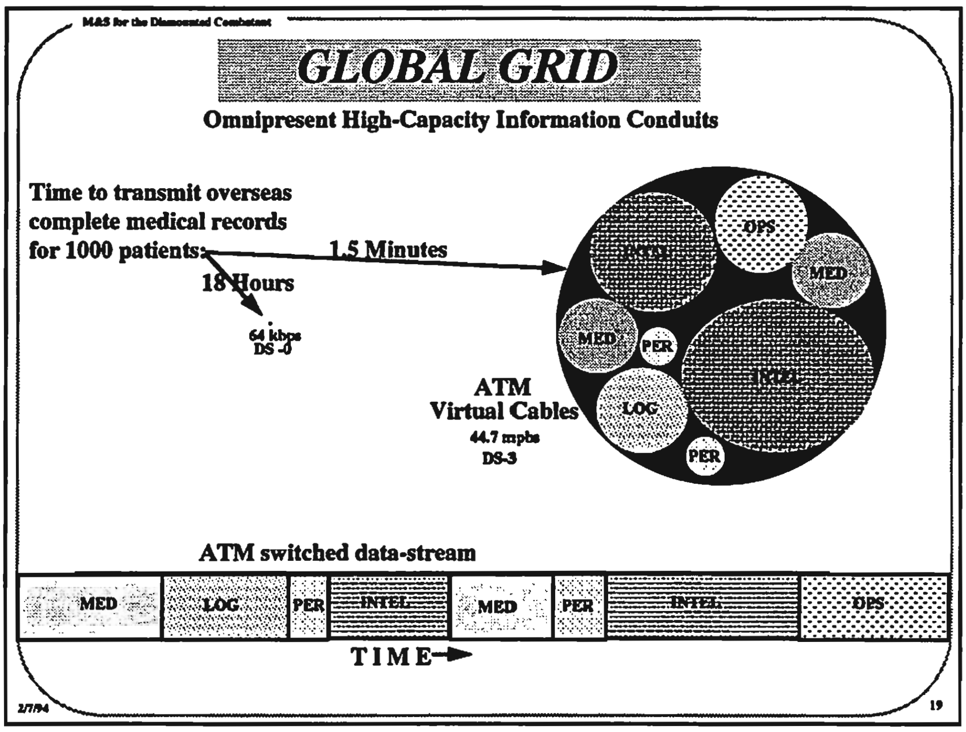
	VIRTUAL		SUBSISTENT (Real)		
	LAN	WAN	TAC Unit	TAC HQ	JTF-Theater
VOICE	wireless B-CDMA	SATCOM	SINCGARS	MSE	SATCOM
PDU	FFDI/ATM	Sonet ATM DS-3	B-CDMA	mmW&DS-1	DS-3

2/7/94 18

Simulators using Ethernet-quality local area networks (LAN) are limited to 7000 packets per second, constraining Distributed Interactive Simulation to about 10^3 objects, against a requirement for 10^6. Contemporary wide-area networks (WAN) for simulation encounter dysfunctional transmission latencies. Improvements of LAN speed of one order of magnitude can be provided by Fiber Distributed Data Interfaces (FDDI). High speed fiber-optic WAN are already commercially available.

However, there are other solutions. One is to move digital voice communications to wireless media, a solution being adopted for PCS/PCN; e.g., the Negroponte switch, a device for transmitting voice by air and video by wire. Another is to introduce ATM switching into the LAN.

For purposes of virtual simulation, it seems reasonable to transmit voice via Broadband Code Division Multiple Access (B-CDMA) LANs, and satellite WAN, coupled with PDUs transmitted on fiber-optic SONET/ATM WAN. Similarly, for purposes of subsistent (real) simulation, especially tactical engagement simulation (TES), it would seem reasonable to transmit voice via standard military radios and SATCOM, and to use B-CDMA plus a combination of millimeter wave and fiber optics to move PDU-like data concerning entity-level behaviors that control iconic performance in netted virtual or constructive simulations.



Here is a medical example of how SONET/ATM can help digitize the battlefield:

The US Army is already practicing telemedicine, and intends to install 64kbs satellite comms between Walter Reed and Macedonia this month, using video-compression to support tele-consultation. Compare this service with a hypothetical nexus of high-capacity communications, both fiber and SATCOM, that enables a US expeditionary force to dispense with carrying medical records, even in digital format, forward into its Theater of Operations, confident that these could be transmitted on demand. A corpus of records, such as those for 1000 patients, would require a day and half of transmission by the present tele-consultation system, but only 1.5 minutes by the high-capacity circuit.

More importantly, instead of using a dedicated circuit, the AMEDD could count on its packets being interleaved by the ATM switch with other forms of military communications — logistics, intelligence, personnel, and operations — so that the same communication network could support many military end-users simultaneously . In the event of a medical emergency, the network would allocate more throughput to meet the medical demand, so that tens of consultations could be conducted simultaneously, routed to different hospitals in CONUS.

At the direction of Congress, in September 1993 the Defense Information System Agency demonstrated that it could incorporate many forms of traffic on a SONET/ATM network, one segment of which used a commercial satellite, and showed that it could handle the complicated security and network management issues entailed.

targeting — for enhanced horizontal integration through technology insertions extending the digitized battlefield to every dismounted combatant.

Use the DSI to embrace all parties engaged in the 21 CLW development. Make 21 CLW a paradigm for developing a system designed for the digitized battlefield.

M&S for the Dismounted Combatant

VISION

The Dismounted Battle Space Battle Laboratory:

- **Moves out on 21 CLW military worth analyses:**
  - **Supports TRAC in upgrading JANUS 4.0, CASTFOREM**
  - **Designs, conducts, analyzes constructive, virtual and subsistent (real) simulations**
- **Takes the point in digitizing dismounted combat**
- **Leads development of new BDS-D components:**
  - **Broadband communications for distributed simulation**
  - **Distributed processing system *LEGION***
  - **Object differentiated, DMA-sourced terrain data bases**
  - **I-PORT**
  - **PSM, & PSM-instrumented TES**
  - **INFOSCOPE**
- **Helps field unstoppable Infantry, Marines, SOF**

2/7/94 21

My vision is that this Battle Laboratory shall lead an attack on a broad front, from S&T across RDT&E, through training and ops rehearsal, near-term and far-term, to:

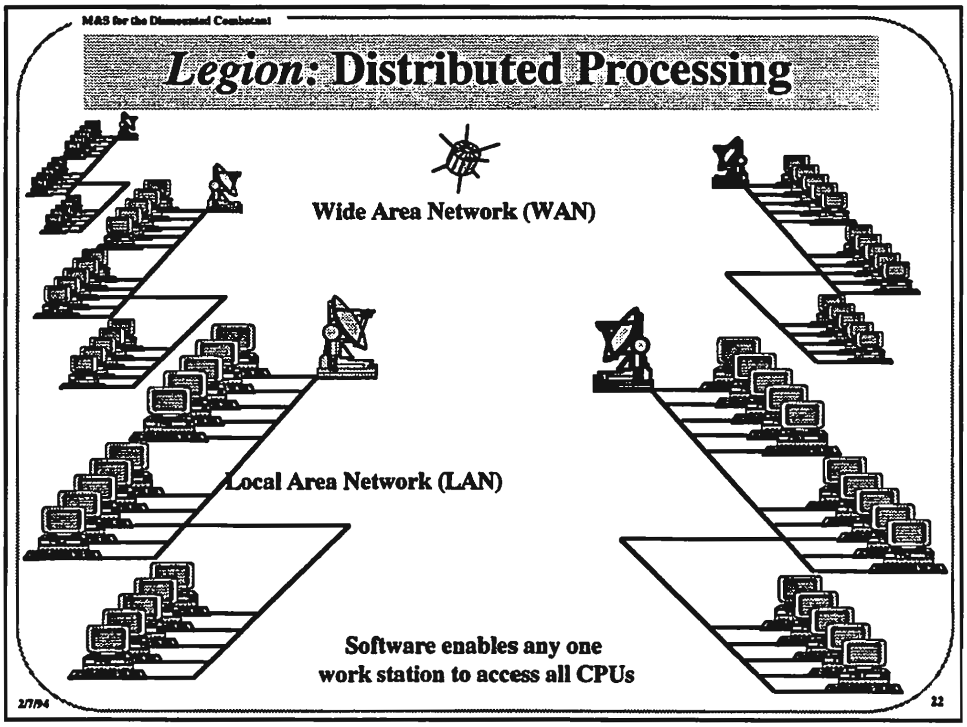
A. Conceive, and catalyze development of requisite materiel, training techniques, and tactics — with and for Commandant, USMC, and USCINCSOC — to produce the mightiest foot fighters the world has ever known.

B. Complete military worth analyses for 21st Century Land Warrior NLT end FY1996.

C. Enable full time participation by infantrymen at Benning in the training activities of the Virtual Brigade at Fort Knox, and, ultimately, virtual units anywhere.

C. Provide test sites for maturing new analytical, evaluative, and training tools within the framework of the Battlefield Distributed Simulation-Developmental, and the Combined Arms Tactical training System.

Each of the topics listed will be discussed in turn, punctuated with illustrations of new tools this Battle Laboratory could use to translate vision into future victories.



There is an unsolicited proposal from a group of eminent civilian scientists, currently being staffed at ARPA and the National Science Foundation, to build a large virtual computer composed of a metasystem of disparate workstations, vector supercomputers, and parallel supercomputers, connected by broad-band communications. The project is referred to as LEGION, and will be built around object-oriented parallel-processing software called MENTAT.

While MENTAT exists as a prototype, driving one local area network, its proponents visualize its evolving, step by step, into an "industrial strength" program capable of successive expansions to other Local Area Networks via a broad-band Wide Area Network. The diagram shows satellite communications being employed for the WAN, but in the SONET/ATM scheme of the *Global Grid*, the WAN almost surely would use fiber as well.

The Institute for Defense Analyses has completed a preliminary evaluation of the LEGION concept, including a site visit to observe MENTAT in operation, and deems the project worthy of experimentation. Based on its work, IDA is prepared to develop a test plan.

Obviously, this is "dual-use" technology. If successful, concepts such as LEGION could have an impact on U.S. private enterprise like Internet's. The Army could furnish, here at Fort Benning, to the Army's own advantage, an experimental site in a well-structured undertaking that will involve large amounts of parallel processing for supporting all three forms of TES.

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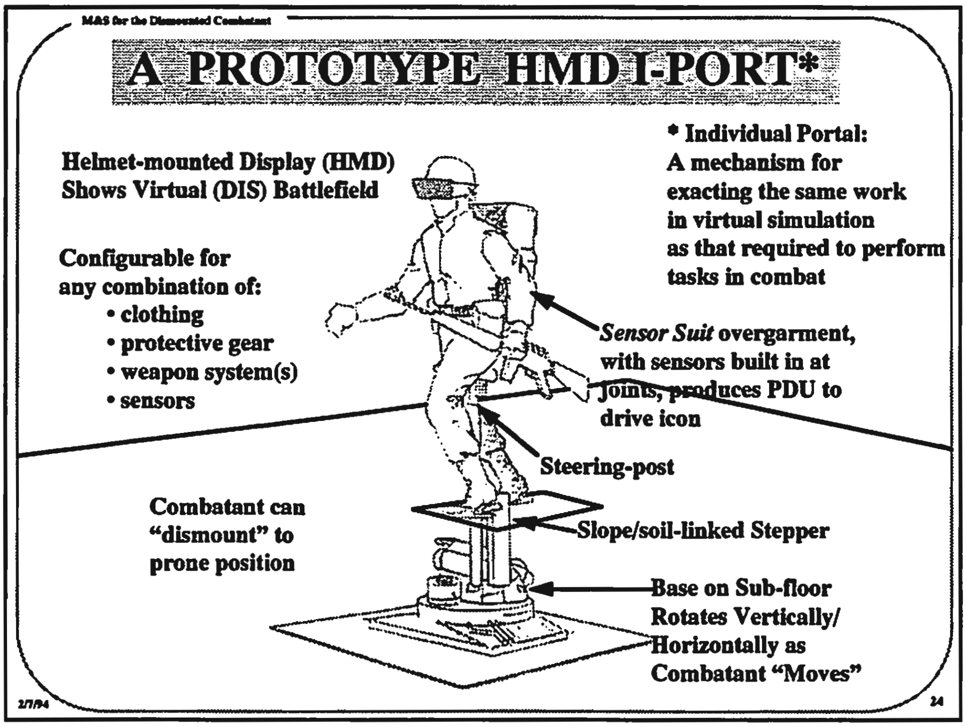
2/7/94 23

The Human Resources Division (HRD) of the Army Research Laboratory (ARL) has contracted with Sarcos Research Corporation(SRC), affiliated with the University of Utah's Center for Engineering Design (CED), to construct motion platforms to enable a person to walk or run within a computer-generated, synthetic environment. SRC and CED are world leaders in technologies relating to digitization of the individual, such as tele-operated undersea robots for the U.S. Navy, and prosthetic devices for the Veterans Administration; SRC has also built long-endurance, apparently animate machines used in theme parks in Florida and California.

Deputy Assistant Secretary of the Army for Research and Technology George T. Singley directed ARL to accelerate the SRI contract with a view to supporting this presentation with a functioning prototype of the objective motion platform combined with different audio-visual systems.

The resultant devices are called **I-Port** because they provide an individual portal into synthetic battle environments, mechanisms allowing a dismounted combatant to function like a vehicular simulator in SIMNET.

The three I-Ports you will see all have the same locomotion mechanism, but different audio-visual systems. SRC is prepared to undertake a program of progressive development of both components.

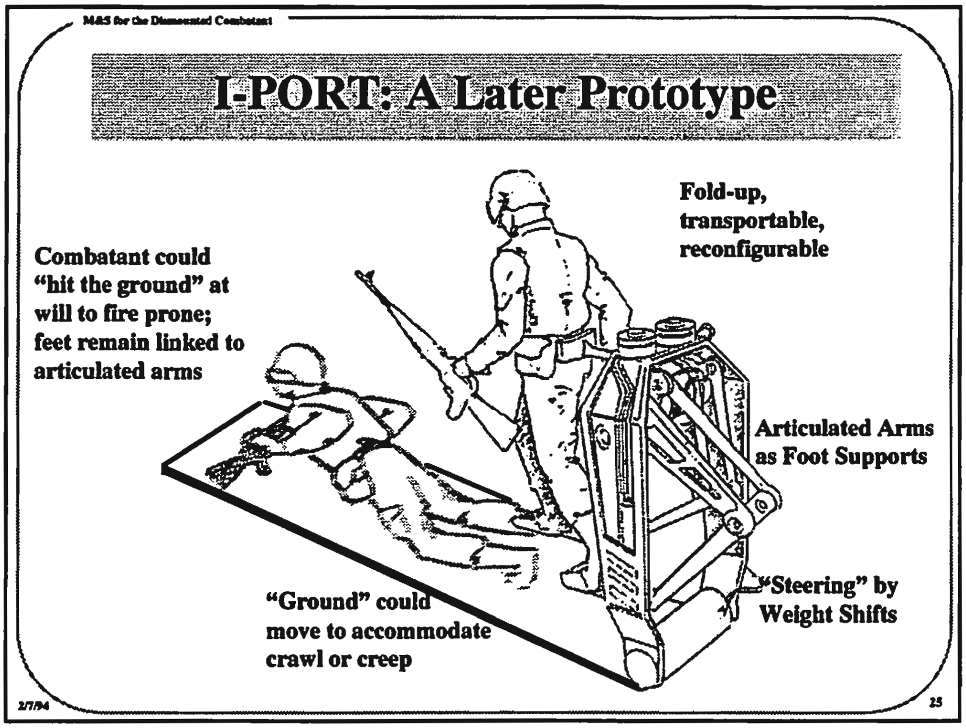


Shown is a straight-forward mechanical interface with Distributed Interactive Simulation (DIS) via Motion Platform and Head Mounted Display. Unlike commercially available versions of "virtual reality" mechanisms, I-Port enables locomotion on the DIS battlefield, and requires exertion. The combatant indicates the direction in which he wishes to move by exerting pressure with his thigh on the centered steering post, and steps off. Ski-binding-like retainers allow the machine to track his weight-shifts and foot-movements, and to offer solid resistance to indicate to him the ground he is traversing: its location, slope, and trafficability. His running or walking gait will determine the speed with which he traverses ground within DIS, and produce Protocol Data Units (PDU) to control an icon within DIS representing him. In the mechanism shown, locomotion information from the simulator is entered into HRD's JACK model, and JACK generates DIS instructions for his icon's lower extremity movements, speed and direction. Two versions of the HMD will be used here today: one is an inexpensive, low fidelity; the other is a more expensive, but higher fidelity display.

I-Port also uses *Sensor Suit,* developed at CED for recording digitally the movements of humans engaged in strenuous physical exercise: sensors positioned about the body transmit precise digital data on what the wearer is doing. Sensor data is then converted into DIS Protocol Data Units that translate posture and gestures to the icon.

Overall, SRC aims at a cost-effective, transportable design, and seeks to develop it in conjunction with the user.

Let's show the apparatus in operation, and how it looks in DIS.

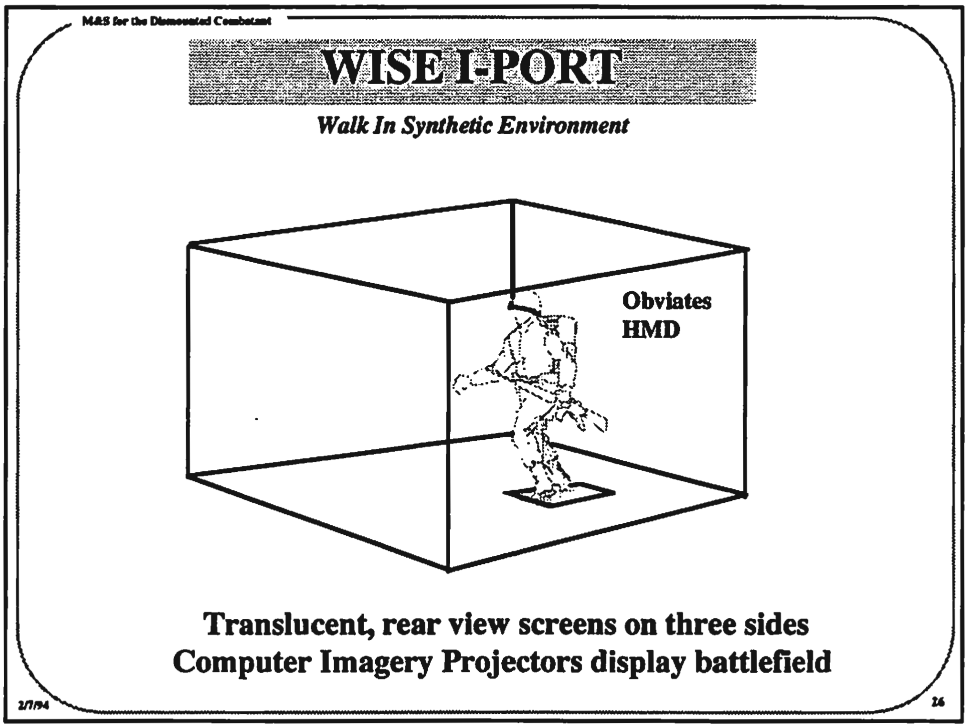


To give you some idea of where SRC intends to take I-Port, here is a sketch of the next evolutionary step, a folding, transportable motion platform with light, strong, articulated arms. SRC and CED have extensive experience with building robotic arms — anthropomorphic, powered mechanisms that perform like the human arm. This prototype uses two CED powered arms to support the combatant when he is moving, and senses his gait and direction from his weight shifts.

To enable the combatant to creep or crawl, the I-Port base might include a tread-mill-like moving belt, or bed of rollers that would move his icon appropriately, yet keep him stationary, next to the I-Port. The combatant's feet would remain attached to the mechanism. To resume running, he would stand up, and "push off."

Also planned are modular "props" that could be quickly placed around the motion platform to represent the cover and weapon rests available in a foxhole, or bunker, or in a building.

What is shown is a **reconfigurable simulator** that can be used with any of the Army's current or projected weapons, and with any form of battle equipment for the dismounted combatant, present or projected.



Another way to provide audio-visual stimuli from the synthetic battlefield is to surround the combatant with rear-projection screens on which are thrown computer-generated images derived from DIS data. In turn, the apparatus furnishes the DIS network a complete description of the locus and activity of the combatant. One major advantage of this technical approach is its dispensing with the Head Mounted Display, so that the combatant can wear laser protective lenses, night vision goggles, a gas mask, or any other facially-mounted equipment, such as that postulated for the 21 Century Land Warrior.

WISE is easily reconfigurable, allowing evaluation of new materiel or new concepts for dismounted combat within simulations of combined arms warfare. New aspects of weaponry could be explored in virtual prototype, quickly and relatively inexpensively — gear such as weapon interfaces with a heads-up display. Moreover, the device could lend itself to experiments with novel command and control mechanisms, such as visible or aural indicators for situational awareness. And it could be used to probe novel force structures, such as a dismounted infantry formation that employs an agile, tele-operated robot to amplify its ability to control ground.

We will now put all three I-Port prototypes into action. Most of you are familiar with "73 Easting," the SIMNET recreation of the battle between the 2d Cavalry and the Tawalkana Division of the Iraqi Guards. You will join Ghost Troop as it approaches the cantonment area of Iraq's armor training center, and watch an incident that did not occur in February, 1991, but could have, an incident involving U.S. cavalry scouts fighting dismounted.

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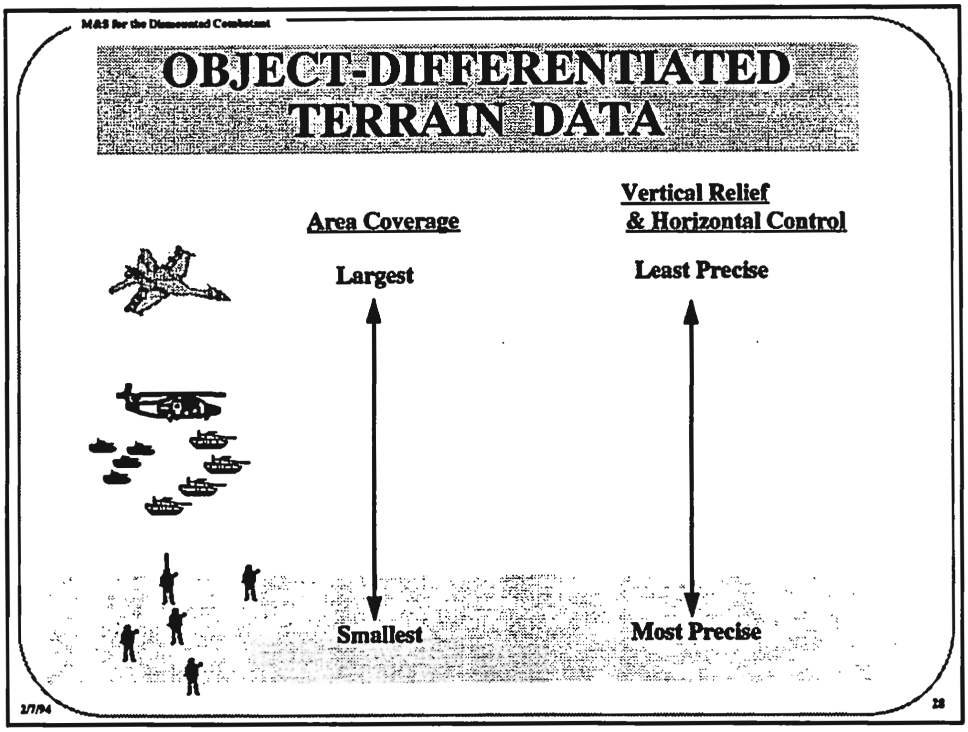
2/17/94 27

The toughest challenge facing a dismounted combatant is making personal decisions about how to use the infinite variations of terrain for cover and concealment. These are often literally life and death choices. Hence, in any model or simulation of combat for dismounted combatants, data concerning the surface of the earth and the works of man thereon must be sufficiently detailed to portray such choice. In particular, accurate information on vertical elevation is important, for a ditch or a depression in the ground of negligible importance for an armored vehicle may mean survival for a dismounted combatant. Up to now, the data most often employed for constructive and virtual simulation has been the Defense Mapping Agency's Digital Terrain Elevation Data Level 1, usually referred to as DTED-1, which has post spacings (vertical data) at about 100 meters. In limited areas, for special purposes, the Defense Mapping Agency has prepared some DTED Level 2, with about 30-meter posts. Even this level of detail will not support simulation for dismounted combatants.

The Defense Mapping Agency could produce even higher levels of detail, but costs go up exponentially for any producer as level of detail increases. Precision is crucial: DMA can provide horizontal and vertical control for source material to qualified coproducers, who can then exploit images on their own work stations to generate reliable, detailed data sets. This is good news for all three forms of simulation, and this Battle Laboratory is the appropriate place to unveil the results of such collaboration between the Defense Mapping Agency and those who can elaborate on its products.



SIMNET uses one rubric for terrain visualization. There is an argument for using a least three different rules for displaying the synthetic environment, differentiated one from another by the attributes of the object whose point of view is being simulated:

- Fighter aircraft require visualization of very extensive areas, but accuracy of relief is less important that object relationships, e.g. azimuth, range, and elevation of opposing aircraft

- Vehicles that operate close to the nap of the earth require more precise data, particularly horizontal precision, but relatively less area coverage

- Dismounted combatants require greatest precision in horizontal control and in vertical relief, but the least area defined

All three of these visualizations can be derived from the same digital data base, provided that it has inherent the horizontal and vertical controls for the most demanding case, the viewpoint of the dismounted combatant. DMA has provided the appropriate tools.

Let's look at some examples.

MAS for the Dismounted Combatant

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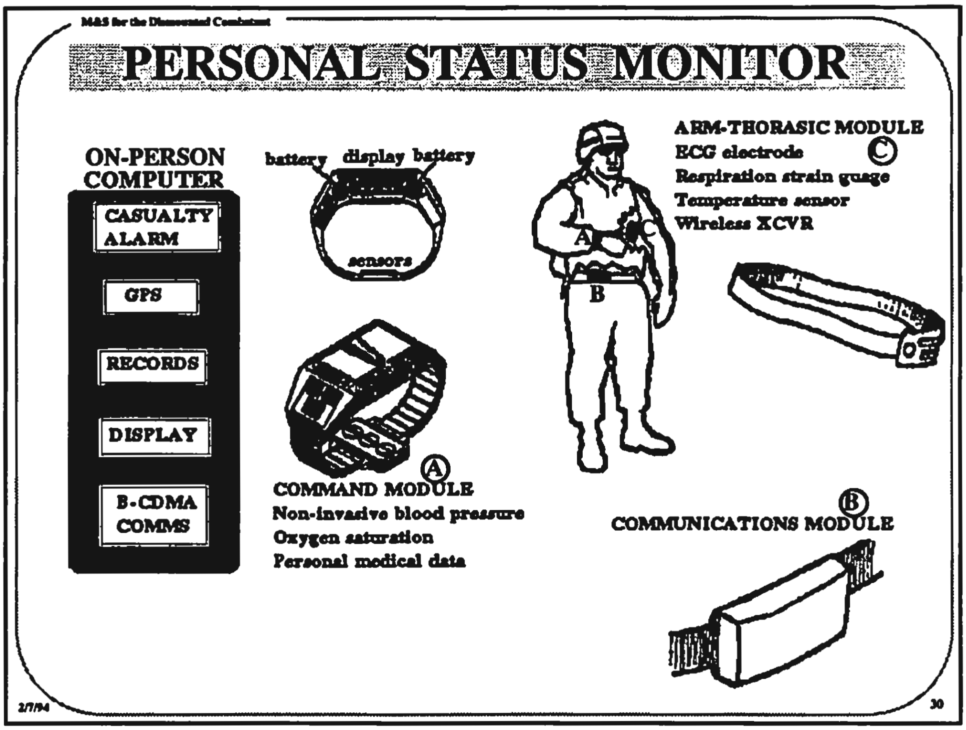
2/7/94 29

The Louisiana Maneuvers FTX for the 18th Field Hospital last summer simulated the existence of the Personal Status Monitor or PSM, in effect picking up the story of each "combat casualty" from the time medics reached him or her. Today be the first showing of an operational prototype of PSM.

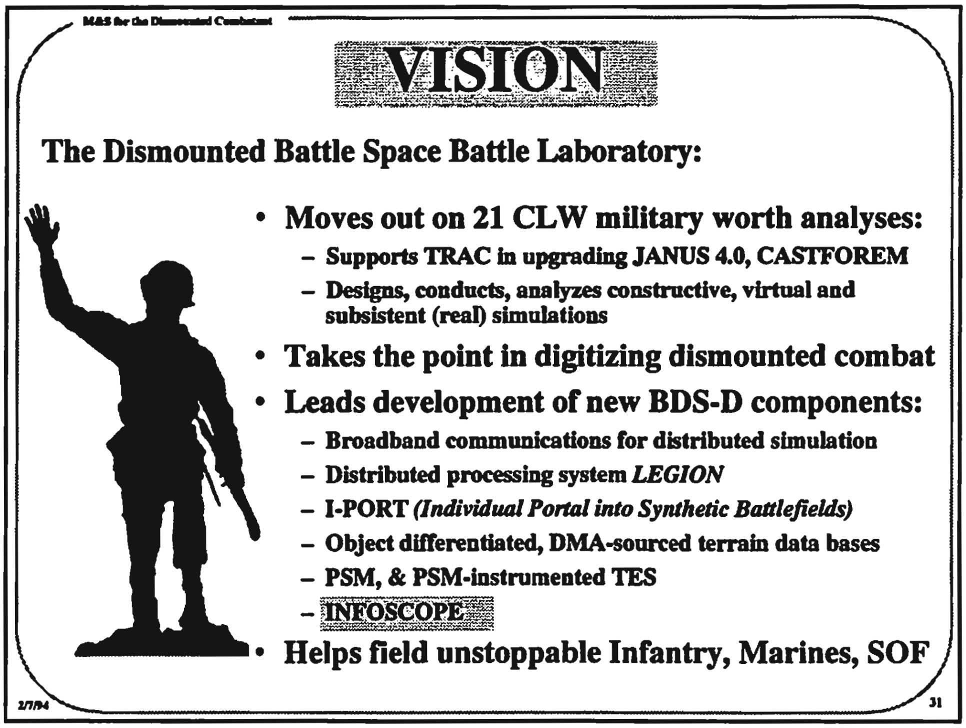
The Personal Status Monitor (PSM) is an AMEDD-ARPA development aimed at medical sensors to be worn on person, coupled with position fixing and communications components. The primary purpose of PSM is to flag incipient or actual casualties, and to facilitate emergency care. The secondary purpose is, on command, to locate selected combatants. Inbound signals consist of GPS signals and command polling; outbound signals consist of data re medical sensors, and geo-positioning. Neither require an act of volition by the wearer. Hence, each PSM will constitute one node of a *Personal Communications Network* (PCN). Through a Combat Medic Associate unit, first aid personnel can access data from each node, and the PCN can be accessed by both medical and operational commanders.

The significance of PSM for this Battle Laboratory extends beyond its wartime applications. Here is a mechanism for keeping track of each dismounted combatant in subsistent (real) TES; combined with a detailed terrain data base, and information from sensors concerning weapon events (not to be shown today), an exact automated record of the "combat" could be generated for use in analysis and after action reviews. In short, PSM could be a wartime life saver, and the core of a peacetime TES instrumentation system.



Each PSM would have these characteristics:

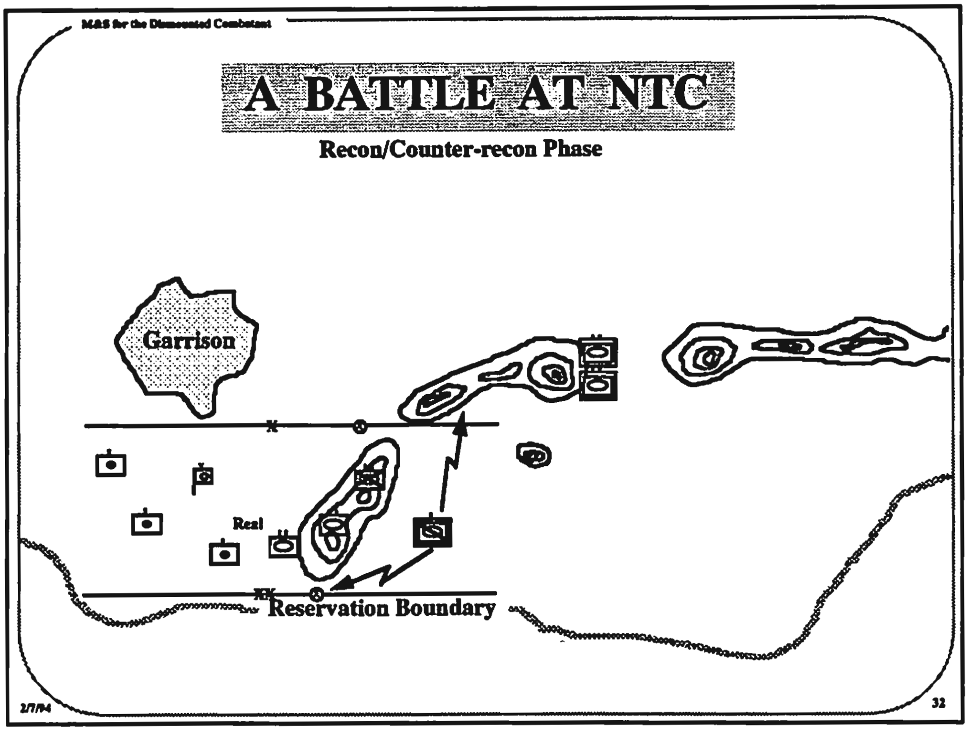
- Monitors heart rate, respiration, blood pressure, SaO_2, and temperature
- Functions automatically: either (1) alarm, or (2) respond to poll
- Unobtrusive, waterproof and rugged, with low weight and power
- Integrated with Global Positioning System (GPS)
- PCN node, with encrypted, Low Probability of Intercept (LPI) communications
- Individual identity among thousands of subscribers
- Compatible with SONET/ATM and *Global Grid*
- Flexible capabilities for relay — both aircraft and satellite
- Range encompassing deployed land, sea, or air task forces
- Free from multi-path and near-far disruptions
- Able to port without interference into existing computers and communications
- FCC authorization, with efficient utilization of assigned frequencies
- Commercial (dual-use) applications (to insure a wartime production base)



About one year ago, I witnessed a battle at the National Training Center that included a spectacular, but wholly unrealistic air strike, and a scathing after action review in which the U.S. commander was castigated for "losing the reconnaissance battle." This led to suggestions to ARPA that Col. Bob Reddy acted upon, and to this first public showing of a device designed to improve simulation at the Combat training Centers by allowing dismounted soldiers to see objects on the terrain that exist only in constructive or virtual simulations.

INFOSCOPE is a man-portable mechanism designed to redress asymmetry in subsistent or real simulation by adding to an FTX units or facilities generated from a constructive or virtual simulation. INFOSCOPE consists of an eyepiece that clamps onto an observation device or weapon sight, and injects into its field of view an icon representing any object present in the simulation, so long as the observer has established line of sight. In the version shown here today, INFOSCOPE draws mainly on JANUS 4.0, and is built for clamping onto MELIOS, the new hand-held, thermal-imaging laser range finder; its power supply, GPS chip, and radio is intended to be housed in a belt pack.

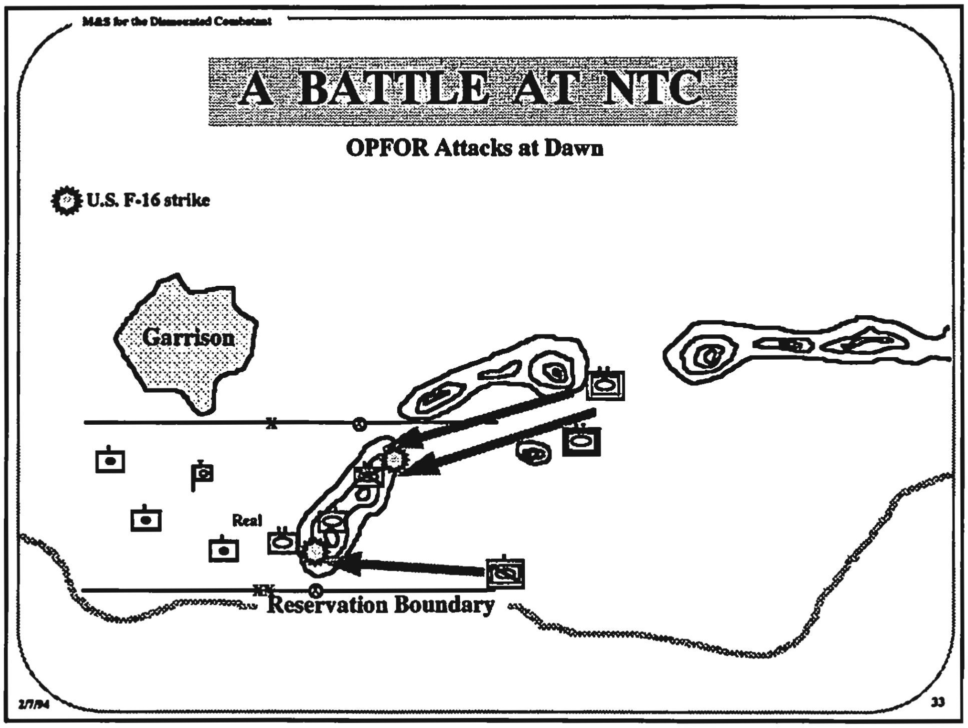
But let me walk you through the NTC battle, and show you how this device could have helped better to plan and to conduct close air support, and to level the playing field between the U.S. forces and OPFOR.



The diagram portrays the situation around mid-night, following a day in which the U.S. brigade shown had been attacking, and had seized the high ground southwest of the garrison late in the afternoon. There it had been ordered to dig in, and to defend the ridge against an OPFOR counterattack that the division's G-2 predicted for first light the following morning.

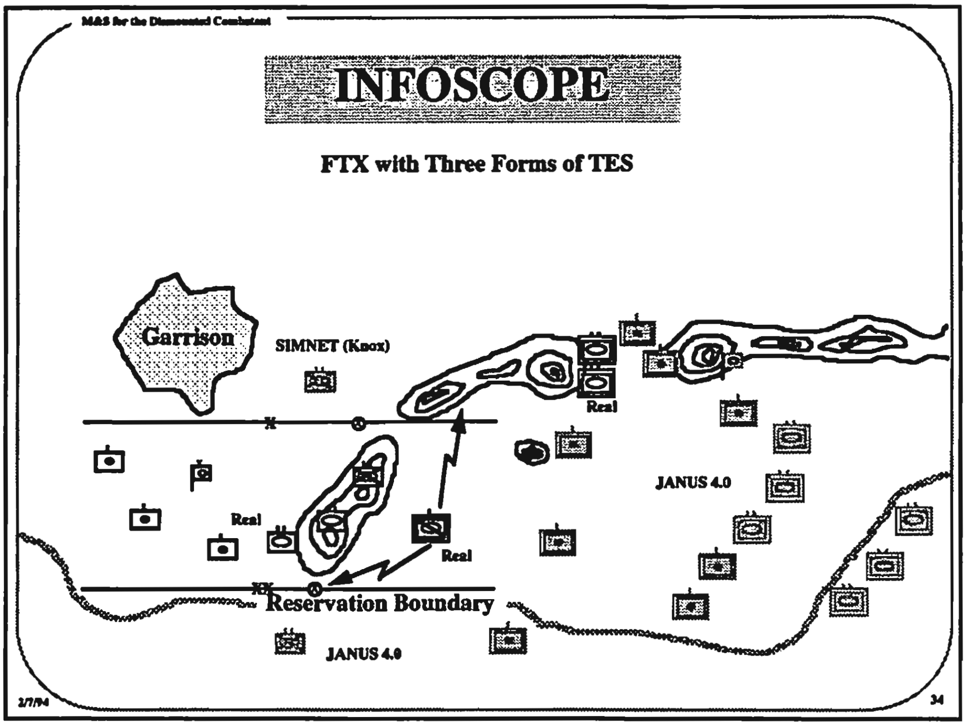
In the battle that followed, like most battles at the National Training Center, the winner of the reconnaissance/counter-reconnaissance contest prevailed. Yet, as usual, the odds were stacked heavily in favor of the OPFOR, who not only fights on familiar terrain, but also has the distinct advantage of being represented on the ground only by an assault echelon. Whereas the U.S. force is fully arrayed — command posts, artillery batteries, trains, and all the activity associated with replenishment and preparation for defensive operations — OPFOR is allowed to conceal those units that will figure in close combat shortly after dawn — in this case, to the northeast, out of zone, behind the ridge. No matter how energetically the U.S. commander pushed his reconnaissance, his patrols could observe and report no OPFOR activity other than chance encounters with a very effective OPFOR cavalry screen. Note that, from the U.S. brigade's perspective, the battlefield is largely empty. There are no friendly formations to be observed on the flanks.

As for OPFOR, his patrols, from the high ground immediately northeast of the brigade's left limiting point, could observe and report the location of virtually every unit in the brigade, enough to anticipate in almost every detail the brigade commander's plans for defense.



In the early morning hours, the OPFOR reconnaissance element commenced air and ground activities in the south of its zone designed to draw the defender's attention to that sector. Heavy, very accurate artillery fire drenched the U.S. units, particularly the two armor battalions on the right (south). As the rim of the sun broke the horizon, OPFOR laid heavy smoke concentrations across the front that, lit by the first rays, threw a red curtain over the battlefield. Well concealed from U.S. defenders, two battalions advanced at top speed, aiming squarely at the one U.S. mechanized infantry battalion defending on the north. The attack was well coordinated. The first OPFOR units to emerge from the smoke were on the south, attack helicopters and tanks heading for the right flank of the U.S. position, and attracting attention and defensive fires. The attackers on the north were not spotted through the smoke until they were within one thousand meters.

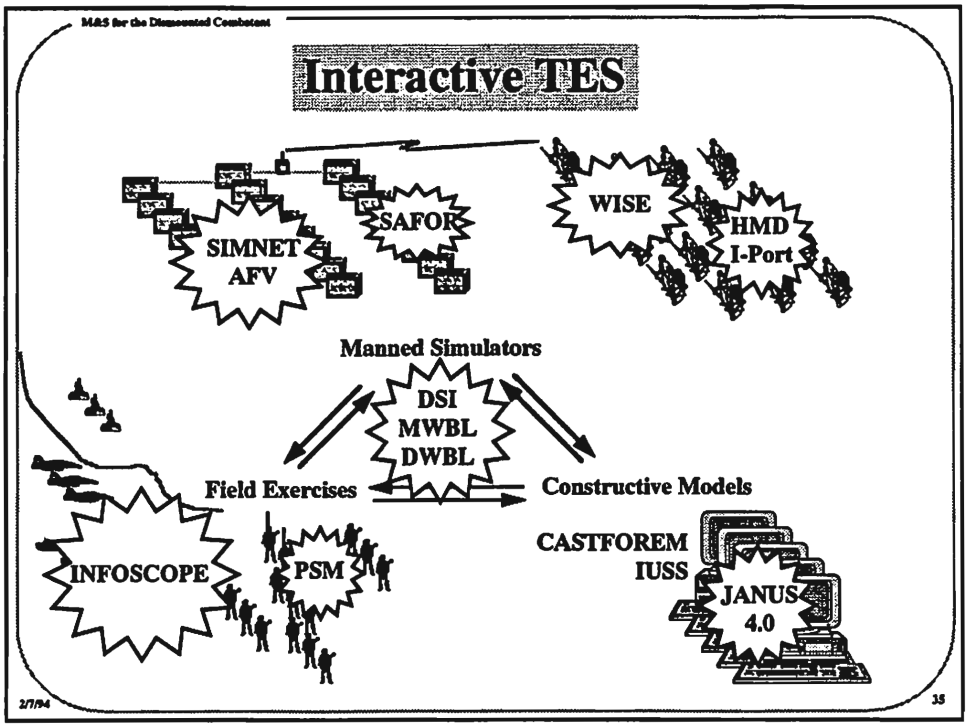
The U.S. brigade commander then called for air support, knowing that there were ten F-16s scheduled in the division's zone at about that time. By the time his request had been approved, however, the lead elements of the OPFOR had crashed into the U.S. defenses, and the resulting close combat could best be described as a melee. The air strikes, delivered within the U.S. defensive positions, were too late. OPFOR tanks broke around the left flank, and drove into the brigade's rear, straight for its command post. The battle was over.



It was clear that the U.S. brigade commander fought blinded, not alone by smoke, but by lack of ability among his troops to observe and report in the OPFOR rear, as the OPFOR had been able to in his. Since actual units will not be available to portray realistically the entire array of OPFOR that would have figured in an attack such as just described — artillery, command posts, supply and maintenance activities — it seemed desirable to find a way to portray what was out there to the U.S. side, and to reward adroit reconnaissance by the U.S. in the same way that it paid off for OPFOR. Given the advent of JSTARS and other broad area sensors, having such information in digital form seems essential for simulating the OPFOR array to those sensors, and passing digital information for tactical decision and action is what "digitization of the battlefield" is all about.

In the situation portrayed, the U.S. commander has sent three MELIOS-equipped scouts forward on foot to the lone hill in the north of his zone. From that position (black triangle), the patrol can observe and report (1) the position of the real OPFOR armor to their northeast, (2) the artillery battery in position to their immediate east, (3) other artillery and a possible command post at a greater range beyond, and (4) the composition and location of follow-on forces to the southeast — all generated by JANUS 4.0. Note that through INFOSCOPE U.S. forces in the brigade can "observe" friendlies on the flanks: in this instance, the left flank task force of the U.S. division to its south [a JANUS generated unit], off the reservation, and a SIMNET battalion on the right flank of the brigade to its north.

Now the U.S. brigade commander can bring fire power to bear decisively: on the assault echelon, on fire support and C4I elements, and on the follow-on echelons. Air support, if available, can be used far more effectively.



In the illustration you are about to witness, we will employ all three forms of Tactical Engagement Simulation — constructive, virtual, and subsistent (real).

Soldiers mounted on the two HMD I-Ports here at the Dismounted Warfighting Battle Laboratory in Fort Benning will be joined on the terrain between here and the Infantry School by the soldier with PSM and the INFOSCOPE. Supported by manned SIMNET AFV here at Fort Benning, this fire team will engage manned SIMNET armored fighting vehicles at the Mounted Warfighting Battle Laboratory, Fort Knox, supplemented by Semi-automated forces generated at both Forts Benning and Knox, and by objects derived from JANUS 4.0, running on a work station in an adjacent room in this building.

The mission assigned the force is to attack the OPFOR positioned in front of the Infantry School. As you will see, the intend to do so with fire, and then to close in a mounted assault.

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MAS for the Dismounted Combatant

21st Century Land Warrior

- **Develop, test, and train performing combat tasks**
  - Teamwork
    - » DBSBL & ARI
    - » Industry, ARL, & Natick RDEC
    - » OPTEC
  - Combined Arms TES
    - » Constructive
    - » Virtual
    - » Subsistent

Mature Subsystem for Testing, Training, Operational Rehearsals

- **Advanced Technology Demonstrations (ATD)**
  - 1996 Interim ATD with prototypes
    - » Confirm C^4I, form, fit, and function
    - » Extend military worth analyses
  - 1998 Culminating ATD: light infantry platoon in STX/FTX
  - Transition to minimal Engr Dev 6.3b, 6.4

2/8/94 37

We have been writing and talking about this technology since 1990. Now we have been able to show you it in action. If those who control the purse strings will buy the tools, this Battle Laboratory can innovate like no other.

Though some here may find it galling, the Mounted Battle Space Battle Laboratory has provided a paradigm worth emulating:

- Form a close partnership with the Army Research Institute — it is germane that the ARI unit in Orlando has studied the combat tasks of dismounted combatants, soldiers and SOF, and identified those amenable to virtual simulation. That analysis deserves to be revisited, and extended to include all three forms of TES.
- Foster close cooperation with industry and the Army Materiel Command. 21 CLW can draw heavily on commercially driven development.
- Bring the test and evaluation community into any development early, to help them understand how the system is supposed to perform, and to aid them in devising effective test plans.
- Insure that training and testing takes place in a combined arms context, so that the full benefits of digitizing the battlefield can be realized.
- Start now to build the 21 CLW training subsystem, evolving it from your developmental simulators and test instrumentation.

This Battle Laboratory leading, American armed forces can thereby field the most formidable dismounted combatants in history.