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ADAPTING FUTURE WIRELESS TECHNOLOGIES

January 2002

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CONFLICT OF INTEREST

Conflicts of interest did not become apparent as a result of the Panel's recommendations.

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13. ABSTRACT (Maximum 200 words)

The Army Science Board Panel focused on: (1) Identifying and assessing wireless technologies that may enhance and support the features required to ensure tactical information dominance; (2) Addressing the role of information management in sizing system capacity and issues such as quality of service; (3) Evaluating the degree of enhancement that could be offered by commercial technologies in each of the layers in the 3-D architecture (terrestrial, A/B, space) to achieve connectivity; (4) Addressing vulnerabilities and methods to counter use by adversaries. (5) Addressing issues posed by legacy systems. (6) Addressing joint and coalition issues.

The Panel's overarching recommendations include investing more in wireless infrastructure based on commercial advances, focusing management attention on communications UAVs and payloads, developing systems capable of multiple air interfaces with access to multiple bands, establishing an Army process for systematically evaluating new, disruptive technologies & integrating them into the GIG, and treating Army wireless systems in a merged context of "Network Operations" comprising converged voice and data. The Panel also recommends that JTRS should be directed toward incorporating future commercial waveforms, and that the spectrum management business model should be reengineered to support flexible, shared access to spectrum.

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Adapting Future Wireless Technologies

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Army Science Board (ASB)
Ad Hoc Study
Adapting Future Wireless Technologies

18 January 2002

Chairperson: Ms. Ginger Lew

Co-Chairperson: Mr. Kalle Kontson

This study was initiated in the beginning of 2001 due to the importance and potential impact of wireless technology on the ability to enable the full potential of the Objective force. The study placed an emphasis on use of advances in commercial wireless technologies.

The study was accomplished during a short, but intensive period. Information gathering and analysis was accomplished primarily in March through June of 2001. The results were documented in two forms: an executive summary report, and this detailed report. First rough drafts of the reports were completed prior to the July 2001 ASB Summer Study session to enable the application of results to the ASB Soldier Systems study. Publication of final reports was delayed to allow time for briefings to the sponsors. This report is presented in a briefing format with explanatory text following each briefing chart.

The study was chaired by Ms. Ginger E. Lew, CEO of the Telecommunications Development Fund. It was co-chaired by Mr. Kalle R. Kontson of the IIT Research Institute.

Study Sponsors

- 2001 Ad Hoc Wireless Study Co-Sponsors
  - Assistant Secretary of the Army (Acquisition, Logistics and Technology)
  - Director for Information Systems, Command, Control, Communications and Computers (DISC4)
  - Commanding General, Communications and Electronics Command (CECOM)
  - Commanding General, U.S. Army Signal Center & School (SIGCEN)

This is a list of the sponsors of the study.

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This is a list of the contributors to the study. Special thanks go to Ms. Lisa Rulli and Mr. Jeff Ozimek for outstanding support in arranging access to the right information under the pressure of a very aggressive schedule.

TOR Items Addressed

Due to large scope of TOR and limited time, focus was on communications and the following, though many related issues deserve further study (Note: see full TOR in Appendix):

- Examine potential future commercial wireless capabilities and recommend which may have applicability for the Objective Force.
- Identify the range and source of devices that may operate in most deployment situations-desert, urban, and jungle.
- Identify and evaluate process models on how the Army may integrate future wireless technologies.
- Identify and assess opportunities for the Army and military to become more involved with and facilitate shaping emerging commercial standards and protocols.
- Identify and assess wireless technologies that may enhance and support the features required to ensure tactical information dominance.

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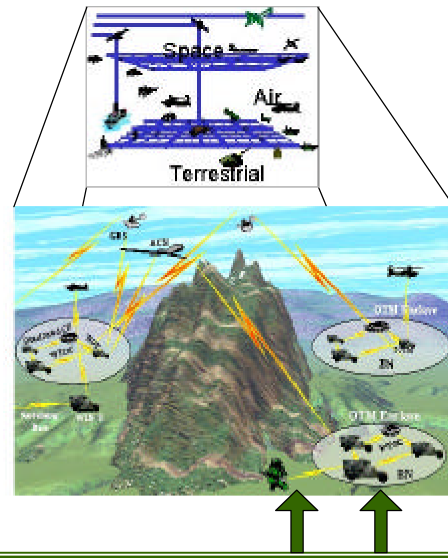
A complete summary of the Terms of Reference (TOR) for the study is shown in Appendix A of this report. Due to the scope and breadth of the complete TOR, the Ad Hoc Study team felt that the four months allocated to complete the study would only allow for comprehensive coverage of the items listed on this slide. Many of the remaining TOR items are partially covered or touched on in this report, but comprehensive treatment of those items will require additional study.

Wireless Domains: GIG/ WIN-T

- Three Domains as defined in the GIG and WIN-T
  - Space
  - Air
  - Terrestrial
- Wireless Comm Applications Include Voice, Data, Messaging, EW, Sensors, Navaids, SIGINT in All Domains



Army Warfighter's Connections to the Army Tactical InfoSphere

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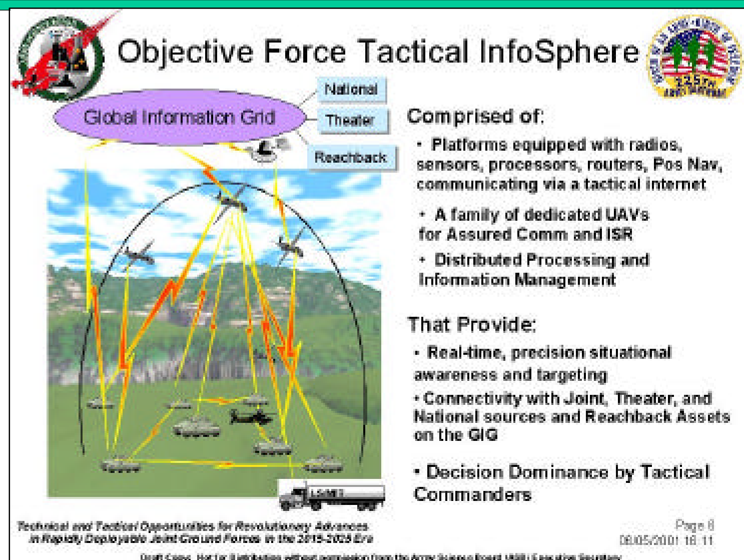
At the time of preparation for this report, the Global Information Grid (GIG) Capstone Requirements Document (CRD) draft provided one of the best DoD-level descriptions of the military network of the future, with the wireless networks operated by the Army being an integral part of the GIG. Within that context, the ASB Summer Study of the year 2000 defined a concept for an Army Tactical Infosphere. The Tactical InfoSphere is a combination of C4ISR capabilities organized to support Army or Joint forces in the accomplishment of a mission. It consists of organic and dedicated sensors, a robust command and control system, rules for rapid distribution of information through the InfoSphere, and all the communication nodes of the tactical units assigned to the force concerned. The diagram shows the operation of elements of the InfoSphere.

The Tactical InfoSphere is a key part of the Global Information Grid and is linked to organizations and resources which will support the operations outside the Army Tactical InfoSphere. These would include tactical units and higher staffs operating from reachback locations; supporting National assets, such as satellite sensors; logistic organizations charged with pushing supplies forward; and training resources for the tactical units to maintain peak readiness while awaiting employment. The Tactical InfoSphere thus consists of any platform, on the ground, in the air, or in space, that is equipped with a radio, sensor, processor, router, or location device that participates in the information gathering and distribution for the Warfighter. Wireless connections are the implementation mechanism for maintaining all facets of information exchange in the highly mobile, rapidly changing battelfield; whether the terrain is urban, tropical, mountainous, forested or desert.

WIN-T will be a key ingredient in the core of the Army Tactical Infosphere; it is a central piece in the Army's implementation of the GIG in the tactical battlefield. WIN-T acquisition strategy is based upon integration of commercial wireless technology, such as that identified in this study.

Information Dominance

•Mobile Army of the Future is heavily dependent upon wireless communications.
•Need connectivity from all echelons to Tactical Infosphere **and** GIG.
•Reliable, Robust, Mobile comm is essential!



•What Technologies are needed?
•How many satellites and UAVs?
•Imperative to have mobile ad hoc network!

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Simply stated, Information Dominance is the condition where the ratio of our usable information to the enemy's information is much greater than one. The information must be usable in the sense that it can be translated readily into relevant knowledge in a timely manner, without overburdening the user. To achieve this condition, we must:

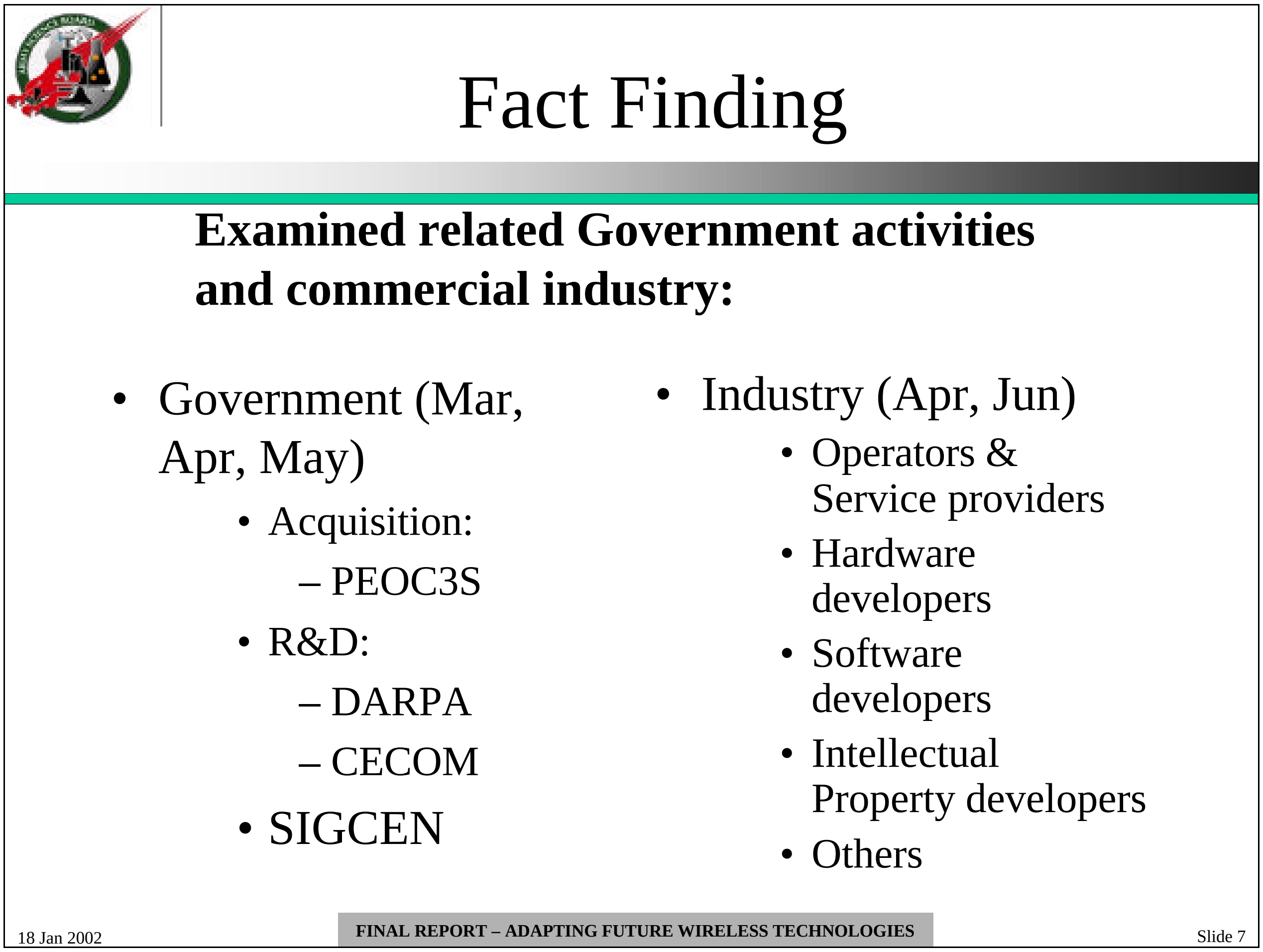
• Locate enemy targets in a timely and efficient manner.

• Deny the enemy the ability to locate and identify us in a timely manner.

• Get the right information to the right echelons in the right format at the right level of detail at the right time.

• Deny the enemy's ability to attack our information systems and employ cover, concealment and deception.

Wireless communications will be the enabling technology to achieve and maintain Information Dominance for Army Warfighters. It will provide the connectivity throughout all levels of the Tactical Infosphere and the GIG. In order to operate in rapidly changing diverse environments, and potentially hostile situations, the Army wireless systems designs must go beyond commercial implementations to achieve the reliability, robustness, and mobility that is needed to assure Information Dominance. The vision developed in the 2000 ASB Summer Study included Ad Hoc wireless networking as an essential ingredient of the Tactical Infosphere. Our challenge in the study documented in this report is to identify the technologies and supporting infrastructure that can positively contribute to successfully building the wireless connectivity which meets the Army's needs.



In order to meet the challenge of finding applicable wireless technologies, our Ad Hoc Study team contacted as many high-yield sources of developments and technology implementations as was possible during the timeframe of the study. These included both Government and commercial industry sources, as listed on the slide. A complete list of contacts and information briefings received by the team is listed in Appendix B.

The team made a concerted effort to cover the three principal facets of the DoD wireless systems: doctrine, research & development, and procurement. Overall, there is some very encouraging news in the Army, and the DoD in general. The Army and the DoD have been making some significant progress toward adopting, adapting or developing wireless systems that may become competitive with commercial technology achievements, and promise to offer leap-forward capability, if implemented properly.

When examining industry, the team also tried to cover the waterfront in terms of the perspectives, interests and insights that could be gleaned for making an intelligent forecast about what commercial technology could offer in the future. This required examination of not only the raw technologies, but perhaps more importantly, the underlying business case for pursuing these technologies.

Report Layout

- 3-D Architecture
  - Space: Findings, Conclusions, Recommendations
  - Air: Findings, Conclusions, Recommendations
  - Terrestrial: Findings, Conclusions, Recommendations
- Special Topics
  - Vulnerabilities: Findings, Conclusions, Recommendations
  - Spectrum: Findings, Conclusions, Recommendations
  - Acquisition: Findings, Conclusions, Recommendations
- Overarching Conclusions
- Overarching Recommendations

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We have prepared two documents as a result of this study: one is an Executive Summary (less than 20 pages, PowerPoint), and the other is this detailed report. The detailed report is organized and presented as separate Findings, Conclusions and Recommendations for each of six topics, and then concludes with overall, overarching conclusions and recommendations.

Our selection of six topics is shown in the first two major bullets of this slide. This particular breakdown was motivated by first addressing those technologies which logically fell into the three basic architecture elements of the GIG concept: space, air and terrestrial. Although there is plenty of overlap, each of these three “layers” brings with it sufficiently unique characteristics and requirements to justify separate treatment. For example, the technology and business issues associated with commercial SATCOM are quite different than those associated with a terrestrial “cellular” system. How those attributes translate into the ability to meet Army needs are quite different, as well.

In addition to the three topics defined by architecture, there are three “special topics” defined: vulnerabilities, spectrum, and acquisition. These are treated as special topics because they have implications that pervade all three layers of the GIG architecture, and are viewed as having significant impact on the Army’s ability to achieve effective wireless implementations in all three layers.

Findings – Space

- Perceived Army Needs:
  - Need for seamless integration of SATCOM into Army networks
  - Need to integrate evolving commercial SATCOM services and products
- What we've found in DoD/Army:
  - Army Policy allows commercial SATCOM
  - Army uses commercial mobile SATCOM systems today
- What we've found in commercial:
  - Commercial satellite voice/data systems proliferating/evolving
  - New technology and architecture opportunities emerging
  - Uncertain business viability – lack of enthusiasm by wall street investors
  - Socio-political issues are numerous: assured access, landing rights, lease costs, international ownership, use restrictions, contract agreements
  - Same systems are available for use by adversaries: thus, adversaries will be potent and we may not be able to deny use

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Army Policy allows commercial SATCOM as a viable alternative for transmitting unclassified, non-mission essential general-purpose communications – i.e. which support logistics and general purpose connectivity and don't require hardening or assured access. The Army must compete with civilian users and other system customers including potential adversaries when using these resources. The operations concepts employed must recognize that there is little priority or preemptive service available to the Army user. However, this capability has proved effective in operations in Bosnia, the Middle East and in Korea.

Commercial satellite voice and data systems are proliferating and evolving. The financial viability of these systems to date has been questionable and many are being fielded much later than originally planned. However, as they emerge, they offer the opportunity for effective Army communications at costs orders of magnitude less that the traditional costs for dedicated MILSATCOM Systems. In addition, the dual use of the technology allows the Army to leverage the billions of dollars being invested commercially.

Three "types" of commercial SATCOM systems are currently in use and have utility to the Army. They are:

• Leased transponder "bent pipe" – This can be referred to as the Intelsat and INMARSAT model. These services have been used by the Army for many years. US peacekeeping forces in Bosnia and Hungary used commercial SATCOM capabilities provided by Sprint. Commercial SATCOM terminals were relocated from Alaska to Panama during operation Just Cause. The INTELSAT and INMARSAT systems were used extensively to support Desert Shield and Desert Storm operations.

• Mobile subscriber – the Iridium model. Several commercial SATCOM systems have been proposed to provide service to Mobile handsets or user devices providing PCS-like services. Some of these systems, like ICO and Iridium provide worldwide coverage. These are beginning to be used by the military, and may offer some additional opportunities. The DoD Iridium program currently underway will provide considerable opportunity for the Army to test commercial-based PCS capability.

• Commercial "GBS-like" direct broadcast data services – the DirecTV, EchoStar, Worldspace & XM radio model are increasingly improving their capabilities. Capabilities like "Live" streaming video to desktop and mobile users, and reliable multicast delivery of large files are provided by these systems. These types of Commercial services are not yet used by the military, but they offer capability opportunities that are similar, and in many cases more capable than those provided by the DoD Global Broadcast System (GBS).

These systems offer worldwide availability. However, they use multiple and often proprietary air interfaces which can require multiple user terminals or multi-waveform capable user terminals.

An immediate advantage is the decreasing service and hardware costs due to competitive pressures. This trend will continue as more systems become operational. Unfortunately, several emerging commercial SATCOM systems have failed. The experiences of ICO, Iridium, Globalstar, Orbcomm "on-the-move" SATCOM systems have dampened the enthusiasm of Wall Street investors. Iridium and ICO both had initial failures subsequently ending in bankruptcy. ORBCOM recently went into Chapter 11 bankruptcy and is now with new owners. Globalstar was declining to pay its debtors and was starved for cash. Its survival is questionable. Iridium is operational under new leadership and is being primarily funded by DoD. ICO has been restructured and is being retargeted to data as opposed to voice-exclusive services.

The profitability of many emerging commercial satellite based systems remains to be proven. Even some of the more commercially successful satellite system (e.g.; the DirecTV direct broadcast television system) have yet to show a profit. It is doubtful that commercial investment in new systems will return to the level seen in the late 1990's until business viability is shown and investors see proven return on investment. These business pressures offer opportunities for Army to join with vendors in developing future capabilities; but, not without risk

Voice, video, messaging, and data services are increasingly being provided by digital SATCOM systems. This trend is expected to continue although it will be at a slower pace than originally thought in the late 1990's. Many of these can be easily purchased via Government-Wide ID/IQ Contracts: GSA/FTS, DSTS-G.

Conclusions and Recommendations – Space

- Conclusions:
  - Commercial services available now of value to Army
  - Service providers may change quickly as the Army seeks to maintain long-term plans
  - Commercial satcom technologies present derivative product opportunities for military space and air (UAV) application
  - Commercial does not address security and denial of service
- Recommendations:
  - Expand use of commercial SATCOM to lower echelons
    - Such as: Echostar, Iridium, Worldspace, XM satellite radio, etc
  - Army establish funded activity to understand mobile SATCOM capabilities/technologies and translate to military requirements
  - Expand existing Army role as US Rep to NATO for SATCOM to other Allies and potential coalition partners to:
    - Develop common procedures & policies for use of commercial mobile SATCOM
    - Establish technology forum

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Commercial service providers may change quickly as the Army seeks to maintain long-term plans. This is an advantage because the Army can take advantage of competitive pricing. However, it presents planning problems because it makes it impossible for the Army to develop long range specific system designs and operational concepts.

Commercial SATCOM technologies present derivative product opportunities for military space and air (UAV) applications. Examples are: broadcast technologies, on board switching/routing, information management, storage, retrieval, authorization, and authentication on the fly.

No commercial systems provide "protected – jam resistant service" or assured military access. Therefore, DoD should retain Milstar for essential warfighter communication.

The Army may have an opportunity to expand use of commercial satellite communications capabilities. To capitalize on this opportunity, the Army should establish funded activities to understand mobile SATCOM capabilities/technologies and translate them to military requirements. Recommended Army activities include such things as:

- Research application of new "GBS-like" direct to user broadcast systems and technologies.

- Explore transfer of technology to airborne (UAV) relay/data distribution applications.

- Establish a standing relationship with commercial SATCOM technology developers and service providers.

- Influence the design of services and technologies to support Army needs.

- Influence protocols and standards used for terrestrial and air interfaces.

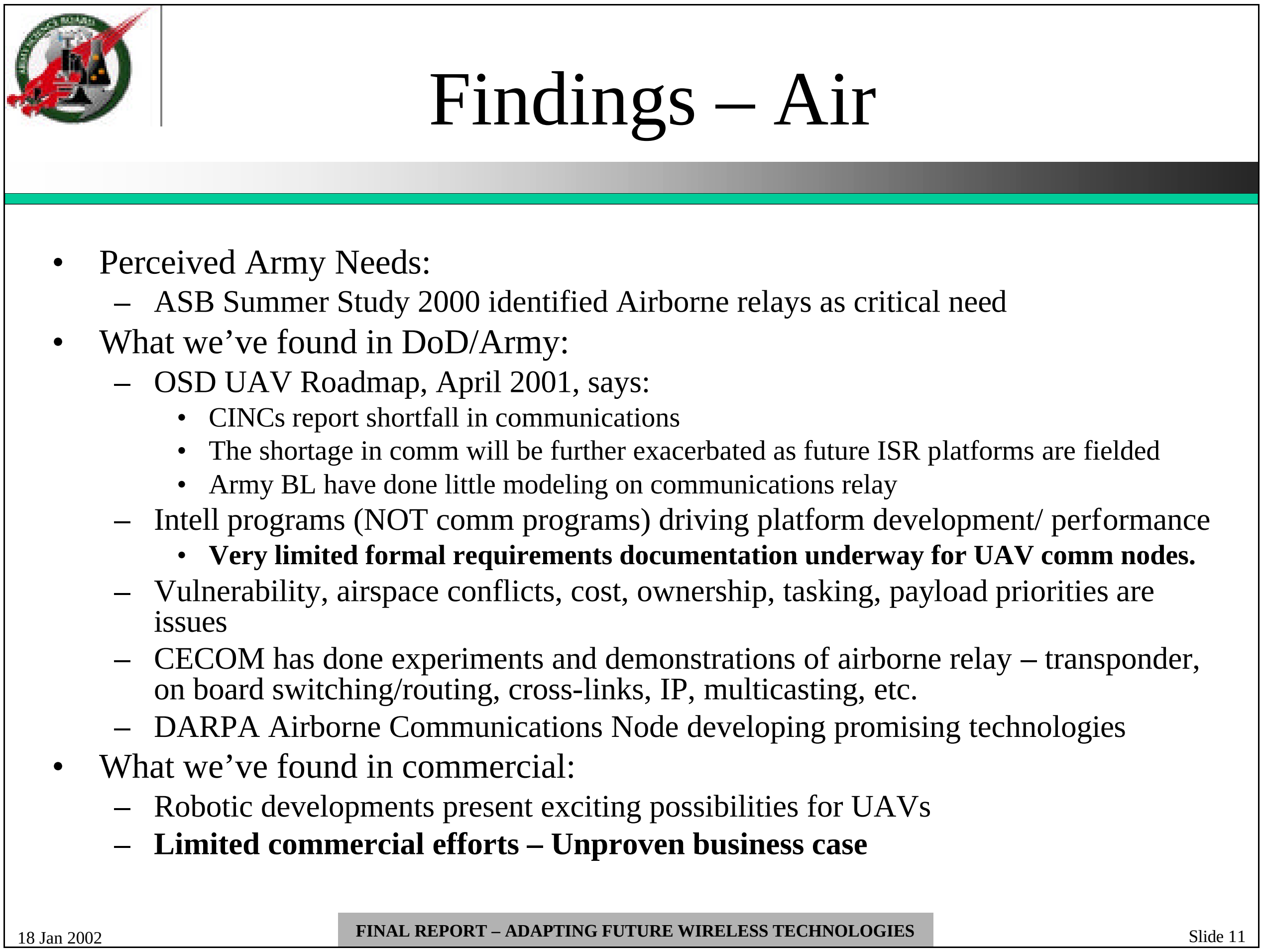
- Provide advocacy and regulatory presence where needed.

The Army should also build on its existing role as US Rep to NATO for SATCOM to other Allies and potential coalition partners to:

- Develop common procedures and policies for use of commercial mobile SATCOM.

- Establish technology forum to interact with international SATCOM technology R&D and manufacturing communities.

The Army should purchase "Reserved" capacity long term - Unused capacity can be offered for resale on open market as a "Preemptable" service via second SATCOM service provider => Global Surge. There may, however, be legal issues involving "landing rights" in worldwide deployments.



The ASB Summer Study for 2000 identified airborne relays as a critical need for the Army. Unmanned Aerial Vehicles (UAVs) potentially offer the best platform for such a system. UAVs can be used to host switching and routing equipment, house network management and operations, and data storage equipment, providing wide area coverage and making more info available in real time as needed. While much has been accomplished with UAVs in recent years, we are not aware that the Army has fielded an airborne relay communications platform. Yet, this is a very promising application of UAV technology.

In analyzing the state of affairs with respect to Army and DoD UAV efforts, we noted the following:

- Intelligence programs are the main drivers and direct much of the funding for Army and DoD UAV platform development. Intelligence UAV activities have payloads and operational requirements that are much different from Communications UAVs.

- The Office of the Secretary of Defense (OSD) in their April 2001 OSD UAV Roadmap notes that:

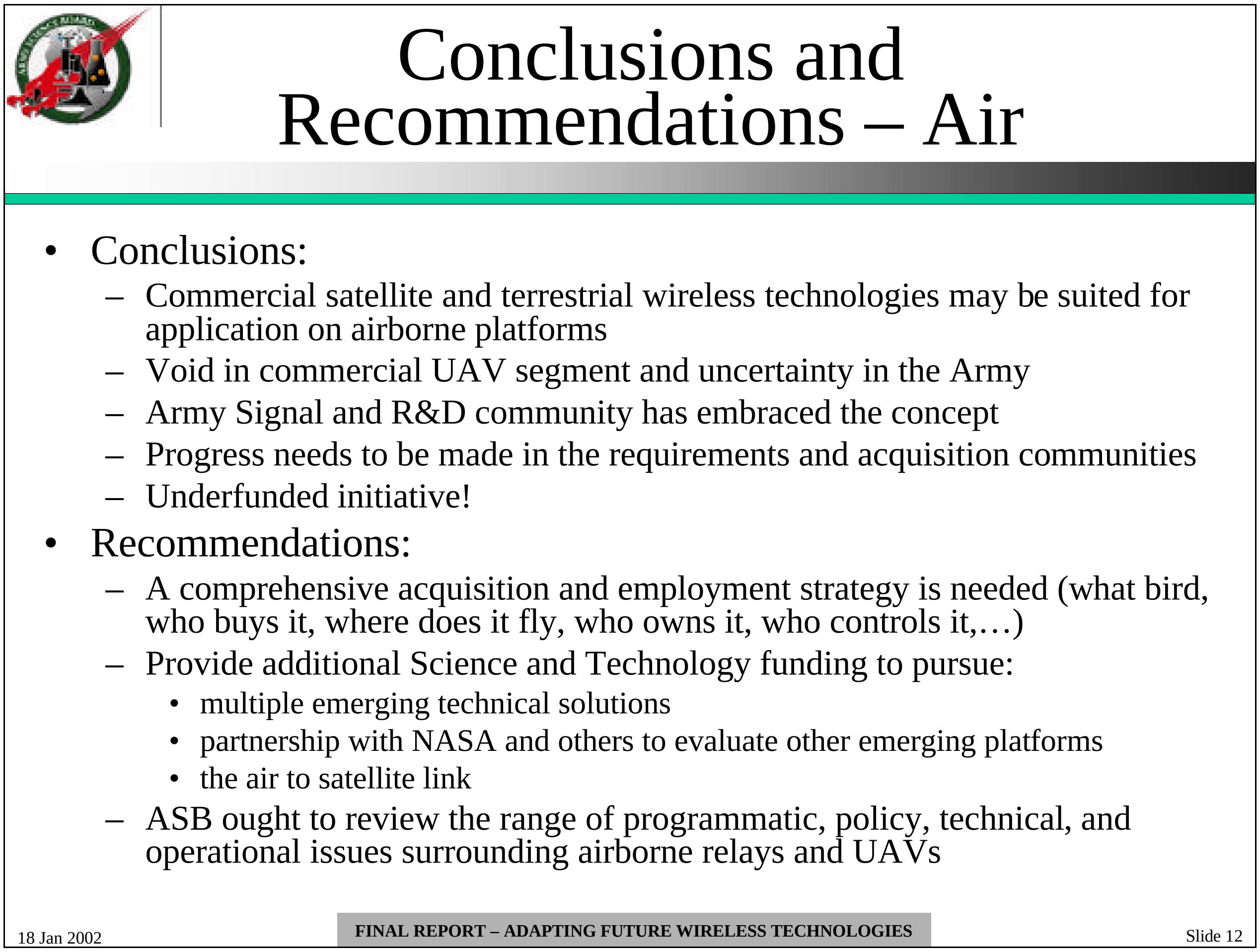
• CINCs report a shortfall in communications. By 2010, existing and planned capacities are forecast to meet only 44% of the need projected by JV 2010 to ensure information superiority. [Section 4.2.5]

• To date, Army BattleLab activities have focused on scouting, sensor, and UAV modeling with little work done on communications relay. [Section 5.2.3]

• The shortage in long haul, wideband, OTH [communications] will be further exacerbated as future Intelligence Surveillance and Reconnaissance platforms are fielded. {Section 5.5]

• CECOM has completed demos and experiments, but the Army has not been able to actually field a system to date.

With respect to commercial efforts, we noted that new robotic developments make for some exciting possibilities for UAVs (e.g. Carnegie Mellon Univ. "multiple robots, one mind" research). However, there is a significant void in UAV communications R&D. There is high skepticism on the part of private investors about the unproven business case and need for UAV communications. Angel Technologies, AeroVironment/SkyTower; Helios/NASA project; Volacom, ATG/StratSat Technologies, StratCom (Air Force), Space Data are all looking for private funds without much success. Once funded, estimated time frame for deploying first systems is minimum 3 to 4 years away. Thus, any significant R&D and deployment will most likely need to be funded by DoD.



Commercial wireless technologies are being developed at a rapid pace. Research in manufacturing smarter and smaller and more robust routing and switching equipment, programmable ASICs, holographic data storage and data caching are receiving significant amount of private investment. Many of these technologies appear to offer some exciting opportunities for DoD leverage into UAV or other airborne platforms.

The Army Signal and R&D communities have embraced the concept of using airborne platforms for communications as one of three critical communications layers. However, progress needs to be made to synchronize the potential capability of the airborne systems to the needs of the requirements and acquisition communities.

The ASB recommends that:

• A comprehensive acquisition and employment strategy is needed. This includes identification of the types of platforms needed, who will purchase them, who will maintain and operate them, how airspace will be managed with other services, commercial aviation, and other countries.

• The DOD and Army should provide additional Science and Technology funding to pursue:

- Emerging technical solutions to satisfy the Objective Force Architecture communications needs, such as wireless PCS, broadcast methods (such as XM Radio, EchoStar), smart antennas, network management, and data caching methods.

- Partnerships with NASA and other programs (Helios NASA project and the StratComm Air Force project) to evaluate other emerging platforms more suited to the communications mission.

- Air to satellite link (for example, Boeing Connexion), cell towers in the sky.

The ASB should undertake a comprehensive, dedicated review of the range of programmatic, policy, technical, and operational issues surrounding airborne relays and UAVs, especially as relates to ownership and operations.

Findings – Terrestrial

- Perceived Army Needs:
  - Information dominance is the key combat multiplier
  - Pushing and pulling info to and from the brigade level and below is critical
  - Highest need is for robust mobile terrestrial communications network – most complex – most fragile to establish and maintain "on the move"
  - Mobile Ad Hoc Self-Healing Network is mission critical
- What we found in DoD/Army
  - MOSAIC, WLAN, PING, C2 Protect, Terrestrial PCS, Universal Handset, Global Mobile Information Systems, Small Unit Operations, JNMS, NETOPS
  - JTRS system is making advances primarily on legacy waveforms, but not enough forward emphasis on integrating new waveforms

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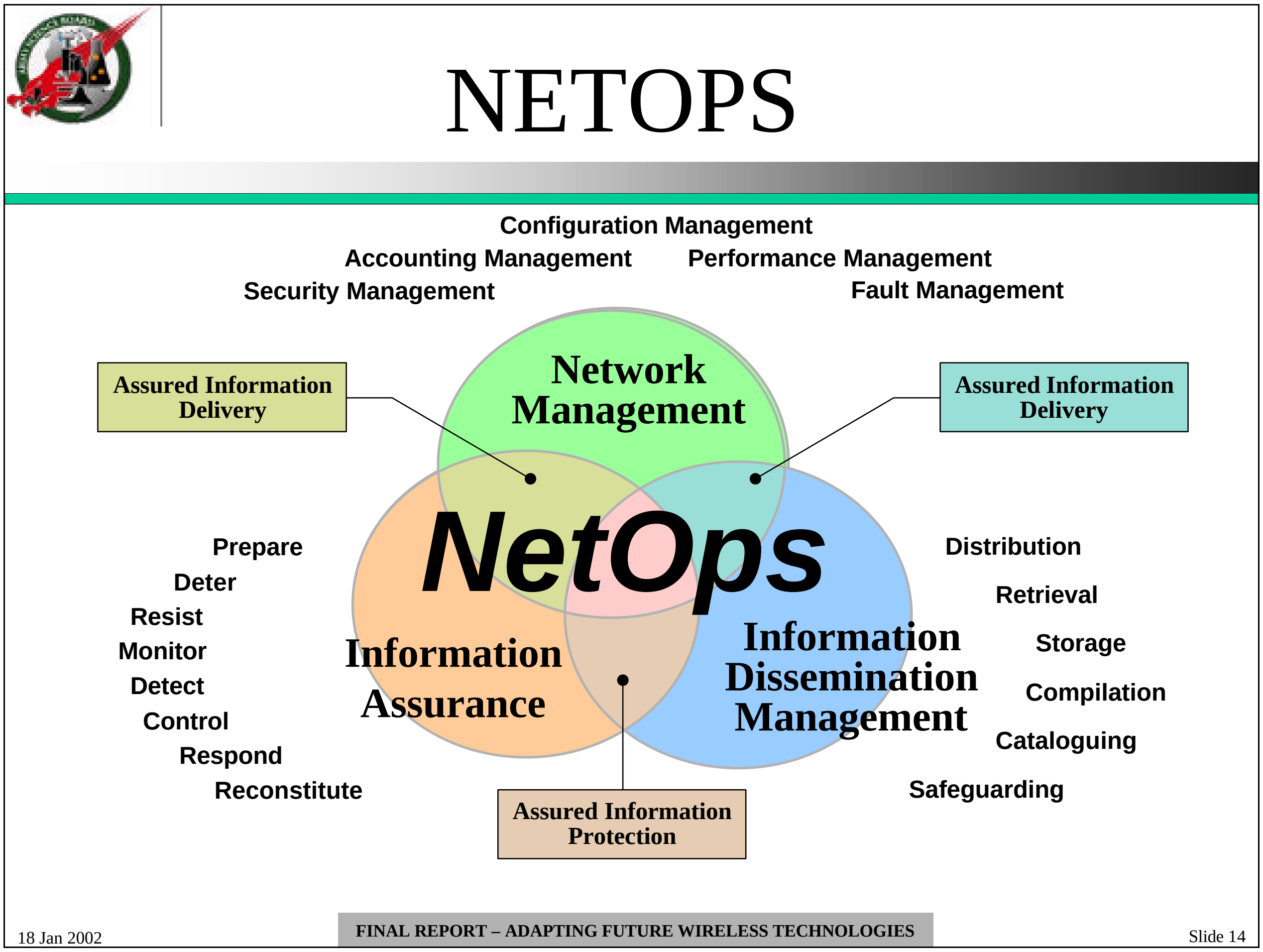
The lighter, more agile Objective Force will be heavily dependent on Information Dominance to enable dominance of the full spectrum of situations the force will face. The ability to push and pull information down to and across the lower echelons (below Brigade) is critical to sustain the advantage and autonomy envisioned for this force. The terrestrial communications supporting the Objective Force will demand:

- A robust, jam-resistant mobile infrastructure.
- Dynamic, flexible addressing.
- Adaptive, self-healing, multi-hop routing.
- Integral information assurance; quality-of-service (QoS) management.

In the future terrestrial architecture, every platform, to the level of the individual soldier, must have wireless connectivity to the other force elements and platforms; the FCS, higher and lower echelons, sensors, etc. Communication within the force needs to be agile and robust. We must minimize the effort required to manage the network, while maximizing the ability of each unit to simply and immediately effect communications with virtually any other element or platform. The architecture for this terrestrial network will be heavily weighted toward dependence on supporting infrastructure, just as commercial cellular communications is dependent on towers and routers today. For the Army, that infrastructure cannot be fixed, cannot be vulnerable to failure, and must be able to establish and maintain versatile connectivity while the entire force is on the move and on an unpredictable course toward accomplishing the mission. These additional requirements add an unprecedented level of complexity that goes well beyond commercial implementations of today. It is critical to the mission success that the terrestrial domain of the Army's C4ISR is based on mobile, ad-hoc, self-healing wireless network technology. This technology goes beyond just radios; it is comprised of a combination of network operations (NETOPS), user devices, and mobile infrastructure to support routers on the move.

The Army is actively pursuing elements of this overall wireless network design. At CECOM, the MOSAIC, WLAN, PING, Terrestrial PCS and Universal Handset programs are pursuing advanced research and development of the individual multi-mode devices, the mobile infrastructure, mobile network routing, and adaptation of commercial wireless technologies to the complex requirements of the Army. In the DoD, the Global Mobile (GLOMO) and Small Unit Operations/Situational Awareness System (SUO/SAS) are also addressing the device design and ad-hoc network management technologies that will be needed. NETOPS is being pursued under the JNMS program. These programs will provide some of the piece parts of the overall technology combination that will be required.

While the Army and DoD are pursuing separate technologies at the R&D level to effectuate the radically different terrestrial wireless system designs, existing procurements are not showing signs of having seen or heard the message. For example, the JTRS system should be capable of serving as one of the key "radio" systems in the future, packet-switched wireless network. Yet, nearly all emphasis is being placed on development of legacy waveforms that are primarily oriented toward circuit switched, simplex communications technologies. NETOPS developments are also currently directed toward this legacy architecture.



Migration from our current legacy tactical communications to mobile, ad-hoc, self-healing wireless network technology at the lowest echelons of the tactical force will force dramatic changes in Network Operations (NETOPS). NETOPS comprises the combined execution of network management, information assurance and information dissemination management, as depicted on this slide. NETOPS applications supporting the Objective Force C4ISR must be able to support:

• The evolution from circuit-switched to packet-switched communications.

• Highly mobile, ad-hoc, self-healing wireless networks.

• Automated, adaptive management of the physical layer down to the individual wireless devices.

The convergence of radio functions with information management systems will provide the enabling technology to build network-centric operations capability into the Objective Force; but only if the NETOPS technology is developed to provide for seamless, adaptive wireless connectivity to every "platform" in the Objective Force. Such connectivity must be able to be established and maintained in a reliable, secure manner with minimal effort by the user. In essence, the user must be able to merely enter the tactical setting and the C4ISR system-of-systems will associate the user's wireless communications with the surrounding environment. User preferences for operating modes, choices of networks, prioritization and other operating parameters can be managed by the user, or can be set to function automatically, as most of the new generation of commercial portable communications devices do. To set up complex NETOPS supporting this operational construct requires the infusion of some advanced network management technologies that can accommodate the convergence of radio networks and data networks under a single network architecture.

Commercial vendors have developed basic NETOPS capability that is applicable to the fixed infrastructure, i.e., where the cell-site towers don't move. The next generations of commercial wireless systems will require more advanced NETOPS capability as wireless operators begin implementing variable bandwidth and multiple applications in a single device; i.e, the convergence of voice, video and data on a single network using common air interfaces. However, there are additional complexities involved with NETOPS in the mobile infrastructure that is required by the Army's Objective Force. The Army's MOSAIC program will provide a sample of the solutions that may help address this need, but the Army must be prepared to invest heavily in developing the operational capability to conduct NETOPS within the radically different network-centric wireless architecture of the future.

Findings – Terrestrial

- What we found in Commercial
  - Commercial wireless is tethered to extensive infrastructure
  - Not addressing the requirements unique to Army
  - Significant activity in multifunction chips, device power, handset display and processing technology, and power sources
  - Developing multimode, multiband devices, adaptive antennas
  - No single air interface meets all needs
  - Many large and small vendors have extensive technologies in network operations and optimization, and QoS

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Our review and findings in the the commercial sector reveals a mix of applicable technology advances in three areas: infrastructure technologies, user devices and NETOPS.

Commercial industry is primarily addressing mobile users, but is not substantively addressing the mobile infrastructure, transmission security and AJ/LPD requirements unique to the Army. There is some work being done by Qualcomm and Universal Broadcast Systems (Canada) to build transportable base stations, and Cisco is also developing routers for Networks in Motion implementing Mobile IP and optimal routing. Their IOS Mobile Router is supported on many Cisco Routers and enables "multi-hop" routing. It is unclear that these technologies can be applied directly to a highly mobile, on-the-move tactical setting. Further research by the Army is needed. We identified only one commercial entity attempting to market mobile base stations, and they are struggling, and encountering difficulty with the business model. This is one technology area where it appears that the Army needs to lead the way.

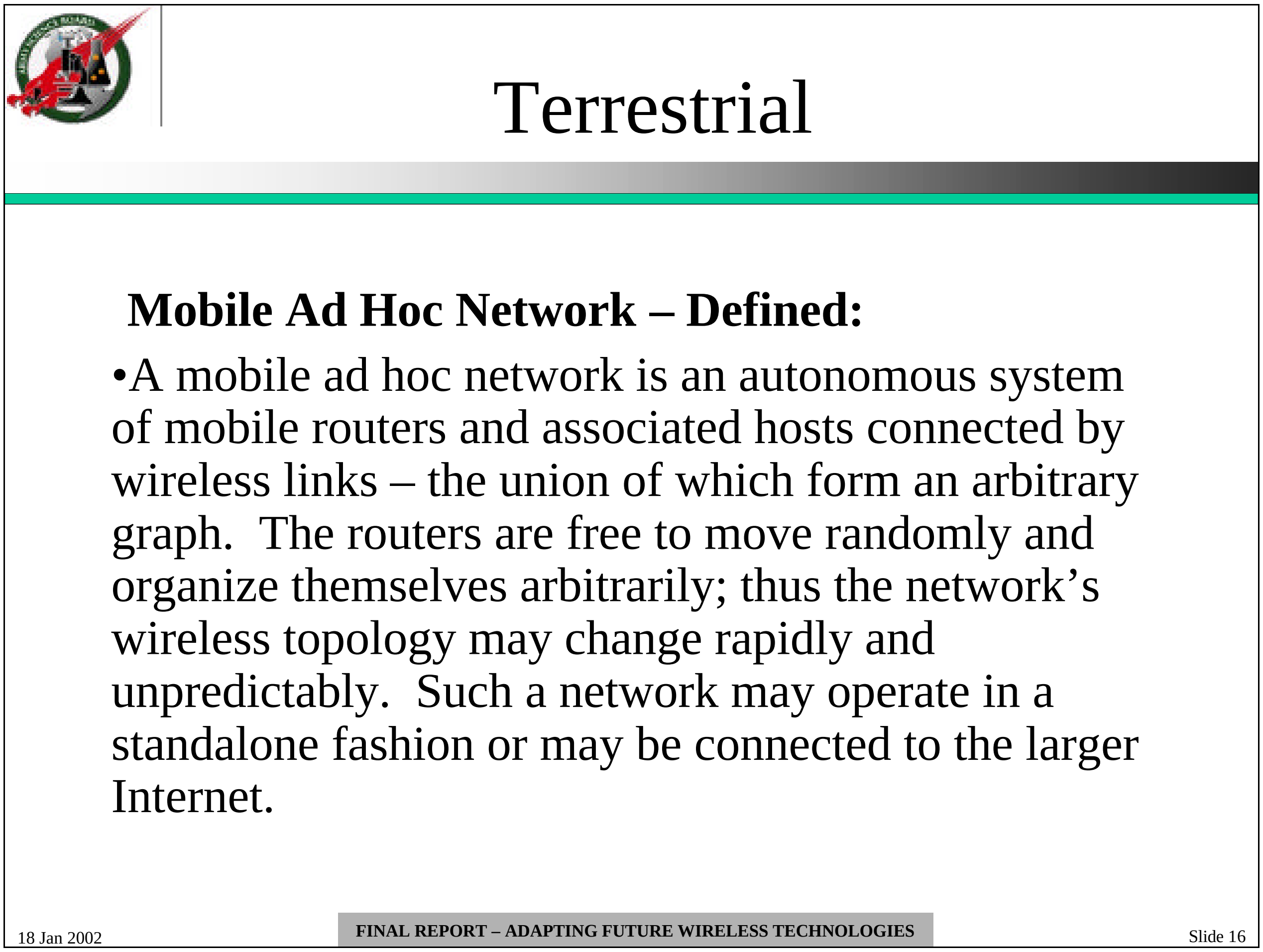
There are promising developments within the commercial sector in device technology. Many of these developments can be applied to Army needs, and there are already efforts to do so in some areas (e.g., CECOM's Universal Handset is based largely on commercial ASIC technologies). There is significant activity in developing multifunction chip sets to enable multi-mode operations in a single handset. The industry already has designed and built handsets that are enabled to switch among multiple air interfaces for cellular connection (CDMA, AMPS), device-to-device device connections (Bluetooth), and wireless LAN connections (802.11x

WLAN). These developments are an affirmation that no single air interface meets all needs, and thus, multi-mode flexibility is going to be required in the near term. This trend in commercial technology development provides opportunities to the Army. We note, however, that COTS products may have some limitations in tactical operations; for example, WLANs have no Type 1 security or packet forwarding, limited AJ/LPD, and constrained frequency availability.

In addition, power management, handset display and processing, and power source technologies are rapidly advancing because battery life and user interface issues are critical to the wireless market. These areas are critical issues to the Army as well, since the emerging vision of the Objective Force includes the provisioning of individual wireless devices for every Soldier.

There are also some promising device developments in antennas. We found significant advances in fixed-tower, adaptive, smart antennas, scanning antennas and tunable components (e.g., ArrayComm, Paratek, Metawave and EMS Technologies). There is more limited focus on wide multiple band ranges, and on-the-move capability. At the handset level, conformal antenna designs beginning to appear in mobile units (e.g., Harris and Paratek).

The findings regarding NETOPS are discussed to some degree in the previous slide. Generally, we have found that large infrastructure operators have extensive technologies in network operations and are heavily involved in QoS management and network optimization (Verizon, SBC, Sprint, Worldcom). We also found that the underlying technologies for these NETOPS systems are developed by many small companies, such as: BlueKite, ByteMobile, Speedwise, TCSI, Ascom, Comarco, Grayson, Scoreboard, Starent Networks, Watercove Networks, Winphoria, and Schema.



During our study of terrestrial wireless technologies, one key technology area that stood out was the utilization of mobile ad hoc networks within tactical military networks . This slide defines mobile, ad hoc networking. To implement the Objective Force C4ISR and maintain reliable, versatile communications through and across all echelons requires integration of ad hoc networks with layered hierarchical networks (land, air, and space segments) in an IP environment. This demands:

• Aggregation of nodes into appropriate multi-hop subnets.

• Representation of broadcast entities such as aircraft, TUAVs as gateways/routers.

• Flexible addressing with automatic configuration.

• Mobility management in highly transient environments - Modifications to Mobile IP.

• Internet Protocol version 6 (IPv6) to Internet Protocol version 4 (IPv4) transition methodology.

The Army must develop methodologies for QoS adaptation (management of routing, priorities, bandwidth, power consumption, frequency) and information assurance with adaptive response based on perceived level of attacks. The Army's R&D approach is based on integration with JTRS-compliant radios and exploitation of their inherent software-definable flexibility for QoS-based performance management. Information assurance demands wireless security protocols. Some wired network mechanisms for encryption and authentication are applicable to wireless networks; Wireless Transport Layer Security (WTLS) of WAP Forum Derived from the Transport Layer Security Protocol (TLS) – RFC 2246; Wired Equivalent Privacy (WEP) – used by 802.11 and Bluetooth; Public Key Infrastructure (PKI) that is considered as a vehicle to distribute private keys. However, dynamic key management in large ad hoc networks can be complex. Within the DoD, GloMo efforts address hierarchical key distribution over multicast networks for Wireless information assurance.

Additional issues in ad hoc, mobile networks are introduced due to vulnerability of wireless networks. Distributed analysis of attack attempts and responses may need to be an integral part of the network management system, along with multi-layer optimization (e.g., routing vs perceived intrusion level).

Findings - Terrestrial

Mobile Ad Hoc Network continued...

- What we found in DoD/Army
  - DoD (DARPA) Programs supporting ad hoc networks: Glo Mo, SUO/SAS, survivable Ad Hoc Routing Protocol (TBRPF), FCS, Ad Hoc networks with directional antennas
  - CECOM MOSAIC
    - Self-healing, mobile ad hoc networks, vertical routing optimization
    - Adaptive self-configuring protocols
    - QoS across the network
- What we found in Commercial
  - Commercial primarily addressing mobile users, but not mobile infrastructure

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This slide summarizes what we have found in the DoD and the Army on these specialized technologies that support mobile ad hoc networking. At the DoD level there are several DARPA programs that have recognized the requirements for mobile ad hoc networking as a central feature in providing robust communications capability to the new force elements and systems, such as the Future Combat System. These programs have been discussed previously in this report.

Within the Army, the MOSAIC program is deserving of special attention because it is the one program that has tackled head-on the technical issues associated with establishing and managing an on-the-move infrastructure supporting an IP-based wireless communication architecture. Programs such as MOSAIC and DARPA’s SUO/SAS are going to be a key source of the enabling technology to support the building of an operational, deployable C4ISR grid for the Objective Force, the Tactical Infosphere.

As stated previously, in the commercial sector we found little emphasis on solving the mobile infrastructure problem. However, some considerable work is being done to provide technical solutions to the problem of mobile IP-based user terminals (handsets and vehicular-mounted devices). Cisco is developing routers for Networks in Motion to provide mobile IP support and optimal routing as a feature of their routers. Some of this work can be adapted to address the ad hoc network problems faced by a highly mobile Objective Force. Much of the focus is on multi-hop network models. This work involves dynamic, flexible IP addressing and is evolving, but it is still too early to tell how much of the commercial technology can be adopted or adapted in programs such as MOSAIC. That is why the MOSAIC program is important; it is the research and development test-bed where the application of specific mobile, packet-routed communications technologies can be tried, and promising adaptations can evolve.

Conclusions And Recommendations – Terrestrial

Conclusions:

- Significant commercial technology advances in multifunction chips, device power, handset display and processing technology, network ops, and power sources available now of value to Army
- Significant political, legal, economic and technical issues
- Mobile Ad Hoc Networks are not being addressed by commercial industry

Recommendations

- Army should work with wireless network carriers to leverage their network management technologies
- Multi-band, multimode capability needs to be pursued vigorously in conjunction with commercial partners and coalition nations
- Develop a process to systematically review new commercial technologies and integrate them into DoD/Army programs in order to leapfrog own research efforts
- Army must continue to take lead to develop mobile infrastructure (e.g., MOSAIC)

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While there is widespread commercial use and advances in air interfaces (such as CDMA, GSM, GPRS, Bluetooth, 802.11, UWB), no single air interface meets multi-functional, multi-terrain, multi-environment Army requirements. Much of the Army's work in adapting commercial wireless is based on heavy reliance on CDMA; yet the world market base is dominated by GSM (only 20% CDMA). The ability to pursue multiple threads in technology adaptation and development is seen as a necessary ingredient to success. Pursuing only CDMA-based solutions may result in technological isolation.

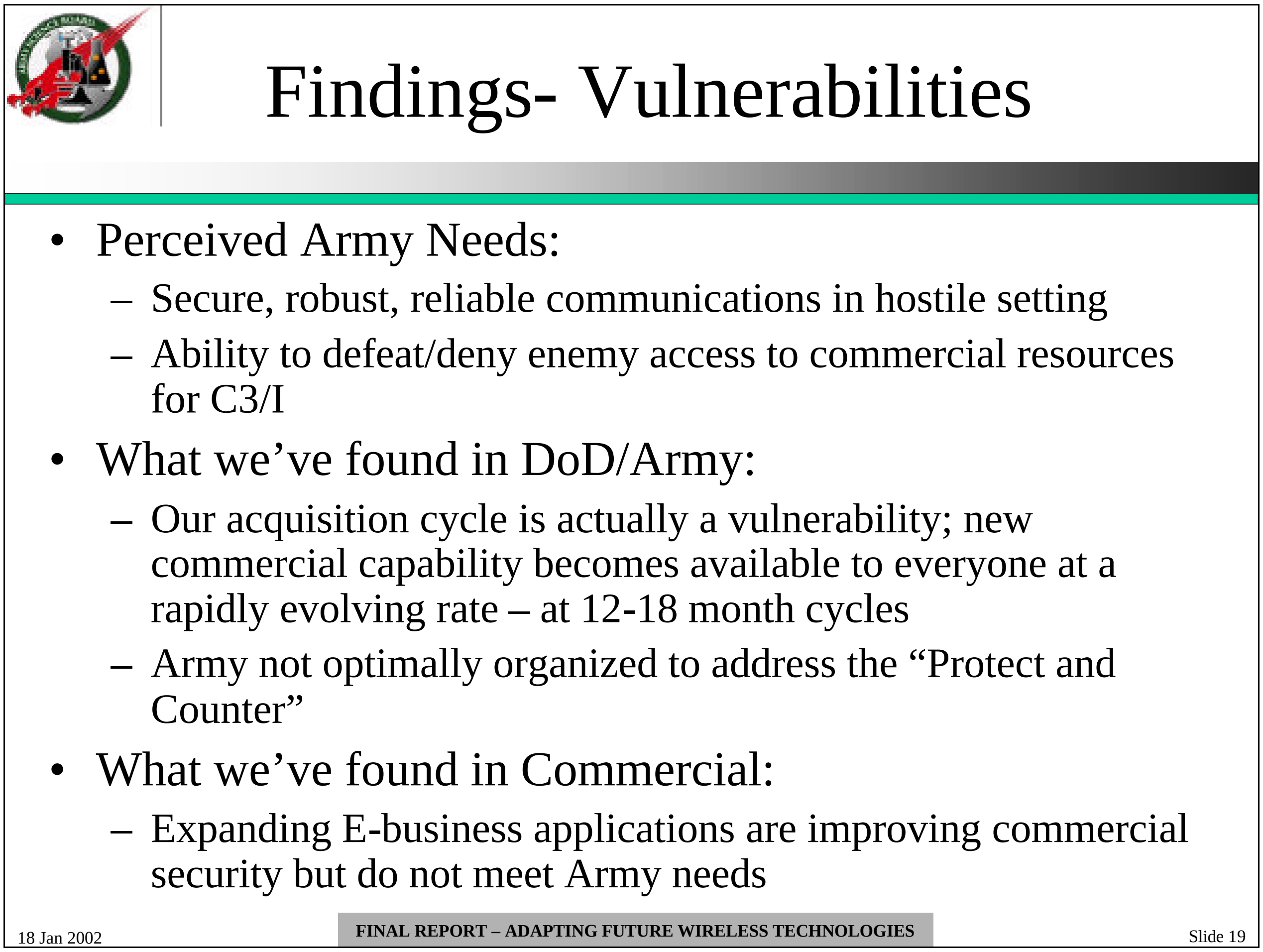
Toward this end, there is a wealth of individual device and component technologies that are very promising. These component technologies should be approached and integrated as piece parts of the total integrated solution for a multi-function, multi-band wireless system of systems. The equipment manufacturers are the logical source of such technologies. In addition to component technologies, such as chip sets and power management, commercial industry has also made some progress toward developing solutions for the complex NETOPS problems associated with wireless networks. Many of these solutions are being applied by the wireless carriers, although they are often developed by small companies specializing in the new breed of network management automation systems.

Applying commercial technologies causes us to address many technical issues. Thankfully, the Army has shown the foresight to start addressing these technical issues. In addition to technology, the authorization to buy and use commercial technology may depend as much on economics and policy. For example, the authorization to build and use CDMA, IS-95 standard modes in each and every military radio depends on the Army's willingness to pay for service, and the carrier's willingness to allow third-party equipment to join their networks.

The one technology area where the commercial industry does not offer a substantial cache of applicable technology is the development of mobile, ad hoc wireless networks that support a highly dynamic, on-the-move infrastructure.

Our recommendations are listed here. We see significant opportunities to partner with wireless infrastructure carriers to leverage their NETOPS technology. We also see significant opportunities to partner with user device manufacturers to influence standards and accelerate deployment of the required multi-mode, multi-function systems such as the Universal Handset and JTRS. And finally, the Army must continue to take the lead to develop mobile infrastructure (e.g.; MOSAIC). Investment in programs such as MOSAIC are critical to moving from our legacy, circuit-switched technologies to an architecture that is capable of supporting Information Dominance.

We should also stress the importance of being a player in some of the forums that influence standards and technologies. For example, some of the working groups that will influence technology are: IETF NGTRTANS WG (Next generation transition); IETF MOBILEIP WG (IP Routing For Wireless/Mobile Hosts); Mobile Ad hoc Network (MANET) IETF MANET WG; Commercial SDR working groups (SDR Forum). Some of these working groups are already being attended by military representation. We should seek a stronger, more influential presence as potential developers and users of the subject technologies.



Previous ASB summer studies have emphasized the critical need for having secure, robust, reliable communications in hostile setting. Features include anti-jam (AJ); low probability of intercept (LPI); anti-intrusion; anti-deception; early warning; secure; quality of information assurance - delivered via ruggedized hardware devices.

A strong corollary to the Army having robust and secure communications is its ability to defeat/deny enemy access to commercial resources for C3/I.

In today's world, where wireless communications is readily available, and in some countries, in advance of what is commercially available in the U.S., hostile agents may have equal or better access, thus having potential parity. The situation is further exacerbated by the Army's acquisition cycle which is geared more for heavy infrastructure equipment (planes, tanks, etc.) rather than rapidly cycled technology components. Further, the lack of a systematic assessment of commercially available technologies (especially wireless technologies) further hinders the Army's ability to defeat or deny enemy access to commercial resources. New commercial capabilities are becoming available to anyone who is nimble, and has the financial resources and wherewithal to integrate and deploy.

What we've found in commercial industry: Expanding electronic and mobile business applications are increasing industry awareness and development of commercial security tools. Commercial companies are developing security tools, network protection (firewalls), network intrusion systems, network monitoring systems, and QoS hardware and software tools. However, they may not be as robust as required to meet military requirements. Generally, commercial developers are not dealing with AJ or offensive EW.

Conclusions and Recommendations - Vulnerabilities

- Conclusions:
  - Commercial industry will offer more and better security solutions as the wireless internet matures
  - Army needs to conduct its own counter and protect program
  - Leveraging commercial advances requires the Army to implement a process:
    - Include modeling and simulation, testing, exercises, and training with realistic countermeasures
- Recommendation:
  - The issue of “protect ours/counter theirs”, and “forceably or covertly acquire theirs” should be addressed simultaneously by the same people
    - Countermeasures should be organic to Objective Force
    - Establish an integrated, technical “Protect and Counter” activity

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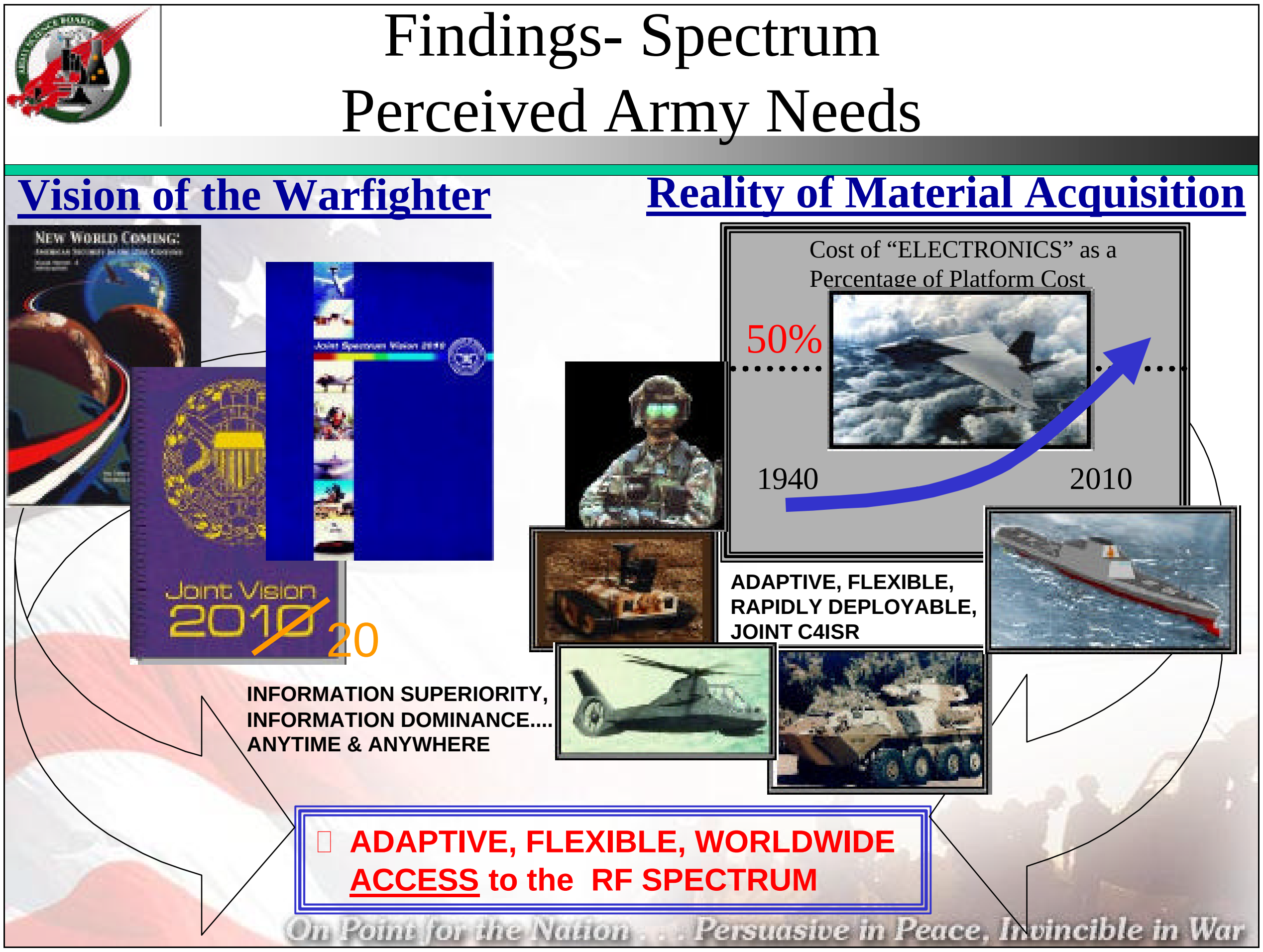
Consumer and enterprise demands will prompt development of more robust and secure solutions, especially as e-commerce opportunities expand and mobile workforces demand greater access to enterprise systems.

Nonetheless, the Army will still need to conduct its own protect and counter programs. The ASB recommends that the Army establish an integrated, technical “Protect and Counter” activity to identify and develop hardening, exploitation and countermeasures solutions for the Objective Force and all Army components of the GIG/WIN-T. Further, we recommend that the “protect and counter” activity be conducted by the same people.

It should be noted that the “protect ours/counter theirs” approach must incorporate a systematic method of tracking communications technology development in real time. Otherwise, the Army’s efforts will consistently lag behind what is readily available to the enemy with financial resources to buy and deploy technology at a more rapid rate than the Army.



The special topic of spectrum is one that pervades all aspects of wireless communications. During the 1990's, the DoD published a number of "vision" documents, all of which depicted a future Warfighter scenario where heavy dependence on Information Dominance was a central feature. The enabling technologies in that vision are mostly wireless, and a central implication is that these wireless technologies must be able to carry far more information, much more flexibly, rapidly and reliably than current radio systems would allow.

The practical expression of that vision is found in the trends and realities of future material acquisition. The new Warfighter platforms, including the individual soldier, are enabled with sophisticated electronics which often comprises over half the cost of the total platform equipment suite. Flexible, adaptive, rapidly deployable C4ISR that can operate at a minimum in a Joint environment, if not a coalition environment, is a feature of every new weapons system, and support system, as well. Wireless connectivity and wireless information networks are the only practical means for achieving the end objective; a force which is based on equipment that inherently provides the ability to command Information Dominance in every situation.

Since the radio frequency spectrum is going to host this wireless explosion, it is clear that the Army will need access to more spectrum than it currently has, just like the other services and the commercial sector, as well. But not only do we need more of it, but the way we must access the spectrum when opposing a clever, technology-enabled adversary must also change. Deploying adaptive, flexible systems anywhere in the world requires that those systems be able to access the spectrum in adaptive, flexible ways, anywhere, anytime. This is why this is a special topic -- the current availability of spectrum in the military is shrinking, not growing; and, the rules, regulations and processes used to provide spectrum access to systems is currently not flexible, adaptive, or even predictable.

Findings – Spectrum

- Perceived Army Needs:
  - Opportunistic systems that are adaptive & agile in the spectrum domain will be significantly more capable, reliable, robust, and survivable
  - Tactical mobile needs will likely double by 2010; FCS and Objective Force requirements will add to that
- What we've found in DoD/Army:
  - DoD has "lost" over 200 MHz to industry
    - Nearly all is Prime Spectrum used by Army for Tactical Mobile Comms
    - More may go to "3G"
  - Current DISC4, Army Spectrum Manager has launched several initiatives: vision, objectives and plan of attack
    - Started network-centric spectrum requirements study (due in FY02)
    - Revising Spectrum Certification process in the Army
    - Developing a Spectrum Management Architecture - Systems, Ops, Tech

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Because the future Army operations will be immersed in multiple, rapidly changing scenarios and environments, the Objective Force will require C4ISR that responds smoothly and effortlessly to the need to connect through the wireless medium. Ideally, Army wireless systems should be capable of operating through existing wireless infrastructure (e.g., cell towers or satellites) when that is the most expedient mode, or operate in a peer-to-peer mode when access to local infrastructure is not possible, or not advisable. Adaptive, agile spectrum access is a prerequisite to such operational capability. In addition, Army wireless systems must be anti-jam, reliable and secure.

According to the most recent predictions for spectrum bandwidth requirements, our spectrum needs to support mobile tactical systems will nearly double by the year 2010. These requirements demand spectrum in the bands that are capable of supporting mobile operations; essentially below 3 GHz. These predictions do not fully address the additional needs of the Objective Force and the Future Combat System (FCS), both of which have evolved since the forecasts where done. At the same time, the DoD is losing spectrum in those same prime bands. Since the passage of the Omnibus Budget Reconciliation Act of 1993 (OBRA-93) and the Balanced Budget Act of 1997 (BBA-97), the DoD has surrendered 247 MHz of prime spectrum to be auctioned to commercial operations. Recent activities to find more spectrum to support 3G implementation in the US have placed even more spectrum in jeopardy. So, while the Army's needs are expanding, our access to spectrum is shrinking.

These trends have not gone unnoticed in the Army. The Army Spectrum Manager in DISC4 has developed a vision of where we should be going, and recognizes cultural differences and entrenchment by current worldwide spectrum management authorities as a significant obstacle. He advocates a National-level fresh look at policy and process, and he advocates spectrum ACTDs to prove-in shared access. The Army Spectrum Manager has also redirected his limited resources to address a vision, objectives and plan of attack that will initiate changes in the process. For example, he has started network-centric spectrum requirements study, and has begun revising the Spectrum Certification process for Army communications equipment that will promote tighter teaming arrangement with developers/PMs. This will promote more rapid acceptance of advanced designs in spectrum access technologies. In effect, the DISC4 Army Spectrum Manager is attempting to arm his spectrum certification staff as agents of change to accommodate new, adaptive, agile systems designs that are capable of implementing shared access to the spectrum. As another initiative, they are developing a SM architecture that will define the systems, operations and technologies needed to support the job of the spectrum manager of the future.

Findings – Spectrum

- What we've found in Commercial:
  - Commercial growth (3G/4G) will demand much more spectrum
  - Auctions: Imbue spectrum with high economic value and vested property interest
    - Estimated amounts (by 2005): $30B - $50B
  - Industry and regulatory interest in "spectrum efficiency"

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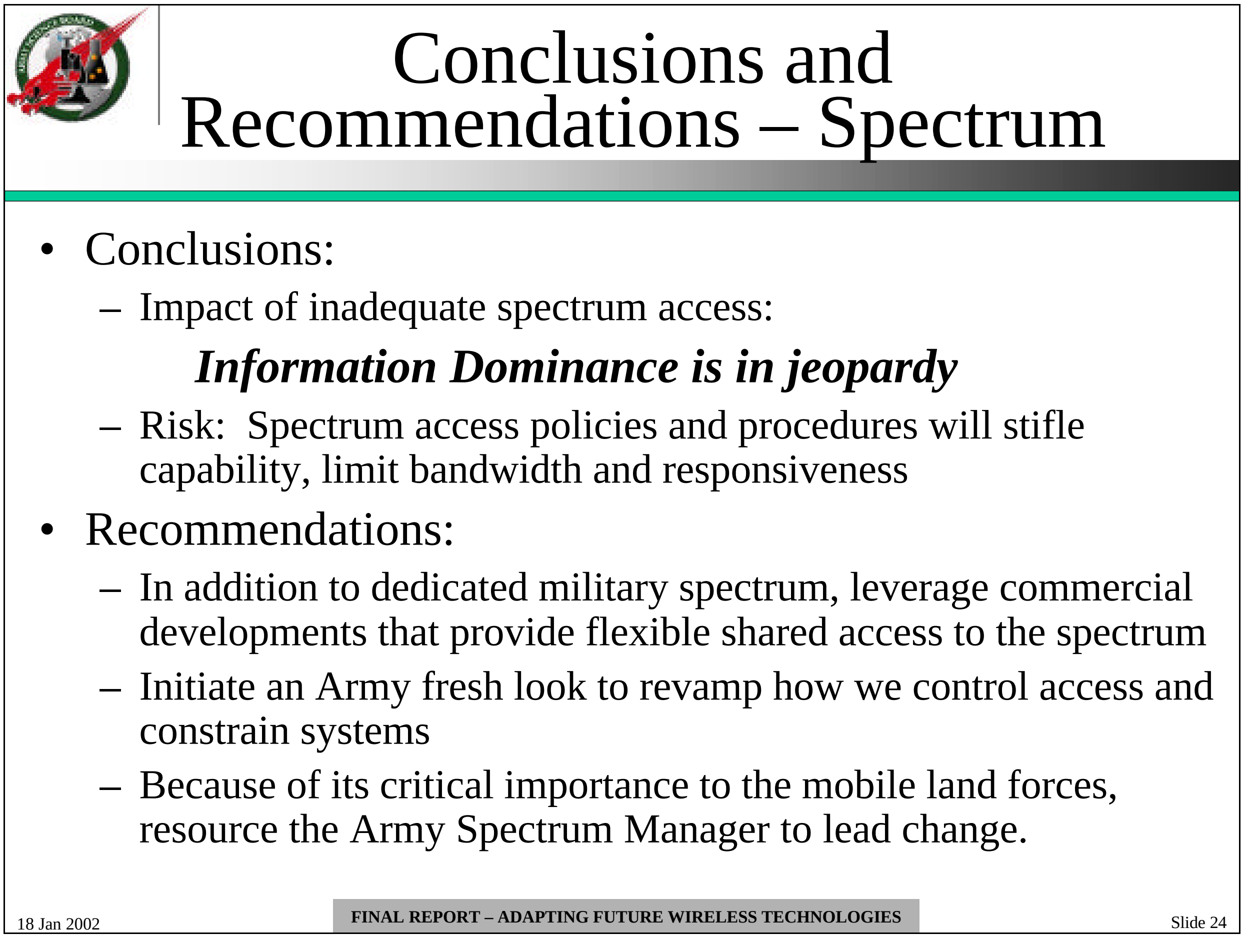
At the height of the telecommunications building boom in the commercial wireless industry, estimates of the spectrum required to support the evolution of 3G and 4G systems were as high as 400 to 600 MHz, depending on the geographic area. This spectrum will also be needed from the prime spectrum bands, below 3 GHz. Many of these estimates have been revised since the bubble burst in the industry, but demand and pressure is still high.

The effects of these projected needs are rapidly working their way to the auction block, where spectrum is sold to the highest, qualified bidder. While the auctions appear on the surface to be a sensible way to distribute spectrum access and recover revenue for the Government at the same time, a more subtle effect of this process is also set in motion. That effect is the vestment of property interest in the spectrum holdings. It brings with it all the legal entanglements of dealing with property; for instance, when a spectrum "owner" declares bankruptcy. By 2005, as much as $50B, and perhaps more, will have been spent on spectrum in the US alone, with twice that being spent abroad. This trend tends to reinforce the ownership model of spectrum management, and makes sharing, and spectrum agility by Army systems a tough sell.

Because this resource is so valuable, the private sector invests heavily in "spectrum efficiency" technologies. Emphasis has been on adopting spectrum efficient air interfaces (e.g., CDMA, QAM, OFDM) and implementing spatial reuse (e.g., smart antennas & site topologies). The commercial sector is also pursuing multiple air interface technologies that leverage the effective spectrum use that is made possible by designing adaptive, agile systems. For example, commercial vendors are combining multiple band CDMA (e.g., 900 and 1900 MHz), Bluetooth (2400 MHz) and 802.11 WLAN (2400 MHz) into a single handset (e.g., QualComm). Multiple-air interface, software-defined base stations are also being designed and built, although it is not certain whether the operators see the business case for investing in those technologies, at this time.

There is also increased regulatory interest in spectrum efficiency reflected in recent FCC activities, such as:

- Software Defined Radio - FCC NOI and NPRM
- Ultrawideband - FCC NOI and NPRM
- Secondary Markets - FCC NOI and NPRM



When considering the opposing trends in Army spectrum requirements and Army spectrum access, it seems that one of the foundations of our vision for success, Information Dominance, may be in jeopardy unless we make some fundamental changes to our policies and procedures. Because spectrum has become so valuable, it is increasingly difficult to negotiate access to it. It's like beachfront property; most of it is privately owned, you can't go there without the owners permission, and the owner doesn't want you there whether he is using it or not. On the other hand, because spectrum is so scarce, industry and the DoD have both begun to invest in spectrum efficient technologies, and are beginning to consider alternative ways of getting the most out of the valuable resource.

It is clear that the Army Spectrum Manager's office in DISC4 has already begun to worry these issues. To optimize the Army's ability to leverage the advantages of spectrum access, instead of being constrained by lack of access, we recommend the Army do the following:

• Work with FCC and industry:

1. To integrate commercial modes/air interfaces into Army systems,
2. Obtain shared access to commercial spectrum and infrastructure, and
3. Conduct cooperative ACTDs to prove shared access can work.

• Initiate an Army "fresh-look review" to revamp how we control access and constrain systems. We should commission the review with "new players", not the same spectrum experts who keep repeating the same solutions founded on the Communications Act of 1934.

• Commit the Army to play in the National arena and pursue a National Spectrum Plan.

• Resource the Army Spectrum Manager to lead the change

Findings - Acquisition

- Perceived Army Need:

  "THE UNPRECEDENTED LEVELS OF INTEGRATION NECESSARY FOR OBJECTIVE FORCE PLATFORM AND C4ISR SYSTEMS DEMANDS EXPANDED AND NEW ENTERPRISE-WIDE ORGANIZATION AND PROCESS FOR RDA AND REQUIREMENTS" *

- Goal: ***A C4ISR architecture that is evolvable by design***

*ASB Summer Study 2000, Technical and Tactical Opportunities For Revolutionary Advances in Rapidly Deployable Joint Ground Forces in the 2015-2025 Era, Information Dominance Panel

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Our vision of future C4ISR in the Army was described in last years Summer Study. In that vision we expect the integration of multiple functions into "single box" implementations. Convergence of data processing and RF technologies will enable multi-mode, multi-band, adaptive wireless systems that can support a range of requirements for communications and sensing. To achieve such unprecedented levels of integration, the Army must adopt new and different approaches to requirements definition, and research, development and acquisition (RDA).

Two prominent changes in the attributes of these future C4ISR systems-of-systems are driving toward significant changes to our acquisition processes. These are:

• Convergence of technologies into single, integrated systems enabling multiple functions that have heretofore been "procured" as separate enabling technologies, under separate procurement programs. Ultimately, the vision anticipates convergence of information technology, communications, intelligence, sensors, surveillance and electronic warfare into each individual platform, including the individual soldier. Each single platform operates in the network-centric environment where the knowledge management and command & control functions are managed for that platform through wireless-technology-enabled interactions with its surroundings; both friendly and hostile.

Procurement of such converged, integrated systems may also demand convergence of acquisition authority and expansion of new technology procurement processes.

• Aggressive use of commercial wireless technologies in the integrated, multi-function electronic suites within each platform. These commercial technologies will demand adaptation to commercial modes of operation, and commercial technology "acquisition" cycles that drive the commercial wireless marketplace. It is important to note that adaptation to commercial modes of operation must be implemented as complementary to required military modes within military systems, and not as a outright substitute for military systems. This makes the role of RDA more complex, and the importance of integration and convergence increases dramatically in the acquisition of new systems.

The goal of the acquisition process must be to put into place the trappings to institutionalize development of C4ISR systems under an architecture that is "Evolvable-by-Design". What we mean by that is best illustrated by example: when the C4ISR suite for the Future Combat System is operational in 2015, the system should be able to accept addition of a new sensor suite as easily as a new "WebCam" video camera and supporting software is loaded into a PC; or, when 4G wireless air interfaces and user applications begin hitting the market in 2012, the soldier radio/electronic suite should be able to be upgraded to add the militarized version of that modality to the communications functions available to the soldier.

Findings - Acquisition

- What we've found in the DoD/Army:
  - The Global Information Grid (GIG) CRD establishes an open systems architecture (OSA) for DoD C4ISR
  - Army's WIN-T will conform to the GIG CRD
  - Resource Issues:
    - CECOM RDEC funding level only permits limited, single-thread technical approaches
    - CECOM RDEC ability to be technology integration agent is not being maximized for technology insertion and upgrade
    - Army funding process discourages abandonment of unpromising technologies
- What we've found in Commercial:
  - Commercial technology "acquisition" pursues multiple threads until one or more dominates
    - Examples: Beta vs VHS vs DVD
  - Strategic partnerships critical to shortening time to market- Army could benefit from similar arrangements

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The Global Information Grid (GIG) CRD describes an open systems architecture for DoD C4ISR. This architecture facilitates "plug-and-play" of commercial products and technology, including wireless systems. Within the Army, it is the Army's WIN-T system that will host many, if not most of the wireless technologies that will be fielded by the Tactical Army during the next 15 to 20 years. Together with the Tactical Internet, WIN-T is identified as the core of the Army Tactical Infosphere; one of the Army's central pieces of the GIG. At this time, it is expected that WIN-T will conform to the GIG CRD. The WIN-T acquisition strategy is based upon integration of commercial wireless technology such as that identified in this study; however, it is not clear how the functional integration described in our vision will be accommodated in the procurement. It is also not clear how the rapid evolution of commercial wireless technologies will be accommodated in lock-step with the WIN-T acquisition to effectuate an "Evolvable-by-Design" architecture.

When we looked at the research and development within the Army's CECOM RDEC, we found constraints imposed by both resource limits, and business processes. Because the integration of commercial modes into military systems will require mostly adaptation, rather than outright adoption, a significant amount of R&D is still required. Often there are several approaches in the marketplace that may succeed for the Army, just as there are in the commercial market. Due to resource constraints, the Army can only afford to pursue one technology thread, and hope that it turns out to be the winner. The Army R&D community is also constrained by the lack of a well-defined and aggressive ability to act as a technology integration agent within formal procurement programs. For example, there are some very promising developments being pursued in several of the RDEC programs; e.g., Universal Handset, MOSAIC, Tactical PCS. However, it is not clear how these developments might be reflected in the WIN-T procurement when that procurement finally gets legs and has its own momentum, along with its strict requirements for delivery. Our third observation relates to the business processes associated with budgeting and funding of formal programs. It appears that the formalities of establishing programs geared toward Science and Technology Objectives (STO's) introduce a significant down side; that is, the reluctance to give up on unpromising technologies and shift quickly to pursue promising technologies. Often there is ample technical evidence to justify a radical change or abandonment of approach, but such a change jeopardizes program funding. The R&D funding process must accommodate more agility. We recognize that, in the extreme, allowing too much freedom of programmatic approaches could also lead to chaos and waste. At this time it seems we are unduly constrained in the other extreme, thereby choking off the ability to abandon dead-end technologies and reprogram funds to pursue the best opportunities in lockstep with the rapid time-scales of commercial wireless development.

When we reviewed the equivalent commercial acquisition process, several attributes stood in stark contrast to the Army. First, commercial industry, especially US industry, typically pursues multiple technology threads and lets the market decide, for better or worse, as the case may be. Some examples are: BetaMax vs VHS vs DVD in the 1980s and 1990s video recording technology wars, where it was not at all clear that the best technology won the day until the recent conversion to DVD; and, as a second example, the current divide between wireless CDMA and TDMA camps, where both standards are thriving and may not converge for 10 or 20 years, if at all. In addition, commercial industry uses business practices and relationships to “catalyze” development and shorten time to market. There are strategic partnerships among wireless operators, equipment vendors and, more recently, information technology companies. Also, venture capital companies play an invaluable role by researching technology sources and funding new technology development.

It goes without saying that the commercial side of wireless technology research and development enjoys a distinct advantage: money. The estimated annual revenue from wireless services in the US is expected to be near $80B by 2005. The amount of investment in wireless technology infrastructure to tap into that market is enormous, estimated to be over $100B already, and growing.

Recommendations – Acquisition

- Enhance CECOM role as a technology integration agent
- Adopt procedures that allow CECOM to stop technology review if it is not promising/appropriate w/o fear of funding loss
- Establish process to insure funding is set aside to transition promising technologies (such as from DARPA to the services for acquisition)
- PM acquisition programs need funding to do major systemic improvements to incorporate newer technology and systems after initial fielding. Example: ACUS Modernization upgrade, not typical P3I
- Possible new approach to technology assessment: Army should establish a capability to seek, identify and evaluate promising technologies the way VC firms do.

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The business practices of Army acquisition need to become better adapted to develop systems under a communications architecture that is Evolvable-by-Design, thus allowing for continuous upgrades in a plug-and-play fashion, as contemplated in the GIG concept. To enhance the Army's ability to work toward such a goal, we have identified some specific recommendations.

First, the Army needs an emerging technology integration agent for evaluation, development, and to serve as a bridge to implementation within established acquisition programs, such as the WIN-T. CECOM RDEC has a significant role to play as a technology integration agent; they are already serving in that role for research and development of new technologies offered by the commercial sector (e.g., MOSAIC, Universal Handset, BSN). However, their role to insert successful program technologies into existing programs is not clearly defined. If CECOM RDEC is the logical candidate to serve as the emerging technology integration agent for new technologies, the Army should define and implement the following:

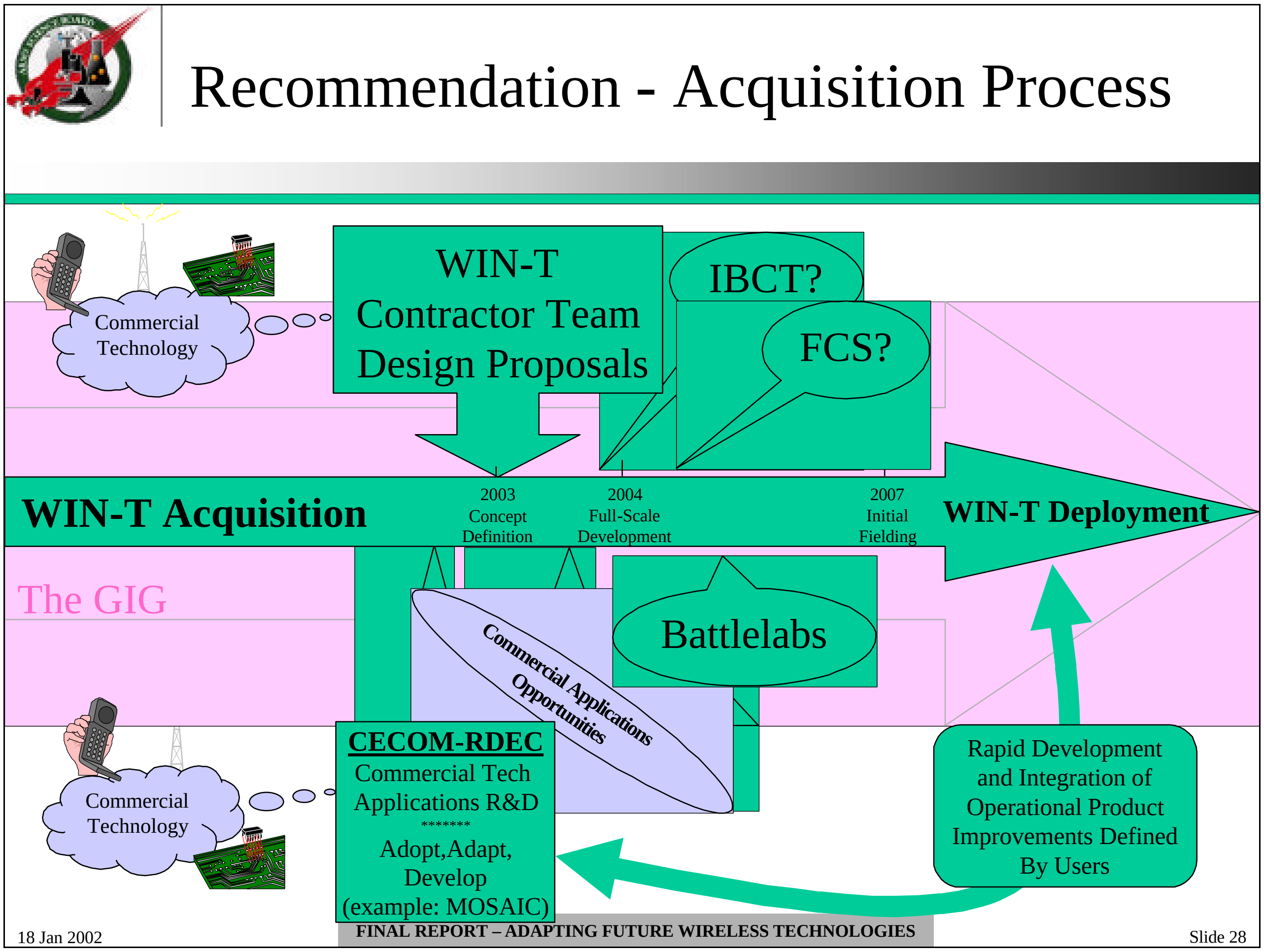
- Develop new procedures to allow for abandonment or redirection of R&D programs which have become less promising, without jeopardizing funding or otherwise invoking disincentives for the research effort.

• Develop a better pre-deployment process to transition RDEC programs into system designs without violating procurement guidance, or defeating contractor initiative.

• A post-deployment role should be established. For example, RDEC should become the source for WIN-T wireless information technology insertion and upgrade.

• Provide for setting aside sufficient funds in every C4ISR acquisition program to resource transition of new, promising technologies during both the pre-deployment, and post-deployment stages of procurement. In addition, sufficient R&D funds to pursue multiple technology threads must be available to RDEC.

The Army should also explore possible new approaches to technology assessment. Specifically, the Army should consider establishing a capability to seek, identify and evaluate promising technologies the way VC firms do. These firms seek out promising, small, high-tech firms, and establish partnerships with them through CRADAs, joint ventures, or dual-use technology contracts. An interesting precedent for a business model can be found in the In-Q-Tel and CIA relationship. In-Q-Tel, sponsored by the CIA, evaluates applicable IT for possible investment to produce valuable products for the CIA, as well as commercial product development. The process of reviewing promising technologies using this business model seems to offer some advantages by simultaneously evaluating commercial market viability and technology worthiness across a broad range of technology sources.



This graphic is an attempt to illustrate a possible process for implementing an acquisition approach that promotes integration of new, promising technologies into an communications architecture that could become "Evolvable-by-Design".

The WIN-T program is used as the basis for this illustration because it is a centerpiece of the Army's communications infrastructure for the foreseeable future. Thus, WIN-T must host many of the new wireless technologies adopted, adapted or developed by the Army. The WIN-T acquisition program is depicted as the solid green horizontal arrow in the middle, immersed in a larger, less well defined collection of information information systems acquisition programs called the GIG. The timelines shown are approximate, and are being used for illustration purposes, only.

The formal role of defining system design is primarily vested in the contractors that will be chosen to build the system, as shown above the WIN-T arrow. While these contractors will be encouraged to introduce commercial technologies into the design, there is a danger that those designs will become static at the time of the contract issuance, unless specific provisions for evolution of the design are introduced. The role of other C4ISR capabilities produced in related programs (such as the Interim Brigade Combat Team, and the Future Combat System, and other R&D efforts) must be defined, and a path for integration of new and good designs must be established.

Our recommendation is that the CECOM RDEC become the designated agent to integrate new technologies into the Evolvable-by-Design architecture, as illustrated in the bottom part of the graphic. RDEC should be the action agency for research and development of promising commercial technologies, as they currently do. But in addition to that R&D role, RDEC should have a formal role in transitioning their success stories into actual program elements within the WIN-T acquisition program. These technology transitions must be capable of being incorporated at various times within the life-cycle of the WIN-T program, to include post-deployment introduction of product improvements (such as introduction of a militarized 4G waveforms into the WIN-T system). The commercial technology opportunities can flow directly from CECOM RDEC, or may flow from other sources such as a successful test or demonstration at one of the Battle Labs.

To do this, both the operating practices of CECOM RDEC must be changed, and the acquisition processes and procedures within the program managers offices must change to accommodate an evolving system design that promotes integration of Army-developed as well as contractor-developed technologies as an essential part of the contractor's performance.

Overarching Conclusions

- Wireless technology is critical to Information Dominance: DoD/Army current efforts in communications infrastructure (space, air & terrestrial) may result in shortfall - "no dial tone"
- Significant commercial activities in most sectors can be a "short cut to the future"
- In space there are a number of providers which can supply services with business reasons to do so and Army can be a valued customer
- SATCOM transmission and network operations technologies can be of significant value - may also be transferred to UAV platforms
- No single air interface meets Army needs under all circumstances
  - Multi-band, multi-mode handsets and mobile infrastructure need to be developed - leverage commercial advances
  - May require a new paradigm: dynamic, shared access to spectrum
- Critical gap in Airborne Relays - no abundant commercial technology - Army must lead on UAV relay

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Based on the forgoing findings, this chart provides a summary of the main, overarching conclusions reached by the Study Team.

Implications for Organization and Personnel

- Rapid convergence of wireless communications and information network technologies is pressuring different organizations and personnel skills to converge, also
- Army needs to move from thinking of communications as purely radio waves to new air interfaces, new waveforms, and complex network operations
  - Signal officers are becoming network managers… network managers are becoming signal officers.
- Training and Doctrine issue: Are we organized and trained to do the wireless Network Operations job?

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Rapid convergence of wireless communications and information network technologies is pressuring different organizations and personnel skills to converge, also. The Army needs to move from thinking of communications as purely radio waves to new air interfaces, new waveforms, and complex network operations. Within the Army, communications should be viewed in context of "Network Operations" – convergence of voice and data. As a result, the signal organization has to transform. Signal officers are becoming network managers… network managers are becoming signal officers. We may need to look at our training and doctrine to be sure it is consistent with this trend.

Overarching Recommendations

- Invest more in wireless infrastructure leveraging commercial advances - partner with wireless carriers, developers, operators
- Leverage commercial technologies which focus on multiple air interfaces, and access to multiple bands
  - JTRS should be directed toward incorporating future commercial waveforms
  - Re-engineer the spectrum management business model for obtaining flexible, shared access to spectrum – leverage SDR research
- Establish a process for systematically evaluating new, disruptive technologies & integrating into the GIG – look at In-Q-Tel model
- Within the Army, communications needs to be viewed in merged context of "Network Operations" – convergence of voice and data
- Initiate a Summer Study on UAVs and payloads
- Continue study in commercial wireless area

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Based on the findings of this study, the Study Team recommended a number of actions listed in the preceding parts of this report. The overarching recommendations are shown on this slide. The last two pertain to continued ASB studies. Because of the perceived significant gap in UAV communications deployment, we recommend that the ASB conduct a study on UAV communications technologies and operational requirements. We further recommend that the ASB Ad Hoc Commercial Wireless Panel continue its work. Given the short (11 weeks) the panel had to conduct this review, there are significant developments in wireless technologies that were not examined. In addition, the rapid pace of changes in this technology area requires a nearly continuous refresh rate.

APPENDIX A

TERMS OF REFERENCE

TOR Summary

- Assumptions
  - Study participants will leverage associated past study efforts by the Army, other Service Science Boards and RAND
  - Army Objective Force units will be fielded in the 2010 timeframe
  - These units will be highly mobile, extremely deployable and adaptable to emerging situations.
  - Conduct enroute mission planning and accessibility to "up to the minute" logistical information will be required.
  - Equipment ruggedization may be a key acquisition criterion.
  - A portion of operational communications must be secure & robust.
  - Terrain and operational tactics will drive the communications technology needs and developments.

TOR Summary

- Guidance
  - Examine potential future commercial wireless capabilities and recommend which may have applicability for the Objective Force.
  - Identify the range and source of devices that may operate in most deployment situations-desert, urban, and jungle.
  - Provide specific recommendations and associated next steps for incorporating graphics, future voice capabilities, available power sources, computer visioning capabilities, and future information management and compression technologies.
  - Identify and evaluate process models on how Army might integrate future technologies.
  - Identify and assess opportunities for the Army and military to become more involved with and facilitate shaping emerging commercial standards and protocols.

TOR Summary

- Guidance (continued)
  - Identify and assess wireless technologies that may enhance and support the features required to ensure tactical information dominance.
  - Address the role of information management in sizing system capacity and issues such as quality of service.
  - Evaluate the degree of enhancement that could be offered by commercial technologies in each of the layers in the 3-D architecture (terrestrial, A/B, space) to achieve connectivity.
  - Address vulnerabilities and methods to counter use by adversaries.
  - Address issues posed by legacy systems.
  - Address joint and coalition issues.

TOR Items Addressed

- Examine potential future commercial wireless capabilities and recommend which may have applicability for the Objective Force.
- Identify the range and source of devices that may operate in most deployment situations-desert, urban, and jungle.
- Identify and evaluate process models on how the Army may integrate future wireless technologies.
- Identify and assess opportunities for the Army and military to become more involved with and facilitate shaping emerging commercial standards and protocols.
- Identify and assess wireless technologies that may enhance and support the features required to ensure tactical information dominance.

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To reduce the TOR to a practical scope, the panel focused on these specific TOR items.

The Terms of Reference memorandum follows in full.

DEPARTMENT OF THE ARMY
OFFICE OF THE ASSISTANT SECRETARY OF THE ARMY
ACQUISITION LOGISTICS AND TECHNOLOGY
103 ARMY PENTAGON
WASHINGTON DC 2031-0103

2 MAR 2001

REPLY TO
ATTENTION OF

Mr. Michael Bayer
Chairman, Army Science Board
2511 Jefferson Davis Highway, Suite 11500
Arlington, Virginia 22202

Dear Mr. Bayer:

I request that the Army Science Board (ASB) conduct a study on "Adapting Future Wireless Technologies" as a means of exploring opportunities for modernizing the Objective Force given future budgetary constraints. Appointed ASB members and consultants to this study are to consider the Terms of Reference (TOR) as a guide and may expand the study to additional relevant issues. Modifications to the TOR must be addressed with the Chairman of the ASB.

Background:

a. Army modernization will continue to be a challenge in the near and mid term due to very little upward movement in the Army's budget top-line. Modernization will be based on both 1) adopting or adapting commercially available technologies or developing technologies internally to meet Army needs; and 2) using potential industry business processes that quickly jump-start and leverage emerging technology.

b. I envisage that this study will provide practical insights into potential opportunities for leveraging the significant wireless technologies to maintain modernization during an era of flat or declining budgets as percentage of the gross domestic product. The results of the study should highlight science and technology opportunities that will assist Army Leadership prioritize research, development and acquisition in order to yield dramatic improvements to the Objective Force. The study should also highlight potential pitfalls associated with adapting commercial wireless technologies to determine the viability of using such an approach for modernization.

Assumptions:

(1) Study participants will leverage associated past study efforts by the Army, other Service Science Boards and RAND.

(2) Objective Force units will be fielded in the Army beginning in the 2010 timeframe.

(3) These units will be highly mobile, extremely deployable and adaptable to emerging situations.

(4) They will be required to conduct enroute mission planning and have accessibility to up to the minute logistical information.

(5) Equipment ruggedization may be a key acquisition criterion.

(6) At least a portion of operational communications must be secure and robust.

(7) Terrain and operational tactics will drive the communications technology needs and developments.

TOR: The study should be guided by, but not limited to the following:

(1) Examine potential future commercial wireless capabilities and recommend which capabilities may have applicability for the Objective Force.

(2) Identify the range and source of the devices that may operate, or show the promise of operating, in most deployment situations – desert, urban, and jungle.

(3) Provide specific recommendations and associated next steps for incorporating graphics and future voice capabilities as well as available power sources, computer visioning capabilities and future information management and compression technologies.

(4) Identify and evaluate process models on how the Army might integrate future technologies.

(5) Identify and assess opportunities for the Army and military to become more involved with and to facilitate shaping emerging commercial standards and protocols.

(6) Identify and assess wireless technologies that may enhance and support the features required to ensure tactical information dominance.

(7) Address the role of information management in sizing system capacity and issues such as quality of service (QOS).

(8) Evaluate the degree of enhancement that could be offered by commercial technologies in each of the layers in the 3-D architecture (terrestrial, A/B, space) to achieve connectivity.

(9) Address vulnerabilities and methods to counter use by adversaries

(10) Address issues posed by legacy systems

(11) Address joint and coalition issues

Study Sponsorship: Co-Sponsors for this study will be Assistant Secretary of the Army (Acquisition, Logistics and Technology); Director for Information Systems Command Control, Communication and Computers; Commanding General, Communications and Electronics Command; and Commanding General, U.S. Army Signal School.

Schedule: The study panel will initiate the study immediately and conclude its effort by June 30, 2001.

Sincerely,

Kenneth J. Oscar
Acting Assistant Secretary of the Army
(Acquisition, Logistics and Technology)

APPENDIX B

SITE VISITS AND BRIEFINGS RECEIVED

Fact Finding

	Operators/Service Providers	Hardware Developers	Software Developers	Intellectual Property Developers	Government R&D	Government Acquisition	Others
GOVERNMENT							
PEO C3S					X	X	
CECOM					X	X	
SIGCEN						X	
DARPA FCS Comm					X		
DARPA FCS					X		
INDUSTRY							
BBN				X			
Speedcom			X	X			
Aether				X			
Electric Fuel		X					
Global Star	X						
Gilder Report							X
CISCO		X	X	X			
Motorola		X	X	X			
Harris		X		X			
Raytheon		X		X			
Ellipso	X			X			
Time Domain		X		X			
SRI	X		X	X			
XM Satellite Radio	X		X	X			
Verizon	X	X					
Worldspace	X		X	X			
Terabeam	X	X	X	X			
Echostar	X		X	X			
Qualcomm		X	X	X			
Microsoft			X				
In-Q-TEL				X	"X"		X

Sites Visited and Presentations

- Mar 21-23: CECOM - Fort Monmouth, NJ
  - Army Systems Engineering Office (ASEO) - Mr. R. Herrick
  - Information Dominance, 2000 - Mr. J. Cittadino
  - PEO C3S COMM Overview - Mr. J. Latham
  - S&TCD Overview - Mr. D. Keetley
  - MOSAIC - Mr. G. Blohm
  - Sensor Networks - Ms. G. Grant
  - Spectrum/Bandwidth - Mr. P. Major
  - Information Assurance - Mr. C. Pilla
  - Universal Handset & PCS - Mr. F. Loso
  - Wireless LAN - Mr. J. Inserra
  - Army IPv6 Initiatives - Ms. M. Farah-Stapleton
  - IDM-T in the Lab - Mr. M. Rzeplinski
  - Tour SATCOM Test Facility - Mr. K. Blum
  - Tour Labs (PCS, WRN, Wireless LAN, PING, BSN) - Ms. N. Gibson

Sites Visited and Presentations

- April 17-19: Commercial Wireless Companies, Meeting One -Presidential Towers, VA
  - SIGCEN – Mr. T. Mims
  - DARPA – Dr. J. A. Freebersyser
  - BBN – Mr. C. Elliott
  - Speedcom – Mr. L. Watkins
  - Aether – Mr. K. Whitehead
  - Electric Fuel – Mr. R. Putt
  - Global Star – Mr. L. Murphy
  - Gilder Report – Mr. N. Tredennick
  - Cisco – Mr. E. Paradise
  - Motorola – Mr. K. Brady, Mr. B. Fivek, Mr. S. Sharkey
  - Harris – Mr. M. Barron, Mr. E. Svatik, Mr. J. Sonnenberg
  - Raytheon – Dr. M. Unkauf, Mr. J. Rodriguez
  - Ellipso – Mr. G. Helman, Mr. J. Brosius, Mr. D. Castiele
  - Time Domain – Dr. D. Kelly, Mr. F. Koye
  - FCS C4ISR – Mr. R. Ruth
  - SRI – Dr. Sastry

Sites Visited and Presentations

- May 23: US Army SIGCEN - Ft. Gordon, GA
  - Emerging Communication Requirements - Defense Communications Division
  - Extending the Littoral Battlespace/Fleet Battle Experiment-I (ELB/FBE-I) - Battle Command Battle Laboratory
  - Millenium Challenge 2002 (MCO2) - Battle Command Battle Laboratory
  - Tour of the Battlelabs

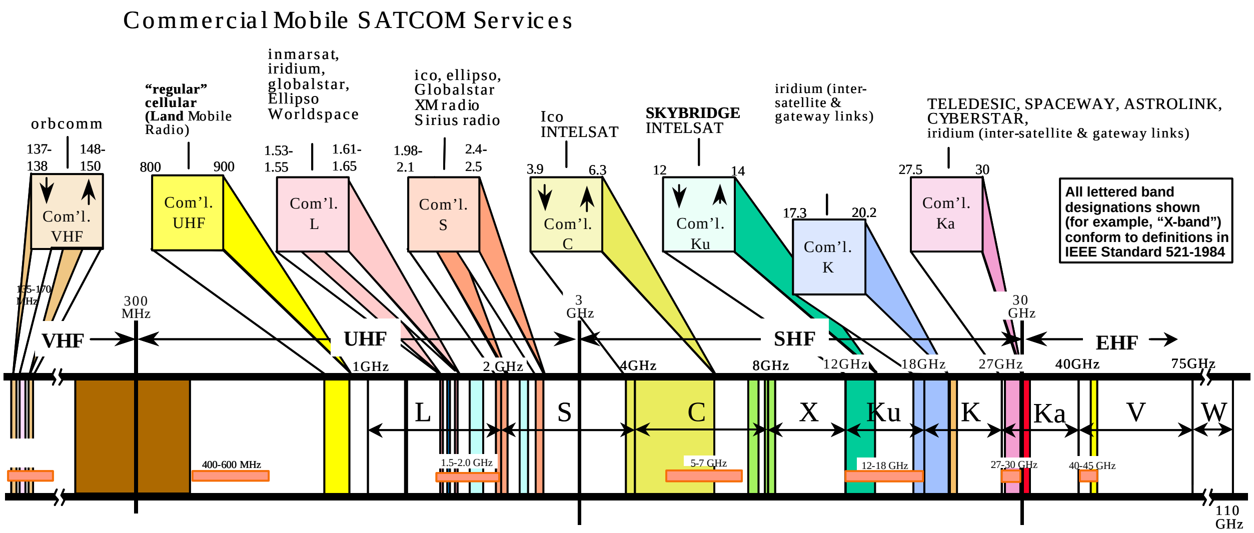
Sites Visited and Presentations

- Jun 4-5: Commercial Wireless Companies, Meeting Two - Presidential Towers, VA
  - XM Satellite Radio – Mr. J Wormington
  - Verizon – Mr. R. Phillips, Genuity & Mr. B. Fleming
  - Worldspace - Dr. S. J. Campanella, Mr. P. Kim, Mr. J. Drexler, Dr. T. Abdel-Nabi
  - Terabeam – Mr. J. Olson Mr. J. Schuster
  - Echostar Data Networks – Mr. J. Stratigos
  - Qualcomm – Mr. M. Lapidula
  - Time Domain - Dr. D. Kelly
  - Microsoft – Mr. J. Justice
  - In-Q-TEL - Mr. R. Stratton

APPENDIX C

SATCOM FINDINGS

Commercial SATCOM Frequency Usage



Emerging Commercial Mobile Narrowband SATCOM Systems

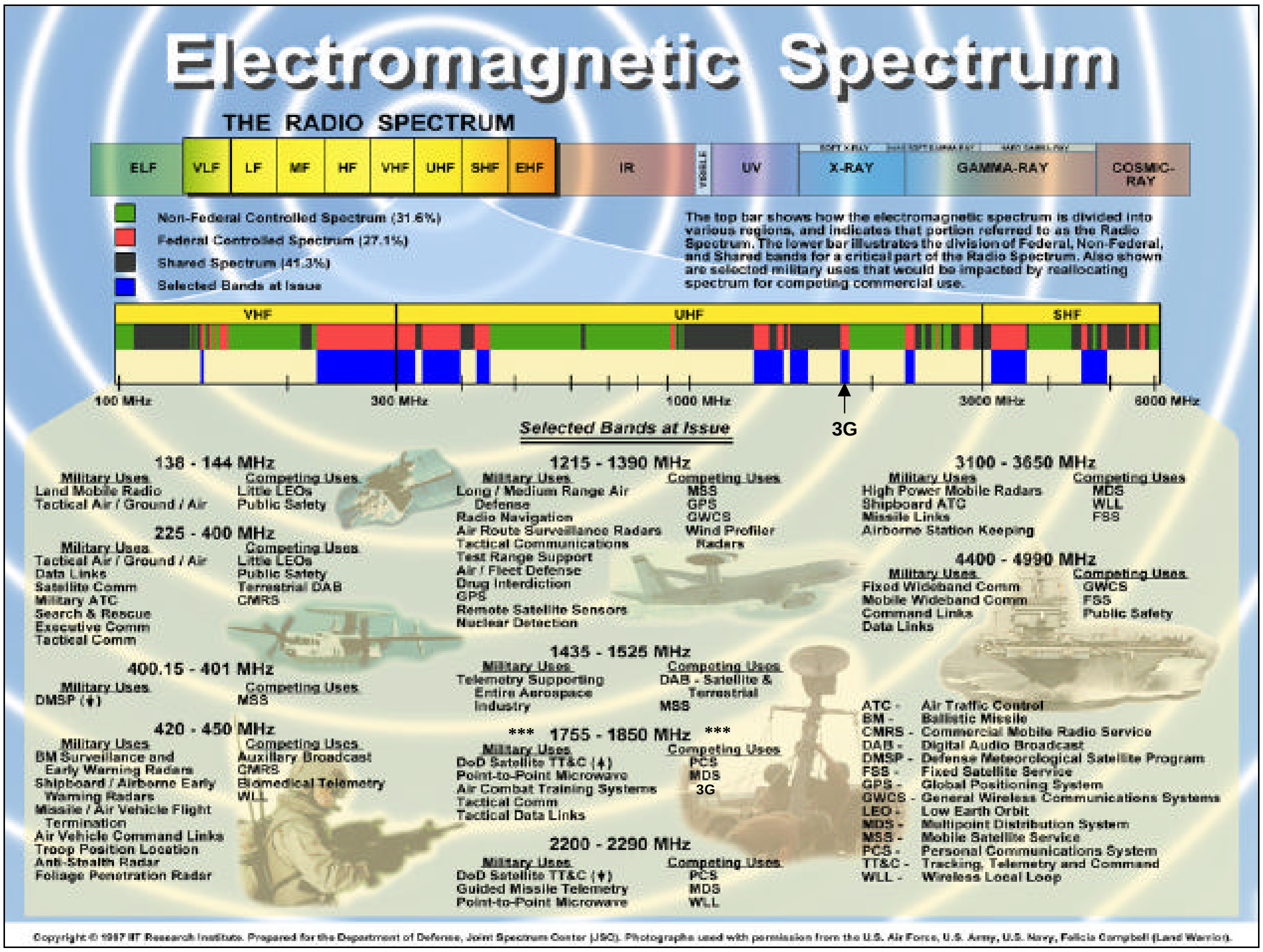
	INMARSAT	IRIDIUM	GLOBALSTAR	ICO	ORBCOMM	ELLIPSO
Services	Voice, Data	Voice, data, paging, messaging	Voice, data	Voice, data, messaging	Messaging	Voice, data
Orbit	GEO	LEO	LEO	MEO	LEO	Elliptical & MEO
Coverage	Global	Global	68N to 68S	Global	Global	
Number of Satellites	8	66	48	12	35	10 Elliptical 7 Circular MEO
Operating Band	L and C	L, K, Ka	L, S, and C	S and C	VHF	L and S
Data Rate	Up to 432 kbps by 2004	2.4 kbps	Up to 9.6 kbps	Up to 144 kbps	Up to 9.6 kbps	Up to 9.6 kbps
Current Status	Operational	Returning from Bankruptcy	Delay and financially unstable	Delayed and financially stable	Returning from Bankruptcy	Lost License
2010 Availability	Probable	Possible	Possible	Probable	Possible	Not expected
Note		DOD now achor tenant	User must be in same satellite footpring as Gateway being used	Inmarsat is experienced and profitable mobie SATCOM provider	Low data rate will become a disadvantage	Development not expected to proceed

Emerging Commercial Mobile SATCOM Data systems

	CYBERSTAR (Loral)	SIRIUS RADIO	XM RADIO	WORLDSPACE	ASTROLINK (Lockheed)	SPACEWAY (Hughes)	TELEDESIC	SKYBRIDGE (Alcatel)
Services	Data, multicast	Digital data based entertainment	Digital data based entertainment	Digital data based entertainment	Data, point to point, multicast	Data	Data	Data
Orbit	GEO	Elliptical	GEO	GEO	GEO	GEO	LEO	LEO
Coverage	Global	CONUS	CONUS	Asia, Africa, South America	Worldwide	Worldwide	Worldwide	Worldwide
Number of Satellites	3	3	2	3	9	8	288	80
Operating Band	Ka	S	S	X and L	Ka	Ka	Ka	Ku
Data Rate	400 kbps	8 Mbps????	8 Mbps	Up to 128 kbps	Up to 20 Mbps up Up to 155 Mbps down	Data Up to 1.5 Mbps Broadcast 6 Mbps Up to 108 Mbps down	Up to 2 Mbps up Up to 64 Mbps down	Up to 2 Mbps up Up to 60 Mbps down
Current Status	2003 Service	2001 service	operational	2001 service	2003 service	2003 service	2005 service	2002 service
2010 Availability	Probable	Probable	Probable	Probable	Probable	Probable	Probable	Possible
Note		One way system	One way system	Currently one way, 2 way under development				

APPENDIX D

SPECTRUM FINDINGS


Electromagnetic Spectrum
THE RADIO SPECTRUM
ELF
VLF
LF
MF
HF
VHF
UHF
SHF
EHF
IR
VISIBLE
UV
X-RAY
GAMMA-RAY
COSMIC-RAY
Non-Federal Controlled Spectrum (31.6%)
Federal Controlled Spectrum (27.1%)
Shared Spectrum (41.3%)
Selected Bands at Issue
The top bar shows how the electromagnetic spectrum is divided into various regions, and indicates that portion referred to as the Radio Spectrum. The lower bar illustrates the division of Federal, Non-Federal, and Shared bands for a critical part of the Radio Spectrum. Also shown are selected military uses that would be impacted by reallocating spectrum for competing commercial use.
VHF
UHF
SHF
100 MHz
300 MHz
1000 MHz
3000 MHz
6000 MHz
3G
Selected Bands at Issue
138 - 144 MHz
Military Uses
Land Mobile Radio
Tactical Air / Ground / Air
Competing Uses
Little LEOs
Public Safety
225 - 400 MHz
Military Uses
Tactical Air / Ground / Air
Data Links
Satellite Comm
Military ATC
Search & Rescue
Executive Comm
Tactical Comm
Competing Uses
Little LEOs
Public Safety
Terrestrial DAB
CMRS
400.15 - 401 MHz
Military Uses
DMSP (✝)
Competing Uses
MSS
420 - 450 MHz
Military Uses
BM Surveillance and Early Warning Radars
Shipboard / Airborne Early Warning Radars
Missile / Air Vehicle Flight Termination
Air Vehicle Command Links
Troop Position Location
Anti-Stealth Radar
Foliage Penetration Radar
Competing Uses
Auxiliary Broadcast
CMRS
Biomedical Telemetry
WLL
1215 - 1390 MHz
Military Uses
Long / Medium Range Air Defense
Radio Navigation
Air Route Surveillance Radars
Tactical Communications
Test Range Support
Air / Fleet Defense
Drug Interdiction
GPS
Remote Satellite Sensors
Nuclear Detection
Competing Uses
MSS
GPS
GWCS
Wind Profiler Radars
1435 - 1525 MHz
Military Uses
Telemetry Supporting Entire Aerospace Industry
Competing Uses
DAB - Satellite & Terrestrial
MSS
*** 1755 - 1850 MHz ***
Military Uses
DoD Satellite TT&C (✝)
Point-to-Point Microwave
Air Combat Training Systems
Tactical Comm
Tactical Data Links
Competing Uses
PCS
MDS
3G
2200 - 2290 MHz
Military Uses
DoD Satellite TT&C (✝)
Guided Missile Telemetry
Point-to-Point Microwave
Competing Uses
PCS
MDS
WLL
3100 - 3650 MHz
Military Uses
High Power Mobile Radars
Shipboard ATC
Missile Links
Airborne Station Keeping
Competing Uses
MDS
WLL
FSS
4400 - 4990 MHz
Military Uses
Fixed Wideband Comm
Mobile Wideband Comm
Command Links
Data Links
Competing Uses
GWCS
FSS
Public Safety
ATC - Air Traffic Control
BM - Ballistic Missile
CMRS - Commercial Mobile Radio Service
DAB - Digital Audio Broadcast
DMSP - Defense Meteorological Satellite Program
FSS - Fixed Satellite Service
GPS - Global Positioning System
GWCS - General Wireless Communications Systems
LEO - Low Earth Orbit
MDS - Multipoint Distribution System
MSS - Mobile Satellite Service
PCS - Personal Communications System
TT&C - Tracking, Telemetry and Command
WLL - Wireless Local Loop
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APPENDIX E

PARTICIPANTS LIST

PARTICIPANTS LIST

ARMY SCIENCE BOARD 2001 AD HOC STUDY

ADAPTING FUTURE WIRELESS TECHNOLOGIES

Panel

Ms. Ginger Lew, Chair
Telecommunications Development Fund

Mr. Kalle Kontson, co-Chair
IIT Research Institute

Dr. Walter J. Atkins
Pacific HiTech Development LLC

Mr. John Cittadino
JCC Technology Associates, Inc.

LTG Paul E. Funk (USA, Ret.)
Institute for Advanced Technology

Ms. Frieda Suzanne Jenniches
Northrop Grumman Corporation

Dr. Donald Kelly
Time Domain Corporation

Mr. Veloris Marshall
Marshall Communications Corp.

Mr. Peter Steensma
ITT Aerospace Communications

Gov't Advisors

Mr. Tom Mims
SIGCEN

COL David Shaddrix
DISC4

Staff Assistants

Mr. Jeff Ozimek
CECOM

Ms. Lisa Rulli
CECOM

Sponsors

HON Claude Bolton
Assitant Secretary of the Army for Acquisition, Logistics and Technology

LTG Peter M. Cuviello
Army Chief Information Officer / G- 6 (formerly titled "DISC4" as in TOR)

BG Janet E. A. Hicks
Commanding General, United States Army Signal Center and Fort Gordon

MG William H. Russ
Commanding General, United States Army Communications-Electronics Command and Fort Monmouth

APPENDIX F

ACRONYMS

ACUS	Area Common-User System
ASB	Army Science Board
BBN	Bolt, Beranek, Newman (bbn.com); implemented 4 site initial ARPANET
BL	Battle Labs
C3S	Command, Control, and Communications Systems
C4ISR	Command, Control, Communications, Computers, Information, Surveillance and Reconnaissance
CECOM	Communications – Electronics Command
CEO	Chief Executive Officer
CIA	Central Intelligence Agency
CINC	Commander-in-Chief
CRD	Captsone Requirements Document
DARPA	Defense Advanced Research Projects Agency
DISC4	Director of Information Systems for Command, Control, Communications and Computers
DoD	Department of Defense
ELB/FBE-I	Extending the Littoral Battlespace / Fleet Battle Experiment - I
EW	Electronic Warfare
GBS	Global Broadcast System
GIG	Global Information Grid
ID/IQ	Indefinite Delivery/Indefinite Quantity (contract)
IDM-T	Information Dissemination Management-Tactical
ICO	ICO Global Communications; a commercial provider
INMARSAT	International Maritime Satellite
INTELSAT	Intelligence Satellite
IPv6/v4	"The Next Generation Internet"
MCO2	Millenium Challenge 2002, an Army Transformation Experiment
MILSATCOM	Military Satellite Communications
MOSAIC	Mobile On-the-move Secure Adaptive Integrated Communications
NASA	National Aeronautics and Space Administration
NATO	North Atlantic Treaty Organization
ORBCOM	A commercial wireless provider
OSD	Office of the Secretary of Defense
OTH	Over the Horizon
P3I	Pre-Planned Product Improvement
PCS	A commercial cell phone system; Personal Communications System
PEOC3S	Program Executive Officer Command, Control, and Communications Systems
R&D	Research and Development
S&TCD	Space and Terrestrial Communications Directorate
SATCOM	Satellite Communications
SIGCEN	U.S. Army Signal Center and School
SIGINT	Signal Intelligence
TOR	Terms of Reference; a study request with guidelines
UAV	Unmanned Aerial Vehicle
WIN-T	Warfighter Information Network - Terrestrial; a future ground communications system
XM	a commercial satellite digital radio system

APPENDIX G

DISTRIBUTION

Addressee	Copies
ARMY	
Secretary of the Army, Pentagon, Room 3E700, Washington, DC 20310-0101	1
Under Secretary of the Army, Pentagon, Room 3E732, Washington, DC 20310-0102	1
Deputy Under Secretary of the Army (Operations Research), Pentagon, Room 2E660, Washington, DC 20310-0102	1
Administrative Assistant to the Secretary of the Army, Pentagon, Room 3E733, Washington, DC 20310-0105	1
General Counsel, OSA, Pentagon, Room 2E722, Washington, DC 20310-0104	1
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