Broad Agency Announcement

Mobile Ad hoc Interoperability Network GATEway (MAINGATE)

STRATEGIC TECHNOLOGY OFFICE

DARPA-BAA08-21

30 May 2008

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Part One: Overview Information

- **Federal Agency Name** – Defense Advanced Research Projects Agency (DARPA), Strategic Technology Office (STO)
- **Funding Opportunity Title –** Mobile Ad hoc Interoperability Network GATEway (MAINGATE)
- **Announcement Type –** Broad Area Announcement – Initial Announcement
- **Funding Opportunity Number –** Broad Agency Announcement (BAA) 08-21
- **Catalog of Federal Domestic Assistance Numbers (CFDA)** – Not Applicable
- **Dates**
  - Industry Day 13 June 2008
  - Proposal Due Date 14 July 2008
- **Concise description of the funding opportunity -** DARPA / STO is looking to develop the next generation Network Centric Radio System (NCRS), with additional capabilities and an assured affordable unit price to the user. DARPA envisions two critical technologies for achieving these new goals: 1.) a backbone radio architecture that enables a versatile Internet Protocol (IP) network and 2.) a radio gateway that enables legacy analog and digital communications systems to be internetworked. As with NCRS, the MAINGATE will enable heterogeneous groups of radios to be integrated into a heterogeneous network tolerant to high latency and packet loss. The technologies developed for the program will permit affordable, tactical, real-time, high fidelity video, data, and voice services to be deployed in a networked environment to support tactical operations in either Maneuver or Dismounted operations. As a result of this effort, DARPA expects a clear demonstration of advanced mobile ad hoc network (MANET) gateway technology that will incorporate a wireless IP-capable network (WIPN), which provides interconnectivity between nodes bridging heterogeneous mixtures of radio networks. A unique characteristic of the MAINGATE program is the integration of a "default" IP radio network as part of the gateway.
- **Anticipated individual awards** – One award is anticipated. The Government reserves the right to award one, several, or no awards on this BAA.
- **Types of instruments that may be awarded --** Procurement contract or other transaction.
- **Any cost sharing requirements** - Not Required.
- **Agency contact –** The BAA Coordinator for this effort can be reached through electronic mail: BAA08-21@darpa.mil or mailed to:
  - Points of Contact
    The Technical POC for this effort is Larry Stotts, PhD.
    DARPA/STO
    ATTN: BAA08-21
    3701 North Fairfax Drive
    Arlington, VA 22203-1714

Part Two: Full Text of Announcement

1. FUNDING OPPORTUNITY DESCRIPTION

The Defense Advanced Research Projects Agency often selects its research efforts through the Broad Agency Announcement (BAA) process. Mobile Ad hoc Interoperability Network GATEway (MAINGATE) BAA 08-21 will appear on the FedBizOpps website, http://www.fedbizopps.gov/. The following information is for those wishing to respond to the BAA08-21.

The Defense Advanced Research Projects Agency's (DARPA) Strategic Technology Office (STO) is soliciting proposals under this BAA for the performance of research, development, design, and testing to support the DARPA MAINGATE effort.

1.1. PROGRAM OVERVIEW

The after-action analyses of the command and control systems from many of the conflicts since Vietnam indicate a consistent inability to communicate between the services during joint operations and exercises. After Grenada, a Government Accounting Office (GAO) report indicated that air support operations between the Army ground forces and Marines were hampered due to the incompatibility of their radios. These shortfalls continued through to the 1990 Persian Gulf War as presented in a 1992 report to Congress, which described the problems in establishing an interoperable network across disparate communications systems. Interoperability enables information to be exchanged among disparate systems directly and satisfactorily. These same issues are also prevalent in the non-DoD communications systems used for public safety organizations as seen during the response to the terrorist attacks of September, 2001.

Early in the 21st Century, many of the DoD efforts focused on enabling Network-Centric Warfare (NCW). In particular, NCW was to allow warfighters to take advantage of all the available information within the Battlespace in a rapid and flexible manner. One example is the enabling of an effective sensor-to-shooter process. The key development for this process was the Global Information Grid (GIG), which is the network fabric upon which to build a "Systems of Systems". Mobile networking is one piece of the GIG and is built upon the premise of using the proposed interoperable Joint Tactical Radio System (JTRS) family of radios. The JTRS family of radios is still under development, with projected delivery beginning at the end of this decade.

The DARPA Network Centric Radio System (NCRS) Program provided the first tactical mobile ad hoc, heterogeneous networking capability in the Department that exceeds the current performance of the Joint Program Executive Officer' JTRS's Ground Mobile Radio requirements and demonstrated capabilities. It also networked legacy military, coalition, first responder and future radios through its gateway architecture; that interoperability among proprietary and non-proprietary, joint, coalition and first responder radios is also a first in the Department. What NCRS demonstrated, that other gateways have not, is interoperability with links experiencing high packet losses and long duration disruptions. See Appendix C.

The objective of the Mobile Ad hoc Interoperability Network GATEway (MAINGATE) program is to develop the next generation Network Centric Radio System (NCRS) with

additional capabilities and an assured affordable unit price to the user. DARPA envisions two critical technologies for achieving these new goals: 1.) a backbone radio architecture that enables a versatile IP network and 2.) a radio gateway that enables legacy analog and digital communications systems to be internetworked. As with NCRS, the MAINGATE will enable heterogeneous groups of radios to be integrated into a heterogeneous network tolerant to high latency and packet loss. The technologies developed for the program will permit affordable, tactical, real-time, high fidelity video, data, and voice services to be deployed in a networked environment to support tactical operations in either maneuver or dismounted operations. As a result of this effort, DARPA expects a clear demonstration of advanced mobile ad hoc network (MANET) gateway technology that will incorporate a Wireless IP-capable Network (WIPN), which provides interconnectivity between nodes bridging heterogeneous mixtures of radio networks. A unique characteristic of the MAINGATE program is the integration of a "default" IP radio network as part of the gateway. The program will be designed around a test-build-test philosophy through intermediate and final field evaluations, which will lead to Limited User Testing (LUT) by US and Allied Experimental Forces evaluating the affect of MAINGATE on new tactics, techniques and procedures (TTPs) designed for the networked maneuver and dismounted forces.

MAINGATE will be a connection point that allows a multitude of users employing a heterogeneous set of radio technologies (both proprietary and non-proprietary) on different stub-nets to attach to and communicate through an IP Network. The WIPN will provide the default high bandwidth connectivity among air and ground mobility platforms. The network will include the integration of adaptive communications architecture, flexible routing architecture, and heterogeneous application services. It is envisioned that a large fraction of the IP networking technology will be commercial or based upon commercial systems. Only components and subsystems at an approximate maturity of Technical Readiness Level (TRL)-6 will be considered for entry into this effort. For technology and software maturity analysis of the proposed approach, the TRL and Software Technical Readiness Level (STRL) tables included in this BAA are the correct metrics to use. Service calculators, such as the Air Force TRL calculator, are not appropriate for the MAINGATE program TRL assessment. See Appendix B.

MAINGATE must address DoD specific and coalition radios and networks; commercial radios and networks; and relevant applications for seamless integration, as well as the capacity to attach to other IP networks (e.g. SATCOM) to provide both redundant and Beyond Line of Sight (BLOS) networking. The output of this program will be a demonstrated suite of hardware and software components that can be configured for specific DoD, coalition, and first responders/public safety requirements. A MAINGATE node consists of the gateway, mobile ad hoc network (MANET) IP radio, WAN port, LAN port, and operator console for a recurring production unit cost target (sell price to the government) of $60K (FY08$) per unit for a volume purchase of 1,000 units after program completion. See Figure 1. The hardware and software suites will be used to provide the commander kits that include the gateway integrated with the WIPN, an operators console, and networking.

The final demonstration is to show the operational utility of the MAINGATE node in a TRL-6 prototype development unit, with a clearly substantiated (direct material, direct labor, indirect adders, fee, etc.) unit production cost estimate which provides confidence in achieving the cited unit price above in a 1,000 unit purchase. This TRL achievement will be assessed based on

reasonable development-like testing, as spelled out in Appendix B. In other words, performance of the equipment under simulated operational environments will need to be assessed experimentally during the program, e.g., humidity, temperature, salt fog testing in lab. No other mechanism/process for TRL maturity assessment will be accepted.

The program also includes two priced options to provide equipment for Limited User Testing (LUTs) by US and Allied Experimental Forces. If exercised, the options provide for a large-scale engineering evaluation of MAINGATE in a fielded environment. Part of the evaluation will be MAINGATE's ability to enable new tactics, techniques and procedures (TTPs) designed for the networked maneuver and dismounted forces.

1.1.1. Technical Description

The following information provides the proposer the technical detail of the envisioned MAINGATE. The technical information contained in Appendix A takes precedence over all other technical information provided in this BAA.

The MAINGATE provides the Layer 3 interconnection between heterogeneous sets of radio networks using transport over an IPv6 WAN, IPv4 LAN, or Wireless IP Radio (WIPN). The MAINGATE must support military and tactical applications using military, commercial, and public safety radio networks. The physical configuration will include a minimum of six (6) slots to support interfaces to legacy radios and networks, as well as a WIPN radio for default MANET connectivity among the MAINGATE nodes. In addition, ports for a WAN connection and a LAN connection must be included. MAINGATE also will require an operator console for network and device management. See Figure 1.

Applications

The MAINGATE IP MANET Radio Network will have a baseline application of video dissemination. In particular, it will focus primarily on the transport of real time video from a variety of analog and digital networked sensors to dismounted soldiers, Maneuver Force elements, tactical operational centers and upper echelons elements. The system must support a minimum of twenty (20) simultaneous 384 kbps video streams, as well as voice and data applications, peer-to-peer applications (e.g. CHAT), situational awareness, e.g. using FALCON View, and network management using spectrum allocation on the order of 6.5MHz. See Figure 2 for example LUTs structure.

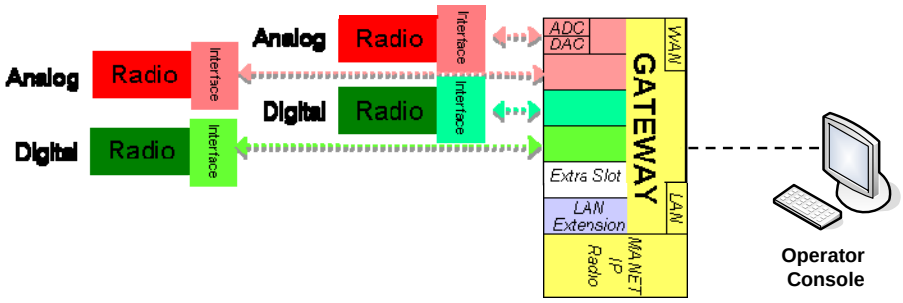


Figure 1. MAINGATE High Level Architecture

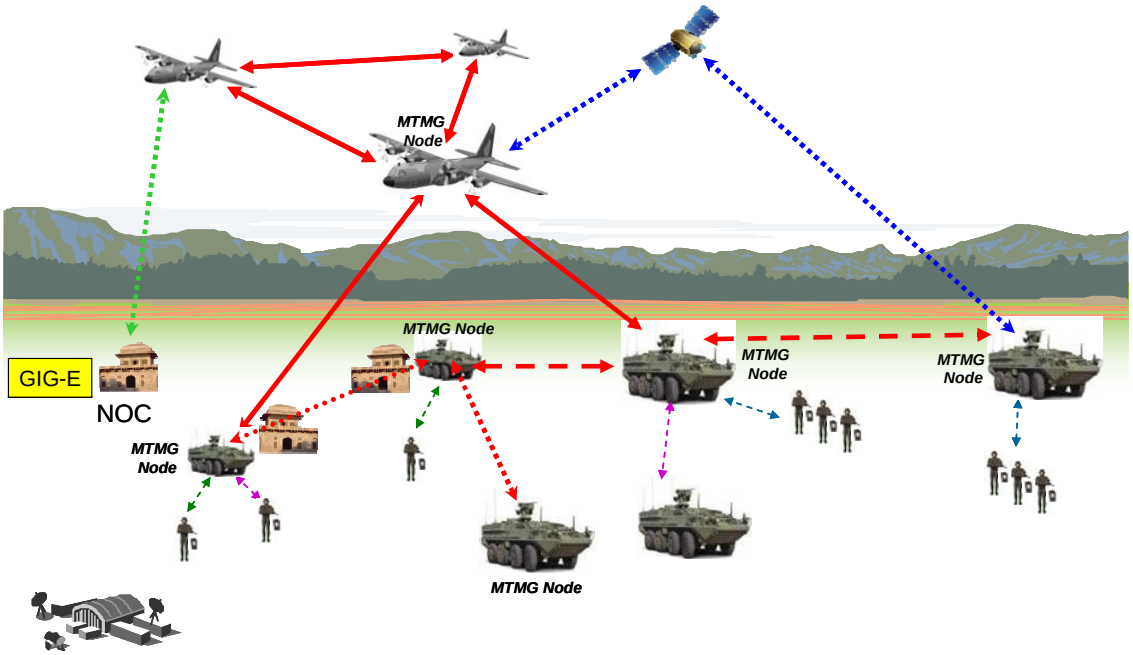


Figure 2. Operational Concept

Legacy Radio Interfaces

The heterogeneous mixtures of legacy radio devices include commercial, public safety, and military types of data and voice radios and radio networks. Some radios, such as SecNet11, already are IPv4 compatible. However, many of the legacy voice radios, such as PRC-117, do not support digital transport. The MAINGATE will support, at a minimum, the following radio networks:

- Military: EPLRS, MicroLight EPLRS, SLICE/SRW, SecNet11, PRC-117F, SINCGARS, PRC 117, PRC-119, PRC-150
- Public Safety: 4.9 GHz Public Safety, 800 MHz Public Safety (P25 Family)
- Commercial/Consumer: 802.11g, WiMAX (2.5 GHz), UMTS, Family Radio Service (FRS), Cellular, VOIP devices, and PSTN.

Many of the non-commercial systems use proprietary protocols and formats, thus requiring development of mechanisms to directly access application layer information. In addition, these systems use unique interfaces which could require specific interface "kits". The kits are necessary to connect each of the radio-types to the MAINGATE. The gateway function of the

MAINGATE provides the interconnection, at the network layer, among the mixtures of radio networks. The gateway prepares information from the legacy radio devices to use transport (TCP, SCTP, etc) across either a local area network (e.g. WIPN, SATCOM, wired) or wide area network (e.g. Internet, Global Information Grid). This requires converting incompatible protocols, data structures, and addressing schemes to operate seamlessly on the IPv6 WAN, IPv4 LAN, or Wireless IP Radio (WIPN). This will include, for example: conversion of analog application signals (e.g. voice) to digital streams, automated (or with minimal user interaction) addressing, and data packet encapsulation. It is envisioned that providing appropriate automated addressing mechanisms between dissimilar systems will be a distinct challenge. The gateway uses a modular architecture that will enable the development of *legacy radio* which will be form-fit and plug-n-play compatible. Thus, as new radio networks are determined to be added to the gateway, only a new hardware/software module will be developed without any hardware or software changes to the gateway.

As described above, MAINGATE will interface to legacy radios via customized (per interface type and not necessarily to class or type of radio) interfaces. Those interfaces will need to address control functions as well as application and networking functions. It is envisioned for illustrative purposes that there are three primary classes of radio networks that will be encountered:

- Analog voice radio networks use narrowband channel (and code) selection for providing some rudimentary networking capability. Additionally, multiple talk groups can also be bridged by using multichannel radios. These operation principles are common between military, public safety, and commercial systems. It is expected that the application layer (e.g. voice) will be the applicable mechanism in which to connect these units to the gateway (See Appendix C). Albeit there can be differences in the voice interface between radios, there is uniformity of access through external headset/speaker-microphone connects. The control mechanisms for channel and call group selections may not be accessible and thus mechanisms or procedures in which to enable selection of a call group/channel frequency or the processes to which a user/operator is tasked are needed. Thus unicast, multicast, and broadcast routing will be implemented.

- Digital voice networks use packet data transmissions over discrete channels (broadband, wideband, and narrowband)[1] and/or groups of channels (and codes) and use control channels to provide automated channel, codes, and talk group(s) selection. These operation principles are common between military, public safety, and commercial systems[2]. There are differences between the specific implementations such as the use of *trunked radio network* technology for public safety and the use of dedicated control channels for commercial systems. As with the analog voice radio networks, the application layer will be the common mechanism in which to connect these units to the gateway. The electrical access to the digital voice data may not be provided or may use

[1] In this context, Narrowband is specified as a bandwidth of 25 kHz or less, Wideband is from 25 kHz to 1000 kHz, and Broadband is over 1000 kHz for carrier frequencies under 6 GHz.
[2] We do not address proprietary implementation of Short Message Service (SMS) and other data services that operate on 2G voice networks. We consider only the advanced digital data network capacity for those applications. Proposals that address those system features are desired but not required.

proprietary connectors and thus may require the same mechanisms that are available to analog voice radio networks. However, the gateway can provide automated control and interconnection between peers or talk groups when access to the digital voice data and the control data is possible. Thus unicast, multicast, and broadcast routing will be implemented.

- Digital data networks use packet data transmissions over discrete channels (broadband, wideband) and/or groups of channels (and codes) and use control channels to provide channel selection. Most wireless digital data networks are connection-based systems. The data packet structures can be well defined (e.g. Internet Protocol) or proprietary and contain routing information (destination, routing, QoS) and application-specific information. The operation is highly varied between implementations. Commercial cellular systems use proprietary data structures and protocols between the infrastructure (base station) and the remote unit (mobile station). Other commercial systems have specific IP addresses. Others may use proprietary or system-specific addressing schemes and protocols. Most likely there is electrical access to the digital voice data. However, when the digital data is not accessible then the same mechanisms employed with analog voice radio networks will be used. However, the gateway can provide automated control and interconnection between peers or talk groups when access to the digital voice data and the control data is possible. Thus unicast, multicast, and broadcast routing will be implemented.

Wireless IP Network

The Wireless IP Network (WIPN) has been under development throughout the DoD for the past decade. The WIPN consists of a network centric radio (NCR) and a flexible network management software suite. The wireless network is expected to provide the capacity for tactical links (ground-to-ground and air-to-ground) operating in the VHF/UHF bands and using omni-directional antennas, that provides a threshold value of 6 Mbps information rate in urban, suburban, and rural terrains. Here, information rate means the useable data rate to the application subset of the design data rate, i.e., data rate less protocol overhead. The goal is to increase the information rate to 20 Mbps. It also is envisioned that the higher frequency bands can exploit directional antennas and thus the goal is to increase the information rate to 100 Mbps using a gateway slot or WAN/LAN ports, and a high data rate disk data link system like Common Data Link (CDL) or Tactical Common Data Link (TCDL). The network management software provides a fully flexible IPv4, IPv6, etc WAN, operating within a MANET supporting up to 64 mobile nodes with 512 separately addressable devices that can stream video sources anywhere on the network. See Figure 3.

The network supports both ISR data streams as well as interactive voice applications. This capability or its functional equivalent has been demonstrated, most recently as part of the DARPA NCRS program. The network must be robust to link outages due to vehicular motion and obscurations. The networking architecture must include the capacity to seamlessly address such link outages by incorporating techniques such as data buffering and Disruption Tolerant Networking[3].

[3] Disruption Tolerant Networking (DTN) http://www.darpa.mil/sto/strategic/dtn.html

Because of the maturity of the WIPN technology base, the proposed MAINGATE system must incorporate components that are TRL 6 or greater. It should be noted that the use of the NCR terminology should not be confused with NCRS program since the program only demonstrated one implementation of NCR technology.

Architectures based on open source software and hardware incorporating open standards are preferred.

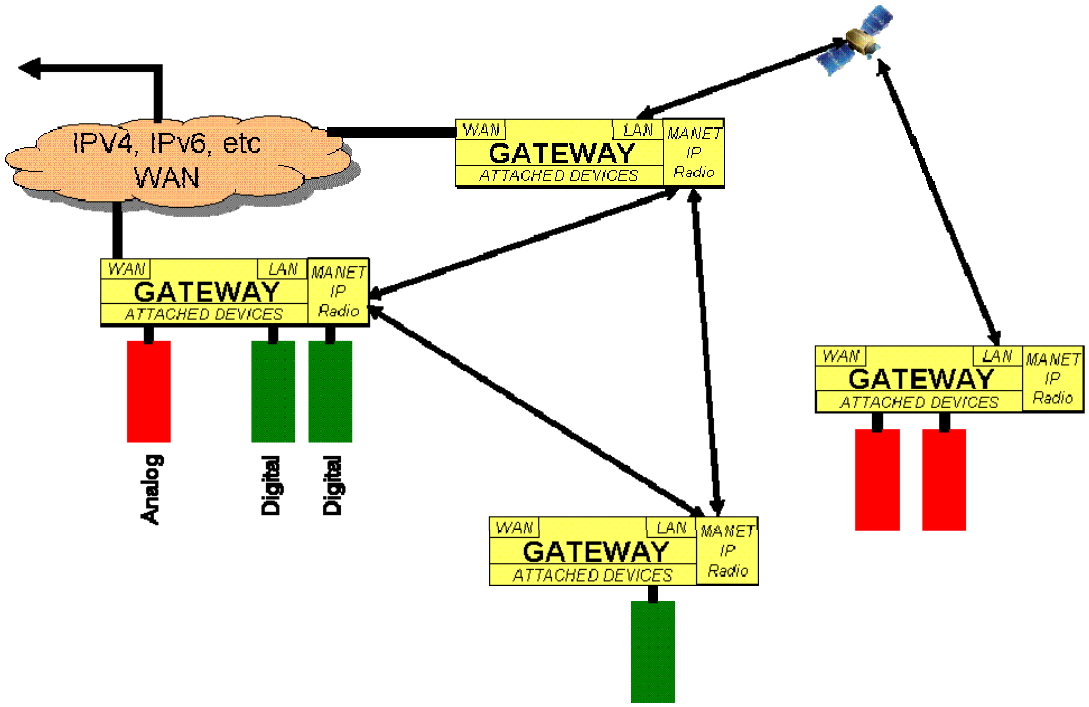


Figure 3: Notional Networking Architecture

Local Area Network and Wide Area Network Connections

It is envisioned that MAINGATE will consist of a WAN port, a LAN port, and six legacy radio ports. One or more of the six module slots can be used for a LAN extension kit to enable the interconnection of multiple LANs.

Each LAN will support a 10/100 RJ45 connection. The gateway must be able to bridge across multiple LANs (e.g. SATCOM and 802.11g) and associated addressing and transport capacities (this may require multiple LAN connections on each gateway). Protocol translation and encapsulation will be necessary to make attached device data streams compatible with the LAN architecture.

Each WAN will support a 10/100/1000 RJ45 connection or any specific connection necessary for accessing the Global Information Grid (GIG). Similar to the LAN, protocol translation and encapsulation will be necessary to make WAN attached device data streams compatible with the WAN architecture (e.g. BGP, etc).

Physical Architecture

The physical architecture is a key attribute of the gateway. Due to the varying physical and electrical characteristics of each of the radios, a modular architecture will be used. The LUTs of the gateway will consist of the gateway platform and a hardware/software kit that will enable radio attachment. It is up to each proposer to determine the optimum (size, capacity, power, reliability, etc.) design subject to the unit cost objective and metrics in Appendix A.

Architectures based on open source software and hardware incorporating open standards are preferred.

MAINGATE Node Cost

The goal for the cost to the government of the MAINGATE node is $60,000 (FY08$) per unit for a volume purchase of 1,000 units at program completion. A MAINGATE node consists of the gateway, MANET IP radio, WAN port, LAN port, and operator console. This does not include the cost of the individual external radios (except for the default WIPN that is an integral part of the gateway) or the cost of legacy radio kits. It is believed that the cost of the legacy radio kits should be low since the majority of the functions are addressed by the gateway.

The detailed technical metrics for the MAINGATE are in Appendix A.

1.1.2. Experimentation and Demonstration Plan Description

(The information listed below may be offset by Government Furnished Equipment (GFE) during contract executions, but the proposer should include all technical and cost factors in the proposal)

The final product should be developed to meet a TRL 6 prototype assessment, as per the guidance in Appendix B, i.e., informal laboratory testing to a level consistent with operational environment guidance in metrics. The proposal should provide sufficient detail regarding how this will be accomplished to ensure consistency with guidance provided in Appendix B.

In addition, the proposer is requested to provide a detailed field experimentation and demonstration plan with the proposal. The plan should be designed to develop, install, and operate the MAINGATE system by combined, coalition, or first responders/public safety forces. This means that the equipment, at the end of the effort, should be at a maturity level that will allow customary military individuals to install, troubleshoot, field maintain, and configure to meet the mission plan. The proposer should plan for not less than 2 field checkouts of MAINGATE equipment, spread out uniformly over the MAINGATE development to allow for early capability and progress assessments. The proposer should also plan a final two week, independent evaluation of MAINGATE by Soldier Battle Laboratory and Allied Experimental Forces, as well as first responders, after an equipment training phase. The government envisions

that the final demonstration will be conducted by uniformed military, combined coalition and/or first responders/public safety forces with no contractor interaction. Final testing is currently envisioned to be conducted at Ft. Benning, GA.

To maximize success at the final evaluation, the checkouts should be considered test-build-test cycles to ensure program metrics can be achieved at program end, i.e., interim performance report cards. The proposer should plan interim checkouts at a location(s) with complex terrain similar to Ft Benning, GA that will show the level of accomplishment in relation to the program metrics. The proposer is encouraged to experiment with the design, node configuration, network configuration, and planned metric accomplishment capability at the interim demonstrations. The following will provide initial guidance on the final demonstration to help proposal preparation. This plan is subject to change and any awardees will be expected to accommodate minor changes without additional government expense.

The proposer should plan for a final demonstration at a CONUS location, such as Ft. Benning, GA, that culminates in a demonstration consisting of ten (10) MAINGATE mobile nodes, two (2) airborne nodes and one (1) HQ node, plus two (2) spare ground nodes. The ten MAINGATE ground nodes should be proposed in a SUV configuration using the rack guidance in metrics section, and will be provided by the contractor. The two airborne nodes will represent surrogate UAV nodes and provided by the contractor, which includes pilots, gas and maintenance support. The following summarizes the envisioned MAINGATE final demonstration configurations:

- 13 MAINGATE nodes
    - One HQ Node
    - 2 Airborne – include all aircraft safety and certification requirements
    - 10 SUVs or similar vehicles
    - SUVs should contain the MAINGATE node with the following expectations:
        - One MAINGATE system will contain the 6 radio interoperability capability
        - 9 SUVs will contain, at a minimum, 2 radio interoperability capabilities
        - NOTE: specific radio types will be determined during demonstration preparation and execution. Interoperability for each of the eighteen radio types and one pair of SATCOM radios will be required.
- A minimum of two additional radios for each of the eighteen radio types to be external to the MAINGATE nodes are required for experimentation and evaluation.

  NOTE: The proposer should consider appropriate spare MAINGATE systems, i.e. two, in their proposal to allow the best probability of success of the 13 node demonstration.

- Final demonstration scenario description:
    - The architecture of the final demonstration should consider the interoperability of the combined, coalition, first responders/public safety, and similar types of radios described in Appendix A.
        - Each ground node should be planned to operate with not less than two external radio types to allow interoperability in the 13 node MAINGATE network.
    - The proposal should describe quality of service types and enhancements to be incorporated

- The proposer should include procurement of the combined, coalition, first responders/public safety, and similar radios in their proposal.

1.1.3. The Government Shall Provide the Following

- Operational scenario
- Opposing force, as required
- Spectrum survey, as required
- Field facilities and logistics support as required for final demo
- Allied radios, as required
- Ground/Air platforms for design, as required

1.1.4. The Proposer Shall Provide the Following

- Satellite access/Frequency authorization as required
- Applications like FALCONVIEW, and transport layer software, documentation, integration support, laptops and ancillary equipment required to support the applications
- Test applications, laptops and ancillary equipment required to support the test applications
- Test Director
- Application and test application integration support for lab and field tests
- Flight safety certification as required
- Field facilities and logistics support as required for interim demo
- SATCOM and/or ISR Feed of same type, Legacy Radios, commercial radios, and First Responder Radios
- Test Vehicles Ground/Air vehicles, including drivers/pilots

1.1.5. Period of Performance

This BAA does not establish a specific period of performance. The government does expect that this effort will be undertaken in a reasonable period of time. Proposers are encouraged to provide their timelines, technical reviews, and other subsequent program reviews/experiments/tests to meet their tailored program plan in the proposal. It should be noted that the timeliness in accomplishing the specific tasks and overall program schedule is an evaluation factor, as well as specific metrics and program accomplishments to outline program success at proposed intermediate points.

The proposer also should consider applicable unit cost and operational cost parameter trade-offs associated with their designs to assist the Government in addressing any future acquisition needs beyond the final demonstration.

1.1.6. Deliverables

The proposer should plan to provide the following deliverables as required by the BAA including all proprietary claims of results, prototypes, IP, or systems supporting and/or needed for use in research, results and/or prototyping. The specific deliverables should include the following and be included in the proposed tasks:

Hardware:

- MAINGATE nodes and legacy radios

Software Source Code:
- Phase source code for ISR product (Video)
- Router Configuration Files
- Radio Configuration Files
- Software Libraries

Reports and Documentation:
- Phase requirements and architecture description document describing the gateway design
- A documented unit production cost estimate that is consistent with the final design projections and discuss the path ahead for achieving the projected unit cost
- A complete project schedule including milestones
- Monthly reports including monthly cost, schedule, and status reporting
- Test and evaluation plans for the two interim demonstrations, final demonstration, and associated experimentation and risk reduction activities
- Final test reports detailing test results

1.1.7 Option 1 and Option 2: MAINGATE Limited User Testing

The baseline program will result in a MAINGATE node system that leads to LUTs by US and Allied Experimental Forces. This option, if exercised, provides for a large-scale engineering evaluation of MAINGATE in a fielded environment. The evaluation will assess MAINGATE's ability to enable new tactics, techniques and procedures (TTPs) designed for the networked maneuver and dismounted forces. Under the Option 1 and Option 2, the proposer shall provide a quantity of 1,000 MAINGATE nodes at the recurring production unit cost target (sell price to the government) of $60K (FY08$) per unit.

1.1.8 Oral Presentation and Demonstration Expectations

The proposer is requested to plan for oral presentations and demonstrations in support of the technical and cost proposal evaluation. This event will occur not later than 60 days following proposal submittal, or at a time negotiated between DARPA and the proposer. The oral presentations and demonstrations should be planned to occur at one, and only one, site during one visit. The oral presentation and demonstration shall not exceed 8 (eight) hours for the combined oral and demonstration events.

The oral presentations should plan for 4 (four) hours with discussions of TRL assessments, supportive documentation, and determination of the proposed components. Test data for TRL 6 components/subsystems should be documented in sufficient detail and in a form that the review team can assess the testing methods, statistical significance of the tests, and results for each component/subsystem proposed for the MAINGATE node. This information must follow the guidance given in Appendix B. The oral presentation also shall address an initial projection of the unit production cost estimate and discuss the path ahead for achieving the projected unit cost. This oral presentation time is not for discussion or clarification of the full proposal. However, the government may ask questions on proposals to help clarify any issues brought up during initial proposal review.

The proposer also should plan for 4 (four) hours to demonstrate ~TRL-6 components and subsystems, which can eventually be integrated into a TRL-6 prototype MAINGATE node. See Appendix B for the appropriate TRL level description. Additional consideration will be given to those proposers who can demonstrate these TRL 6 components and subsystems in a TRL 5 breadboard system emulating MAINGATE. The proposer is expected to show the ability to develop a MAINGATE node that will be able to accomplish the metrics and parameters in this BAA and Appendix A. These demonstrations must allow the evaluation team to see high fidelity laboratory component integration and test in simulated environments, and a systems breadboard demonstration, if possible.

Proposers are encouraged to use indoor and outdoor ranges or demonstration sites, if possible, to show ability to operate in relevant environments.

1.2 PROGRAM METRICS

In order for the Government to evaluate the effectiveness of a proposed solution in achieving the stated program objectives, proposers should note that the Government hereby promulgates the program metrics that may serve as the basis for determining whether satisfactory progress is being made to warrant continued funding of the program. Although the program metrics are specified, proposers should note that the government has identified these goals with the intention of bounding the scope of effort, while affording the maximum flexibility, creativity, and innovation in proposing solutions to the stated problem. The Performance Metrics have been developed to provide a set of measurable indicators that can be validated during the testing phases and are designed to correlate with anticipated operational scenarios. The criteria for the program metrics are contained in Appendix A.

Proposals should cite any additional quantitative and qualitative success criteria that the proposed effort will achieve at the program's metric measurement milestones.

2. AWARD INFORMATION

A single award is anticipated, however, the government reserves the right to select one, several, or no awards under this BAA. The amount of resources made available under this BAA will depend on the quality of the proposals received and the availability of funds.

The Government reserves the right to select for negotiation all, some, one, or none of the proposals received in response to this solicitation, and to make awards without discussions with proposers. The Government also reserves the right to conduct discussions if the Source Selection Authority later determines them to be necessary. If warranted, portions of resulting awards may be segregated into pre-priced options. Additionally, DARPA reserves the right to accept proposals in their entirety or to select only portions of proposals for award. In the event that DARPA desires to award only portions of a proposal, negotiations may be opened with that proposer. If the proposed effort is inherently divisible and nothing is gained from the aggregation, proposers should consider submitting it as multiple independent efforts. The Government reserves the right to fund proposals in phases with options for continued work at the end of one or more of the phases.

Awards under this BAA will be made to proposers on the basis of the evaluation criteria listed below (see section labeled "Application Review Information", Sec. 5.), and program balance to provide overall value to the Government. Proposals identified for negotiation may result in a procurement contract or other transaction depending upon the nature of the work proposed, the required degree of interaction between parties, and other factors.

3. ELIGIBILITY INFORMATION

3.1 ELIGIBLE APPLICANTS

All responsible sources capable of satisfying the Government's needs may submit a proposal that shall be considered by DARPA. Historically Black Colleges and Universities (HBCUs), Small Businesses, Small Disadvantaged Businesses and Minority Institutions (MIs) are encouraged to submit proposals and join others in submitting proposals; however, no portion of this announcement will be set aside for these organizations' participation due to the impracticality of reserving discrete or severable areas of this research for exclusive competition among these entities. Independent proposals from Government/National laboratories may be subject to applicable direct competition limitations, though certain Federally Funded Research and Development Centers are excepted per P.L. 103-337§ 217 and P.L 105-261 § 3136. Proposers from Government / National Laboratories must provide documentation to DARPA to establish that they are eligible to propose and have unique capabilities not otherwise available in private industry.

Foreign participants and/or individuals may participate to the extent that such participants comply with any necessary Non-Disclosure Agreements, Security Regulations, Export Control Laws, and other governing statutes applicable under the circumstances.

3.1.1 Procurement Integrity, Standards of Conduct, Ethical Considerations, and Conflicts of Interest

Current federal employees are prohibited from participating in particular matters involving conflicting financial, employment, and representational interests (18 USC 203, 205, and 208.) The DARPA Program Manager for this BAA is Dr. Larry Stotts. As of the date of first publication of the BAA, the Government has not identified any potential conflicts of interest involving this program manager. Once the proposals have been received, and prior to the start of proposal evaluations, the Government will assess potential conflicts of interest and will promptly notify the proposer if any appear to exist. (Please note the Government assessment does NOT affect, offset, or mitigate the proposer's own duty to give full notice and planned mitigation for all potential organizational conflicts of interest, as discussed below.) The Program Manager is required to review and evaluate all proposals received under this BAA and to manage all selected efforts. Proposers should carefully consider the composition of their performer team before submitting a proposal to this BAA.

The two underlying FAR 9.505 principles for avoidance of organizational conflicts of interest are (a) preventing the existence of conflicting roles that might bias a contractor's judgment; and (b) preventing unfair competitive advantage. All proposers and proposed subcontractors must identify potential organizational conflicts of interest (FAR 9.5) of which they are aware. All

relevant facts must be disclosed. The disclosure shall include a description of the action the proposer has taken or proposes to take to avoid, neutralize, or mitigate such conflict. Proposals that fail to fully disclose potential conflicts of interests and / or do not have plans to mitigate this conflict will be returned without technical evaluation and withdrawn from further consideration for award.

In addition, all Proposers must affirm whether they are providing scientific, engineering, and technical assistance (SETA) or similar support to any DARPA technical office(s) through an active contract or subcontract. All affirmations must state which office(s) the Proposer supports and identify the prime contract numbers. Affirmations shall be furnished at the time of proposal submission. Without prior approval from the DARPA Director, a Contractor may not simultaneously act as a SETA contractor and a Performer.

If a prospective Proposer believes that any other potential conflict of interest exists or may exist (whether organizational or otherwise), the Proposer should promptly raise the issue with DARPA by sending Proposer's contact information and a summary of the potential conflict by email to the mailbox address for this BAA at BAA08-21@darpa.mil, before time and effort are expended in preparing a proposal and mitigation plan. If, in the sole opinion of the Government after full consideration for the circumstances, any conflict situation cannot be effectively mitigated, the proposal may be returned without technical evaluation and withdrawn from further consideration for award under this BAA.

3.2 COST SHARING/MATCHING

Cost sharing is not required for this particular program; however, cost sharing will be carefully considered where there is an applicable statutory condition relating to the selected funding instrument (e.g., for any Other Transactions under the authority of 10 U.S.C. § 2371). Cost sharing is encouraged where there is a reasonable probability of a potential commercial application related to the proposed research and development effort.

3.3 OTHER ELIGIBILITY CRITERIA

Collaborative efforts/teaming are encouraged. A list of qualified proposers open to teaming will be maintained on the password controlled website at https://extranet.darpa.mil/sites/sto/maingate/,DanaInfo=sharepoint.extranet.darpa.mil,SSL+default.aspx to facilitate formation of teaming arrangements between interested parties. Qualified proposers may submit their organization's contact information for posting to BAA08-21@darpa.mil. The information to be posted will be the organization name, point of contact name, phone number, and email address. Specific content, communications, networking, and team formation are the sole responsibility of the participants. Neither DARPA nor the Department of Defense (DoD) endorses the destination web site or the information and organizations contained therein, nor does DARPA or the DoD exercise any responsibility at the destination. This website is provided consistent with the stated purpose of this BAA.

4. APPLICATION AND SUBMISSION INFORMATION

4.1 ADDRESS TO REQUEST APPLICATION PACKAGE

Other than the program documentation referenced in section 7, this solicitation contains all information required to submit a proposal. No additional forms, kits, or other materials are needed. This notice constitutes the total BAA. No additional information is available, nor will a formal Request for Proposal (RFP) or additional solicitation regarding this announcement be issued. Requests for same will be disregarded.

4.2 CONTENT AND FORM OF APPLICATION SUBMISSION

Proposers are required to submit full proposals at the time and date specified in the BAA in order to be considered during the initial round of selections; however, proposals received after this deadline may be received and evaluated up to one year from date of BAA posting on FedBizOpps. Full proposals submitted after the due date stated in the BAA or due date otherwise specified by DARPA after review of proposal may be selected contingent on the availability of funds.

Restrictive notices notwithstanding, proposals may be handled, for administrative purposes only, by a support contractor. This support contractor is prohibited from competition in DARPA technical research and is bound by appropriate nondisclosure requirements.

Proposers must submit an original and five (5) copies of the full proposal and two (2) electronic copies of the full proposal [in PDF (preferred)] on a CD-ROM. However, tables included in the cost proposal shall also be provided in MS Excel™ format with calculations formulae intact to allow traceability of the cost proposal numbers across the prime and subcontractors. If the PDF submission differs from the Excel submission, the PDF shall take precedence. Each copy must be clearly labeled with BAA 08-21, proposer organization, proposal title (short title recommended), and Copy x of 5.

All administrative correspondence and questions not containing controlled information on this solicitation, including requests for information on how to submit a proposal to this BAA, should be directed to BAA08-21@darpa.mil. Correspondence and questions containing Controlled Unclassified Information (CUI) should be submitted via the password controlled website indicated in section 7. DARPA intends to use electronic mail for correspondence regarding BAA 08-21. Proposals may not be submitted by fax or e-mail; any so sent will be disregarded. DARPA encourages use of the Internet for retrieving the BAA and any other related information that may subsequently be provided.

4.2.1 Restrictive Markings on Proposals

All proposals should clearly indicate limitations on the disclosure of their contents. Proposers who include in their proposals data that they do not want disclosed to the public for any purpose, or used by the Government except for evaluation purposes, shall-

(1) Mark the title page with the following legend:

> Supporting cost and pricing information in sufficient detail to substantiate the summary cost estimates in C. above. This proposal includes data that shall not be disclosed outside the Government and shall not be duplicated, used, or disclosed-in whole or in part-for any purpose other than to evaluate this proposal. If, however, a contract is awarded to this

proposer as a result of, or in connection with, the submission of this data, the Government shall have the right to duplicate, use, or disclose the data to the extent provided in the resulting contract. This restriction does not limit the Government's right to use information contained in this data if it is obtained from another source without restriction. The data subject to this restriction are contained in sheets [insert numbers or other identification of sheets]; and

(2) Mark each sheet of data it wishes to restrict with the following legend:

Use or disclosure of data contained on this sheet is subject to the restriction on the title page of this proposal.

All other markings are non-conforming and shall be avoided. See Section 6.0, for additional information.

4.3 FORMATTING CHARACTERISTICS

4.3.1 Proposal Format

All proposals must be in the format given below. Nonconforming proposals may be rejected without review. Proposals shall consist of two volumes. All pages shall be printed on 8-1/2 by 11 inch paper with type not smaller than 12 point. Smaller font may be used for figures, tables and charts. The page limitation for proposals includes all figures, tables, and charts. Volume I, Technical and Management Proposal, may include an attached bibliography of relevant technical papers or research notes (published and unpublished) which document the technical ideas and approach upon which the proposal is based. Copies of not more than three (3) relevant papers can be included with the submission. The bibliography and attached papers are not included in the page counts given below. The submission of other supporting materials along with the proposals is strongly discouraged and will not be considered for review. Except for the attached bibliography and Section I, Volume I shall not exceed {125} pages. Maximum page lengths for each section are shown in braces { } below. All proposals must be written in English.

<u>4.3.2.1 Volume I, Technical and Management Proposal</u>

<u>Section I. Administrative</u>

A. Cover sheet to include:

(1) BAA number

(2) Technical area

(3) Lead Organization Submitting proposal

(4) Type of business, selected among the following categories: “LARGE BUSINESS”, “SMALL DISADVANTAGED BUSINESS”, “OTHER SMALL BUSINESS”, “HBCU”, “MI”, “OTHER EDUCATIONAL”, OR “OTHER NONPROFIT”

(5) Contractor’s reference number (if any)

(6) Other team members (if applicable) and type of business for each

(7) Proposal title

(8) Technical point of contact to include: salutation, last name, first name, street address, city, state, zip code, telephone, fax (if available), electronic mail (if available)

(9) Administrative point of contact to include: salutation, last name, first name, street address, city, state, zip code, telephone, fax (if available), electronic mail (if available), total funds requested from DARPA, and the amount of cost share (if any) and

(10) Date proposal was submitted.

B. Official transmittal letter.

Section II. Summary of Proposal

A. {3} Innovative claims for the proposed research. This section is the centerpiece of the proposal and should succinctly describe the uniqueness and benefits of the proposed approach relative to the current state-of-art alternative approaches.
B. {2} Deliverables associated with the proposed research and the plans and capability to accomplish technology transition and commercialization. Include in this section all proprietary claims to the results, prototypes, intellectual property, or systems supporting and/or necessary for the use of the research, results, and/or prototype. If there are not proprietary claims, this should be stated.
C. {2} Cost, schedule and milestones for the proposed research, including estimates of cost for each task in each year of the effort delineated by the prime and major subcontractors, total cost and company cost share, if applicable. **Note: Measurable critical milestones should occur every three months after start of effort.** These milestones should enable and support a go/no go decision for the next part of the effort. Additional interim non-critical management milestones are also highly encouraged at a regular interval.
D. {2} Cost, schedule, and milestones for Option 1and 2: MAINGATE Limited User Testing
E. {3} Technical rationale, technical approach, and constructive plan (to include the experimentation and demonstration approach) for accomplishment of technical goals in support of innovative claims and deliverable production. (In the proposal, this section should be supplemented by a more detailed plan in Section III.)
F. {2} General discussion of other research in this area.
G. {2} A clearly defined organization chart for the program team which includes, as applicable: (1) the programmatic relationship of team member; (2) the unique capabilities of team members; (3) the task of responsibilities of team members; (4) the teaming strategy among the team members; and (5) the key personnel along with the amount of effort to be expended by each person during each year.
H. {1} A one-slide summary of the proposal in PowerPoint that quickly and succinctly indicates the main objective, key innovations, expected impact, and other unique aspects of the proposal.

Section III. Detailed Proposal Information

A. (15} Statement of Work (SOW) - In plain English, clearly define the technical tasks/subtasks to be performed, their durations, and dependencies among them. The page length for the SOW will be dependent on the amount of the effort. For each task/subtask, provide:
   - A general and understandable description of the objective (for each defined task/activity);
   - The start and end date of each task/activity;
   - A detailed technical description of the approach to be taken to accomplish each defined task/activity);
   - Identification of the primary organization responsible for task execution (prime, sub, team member, by name, etc.);

- The exit criteria for each task/activity - a product, event, or milestone that defines its completion. Describe how the task/activity ties to a payable milestone, if applicable.
- Define all deliverables (reporting, data, reports, software, etc.) to be provided to the Government in support of the proposed research tasks/activities.
- The SOW task/subtask numbering shall be consistent and traceable to the task/subtask numbering in the Cost Proposal.

Note: It is recommended that the SOW be developed so that each Phase of the program is separately defined. Do not include any proprietary information in the SOW.

B. {5} Description of the results, products, transferable technology, and expected technology transfer path enhancing that of Section II. B.
C. {5} Detailed technical rationale enhancing that of Section II.
D. {42} Detailed technical approach enhancing and completing that of Section II.
E. {20} Detailed experimentation and demonstration plan
F. {3} Comparison with other ongoing research indicating advantages and disadvantages of the proposed effort.
G. {3} Risk assessment and mitigation of key technical approaches.
H. {5} Discussion of proposer's previous accomplishments and work in closely related research areas.
I. {2} Description of the facilities that would be used for the proposed effort.
J. {2} Detail support enhancing that of Section II, including formal teaming agreements which are required to execute this program.
K. {2} Cost schedules and milestones for the proposed research, including estimates of cost for each task in each year of the effort delineated by the primes and subcontractors, total cost, and any company cost share. **Note: Measurable <u>critical</u> milestones should occur every three months after start of effort.** <u>Additional interim status milestones are also highly encouraged at regular intervals.</u> Where the effort consists of multiple portions which could reasonably be partitioned for purposes of funding, these should be identified as tasks with separate cost estimates for each. Additionally, proposals should clearly explain the technical approach (es) that will be employed to meet or exceed each program metric and provide ample justification as to why the approach (es) is/are feasible.
L. {2} Cost, schedule, and milestones for Option 1and 2: MAINGATE Limited User Testing

<u>Section IV. Additional Information</u>
A brief bibliography of relevant technical papers and research notes (published and unpublished) which document the technical ideas upon which the proposal is based. Copies of not more than three (3) relevant papers can be included in the submission.

<u>4.3.2.2 Volume II, Cost Proposal – {No Page Limit}</u>
Cover sheet to include:
(1) BAA number;
(2) Technical area;
(3) Lead Organization submitting proposal;

(4) Type of business, selected among the following categories: "LARGE BUSINESS", "SMALL DISADVANTAGED BUSINESS", "OTHER SMALL BUSINESS", "HBCU", "MI", "OTHER EDUCATIONAL", OR "OTHER NONPROFIT";
(5) Contractor's reference number (if any);
(6) Other team members (if applicable) and type of business for each;
(7) Proposal title;
(8) Technical point of contact to include: salutation, last name, first name, street address, city, state, zip code, telephone, fax (if available), electronic mail (if available);
(9) Administrative point of contact to include: salutation, last name, first name, street address, city, state, zip code, telephone, fax (if available), and electronic mail (if available);
(10) Award instrument requested: cost-plus-fixed-free (CPFF), cost-contract—no fee, cost sharing contract – no fee, or other type of procurement contract (*specify*), or other transaction;
(11) Place(s) and period(s) of performance;
(12) Total proposed cost separated by basic award and option(s) (if any);
(13) Name, address, and telephone number of the proposer's cognizant Defense Contract Management Agency (DCMA) administration office (*if known)*;
(14) Name, address, and telephone number of the proposer's cognizant Defense Contract Audit Agency (DCAA) audit office (*if known*);
(15) Date proposal was prepared;
(16) DUNS number;
(17) TIN number;
(18) Cage Code;
(19) Subcontractor Information;
(20) Proposal validity period; and
(21) Any Forward Pricing Rate Agreement, other such approved rate information, or such other documentation that may assist in expediting negotiations (if available).

Detailed cost breakdown for the Cost Proposal includes:

(1) Total program cost broken down by major cost items to include:

i. Direct labor, including individual labor categories, with associated labor hours and associated direct labor rates. [Note: Labor hours for Key Personnel across each Work Outline (WO) element should be specifically identified.]
ii. If consultants are used, proposer must provide a consultant agreement or other document which verifies the proposed loaded daily/hourly rate.
iii. Indirect costs including Fringe Benefits, Overhead, General and Administrative Expense, Cost of Money, etc. (Must show base amount and rate application).
iv. Travel – Number of trips, number of days per trip, departure and arrival destinations, number of people, etc.
v. Other Direct Costs – Should be itemized with costs or estimated costs. Backup documentation should be submitted to support proposed costs.

(2) Major program tasks by both Calendar Year (CY) and US Government Fiscal Year (GFY).

(3) Itemization of Subcontracts (>$100K) and equipment purchases, to include: a cost proposal as detailed as the Proposer's cost proposal (and bid to the same WO element structure as the proposer); the Subcontractor's cost proposal can be provided in a sealed envelope with the Proposer's cost proposal. All Materials should be specifically itemized with costs or estimated costs. An explanation of any estimating factors, including their derivation and application, shall be provided. Please include a brief description of the Proposers' procurement method to be used and provide your subcontract analysis. Subcontractor proposals should include corresponding details associated with Internal Work Orders (IWO) or similar arrangements. [Note: The Prime Contractor is responsible for compiling and providing all Subcontractor proposals to the Procuring Contracting Officer (PCO).];
(4) Itemization of any Information Technology (IT) purchases including subcontractor cost. [Note: For IT [4] equipment purchases, include a letter stating why the Proposer cannot provide the requested resources from its own funding.]
(5) Summary of projected funding requirements by month;
(6) Any Government Furnished / Facilities / Information applicable across WO elements shall be identified, sources and need date noted, and corresponding costs identified.
(7) The source, nature, and amount of any industry 'cost-sharing' shall be provided. The utilization timeframe and associated WO elements being leveraged by the industry 'cost-sharing' shall be described in sufficient detail.

The Cost Proposal shall provide visibility into the applicable (1) to (7) areas for each WO element contained in the SOW. The WO used for the Cost Proposal should be consistent and traceable to the SOW. Each Cost Proposal WO element must be clearly mapped to the appropriate SOW WO. There shall be a single master WO element structure (at a minimum of 3 or 4 level) utilized for the Prime <u>and</u> IWO transfers as well as Subcontractors. Ensure all IWO and Subcontractor efforts are mapped to the applicable WO element(s) that detail the work to be performed, i.e., any given WO element could have Prime, IWO, and Subcontractor efforts associated with it. As such, IWO and Subcontractor costs shall not be shown only as single line item Other Direct Costs ODC to the Prime. The IWO and Subcontractors shall provide the same level of cost detail as the Prime. This includes labor hours, labor dollars, and material. In Summary Tables, ensure that Prime, IWO, and Subcontractors are all discretely identified.

[4] IT is defined as "any equipment, or interconnected system(s) or subsystem(s) of equipment that is used in the automatic acquisition, storage, manipulation, management, movement, control, display, switching, interchange, transmission, or reception of data or information by the agency. (a) For purposes of this definition, equipment is used by an agency if the equipment is used by the agency directly or is used by a contractor under a contract with the agency which – (1) Requires the use of such equipment; or (2) Requires the use, to a significant extent, or such equipment in the performance of a service or the furnishing of a product. (b) The term "information technology" includes computers, ancillary, software, firmware and similar procedures, services (including support services), and related resources. (c) The term "information technology" does not include – (1) Any equipment that is acquired by a contractor incidental to a contract; or (2) Any equipment that contains imbedded information technology that is used as an integral part of the product, but the principal function of which is not the acquisition, storage, manipulation, management, movement, control, display, switching, interchange, transmission, or reception of data or information. For example, HVAC (heating, ventilation, and air conditioning) equipment such as thermostats or temperature control devices, and medical equipment where information technology is integral to its operation, are not information technology."

A description of the basis of estimate (BOE) across all WO elements shall be provided. Highlight key personnel labor included in specific WO elements. For basis of estimate descriptions for software-related WO elements, provide an estimate of total source lines of code (SLOC) required and how much is New, Modified, and direct Reuse code as well as historical software productivity and historical SLOC growth on similar efforts. For basis of estimate descriptions for hardware-related WO elements, provide the unit cost, total cost, and total number of ship-sets, at the line replaceable unit (LRU) level, included in the Cost Proposal. The configuration of and total number of ship-sets shall be consistent with what is described in the Technical Proposal across each phase. A Hardware Utilization Matrix shall be provided.

Provide supporting cost and pricing information in sufficient detail to substantiate the Summary cost estimates provided. Include a description of the method used to estimate costs and supporting documentation. Note: "cost or pricing data" as defined in FAR Subpart 15.4 shall be required if the proposer is seeking a procurement contract award of $650,000 or greater unless the proposer requests an exception from the requirement to submit cost of pricing data. "Cost or pricing data" are not required if the proposer proposes an award instrument other than a procurement contract (e.g., a grant, cooperative agreement, or other transaction.)

Where the effort consists of multiple portions which could reasonably be partitioned for purposes of funding, these should be identified as options with separate cost estimates for each. Include a priced list of long lead material requirements and the associated latest long lead commitment date for each option.

The Cost Proposal shall also provide MS Excel file(s) that provides traceability between the BOEs and the proposed costs across all WO elements and phases. This includes the calculations and adjustments that are utilized to generate the Summary Costs from the source labor hours, labor costs, material costs, etc. input data. Likewise, the costs from IWO and Subcontractor proposals shall be readily traceable to the Prime Cost Proposal in the provided MS Excel file(s).

Organizational Conflict of Interest Mitigation Plan (if applicable) to detail what steps the contractor is performing to mitigate an actual or perceived conflict of interest.

4.4 SUBMISSION DATES AND TIMES

4.4.1 Proposal Date

The proposal (original and five hard copies and two electronic copies) must be submitted to DARPA/STO, 3701 North Fairfax Drive, Arlington, VA 22203-1714 (Attn.: BAA08-21) on or before 4:00 p.m., local Arlington, VA time, 14 July 2008 in order to be considered during the initial round of selections; however, proposals received after this deadline may be received and evaluated up to one year from date of BAA posting on FedBizOpps. Proposals submitted after the initial closing date deadline specified in the BAA may be selected contingent upon the availability of funds, however proposers are warned that the likelihood of funding is greatly reduced.

DARPA will acknowledge receipt of complete submissions via email and assign control numbers that should be used in all further correspondence regarding proposals.

Failure to comply with the submission procedures may result in the submission not being evaluated.

5. APPLICATION REVIEW INFORMATION

5.1 EVALUATION CRITERIA

Evaluation of proposals will be accomplished through a scientific/technical review of each proposal using the following criteria: (a) Ability to meet Program Go/No-Go Metrics; (b) Overall Scientific and Technical Merit on "System" Technology; (c) Overall Scientific and Technical Merit on "Network" Technology; (d) Proposer's Experimentation and Demonstration Technical Approach, Schedule, Execution Plan, and Risk Description; (e) Plans and Capability to Accomplish Technology Transition; (f) Proposer's Capabilities and/or Related Experience; (g) Potential Contribution and Relevance to the DARPA and DoD Mission; and (h) Cost Realism. Proposals will not be evaluated against each other since they are not submitted in response to a common work statement. DARPA's intent is to review all proposals as soon as possible after they arrive; however, proposals may be held and reviewed periodically at DARPA's discretion. The following are descriptions of the above listed criteria:

5.1.1 Ability to Meet Program Go/No-Go Metrics

The feasibility and likelihood of the proposed approach for satisfying the program go/no-go metrics are explicitly described and clearly substantiated. The proposal reflects a mature and quantitative understanding of the program go/no-go metrics, the statistical confidence with which they may be measured, and their relationship to the concept of operations that will result from successful performance in the program.

5.1.2 Overall Scientific and Technical Merit on "System" Technology

The proposed technical approach is feasible, achievable, complete and supported by a proposed technical team that has the expertise and experience to accomplish the proposed tasks. Task descriptions and associated technical elements provided are complete and in a logical sequence with all proposed deliverables clearly defined, such that a final product that achieves the goal can be expected as a result of award. The proposal identifies major technical risks, and planned mitigation efforts are clearly defined and feasible.

The following will be evaluated based on contents of the proposal.

- Understanding of the problem
- Technical approach to solve this problem and combining heterogeneous systems into an integrated MANET network
- The soundness of the size, weight, and power and TRLs of the system design to achieve the program objectives
- Understanding of the technical risk and approach to risk mitigation
- Understanding of platform environment, link geometry, and impacts to system and subsystem requirements

- Specific technical characteristics of all subsystems and approach to achieving appropriate TRLs and packaging objectives for the aggregate system
- Understanding of software development requirements

5.1.3 Overall Scientific and Technical Merit on "Network" Technology

The proposed technical approach is feasible, achievable, complete and supported by a proposed technical team that has the expertise and experience to accomplish the proposed tasks. Task descriptions and associated technical elements provided are complete and in a logical sequence with all proposed deliverables clearly defined, such that a final product that achieves the goal can be expected as a result of award. The proposal identifies major technical risks, and planned mitigation efforts are clearly defined and feasible.

The following will be evaluated based on contents of the proposal.

- The soundness of the proposed network technologies and their support of the program vision and objectives
- Network integration to GIG and military IP net systems
- The scalability of the proposed network technologies and their ability to support networks that scale
- The soundness of the fundamental ideas represented by the proposed network technologies
- The technology risk and risk mitigation approaches for each proposed network technology
- The understanding of network security issues and the adequacy and viability of the proposed network security approach
- Compliance with GIG security and interfacing requirements

5.1.4 Proposer's Experimentation and Demonstration Technical Approach, Schedule, Execution Plan, and Risk Description.

The proposers' description of technical integration and system design will be analyzed with respect to demonstrated ability to execute an experiment and demonstration plan. The plan should describe how the program metrics, schedule, documentation, and execution will lead to providing appropriate reporting. The proposer's abilities to aggressively pursue performance metrics in the shortest timeframe and to accurately account for that timeframe will be evaluated, as well as proposer's ability to understand, identify, and mitigate any potential risk in schedule.

The following will be evaluated based on contents of the proposal.

- The proposer's experiment and demonstration plan, objectives, technical detail, and metrics
- The proposed program schedule/milestones and the development schedule/milestones and whether they will result in a system capability that meets or exceeds the MAINGATE vision and objectives
- Relationship of demonstration to transition objectives
- Resource requirements and associated risk for critical items
- Proposer's ability to understand, identify, and mitigate any potential risk in schedule.

- The plan to validate and demonstrate the network performance objectives (i.e., scalability, interoperability, robustness, etc.) of the network technologies

5.1.5 Plans and Capability to Accomplish Technology Transition

The proposer understands the defense acquisition system and has the capability to transition technology to operational military communities in such a way as to enhance U.S. defense, as measured by the following elements.

- The extent to which the proposer has demonstrated understanding of military acquisition requirements and ability to interact with Government operational and procurement professionals
- Prior experience in transition of technology from research and development to military or commercial utilization
- The ability to meet relevant unit cost and support operational cost parameter considerations to facilitate limited user testing (Option 1) and transition
- The capability to transition the technology to research, industrial, and operational military communities in such a way as to enhance U.S. defense, and the extent to which intellectual property delivered with limitations, if any, creates a barrier to technology transition

5.1.6 Proposer's Capabilities and/or Related Experience

The proposer's prior experience in similar efforts must clearly demonstrate an ability to deliver products that meet the proposed technical performance within the proposed budget and schedule. The proposed team has the expertise to manage costs and schedules. Similar efforts completed/ongoing by the proposer in this area are fully described including identification of other Government sponsors.

5.1.7 Potential Contribution and Relevance to the DARPA Mission

The potential contributions of the proposed effort with relevance to the national technology base will be evaluated. Specifically, DARPA's mission is to maintain the technological superiority of the U.S. military and prevent technological surprise from harming our national security by sponsoring revolutionary, high-payoff research that bridges the gap between fundamental discoveries and their military use.

The following will be evaluated based on contents of the proposal.

- The extent to which the proposed effort supports the DARPA and DoD mission
- The proposed technology's potential for a broad impact on military systems while maintaining sufficient commercial impact to be able to support itself (eventually) in the commercial market

5.1.8 Cost Realism

The objective of this criterion is to establish that the proposed costs are realistic for the technical and management approach offered, as well as to determine the proposer's practical understanding of the effort. This will be principally measured by cost per labor-hour and number of labor-hours proposed for prime, internal work transfers, and subcontractors relative to the

proposed schedule/milestones, material costs, and similar efforts. The evaluation criterion recognize that undue emphasis on cost may motivate proposers to offer low-risk ideas with minimum uncertainty and to staff the effort with junior personnel in order to be in a more competitive posture. DARPA discourages such cost strategies. Cost reduction approaches that will be received favorably include innovative management concepts that maximize direct funding for technology and limit absorption of funds into overhead. The following are specific cost proposal assessment areas in addition to the principal measures.

- The extent to which the proposer followed the BAA instructions and the clarity of the financial factors provided
- The consistency of the cost proposal with the proposed schedule/milestones, i.e., expenditure plan and funding flow will be evaluated and compared to critical development milestones, equipment purchases, and test events
- The experience level and hours proposed for key personnel are provided and commensurate with the technology demonstration plan
- The detail and description of sub-contractor level of effort and mission accomplishment across proposed tasks/activities
- The proposer has provided a product-oriented statement of work of sufficient detail to assess critical development items and relate cost to design, documentation, manufacturing, and test efforts.

After selection and before award, the contracting officer will negotiate cost/price reasonableness.

Award(s) will be made to proposers whose proposals are determined to be the most advantageous to the Government, all factors considered, including the potential contributions of the proposed work to the overall research program and the availability of funding for the effort. Award(s) may be made to any proposer(s) whose proposal(s) is determined selectable regardless of its overall rating.

NOTE: PROPOSERS ARE CAUTIONED THAT EVALUATION RATINGS MAY BE LOWERED AND/OR PROPOSALS REJECTED IF SUBMITTAL INSTRUCTIONS ARE NOT FOLLOWED.

5.2 REVIEW AND RECOMMENDATION PROCESS

It is the policy of DARPA to ensure impartial, equitable, comprehensive proposal evaluations and to select the source (or sources) whose offer meets the Government's technical, policy, and programmatic goals. Pursuant to FAR 35.016(e), the primary basis for selecting proposals for acceptance shall be technical, importance to agency programs, and fund availability. Qualified Government personnel will conduct proposal reviews and if necessary, convene panels of experts in the relevant science and technology areas.

Proposals will not be evaluated against each other since they are not submitted in response to a common work statement. DARPA's intent is to review proposals as soon as possible after they arrive; however, proposals may be held and reviewed periodically at DARPA’s discretion. For evaluation purposes, a proposal is the document described in “Proposal Information,” Section

4.3.1. Other supporting or background materials submitted with the proposal will be considered for the reviewer's convenience only and not considered as part of the proposal.

Restrictive notices notwithstanding, proposals may be handled for administrative purposes by support contractors. These support contractors are prohibited from competing for similar or related DARPA technical research projects and are bound by appropriate non-disclosure requirements.

Subject to the restrictions set forth in FAR 37.203(d), input on technical aspects of the proposals may be solicited by DARPA from non-Government consultants /experts who are strictly bound by the appropriate non-disclosure requirements.

It is the policy of DARPA to treat all proposals as competitive information and to disclose their contents only for the purpose of evaluation. No proposals will be returned. Upon completion of the source selection process, the original of each proposal received will be retained at DARPA, and all other copies will be destroyed.

6. AWARD ADMINISTRATION INFORMATION

6.1 AWARD NOTICES

As soon as the evaluation of a proposal is complete, the proposers will be notified that 1) the proposal has been selected for funding pending contract negotiations, or 2) the proposal has not been selected. These official notifications will be sent via US Mail to the Technical POC identified on the proposal coversheet.

6.2 ADMINISTRATIVE AND NATIONAL POLICY REQUIREMENTS

6.2.1 Security

The Government anticipates that proposals submitted under this BAA will be unclassified. The goal of the MAINGATE program is to develop a communication system that can be readily transitioned to field testing and LUTs. A DD254 will be issued for awardee(s) for the use of OPSEC equipment if required.

In the event that a proposer chooses to submit a classified proposal or submit any documentation that may be classified, the following information is applicable.

Collateral Classified Information: Use classification and marking guidance provided by previously issued security classification guides, the Information Security Regulation (DoD 5200.1-R), and the National Industrial Security Program Operating Manual (DoD 5220.22-M) when marking and transmitting information previously classified by another original classification authority. Classified information at the Confidential and Secret level may only be mailed via U.S. Postal Service (USPS) Registered Mail or U.S. Postal Service Express Mail. All classified information will be enclosed in opaque inner and outer covers and double wrapped. The inner envelope shall be sealed and plainly marked with the assigned

classification and addresses of both sender and addressee. The inner envelope shall be address to:

Defense Advanced Research Projects Agency
ATTN: STO
Reference: (BAA08-21)
3701 North Fairfax Drive
Arlington, VA 22203-1714

The outer envelope shall be sealed with no identification as to the classification of its contents and addressed to:

Defense Advanced Research Projects Agency
Security & Intelligence Directorate, Attn: CDR
3701 North Fairfax Drive
Arlington, VA 22203-1714

All Top Secret materials should be hand carried via an authorized, two-person courier team to the DARPA CDR.

Special Access Program (SAP) Information: Contact the DARPA Special Access Program Central Office (SAPCO) 703-526-4052 for further guidance and instructions prior to transmitting SAP information to DARPA. Top Secret SAP, must be transmitted via approved methods for such material. Consult the DoD Overprint to the National Industrial Security Program Operating Manual for further guidance. *Prior to transmitting SAP material*, it is strongly recommended that you coordinate your submission with the DARPA SAPCO.

Sensitive Compartmented Information (SCI) Data: Contact the DARPA Special Security Office (SSO) at 703-812-1994/1993 for the correct SCI courier address and instructions. All SCI should be transmitted through your servicing Special Security Officer (SSO). SCI data must be transmitted through SCI channels only (i.e., approved SCI Facility to SCI facility via secure fax).

Proprietary Data: All proposals containing proprietary data should have the cover page and each page containing proprietary data clearly marked as containing proprietary data. It is the Proposers' responsibility to clearly define to the Government what is considered proprietary data.
Proposers must have existing and in-place prior to execution of an award, approved capabilities (personnel and facilities) to perform research and development at the classification level they propose. It is the policy of DARPA to treat all proposals as competitive information, and to disclose their contents only for the purpose of evaluation. Proposals will not be returned. The original of each proposal received will be retained at DARPA and all other non-required copies destroyed. A certification of destruction may be requested, provided that the formal request is received at this office within 5 days after unsuccessful notification.

6.3 INTELLECTUAL PROPERTY

6.3.1 Procurement Contract Proposers

6.3.1.1 Noncommercial Items (Technical Data and Computer Software)
Proposers responding to this BAA requesting a procurement contract to be issued under the FAR/DFARS, shall identify all noncommercial technical data, and noncommercial computer software that it plans to generate, develop, and/or deliver under any proposed award instrument in which the Government will acquire less than unlimited rights, and to assert specific restrictions on those deliverables. Proposers shall follow the format under DFARS 252.227-7017 for this stated purpose. In the event that proposers do not submit the list, the Government will assume that it automatically has "unlimited rights" to all noncommercial technical data and noncommercial computer software generated, developed, and/or delivered under any award instrument, unless it is substantiated that development of the noncommercial technical data and noncommercial computer software occurred with mixed funding. If mixed funding is anticipated in the development of noncommercial technical data, and noncommercial computer software generated, developed, and/or delivered under any award instrument, then proposers should identify the data and software in question, as subject to Government Purpose Rights (GPR). In accordance with DFARS 252.227-7013 Rights in Technical Data - Noncommercial Items, and DFARS 252.227-7014 Rights in Noncommercial Computer Software and Noncommercial Computer Software Documentation, the Government will automatically assume that any such GPR restriction is limited to a period of five (5) years in accordance with the applicable DFARS clauses, at which time the Government will acquire "unlimited rights" unless the parties agree otherwise. Proposers are admonished that the Government will use the list during the source selection evaluation process to evaluate the impact of any identified restrictions, and may request additional information from the proposer, as may be necessary, to evaluate the proposer's assertions. If no restrictions are intended, then the proposer should state "NONE."

A sample list for complying with this request is as follows:

NONCOMMERCIAL			
Technical Data Computer Software To be Furnished With Restrictions	Basis for Assertion	Asserted Rights Category	Name of Person Asserting Restrictions
(LIST)	(LIST)	(LIST)	(LIST)

6.3.1.2 Commercial Items (Technical Data and Computer Software)
Proposers responding to this BAA requesting a procurement contract to be issued under the FAR/DFARS, shall identify all commercial technical data, and commercial computer software that may be embedded in any noncommercial deliverables contemplated under the research effort, along with any applicable restrictions on the Government's use of such commercial technical data and/or commercial computer software. In the event that proposers do not submit the list, the Government will assume that there are no restrictions on the Government's use of such commercial items. The Government may use the list during the source selection evaluation process to evaluate the impact of any identified restrictions, and may request additional

information from the proposer, as may be necessary, to evaluate the proposer's assertions. If no restrictions are intended, then the proposer should state "NONE."

A sample list for complying with this request is as follows:

COMMERCIAL			
Technical Data Computer Software To be Furnished With Restrictions	Basis for Assertion	Asserted Rights Category	Name of Person Asserting Restrictions
(LIST)	(LIST)	(LIST)	(LIST)

6.3.2 Non-Procurement Contract Proposers – Non-Commercial and Commercial Items (Technical Data and Computer Software)

6.3.2.1 Noncommercial and Commercial Items (Technical Data and Computer Software)
Proposers responding to this BAA requesting an Other Transaction for Prototype shall follow the applicable rules and regulations governing that instrument, but in all cases should appropriately identify any potential restrictions on the Government's use of any Intellectual Property contemplated under that award instrument. This includes both Noncommercial Items and Commercial Items. Although not required, proposers may use a format similar to that described in Paragraphs 1.a and 1.b above. The Government may use the list during the source selection evaluation process to evaluate the impact of any identified restrictions, and may request additional information from the proposer, as may be necessary, to evaluate the proposer's assertions. If no restrictions are intended, then the proposer should state "NONE."

6.3.2.2 All Proposers – Patents
Include documentation proving your ownership of or possession of appropriate licensing rights to all patented inventions (or inventions for which a patent application has been filed) that will be utilized under your proposal for the DARPA program. If a patent application has been filed for an invention that your proposal utilizes, but the application has not yet been made publicly available and contains proprietary information, you may provide only the patent number, inventor name(s), assignee names (if any), filing date, filing date of any related provisional application, and a summary of the patent title, together with either: 1) a representation that you own the invention, or 2) proof of possession of appropriate licensing rights in the invention.

6.3.2.3 All Proposers-Intellectual Property Representations
Provide a good faith representation that you either own or possess appropriate licensing rights to all other intellectual property that will be utilized under your proposal for the DARPA program. Additionally, proposers shall provide a short summary for each item asserted with less than unlimited rights that describes the nature of the restriction and the intended use of the intellectual property in the conduct of the proposed research.

6.4 MEETING AND TRAVEL REQUIREMENTS
There will be a program kickoff meeting at the performer's site and all key participants are required to attend. The proposer should expect to have quarterly program reviews at performer

locations or those proposed. Performers should also anticipate periodic site visits at the Program Manager's discretion.

The Government anticipates that performers will have significant travel requirements in preparation for and conduct of the field demonstrations. The proposer should plan for not less than 2 field checkouts of MAINGATE equipment, spread out uniformly over the MAINGATE development, culminating in a final two week, independent evaluation of MAINGATE by Soldier Battle Laboratory and Allied Experimental Forces, as well as first responders, after an equipment training phase. The proposer should plan interim checkouts at a location(s) with complex terrain similar to Ft Benning, GA that will show the level of accomplishment in relation to the program metrics. Final testing is currently envisioned to be conducted at Ft Benning, GA.

6.5 HUMAN USE

All research involving human subjects, to include use of human biological specimens and human data, selected for funding must comply with the federal regulations for human subject protection. Further, research involving human subjects that is conducted or supported by the DoD must comply with 32 CFR 219, *Protection of Human Subjects* (http://www.dtic.mil/biosys/downloads/32cfr219.pdf), and DoD Directive 3216.02, *Protection of Human Subjects and Adherence to Ethical Standards in DoD-Supported Research* (http://www.dtic.mil/whs/directives/corres/html2/d32162x.htm).

Institutions awarded funding for research involving human subjects must provide documentation of a current Assurance of Compliance with Federal regulations for human subject protection, for example a Department of Health and Human Services, Office of Human Research Protection Federal Wide Assurance (http://www.hhs.gov/ohrp). All institutions engaged in human subject research, to include subcontractors, must also have a valid Assurance. In addition, personnel involved in human subjects research must provide documentation of completing appropriate training for the protection of human subjects.

For all proposed research that will involve human subjects in the first year or phase of the project, the institution must provide evidence of or a plan for review by an Institutional Review Board (IRB) upon final proposal submission to DARPA. The IRB conducting the review must be the IRB identified on the institution's Assurance. The protocol, separate from the proposal, must include a detailed description of the research plan, study population, risks and benefits of study participation, recruitment and consent process, data collection, and data analysis. Consult the designated IRB for guidance on writing the protocol. The informed consent document must comply with federal regulations (32 CFR 219.116). A valid Assurance along with evidence of appropriate training all investigators should all accompany the protocol for review by the IRB.

In addition to a local IRB approval, a headquarters-level human subjects regulatory review and approval is required for all research conducted or supported by the DoD. The Army, Navy, or Air Force office responsible for managing the award can provide guidance and information about their component's headquarters-level review process. Note that confirmation of a current Assurance and appropriate human subjects protection training is required before headquarters-level approval can be issued.

The amount of time required to complete the IRB review/approval process may vary depending on the complexity of the research and/or the level of risk to study participants. Ample time should be allotted to complete the approval process. The IRB approval process can last between one to three months, followed by a DoD review that could last between three to six months. No DoD/DARPA funding can be used towards human subjects research until ALL approvals are granted.

6.6 ANIMAL USE

Any Recipient performing research, experimentation, or testing involving the use of animals shall comply with the rules on animal acquisition, transport, care, handling, and use in: (i) 9 CFR parts 1-4, Department of Agriculture rules that implement the Laboratory Animal Welfare Act of 1966, as amended, (7 U.S.C. 2131-2159); (ii) the guidelines described in National Institutes of Health Publication No. 86-23, "Guide for the Care and Use of Laboratory Animals"; (iii) DoD Directive 3216.01, "Use of Laboratory Animals in DoD Program."

For submissions containing animal use, proposals should briefly describe plans for Institutional Animal Care and Use Committee (IACUC) review and approval. Animal studies in the program will be expected to comply with the PHS Policy on Humane Care and Use of Laboratory Animals, available at http://grants.nih.gov/grants/olaw/olaw.htm.

All Recipients must receive approval by a DoD certified veterinarian, in addition to an IACUC approval. No animal studies may be conducted using DoD/DARPA funding until the USAMRMC Animal Care and Use Review Office (ACURO) or other appropriate DoD veterinary office(s) grant approval. As a part of this secondary review process, the Recipient will be required to complete and submit an ACURO Animal Use Appendix, which may be found at https://mrmc.amedd.army.mil/AnimalAppendix.asp

6.7 PUBLIC RELEASE OR DISSEMINATION OF INFORMATION

The following provision will be incorporated into any resultant contract:

(a) There shall be no dissemination or publication, except within and between the Contractor and any subcontractors, of information developed under this contract or contained in the reports to be furnished pursuant to this contract without prior written approval of the DARPA Technical Information Officer (DARPA/TIO). All technical reports will be given proper review by appropriate authority to determine which Distribution Statement is to be applied prior to the initial distribution of these reports by the Contractor. Papers resulting from unclassified contracted fundamental research are exempt from prepublication controls and this review requirement, pursuant to DoD Instruction 5230.27 dated October 6, 1987.

(b) When submitting material for written approval for open publication as described in subparagraph (a) above, the Contractor must submit a request for public release request to the DARPA TIO and include the following information: 1) Document Information: document title, document author, short plain-language description of technology discussed in the material (approx 30 words), number of pages (or minutes of video) and document type (briefing, report,

abstract, article, or paper); 2) Event Information: event type (conference, principle investigator meeting, article or paper), event date, desired date for DARPA's approval; 3) DARPA Sponsor: DARPA Program Manager, DARPA office, and contract number; and 4) Contractor's Information: POC name, e-mail and phone. Allow four weeks for processing; due dates under four weeks require a justification. Unusual electronic file formats may require additional processing time. Requests can be sent either via e-mail to tio@darpa.mil or via 3701 North Fairfax Drive, Arlington VA 22203-1714, telephone (571) 218-4235. Refer to www.darpa.mil/tio for information about DARPA's public release process.

6.8 EXPORT CONTROL

Should this project develop beyond fundamental research (basic and applied research ordinarily published and shared broadly within the scientific community) with military or dual-use applications the following apply:

(1) The Contractor shall comply with all U. S. export control laws and regulations, including the International Traffic in Arms Regulations (ITAR), 22 CFR Parts 120 through 130, and the Export Administration Regulations (EAR), 15 CFR Parts 730 through 799, in the performance of this contract. In the absence of available license exemptions/exceptions, the Contractor shall be responsible for obtaining the appropriate licenses or other approvals, for obtaining the appropriate licenses or other approvals, if required, for exports of (including deemed exports) hardware, technical data, and software, or for the provision of technical assistance.

(2) The Contractor shall be responsible for obtaining export licenses, if required, before utilizing foreign persons in the performance of this contract, including instances where the work is to be performed on-site at any Government installation (whether in or outside the United States), where the foreign person will have access to export-controlled technologies, including technical data or software.

(3) The Contractor shall be responsible for all regulatory record keeping requirements associated with the use of licenses and license exemptions/exceptions.

(4) The Contractor shall be responsible for ensuring that the provisions of this clause apply to its subcontractors**.**

6.9 SUBCONTRACTING

Pursuant to Section 8(d) of the Small Business Act (15 U.S.C. 637(d)), it is the policy of the Government to enable small business and small disadvantaged business concerns to be considered fairly as subcontractors to contractors performing work or rendering services as prime contractors or subcontractors under Government contracts, and to assure that prime contractors and subcontractors carry out this policy. Each proposer who submits a contract proposal and includes subcontractors is required to submit a subcontracting plan in accordance with FAR 19.702(a) (1) and (2) should do so with their proposal. The plan format is outlined in FAR 19.704.

6.10 REPORTING

The number and types of reports will be specified in the award document, but will include as a minimum quarterly financial status reports. The reports shall be prepared and submitted in accordance with the procedures contained in the award document and mutually agreed on before award. Reports and briefing material will also be required as appropriate to document progress in accomplishing program metrics. A Final Report that summarizes the project and tasks will be required at the conclusion of the performance period for the award, notwithstanding the fact that the research may be continued under a follow-on vehicle.

6.10.1 Central Contractor Registration (CCR)

Selected proposers not already registered in the Central Contractor Registry (CCR) will be required to register in CCR prior to any award under this BAA. Information on CCR registration is available at http://www.ccr.gov.

6.10.2 Representations and Certifications

In accordance with FAR 4.1201, prospective proposers shall complete electronic annual representations and certifications at http://orca.bpn.gov.

6.10.3 Wide Area Work Flow (WAWF)

Performers will be required to submit invoices for payment directly via the Internet/WAWF at http://wawf.eb.mil. Registration to WAWF will be required prior to any award under this BAA.

6.11 AGENCY CONTACTS

Administrative, technical or contractual questions should be sent via e-mail to BAA08-21@darpa.mil. All requests must include the name, email address, and phone number of a point of contact.

7. OTHER INFORMATION

Program documentation consisting of Government Purpose Rights (GPR) material from the Future Combat Systems Communications (FCS-C) program, DARPA Network Centric (DNC) Experiment, the Network Centric Radio System (NCRS) in the High Bandwidth - Communications On-the-Move (HB-COTM) program, MAINGATE Proposer's Day Briefings, FAQs and other information as required can only be released to qualified proposers. In order to qualify, proposers must have a facility clearance from the Defense Security Service (DSS) at any level.

Qualified proposers may request material by sending a completed Company Qualification Document (Appendix D), and Non-Disclosure Agreements (NDAs) to BAA08-21@darpa.mil. Non-Disclosure Agreements (NDAs) are attached in Appendix D and available for download at the following website: http://www.darpa.mil/sto/solicitations/index.html

After submitting the Company Qualification Document and NDAs, approved proposers will be provided a password to the controlled website for access to the program documentation and are responsible to check it for updates during the solicitation period. Technical material (documents and media) received under this solicitation is designated as “Controlled Unclassified Information” (CUI) and is export-controlled. Disclosure to any foreign person would constitute an export, and is therefore prohibited. The information received may not be used, modified,

reproduced, released, displayed or disclosed to other proposers or to the public. Each subcontractor or team member desiring the program documentation for use in proposal preparation must directly request it from DARPA. Proposers are responsible for safeguarding and protecting DARPA CUI at all times. During this solicitation phase, proposers must ensure that a system of general safeguarding requirements is implemented that includes security checks to ensure program documentation is properly secured and perimeter controls that will deter and quickly detect unauthorized entry or removal from the facility. Specific handling instructions for the program documentation are:

- The program documentation shall be handled in a manner that provides reasonable assurance that unauthorized persons do not gain access.

- During working hours, reasonable steps should be taken to minimize risk of access by unauthorized personnel not involved with the solicitation process.

- After working hours, the program documentation shall be stored in locked containers, desks or cabinets.

- No program documentation shall be posted on internal or external computer systems unless they are so configured as to guarantee access to the information only to individuals authorized to access it.

- The program documentation shall not be destroyed but immediately returned to DARPA at the termination of the solicitation phase, or removed from computer systems and so certified to DARPA.

In addition to export controlled material, some program documentation is data delivered under Government contracts/agreements in which the Government has rights and obligations to data produced, furnished, acquired or specifically used in meeting contract performance requirements. Each contract/agreement contains terms that delineate the respective rights and obligations of the Government that will flow-down to proposers regarding the use, duplication, and disclosure of such data.

Proposers will be required to sign a certification agreeing to applicable export control restrictions and handling of data, including agreement to respect specifically identified rights and obligations applicable to each document in the program documentation.

APPENDIX A: PROGRAM METRICS

The Performance Metrics have been developed to provide a set of measurable indicators that can be validated during the testing phases and are designed to correlate with anticipated operational scenarios.

MANET GATEWAY METRICS	CRITERIA	REMARKS
1. Radio	≥ TRL 6	
Frequency Range	VHF/UHF (Low Band)	Use with Omni-Directional Antennas
	Above UHF (High Band)	Use with Directional Antennas
Bandwidth	Support non-contiguous frequency assignments	Instantaneous Bandwidth must support data rate
Mobility	Ground Speed (0-125 kph) Air Speed (0-250 kph)	HMMWV (typical) UH-60 / C-12 (typical)
Overall Information Rate		
- Low Band (VHF/UHF)	> 6 Mbps (T); > 20 Mbps (O)	
- High Band (Above UHF)	> 10 Mbps (T); > 100 Mbps (O)	
IP Radio Bit Error Rate	≤ 1E-4 (uncorrected), ≤ 1E-5 (corrected)	Availability tests over 2 hour period
Adaptive Data Rate	≥ 5 data rates supported	Operation to automatically adjust to highest reliable data rate and thus should extend to low order modulations with narrower bandwidths (e.g. 32 kbps)
RF Link Availability	≥ 95%	Node-to-node when within range
Link Ranges (Ground – Ground)		
- Urban Canyons	200 m (Occluded - LOS)	Horizon is 3.6 km (1.5 mi)
- Suburban	2 km (Occluded - LOS)	Horizon is 3.6 km (1.5 mi)
- Rural	10 km (Occluded - LOS)	Assume elevated antennas
Link Ranges (Air – Ground)	50 km (LOS)	
Link Margin	6 dB	Required margin for all range/rate measurements
Transmitter Power	≥ 50 W	Must support 50 W transmissions to provide sufficient power margin
2. Security	Secure communications capability (i.e. HAIPE) for end-to-end secure transport that is permissible by the source and destination pair;	
LPD/LPI	None (T)	
	Contractor Provided (O)	
Payload	Required	KG-250 or AES-256 or similar

PERFORMANCE	**METRICS**
3. Networking	Field demonstration of both ground to ground and air to ground networking supporting one air platform and eleven (11) ground nodes with direct interface to a tactical gateway and supporting up to 64 IP-addressable nodes and 512 IP addressable devices.
	Demonstrate end-to-end connectivity (between tactical gateways) of > 95% reliability with 75% of end-to-end disruptions < 300 sec;
	Conformity to IPv4 protocol standard IPv4 inclusive of link/network security
	Provide network that supports tactical applications
	Latency of the network to support voice operations (without disruptions) • 300 ms (Threshold for 3 end-to-end hops) • 150 ms (Objective for 3 end-to-end hops)
	Network formation and Network join times that support tactical operations (without disruptions) • < 10 seconds (Network Join) • < 30 seconds (Network Formation of 10 nodes)
	Network supports tactical applications including (but not limited to) • Sensor Data associated with ISR (e.g. video) • Voice (e.g. VOIP) • Peer-to-Peer networking (e.g. distributed CHAT) • Network management

	Supports tactical topologies and routing requirements including (but not limited to)
	• Unicast, multicast, and broadcast traffic
	• Ad Hoc networks that
	  o are autonomous, self forming/healing with minimal or no intervention
	  o dynamically adjust to topology changes

	Network supports network traffic of • 80% of traffic is multicast, and • 20 simultaneous video streams (nominally 384 kbps), and • Normal voice traffic
	Traffic shaping/prioritization to allow resource management of Gateway network traffic.
	Support QoS in standard TCP/IP protocol suite (e.g.) • CS6 • Expedited Forwarding • Assured Forwarding • Best Effort

PERFORMANCE	**METRICS**	**REMARKS**
4. Gateway		
Data Radio Support		
- Military Radios	EPLRS, MicroLight EPLRS, SLICE/SRW, SecNet11, PRC-117F, SINCGARS	Sufficient modules to provide support for the radios listed and capacity to incorporate new modules for radios not listed
- Commercial Radios	802.11g, WiMAX (2.5 GHz), UMTS	Sufficient modules to provide support for the radios listed and capacity to incorporate new modules for radios not listed
- Public Safety/Critical Infrastructure Radios	Terrestrial Trunked Radio (TETRA) 4.9 GHz Public Safety Radio	Sufficient modules to provide support for the radios listed and capacity to incorporate new modules for radios not listed
Voice Radio Support		
- Military Radios	PRC-117, PRC-119, PRC-150, SINCGARS	Sufficient modules to provide support for the radios listed and capacity to incorporate new modules for radios not listed
- Commercial Radios	Family Radio Service (FRS), Cellular, VOIP devices, PSTN	Sufficient modules to provide support for the radios listed and capacity to incorporate new modules for radios not listed
- Public Safety/Critical Infrastructure Radios	800 MHz Public Safety Radio	Sufficient modules to provide support for the radios listed and capacity to incorporate new modules for radios not listed
Wide Area Network Support	IPv4, IPv6, etc. enabled Wide Area Network	Support WAN protocols (e.g. BGP, OSPFv2, and IGMP)
- Military Network	Global Information Grid	
- Commercial Radios	Internet	
Local Area Network Support	IPv4 enabled Local Area Network	
- Military Networks	SATCOM and Terrestrial (e.g. NCR)	
Application Support		
- Routing	Unicast, Multicast, Broadcast	
- Tactical applications	Including (but not limited to) • Sensor Data associated with ISR (e.g. video) • Voice • Peer-to-Peer networking (e.g. distributed CHAT) • Network management	
Data Capacity	> 100 Mbps	Aggregate capacity for entire Gateway
Ports (bidirectional)	Support: • Three (3) Voice Radios • Three (3) Data Radios • One (1) WAN • One (1) LAN	
Physical	Modular Architecture	Additional radios are added by compatibility with current modules or by new modules.

ENVIRONMENTAL	**METRIC**	**REMARKS**
Antenna Testing	IEEE Standard 149-1979, "Standard Test Procedures for Antennas"	Perform to Standard
	IEEE Standard 1100-1999,"Recommened Practice for Powering and Grounding Electronic Equipment"	Perform to Standard
Marking Requirements	MIL-STD-27733, "Modification and Marking Requirements for Test Equipment in Aerospace Vehicles and Related Support Equipment"	Perform to Standard
EMI/EMC	MIL-STD -461 (EMI/EMC electrical interference testing and isolation techniques)	Perform to Standard
Electronic Component Testing	MIL-STD -202 (electronic component testing)	Perform to Standard
Environmental Testing	MIL-STD-810F "Environmental Engineering Considerations and Laboratory Tests." Part II, Laboratory Test Methods	Perform to Standard
		Temperature range: -56.5 (36 kft) to 100 Degrees C
		Method 509.4 - Salt Fog
		Method 520.2 - Temperature, Humidity, Vibration, and Altitude
		MIL-HDBK-1568 - material and processes for corrosion prevention and control in aerospace weapons systems
		MIL-HDBK-1250a - corrosion prevention and deterioration control in electronic components and assemblies
PHYSICAL	**METRIC**	**REMARKS**
Size	5U high (8.75") x 21" deep (Fits in standard 19" rack)	If proposed, data logging and control computer to be located on separate 2U sliding drawer mount (total 19" rack of 7U). All installations for air/ground use should be identical system
Weight	≤45 lbs	Credible Design, with supporting Documentation
Power	<400 Watts (max)	Credible Design, with supporting Documentation
Aircraft Power	400 Hz AC and 28VDC	If other voltage sources are available the contractor can use any available extra power as agreed to by the owner
Ground Power	120V 60Hz AC and 12VDC	

PROGRAMMATIC		**REMARKS**
Test Sites	Interim Test Site Final Test Site	Interim Test site to be proposed by performer (terrain similar to Ft. Benning) Final Test Site, expected to be Ft. Benning, subject to change by Government
Test Duration	10 weeks	Inclusive of setup, personnel training, testing, and demonstrations
Test Participants - Military Personnel - Coalition - First Responders	- US - UK, Canada, Australia, and other NATO - TBD prior to Program Kickoff	All equipment testing and demonstrations must be compatible for operation by non-contractor personnel
Test Equipment	11 Ground MAINGATE Nodes + 2 Spare 2 Airborne MAINGATE Nodes	
- Contractor Furnished	Radios	Include associated support equipment (antennas, mounts, connectors, etc)
	- (2) SATCOM and/or ISR Feed (e.g. ROVER) of same type	These are IPv4 compatible networks
	- (33) Legacy Radios	One (1) of each type (there are 11) for connection to Gateway and two (2) for outside gateway (nominal)
	- (21) Commercial Radios	One (1) of each type (there are 7) for connection to Gateway and two (2) for outside gateway (nominal)
	- (9) First Responder Radios	One (1) of each type (there are 3) for connection to Gateway and two (2) for outside gateway (nominal)
	Test Vehicles	
	- 10 Ground Vehicles	Including drivers
	- 2 Air Vehicles	Including pilots
- Government Furnished		
	Radios	
	- (TBD) Allied Radios	To be determined at Program Kickoff
Ground Platform for Design	Moving Vehicles (e.g. M998 High Mobility Multipurpose Wheeled Vehicle - HMMWV)	Subject to change by Government
Air Platform for Design	UH-60, C-12, C130	Subject to change by Government
COST	**METRIC**	**REMARKS**
Production Unit Cost	$60,000 (FY08$) per unit for a buy of 1,000 units	Total sell price to the Government

APPENDIX B: TECHNICAL READINESS LEVEL (TRL)

This appendix provides background and definitional information related to TRLs to provide the proposer with information for preparation and evaluation of the proposal. This information is outlined from the DoD Technology Readiness Assessment Handbook and outlines requirements approved by the Under Secretary of Defense for Acquisition, Technology, and Logistics.

BACKGROUND

DoD 5000.2-R establishes technology maturity expressed in Technology Readiness Levels (TRLs). The entire process is shown in Figure 1. It is the centerpiece for the Technology Readiness Assessments (TRAs) required for ACAT ID and IAM programs. It is important to have a strong grasp of the TRL concept to assess the technology maturity of the various components, subsystems and overall system in the MAINGATE program. The tables in this section give the TRL fundamentals in the form of brief descriptions, definitions, and indicators that are expected by DUSD(S&T) to substantiate the TRLs. In addition, we will outline the specific process and procedures for conducting the assessment for MAINGATE to provide uniform guidance to the contractor base.

Using TRLs to describe the maturity of technologies considered for use in a new system originated with NASA in the early 1980s. The levels ran from the earliest stages of scientific investigation (level 1) to successful use in a system (level 9), which equates to space flight for NASA. DoD has adopted the NASA definitions—with only minor modifications—for the nine TRLs.

Table 1 gives the DoD TRL levels, definitions, descriptions, and supporting information. It also describes typical documentation to support a TRL assignment. Table 2 includes a set of additional definitions that help provide for the uniform interpretation of the levels. The DoD TRL levels, definitions, and descriptions in Table 1 and the set of additional definitions in Table 2 have been extracted from DoD 5000.2-R, dated April 5, 2002. Figure 2 provides examples of the various levels of maturity for the Honeywell HG 1700 Inertial Measurement Unit used in the Guided Multiple Launch Rocket Systems.

Software is likely to be an important element in many TRAs. Since the TRL definitions in Table 1 reflect a systems approach in which software is treated as a part of a component or system, software TRLs (STRL) are not spelled out specifically in these definitions. However, because some guidelines would be useful in determining the TRLs of the software parts of components, subsystems and systems, a set of software TRL definitions is provided for information in Table 3. These STRLs follow industry practices like CMMI and will not be discussed here.

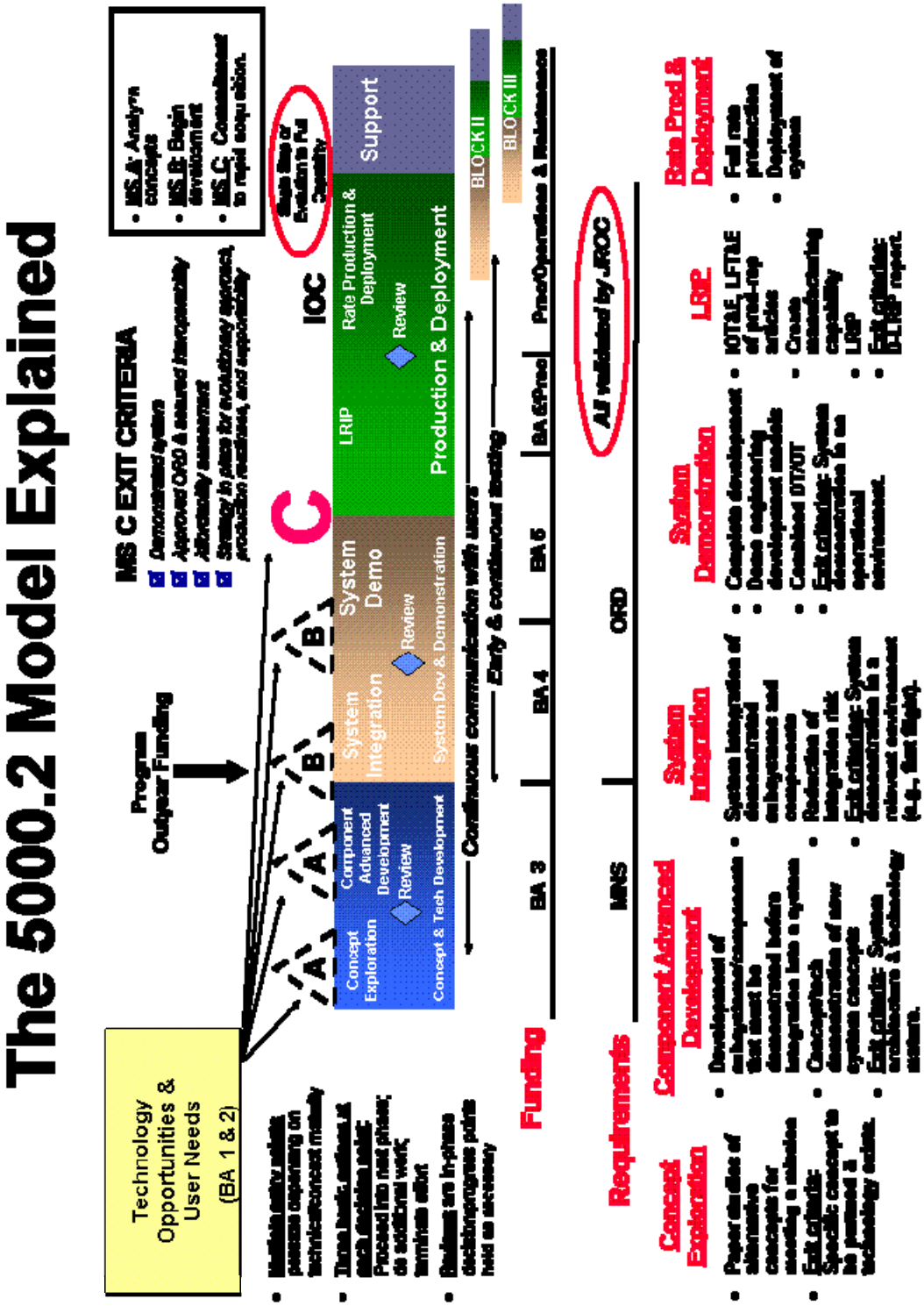


Figure 1. 5000.2 Process

Table 1. TRL Definitions, Descriptions, and Supporting Information

TRL	Definition	Description	Supporting Information
1	Basic principles observed and reported	Lowest level of technology readiness. Scientific research begins to be translated into applied research and development. Examples might include paper studies of a technology's basic properties.	Published research that identifies the principles that underlie this technology. References to who, where, when.
2	Technology concept and/or application formulated	Invention begins. Once basic principles are observed, practical applications can be invented. Applications are speculative, and there may be no proof or detailed analysis to support the assumptions. Examples are limited to analytic studies.	Publications or other references that outline the application being considered and that provide analysis to support the concept.
3	Analytical and experimental critical function and/or characteristic proof of concept	Active research and development is initiated. This includes analytical studies and laboratory studies to physically validate analytical predictions of separate elements of the technology. Examples include components that are not yet integrated or representative.	Results of laboratory tests performed to measure parameters of interest and comparison to analytical predictions for critical subsystems. References to who, where, and when these tests and comparisons were performed.
4	Component and/or breadboard validation in laboratory environment	Basic technological components are integrated to establish that they will work together. This is relatively "low fidelity" compared to the eventual system. Examples include integration of "ad hoc" hardware in the laboratory.	System concepts that have been considered and results from testing laboratory-scale breadboard(s). References to who did this work and when. Provide an estimate of how breadboard hardware and test results differ from the expected

TRL	Definition	Description	Supporting Information
			system goals.
5	Component and/or breadboard validation in relevant environment	Fidelity of breadboard technology increases significantly. The basic technological components are integrated with reasonably realistic supporting elements so they can be tested in a simulated environment. Examples include "high-fidelity" laboratory integration of components.	Results from testing a laboratory breadboard system are integrated with other supporting elements in a simulated operational environment. How does the "relevant environment" differ from the expected operational environment? How do the test results compare with expectations? What problems, if any, were encountered? Was the breadboard system refined to more nearly match expected system goals?
6	System/subsystem model or prototype demonstration in a relevant environment	Representative model or prototype system, which is well beyond that of TRL 5, is tested in a relevant environment. Represents a major step up in a technology's demonstrated readiness. Examples include testing a prototype in a high-fidelity laboratory environment or in simulated operational environment.	Results from laboratory testing of a prototype system that is near the desired configuration in terms of performance, weight, and volume. How did the test environment differ from the operational environment? Who performed the tests? How did the test compare with expectations? What problems, if any, were encountered? What are/were the plans, options, or actions to resolve problems encountered before moving to the next level?
7	System prototype demonstration in an operational environment	Prototype near, or at, planned operational system. Represents a major step up from TRL 6, requiring demonstration of	Results from testing a prototype system in an operational environment. Who performed the tests? How did the test compare

		an actual system prototype in an operational environment such as an aircraft, vehicle, or space. Examples include testing the prototype in a test bed aircraft.	to expectations? What problems, if any, were encountered? What are/were the plans, options, or actions to resolve problems encountered before moving to the next level?
8	Actual system completed and qualified through test and demonstration	Technology has been proven to work in its final form and under expected conditions. In almost all cases, this TRL represents the end of true system development. Examples include developmental test and evaluation of the system in its intended weapon system to determine if it meets design specifications.	Results of testing the system in its final configuration under the expected range of environmental conditions in which it will be expected to operate. Assessment of whether it will meet its operational requirements. What problems, if any, were encountered? What are/were the plans, options, or actions to resolve problems encountered before finalizing the design?
9	Actual system proven through successful mission operations	Actual application of the technology in its final form and under mission conditions, such as those encountered in operational test and evaluation. Examples include using the system under operational mission conditions.	Operational Test and Evaluation reports.

Level	Technology Readiness	Example – HG1700 Inertial Measurement Unit Guided Multiple Launch Rocket System (GMLRS)
1	Basic Principles observed and reported	**Basic research** – Invention of Gas Laser
2	Technology concept and/or application formulated.	**Basic research** – Invention of Ring Laser. Theoretical description of Ring Laser Gyro
3	Analytical and experimental critical function and/or characteristic proof of concept.	**Applied research** – Demonstration of Ring Laser as a rate sensor
4	Component and/or breadboard validation in laboratory environment.	**Applied research** – Demonstration of Ring Laser Gyro (RLG)-based Inertial Measurement Unit (IMU) operation under temperature, shock, vibration, and g-loading
5	Component and/or breadboard validation in relevant environment.	**Advanced Technology Demonstration** – Demonstration of HG1700-based guidance set components (IMU, GPS receiver, control system, flight computer) in a high-fidelity hardware-in-the-loop facility
6	System/subsystem model or prototype demonstrated in a relevant environment.	**Advanced Technology Demonstration** – Demonstration of actual flight-ready HG1700-based guidance set in a high-fidelity hardware-in-the-loop facility and under expected levels of shock, vibration, altitude and temperature
7	System prototype demonstrated in an operational environment.	**System Design and Development** – Demonstration of actual Guided MLRS missile in a flight test sequence from an operational launcher. Successful operation in multiple flight demonstrations
8	Actual system completed and "flight qualified" through test and demonstration.	**Low Rate Initial Production** – Developmental Test and Evaluation of GMLRS in its final form under mission conditions.
9	Actual system "flight proven" through successful mission operations.	**Production** – Operational Test and Evaluation of GMLRS by the soldier, airman, or seaman.

Figure 2. Examples of TRLs for the HG1700

Table 2. Additional Definitions of TRL Descriptive Terms

Term	Definition
Breadboard	Integrated components that provide a representation of a system/subsystem and which can be used to determine concept feasibility and to develop technical data. Typically configured for laboratory use to demonstrate the technical principles of immediate interest. May resemble final system/subsystem in function only.
High Fidelity	Addresses form, fit, and function. High-fidelity laboratory environment would involve testing with equipment that can simulate and validate all system specifications within a laboratory setting.
Low Fidelity	A representative of the component or system that has limited ability to provide anything but first order information about the end product. Low-fidelity assessments are used to provide trend analysis.
Model	A functional form of a system generally reduced in scale, near or at operational specification. Models will be sufficiently hardened to allow demonstration of the technical and operational capabilities required of the final system.
Operational Environment	Environment that addresses all of the operational requirements and specifications required of the final system to include platform/packaging.
Prototype	A physical or virtual model used to evaluate the technical or manufacturing feasibility or military utility of a particular technology or process, concept, end item, or system.
Relevant Environment	Testing environment that simulates the key aspects of the operational environment.
Simulated Operational Environment	Either (1) a real environment that can simulate all of the operational requirements and specifications required of the final system or (2) a simulated environment that allows for testing of a virtual prototype; used in either case to determine whether a developmental system meets the operational requirements and specifications of the final system.

Table 3. Software TRL Definitions

TRL	Definition	Description
1	**SW**: Functionality conjectural	Lowest level of software readiness. Basic research begins to be translated into applied research and development. Examples might include a concept that can be implemented in software or analytic studies of an algorithm's basic properties.
2	**SW**: Technology concept and/or application formulated	Invention begins. Once basic principles are observed, practical applications can be invented. Applications may be speculative and there may be no proof or detailed analysis to support the assumptions. Examples are limited to analytic studies.
3	**SW**: Analytical and experimental critical functions and/or characteristic proof of concept	Active research and development is initiated. This includes analytical studies to produce code that validates analytical predictions of separate software elements. Examples include software components that are not yet integrated or representative but satisfy an operational need. Algorithms run on a surrogate processor in a laboratory environment.
4	**SW:** Functionality demonstrated in a laboratory environment	Basic software components are integrated to establish that they will work together. They are relatively primitive with regard to efficiency and reliability compared with the eventual system. System software architecture development initiated to include interoperability, reliability, maintainability, extensibility, scalability, and security issues. Software integrated with simulated current/ legacy elements as appropriate.
5	**SW:** Functionality and performance demonstrated in a relevant environment	Reliability of software ensemble increases significantly. The basic software components are integrated with reasonably realistic supporting

		elements so that it can be tested in a simulated environment. Examples include "high-fidelity" laboratory integration of software components. System software architecture established. Algorithms run on a processor(s) with characteristics expected in the operational environment. Software releases are “Alpha” versions and configuration control initiated. Verification, Validation, and Accreditation (VV&A) initiated.

TRL	Definition	Description
6	**SW:** Functionality and performance demonstrated in a realistic simulated (live/virtual) operational environment	Representative model or prototype system, which is well beyond that of TRL 5, is tested in a relevant environment. Represents a major step up in software-demonstrated readiness. Examples include testing a prototype in a live/virtual experiment or in simulated operational environment. Algorithm run on processor or operational environment integrated with actual external entities. Software releases are “Beta” versions and are configuration controlled. Software support structure in development. VV&A in process.
7	**SW:** Functionality and performance demonstrated in an operational test environment.	Represents a major step up from TRL 6, requiring the demonstration of an actual system prototype in an operational environment, such as in a command post or air/ground vehicle. Algorithms run on processor of the operational environment integrated with actual external entities. Software support structure in place. Software releases are in distinct versions. Frequency and severity of software deficiency reports do not significantly degrade functionality or performance. VV&A completed.
8	**SW:** Functionality, performance, and	Software has been demonstrated to

	quality attributes validated in an operational environment.	work in its final form and under expected conditions. In most cases, this TRL represents the end of system development. Examples include test and evaluation of the software in its intended system to determine if it meets design specifications. Software releases are production versions and are configuration controlled in a secure environment. Software deficiencies are rapidly resolved through support structure.
9	**SW:** Functionality, performance and quality attributes proven in an operational environment through successive successful accomplishment of mission operations.	Actual application of the software in its final form and under mission conditions, such as those encountered in operational test and evaluation. In almost all cases, this is the end of the last "bug fixing" aspects of system development. Examples include using the system under operational mission conditions. Software releases are production versions and are configuration controlled. Frequency and severity of software deficiencies are at a minimum

TRA FOR COMPONENTS, SUBSYSTEMS AND SYSTEM

For the MAINGATE proposal development and program, the following guidance is provided for conducting TRAs.

Specification Definition:

The contractor shall perform a system design to achieve the MAINGATE metrics using the GFI and other guidance provided in the solicitation/contract. Included in this design will be a definition of the quantitative specification for each major component and subsystem comprising the overall system, a sensitivity analysis related to the design's robustness and ALL underlining assumptions in the design. Major categories in each specification, from the system down to the components, should include at the minimum: (1) Performance (e.g., for an inertial sensor, bias stability, drift rate, scale factor, accelerometer dynamic range); (2) physical (e.g., size, weight, volume, required electrical power); (3) environmental (e.g., temperature range, vibration/power spectrum density; shock; humidity range; waterproof; immersion depth); and (4) programmatic (e.g., test/measurement environment, affordability). Qualitative metrics are not acceptable. It will be complete and unambiguous, using accepted industry standard definitions

as available. The specification for the components, subsystem and systems will be the measurement metrics for the associated TRA.

TRL 5 Assessment:

In Table 1, we see that the definition of TRL 5 is "component and/or breadboard validation in relevant environment." Its description is that the "basic technological components are integrated with reasonably realistic supporting elements so they can be tested in a simulated environment." Examples include "high-fidelity" laboratory integration of components. Figure 2 gives the example that the components of the HG 1700 like the IMU, GPS receiver, control system and flight computer were exercised and evaluated in a high-fidelity "hardware in the loop" facility.

In simple terms, the contractor will be expected to test the components, subsystems and/or systems in the laboratory under some simulated, expected operational conditions, but the breadboard is not expected to meet the full packaging, complete environmental and programmatic specifications. For example, the device will be shown to meet the performance specification while simultaneously experiencing vibration from a vibration table or temperature cycling in a temperature chamber or both. The parts that compose the entity also may not be packaged in its final form as well.

The entity must meet, or exceeds, 100% of the performance, but will not be expected to be tested under all specified ranges because of cost, equipment limitations, or some other reasonable consideration. However, the test must be comprehensive enough (>70% of the range, centered between the two extremes) to give the Government the confidence that the performance variation is not trending towards future catastrophic failure modes at this stage of development. Some statistical testing of the components, subsystems and system ($3 < X < 10$) is expected; greater confidence will be given to more samples being used.

Critical to this assessment is a clear, detailed definition of the tests and procedures that were used. This definition must be documented with the analyzed test results for review by the Government and non-Government Subject Matter Experts (SMEs).

TRL 6 Assessment:

In Table 1, we see that the definition of TRL-6 is "System/subsystem model or prototype demonstration in a relevant environment." Its description is that the "representative model or prototype system, which is well beyond that of TRL-5, is tested in a relevant environment." It represents a major step up in a technology's demonstrated readiness and the S&T entrance criteria for a Milestone B Decision. This is normally the assessment that comes after the Component Technology Development (Exit Criteria; see figure 1). Examples include testing a prototype in a high-fidelity laboratory environment or in simulated operational environment" Figure 2 gives the example that the demonstration of a flight-ready HG-1700-based guidance set, exercised and evaluated in a high-fidelity "hardware in the loop" facility under expected vibration, shock, altitude and temperature.

In simple terms, the contractor will be expected to test the subsystems, system and/or prototype in the laboratory under full simulated, expected operational conditions. Unlike TRL-5, the subsystems, system and/or prototype is expected to meet all the specification, including the full packaging, complete environmental and programmatic specifications. It will not be evaluated under the full formal testing outlined by Acquisition and IOT&E policies, requiring a statistical Test and Evaluation Master Plan (TEMP) and formal documentation, but enough testing is expected to provide the Government with confidence that it would pass the formal process. In other words, sufficient statistical testing must be exercised to ensure that a zero/minimal set of unknown unknowns will occur in future development, if it occurs. The entity must meet, or exceed, 100% of the complete specification.

Critical to this assessment is a clear, detailed definition of the tests and procedures. This definition must be reviewed and approved by the Government before execution. In addition, all tests will be observed by a Government official or representative. These requirements are mandated to ensure Government expectations are met. As stated above, this TRA could provide a Technology Maturity Assessment for a future Program of Record at the Milestone B stage, hence the reason for the extra scrutiny.

Based on the customers' desire before the end of Phase 2, a Technical Maturity Assessment may be formally signed between the DARPA Director and the receiving Program Executive Officer or appropriate Acquisition Executive, and the aforementioned contractor derived specification will be replaced with a set of Key Performance Parameters (KPPs), defined solely by the customer. This set of KPPs will be in accordance with the customer's Operational Requirement Document (ORD) or equivalent documentation. In this assessment, all testing will be performed independent of contractor testing, either by representatives from the Government, an independent, disinterested contractor/ FFRDC, or a combination of the aforementioned. To ensure operational utility, some Limited User Testing be done as part of this assessment as well.

<u>TRL 7 Assessment</u>:

In Table 1, we see that the definition of TRL 7 is "System prototype demonstration in an operational environment." Its description is that Prototype near, or at, planned operational system represents a major step up from TRL 6, requiring demonstration of an actual system prototype in an operational environment such as an aircraft, vehicle, or space. Examples include testing the prototype in a test bed aircraft." This is normally the assessment that comes after the System Integration portion of System Development and Demonstration (Exit Criteria; see figure 1). Figure 2 gives the example of actual demonstration of a GMLRS flight test from an operational launcher. It requires successful operations in multiple flight operations.

TRL 7 testing (aka Developmental Testing or DT) requires formal documentation like a TEMP developed by representatives from the Service and OSD testing communities. All documentation is reviewed by numerous groups and organizations, and approved by the pertinent Acquisition Executive before execution. All testing is done independently by the Government, and periodic reports come out outlining test results and analyses. This type of assessment is beyond what is required by MAINGATE, and DARPA, in general, and is provided for informational purposes only.

APPENDIX C: Article: MANET GATEWAYS: Radio Interoperability via the Internet, not the Radio

(Cleared for Public Release, Distribution Unlimited, DARPA Case 10187)

MANET GATEWAYS: Radio Interoperability via the Internet, not the Radio

ABSTRACT

The objective of the DARPA Network Centric Radio System[5] Program was to design, develop, integrate, and demonstrate the enabling communication technologies and system capabilities required to enable network centric warfare. NCRS is a First Generation Mobile, Ad Hoc Network designed to enable ground and airborne vehicle based on-the-move and on-the-halt network centric connectivity using both IP and non-IP enabled devices. It demonstrated a gateway architecture that can offer radio interoperability among various current, future, coalition and first responder communications radios, via the network, not the radio. This capability illustrated a new dimension for communications interoperability for radio systems developers.

INTRODUCTION

The focus of debate throughout the commercial, public safety, and military communications research communities has been on the mechanisms to enable inter- and intra-community communications interoperability. Previous attempts at providing such interoperability have focused on the physical layer by creating an "interoperability band" and a single "interoperability waveform". In fact there have been multiple attempts at such a solution all meeting similar outcomes: new technology or changes in funding or development project create fragmented or outdated solutions that are essentially ignored by the operational communities. The onset of wideband devices and digitally addressable analog components has recently provided a new approach in software definable radios or SDRs. The SDR approach is still physical layer solution in which the radio has the capacity to be modified to create common waveform networks. This approach, albeit the ultimate solution for ubiquitous communication between these communities has faced numerous technical and affordability challenges. A new approach is both possible and necessary for providing interoperable radio systems without reliance only physical layer techniques.

The military had the first need for highly interoperable radio systems. The after-action analysis of the command and control systems from many of the conflicts since Vietnam indicated a consistent inability to communicate between the services during joint operations and exercises. After Grenada, a GAO report [1] indicated that air support operations between the Army ground forces and Marines were hampered due to the incompatibility of their radios. These shortfalls continued though to the 1990 Persian Gulf War as described in a 1992 report to Congress [2],[3] that described the problems in establishing an interoperable network across disparate communications systems. Interoperability enables information to be exchanges among the

[5] NCRS was formerly known as the Future Combat Systems Communications.

services directly and satisfactorily. These same issues are also prevalent in the non-DoD communications systems used for public safety organizations as seen during the response to the terrorist attacks of September, 2001.

Early in the 21st Century, the focus of many of the DoD efforts was on how to enable Network-Centric Warfare (NCW). In particular, NCW was to allow warfighters to take advantage of all the available information within the Battlespace in a rapid and flexible manner. One example is the enabling of an effective the sensor-to-shooter process. A means to seamlessly connect the array of disparate sensor, command and control, and weapon systems each with a separate communication system into an effective, integrated system was needed. The key enabler to this process was development of the Global Information Grid (GIG) communications system [1][21]. The GIG is the network fabric for which to build a "Systems of Systems" to fulfill the ultimate goal of network centric warfare. Mobile networking is one piece

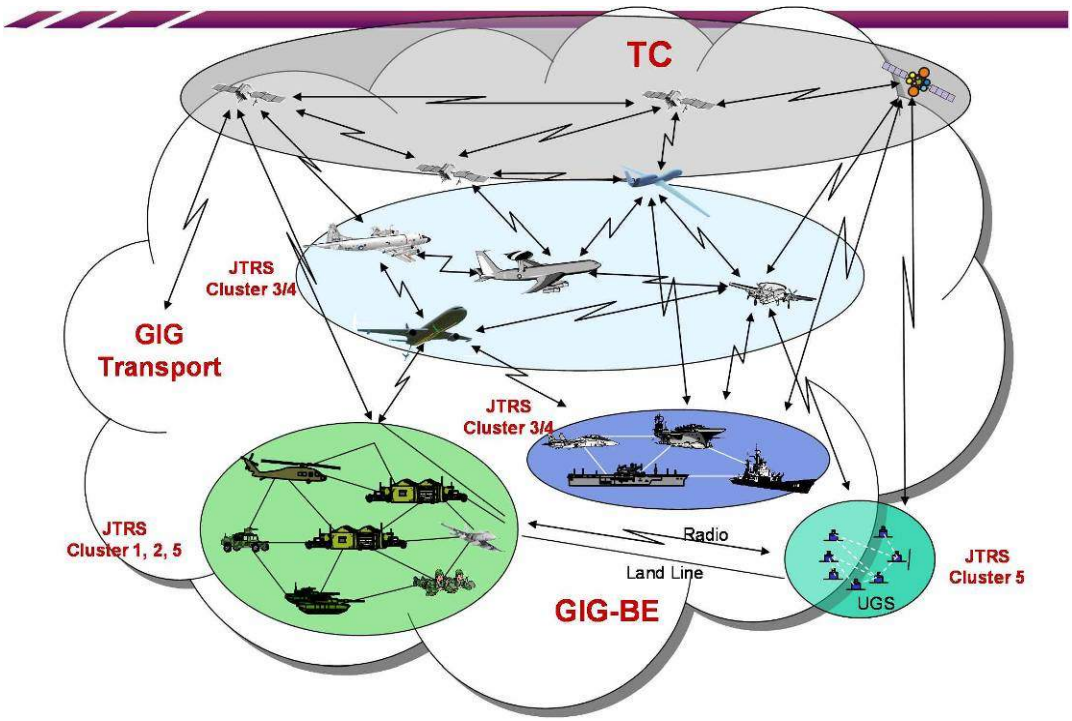


Figure 1 : Global Information Grid Communications System

of the GIG and is built upon the use of the interoperable Joint Tactical Radio System (JTRS) [19,20]. The primary mechanism for interoperability for the JTRS has been the use of software defined radio (SDR) features to provide physical layer compatibility.

As noted above, the more flexible and ubiquitous solution for interoperable communications comes from the physical layer and MAC adaptation obtained with the SDR technology. Many of the technical challenges for SDR lie in their power efficiency, size, and cost [15-17]. These challenges motivated the DARPA to look at alternative technologies to enable interoperability in battlefield communications through the development of a network-centric radio system.

The initial DARPA Network Centric Radio System (NCRS) Program designed, developed, integrated, and demonstrated the basic enabling communication building blocks and system capabilities required to enable network centric warfare. This system was initially developed during 2000-2003 timeframe. NCRS is a First Generation Mobile, Ad Hoc Network (MANET) designed to enable ground and airborne vehicle based on-the-move (OTM) and on-the-halt (OTH) network centric connectivity. Its dual High (above 10 GHz) and Low (below 3 GHz) Bands operation would provide a comparable data rate and coverage area to the anticipated Joint Tactical Radio System (JTRS) Wideband Network Waveform (WNW) vehicle-based Brigade and below communications, and Warfighters Information Network-Tactical (WIN-T) for Above Brigade Communications, respectively.

However, it became clear in late 2003 that NCRS was missing the one capability that had been plaguing the developers for the past few decades – radio interoperability at the tactical level. NCRS was then modified during the period 2004-06 to enable gateway architectures that offered interoperability among various current, future, coalition and first responder communications radios, via the network, not the radio. This represented a radical departure from the traditional physical layer interoperability that is described above.

This paper describes the development of a Network Centric Radio System including the challenges associated with provide the networking of heterogeneous nodes, network scalability, and use of efficient protocols. The field testing results of this new communications architecture are provided.

THE DEVELOPMENT OF A NETWORK CENTRIC RADIO SYSTEM

The DARPA Network Centric Radio System (NCRS) Program designed, developed, integrated, and demonstrated the basic enabling communication building blocks and system capabilities required to enable NCW. Figure 2 is the demonstrated capabilities of initial NCRS in both Low (below 3 GHz) and High Band (above 10 GHz) operations during demonstration in August 2003.

Additional network capabilities of the NCRS are evident when compared to currently deployed communications systems for the US military:

- The incorporation of *adaptive modulation* on a per-link basis continually maximizes multi-megabit data rate for given link and network utilization conditions. Assured network connectivity upwards of ranges up to 150 km for air-to-air and air-to-ground line-of-sight is achieved using an extended range waveform mode for wide area missions.
- The *network flexibility* of NCRS offers to adapt to a wide range of deployment scenarios, applications, and traffic types. Preliminary studies of current tactical network planning for systems such as FBCB2[6], suggests potential improvements to eliminate up to 12 of 13 database tables and upwards of 150,000 entries used for network routing. Inherent to MANET protocols used in NCRS is a high level of adaptation to the dynamics of

[6] Force XXI Battle Command, Brigade-and-Below, FBCB2, will provide situational awareness and command and control to the lowest tactical echelons. It will facilitate a seamless flow of battle command information across the battlespace, and will interoperate with external command and control and sensor systems [18]

Initial NCRS Metrics	Goals		Demonstrated	
20 Node Average Aggregate Network Throughput	**Anti-Jam Performance**	**High Data Rate Performance**	**Anti-Jam Performance**	**High Data Rate Performance**
- Low Band	200 kbps	10 Mbps	203 kbps	10.3 Mbps
- High Band	1 Mbps	70 Mbps	24 Mbps	50 Mbps
Beam Pattern				
- Low Band	45º AZ		39º AZ	
- High Band	4.5º EL x 12º AZ		4.5º EL x 12º AZ	
Processing Gain				
- Low Band	40 dB		41.6 dB	
- High Band	14 dB		19.4 dB	
Network Latency				
- 10% of the average system load (< 200 msec)	90.0%		90.0%	
- 30% of the average system load (< 1 sec)	90.0%		88.8%	
- 60% of the average system load (< 30 sec)	90.0%		98.9%	
Transition between High Band/Low Band	< 1 sec		1 sec	
Packet Delivery				
- 10% of the average system load	90.0%		75.0%	
- 30% of the average system load	90.0%		73.8%	
- 60% of the average system load	90.0%		88.3%	
20 Node Network Initialization Time	< 6 min		2 min	
Node Entry Time	< 30 sec		10 sec	
Detect node Exit Time	< 10 sec		5 sec	

Figure 2 Demonstrated capabilities of Initial NCRS Low and High Bands Operations, August 2003.

topology, network membership, and link conditions. Thus the networking overhead is streamlined to localized links.

- Techniques applied at both Channel Access and Routing components ensure *prioritization* of critical traffic flows and reliable delivery under both nominal and congested network states in changing service conditions. Unicast and multicast routing protocols in NCRS rapidly adapt to changing topologies for effective traffic dissemination in support of existing and emerging user applications.

In late 2003 modifications were made to NCRS to enable radio interoperability at the tactical level. In response, the Low Band portion of the NCRS capability underwent a software upgrade[7]. Its overall throughput performance was still comparable to that of the anticipated JTRS WNW operating within the lower tiers of the Transformational Communications Architecture (TCA), but with one added capability. The NCRS architecture now includes gateways. Thus NCRS is compatible with TCA and offers interoperability among various current, future, coalition and first

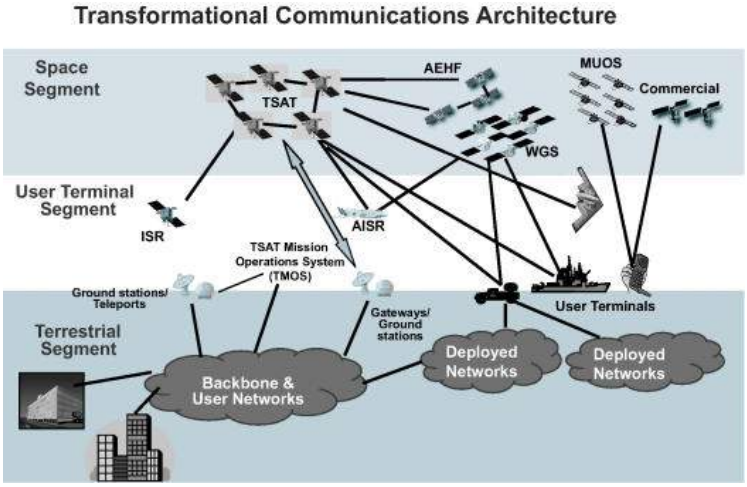


Figure 3 Transformational Communications Architecture (TCA)

[7] Consulting & Engineering Next Generation Networks (CENGEN) extended software originally developed for the US Marine Corp CONDOR Program, and from Raytheon Fullerton

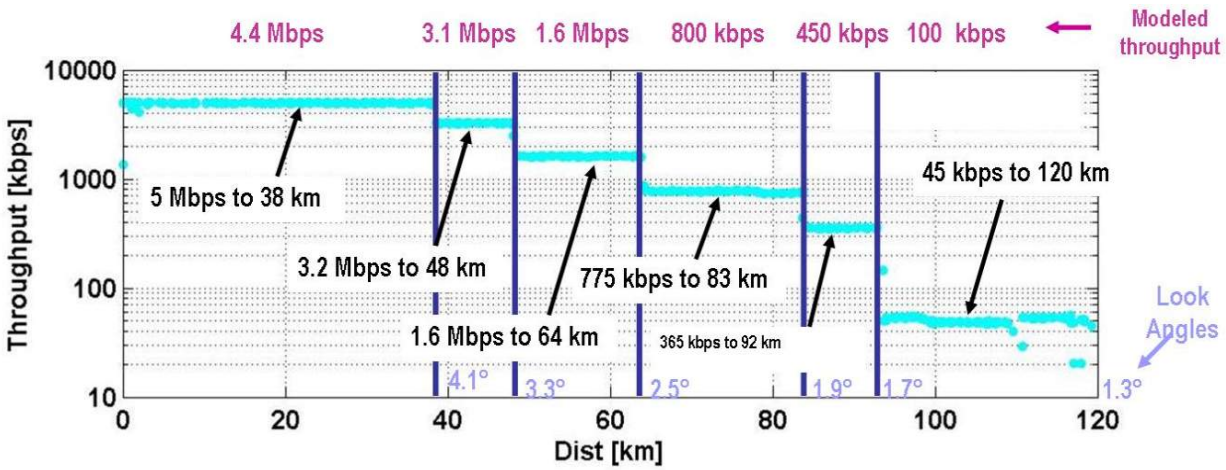


Figure 4 Typical Measured NCRS Air-to-Ground System Throughput versus Range

responder communications radios, via the network, not the radio.

During the month of January, 2006, a set of culminating unscripted operational experiments and demonstrations were conducted. The demonstrations consisted of operating up to 14 mobile network elements, or nodes, with a variety of communication systems and user applications. The nodes were deployed as military units including a Mechanized Infantry Battalion, with Battalion and Company units. The communication systems included tactical "stub-nets" which operated at lower tactical echelons (e.g. Intra-Company links), a high data rate primary Tier-1 communication system which provided connectivity between higher echelon elements (e.g. Battalion-Company links), secondary/back-up Tier-1 communication systems, and Tier-2 communications that provided connectivity to echelons above the Battalion. This heterogeneous mix of communication systems were interconnected using the Condor system [25] in which IP routers automatically routed application data between the various elements using the most efficient routes and radio systems.

Applications that were supported by the DARPA NCRS network included: Command Post of the Future, and Command and Control Personal Computer (C2PC), for Situational Awareness and Battlefield Command and Control; Video Data Streams from IP Cameras on selected network elements (both airborne and ground simultaneously); IP Chat; Voice Over IP (VOIP); and Network Maintenance Data (CenGen Network Manager). But more importantly, interoperable communications was demonstrated among the following digital and analog systems during those experiments: Command Post of the Future's and Cisco VoIPs, the ITT Soldier Radio, the Enhanced Position Location Reporting Systems (EPLRS), HAVEQUICK I/II (PRC-117), the Single Channel Ground and Airborne Radio System (SINCGARS/PRC-119) and the High Frequency MAN-PACK Radio (HFMR/PRC-150). Here is a summary of the key demonstration achievements:

- Demonstrated rapid autonomous mobile ad-hoc network formation and maintenance during tactical mobility scenarios (self-forming and self-healing)
- Demonstrated Link ranges in excess of 60 km at full 5 Mbps data rate (Terrain / geometry dependent)

- Demonstrated Maximum link range at lower, but operationally useful data ranges demonstrated to over 120 km (e.g., 800 kbps at 150 km during one test)
- Demonstrated Adaptive Data Rate (ADR), also known as Adaptive Modulation, shifts between link data rates to maintain reliable data transfer under changing link conditions
- Demonstrated low latency, multi-hop relay capability with adaptive throughput under changing link conditions, including arbitrary airplane, helicopter and vehicle speeds

Figure 4 is a summary of typical link operations.

This paper examines the technologies and capabilities developed by the DARPA NCRS Program and describe the system's performance in establishing the robust communications environment for the network-enabled command, control and information dissemination needed for successful Major Combat Operations (MCO), Security and Sustain Operations (SASO), and other military operations in the future. Sample experimental data obtained at Fort Benning will be presented and discussed.

HETEROGENEOUS VERSUS HOMOGENENEOUS NETWORKING

The first challenge to address when developing a network centric radio system is the fundamental issue associated with using homogeneous node types or a mixture of node types. The current wired internet is based upon a common internet protocol and a robust routing table capability. Routing tables are fairly static and change only over long time scales[8]. Therefore, the wireless technology that has been developed has exploited the static, homogeneous characteristics of the wired internet. Military mobile networks exhibit significant number of differences to the wired internet. Mobile networks are actually a Network of Networks in both physical instantiations and in network structure. Mobile networks operated and interface between unattended ground sensors, pedestrians, ground vehicles, low altitude aircraft, ships, high altitude aircraft, and satellite platforms. Each platform has different characteristics in mobility, available power, line-of-sight, latency tolerance, etc. Each of the platforms will exhibit differing networking requirements and place challenges on the interfaces between them.

[8] Mobile IP is a solution for introducing mobility for IP and routing tables. It uses an intermediate device/server to allow the routing tables to remain static and that the end-point addressing is morphed to a temporary IP address to reflect it current attachment point in the network. In essence, it has two IP addresses: one static, one dynamic.

Network of Networks architectural challenges are in three operational domains: within an individual network, within network-to-network connectivity, and between coalition networks.

In addition to Network scaling, the Network-to-Network connectivity challenges have the additional challenge of disparate physical layers between the networks that will require real-time, continual adaptation and conversion between modalities (RF and optical), waveforms and protocols. This problem distinguishes between routers for transport between similar networks and gateways for transport across different networks as depicted in Figure 5. An example of a

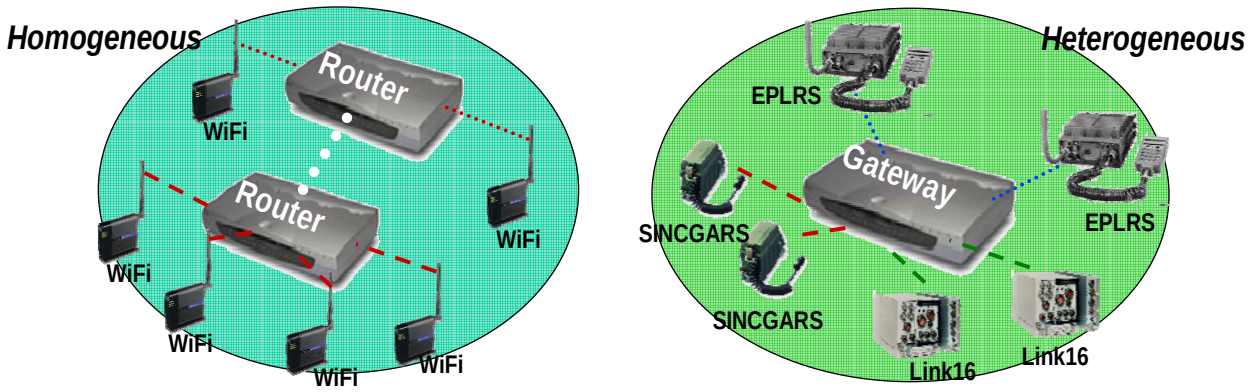


Figure 5 Homogeneous Networks Architectures Employ Routers versus Heterogeneous Military Mobile Networks Employ Gateways between Disparate Networks/Radios

router would be WiFi to WiFi networking, cellular telephony to cellular telephone networking. The physical and MAC layers would be similar with potentially differing protocols such as TCP, UDP, SCTP, etc. A gateway connects disparate nodes with differing physical attributes, waveforms, and protocols. Gateways have the capacity to bridge between differing networks such as infrastructure based, ad hoc, MANET, etc.

A potentially more serious Network-to-Network challenge is the routing and quality of service (QoS) constraints[9] when attempting to route across networks with different capacities. The problem of transmitting a video stream across a Mbit/sec link followed by a Kbit/sec link needs to be addressed. However, should it be addressed by the application layer (i.e. send less bits across the network via judicious selection), network layer (i.e. reduce the number of bits at the high-low bandwidth interface), or just to let the QoS be exceedingly poor.

Finally, more relevant situations are the challenges to operate coalition networks. In this case, the waveforms and protocols are not common and thus negotiations are needed within the physical, MAC, and network domains. Routing, especially for secure communications, becomes problematic. Coalition partners may not wish to provide detailed routing information of there network to a potentially untrusted partner and thus new schemes are needed to provide a useable networking interface.

[9] e.g. latency data rate, jitter

Again, heterogeneous mobile networking systems limit the utility of networking architectures developed for homogeneous systems. Current router technology does not provide the interoperability between heterogeneous networks. New techniques that can discover, translate, and negotiate within gateway-level architecture are becoming necessary and will be described in the later sections.

HETEROGENEOUS NETWORKING ARCHITECTURE

Since the capacity to deploy a homogeneous network will not be available in the near-term, the NCRS challenge is to design the architecture to address the range of node types. The NCRS architecture addresses this issue by providing a terrestrial backbone network for feeder stub networks integrated through heterogeneous network gateways. Airborne relays with the

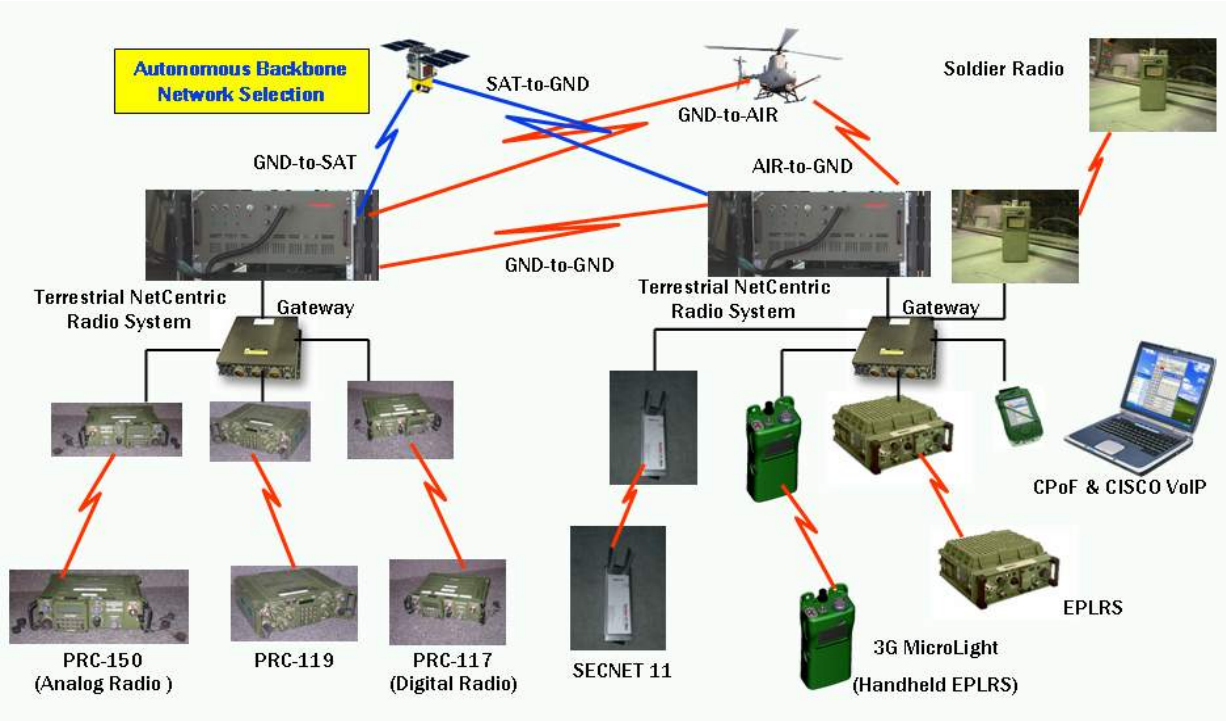


Figure 6 Simplified Network Architecture

primary mission to support communications were used to provide broadband connectivity over several tens of kilometers. Lower data rate SATCOM terminals were used to maintain beyond line-of-sight (BLoS) connectivity during infrequent NCRS outages [6]. The vehicular autonomously selected the best available backbone network. Feeder stub networks (PRC-150, PRC-119, PRC-117, SECNET11, Soldier Radio, EPLRS, and MicroLite) were used for small unit tactical communications in the vicinity of the vehicular backbone node. All voice, video, and data

traffic was transported between feeder networks over the backbone network. Command & Control (C2) information was managed by the CPoF application. Figure 6 depicts the simplified network architecture where the vehicular node provided the autonomous backbone network selection between terrestrial and satellite paths.

NETCENTRIC RADIO

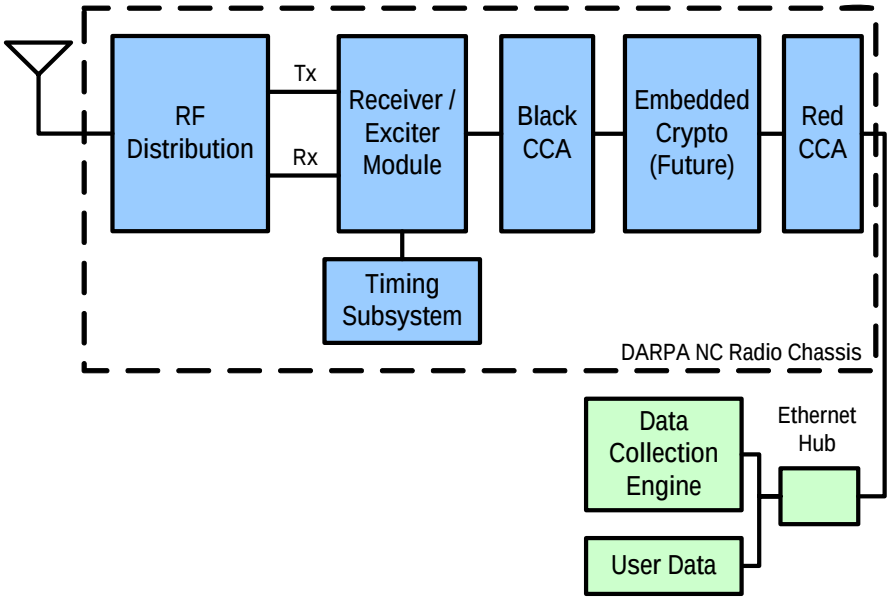


Figure 7 Terrestrial NetCentric Radio Block Diagram

ARCHITECTURE

A high-level view of the architecture of each terrestrial NCRS node is shown in Figure 7. Antennas are connected to an RF distribution module that contains the necessary RF filters, switches, attenuators, and power and low-noise amplification for high dynamic range operation. An FPGA-based receiver/exciter module performs digital up/down conversion and OFDM waveform modulation and demodulation with reference timing from the GPS/Rubidium timing sub-system. MAC and datalink neighbor discovery, QoS, and scheduling functions are implemented on a General Purpose Processor (GPP) running on a 'black' circuit card assembly (CCA). MANET routing functions run on a GPP on a 'red' CCA. An architectural placeholder is reserved for future insertion of embedded crypto. Full Red/Black security implementation was beyond the scope of this radio system development. The red CCA interconnects to user data and a data collection engine through an Ethernet hub.

Each node is GPS synchronized for uniform network timing. A Rubidium oscillator enables operation during GPS outages. An omni-directional antenna for horizon and low elevation coverage, and an overhead coverage antenna (or ground coverage for airborne radio deployments are power combined for hemispherical coverage. An external data collection system was used to log test data for radio network performance analysis.

WAVEFORM MODES AND ADAPTIVE DATA RATE

The terrestrial net-centric radio system provides the backbone for the radio gateways. The waveforms implemented within the are critical to provide malleable performance based on physical layer constraints (range, interference) and networking requirements. The radio modem implements a half-duplex slotted TDMA frame structure with 5.8 ms slots. The waveform modes used a combination of different modulation, waveform coding and bandwidth settings to achieve the desired tradeoffs between data rate and receiver sensitivity. A node either transmits or receives on each time slot. When transmitting, one of seven possible OFDM-based waveform modes can be sent. The receiver modem autonomously discovers the transmitted waveform mode upon reception so that the transmitter may make waveform mode selections without closed-loop feedback. The waveform is capable of modulating from one to six non-overlapping 1.2 MHz wide frequency segments. Segments are placed within a 20 MHz bandwidth span and may be discontiguous to support fragmented spectrum allocations as shown in Figure 8. BPSK and QPSK modulation are supported with ½ rate Turbo FEC and an optional additional layer of Walsh Transform coding. From the many possible combinations of waveform formats, a subset of formats as shown in Table 1 was selected to incrementally step through increasing data rate modes as supported by link conditions. The most robust waveform mode (Walsh5-1) was used for neighbor discovery and maintenance.

Table 1 Waveform Modes

Waveform Mode	**Waveform Parameters**		
	Description	***Burst Rate***	***Sensitivity (dBm)***
Walsh5-1	BPSK, Walsh5, 1 segment	117 kbps	-105.8
Walsh5-2	BPSK, Walsh5, 2 segments	234 kbps	-102.8
BPSK-1	BPSK, ½ rate FEC, 1 segment	556 kbps	-99.5
BPSK-2	BPSK, ½ rate FEC, 2 segments	1.1 Mbps	-96.5
BPSK-4	BPSK, ½ rate FEC, 4 segments	2.2 Mbps	-93.5
QPSK-4	QPSK, ½ rate FEC, 4 segments	4.5 Mbps	-90.5
QPSK-6	QPSK, ½ rate FEC, 6 segments	6.7 Mbps	-88.7

The system utilized an Adaptive Data Rate (ADR) capability that automatically maintained the highest supportable data rates to all neighbor nodes. ADR independently adjusted the mode to every neighbor node in real time to maximize operating range and data throughput. The ADR algorithm accomplished this via closed loop mode control based on SNR at the receiving node and link packet error rates. Independent modes are maintained on each direction of every link.

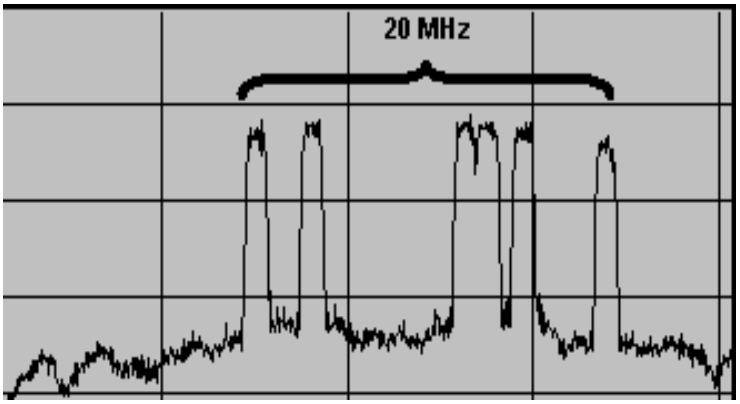


Figure 8 Discontiguous Spectrum Operation

SCALABILITY OF MANETS

Although the architecture depicted addresses many of the issues of network and node heterogeneities, scalability for data routing remains as the primary challenge for mobile ad-hoc networks (MANETs). The mobility will create topology changes causing an increase in network overhead and thus require a serious demand on network resources to maintain accurate routing tables. Military systems, especially unattended ground sensors (UGS) and dismounted soldiers, represent the greatest challenge because of serious power limitations as well as the need to scale to 1000's of nodes. The importance of this merits some discussion of its own.

All communications systems have trade-offs in capacity, which is a function of numbers of users, signal-to-noise ratio and data rate/bandwidth (the Shannon limit). For example, Time Division Multiple Access (TDMA) allows a subscriber access to the peak data rate/bandwidth only for the small interval of time (Slot) which is allocated among many users. As the number of users goes up, the number of slots accessed goes down. The limitation comes when there are not enough slots to service the data rate needs of all users, causing the data to be buffered at each transmitting node; at that point, the "1's" or "0's" of the data cannot be sent in a timely manner. Similar limitations exist for the other multiple access techniques[10]. The bottom line, classical communications systems do not have unlimited scaling.

The internet has unfortunately provided the impression that wireless should be as scalable as fiber optics networks in adding an unlimited number of users at high data rate. The reason why the fiber optic network performs well is; (1) very spectrum rich (~12,800 GHz of bandwidth theoretical based on today's technology) and has no EMI or atmospheric issues because of the fibers being a closed channel. Thus, the community can use inefficient protocols that automatically send any message three times and other techniques for improved Quality of Service because of the magnitude of the available bandwidth, as well as not needing to worry about interference, jamming and other link degradations.

On the other hand, wireless communications only has 3 GHz of available spectrum, of which the DoD owns around 0.3GHz. To date in the DoD, high bandwidth links are exclusive, highly directional, point-to-point communications like Common Data Link (270Mb/s; ~0.3GHz) and Tactical Common Data Link (10.71Mb/s; ~0.01GHz). The highly directional antennas make spectrum sharing, EMI, link degradation, etc., secondary concerns for both systems.

However, tactical networks generally do not use directional antennas, but rather omni-directional antennas. Hence, spectrum sharing, EMI, link degradation, etc., are primary concerns. The result is limited tactical range for the network and bandwidth allocation on the order of a few Mb/s (0.003-0.01GHz). Out of this allocation, one must split the data rate into information data rate and overhead for specific system requirements such as wireless protocol bits, LPI/LPD, anti-jam, and Forward Error Correction Coding . The limited resources and the requisite overhead are the major factors in limiting how well MANETs can scale.

[10] Cellular systems have a slightly better capacity because of frequency reuse over distance, closely spaced towers, and power control, but they still suffer from the same peak capacity limitations in a limited area.

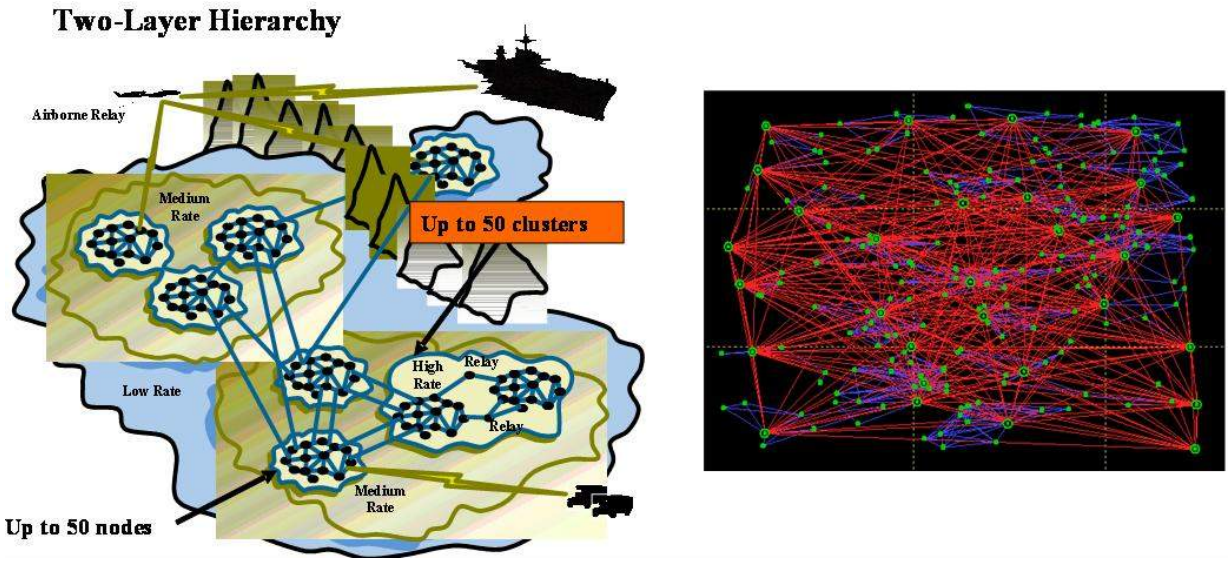


Figure 9 SUO SAS hierarchical structure scalable to 10,000 nodes

If a MANET is allocated a few MHz of bandwidth, which yields a few Mb/s of data rate, one will have to allocate specific data rates to each user to allow communications among all users simultaneously and without interference. First order rule is to provide flat resource allocation using the "divide by (N-1) rule, with N being the number of users. For example, consider 5 Mb/s of data rate shared among 6 users, each with 1 Mb/s of data rate to send. (NCRS, among other MANETs, allows non-equal data rate to be assigned to each user, but that is just a detail for this discussion.) In other words, it operates just like classical systems governed by the same Shannon Limit. Currently, MANETs like DARPA Small Unit Operations Situational Awareness System (SUO SAS) [22-24] and NCRS Programs can allocate address to large groups. Figure 9 illustrates the large group addressing done by the SUO SAS program, where we have 10,000 nodes, 50 nodes per cluster, up to 50 clusters, and multiple "group." The resulting data rate for each node then will be low if the original data rate is a few Mb/s, e.g., 4Mb/s yields ~400 b/s node-to-node data rates. In practice, those data rates will be too low to be of any real use to most warfighters. Hence, this leads to the general consensus that MANETs are only useful with small groups.

How would one fix this situation? One use direction antennas like instantiations of NCRS at frequencies above 2 GHz, as well as natural terrain masking to allow groups behind tree, obstacles etc., to improve frequency reuse. Also, airborne relays ("Cell tower") and SATCOM also can help frequency reuse via over the horizon masking of the LOS signals. Thus, one can build up a tiered network architecture like the ATT and others to provide better scaling for the network.

Thus MANETS do not scale not because of the lack of a robust addressing scheme, but rather because the resulting data rate for a large group of users will be too low to be useful for most real applications given the normal frequency allocation in practice. All MANETs suffer this, including JTRS WNW. There is no way around it due to the Shannon Limit. Unless one is spectrum rich, all communications systems will suffer this limitation.

NETWORKING PROTOCOLS

This section describes the networking protocols implemented in the NCRS. This includes MAC and networking protocols to support MANET operation in the terrestrial segment, QoS prioritization, unicast and multicast routing, and transit net for heterogeneous networking and autonomous backbone route selection.

The NCRS Networking protocols operate at Layers 3 and below in the OSI model. The Network Layer enables unicast and multicast routing using Scoped Link State Routing (SLSR) and Receiver Oriented Multicast (ROM) respectively [7][8]. The Datalink Layer includes a Neighbor Protocol (including Neighbor Discovery) and the Media Access Control (MAC) protocol. The MAC uses a Node Activated Multiple Access (NAMA) protocol to dynamically schedule time slot transmissions. NAMA is a topology dependent MAC protocol that uses the node identifiers, link data rate mode and bandwidth requests of the one- and two- hop neighbors as parameters in a pseudo-random function for channel access scheduling [9]. This approach effectively enables coordinated, collision-free, scheduling that is responsive to changing network demand with minimal overhead.

The NCRS protocol suite is Quality of Service (QoS) aware at the Network and Datalink layers to accommodate applications developed with QoS support in the standard TCP/IP protocol suite. Priority queuing is performed at both the Network and MAC layers. In the data link portion of the MAC, separate queues are maintained for each neighbor with a separate queue for each data rate and QoS level. Data is chosen for transmission in decreasing order from Highest QoS/Highest data rate to Lowest QoS/Lowest data rate.

To allow nodes to find their neighbors, and maintain knowledge of the two-hop topology of their neighborhood, periodic broadcast timeslots are allocated to a neighbor protocol. These timeslots, or control slots, are used by the neighbor protocol to send control packets to update neighbor information. No explicit acknowledgements of the transmissions are needed. Periodic transmissions of the neighbor data assure delivery of consistent information across the two-hop neighborhood.

The NCRS uses a Scoped Link State Routing (SLSR) algorithm for Unicast routing. SLSR introduces the concept of multi-level "scoping" to reduce routing update overhead in large networks. Each node stores the topology information in a topology table. Route updates are computed using the Dijkstra Shortest Path First algorithm [10]. The route on which the packet travels progressively approaches the true shortest path as the packet gets closer to its destination.

The networking software exports routes determined using SLSR into the IETF standard wired Internet routing protocols (e.g. RIP, OSPF, BGP) to support routing over multiple wireless and wired networks [11][12][13]. This allows the terrestrial backbone radio to provide a transit network capability.

The SLSR implementation has the capability of learning or its one-hop neighbors using a "hello" protocol between peer routing processes or directly from the data link portion of the MAC. By re-using the neighbor information from the data link, the SLSR control packet overhead is reduced since there is no need to re-send the inter-scope messages to the one-hop neighbors.

The NCRS uses Receiver Oriented Multicast Routing (ROM) for multicast routing. It applies "on-demand" routing techniques to avoid channel overhead and increase scalability. It uses the concept of "Forwarding Group", a set of nodes which is responsible for forwarding multicast data, to build a forwarding tree for each multicast group. The forwarding group infrastructure reduces storage overhead and can handle a much looser connectivity among multicast members. The reduction of channel/storage overhead and the relaxed connectivity improve ROM scalability for large networks and stability for mobile wireless networks.

ROM is an example of using a Forwarding Group Multicast Protocol (FGMP) that improves upon its predecessors by exploiting a receiver advertisement scheme which is more efficient than a sender-receiver advertisement scheme. ROM can coexist with any unicast routing protocol since it finds its own routes independently. ROM is required in full when used in conjunction with on-demand unicast routing protocols.

The NCRS contains a Network Layer routing function capable of both routing within the terrestrial backbone netcentric radio network and sharing the route information to a Commercial-off-the-Shelf (COTS) router for delivery of data to external destinations. This capability includes mechanisms employed to share unicast and multicast route information between the router embedded in the netcentric radio and a COTS router, such as a Cisco appliance. This function permits the netcentric radio router to support delivery of messages across the terrestrial backbone network when the sources and destinations are both inside and outside the terrestrial backbone, also called Transit Net.

Route information sharing with a COTS Router is accomplished using the Open Shortest Path First (OSPF) routing protocol. Both SLSR and OSPF are enabled on each netcentric radio router. Route redistribution techniques included both standard and non-standard techniques adapted specifically to meet the requirement to autonomously select between the terrestrial backbone netcentric radio network and the BLOS SATCOM network with preference for the terrestrial path. Route advertisement presented several challenges which were all overcome by adjusting OSPF parameters to prevent excessive route redistribution. None of the OSPF modifications implemented in this effort appear to have broken OSPF RFC compliance, as described in RFC 2328 [10]. The OSPF RFC does not describe redistribution methodology.

NETCENTRIC RADIO PERFORMANCE

The NCRS development culminated in a live operational exercise on January 25th 2006. This exercise used all 14 network nodes (8 with DARPA NCRS Units) participating in a 6 hour exercise at Fort Benning, GA. The nodes were deployed as Mechanized Infantry Battalion

which was tasked with capturing two objectives at distances in excess of 75 kilometers from the forward command post. The exercise, dubbed "DNC-E Operation Long Haul", is summarized below and depicted in Figure 10.

The exercise spread the radio network over a roughly 100 km x 100 km operational box, with air-ground link distances of up to 62 kilometers. Throughout the exercise, including maximum range operation, all nodes maintained network connectivity for the vast majority of the operation. Based on route availability data from the Radio Data Collection System, the Battalion TOC (Node 1) maintained complete network connectivity for over 99% of the exercise period. Operator reports of "virtually outage free" Situational Awareness (SA) Displays and IP Chat further corroborate this high level of observed network availability. Figure 10 shows DARPA NC Radio connectivity in 30 minute increments during the exercise. Connectivity between nodes is displayed with green lines. The thickest lines, which comprise majority of those displayed, indicate a high data rate Mode 7 (QPSK-6) connection. Thinner, or dashed/dotted, green lines indicate connection at one of the lower data rates.

Neighbor discovery and maintenance is critical to maintaining traffic flow in a dynamically changing network. These features provide the link level connectivity that is used as the basis to determine network routing and assure that traffic is routed over the most advantageous paths/links. The operational exercise demonstrated neighbor discovery and maintenance during worst-case highly mobile conditions. Figure 10 shows a time-sequenced frames of operation in a roughly 100 km by 100 km operational box. Links (represented by solid lines) were frequently changing both with respect to neighbors and data rate modes. The neighbor discovery and maintenance functions clearly worked as desired to maintain the network in this dynamic environment.

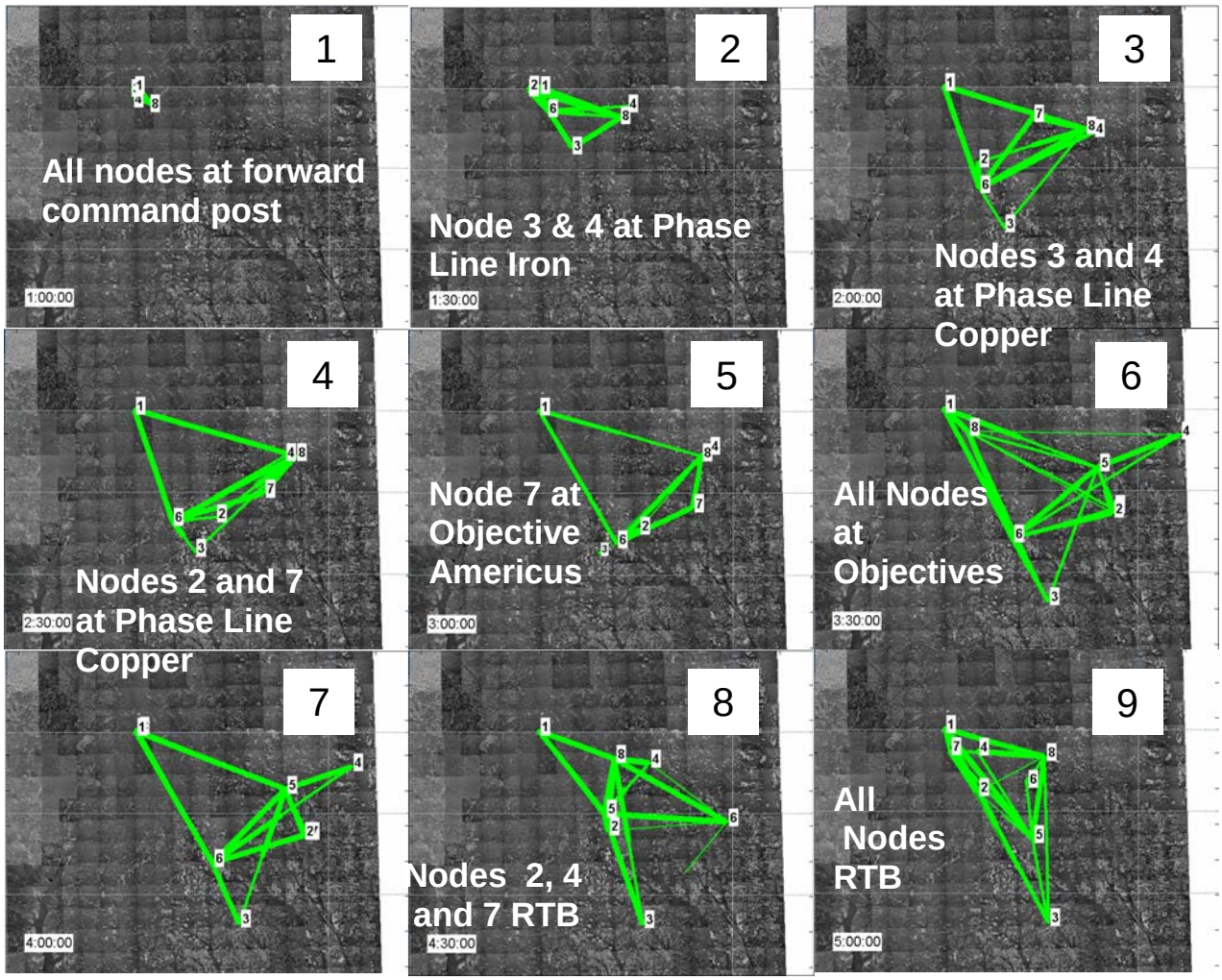


Figure 10 Topology Progression During Demonstration

The exercise included two 500 kbps video feeds: one from the UAV (Node 8) that was sent to the Battalion TOC (Node 1); and one that was sent from the Battalion TAC (Node 2) to the Battalion TOC. The UAV video feed was sent via a direct single hop air-to-ground link throughout the exercise. The Battalion TAC video was sent via a 2-hop ground-air-ground relayed link when the node was deployed. When the Battalion TAC was at or close to the

McKenna assembly area the video was delivered directly to the Battalion TOC via a single hop ground-ground link.

Throughout the duration of the exercise the one-hop UAV video was received error free at the Battalion HQ approximately 91% of the time, based on recorded video packet delivery metrics. The 9% of operation with errors resulted in occasional degraded performance such as "tiling" and "smearing" although the video was rarely completely lost. The Battalion TAC video, which included mostly 2-hop relayed video, was received error free at the Battalion HQ approximately 75% of the exercise period. As expected, the Battalion TAC video showed more incidences of "tiling" and "freezing" due to the higher number of errors. Figure 11 shows the nominal link ranges which were observed during testing compared against the idealized maximum ranges. Actual ranges are reduced from ideal range by a number of factors including

		Predicted Range (Ideal)[3]	Actual Range
Air-Air	QPSK-6	200 km	80 km
	BPSK-1	300 km	150 km
Air-Ground (9000 ft.)	QPSK-6	160 km	60 km
	BPSK-1	>250 km	150 km
Air-Ground (3000 ft.)	QPSK-6	80 km	27 km
	BPSK-1	160 km	68 km

[3]Ideal predicted range does not include RF variability, blockage, or horizon effects

Figure 11 Link Range Performance

platform motion affects (pitch and roll of both airborne and ground platforms resulting in periods of reduced antenna gain), multi-path effects, blockage and horizon effects (at longer ranges for air-ground links, blockage occurred primarily from trees) and the RF variability.

The NCRS Adaptive Data Rate (ADR) capability allowed seamless switching between the seven radio data rate modes as dictated by range and propagation conditions. This allowed the radio system to maintain network connectivity and data exchange even as pairs of nodes exceeded the usable link range for the higher data rate modes. Throughout the testing, ADR independently choose the highest reliable data rate mode for each link.

Figure 12 again shows ADR operation on a two node air-to-ground link on a typical air-to-ground reconnaissance scenario test where the air node flew out to a distance of 120 kilometers. As the UAV node flew away, ADR automatically stepped down the data rate to maintain network connectivity and data exchange out to the maximum data range. At each step, delivered throughput compares favorably with modeled performance projections. Figure 13

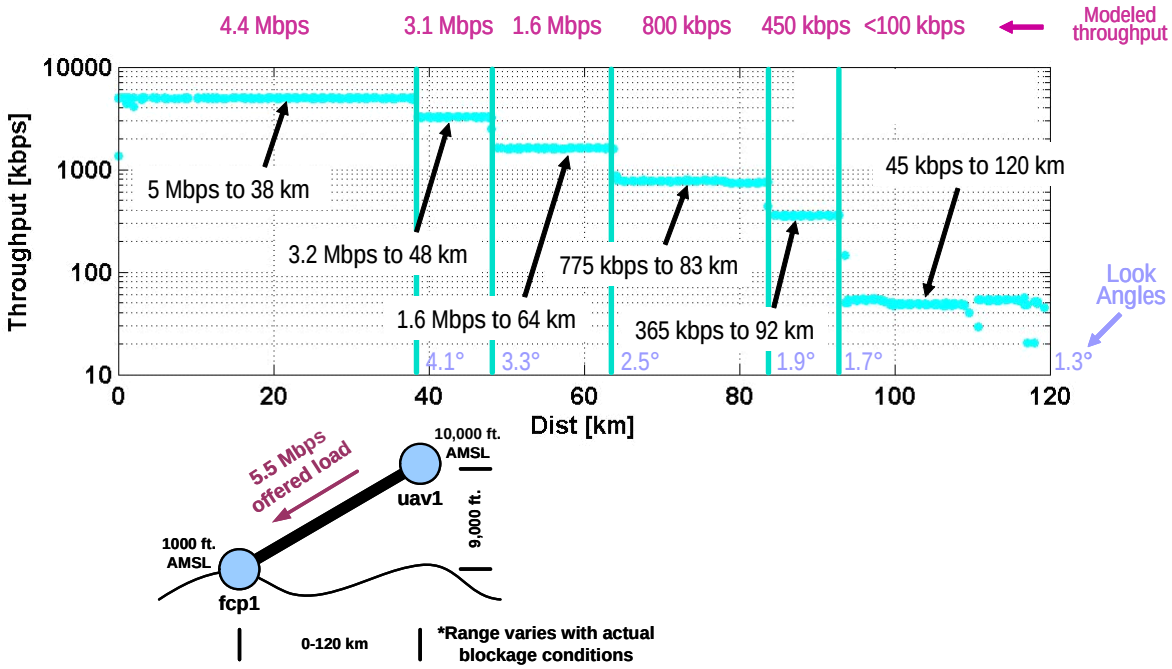
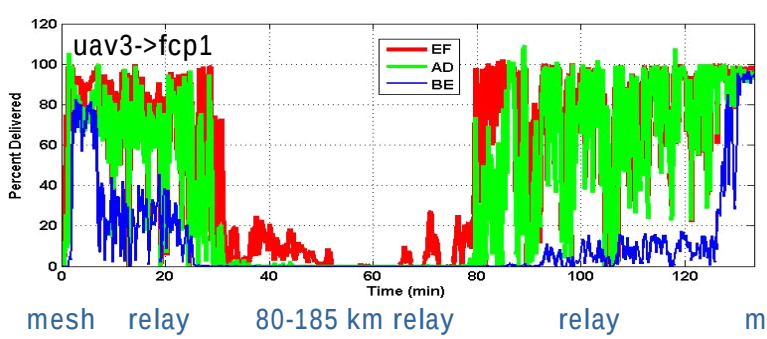


Figure 12 Adaptive Data Rate (ADR) Performance

shows packet delivery percentages for different QoS types as nodes maneuvered from a mesh topology to a relay topology with increasing separation and then returned to the original mesh topology. As the nodes moved away from one another, the ADR algorithm adjusted to maintain connectivity at a lower overall link and network capacity. Under these increasingly congested



Source	Dest	Rate	QoS
uav3	fcp1	4.7M	BE
uav3	fcp1	100k	AD
uav3	fcp1	50k	EF
fcp1	uav1	50k	AD
fcp1	uav1	25k	EF
fcp1	uav3	50k	AD
fcp1	uav3	25k	EF
uav3	uav1	50k	AD
uav3	uav1	25k	EF
all	all	1 bps	all

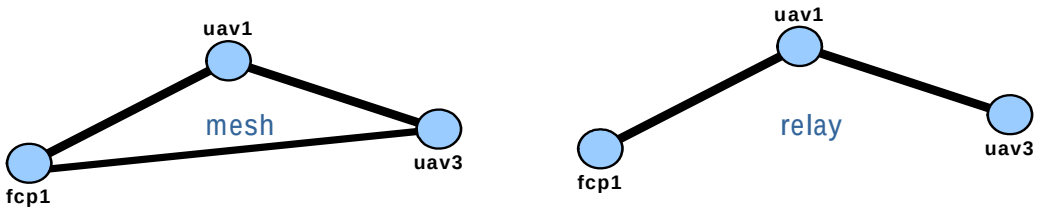


Figure 13 Topology Progression During Demonstration

conditions (constant offered load with reduced network capacity), the results show that the higher QoS data was prioritized, resulting in higher delivery success percentages for link EF than for link AD and higher delivery success percentages for link AD than link BE for the duration of the test.

Routed delivery of low data rate position/location information (PLI) packets during the operational test in excess of 99% network connectivity to Node 1 (Battalion TOC) under dynamic mobility conditions demonstrated reliable unicast routing over multiple hops in a mobile ad-hoc network.

The system was found to provide efficient and robust forwarding of multicast data grams. Multicast routing trees were formed and maintained throughout the test and demonstration runs, while data was forwarding along the trees such that the number of transmissions required to disseminate the data was minimized while ensuring that all nodes able to receive the data (based on bandwidth and QoS constraints) did receive the data. As expected from design considerations, some duplication of multicast packets was observed due to network topology and data rate changes.

SUMMARY

The objective of the DARPA Network Centric Radio System Program was to design, develop, integrate, and demonstrate the enabling communication technologies and system capabilities required to enable network centric warfare. NCRS is a First Generation Mobile, Ad Hoc Network designed to enable ground and airborne vehicle based on-the-move and on-the-halt network centric connectivity. It demonstrated a gateway architecture that offers radio interoperability among various current, future, coalition and first responder communications radios, via the network, not the radio. This capability achieved reliable data transfer under dynamically changing link conditions and node topologies while maintaining prioritized quality of service. Link ranges in excess of 60 km were demonstrated at the full 5 Mbps peak user data rate with connectivity maintained to distances over 120 km using airborne relays performing a "comms-primary" mission.

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APPENDIX D: Company Qualification Document and Non-Disclosure Agreements

Company Qualification
For the
Mobile Ad hoc Interoperability Network GATEway (MAINGATE)
BAA 08-21 Program Documentation

Program documentation consisting of Government Purpose Rights (GPR) material from the Future Combat Systems Communications (FCS-C) program, DARPA Network Centric (DNC) Experiment, the Network Centric Radio System (NCRS) in the High Bandwidth - Communications On-the-Move (HB-COTM) program, MAINGATE Proposer's Day Briefings, FAQs and other information as required can only be released to qualified proposers.
In order to qualify, proposers must have a facility clearance from Defense Security Service (DSS) at any level and provide the following information for your company:

Company Name: _____

Company Address (Unclassified): _____

_____

_____

_____

Point of Contact Name: _____

POC Phone Number: _____

POC Fax Number: _____

POC E-mail: _____

Company CAGE code: _____

Security or FSO Phone Number: _____

Security or FSO Fax Number: _____

Security or FSO e-mail: _____

Company Secure Fax number: _____

Companies must also provide Use and Non-Disclosure Agreement for Technical Data and Restricted Rights and Use and Non-Disclosure Agreement for Access to, and controls for International Traffic in Arms Regulation (ITAR) or Export Administration Regulations (EAR) documentation.

Use and Non-Disclosure Agreements (NDAs) are available for download at the following website: http://www.darpa.mil/sto/solicitations/index.html. The completed NDAs and Appendix D must be emailed to BAA08-21@darpa.mil. Program documentation and instruction for access to the controlled website will be mailed to the authorized company representative after receipt of signed Use and Non-Disclosure Agreements and verification of company cage code.

The recipient is authorized access to the data mentioned above for the sole purpose of preparing a proposal in response to DARPA Broad Agency Announcement BAA08-21 entitled Mobile Ad hoc Interoperability Network GATEway (MAINGATE).

Use and Non-Disclosure Agreement
For the
Mobile Ad hoc Interoperability Network GATEway (MAINGATE)
BAA08-21 Program Documentation

Access to, and controls for International Traffic in Arms Regulation (ITAR) or Export Administration Regulations (EAR)

The undersigned, _____(Insert Name), an authorized representative of the _____(Insert Company Name), (which is hereinafter referred to as the "Recipient") requests the Government to provide the Recipient with technical data Subject to the rules governing access and safeguarding ITAR/EAR-restricted and FOUO information. Those Data are identified in an attachment to this Agreement. In consideration for receiving such Data, the Recipient agrees to use the Data strictly in accordance with this Agreement and references herein.

The Recipient will follow the rules governing access and safeguarding ITAR/EAR-restricted and FOUO information:

Documents that contain export-controlled technical data must be marked with the following warning:
WARNING - This document contains technical data whose export is restricted by the Arms Export Control Act (Title 22, U.S.C., Sec 2751, et seq.) or the Export Administration Act of 1979, as amended (Title 50, U.S.C., App. 2401 et seq.). Violations of these export laws are subject to severe criminal penalties.

Export-controlled information may be disseminated only to U.S. citizens or U.S. Persons (an immigrant resident alien possessing a "green card" is considered to be a U.S. Person for purposes of ITAR and EAR. U.S. Persons can be granted access to unclassified ITAR/EAR restricted information without the requirement for an export license. It is important to note that discussions with a foreign national in the United States, or a person "acting on behalf of a foreign person," constitutes an "export" if it reveals technical information regarding export-controlled technology.

Export-controlled information may be put on an Internet web site only if access to the site is limited to a specific target audience that is authorized to have the information and the information is encrypted.

The possessor of export-controlled information must deny the opportunity for access to foreign nationals or any unauthorized person. The procedures for safeguarding unclassified ITAR/EAR-restricted information are similar to those cited below for For Official Use Only (FOUO) information.

Accessing and safeguarding For Official Use Only (FOUO) information:

FOUO information should be handled in a manner that provides reasonable assurance that unauthorized persons (persons without an official requirement to know the information in the course of their duties in fulfillment of a government contract) do not gain access.

During working hours, reasonable steps should be taken to minimize risk of access by unauthorized personnel. After working hours, FOUO may be stored as a minimum in unlocked containers, desks or cabinets if government or government-contract building security is provided. If government or government-contract building security which provides restricted access to the rooms where FOUO information is not provided, it must be stored at a minimum in a locked desk, file cabinet, bookcase, locked room, or similar place.

FOUO documents and material may be transmitted via first class mail, parcel post, or -- for bulk shipments -- fourth class mail.

Fax or e-mail transmission of FOUO information (voice, data or facsimile) should be by encrypted communications systems whenever practical. FOUO information may be put on an Internet web site only if access to the site is limited to a specific target audience and the information is encrypted.

The authorities for control of ITAR/EAR are as follows:

Legal & Regulatory Authorities
Executive Order 12923 Continuation of Export Control Regulations, 30 June 1994.
Title 22 USC 2778 et seq. – Arms Export Control Act.
Title 50 USC 2401 et seq. – Export Administration Act of 1979 (as amended).
Title 50 USC Appendix, Section 10 – Trading With the Enemy Act of 1917.
Title 15 CFR Export Administration Regulations, part 770.
Title 15 CFR part 779 Technical Data.
Title 22 CFR (Dept. of State) Subchapter M, The International Traffic and Arms Regulation (ITAR) Part 121-130.

The Recipient agrees follow the rules governing access and safeguarding ITAR/EAR-restricted and FOUL information identified above.

Recipient's Business Name _____

By_____
Authorized Representative

Date: _____

Representative's Typed Name _____

And Title _____

Use and Non-Disclosure Agreement For the Mobile Ad hoc Interoperability Network GATEway (MAINGATE) BAA 08-21 Program Documentation

Technical Data and Restricted Rights

The undersigned, _____(Insert Name), an authorized representative of the _____(Insert Company Name), (which is hereinafter referred to as the "Recipient") requests the Government to provide the Recipient with technical data or computer software (hereinafter referred to as "Data") in which the Government's use, modification, reproduction, release, performance, display or disclosure rights are restricted. Those Data are identified in an attachment to this Agreement. In consideration for receiving such Data, the Recipient agrees to use the Data strictly in accordance with this Agreement:

(1) The Recipient shall—

(a) Use, modify, reproduce, release, perform, display, or disclose Data marked with government purpose rights or SBIR data rights legends only for government purposes and shall not do so for any commercial purpose. The Recipient shall not release, perform, display, or disclose these Data, without the express written permission of the contractor whose name appears in the restrictive legend (the "Contractor"), to any person other than its subcontractors or suppliers, or prospective subcontractors or suppliers, who require these Data to submit offers for, or perform, contracts with the Recipient. The Recipient shall require its subcontractors or suppliers, or prospective subcontractors or suppliers, to sign a use and non-disclosure agreement prior to disclosing or releasing these Data to such persons. Such agreement must be consistent with the terms of this agreement.

(b) Use, modify, reproduce, release, perform, display, or disclose technical data marked with limited rights legends only as specified in the attachment to this Agreement. Release, performance, display, or disclosure to other persons is not authorized unless specified in the attachment to this Agreement or expressly permitted in writing by the Contractor. The Recipient shall promptly notify the Contractor of the execution of this Agreement and identify the Contractor's Data that has been or will be provided to the Recipient, the date and place the Data were or will be received, and the name and address of the Government office that has provided or will provide the Data.

(c) Use computer software marked with restricted rights legends only in performance of DARPA STO BAA 08-21. The recipient shall not, for example, enhance, decompile, disassemble, or reverse engineer the software; time share, or use a computer program with more than one computer at a time. The recipient may not release, perform, display, or disclose such software to others unless expressly permitted in writing by the licensor whose name appears in the restrictive legend. The Recipient shall promptly notify the software licensor of the execution of this Agreement and identify the software that has been or will be provided to the Recipient, the date and place the software were or will be received, and the name and address of the Government office that has provided or will provide the software.

(d) Use, modify, reproduce, release, perform, display, or disclose Data marked with special license rights legends (To be completed by the contracting officer. See 227.7103-7(a)(2). Omit if none of the Data requested is marked with special license rights legends).

(2) The Recipient agrees to adopt or establish operating procedures and physical security measures designed to protect these Data from inadvertent release or disclosure to unauthorized third parties.

(3) The Recipient agrees to accept these Data "as is" without any Government representation as to suitability for intended use or warranty whatsoever. This disclaimer does not affect any obligation the Government may have regarding Data specified in a contract for the performance of that contract.

(4) The Recipient may enter into any agreement directly with the Contractor with respect to the use, modification, reproduction, release, performance, display, or disclosure of these Data.

(5) The Recipient agrees to indemnify and hold harmless the Government, its agents, and employees from every claim or liability, including attorneys fees, court costs, and expenses arising out of, or in any way related to, the misuse or unauthorized modification, reproduction, release, performance, display, or disclosure of Data received from the Government with restrictive legends by the Recipient or any person to whom the Recipient has released or disclosed the Data.

(6) The Recipient is executing this Agreement for the benefit of the Contractor. The Contractor is a third party beneficiary of this Agreement who, in addition to any other rights it may have, is intended to have the rights of direct action against the Recipient or any other person to whom the Recipient has released or disclosed the Data, to seek damages from any breach of this Agreement or to otherwise enforce this Agreement.

(7) The Recipient agrees to return these Data, and all copies of the Data in its possession, no later than 30 days after the date shown in paragraph (8) of this Agreement, to have all persons to whom it released the Data do so by that date, and to notify the Contractor that the Data have been returned.

(8) This Agreement shall be effective for the period commencing with the Recipient's execution of this Agreement and ending on the proposal due date for DARPA BAA08-21 entitled Mobile Ad hoc Interoperability Network GATEway (MAINGATE). The obligations imposed by this Agreement shall survive the expiration or termination of the Agreement.

Recipient's Business Name_____

By_____
Authorized Representative

Date: _____

Representative's Typed Name _____

and Title_____

(End of Use and Non-Disclosure Agreement)

ATTACHMENT 1
Use and Non-Disclosure Agreement
For the
BAA08-21 Program Documentation
Mobile Ad hoc Interoperability Network GATEway (MAINGATE)

Technical Data and Restricted Rights

The recipient is authorized access to the data listed below as identified in the agreement for the sole purpose of preparing a proposal in response to DARPA Broad Agency Announcement BAA08-21 entitled Mobile Ad hoc Interoperability Network GATEway (MAINGATE).

1. Raytheon Test Report for the DARPA Network (DNC) Experiment, 21 Feb 2006
2. Raytheon Final Test Report for the Network Centric Radio System (NCRS) in the High Bandwidth – Communications On-the-Move (HB-COTM) Demonstration, 6 Feb 2007
3. CenGen High Bandwith – Communications On-the-Move Test Report, 31 Jan 2007
4. Raytheon Software package
5. CenGen Software package