Request for Solutions (RFS)
Innovate Beyond 5G Program (IB5G) Prototype Project
28 April 2022

1. Purpose and Authority

This Request for Solutions (RFS) is seeking vendors for an Other Transaction Authority (OTA) agreement, for the Innovate Beyond 5G Program (IB5G) Prototype Project. The Government will evaluate the solutions with the intent to competitively award one or multiple Other Transaction (OT) Agreements for prototype projects through the Training and Readiness Accelerator (TReX) vehicle, in accordance with 10 United States Code (U.S.C.) § 4022.

2. Summary and Background

Fifth-Generation Wireless Networking Technologies (5G) is of fundamental strategic importance to the economic well-being of the United States and, consequently, global leadership. 5G promises exponential improvements in traditional network metrics (peak and average data rates/throughput, and capacity) relative to its predecessor (via Enhanced Mobile Broadband services), that constitute the present driver of commercial 5G offerings. Office of the Under Secretary of Defense (OUSD) Research & Engineering's (R&E) Innovate Beyond 5G (IB5G) program seeks to support ideation, design, prototyping, and integration of novel IB5G network concepts and components, leading to demonstration of new capabilities that will allow United States (US) Department of Defense (DOD) operations to dominate the future networked battlespace.

Of greater relevance – aligned with modernization of DoD network needs – is the emerging capability of 5G/IB5G networks to provide connectivity, with desired features for human-to-machine and machine-to-machine (M2M) communications, and scaling to the Internet of Things (IoT), i.e., encompassing a significantly larger number of devices other than purely human consumers. Provisioning of services for such networks rely greatly on confronting network scaling (in terms of `user' density) and service prioritization while achieving lower latency (order of milliseconds) and very high reliability needed for mission critical services besides per user throughput within future all-domain networked battlespace operations. Besides the emphasis on new components and features, of equal significance are modes of management of such tactical networks in the presence of adversarial operations, which exploit advantages resulting from new 5G stand-alone network architectures as well as integration of intelligent, autonomous operations. Accordingly, IB5G is interested in novel advances and engineered solutions on the multiple fronts enabled by commercial 5G technology as a configurable jump-off baseline.

3. General Information

3.1. Vendors interested in responding to this RFS as a Prime must be members of the Training and Readiness Accelerator (TReX). Information about membership can be found at the following webpage: https://nstxl.org/membership/

3.2. The cost of preparing and submitting a response is not considered an allowable direct charge to any Government contract or agreement.

3.3. An individual vendor may not submit more than one solution in response to this RFS as a Prime. A vendor may participate as a subcontractor to multiple responses.

3.4. Non-compliance with the submission instructions provided herein may preclude the vendor from being considered for award.

3.5. Government participants and advisors in the evaluation process will be required to sign non-disclosure agreements (NDAs), as well as ensuring the procedures are in accordance with 41 U.S.C. Chapter 21, Procurement Integrity Act. Note: only Government personnel will be participating in the evaluation.

4. Government Furnished Information (GFI)/ Government Furnished Property (GFP)

4.1. The Government will make available Attachment 1, Security Classification Guide (SCG) 10-040, to those vendors who have been vetted and cleared to receive Distribution A GFI, for use during Solution preparation. In order to obtain the documentation, the vendor shall submit a request in writing to Initiatives@NSTXL.org, with “IB5G Prototype” used in the subject line along with the required documents detailed in Section 4.2 below.

4.2. The vendor is required to complete the Vendor Self Vetting Form (Attachment 8) along with completing and signing the GFI Tech Data Distribution Agreement (Attachment 7) which includes further guidance regarding the handling of the GFI. Upon approval, the vendor will be provided the GFI as needed.

4.3. All hardware and associated technical information provided to the vendor as GFI/Government Furnished Equipment (GFE) is anticipated to be Controlled Unclassified Information (CUI).

4.4. Security Vetting
All vendors who want to compete, bid, or team with others for this effort must be willing to comply with the PEO STRI Security Process for Vetting. All vendors (Prime and Subs) and/or vendors must be vetted for eligibility, suitability, national status e.g., Foreign or USA Foreign Owned, Controlled and Influenced (FOCI) prior to the receipt of any award instrument.

4.4.1. For the RFS and accompanying solutions, the Government anticipates the distribution of Controlled Unclassified Information (CUI) at the classification level of Distribution A. The Government anticipates this effort along with the capabilities it researches, develops, prototypes, demonstrates, and validates will be UNCLASSIFIED based on SCG 10-040. However, in order to develop the IB5G prototype, the vendor(s) will need to have access to non-public export-controlled information. Therefore, any vendor with an intent to prime this effort must possess an approved FOCI mitigation and SECRET FCL.

The Government will provide existing data and information to vetted vendors, as part of the RFS process, to complete the IB5G prototype effort. The Government will also provide the performer(s) access to fielded systems and subject matter experts (SMEs) on a non-interference basis to support design, development, and testing efforts. Each will be determined during the development of the RFS for each RFS that is issued.

The Government will provide the vendor with Security Classification Guides (SCGs) related to the technology developed under the IB5G effort, to ensure that classified information is not inadvertently created by the vendor during execution of the project. Please refer to the following link for more information on SCGs: https://www.esd.whs.mil/Portals/54/Documents/DD/issuances/dodm/520001m_vol1.pdf?ver=2020-08-04-092500-203

4.5. Vendors must provide a list of all Government Furnished Information (GFI) / Government Furnished Equipment (GFE) that the vendor believes is necessary to enable development and demonstration of prototype. Upon review of the requested GFI/GFE, if approved by the Government, the GFI/GFE will be provided to the awardee within a specified timeframe as agreed upon during SOW collaboration, after award. The Government cannot guarantee that all GFI / GFE requests can/will be accommodated.

5. Solutions Paper Responses

5.1. Solution Paper responses shall consist of one volume to include an Administrative, Technical, and Price section. Technical responses will clearly demonstrate the vendor's ability to meet the technical objectives of this effort and transition the expected outcomes of each phase. Responses should clearly address planned documentation deliverables (including format and content) and any planned demonstrations, design reviews, and management reviews. Responses shall be submitted in an editable/executable (not scanned) Word/Adobe PDF format. Vendors are limited to one (1) proposal submission per team. However, each submission may contain responses for each Technical Area: Beyond 5G Mobile Distributed Multi-input, Multi-output (MIMO) Networking & Beyond 5G Integrated Tactical Communication Networks. The Technical section is limited to no more than 12 standard size (8 ½" X

11”) pages for each Technical Area using standard 12-point Arial font. Vendors responding to both Technical Areas will be subjected to a 24-page limit for the Technical Section of the submission. No more than 3 foldouts are allowed with a page size of 11”x17” and will be counted towards the 12-page limit per Technical Area. Please note, each one-sided page will count towards the page count limit. Charts or figures are not bound by the 12-point font requirement but shall be clearly legible. If the solution exceeds the page limitation, the Government may choose not to read any information exceeding the 12-page limit and the information may not be included in the solution evaluation. All PDF’s will be editable (not locked). The Administrative and Pricing Sections along with Sub-Vendor List, Government Desired Rights in Technical Data and Computer Software, List of Figures, Integrated Master Schedule (IMS), Basis of Estimate (BOE), Delivery Schedule, GFI List, and Acronym Definitions do not count towards the page count limit. The proposed solution will be used to collaboratively negotiate a Statement of Work (SOW) after selection for award. The SOW will be incorporated into the OT agreement.

Section	Subsection	Format**	Counted towards page limit		Page Limit*
			Yes	No	
Administrative	Cover Page	MS Word/PDF		X	No Page Limit
	Nontraditional Status	MS Word/PDF		X	
	FOCI Status	MS Word/PDF		X	
	OCI & Mitigation Plan	MS Word/PDF		X	
Technical	Sub-Vendor List	MS Word/PDF		X	12-Page Limit per Technical Area
	Vendor Experience	MS Word/PDF	X		
	Project Management	MS Word/PDF	X		
	Solution Approach	MS Word/PDF	X		
	Technical Approach	MS Word/PDF	X		
	Govt Desired Rights in Tech Data & Computer SW	MS Word/PDF		X	
	Anticipated Delivery Schedule	MS Word/PDF		X	
	Integrated Master Schedule (IMS)	MS Project/ PDF		X	
Price	Pricing Breakout	Excel		X	No Page Limit
	Rough Order of Magnitude (ROM)	Excel		X	
	Basis of Estimate (BOE)	Excel		X	

***The Administrative and Pricing Sections along with the cover pages, Sub-Vendor List, Government Desired Rights in Technical Data and Computer Software, List of Figures, Integrated Master Schedule (IMS), Delivery Schedule, GFI List, and Acronym Definitions do not count towards the page count limit.**

****All PDF's will be editable (not locked).**

The Government anticipates making multiple awards under this requirement. Vendors can respond to one or both Technical Areas. For proper evaluation purposes, each prototype solution must be clearly marked as Technical Area 1, Beyond 5G Mobile Distributed MIMO Networking, and/ or Technical Area 2, Beyond 5G Integrated Tactical Communication Networks. For vendors proposing to both technical areas, the solutions must be segregated. Vendors do not have to submit to both technical areas to be awarded an agreement. The Government will not accept partial solutions pertaining to either technical area. An individual vendor may not submit more than one response per technical area as a prime.

5.2. Administrative Section (unlimited page count)

The following shall be included in the Administrative Section:

- Cover Page
- Nontraditional status
- Foreign Owned, Controlled or Influenced (FOCI) status
- Organizational Conflicts of Interest and Mitigation Plans

5.2.1. Cover Page

The cover page shall include the vendor's name, Commercial and Government Entity (CAGE) Code (if available), Unique Entity ID (if available), NAICS Code, Business Size, Traditional or Non-Traditional status, address, primary point of contact, and status of U.S. ownership. NAICS code for this effort is 541330.

5.2.2 Nontraditional Status

The vendor shall provide its nontraditional business status or its ability to meet the eligibility requirements of 10 U.S.C. §4022. The vendor shall clearly identify and support one of the following award eligibility requirements – with appropriate justification, as applicable.

□ There is at least one nontraditional defense contractor or nonprofit research institution participation to a significant extent in the project. (Ref: 10 U.S. Code § 4022(a)(d)(1)(A))

□ All significant participants in the transaction other than the Federal Government are small businesses or nontraditional defense contractors. (Ref: 10 U.S. Code § 4022(a)(d)(1)(B))

 At least one third of the total cost of the project is to be provided by sources other than the Federal Government. (Ref: 10 U.S. Code § 4022(a)(d)(1)(C))

If the vendor is not a nontraditional defense contractor (NDC) additional information is needed. Vendor shall provide the name and CAGE code information for the NDC participating in the prototype project. Additionally, the vendor shall provide what portion of the work the NDC is performing and an explanation of the significance of the NDC's contribution to the prototype project.

5.2.2.1 Definition of Nontraditional Defense Contractor – an entity that is not currently performing and has not performed, for at least one-year period preceding the solicitation of sources by the Department of Defense (DoD) for the procurement or transaction, any contract or subcontract for the DoD that is subject to full coverage under the cost accounting standards prescribed pursuant to 41 U.S.C §1502 and the regulations implementing such section.

5.2.3 Foreign Ownership, Control, or Interest (FOCI) Status
In accordance with Attachment 2, Security Process for Vetting Contractors, the vendor must include certification that the vendor (and subcontractor(s)) is not Foreign Owned or under USA FOCI status (and are not in merger or purchasing discussions for a foreign company or USA FOCI Company). Should a prospective vendor be unable to so certify, they will be ineligible for award unless the mitigating circumstances in Attachment 2 Security Process for Vetting Contractors are met. In such a case, these mitigating circumstances shall be detailed in an appendix to the Administrative Section.

5.2.4 Organizational Conflicts of Interest and Mitigation Plan
Vendors will submit an Organizational Conflict of Interest (OCI) Mitigation Plan via an appendix to the Administrative Section. In the event there are no real or perceived OCIs, simply state so and annotate what actions would be taken in the event that one is realized.

5.3. Technical Section (12-page count per Technical Area)

The following shall be included within the Technical Section:

- Sub-Vendor List
- Vendor Experience
- Project Management
- Solution Approach
- Technical Approach
- Government Desired Rights in Technical Data and Computer Software
- Integrated Master Schedule (IMS)

5.3.1. Sub-Vendor List

Vendor shall provide a list of all sub-vendors involved and their role within the performance of your submission as an appendix to the Technical Section (which will not count towards the page count). The list shall include FOCI status and OCI, Commercial and Government Entity (CAGE) Code, Business Size and Type (Traditional/ Non-Traditional).

5.3.2. Vendor Experience

Vendor shall describe their company or team's, recent and relevant previous experience in 5G Mobile Distributed MIMO Networking, and/ or 5G Integrated Tactical Communication Networks.

5.3.3. Project Management

Vendor shall describe their company's methodologies, organizational structure, quality assurance processes, and staffing they intend to use to manage this prototype project.

5.3.4. Solution Approach

Solution Approach responses shall include the vendor's proposed technical solution clearly describing the approach, feasibility and technical risks, and mitigation solutions identified in fulfilling the Project Technical Objectives and associated deliverables identified below. The approach shall clearly address planned documentation deliverables (including format and content) and any planned demonstrations, design reviews, feasibility of implementation, total project risk, and management reviews.

5.3.5. Technical Approach

The Innovate Beyond 5G program seeks solutions focused in two main technical areas pertaining to (1) Beyond 5G Mobile Distributed MIMO Networking and (2) Beyond 5G Integrated Tactical Communication Networks.

5.3.5.1 Technical Area 1 - Beyond 5G Mobile Distributed MIMO Networking Technical Objectives:

There exist numerous opportunities for innovation using commercial 5G concepts and components as a launch point that address underlying gaps in support of DoD CONOPS. This effort emphasizes two (2) critical areas:

1. The adaptation of multi-input, multi-output (MIMO) antenna systems and architectures for ad-hoc, mobile network operations.
2. The associated protocol engineering to support end-to-end resilient network performance.

As context, for example, MIMO scaling (increasing the number of antennas) has been successfully demonstrated for terrestrial, cellular operation with infrastructure (base

stations) positioned at desired locations largely for modest (no greater than 100 MHz) channel bandwidths and mid-band Radio Frequency (RF), commonly referred to as Centralized MIMO (C-MIMO). However, DoD tactical networks consist of nodes deployed on mobile platforms of various kinds including dismounted soldiers (at the halt or on the move) plus terrestrial armored vehicles and airborne assets, such as Unmanned Aerial Systems (UAS) or Low Earth Orbiting satellites. 5G Stand Alone (SA) networks potentially allow configuring such nodes as client or network relays as well as enabling cooperation between nodes to achieve various MIMO configurations. This leads to the concept of Distributed MIMO (D-MIMO) operations.

The potential of direct device-to-device or sidelink communications between 5G User Equipment (UE) (in the absence of gNB (generation Node B) or base station infrastructure) is yet another feature of significant relevance for 5G based tactical networks. Similarly, the separation of control and data planes, a fundamental characteristic of 5G network design, indicates new possibilities for network resiliency via enhanced control channels. These merely represent suggestive examples among a host of options based on 5G that can be brought to bear as components of how 5G may be adapted to military (MIL) networks seeking to integrate D-MIMO operation that are inherently ad-hoc by nature. The intended network configurations for this effort are the lowest 2 echelons in a MIL network: intra- and inter-squad and squad-to-command post (CP) communications, as shown in Table 1 below. The scales (squad diameter, inter-squad and squad-to-CP distances) are intended to be indicative of desired sub-net dimensions. We are primarily interested in the design of wireless networks for intra- and inter-squad and squad-to CP, where all links are assumed to be wireless, and the command post is operated in a distributed manner via all functions redundantly mapped to vehicles.

For purposes of this effort, the following assumptions provided in Tables 1 and 2 below may be used as a baseline.

Squad (up to 10 nodes)	Mobile Command Post (up to 100 nodes)
Radius: 10-100 m Per-node data rates: 1-10 Mbps • Inter-squad distance: 1 Km • Assume that each squad is anchored by a terrestrial vehicle	Radius: 1 Km Per node Data Rates: 10-100 Mbps • Squad to Command Post distance: 10 Km

Table 1. Baseline Network Topology

Key Performance Parameter	Development Objective
Operate in multiple frequency bands:	Mid-band: L/C/S/K + High Band: mmWave
Number of operational tactical waveforms	Multiple: inclusive of at least one 5G waveform
Eavesdropper Distance limit	0.5x relevant link distance
Standoff distance for Jammer Detection	10x relevant link distance
Operational resilience to Jammer	Throughput vs Jammer-to-Signal Ratio
Overhead of enhanced control/signaling	Minimize time/frequency resources overhead needed for enhanced control/signaling

Table 2. Key Objectives

Solutions are sought that explore reliable designs for intra- and inter- squad and squad-to-CP networking that focus on exploiting potential offered by MIMO-enabled nodes for resilient and covert communications. Longer range communications (inter-squad or squad-to-CP) will employ directional beams (and potentially use relaying for multi-hop operations) leveraging D-MIMO whereby the information from a single source is sent via coherent RF phased array transmissions using collection of array elements at multiple nodes (see Figure 1) for range extension in Line of Sight (LOS) scenarios and diversity or multiplexing gains in Non-Line of Sight (NLOS). However, scaling and performance at the lowest echelon will be limited by both SWAP (Size, Weight, and Power) of the individual battery-powered nodes and the achievable synchronization accuracy for coherent D-MIMO operations for such nodes using emerging 5G features such as sidelink.

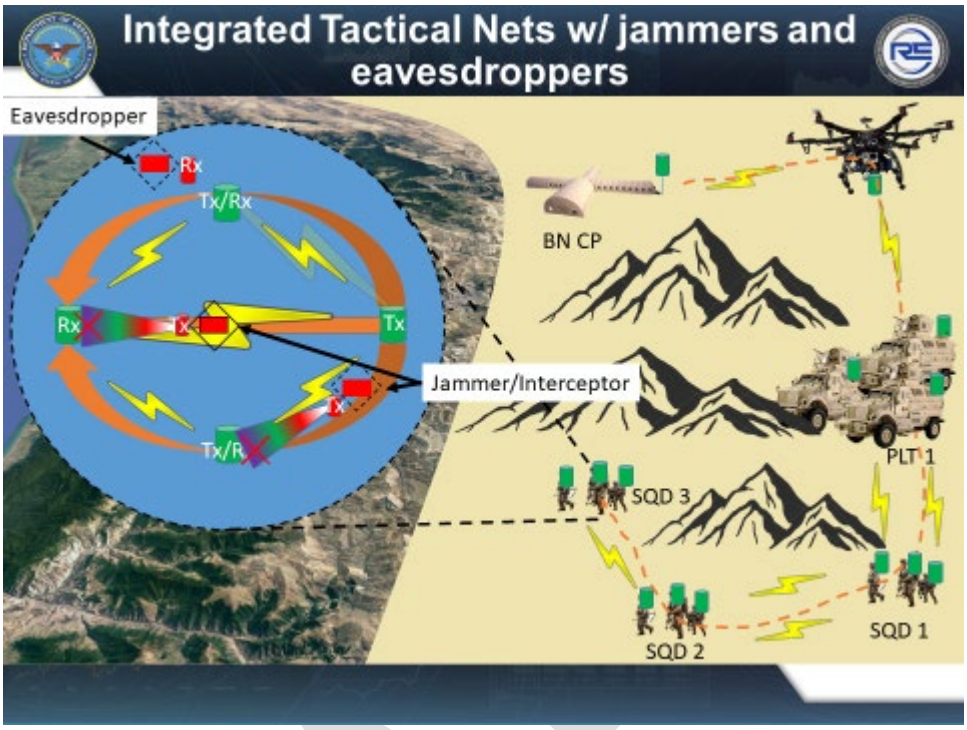

Figure 1. Ad-hoc, Distributed TacNets with MIMO enabled nodes

A potential application of scaling D-MIMO operation is enabling connectivity between squads and command post. This is akin to the notion of Cell-Free MIMO whereby a set of network access points simultaneously serve a number of users over the same time/frequency resources, without a-priori association between users and a single network access point. Cell-Free MIMO has potential for considerable improvement of throughput performance with respect to a conventional small-cell scheme whereby each user is served by a dedicated network access point, provided channel state information is made available in a practically feasible manner to support optimized operation.

The primary purpose of Phase I-II effort will be directed to solutions that outline a complete network design approach for the typical scenarios, with all relevant system parameters (transmit power, frequency band and channel bandwidth, number of channels, user vs. control plane separation, receiver sensitivity, beamforming approaches etc.) identified. Network operations must contend with both eavesdroppers and jammers, while network Key Performance Indicators (KPIs) will include the usual measures (link rates, network throughput, set-up latency, control & signaling resource overhead, etc.), along with resiliency metrics (anti-jam and LPI/LPD capabilities). The proposed effort must demonstrate the enhanced network performance trade-offs among the multiple objectives based on proposed approaches.

For purposes of system design objectives for all phases of Area 1, the proposal should focus on these key areas of system performance, which drive the proposal's

KPI's derived for simulation testing and field testing:

- Integrity: Performance of end-to-end throughput verses range, aggregated time-frequency resources consumed, and power consumed.
- Accessibility: Ability of a Squad and/or individual UE to acquire and use the wireless communications service under varying mobility conditions (stationary and moving).
- Retainability: Ability, once service has been acquired, for a Squad and/or UE to retain the service for long periods of time under varying mobility conditions.
- Latency: End-to-end latency of the wireless communications.
- Capacity: Capacity of the entire system under high wireless network load conditions.
- Resiliency: All above categories under various vectors of adversarial attack.
- SWaP: Overhead of SWaP requirements verses previous technologies.

Exemplar Research, Development, and Extension (RD&E) vectors may include but are not limited to:

- Novel design of 3-D conformal wideband phased array architectures with desirable SWAP properties, including control of (nearby) radio propagation environment via use of intelligent surfaces acting as relays to overcome physical obstacles and extend the network coverage.
- Novel system concepts that implement coherent D-MIMO networking, while remaining cognizant of the need for additional overhead such as distribution of location/timing and channel/network state information to handle mobility. Resulting benefits from coherent distributed beamforming/MIMO include enhanced multi-user communication efficiency with spatial interference suppression/anti-jam capability, and the ability to exploit the natural diversity of D-MIMO operation. Operational fallback to non-coherent operational modes may be considered.
- New directional networking protocols for beamspace management - opportunistic directional beamforming using distributed nodes at mmW (millimeter wave) that offer inherent Low Probability of Intercept/ AntiJam (LPI/AJ) properties and robust link performance, while trading-off data rates and hop distance. Directional protocols that exploit diversity at various levels of the network stack (e.g., due to link MIMO and/or multi-path routing) for robust end-2-end performance.
- Commercial off the shelf (COTS) Software Defined Radio (SDR) based node implementations of above system concepts that meet desired SWaP targets, jamming or interception resistance, transmission security (TRANSEC) features, multi-channel transmit/ receive (Tx/Rx) operation, and/or Dynamic Channel Access capabilities.

Solutions should clearly articulate the fundamental innovations underlying their effort and its potential translation to technology, by demonstrating how their approach

addresses (any of) the following important dimensions in Table 3. Desired R&D + Prototyping Objectives.

Themes	Current	Objective
1. Develop design principles for multi-squad operations	Efforts limited to single network (squad) operation in LOS	Multiple networks in NLOS scenarios, identify performance trade-offs
2. D-MIMO: Explore Link/Network Efficiency vs Diversity/Resiliency in mobile, NLOS environments	Lacks theory of scaling for D-MIMO operations in contested/congested environments with node mobility	Develop scaling theory, trade-offs and quantify limits of possible with current MIMO technology
3. Device/Circuit/Algorithmic Innovations in support of performance goals	Phased Array architecture and Node SWaP limitations-based MIMO	SDR implementations and associated integration aspects for DoD Use
4. New L1/L2 protocol innovations in support of performance goals	Nonexistent protocols.	Added L1/L2 support that makes efficient use of spectrum and power resources while maximizing performance KPI's; methods to mitigate synchronization, networking, channel state information, random access, and unique RF environmental issues

Table 3. Desired R&D + Prototyping Objectives

It is anticipated that the prototype will go through each of the three (3) phases over a respective 12-month period of performance. The prototype may not necessarily complete all phases and the Government may determine success of a prototype at any phase and determine the prototype is ready for production or fielding. The phases are outlined below.

Phase 1: Initial Study, Concept Research and Development:

- **Phase 1 Technical Objective:** During this phase, the performer should primarily focus on an initial design of the Beyond 5G Tactical Networking Layer 1/2 (Layer 1 and Layer 2 Protocols) for the scenarios indicated in Table 3, Desired R&D + Prototyping Objectives (provided above), inclusive of potential D-MIMO integration. The initial objective of the proposed approach should be to unveil underlying performance trade-offs among the major key performance parameters (KPPs) with a view highlighting the art of possibilities and limits with current technology.

A key component of underlying models is to explore scaling of D-MIMO with consideration of necessary operational overhead, leading to a deeper understanding of expected benefits (enhanced communication efficiency) vs. overheads; of particular interest is the ability to quantify impact of node mobility on distributed operations. Further characterization of system operation should include introduction of jammers/interferers and consequent allocation of some design degrees of freedom to anti-jam/interference cancellation.

- **Phase 1 Expected Outcome:** Phase 1 expected outcome will be a white paper based on the study(ies) conducted during phase 1 that identify the most promising design(s) with the potential to scale network dimension(s) with varying degrees of node mobility.

- **Phase 1 Decision Point:** Based upon the expected outcome results of Phase 1, the Government may or may not determine to enter Phase 2. If the Government determines that there is sufficient information within the white paper to progress to Phase 2, the Government will approve the white paper approach in part or in full and allow for the performer to move into Phase 2. The outcome of the white paper may or may not require an update to the SOW. This will be determined by the Government.

Phase 2: Finalize Design, Build, and Demonstrate Initial Prototype:

- **Phase 2 Technical Objective:** Using Phase 1 as launch point, Phase 2 will be largely devoted to:
  a) final design iteration; and
  b) prototyping and implementation of a lab-scale testbed that explores system performance in a controlled setting.
  Vendors will be expected to conduct a demo on-premises as part of a competitive performance evaluation at end of Phase 2.

- **Phase 2 Expected Outcome:** The phase 2 outcome will be a vendor led competitive demonstration of the designed prototype(s). The intent is to down-select 1 or more vendors to move into Phase 3.

- **Phase 2 Decision Point:** Based upon the expected outcome results of Phase 2, the Government may or may not determine to enter Phase 3. The technical details are conditional upon the selected solution and will be further defined during the SOW collaboration.

Phase 3: At-Scale Demonstration and Validation:

- **Phase 3 Technical Objective:** Phase 3 will begin with an update to the SOW. The SOW will be updated based upon the phase 2 outcome(s) and

decision point. The SOW will be used to update the prototype. It is during this phase the performer will transition to a DoD or other Federal testbed infrastructure for prototype performance demonstration and evaluation of typical outdoor environments.

- **Phase 3 Expected Outcome:** Phase 3 the expectation is that design iterations are driven to improve the system performance using the Phase 1 design modeling as a reference. In this sense, the ending Phase 3 expectation is that the system performance achieves within a best effort approximation of the relative model predictions created during Phase 1.

- **Phase 3 Decision Point:** Based upon the expected outcome results of Phase 3, the Government will determine if the prototype has achieved successful completion. The technical details and successful completion criteria are conditional upon the selected solution and will be further defined during the SOW collaboration.

Note: It is expected that the vendor may need to conduct multiple iterations of Phases 1 – 3 to develop the Beyond 5G prototypes to achieve the desired outcomes. Subsequent iterations shall be mutually agreed upon by the Government and the Vendor.

5.3.5.2 Technical Area 2 - Beyond 5G Integrated Tactical Communication Networks Technical Objectives:

B5G Integrated Tactical Comm Nets seeks to investigate the impact/promise of various emerging 5G features for next generation of DoD Tactical Networks that integrate a commercial terrestrial 5G network with airborne network segment. Of particular interest are:

1. Direct D-2-D (Device-to-Device) or Sidelink in 5G networks in ad-hoc mode (outside of any network coverage provided by a traditional gNB)
2. Integrated Access and Backhaul
3. Softwarized and modularized 5G RAN implementations as proposed (for example) by the Open Radio Access Network (O-RAN) alliance.

Of direct interest is the promise of combinations of the above – inclusive of yet-to-be-developed concepts – offer multiple novel architectural options and system design opportunities, which is the focus of this Request for Solutions (RFS). For example, end-user access may be enabled by direct commercial 5G enabled devices that connect to both terrestrial and airborne infrastructure, or alternatively, devices with both 5G and non-5G (proprietary) radio interfaces that communicate via a gateway for necessary Physical Layer (PHY) inter-networking. Further, the airborne node can be implemented in various configurations – as a relay or bridge between two terrestrial UE nodes, or as a moving aerial full-system gNB or parts of a ‘split’ gNB implementation as conformal to O-RAN alliance. These different

architectural options for integration of airborne network segments will drive innovations at the radio, Medium Access Control (MAC) and Radio Link Control (RLC) layers, in conjunction with exploiting the new interfaces offered by softwarized 5G Radio Access Network (RAN) implementations will be critical for desired dynamic operational use. Further, given that 5G networks will increasingly integrate non-human end points (sensors) and end points with human users in tactical operations, new levels of automation, and intelligence will be fundamental to supporting Key Performance Indicators (KPIs) (notably end-2-end latency and reliability) for mission-critical operations and/or recovery from service disruptions due to jamming. See Figure 2. Tactical Networking with Integration of Terrestrial and Airborne 5G Segments below.

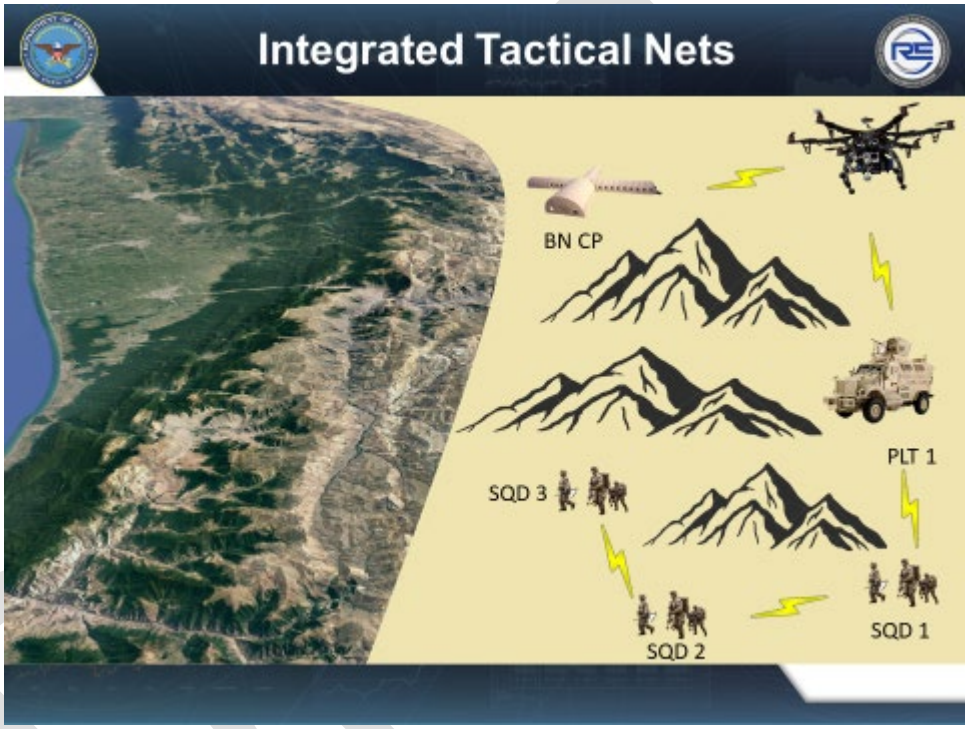

Figure 2. Tactical Networking with Integration of Terrestrial and Airborne 5G Segments

For purposes of system design objectives for all phases of Area 2, the proposal should focus on these key areas of system performance, which drive the proposal's KPI's derived for simulation testing and field testing:

- Integrity: Performance of end-to-end throughput verses range, aggregated time-frequency resources consumed, and power consumed.
- Accessibility: Ability of a Squad and/or individual UE to acquire and use the wireless communications service under varying mobility conditions (stationary and moving).
- Retainability: Ability, once service has been acquired, for a Squad and/or UE to retain the service for long periods of time under varying mobility conditions.

- Latency: End-to-end latency of the wireless communications.
- Capacity: Capacity of the entire system under high wireless network load conditions.
- Resiliency: All above categories under various vectors of adversarial attack.
- SWaP: Overhead of SWaP requirements verses previous technology(s).

Solutions sought will 1) develop novel system architectures and associated system integration aspects and 2) investigate performance trade-offs of proposed solutions with a view towards future tactical network Concept of Operations (CONOPS) intended for joint all-domain operations, Table 4. Major Themes, and as indicated by exemplar RD&E vectors identified below. Phase I-II efforts will be primarily directed to design approaches for integrated tactical network operations that include both terrestrial and airborne segments. Protocol stack engineering should include a full description of all relevant radio level parameters (frequency bands, channel bandwidth, transmit power, PHY layer waveform/modulation/coding) and the effort should expand how the proposed design iterations and subsequent demonstrations lead to desired integrated tactical network performance trade-offs that can be operationalized via these novel RD&E vectors.

Themes	Current	Objective
1. Integration of Terrestrial/Airborne Segments	Exclusive Terrestrial 5G operation only	Exploit various emerging 5G features for joint/integrated operations
2. Design for Resiliency and Autonomous Operation	Pre-programmed, non-adaptive to dynamic operational scenarios	Real-time responsive based on AI/ML approaches and flexible protocol engineering.

Table 4. Major Themes

Exemplar RD&E vectors may include (but not limited to):

- PHY layer aspects of air-2-ground link
- Enhanced Doppler and synchronization challenges, MAC/RLC design aspects
- Hybrid Automatic Repeat Request (HARQ) and hand-off management
    - associated coverage and capacity
- Maturing of Sidelink D-2-D mode (without network coverage) for ad-hoc communications, including device discovery, Peer to Peer (p2p) authentication and network formation
- Mesh network formation using sidelink
    - resilient operation (anti-jam and LPI/LPD) with latency constraints
    - integrated access and backhaul
- Exploit Access Traffic Steering Services (ATSS) to integrate non-5G interfaces in a Multiple Radio Access Technology (multi-RAT)

- Comparative analysis of network architectures for terrestrial/airborne integration
    - routing and transport layers for managing end-2-end latency variations
- For Open-RAN compliant 5G SA network: RAN intelligent controller (RIC) algorithm design for mobility management and interference mitigation/anti-jam

Proposals should clearly articulate – in a section dedicated to this – the fundamental innovations underlying their effort and its potential translation to technology, by demonstrating how their approach addresses (any of) the following important dimensions. For purposes of this effort, the following CONOPS and associated network topology, while not all inclusive (see system performance categories), may be used as an example baseline:

Example Network CONOPS	Example Overall Objectives (all scenarios)
1. [Scenario 1] Multiple vehicles/nodes present. Inter-connect one terrestrial vehicle via a single airborne segment to Beyond Line of Sight (BLOS) vehicle and/or sensors. Exfiltrate data between the vehicles under various conditions to include with and without adversarial threat attacks.	Design and evaluate network KPIs - Network optimization for throughput/latency vs. range, network availability, and network retainability in adversarial presence. • Demonstrate end-to-end route determination and associated latency, design for reconfigurability due to interference or jamming; include multiple routing possibilities during testing.
2. [Scenario 2] Multiple squads present but separated by some distance. Inter-connect one terrestrial squad to a remote (BLOS) terrestrial command post via an integrated terrestrial/airborne network. Exfiltrate data from the terrestrial squad to the remote command post with and then without adversarial threat attacks.	• Characterize end-to-end throughput in steady-state, resiliency to jamming • Characterizations including various conditions of squad/vehicle mobility, and airborne range/altitudes.

Table 5. Example Integrated Network Topology & Communication Objectives

R&D Parameters	Design Investigations
1. Throughput/ Latency/Resources for Scenario 1	• Explore use of 5G sidelink for terrestrial and air-2-ground links: achievable link rates vs range, link rates vs resources, resiliency to jamming, beamforming, initial association/authentication. See also other listed KPI's to measure.

2. Throughput/latency/Resources trade-offs for multi-hop routing (Scenario 2)	• Mesh network formation using sidelink and integrated access + backhaul for spectral efficiency; quantify end-2-end throughput/latency and resiliency trade-offs; ML approaches for trustable automation. See also other listed KPI's to measure.

Table 6: Example Key performance parameters and design objectives

Phase 1: Initial Study and Design Iteration:

- **Phase 1 Technical Objective:** During phase 1, the vendor will achieve the following technical objectives:
  - Finalize set of enhancements to sidelink for enablement of terrestrial/airborne network integration;
  - Quantify network performance via comprehensive network simulation, catalog performance suite.

- **Phase 1 Expected Outcome:** Phase 1 expected outcome will be a white paper based on a Phase 1 study identifying the most promising design(s) with the potential to scale network dimension(s) with varying degrees of node mobility.

- **Phase 1 Decision Point:** Based upon the expected outcome results of Phase 1, the Government may or may not determine to enter Phase 2. The technical details are conditional upon the selected solution and will be further defined during the SOW collaboration. If the Government determines that there is sufficient information within the white paper to progress to Phase 2, the Government will approve the white paper approach in part or in full and allow for the performer to move into Phase 2. The outcome of the white paper may or may not require an update to the SOW. This will be determined by the Government.

Phase 2: Finalize Design, Build, and Demonstrate Initial Prototype:

- **Phase 2 Technical Objective:** During phase 2, the vendor will achieve the following technical objectives:
  - Build lab prototype of tactical network with 5G Open-RAN split compliant core;
  - Build suite of RT-RIC algorithms for tactical network scenarios, in consideration of performance, implementation complexity and network resilience.
  - Evaluate performance for controlled lab environments

- **Phase 2 Expected Outcome:** The phase 2 outcome will be a competitive demonstration of the designed prototype(s). The intent is to down-select 1 or

more vendors to move into Phase 3.

- **Phase 2 Decision Point:** Based upon the expected outcome results of Phase 2, the Government may or may not determine to enter Phase 3. The technical details are conditional upon the selected solution and will be further defined during the SOW collaboration.

Phase 3: At-Scale Demonstration and Validation:

- **Phase 3 Technical Objective:** (At scale demonstration) Performers will be selected based on meeting performance targets in Phases I-II, based on a performance review/down-select at the end of Phase II and subsequent submission of a revised SOW. Performers should plan on transitioning their SW/HW prototype to a DOD or other Federal testbed infrastructure for deployment and evaluation in close-to-operational scenarios...

- **Phase 3 Expected Outcome:** During Phase 3 the expectation is that design iterations are driven to improve the system performance using the Phase 1 design modeling as a reference. In this sense, the ending Phase 3 expectation is that the system performance achieves within a best effort approximation of the relative model predictions created during Phase 1.

- **Phase 3 Decision Point:** Based upon the expected outcome results of Phase 3, the Government will determine if the prototype has achieved successful completion. The technical details and successful completion criteria are conditional upon the selected solution and will be further defined during the SOW collaboration.

Note: It is expected that the vendor may need to conduct multiple iterations of Phases 1 – 3 to develop the Beyond 5G prototypes to achieve the desired outcomes. Subsequent iterations shall be mutually agreed upon by the Government and the Vendor.

5.3.6 Government Desired Rights in Technical Data and Computer Software

The Government requires Government Purpose Rights (GPR) for a five-year period which shall commence upon execution of this transaction agreement. Upon expiration of the five-year period, the Government shall have unlimited rights. Printed deliverable (e.g., printed hardcopies, .doc, web-based html, etc.) will be labeled Distribution D and contain all appropriate markings associated with the distribution classification. All technical data, intellectual property and non-commercial off the shelf (COTS) software are desired to be provided with a minimum of GPR; however, if any non-COTS software cannot be provided with GPR, vendors will be requested to provide a perpetual enterprise license agreement that allows unlimited distribution, modification, and full use of the software without additional fees beyond the cost contracted for the original license agreement.

Any commercial or COTS shall be provided with a transferable license that allows distribution of the software and transfer of the license to any government agency or DOD vendor for any IB5G prototype project related purpose. All software licensing shall include a minimum term of five years of use. All software shall be provided with any available major upgrades, minor updates, security patches and technical support for the entire period of performance. When the addition of new software or hardware is proposed for the system or developed under this solicitation with government funding or partial government funding, the vendor shall ensure that sufficient rights in technical data (software and hardware) are procured to enable the government to maintain and modify the system using government personnel and/or third-party vendors. Government approval is required for exceptions to GPR.

Vendors will be requested to provide pricing to acquire any portion of their solution which is delivered with limited or restricted rights. The Government may choose to license or purchase the rights to these proprietary data upon successful delivery of the prototype.

The vendor shall describe the rights being provided to the Government in terms of technical data, both in software and hardware, so that the Government can maintain and modify the system(s) using Government personnel and third-party contractors. The vendor shall analyze feasible non-proprietary solutions and incorporate them, when applicable to the effort. This includes, but is not limited to, software rights, technical data, source code, drawings and other product definition data, manuals, warranties, and integration efforts.

All technical data and information developed under this effort should be marked with the appropriate marking in accordance with Department Of Defense Instruction (DoDI) 5200.48, Controlled Unclassified Information, USD(R&E) USD(I&S) Memo, Clarifying Guidance for Marking and Handling Controlled Technical Information in accordance with Department of Defense Instruction 5200.48, “Controlled Unclassified Information”, and DoDI 5320.24, Distribution Statements on Technical Documents. This generally should be marked with “DISTRIBUTION STATEMENT A.”

5.3.6.1 For the purposes of this RFS and final award document, the Government will use the data rights and computer software related terms defined in Attachment 5, Data Rights License Terms Definitions.

5.3.6.2 Vendor shall complete the Data Rights Assertions Tables using the format provided in Attachment 4, Data Rights Assertions Tables. The vendor’s assertions, including any assertions of its subcontractors or suppliers must be submitted as an appendix to the Technical Section. The tables must be completed in the format set forth in the attachment, dated and signed by an official authorized to contractually obligate the vendor. If additional space is necessary, additional pages may be included. There is

no page limit for the Data Rights Assertions Tables, and they do not count against the proposed technical solution page limitation.

5.3.7 Anticipated Delivery Schedule

The vendor shall include the anticipated delivery dates with their solution that includes all IB5G Prototype capabilities and completion dates for all tasks and task phases as described in the RFS. Vendors proposing to both Technical Areas are required to submit separate delivery schedules.

5.3.8 Integrated Master Schedule (IMS)

An IMS shall be provided, using Microsoft Project with an identical copy submitted in PDF format. The IMS should be resource loaded with each task including a predecessor (if applicable). The IMS may be attached as an appendix file to the Technical Section. The IMS is not included in the total page count and page count is unlimited. Vendors proposing to both Technical Areas are required to submit separate Integrated Master Schedules.

5.4 Pricing Section (unlimited page count)

The following shall be included within the Pricing Section:

- Pricing Breakout
- Rough Order of Magnitude (ROM)
- Basis of Estimate (BOE)

5.4.1. Pricing Breakout

Vendors shall submit a fixed price solution, further divided into severable milestones. The Government is not dictating a specific price mechanism. Milestones should be clearly defined, with sufficient detail, what is being delivered at each milestone and phase. The vendor’s pricing milestones may vary from the defined decision points, dependent upon the proposed solution. Each milestone price should reflect the anticipated value the Government will receive toward accomplishment of the OTA goals and objectives at the time the milestone is completed. The price section has no page number limitation.

The prototype project will be incrementally funded as funding becomes available. The Government may not fund the full value of this agreement based on the outcome of the various demonstrations conducted throughout the period of performance.

5.4.2 Rough Order of Magnitude (ROM)

Vendors shall provide a ROM for potential follow-on production activities as described in Section 9: Follow-on Activities to include the following:

Describe your licensing/pricing model(s) and include a high-level ROM for your described solution's recurring and non-recurring costs (e.g., installation/set-up, initial training, sustainment costs, upgrade costs and other associated/ add-on services) for a Production/Maintenance environment.

Vendors shall clearly identify any anticipated sustainment/maintenance costs and risks for its solution. In the Technical Section, Vendors should identify technical approaches and rationale within its proposed solution that will result in sustainment cost savings for the government. Sustainment cost savings from the technical approaches shall be quantified and provided.

Please note, the Follow-On Production ROM, as well as the follow-on sustainment costs, will assist in future planning efforts for potential follow-on efforts and will **NOT** be part of the evaluation.

5.4.3 Basis of Estimate

Proposing vendors are requested to provide a Basis of Estimate (BOE) for the entire effort.

6. RFS Response Instructions

6.1 The Government intends to make multiple OT awards as a result of this RFS.

6.2 All questions related to this RFS shall be submitted utilizing the Vendor Questions Form provided in Attachment 3. Questions must be submitted via email to initiatives@nstxl.org, with "IB5G Prototype Vendor Questions" in the subject line.

6.3 **Questions must be submitted no later than 12:00 PM EDT on TBD.** Questions received after the deadline may not be answered. Questions shall not include proprietary data as the Government reserves the right to post submitted questions and answers, as necessary (and appropriate) to facilitate vendor solution responses.

6.3.1 The Government reserves the right to post submitted questions and answers, as necessary (and appropriate) to facilitate vendor Solution Paper responses. Submitted questions will be posted without identifying company names.

6.4 **Solution Responses shall be submitted no later than 12:00 PM EDT on TBD.** Solution Responses shall be submitted electronically to initiatives@nstxl.org, with "IB5G Prototype Solution" used in the subject line. Any submissions received after this time on this date may be rejected as late and not considered.

6.4.1 Vendors must clearly state assumptions made within their response. Vendors are encouraged to challenge any Government assumptions or restrictive requirements in its individual solution and should articulate any major discrepancies between the RFS and its technical solution. Should a vendor's solution require a change in policy and/or statute, the vendor shall outline within their technical section, and describe why the change is needed to realize the benefit of the vendor's prototype (and potential production).

6.4.2 Vendor's solutions shall be valid for at least 180 days after submission.

7. Evaluation and Selection Process

7.1 Solution papers will be evaluated with consideration given to the vendor's ability to provide a clear description of the proposed solution, technical merit of the response, feasibility of implementation, vendor's experience, and total project risk. The proposed project price, delivery schedule, and data rights assertions will be considered as aspects of the entire response when weighing risk.

7.2 The Government will evaluate the degree to which the submission provides a thorough, flexible, and sound approach in response to the ability to fulfill the requirements. The Government will evaluate the following:

- Technical Merit and Feasibility – Evaluation will be based on the vendor's technical analysis and design approach to carry out the Technical Objectives as identified in RFS Section 5.
- The performing vendor's experience designing, developing, prototyping, and producing 5G technologies.
- The performing vendor's recent and relevant experience working with the Government in an agile and adaptable manner through collaboration and iteration. Projects worked in the last three (3) years are considered recent.
- Management Capabilities to include team composition/personnel and sub-vendor involvement, including a description of subcontractor tasks and experience, as well as manufacturing capabilities and facilities.

7.3. In addition, interested vendors are required to provide the following:

- Fixed price amount further divided into severable milestones (RFS Section 5.4.1).
- Basis of Estimate (BOE) as described in RFS Section 5.4.3.
- An IMS for the entire effort with identified deliveries throughout the development of the prototype. (RFS Section 5.3.8).

- Data Rights Assertions Table, Attachment 4: The technical response is expected to clearly outline the appropriate assertion rights in technical data, computer software and software documentation that will be delivered with the solution.
- The vendor's approach to provide life cycle maintenance to sustain capabilities during the duration of the IB5G effort (36 months).
    - Follow-on Production Rough Order of Magnitude (ROM) pricing should include vendor's approach for handling follow-on activities described in (RFS Section 5.4.2). The Government will not evaluate vendor submissions related to sustainment and follow-on activities; however, the Government will seek a pricing estimate (ROM) for future planning purposes.

7.4 Cost and Pricing Breakdown

It is important to note, the entire 5-year prototype project has a maximum ceiling budget of $13,700,000 per technical area. The government anticipates up to $12,000,000 of available funding for the first year of this project, beginning in Fiscal Year (FY) 2022.

7.5 Selection Process

7.5.1 The Government will review each vendor's submittal against the criteria as described in Sections 7.2 and 7.3, with major consideration given in no specific order of importance to the technical merit, feasibility of implementation, and total project risk. The proposed project price, delivery schedule, and data rights assertions will also be considered as aspects of the entire response when weighing risk and reward. Further, the Government will evaluate the degree to which the proposed concept provides an innovative, unique – yet realistic and sustainable - approach to meeting the IB5G Prototype technical capabilities and objectives.

7.5.2 Assessment of risk is subjective. If the risk is obvious or the schedule seems overly aggressive, the Government will consider that in the total risk assessment. Vendors are responsible for identifying risks within their submissions, as well as providing specific mitigation solutions. If sufficient validation of the proposed information is not provided, the Government may reject the submission.

7.5.3 Unsupported assertions will be discounted by the evaluators. Technology and Manufacturing Readiness Levels will be considered when weighing the benefit of the proposal.

7.5.4 The Government anticipates awarding to the vendor(s) whose response best satisfies the Government's objectives, referenced in Section 5.3.5, and will be most advantageous to the Government with price and other factors considered.

7.5.5 In making the final decision it may become necessary to compare the proposals of each vendor against the other, but the Government anticipates that its decision is more likely to be made based on each vendor's submittal as evaluated against the criteria described above and a determination of which solution(s) is/are determined to be the most advantageous to the Government.

8. Additional Information

8.1 Export Controls

Research findings and technology developments arising from the resulting proposed solution may constitute a significant enhancement to the national defense and to the economic vitality of the United States. As such, in the conduct of all work related to this effort, the recipient will comply strictly with the International Traffic in Arms Regulation (22 C.F.R. §§ 120-130), the National Industrial Security Program Operating Manual (DoD 5220.22-M) and the Department of Commerce Export Regulation (15 C.F.R. §§ 730-774).

8.2 Interaction and/or Disclosure with Foreign Country/Foreign National Personnel

The Vendor should comply with foreign disclosure processes described in US Army Regulation (AR) 380-10, Foreign Disclosure and Contacts with Foreign Representatives; Department of Defense Directive (DoDD) 5230.11, Disclosure of Classified Military Information to Foreign Governments and International Organizations; and DoDD 5230.20, Visits and Assignments of Foreign Nationals.

8.3 Cyber Incident Reporting: The awardee will properly protect data and comply with specific Government reporting procedures in the event Government data is compromised.

8.4 By submitting a response, respondents shall clearly certify whether covered telecommunications equipment or services **will or will not** be included as a part of its offered products or services to the Government in the performance of this effort.

All respondents are required to submit applicable documentation to www.sam.gov concerning Section 889 (Prohibition on Certain Telecommunications and Video Surveillance Services or Equipment). Submissions from vendors with delinquent, incomplete, or missing information related to Section 889 shall be deemed non-compliant.

8.5 All submissions will be unclassified. Submissions containing data that is not to be disclosed to the public for any purpose or used by the Government except for evaluation purposes will include the following sentences on the cover page:

“This submission includes data that will not be disclosed outside the Government, except to non-Government personnel for evaluation purposes, and will not be duplicated, used, or disclosed -- in whole or in part -- for any purpose other than to evaluate this submission. If, however, an agreement is awarded to this Company as a result of -- or in connection with – the submission of this data, the Government will have the right to duplicate, use, or disclose the data to the extent agreed upon by both parties in the resulting agreement. 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]”

8.6 Each restricted data sheet should be marked as follows:
“Use or disclosure of data contained on this sheet is subject to the restriction on the title page of this submission.”

9. Follow-On Activities

Pursuant to 10 U.S.C. 4022(f), if competitive procedures were used for the selection of parties for participation in the transaction for a prototype pilot and the participants in the transaction successfully completed the prototype project, production OTs are authorized and offer a streamlined method for transitioning into follow-on production without competition. Potential follow-on production contracts may be either sole source, based on successful completion of the prototype project within the scope of this document, or competed at the discretion of the Government. Follow-on activities could include system and software updates to address obsolescence, concurrency, evolving training requirements, and technology insertion.

If the IB5G prototype project is successfully completed [feasibility and utility of the prototype(s) are demonstrated and assessed, and IOC is gained], the Government anticipates transitioning into production. A Rough Order of Magnitude (ROM) for follow-on activity may be required and will be determined during the development of each RFS.

Prior to issuing a sole source Follow-On continuation of prototyping or a production agreement or contract, the Government will enter negotiations with the awarded vendor. The negotiations may include evaluation of all potential cost element categories applicable to the effort and may also use price realism analysis. The Government will utilize the most applicable method in determining cost elements and prices are fair and reasonable.

10. Attachments

To support the IB5G prototype project RFS, the following documents will be provided. Each document will be marked and protected accordingly to support distribution and

storage. This may include the vetting of vendors, in accordance with established Government policy and procedures, prior to distribution.

Attachment 1, Security Classification Guide (SCG) 10-040, Distribution A
Attachment 2, Security Process for Vetting Contractors
Attachment 3, Questions Form
Attachment 4, Data Rights Assertions Tables
Attachment 5, Data Rights License Terms and Definitions
Attachment 6, Terms and Conditions and EULA
Attachment 7, GFI Tech Data Distribution Agreement
Attachment 8, Vendor Self Vetting Form