



5G

2019

Defense Science Board Task Force

Defense Applications of 5G Network Technology

DISTRIBUTION STATEMENT A

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The DSB is a Federal Advisory Committee established to provide independent advice to the Secretary of Defense. Statements, opinions, conclusions, and recommendations in this report do not necessarily represent the official position of the Department of Defense (DoD).



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DEFENSE SCIENCE
BOARD

MEMORANDUM FOR UNDER SECRETARY OF DEFENSE FOR RESEARCH AND
ENGINEERING

SUBJECT: Final Report of the Defense Science Board Quick Task Force on Defense
Applications of Fifth Generation Network Technology

We are pleased to forward the final report of the Defense Science Board (DSB) Quick Task Force on Defense Applications of 5G Network Technology. The Task Force completed an extensive technical review of the state-of-the-art in fifth generation (5G) communications and related technology and offers important recommendations on how the Department should approach adoption of 5G network technology. The study's findings apply to six overarching areas: enhanced mission capabilities; leveraging existing network software, infrastructure, and hardware; spectrum; security; supply chain; and standards.

The report provides key recommendations which align with a proposed DoD 5G Strategy to help the Department successfully and securely adopt 5G network technologies. I fully endorse all the recommendations contained in this report and urge their careful consideration and soonest adoption.

A handwritten signature in black ink, appearing to read "Craig Fields", is positioned above the printed name.

Craig Fields
Chairman, Defense Science Board



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MEMORANDUM FOR THE CHAIRMAN, DEFENSE SCIENCE BOARD

SUBJECT: Final Report of the Defense Science Board Quick Task Force on Defense Applications of Fifth Generation Network Technology

The final report of the Defense Science Board (DSB) Quick Task Force on Defense Applications of 5G Network Technology is attached. In accordance with its charter, the study defines a path for DoD 5G adoption that mitigates supply chain risk, established spectrum co-existence procedures and revamps existing communications infrastructure.

The Task Force analyzed 5G technology programs across the DoD, U.S. Government Agencies, Industry and Academia and, based upon their findings, developed a proposed DoD 5G Strategy. If adopted and acted upon expeditiously, this strategy will provide the Department with a near-term plan to ensure a vibrant U.S. research and development (R&D) base for "5G and beyond" telecommunications standards, capabilities and industry; long-term U.S. competitiveness in the global communications and network base; and a safe, secure, trustworthy and resilient communications infrastructure option for the U.S. at home or abroad, our Allies and treaty partners.

This report provides key recommendations to help the Department successfully and securely adopt 5G network technologies. The committee believes that the recommendations contained in this report are executable in less than five years, with many actionable in the immediate future. The committee encourages quick adoption of these recommendations, or we jeopardize our national technological leadership in this important sector.

I would like to express my thanks to the members of the Quick Task Force, the Defense Science Board Executive Secretariat, the government advisors and Defense industry experts for dedicating their time, resources, talent, and expertise that were vital for developing this report. We are pleased to forward the final report of the Defense Science Board (DSB) Quick Task Force on Defense Applications of 5G Network Technology.

Alfred Grasso
Study Chairman

Executive Summary

Introduction

Emerging 5G network technology offers the Department of Defense (DoD) access to advanced communications and networking with much improved data rates, lower latency, and significant potential energy savings over existing 4G networks. The integration of 5G technology could give DoD an opportunity to adopt at lower cost the benefits of these systems for operational needs. Improved commercially available 5G technology offers DoD many operational benefits but also presents new challenges in cyber security, spectrum management and network optimization. The Defense Science Board (DSB) Quick Task Force (TF) on Defense Applications of 5G Network Technology was established to define a path for potential DoD 5G adoption that mitigates supply chain risk, establishes spectrum co-existence procedures and revamps existing communication infrastructure.

The DSB report on Defense Applications of 5G Network Technology concludes that there can be significant benefits from using 5G technology in the DoD but inherent supply chain, cyber, Radio Frequency (RF)/Electronic Warfare (EW) and virtual/physical vulnerabilities create significant mission risk. Any deployment of 5G in DoD infrastructure must be measured against mission criticality and acceptable risk. This executive summary reviews TF findings and recommendations considered necessary for a successful 5G DoD deployment.

Scope of Study

From November 2018 to March 2019 the Quick Task Force held monthly meetings to deliberate and receive briefings on the 5G landscape. Experts and practitioners from a wide array of backgrounds including the DoD, Intelligence Community (IC), other Government Agencies, Academia, think tanks and Industry shared their insights and information.

The breadth of knowledge and expertise shared with the TF throughout the study ensured the most complete and accurate information available to-date. Those findings and their associated recommendations are summarized below and are detailed in the TF's classified report. The committee believes that if these recommendations are acted upon expeditiously, DoD can reap significant benefits from the use of 5G technology.

Additional information exists at a higher classification level available to those with appropriate access. Please contact the DSB Office for more information.

DoD 5G Findings

The Task Force deliberations resulted in the following six overarching findings.

Finding 1: 5G Bandwidth (BW) and services, low power implementations and low latency capabilities may enhance DoD current mission capabilities and have potential to create new mission capabilities.

- Multiple strategies for adopting 5G must be considered
- Insufficient 5G resources and testbed(s) capable of evaluating current and proposed standards, capabilities and technologies exist

Finding 2: While 5G largely evolves from 4G, much has changed – significant shifts in IP, authorities in standards development and supply chain have occurred.

- 5G capability is inexorably intertwined with leading edge microelectronics
- Much activity was observed with little coordination and a lack of strategic direction
- China is known to influence/coordinate positions before major standards decisions and seeks to control future standards

Finding 3: Inherent supply chain, cyber, RF/EW and virtual/physical vulnerabilities create significant mission risk.

- The lack of a U.S. integrator and Radio Access Network (RAN) vendor industrial base creates challenges
- Continuous testing and experimentation can help mitigate risk while creating new opportunities
- Findings and recommendations from the DSB's earlier and current cyber studies apply

Finding 4: Network function virtualization, new radio, security enhancements present mission opportunities.

- New spectrum and new radio capabilities create opportunities for increased spectrum sharing, high BW transmission with Low-Probability-of-Intercept (LPI)/Low-Probability-of-Detection (LPD)/Low-Probability-of-Jamming (LPJ) characteristics
- 5G security enhancements provide an added layer of protection over 4G
- 5G commercial satellite options have the potential to create unprecedented opportunities for global communications

Finding 5: New and emerging technology presents an opportunity to regain leadership for future 3rd Generation Partnership Project (3GPP) standards releases.

- Ultra-densification of cellular networks with heavy reliance on small, micro- and pico cells will create new mission opportunities
- Artificial Intelligence (AI) and machine learning in the protocol stack will enhance performance
- Design and fabrication of components at commercial timescale can be applied to antenna arrays

Finding 6: 5G Deployment must be measured against mission criticality and acceptable risk.

DoD 5G Strategy Recommendations

Recommendation 1: Adopt 5G for military use in lightly contested environments.

- DoD CIO in collaboration with USD(A&S) and USD(R&E) should adopt 5G with security enhancements for military use in a lightly contested environments and publish policy, guidance and a roadmap for DoD on 4G acquisition/deployment and 5G adoption
- DoD should leap-frog Base Infrastructure 4G LTE service acquisition and accelerate full spectrum 5G deployment
- DoD should apply a “5G first” policy for infrastructure upgrades and recapitalization to include wireless applications
- Service acquisition executives should prioritize 5G infrastructure deployment over alternate means
- DoD CIO should formalize and implement a lessons-learned process to inform future standards, architecture development and deployments

Recommendation 2: Develop a secure 5G system for contested environments and critical applications.

- USD(A&S) should lead the planning and execution of programs to kick-off an effort to develop hardened and secure 5G technologies and infrastructure with specific attention to supply chains
- The DoD should increase its emphasis on system safety, recognizing that emerging use cases include mission critical applications such as industrial controls and autonomous vehicles.
Security is a vital component of system safety and a zero-trust network architecture with added provisions for ensuring the integrity of the supply chain are recommended

Recommendation 3: Create test beds for exploring innovative use cases.

- USD(R&E) should create an innovation test bed/proving ground and a set of activities and challenges to develop 5G applications tailored for DoD missions in both uncontested and contested environments
- The DoD should conduct exercises to identify vulnerabilities, attack vectors, exploitation and mitigation opportunities
- In collaboration with industry partners and National Institute of Standards and Technology (NIST), the DoD should utilize the test bed to establish evidence-based positions on key features, security and safety, and drive future standards releases

Recommendation 4: Stand-up a telecommunications security program.

- USD(R&E) in collaboration with the Director of National Intelligence (DNI) should stand up a telecommunications security program to identify vulnerabilities, opportunities and mitigation plans
- DoD CIO should employ the FedRAMP moderate or high baselines supplemented with DoD FedRAMP+ controls/control enhancements to assess Core Service Providers toward a DoD provisional authorization
- DISA/CYBERCOM should make provision for continuous, independent out-of-band monitoring of packet streams for 5G data to validate availability, confidentiality, and integrity of systems

Recommendation 5: Develop a DoD 5G supply chain management strategy.

- USD(R&E) should recruit talented, well-informed cadre of engineers, computer scientists and manufacturing experts with comprehensive knowledge of parts designs and embedded software
- USD(A&S) and service acquisition executives should establish acquisition procedures to buy in variety, buy often and buy fast – both COTS and GOTS and seek to obscure destination; alternate fabrication methodologies and insert ‘dielets’ for trustworthiness
- USD(A&S) and USD(R&E) should provide seed funding for Western industrial base alternatives of key system components, e.g., Radio Access Networks
- USD(R&E) should establish and maintain outreach to other entities to influence evolving standards and techniques to improve affordable assurance
- DoD CIO, in collaboration with NIST, should establish supply chain standards and prioritize them within 3GPP working groups

Recommendation 6: Create a program for “vulnerability analysis.”

- USD(R&E) and DARPA, in collaboration with the intelligence community, should conduct cybercentric vulnerability research for emerging 5G telecommunication hardware and software components

Recommendation 7: Develop and execute a 3 year 5G+ S&T roadmap.

- USD(R&E) in collaboration with DNI, should develop and execute a 3 year 5G S&T roadmap to influence future 3GPP releases and develop new and novel uses of 5G systems, subsystems and components
- DARPA should leverage ongoing satellite research efforts to influence 3GPP 5G satellite standard development and plan to deploy 5G satellite backhaul by 2021
- USD(R&E) should increase investment in emerging 5G technologies such as AI and ML in protocol stack, fog computing, massive MIMO, mmWave chipsets, and V2X for tactical and maritime operations
- USD(R&E) and DARPA should initiate an alternative RAN development program with industry partners; USD(A&S) should provision a minimum buy to attract industry participation

Recommendation 8: Develop a 5G+ Standards Engagement Plan.

- USD(R&E) should recruit a talented, well-informed cadre of engineers, computer scientists and manufacturing experts with comprehensive knowledge of parts designs and embedded software
- The standards coordination body should establish a preliminary list of standards for development

Recommendation 9: Establish a new bi-direction spectrum sharing paradigm.

- National Telecommunications and Information Administration (NTIA) and Federal Communications Commission (FCC), with support from the DoD CIO, should develop a National Spectrum strategy
- NTIA and FCC, with support from DoD CIO, should establish a National Spectrum Information Technology (IT) modernization program responsible for the next generation spectrum tools
- DoD CIO should develop a DoD spectrum strategy, roadmap and action plan aligned with the National Strategy that identifies upcoming requirements and proposed regulatory changes to

support flexible spectrum access and electromagnetic spectrum operation for national security missions in less than one year

- DoD CIO should develop a 5G+ roadmap action plan with attention to needed policy changes policies within six months. Particular attention should be applied to the utilization of 5G's emerging technology such as bandwidth parts, programmable resource block, carrier aggregation, beamforming and adaptive nulling to develop bi-directional sharing methods and new spectrum co-existence features across the low, mid and high spectrum bands
- DoD CIO/DISA Defense Spectrum Agency and USD(R&E) should request appropriated funds to facilitate R&D of advanced secure spectrum sharing technologies and techniques to facilitate DoD spectrum access

Recommendation 10: Accelerate mmWave technology development and transition.

- USD(R&E) should accelerate 5G mmWave applications and technology development in the 28GHz and 37GHz bands as the first priority, followed by other bands
- DARPA should refine propagation models and investigate the feasibility of adapting 5G fixed mmWave technology to mobile, airborne and satellite links
- DARPA should continue to track the development of 5G mmWave technology and create new opportunities for advancement

Study Membership

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MEMORANDUM FOR CHAIRMAN, DEFENSE SCIENCE BOARD

SUBJECT: Terms of Reference – Defense Science Board Task Force on Defense Applications of 5G Network Technology

New 5G network technology offers the Department of Defense (DoD) access to advanced communications and networking with much improved data rates, lower latency, and significant potential energy savings over existing 4G networks. The development of the 5G standards and associated hardware and software is being led by companies from around the world, and large-scale deployment of 5G systems will likely begin in the early 2020s. The integration of 5G technology could give DoD an opportunity to adopt at lower cost the benefits of these systems for operational needs.

Improved commercially available 5G technology offers DoD many operational benefits but also presents new challenges in cyber security, spectrum management and network optimization. The task force should define a path for DoD 5G adoption that mitigates supply chain risk, establishes spectrum co-existence procedures and revamps existing communication infrastructure. At a minimum, the analysis should provide a description and assessment of:

1. What current missions will be enhanced and what new missions can be enabled by the adoption of 5G technology?
2. How can DoD leverage its existing network software, base infrastructure, and hardware to enable a rapid adoption of 5G?
3. Spectrum
 - a. What should the DoD spectrum management strategy be for allocating the significant, new bandwidth enabled by 5G?
 - b. What are the possible implementation challenges in low (below 6 GHz), mid (6 – 24GHz) and high (24 – 86 GHz) bands?
4. Security
 - a. Are there unique network security or reliability vulnerabilities inherent in the 5G approach?
 - b. What additional security features should be added for 5G missions such as Enterprise Mobility, International communications, Senior Leader Communications and Tactical Operations? For Internet of Things (IoT), Vehicle-to-Vehicle or Vehicle-to-Infrastructure (V2X), Distributed Artificial Intelligence (AI) and low Latency DoD 5G applications?

5. Supply Chain

- a. Are there supply chain vulnerabilities to be addressed for the implementation of 5G systems?
- b. What network or supply chain vulnerability mitigation program/requirements should be established before large-scale adoption of 5G technology in DoD?

6. Standards

- a. What commercial standards should DoD adopt for 5G applications (e.g. autonomous driving, IoT)?
- b. Should DoD request new or modified standards for 5G attribute components (e.g. Identity Management, multiple-input and multiple-output (MIMO) antennas, beam forming arrays)?

This task force will be sponsored by me as the Under Secretary of Defense for Research and Engineering (USD(R&E)). Mr. Alfred Grasso will serve as the task force Chair and the Executive Security will be Fred Moorefield. Lt Col Milo W. Hyde IV, DSB Executive Director and Designated Federal Official, will serve as the DSB Secretariat. This study is to be completed by March 31, 2018. At that time, a final briefing will be presented to the sponsor. Extensions for unforeseen circumstances will be handled as necessary.

The study members are granted access to those DoD officials and data necessary for the appropriate conduct of their study. I will serve as the DoD decision-maker for the matter under consideration and will coordinate decision-making as appropriate with other stakeholders identified by the study's findings and recommendations.

The study will operate in accordance with the provisions of P.L. 92-463, the "Federal Advisory Committee Act," and DoD Instruction 5105.04, the "DoD Federal Advisory Committee Management Program." It is not anticipated that this study will need to go into any "particular matters" within the meaning of title 18, United States Code, section 208, nor will it cause any member to be placed in the position of action as a procurement official.



Michael D. Griffin