DEPARTMENT OF DEFENSE
DEFENSE SCIENCE BOARD

Task Force on Military Satellite Communication and Tactical Networking

Executive Summary

March 2017

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Executive Summary

Introduction

Our Nation's missions around the globe are enabled by robust Military Satellite Communication (MILSATCOM) and tactical networks. These networks transport command and control (C2), sensor, and intelligence, surveillance, and reconnaissance (ISR) information to enable timely and decisive operations. Advances and proliferation in advanced electronic warfare (EW), kinetic, space, and cyber capabilities threaten our ability to maintain information superiority. Preserving the reliability of these networks requires not only improved communication techniques for low probability of detection, interception, and denial, but also an enhanced infrastructure for protection.

The estimated and projected electronic threats against satellite communication (SATCOM) have rapidly escalated in the last few years and will continue to increase in the foreseeable future. Under severe stress situations, jamming can render all commercial SATCOM and most defense SATCOM inoperable, except for the low- and medium-rate modes of defense extremely high frequency (EHF) SATCOM. This reality should be considered a crisis to be dealt with *immediately*. In addition, network operations in stressed situations can be spotty to non-existent.

To address this situation, this Task Force undertook a year-long study to review the current U.S. military satellite communication, tactical networking, and emerging commercial communication technologies and capabilities and identified shortfalls within existing and planned capability development. This report conveys the Task Force findings and proposes near-, mid-, and long-term system, enterprise, and technology improvements needed to allow effective operations against advanced threats.

Scope of Study

In December 2014, the Under Secretary of Defense for Acquisition, Technology, and Logistics (USD(AT&L)) signed the "Terms of Reference – Defense Science Board Task Force on Military Satellite Communication and Tactical Networking." As a result, the Chairman of the Defense Science Board established a task force on MILSATCOM and tactical networking. The study's Co-chairmen led an investigation on areas of interest related to military communications capabilities.

The Task Force convened a series of meetings from April 2015 to April 2016 and received briefings on MILSATCOM and networking topics from subject matter experts in the Department of Defense (DoD), the broader U.S. Government, think tanks, Federally Funded Research and Development Centers (FFRDCs), and the private sector. All Services were invited to provide their perspectives on satellite communications, tactical networking, and anti-access, area denial (A2/AD) challenges. The Task Force focused its discussions and this report on what it believes are the most urgent communications and networking issues for the DoD, within the broad Terms of Reference.

Major Findings

- MILSATCOM will be contested by a myriad of effects ranging from reversible to destructive.

- The current ground network architecture does not scale beyond a few tens of users and lacks anti-jam (AJ) capabilities. Ground tactical networks must be better connected and protected, accommodate ever increasing traffic, and require fewer resources to operate.

- There is no single unifying tactical network for the air layer.

- Minimum essential communications and connectivity needs are not well-defined or exercised.

- DoD communications are managed as a set of stovepipes, with acquisition authority for space, ground, and terminal components spread across multiple organizations and Services.

Recommendations

1. The Air Force Acquisition Executive should accelerate production and increase the quantity of Advanced Extremely High Frequency (AEHF) terminals for bombers and C2 aircraft. The Army Acquisition Executive should produce and increase the quantity of AEHF terminals for battalions.

2. The USD(AT&L) should accelerate the deployment of the Protected Tactical Waveform (PTW) and the Protected Tactical Enterprise Service (PTES) for use over commercial and MILSATCOM and the development of the PTS; the Army Acquisition Executive should accelerate PTW modem development and deployment to the Soldier Network Extensions (SNEs) and should plan to incorporate the PTS into all SNEs.

3. The Army should migrate a Blue Force Tracking (BFT) capability to the Protected Anti-Jam Terminal System (PATS) system to provide more protection for this critical service.

4. A low-rate, AJ, low probability of detection (LPD), and low probability of intercept (LPI) "random access packet" network should be developed.

5. The Air Force Space Command (AFSPC) and Defense Information Systems Agency (DISA) should establish a pathfinder program to leverage and utilize existing/evolving commercial communication satellite systems.

6. The Air Force and Navy Acquisition Executives should accelerate Link-16 enhancements and development of a next generation directional network.

7. The Army Acquisition Executive should redirect investments from the current Wideband Networking Waveform (WNW) and use these funds to: (1) acquire additional HNW capability; and (2) evolve HNW to increase AJ capability and address scalability. At the same time, the Army Communications-Electronic Command (CECOM) should re-design the ground wireless network for scalability, capacity, resiliency, and ease of configuration.

8. A Master Control Plane should be developed for internetworking and improved information assurance. The Task Force believes this initiative will be best led by a DoD network architect office with the involvement of DISA, the Navy Space and Naval Warfare Systems Command (SPAWAR), and other Service network offices.

9. The Assistant Secretary of Defense for Research and Engineering (ASD(R&E)) should apply science and technology (S&T) investment toward alternative, protected, beyond-line-of-sight (BLOS) architectures.

10. The National Security Agency (NSA), working closely with DISA and the U.S. Cyber Command, should address fiber network vulnerabilities.

11. The Navy should reduce its reliance on commercial providers by developing an organic capability to architect the network and pursue non-commercial solutions when appropriate.

12. All Services and Combatant Commands (CCMDs) should develop and exercise with Tactics, Techniques, and Procedures (TTP) for operation with degraded MILSATCOM services. The Services should identify their minimum mission essential information exchange requirements and train with that thin line of communication.

13. The Secretary of Defense should appoint a single, central authority for communications with responsibility to architect the overall DoD interconnected network and allocate resources and work with operational elements to create the necessary training and materiel solutions.

Appendix A: Task Force Terms of Reference

THE UNDER SECRETARY OF DEFENSE
3010 DEFENSE PENTAGON
WASHINGTON, DC 20301-3010

ACQUISITION,
TECHNOLOGY
AND LOGISTICS

DEC 0 1 2014

MEMORANDUM FOR CHAIRMAN, DEFENSE SCIENCE BOARD

SUBJECT: Terms of Reference – Defense Science Board Task Force on Military Satellite
Communication and Tactical Networking

US defense systems have become increasingly reliant on military satellite communication and tactical networks for integrating significantly larger amounts of information. New command and control networks, sensors for intelligence, surveillance, and reconnaissance (ISR) and weapon systems for tactical operations are creating orders of magnitude larger amounts of data to be transferred across military communication networks. Advanced electronic warfare and cyber threats have the potential of significantly reducing the reliability of these networks, and covert operations require improved techniques for communication with low probability of detection and interception.

The study will review the current US military satellite communication and tactical networking capabilities, identify shortfalls within existing and planned capability development, and then propose mid- and long-term system and technology improvements needed to allow effective complex operations against advanced threats. Specifically, the study will investigate military satellite communications systems and address questions such as: what is achievable for assured communications within current modernization and development programs; what is the potential of new technology; what are the new satellite architectural concepts that will offer greater robustness for wideband communication with greater resistance to kinetic, electronic, and cyber attacks. Additionally, the study will investigate military tactical networks and address questions such as what is the current state of military tactical network interoperability across heterogeneous platforms; what are the recommended future tactical network architectures and systems; and how can the rapidly evolving commercial networking systems and technology be best applied, when applicable, to military tactical networks.

I will sponsor the study. Dr. Vincent Chan and Mr. Alfred Grasso will serve as Co-chairmen of the study. Lt Col Michael T. Manor, USAF, (Joint Staff) will serve as Executive Secretary. Lt Col Michael Harvey, USAF, will serve as the DSB Secretariat Representative.

The study will operate in accordance with the provisions of P.L. 92-463, the "Federal Advisory Committee Act" and DoD Directive 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.

Frank Kendall

Appendix B: Task Force Membership

Co-Chairmen

Dr. Vincent Chan
Mr. Alfred Grasso

Members

Mr. Gregory Neal Akers
LTG Steve Boutelle, USA (Ret.)
ADM Archie Clemins, USN (Ret.)
Dr. Cynthia Dion-Schwarz
Dr. Kenneth Hetling
Dr. Malina Hills
Dr. Joseph Mitola

Honorable Arthur Money
Mr. Marc Richard
Mr. James Shields
Mr. George Spix
Dr. J. Scott Stadler
Dr. Robert Wisnieff
Mr. Vincent Vitto

Government Advisors

Dr. John Chapin (through Dec 2015)
DARPA
Mr. Randall Conway
DOD CIO

Mr. Richard Pino
OUSD(AT&L)
Mr. Mark Segal
NSA/CSS

Executive Secretary

LTC Michael Dean, USA
JS/J6

DSB Secretariat

CAPT Jeff Nowak, USN
Defense Science Board

Lt Col Victor Osweiler, USAF
Defense Science Board

Support

Mr. Matthew Lytwyn, SAIC
Ms. Kathleen McGlynn, SAIC

Appendix C: Briefings Received

April 23-24, 2015

Intelligence Community Threat Briefing
Defense Intelligence Agency

Intelligence Community Threat Briefing
Office of the Director of National Intelligence

Intelligence Community Threat Briefing
Central Intelligence Agency

Military Services Network/Satellite Capabilities and Campaign
U.S. Marine Corps

Military Services Network/Satellite Capabilities and Campaign
U.S. Army

Military Services Network/Satellite Capabilities and Campaign
U.S. Navy

Military Services Network/Satellite Capabilities and Campaign
U.S. Air Force

June 2-3, 2015

RDA Task Force
OUSD(AT&L)

PACOM Concept of Operations
PACOM

Air Force Red Team Briefing
Air Force Red Team

Protected Tactical Modem
The MITRE Corporation

Near Peer C4ISR Architecture
MIT Lincoln Laboratory

June 25-26, 2015

MILSATCOM Constellation Lead-Off
The Aerospace Corporation

MILSATCOM Terminals
U.S. Air Force

MILSATCOM Orbitology
The Aerospace Corporation

FAB-T
U.S. Air Force

MILSATCOM WGS
The Aerospace Corporation

MILSATCOM AoAs and AEHF POR
The Aerospace Corporation

COMSATCOM Strategy/Air Force Pathfinders
U.S. Air Force

July 13-14, 2015

Ground Tactical and Wireless Networks
U.S. Army

RAND 2013 Wireless Study
RAND Corporation

Link 16
DOD CIO

Link 16 and CDL Resiliency
U.S. Air Force

Airborne Networking
MIT Lincoln Laboratory

CDL
OUSD(AT&L)

APM Discussion on Navy's ADNS Capabilities
(PEO-C4I)
U.S. Navy

Ground Tactical Networks
MIT Lincoln Laboratory

August 6-7, 2015

Multiple NSA Briefings
NSA

Enterprise (Teleports and Gateways)
DISA

Command Center Mission/Orientation
DISA

Commercial SATCOM/EMSS-Global
DISA

Gateway SATCOM Operations
DISA

September 24-25, 2015

PNT Resiliency
The Aerospace Corporation

Wooden Chalice
The MITRE Corporation

A2/AD Wargaming and Network Assessments
RAND Corporation

MILSATCOM Threat Analysis
Lincoln Laboratory

Spectrum Operations
Lincoln Laboratory

Laser Communications
Lincoln Laboratory

Current Research in WB HF
The MITRE Corporation

Cyber Defense of SATCOM
Lincoln Laboratory

December 16-18, 2015

Tactical Waveforms/MANETs
Harris Corporation

Protected Band SATCOM
AFSPC

Posturing the Satellite Communications
Enterprise
AFSPC

Space Security & Defense Program
AFSPC

Fighting SATCOM
AFSPC

Schriever Wargames
AFSPC

SATCOM Requirements
AFSPC

Joint Interagency Combined Space Operations
Center
AFSPC

PSCS AoA
AFSPC

USSTRATCOM Briefing
USSTRATCOM

ARSTRAT Briefing
ARSTRAT

Tactical SATCOM Discussion for Defense
Science Board
Lockheed Martin

Kratos Briefing
Kratos

ViaSat Briefing
ViaStat

Inmarsat Briefings
Inmarsat

Intelsat General Briefings
Intelsat

ART
DARPA

ELASTx
DARPA

PNT Portfolio
DARPA

SSPARC
DARPA

MHS
DARPA

C2E
DARPA

WND
DARPA

XS-1 Rapid Access
DARPA

SeeMe
DARPA

CSP Seedling
DARPA

SATCOM Topics
OUSD(AT&L)

ONR Briefing
ONR

AFRL Space Vehicles Directorate: Space
Communications S&T for MILSATCOM
AFRL

RDECOM (CERDEC) Briefing
RDECOM (CERDEC)

February 11-12, 2016

NRO Briefing
NRO

Microsoft Cloud Brief
Microsoft

Juniper Brief
Juniper Networks

Cisco Brief
Cisco Systems

Google Brief
Google

Networking in a Hyperscale Cloud
Amazon Web Services

April 28-29, 2016

Raytheon Brief
Raytheon

Northrop Grumman Brief
Northrop Grumman

Lockheed Martin Brief
Lockheed Martin

Boeing Brief
The Boeing Company

NRC Brief
National Research Council

Appendix D:Acronyms

A2/AD	Anti-Access/Area Denial
ADNS	Automated Digital Network System
AEHF	Advanced Extremely High Frequency
AFSPC	Air Force Space Command
AJ	Anti-Jam
AoA	Analysis of Alternatives
ARSTRAT	Army Forces Strategic Command
ASD(C3I)	Assistant Secretary of Defense For Command, Control, Communications, and Intelligence
ASD(R&E)	Assistant Secretary of Defense for Research and Engineering
ATH	At-the-Halt
ATIP	Advanced TDMA Interface Processor
BCT	Brigade Combat Team
BFT	Blue Force Tracking
BLOS	Beyond Line-of-Sight
C2	Command And Control
C2E	Communications in Contested Environments
C4I	Command, Control, Communications, Computers, and Intelligence
CCMD	Combatant Command
CDL	Common Data Link
CECOM	Communications-Electronic Command
COTS	Commercial Off the Shelf
CSS	Central Security Service
DARPA	Defense Advanced Research Projects Agency
DDR&E	Director of Defense Research and Engineering
DISA	Defense Information Systems Agency
DoD	Department of Defense
DSB	Defense Science Board
EHF	Extremely High Frequency
ELF	Extremely Low Frequency
EPS	Enhanced Polar System
EW	Electronic Warfare
FFRDC	Federally Funded Research and Development Center
GaN	Gallium Nitride

GIG	Global Information Grid
GMR	Ground Mobile Radio
GPS	Global Positioning System
GRRIP	Global Rapid Response Information Packet
HAIPE	High Assurance Internet Protocol Encrypter
HF	High Frequency
HMMWV	High Mobility Multipurpose Wheeled Vehicle
HMS	Handheld, Manpack and Small Form Fit
HNR	Highband Networking Radio
HNW	Highband Networking Waveform
IFDL	Intra Flight Data Link
INTOP	Integrated Topsides
IP	Internet Protocol
ISR	Intelligence, Surveillance, and Reconnaissance
JTRS	Joint Tactical Radio System
LOS	Line-of-Site
LPD	Low Probability Of Detection
LPI	Low Probability Of Intercept
MADL	Multifunction Advanced Data Link
MAJE	Mitigation and Anti-Jam Enhancement
MANET	Mobile Ad Hoc Networking
MCX	MILSATCOM Advanced Concepts Division
MHS	Mobile Hotspots
MHz	Megahertz
MILSATCOM	Military Satellite Communications
MILSTAR	Military Strategic and Tactical Relay
MNVR	Mid-Tier Networking Vehicular Radio
NATO	North Atlantic Treaty Organization
NC3	Nuclear Command, Control, and Communications
NCW	Network-Centric Waveform
NDI	Non-Developmental Item
NDIA	National Defense Industrial Association
NIPRNet	Non-Classified Internet Protocol Router Network
NRO	National Reconnaissance Organization
NSA	National Security Agency

ONR	Office of Naval Research
OTM	On the Move
OUSD(AT&L)	Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics
PACOM	Pacific Command
PATS	Protected Anti-Jam Terminal System
PHY	Physical Layer
PLI	Position Location Information
PoP	Point of Presence
POR	Program Of Record
PTES	Protected Tactical Enterprise Service
PTS	Protected Tactical Satellite
PTW	Protected Tactical Waveform
QoS	Quality of Service
RF	Radio Frequency
RHN	Regional Hub Node
S&T	Science and Technology
SA	Situational Awareness
SATCOM	Satellite Communications
SMC	Space and Missile Systems Center
SEV	Space Enterprise Vision
SHF	Super High Frequency
SINCGARS	Single Channel Ground-Air Radio System
SIPRNet	Secret Internet Protocol Router Network
SITREPS	Situational Reports
SMART-T	Secure Mobile Anti-Jam Reliable Tactical Terminal
SMC	Space and Missile Systems Center
SMC/MCX	Space and Missile Systems Center MILSATCOM Advanced Concepts Division
SNAP	SIPR/NIPR Access Point
SNE	Soldier Network Extension
SONET	Synchronous Optical Network
SPAWAR	Space and Naval Warfare Systems Command
SRW	Soldier Radio Waveform
STT	Satellite Transportable Terminal
T2C2	Transportable Tactical Command Communications
TCN	Tactical Communications Node
TDMA	Time Division Multiple Access
TIP	TDMA Interface Processor
TTNT	Tactical Targeting Network Technology

TTP	Tactics, Techniques, and Procedures
UAV	Unmanned Aerial Vehicle
UHF	Ultra-High Frequency
USD(AT&L)	Under Secretary of Defense for Acquisition, Technology, and Logistics
USSTRATCOM	U.S. Strategic Command
VLF	Very Low Frequency
VWP	Vehicle Wireless Package
WBHF	Wideband High Frequency
WGS	Wideband Global SATCOM System
WIN-T	Warfighters Information Network Tactical
WND	Wireless Network Defense
WNW	Wideband Networking Waveform
XDR	Extended Data Rate