Advanced Wireless Technologies at DARPA

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Innovation in Support of National Security

- Solve National-Level Problems
- Enable Operational Dominance
- High Risk Technology Development, Exploitation -- Avoid Surprise
The Secret to Scoring

“Skate to where the [requirements] will be”

-Wayne Gretsky
Think Differently!

Revolutionize the way we exploit RF

The Synergy of Energy

- Bits are Bits & RF is RF
- Mission Functionality is determined by Software
**Premise:** As RF disciplines become digital the opportunity exists to exploit, completely, the information contained in the electromagnetic wave.

**DARPA Philosophy:** RF is RF. Bits are Bits. Fusion of Communications/SIGINT/EW/IW enabled by:

- Software definable radios
- MEMS Technologies
- High power amplifiers
- Broadband antenna advances
- Robust interference cancellation

Multi-mission capability in a single system breaks down traditional stovepipes and makes interoperability straightforward.
Assured communications anywhere in the world without infrastructure and zero setup time
ACN Concept 2000-2002

Signals Intelligence
Information Warfare
Electronic Warfare
RF Energy
Receiver / Transmitter
Processing
Comm
Signals Intelligence
Information Warfare
Electronic Warfare
Common Programmable Hardware - Functionality Based on Software
Continuous Operation During In-flight Reconfiguration
ACN: A Single System Servicing Many Missions

Approach

- Develop a Real-Time Programmable, Platform Agnostic, Multi-Mission (Communications, SIGINT, EW & Electronic Attack) Payload
- Develop, Mature & Demonstrate Technologies Necessary to Implement the Design.
- Demonstrate End-to-End System Design in Laboratory

Top Technical Challenges

- Simultaneous Multi-Mission Operation
- Scaleable Size, Weight, and Power - Modular/Scaleable Design Supporting Integration on Multiple Platforms (25 lbs. to 900 lbs.)
- Co-Channel Interference Mitigation/Jamming Mitigation
- Autonomous Mobile Ad-Hoc Networking
- Information Assurance - Robust Operation Against Jamming and Intrusion
Small Unit Operations Situation Awareness System Program

1. Maintain communication links anywhere, anytime
2. Maintain the network all of the time
3. Estimate position anywhere, anytime
4. Interface with warriors and sensors
SUO SAS Concepts

Develop secure, robust communication and information management prototype to enable information superiority for individual warfighter

Highly Adaptive Radio
- Extreme Frequency Agility (20 MHz – 2,500 MHz)
- Data Rate (up to 2 Mbps)
- AntiJam, Low Probability of Detection

Mobile, AdHoc, Peer-to-Peer Networking
- Mobile Networking
- Scaleable to 10,000 entities
- Voice and Data Transmission

Precision Navigation without GPS
- Radio ranging inside buildings, urban canyons etc. without GPS
- 2m range precision in 3D

Distributed Information Management
- Data/Voice to Groups managed by organization, tasks, and position
- Situational Awareness Data (Red and Blue) filtered by organization, tasks, position and threat status

SUO SAS is Built!
FCS-Communications

Assured communications for Army Future Combat System

**System Tech Investment**
- RF Information Assurance (Network Layer and Below)
- Mobile Ad Hoc Networking With Directional Antennas and QoS for Real-Time Traffic
- Modeling and Simulation

**RF Technology Investment**
- High Band Technology
  - Highly Directional Antennas, Transmitters, Receivers, etc.
- Low Band Technology
  - Directional Antennas, Transmitters, Receivers, etc.
  - Advanced Modulation/Coding/Signal Processing in a Software Radio Framework

Enabling Network-Centric Warfare
Future Combat Systems
Notional Cell Communications Traffic Attributes

Reverse Link (LPD)
- Sensor Data
  - UAV – MTI, Imaging
  - Dismounted – Voice, SA Reports
  - UGS – Reports, Images
  - FCS - RS, I/DF: Target Reports/Images, BDA, SA Reports, DTED, Video

Forward Link (A/J)
- Command and Control
  - Way Points, Commands
  - Target Folder Coordinates and Templates
  - SA Updates
  - Tele-operation
  - Fire Control

- FCS Becomes a Target without Assured Communications

Tactical UAVs (2)

Indirect Fire (2)

Direct Fire (2)

Troop Carriers (2)

Robotic Sensors (2)

Unattended Sensors (100)

Dismounts (30)
WolfPack Program Vision
Close, Distributed, Networked RF Spectrum Dominance

**Precision**

- **Denial**
- **Deception**
- **Disruption**

**Detection**

**Communication Service Layers**

- Application
- Presentation
- Session
- Transport
- Network
- Data Link
- Physical

**Conventional Jamming Systems**

"The Challenge"

- Develop technology enablers
- Implement innovative techniques

...with no Fratricide!
Close approach enables low power/LPD signal detection and blanket attack.

Distributed units enable wide area spectrum monitoring and directed attack.

Network awareness permits precision attack/avoidance with minimum power.

WolfPack Technology responds to advanced LPD/LPI, Packet Network Radios.
**TODAY**: Spectrum statically allocated

**FUTURE**: Dynamically allocating spectrum in frequency, space, and time may improve utilization by a factor of 10
Develop both the Enabling Technology and the System Concepts to *Dynamically* Allocate Spectrum

- Improve Efficiency (<<1 %) of Current, Static Allocations to voice and data by a Factor of 20 (as measured by MHz km²)
- Provide Capability to Share Spectrum with Other Providers
XG Spectrum Planning

4th Infantry Division

- 25 km
- 25 km
- 80 km
- 40 km

Reserve

FI

FII

= 500+ Individual Allocations
Spatially Deconflicted from 20:1 – 500:1

Data generated by OSAM

Current War Plans incorporate J-12 Input on Spectrum Allocation that is Static for the “Entire” Theater

- Allocations are Made to be Risk Adverse
  - 99.9% Allocation Reliability
  - 97% Connection Reliability
- Planning can Take up to Months to Deconflict
  - e.g. Naval Group will use Same Allocations for 6 Month Deployment
XG Technology Challenges

**Predict or React to the Available Spectrum through Dynamic MAC Layer ...**

... Invest in Heterogeneous, Wideband MAC Subsystems

Either Move in Frequency or Become Malleable ...

RF emitters detect each other and adjust automatically

... Invest in multiple time-frequency agile waveforms

XG Requires Integration of New Control Techniques and Agile Waveforms That Balance Complexity and Capacity
Tera-Hertz Operational Reachback (THOR)

Connect the warfighter, in theater, to the fiber optic infrastructure using mobile free space optical communications.
Enable the Deployed Warfighter to enjoy the same level of connectivity that is enjoyed while not deployed.

Off load high demand and scarce space communications assets by exploiting connectivity via ubiquitous terrestrial fiber.

Complete the global grid by tying space-air-surface-subsurface platforms together.

**THOR Vision**

“Fiberless Fiber” will complete the Global Grid and provide secure, assured, high data rate and end-to-end communications to airborne, terrestrial, surface, and subsurface warfighters by developing, integrating and demonstrating innovative optical system concepts and technologies.
Briefing Complete