CERDEC Contributions to Army Battle Command Networking Efforts

CERDEC
US ARMY – RDECOM

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Mr. David Jimenez

Director, Space & Terrestrial Communications Directorate

Evolution of Army Networking

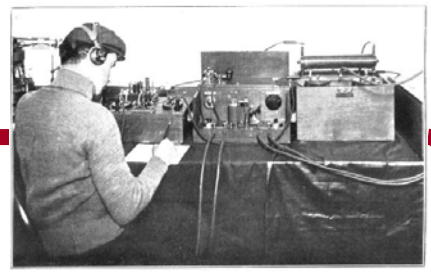
Civil War

U.S. Army Signal Corps (1860)

Telegraph

WWI Pigeon, Mocker

World War I



Clark Portable Army Radio Set (1906)

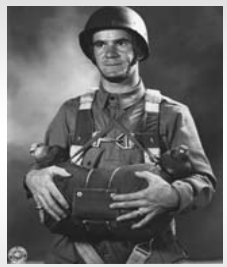
Vietnam

PRC-77

PRT-4 & PRR-9

World War II

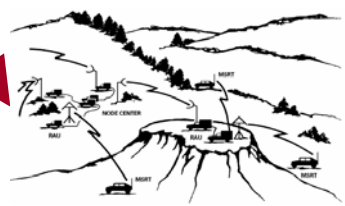
WWII Radios



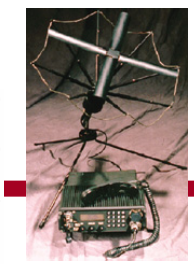
United States Army Pigeon Service

PRC-6

1980s-2006+



MSE



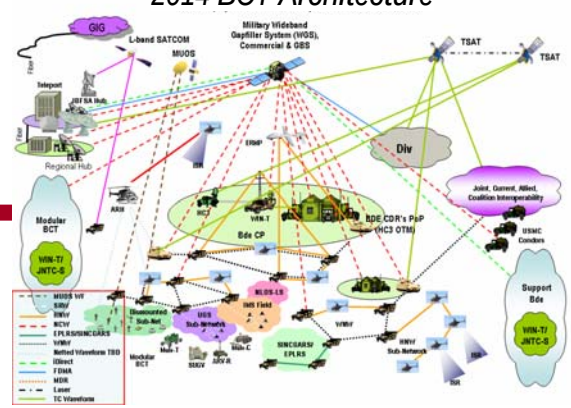
Manpack UHF SATCOM

SINCGARS

EPLRS

Tactical Internet

2014 BCT Architecture

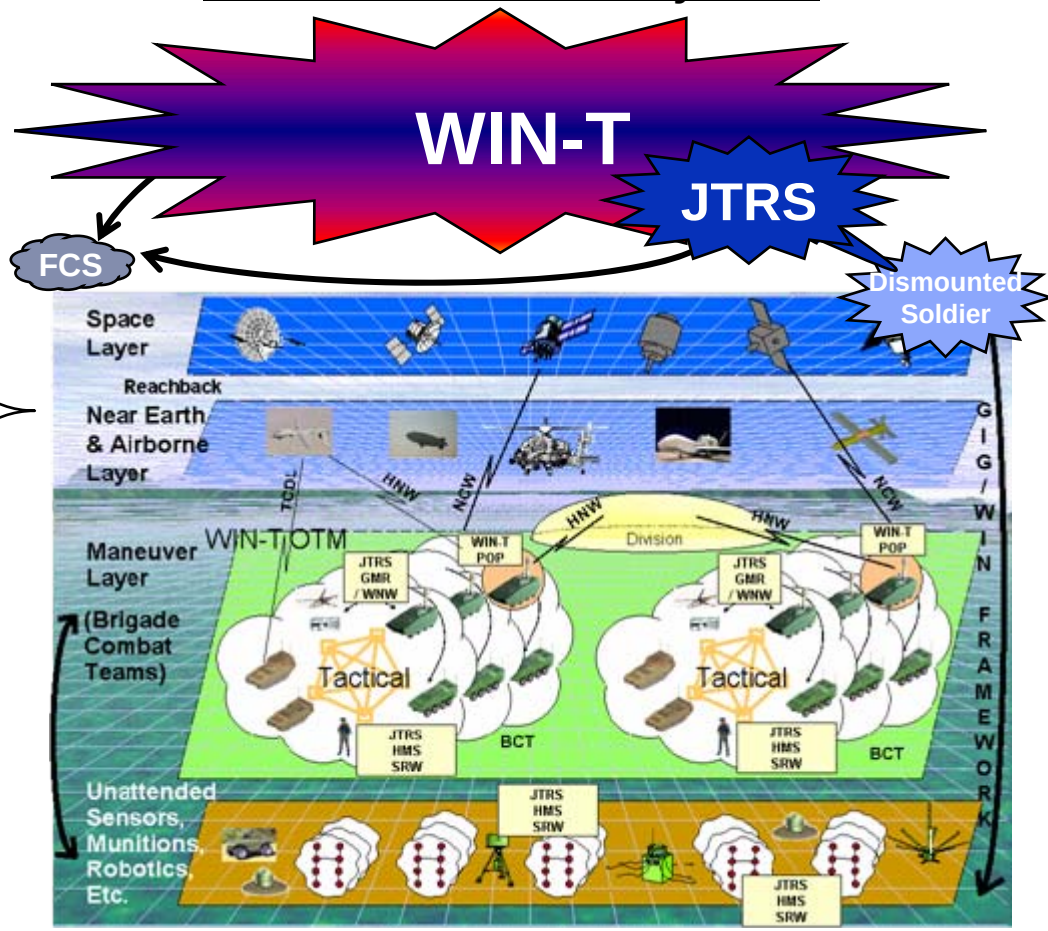


Major Communications Thrusts

Connectivity **Capacity** **Security**

- Mobile Networking
- Antennas
- Information Assurance

Future Force Comms Systems



Comparison of Commercial & Military Communications Architecture

RDECOM

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Commercial

- Mobile Subscriber, Fixed Infrastructure
- Pre-configured Networks
- Tall, Fixed Antenna Towers
- Fiberoptic Internodal Connections
- Spectrum Availability
- Fixed Frequency Assignments
- Protection: None ➲ Privacy (single level)
- Interference Rejection is Somewhat Important
- Low probability of Detection (LPD) is not an issue

COMMERCIAL	TACTICAL
	
High Bandwidth	Small Bandwidth
	
Primarily Robust Static Infrastructure	Radio-Based Highly Mobile Comms
	
Highly Skilled Large Teams	MOS w/Multi-duties

Military

- Mobile Subscriber - Mobile Infrastructure
- Ad Hoc, Self Organizing Networks
- Small, Easily Erectable Masts; Low Profile OTM Antennas
- Mobile, Wireless, Internodal Connections
- Restricted Frequency Assignments; Geographically Impacted
- Protection: None ➲ Top Secret/ SI (Multiple, Simultaneous Levels)
- Interference Rejection and Antijam are Critical
- Low Probability of Detection (LPD) is Critical

Strategy = ***Adopt*** ***Adapt Modify*** ***Develop and/ or Influence***

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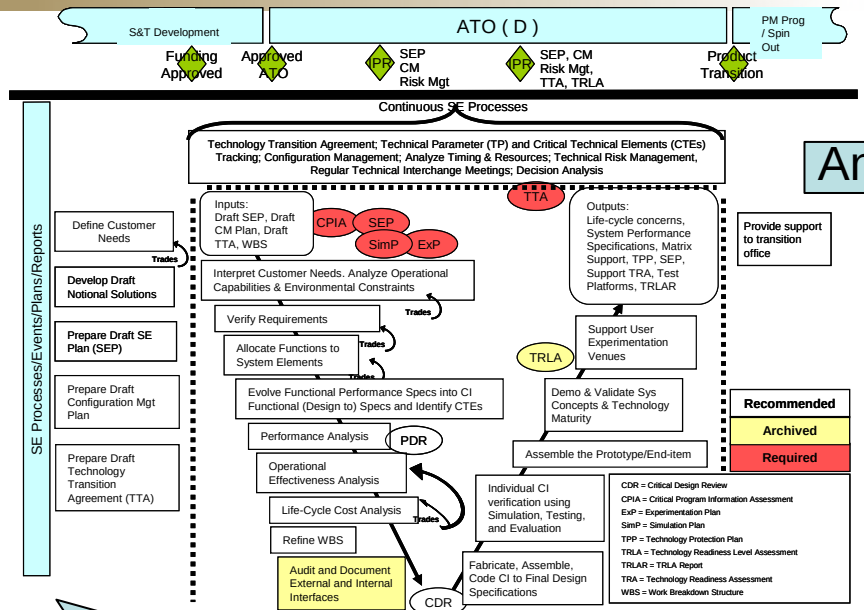
Systems Engineering (SE) Approach



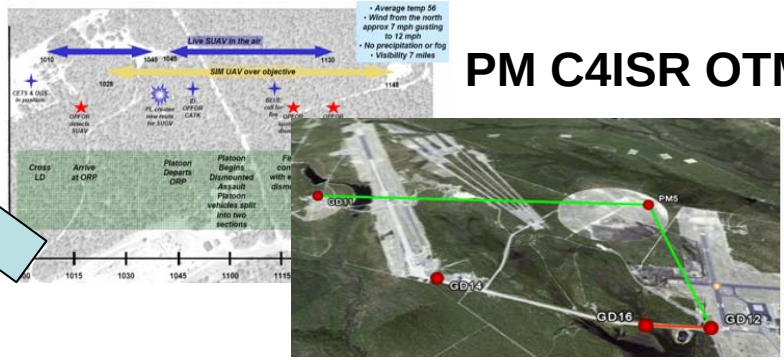
SE Process

Analysis

Applied to Customers Requirements:
FCS BW for BC
FCS Voice Architecture Study
FCS Network Assumptions Whitepaper
Tactical Network Ground Forces Study
Etc….

Test & Validation

Lessons Learned



PM C4ISR OTM

Architecture
- Operational Views
- System Views
- Technical Views
- Network Model Development

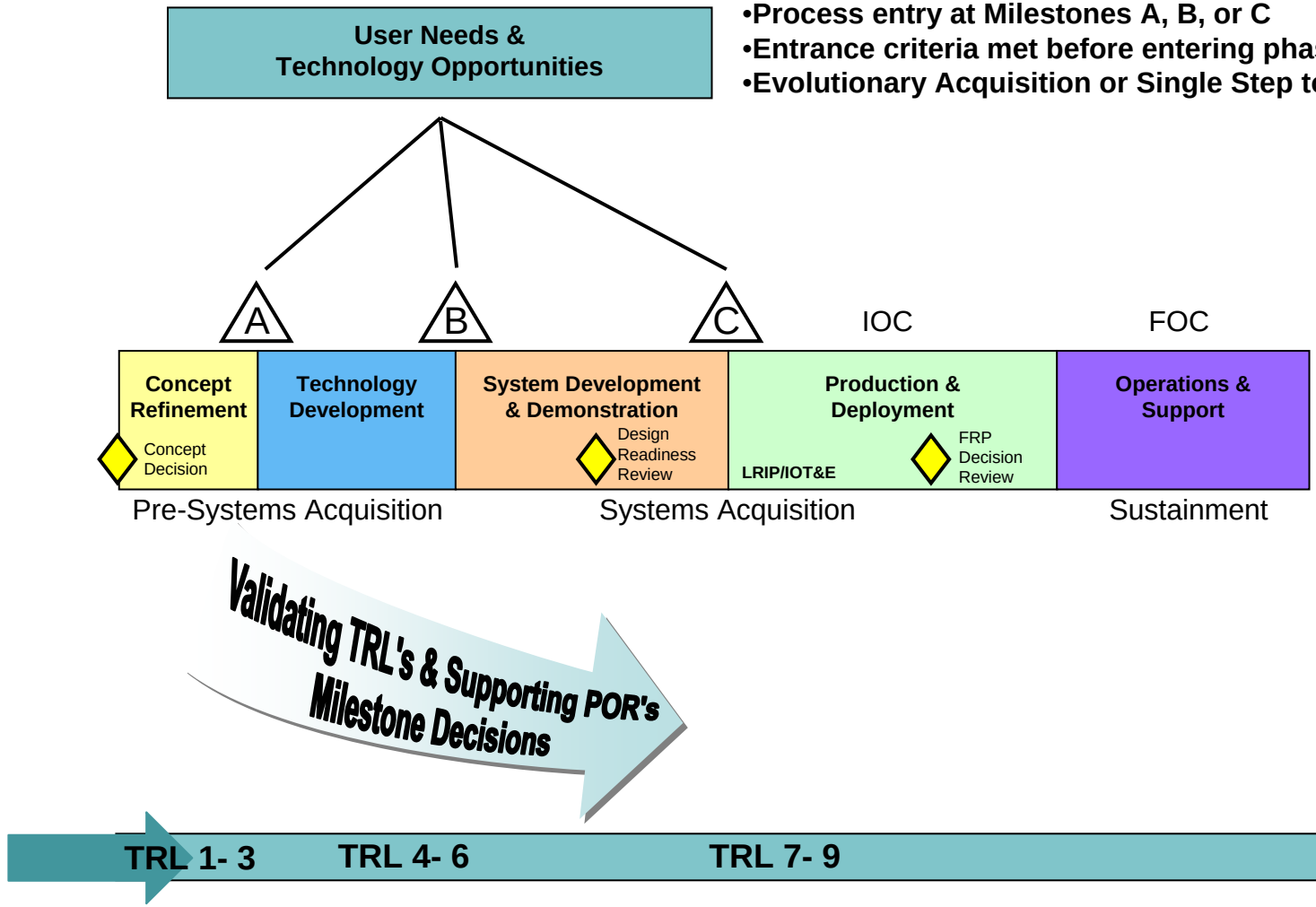
Network M&S
- OPNET
- CES/QUALNET
- NETWARS

Field & Experimental Testing/Evaluation
- PM C4ISR OTM
- Data Collection

Emulation

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

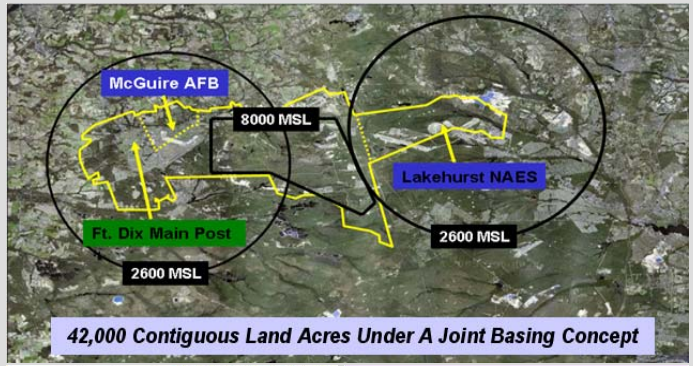
Technology Development and Maturation



PM C4ISR On-The-Move

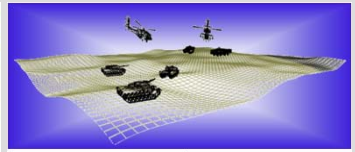
- R&D ***venue*** offering the ***Tech Base*** and ***Programs of Record*** a ***continuous*** and enduring ***evaluation*** capability for Network Centric Warfare (NCW) concepts
- Conducts Live, Virtual, and Constructive ***technology demonstrations*** currently supporting scales on the order of ***100 live and 3,000 virtual/constructive*** entities
- Provides a ***relevant environment*** to assess emerging technologies in a C4ISR ***System-of-Systems (SoS)***
- ***Mitigate risk*** for FCS Concepts, Future Force technologies
- Opportunities for ***acceleration of technology insertion*** into the Current Force
- Venue for ***validation of Technology/Software/ Integration Readiness Levels***
- Includes a ***state-of-the-art instrumentation, data collection & reduction*** (IDC&R) tool suite that supports the quantification of NCW activities
- Employs system of systems engineering methods that promote ***rapid SoS reconfiguration*** and enable repeatable assessments
- Has a diverse set of experience over the past seven years in working with dozens of government and industry partners to ***integrate and execute large-scale, distributed Live/Virtual/Constructive events***

Fort Dix – McGuire AFB – Lakehurst NAES Joint Megabase



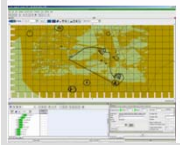

Open/Rolling


Heavily Foliated

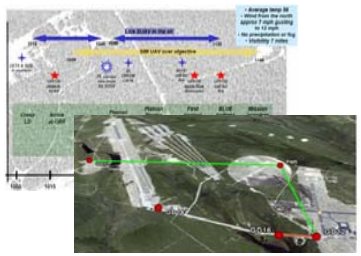



Maneuver Corridors


3x MOUT Sites

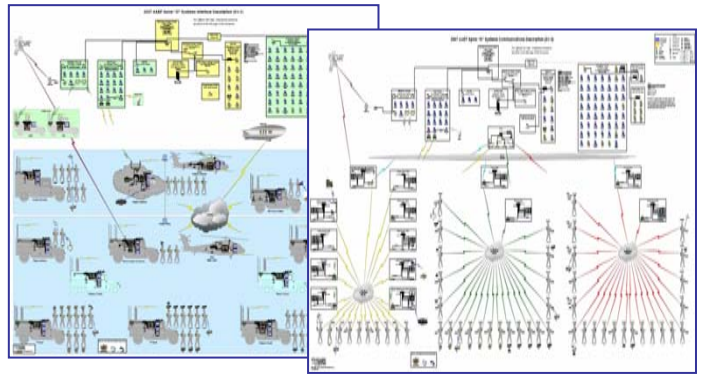



Seamless LVC Integration


Seasoned team of subject matter experts & analysts


Warfighters and scientists working side by side


Seven years of field experimentation experience


SoS engineering processes & procedures – rapid prototyping frameworks

Linking Battle Command Metrics Across Multiple Domains

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Technical Metrics

C4ISR System Performance

- Network Connectivity
- Message Completion Rate
- Probability of Detection
- Probability of Identification
- Detection Accuracy
- Power Usage
- Visualization Resolution

System Knowledge

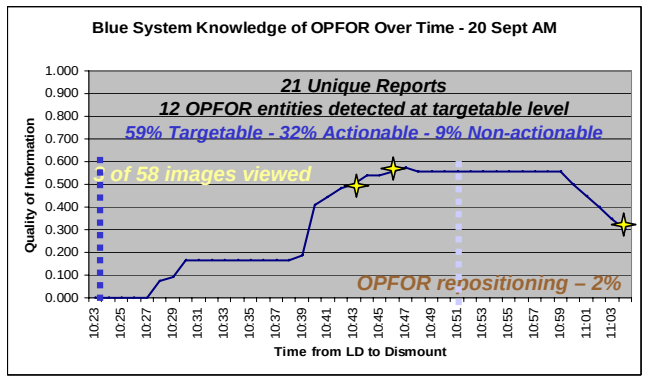
Quality of Information

- Accuracy, Completeness & Timeliness of Information about Threat
- Level of Situational Awareness Achieved
- Number and Types of Decisions Made

Operational Metrics

Soldier Unit Performance

- Time to Execute Mission
- Blue Losses
- Red Losses
- Degree of Surprise
- Ability to Maneuver Undetected
- Number of PIR Satisfied



Quantifying How Technical Performance Impacts Operational Effectiveness

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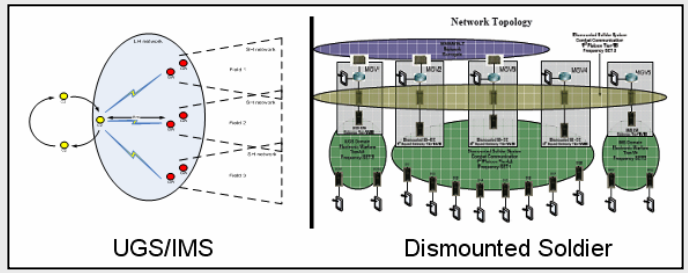
Support to PM Programs and Tech Base Efforts

PM WIN-T 2007 Increment 2
Engineering Field Test
- Critical Technology Elements
- Network Scalability



JTRS SLICE SRW 2006/7
Technical Field Tests
- Waveform maturation

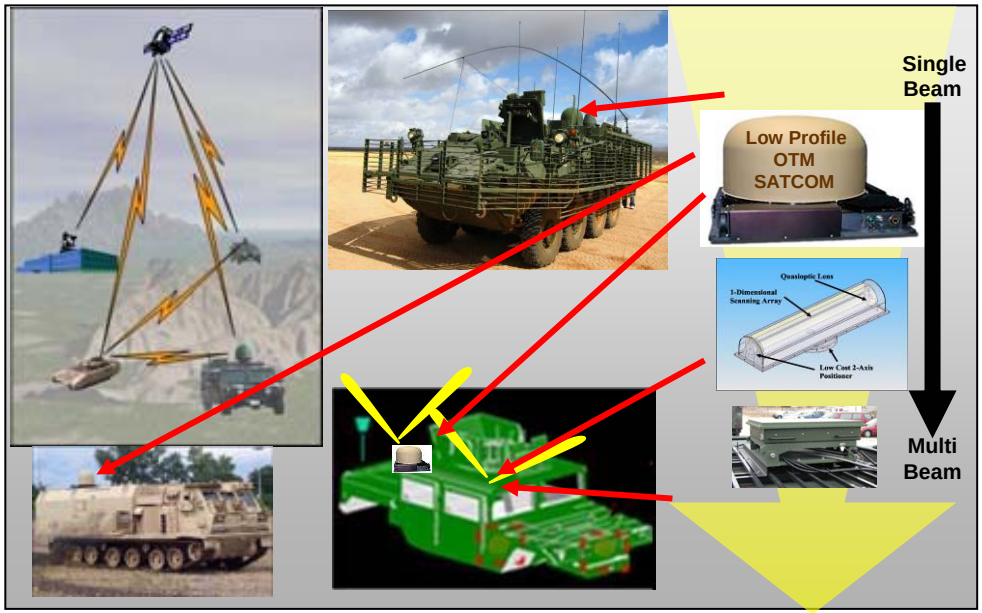
PM C4ISR OTM
SEE FIRST
UNDERSTAND FIRST
ACT FIRST
FINISH DECISIVELY.
ENABLING THE FUTURE FORCE

PM FCS 2007
Technical Field Tests
- SUGV Teleoperation
- T-UGS / U-UGS
- NEBC Technology Transition

Natick Soldier Center 2006/7
Future Force Warrior
- Exit Criteria Testing
- Transition to PEO Soldier

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Networking Technology Transitions



- *Body Wearable Antenna Technologies for SRW*
- *2 Port Low Profile Antenna for Wideband Networking Waveform (WNW)/ Soldier Radio Waveform (SRW) bands*
- *Antenna optimization Modeling and Simulation for Command & Control Vehicle (C2V) and Reconnaissance & Survivability Vehicle (R&SV)*

- ***Tactical Wireless Network Assurance***
  - ***- Black Side Intrusion Detection system***
- ***Soldier Radio Waveform***
  - ***- Mobile AdHoc networking for Soldiers, sensors, munitions***
- ***Command and Control of Robotic Entities (C2ORE)***
  - ***- UAV mission planning and execution software autonomously controls multiple UAVs***
  - ***Enhances planning and management of unmanned sensor assets (UGS, UAV, UGV, etc)***

Soldier Radio Waveform (SRW) Communications Within the Emerging C4ISR Architecture

RDECOM

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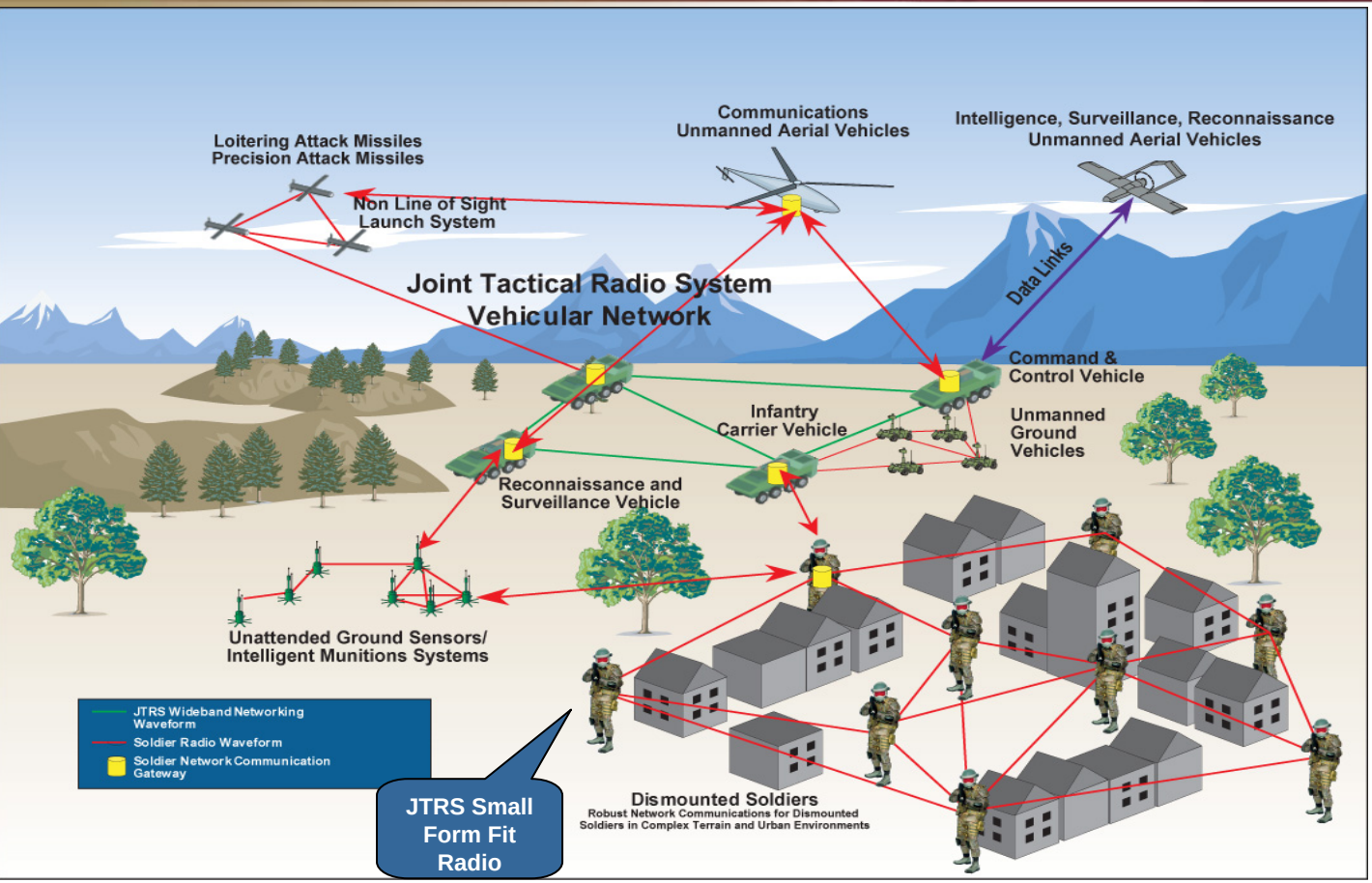


Ground Soldier System

Unmanned Ground Vehicles

Unmanned Aerial Vehicles

Intelligent Munitions Systems

Unattended Ground Sensors

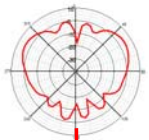
Non-Line of Sight-Launch Systems

The Soldier Radio Waveform is a mobile, ad-hoc, networking waveform developed and transitioned to provide improved voice and data communications, for platforms with Size, Weight, and Power constraints. Hosted on Joint Tactical Radio Systems (JTRS) Handheld Manpack Small Form Factor (HMS) and **Ground Mobile Radio (GMR)**

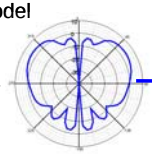
Antenna M&S Performance on Vehicles Process

Antenna Model Validation

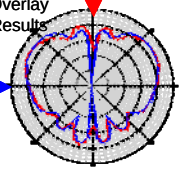
Anechoic Chamber Measurement



xFDTD Antenna Model



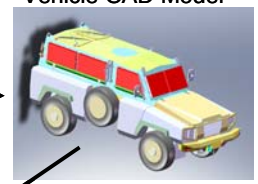
Overlay Results



Platform Model Validation

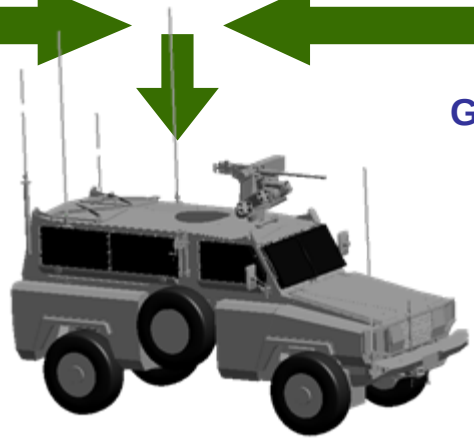
Actual Vehicle

Vehicle CAD Model



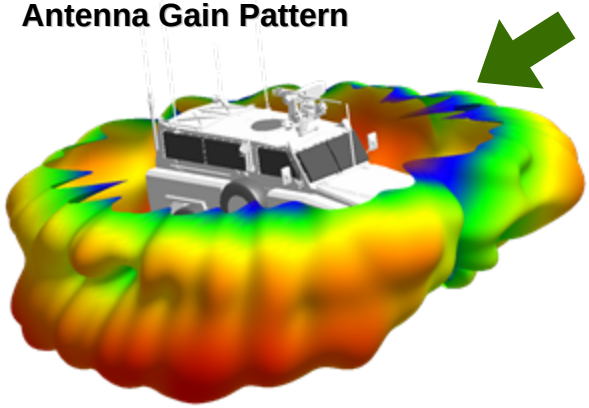
xFDTD Electromagnetic Meshed Model

Vehicle Model with Validated Antennas



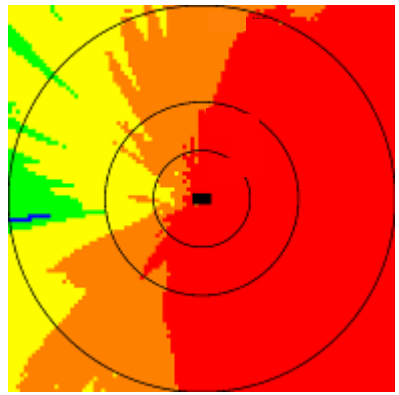
Finite Difference Time Domain (FDTD) Simulation

360° Far-Field Antenna Gain Pattern



Geometrical Theory of Diffraction (GTD) Simulation

Power Contour Plots



Hybrid M&S Results

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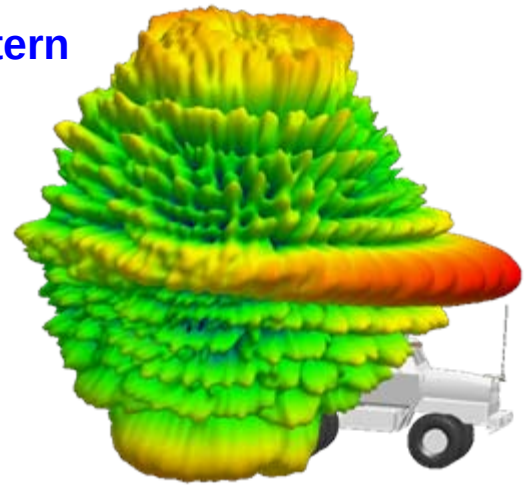
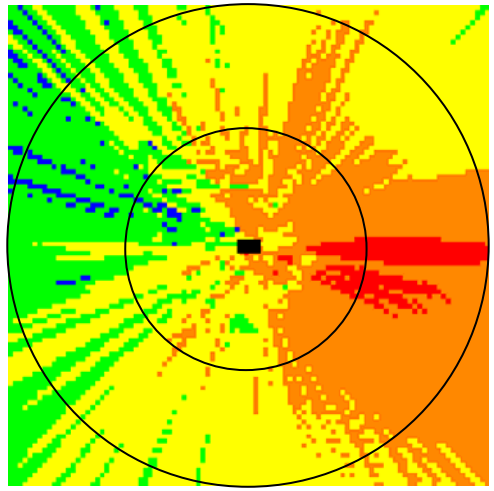
Example: MRAP Antenna Placement Optimization

SPAWAR Recommended Location

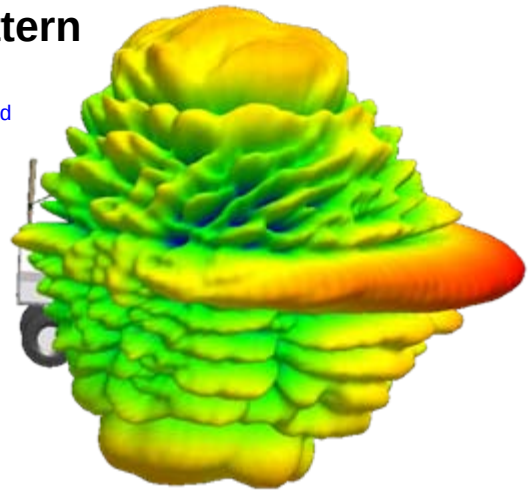
Poor Pattern

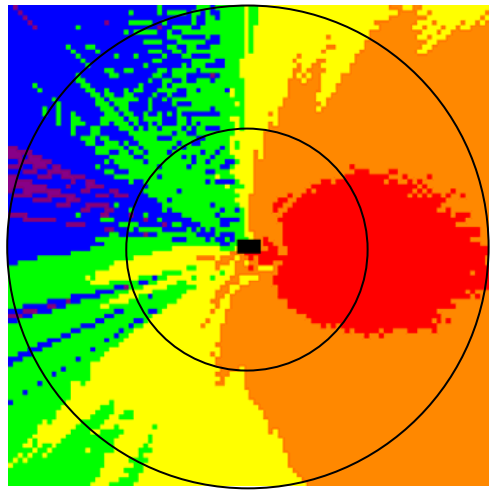




CERDEC M&S Placement with **Optimized Pattern**

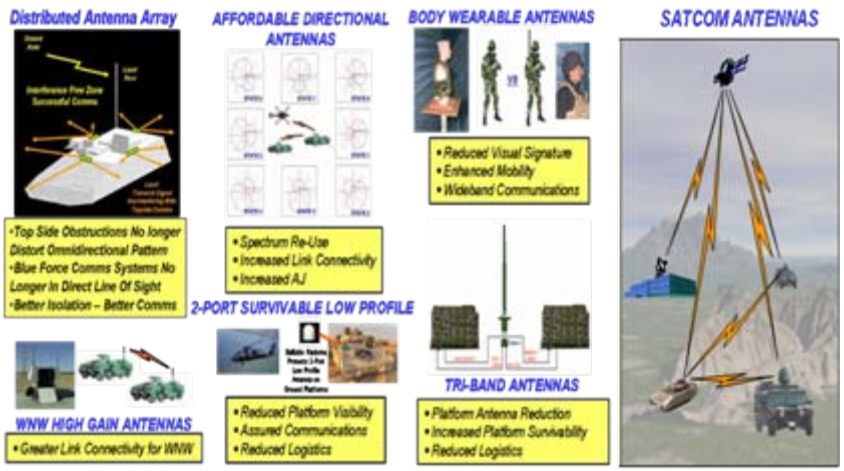
115 Antenna Base @ 2 meters Above Earth Ground





TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

D.C4.2006.04 / Tactical Network and Communications Antennas (TNCA)



Purpose:

- ***Develop Affordable, Low Profile Solutions For OTM SATCOM***
- ***Develop Affordable Directional Antennas for Terrestrial Directional Networking***
- ***Develop Omni-directional Antennas With Higher Gains, Lower Profiles with Ballistic Radomes, and Multiple Ports to Reduce the Number of Platform Antennas***
- ***Develop Integrated Antennas for Dismounted Soldier***
- ***Develop Distributed Antennas to Improve Omnidirectional Antenna Performance and Reduce Cosite Interference***

Products:

- ***Low Cost Ku/Ka Band OTM SATCOM Antenna Systems***
- ***Low Cost X-band Point Of Presence***
- ***Efficient Ku and Ka Band Power Amplifiers***
- ***Low Profile Single Beam Ku/Ka SATCOM Ant System***
- ***Low Profile Multibeam Ku/Ka/Q SATCOM Ant Analysis***
- ***Affordable Terrestrial Directional Antennas***
- ***WNW High Gain Omni Antennas***
- ***2-Port Low Profile Omni Antennas with Ballistic Radome supporting multiple waveforms (Ground/RW)***
- ***3-Port Tri-band Omni Antennas***
- ***Integrated Body Wearable Antennas***
- ***Distributed Antenna Array***

Payoffs:

- ***Affordable OTM SATCOM and Terrestrial Directional Ants.***
- ***Reduced Visual Signatures & Antenna Counts***
- ***Improved Link Connectivity and Ballistic Protection***
- ***Reduced Platform Power Consumption***

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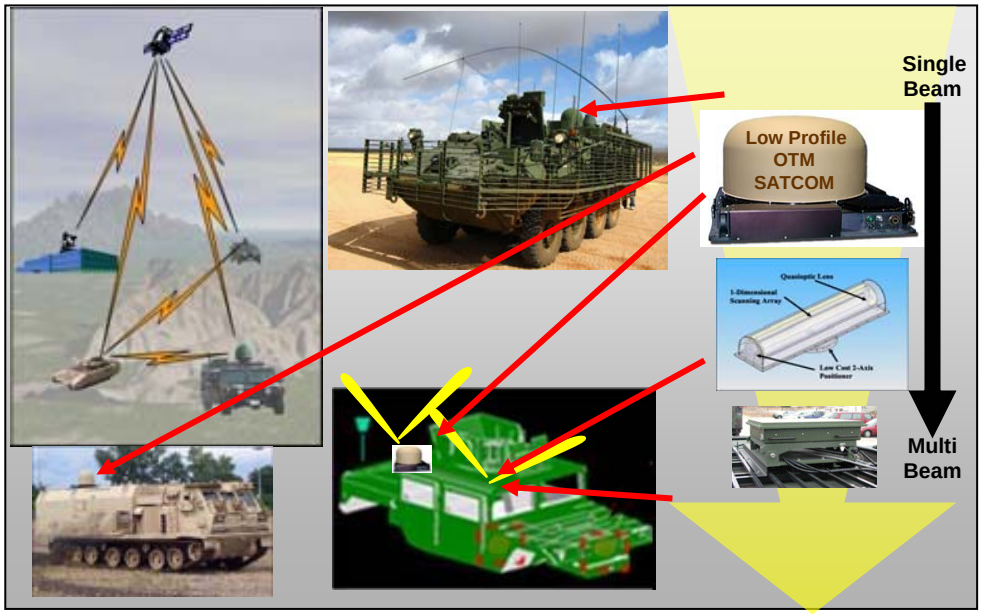
D.C4.2009.01 / Affordable Low Profile Satellite (ALPS) Comms On-the-Move



Purpose:

- *Develop, mature, and demonstrate low profile antennas for directional and satellite communications (SATCOM) on-the-move (OTM)*

Products:

- *Low-profile, single-beam (Ku/Ka) antenna*
- *Low-profile, multi-beam (Ka/Q) antenna*
- *Single-beam high capacity communications capability (HC3) (Ka/Q) antenna*
- *Small aperture blue force tracking (BFT) antenna*
- *C/Ku Affordable Directional Antenna*
- *Integrated Ka/Q-band Power Amplifier*

Payoff:

- *Increased Communications Capabilities at all echelons through greater use of SATCOM OTM*
- *Reduced platform burden through reductions in antenna size, weight, and power(SWaP)*
- *Increased survivability through reduced visual signature*
- *Affordable SATCOM OTM for the warfighter through antenna cost reductions*

D.C4.2003.01. / Tactical Wireless Network Assurance (TWNA)

Purpose:

To develop and transition wireless network protection solutions for a tactical Mobile Ad-hoc Networking (MANET) environment that is typical of WIN-T and the Future Force.

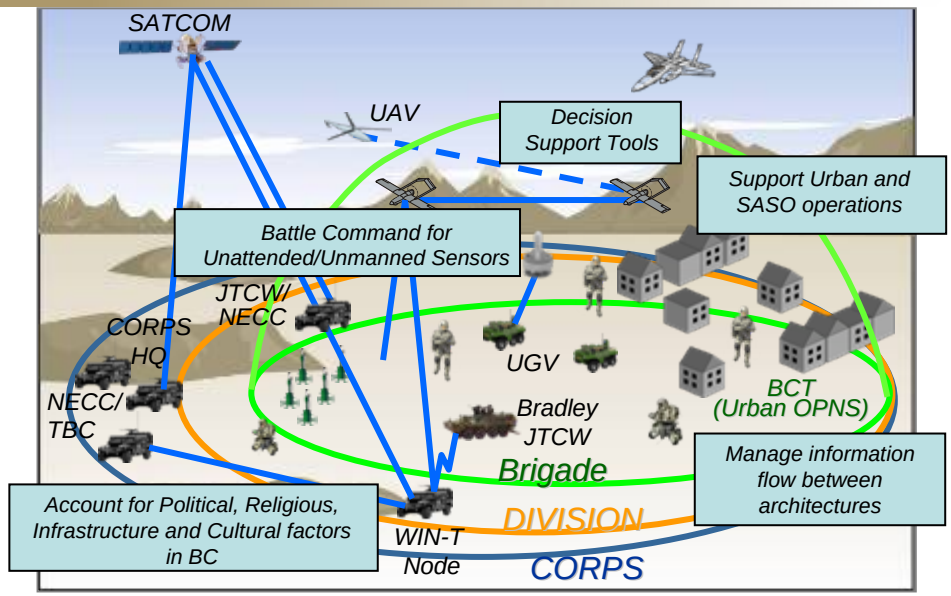
Product:

- Tactical security administration tool for mobile wireless environment.
- Intrusion Detection Algorithms for MANET routing protocols
- Tactical Public Key Infrastructure (TPKI)
  - Architecture
  - Certificate Issuance
  - Field Replacements
  - Revocation

Payoff:

- Prevent threat Information Warfare attacks from damaging mobile networks.
- Maintain Warfighter trust/confidence in battlefield information.
- Reduce system and network vulnerabilities.

D.C4.2006.01 / Network Enabled Command and Control (NEC2)



Purpose:

Develop and transition software and algorithms that tailor and manage the flow of Battle Command (BC) information and C2 services between current and future systems throughout all phases of operations and environments

Products:

- ***Battle Command Planning/execution/re-planning products for:***
  - ***Dismounted applications in Complex and Urban Terrain***
  - ***Current Force Tactical C2 Systems***
  - ***Unmanned systems and sensors***
  - ***Decision support tools that account for political, religious, cultural and other factors***
- ***Managed Connectors that govern the flow of information between disparate architectures while globally managing resources***

Payoff:

- ***Increased speed/quality of BC planning and execution adjustments***
- ***Improved commanders' understanding of Battlespace and related factors***
- ***Faster decision-making***

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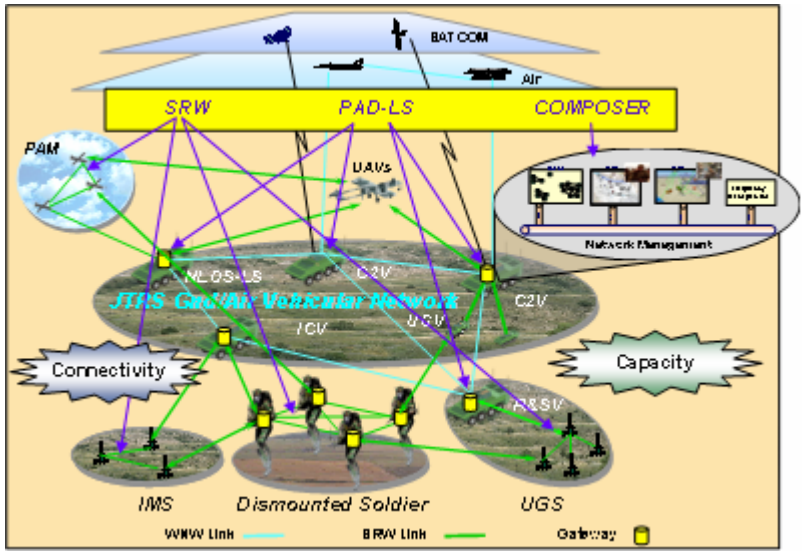
D.C4.2006.03 / Tactical Mobile Networks (TMN)



Purpose:

- **Develop Soldier Radio Waveform (SRW) for Dismounted Soldier and manned & unmanned systems.**
- **Develop communications and networking technologies that address Future Force constraints for bandwidth and connectivity while on the move.**

Product:

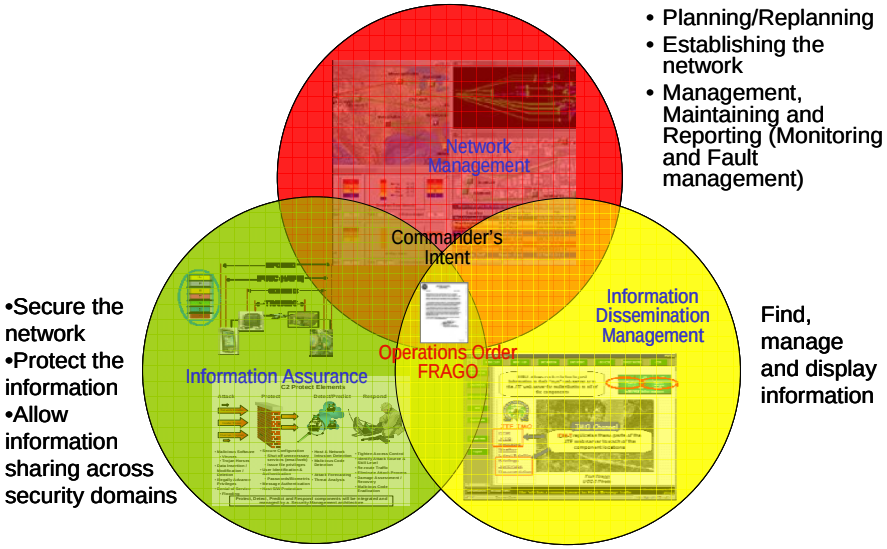
- **JTRS Software Communications Architecture (SCA) v2.2 compliant, energy-efficient Soldier Radio Waveform (SRW)**
- **PILSNER Proactive Diverse Link Selection (PAD-LS) algorithms to enhance OTM connectivity and capacity**
- **Faster than real time dynamic link estimation for connectivity and capacity for Network Management and man in the loop experimentation**

Payoff:

- **Energy efficient voice & data tactical communications for Ground Soldier Systems/Future Force Warrior and sensor-to-shooter linkages**
- **Increased OTM connectivity and usable bandwidth**
- **Enable commanders to plan communication coverage for OTM Coarse Of Action (COA)**
- **Addresses PM FCS (BCT) Critical Technology #7B (SRW), Risk #93 mitigation (SRW Availability) to support “Network Ready”**

•COMPOSER: Comms Planner for Operational and Simulation Effects with Realism

D.C4.2008.02 / Tactical Information Technologies for Assured Network Operations (TITAN)



Purpose:

- Develop, mature, and demonstrate modular tools and technologies that significantly improve the network planning and management of the tactical network
- Develop, mature, and demonstrate security tools to protect mobile networks from attacks and allow information to be shared across security domains
- Develop, mature, and demonstrate agent enhanced Battle Command (BC) tools to enable real time situational awareness and relevant strategic and tactical battlefield information sharing

Products:

- Automated Network Management (NM) Tools
- Information Assurance (IA) Tools
- Space/Strategic and Tactical Information Dissemination and Management (ID&M) Applications and COA development

Payoff:

- Reduce manpower and network management configuration time
- Share information across security domains while ensuring trust/confidence in information being sent to the Warfighter
- Improve information sharing by providing relevant information from strategic to a tactical operational unit

- **Affordable Satellite Antennas for Transformation Comm Systems**
  - On The Move Multi band, single/multi beam
  - Affordable phased array antennas
- **Advanced Wireless Security Services**
  - Integrated Information Assurance (IA) Correlation and Response
  - Software Cross Domain Security Services
- **Cognitive Networking**
  - Multi-Function RF systems (Radio / EW)
  - Dynamic Spectrum Access Capabilities
  - Adaptive middleware for applications to adjust to network conditions.

Process for Cognitive Network Project Development

Current Knowledge base Inputs: DARPA, Industry, ARL Etc...

Req'ts Definition

HW/SW Architecture

Disciplined Systems Engineering Approach

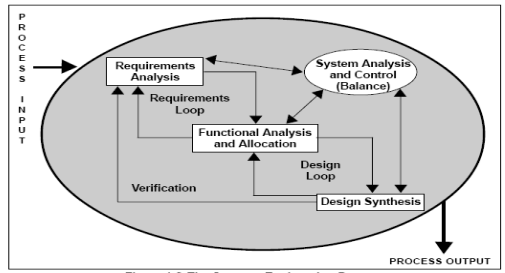


Figure 1-3. The Systems Engineering Process

A. Dynamic Spectrum Process & Sensing
B. Networking
C. Data Exchange & Dissemination
D. Information Assurance
E. Applications
F. Cognitive Management
G. HW Design & Development
H. Cross Layering
I. System Evaluation

Simulation/ Emulation

Development Of Prototypes

Testing/ Demos

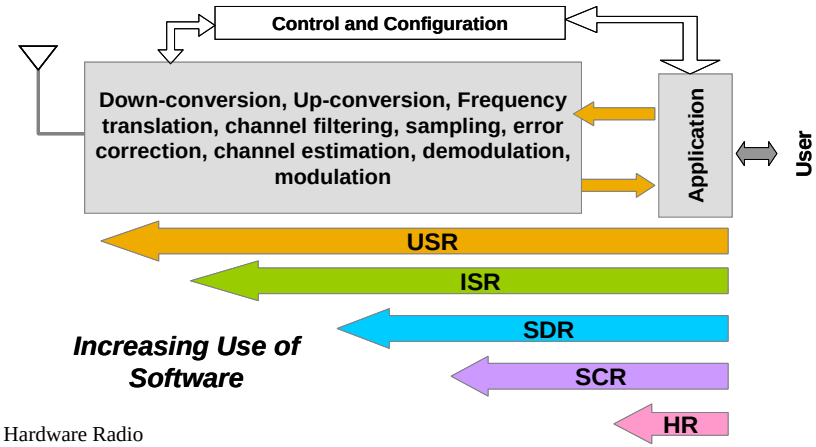
Analytical Assessment Using Req't & CBMANET Scenario

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Cognitive Network & Radio Study

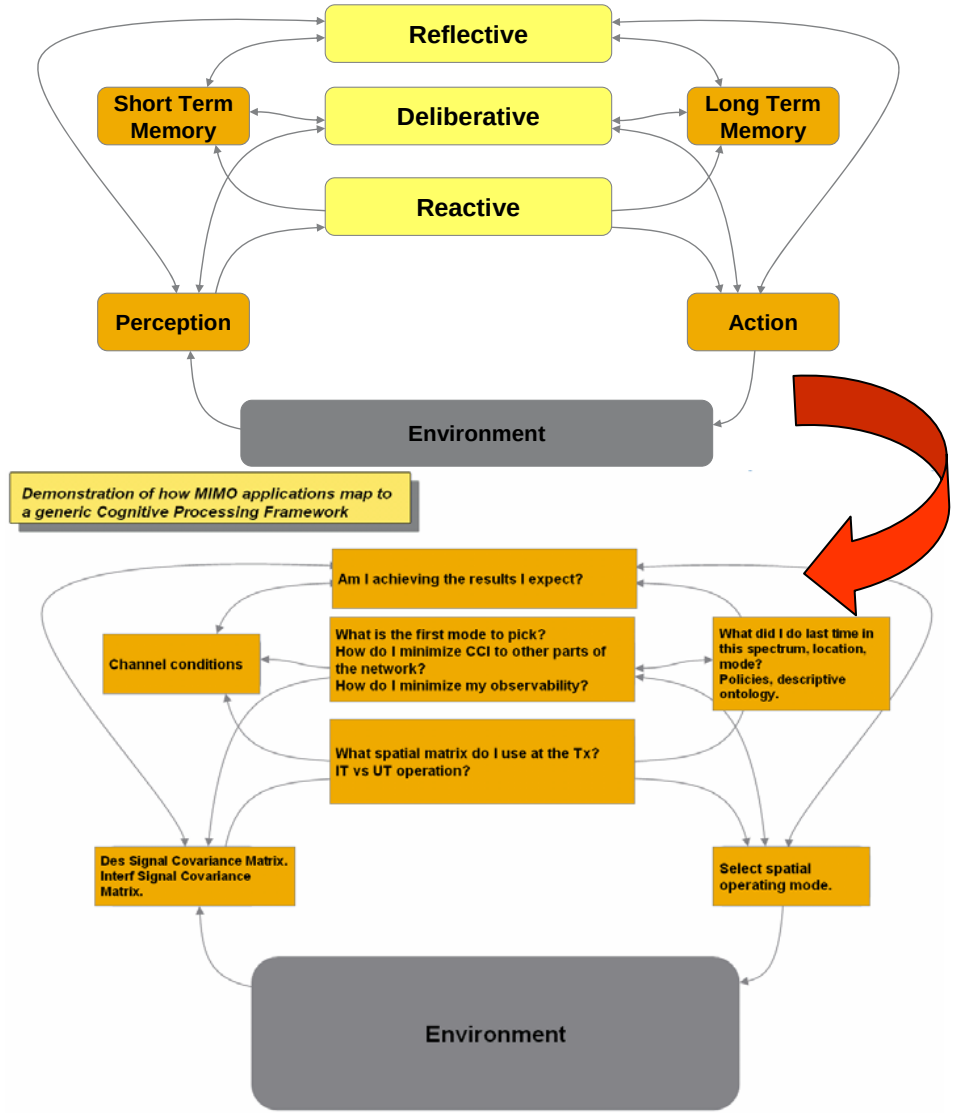
***Description*:** A cognitive network consists of technologies that can perceive current network conditions, and then sense, plan, decide and act on those conditions. The network can learn from these adaptations and use them to make future decisions, all while taking into account end-to-end performance goals and user needs

***Benefits*:** A cognitive radio has awareness of changes in its environment and adapts its operating characteristics to improve its performance or to minimize a loss in performance

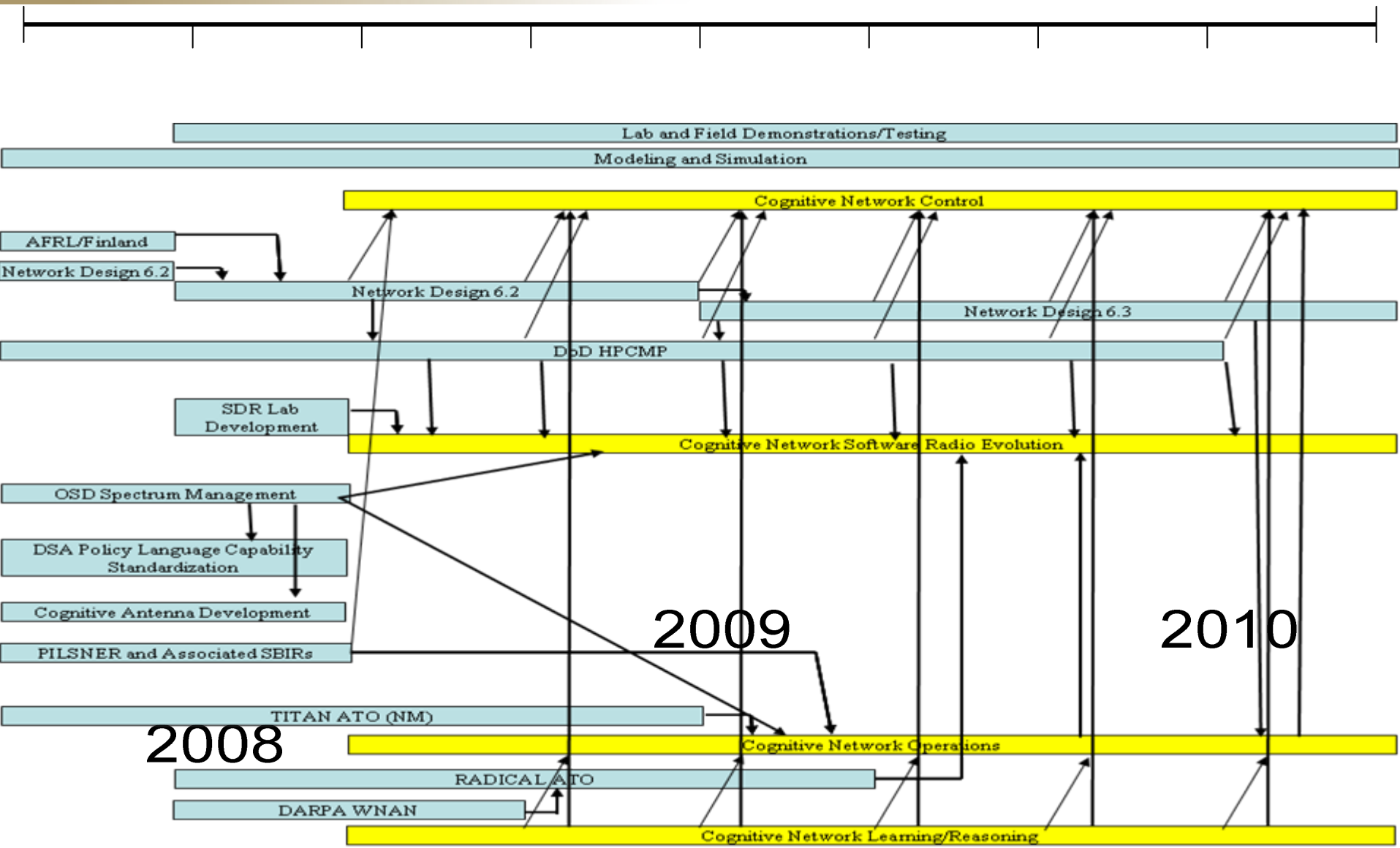


HR – Hardware Radio
SCR – Software Controlled Radio
SDR – Software Defined Radio
ISR – Ideal Software Radio
USR – Ultimate Software Radio

Generic Cognitive Processing Framework – An Example



Cognitive Network High-Level Roadmap



Example: Cognitive Radio Benefits

Current Radio Architectures

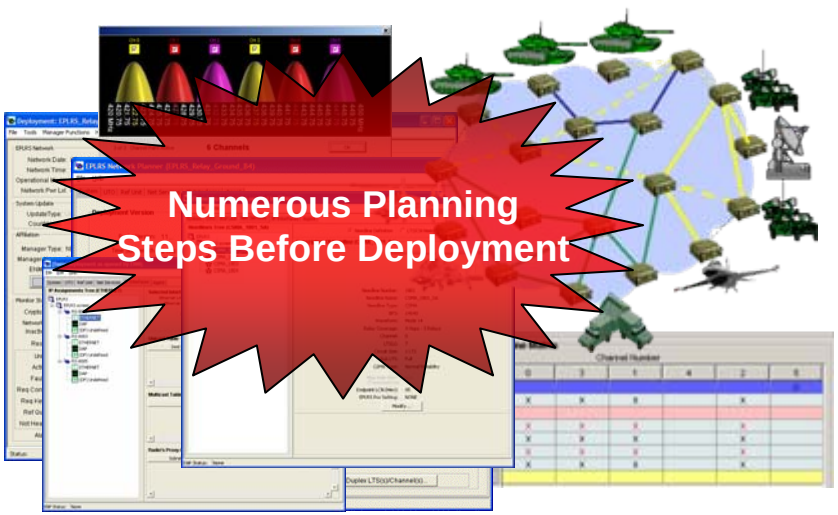
- Extensive planning before deployment
- Detailed organization structure required accounting for every radio
- Detailed definition of Comm. Circuits and static routing procedures
- Intensive training for network development
- Static Network Configuration
- Limited network adjustment
- Individual nodes unaware of conditions experienced by other nodes
- Unaware of context of operation

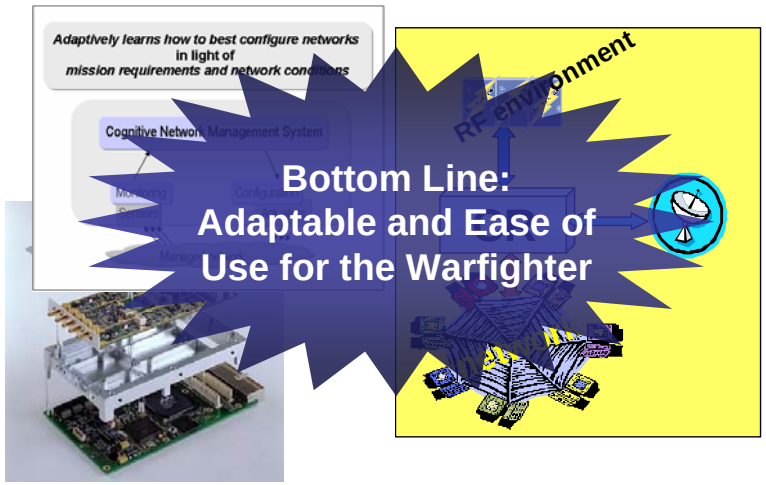
Cognitive Radio R&D

Future Cognitive Radio Architectures

- Automated Policy Planning
- Policy Adjustment Based on Needs
- Less “Knobs” for the Warfighter
- Lessens training required for operators
- Decisions made to meet requirements of user with minimal interaction
- Variable network configurations in real-time
- Automated response fostering optimum network performance
- Learning from user experiences in entire network to adjust goals
- Automatic adaptation based on changing context

Legacy Example: EPLRS





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Questions?