



# DARPA Networking and Communications Overview

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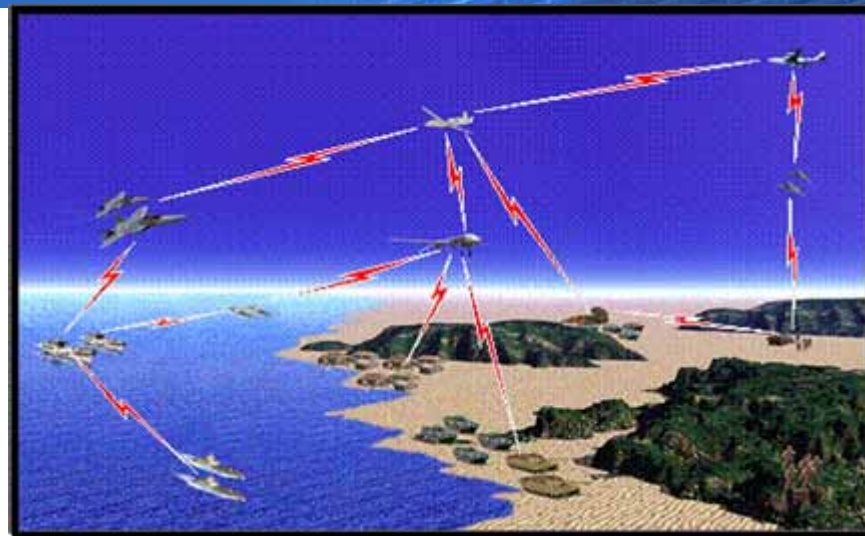
# Military Operations Structure



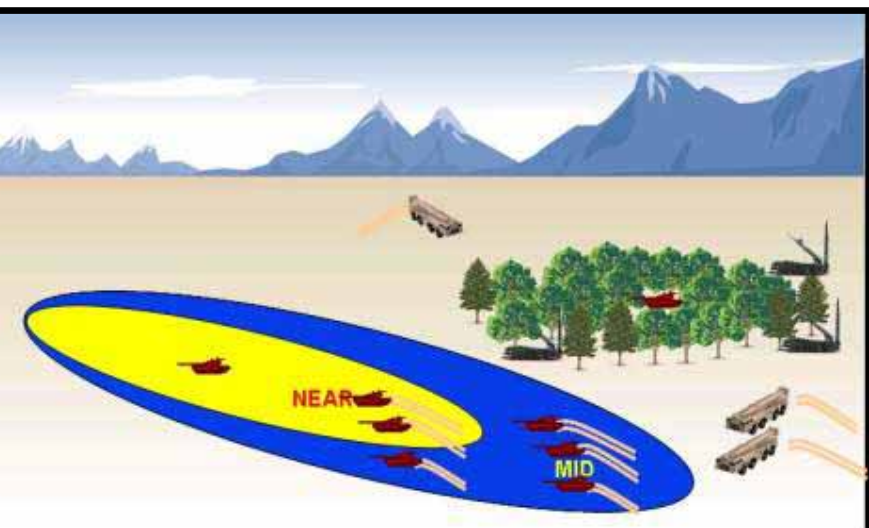
## Network Centric Enterprise

**Strategic and operational level of deployment and warfare**

- Cleared Personnel – TS/SCI
- Links air, ground and naval campaigns
- Engages by operational maneuver and strategic strikes
- Provides information, resources, and sustainment connectivity
- Large C4ISR backbone and infrastructure
  - Rides on GIG and Extensions
  - Can leverage commercial info systems
  - IPv6 early adopter
  - Susceptible to many IA threats



***Bridge the Gap***



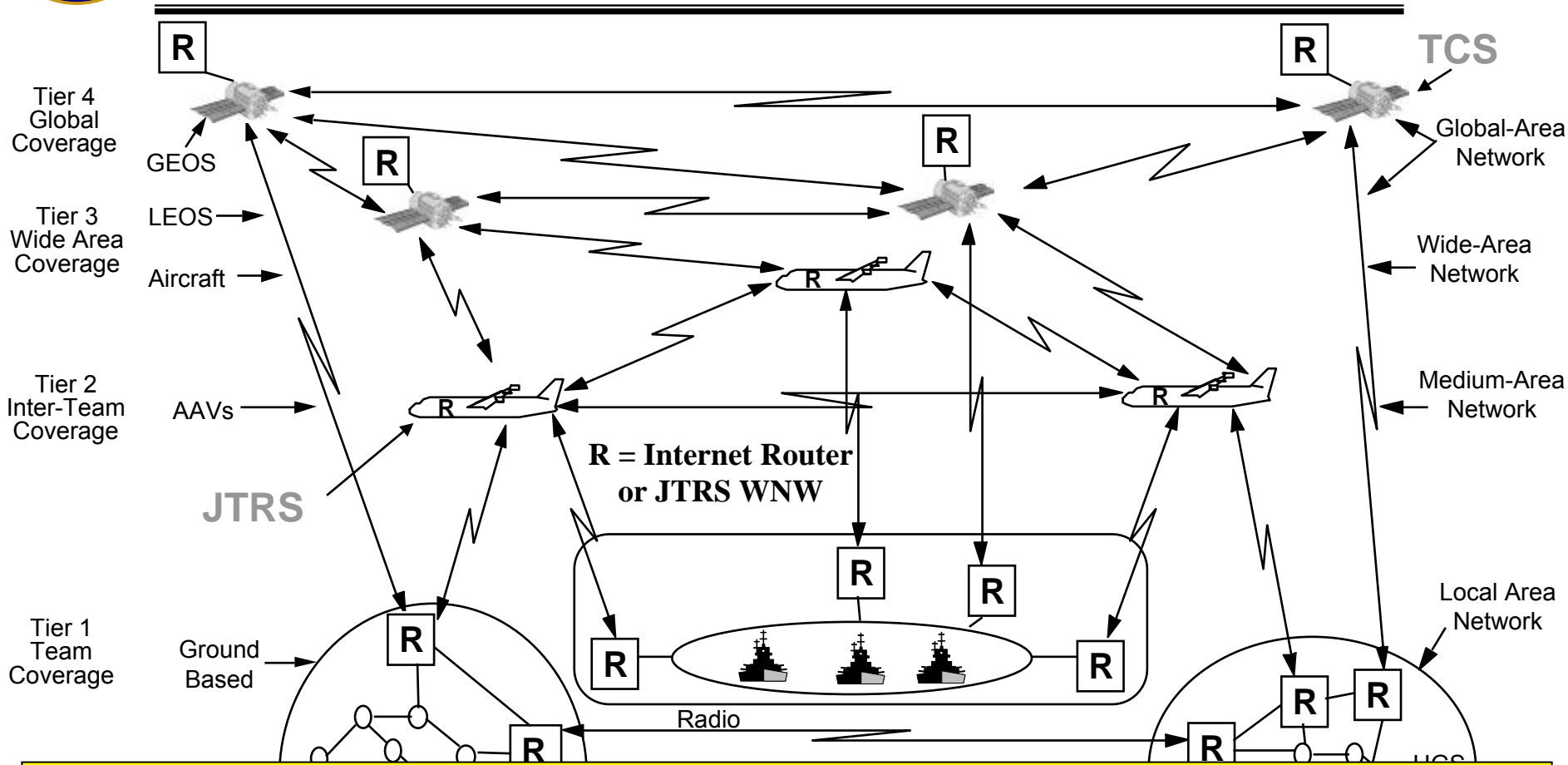
## Network Centric Warfare

**Tactical level of deployment and warfare**

- Uncleared Personnel
- Links effects to targets
- Engages directly with the enemy
- Must be agile, adaptive and versatile
- Minimal, “portable” C4ISR infrastructure
  - Rides on tactical communications
  - Requires LPD/LPI transmission security
  - NCW weapons susceptible to IA attack

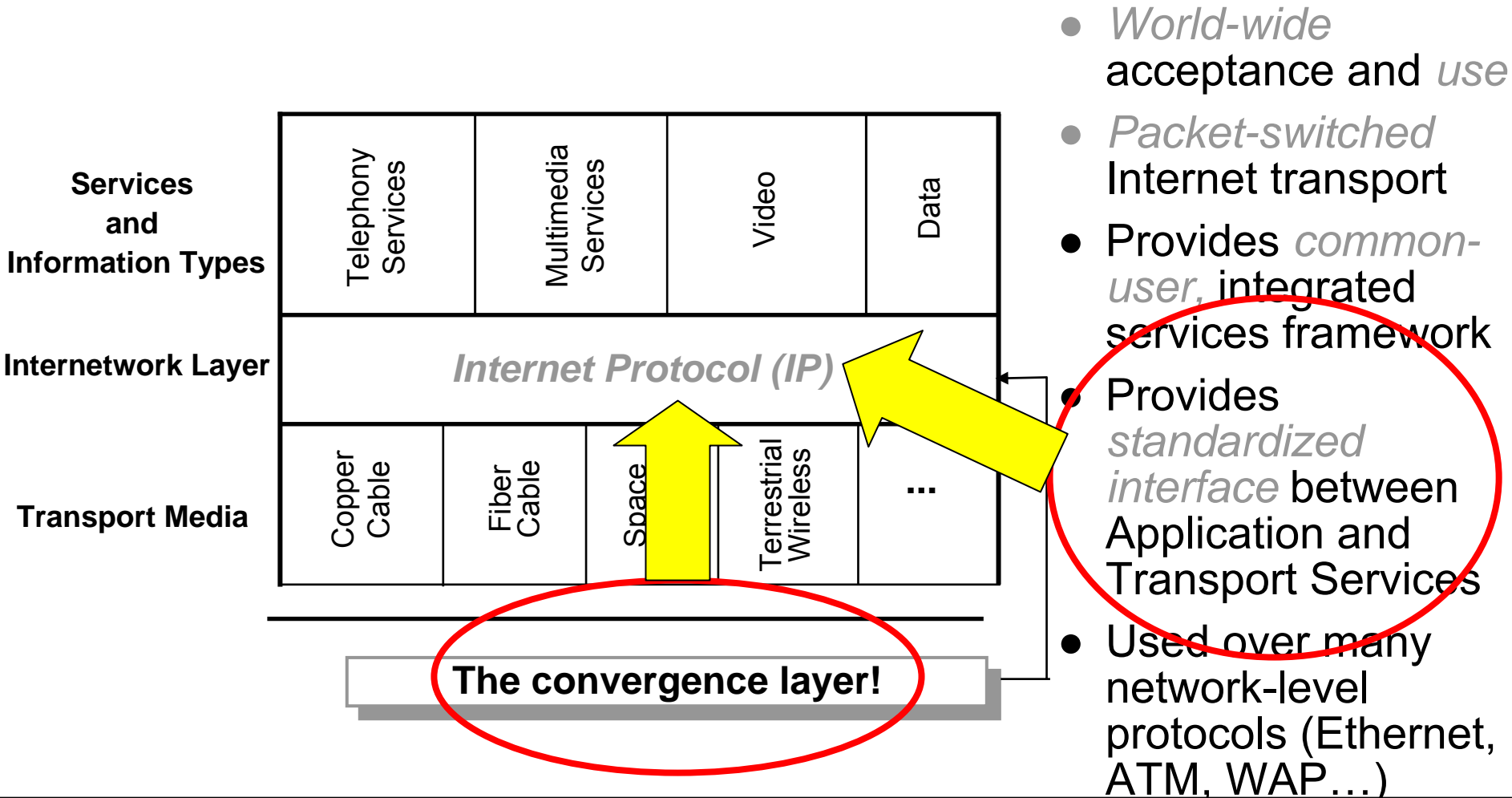


# GIG: Transport Layer



**How Is Communications Interoperability Facilitated Here?**

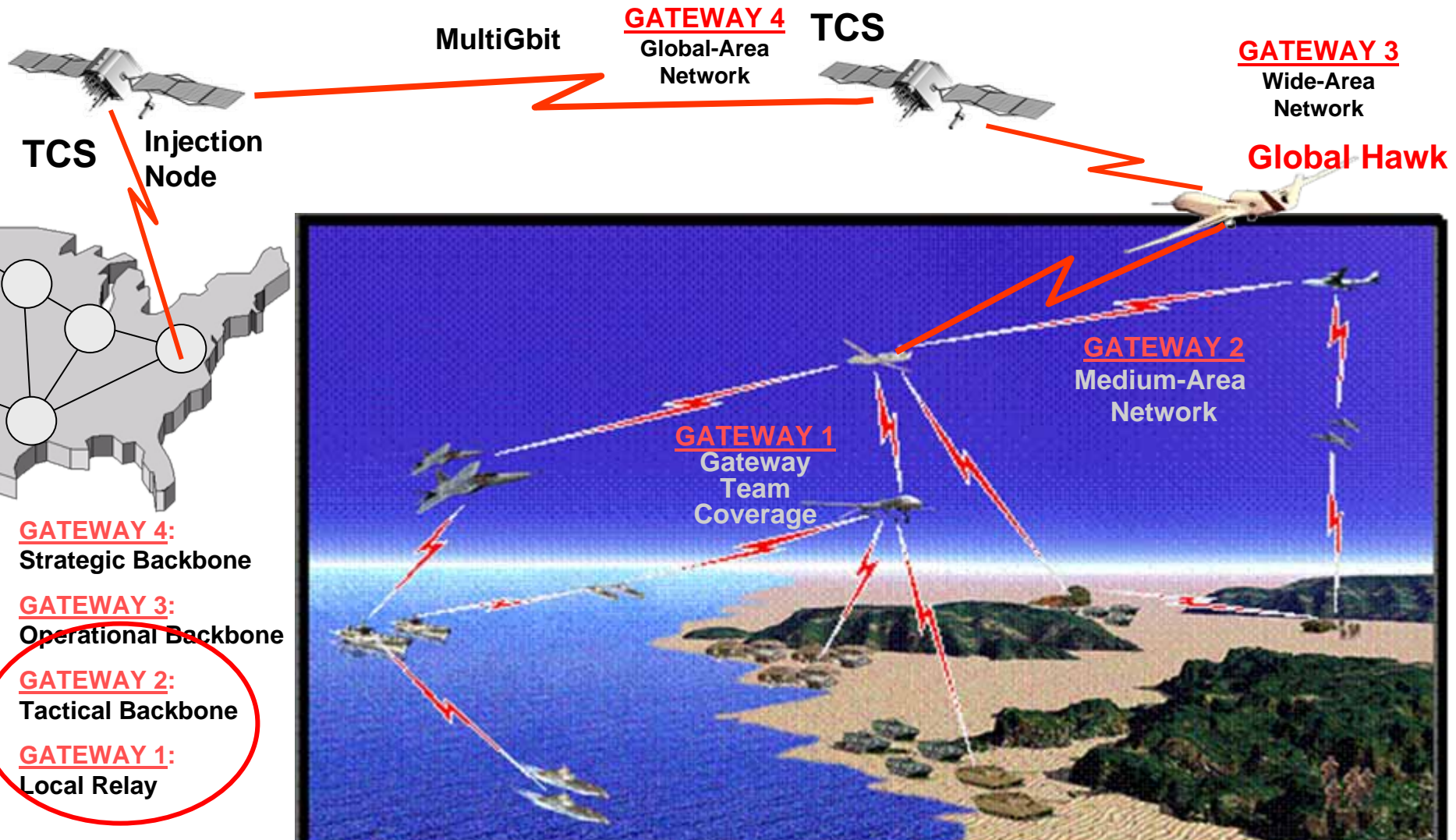
**Build The Net**



**Answer: Communications Interoperability via the Network!**



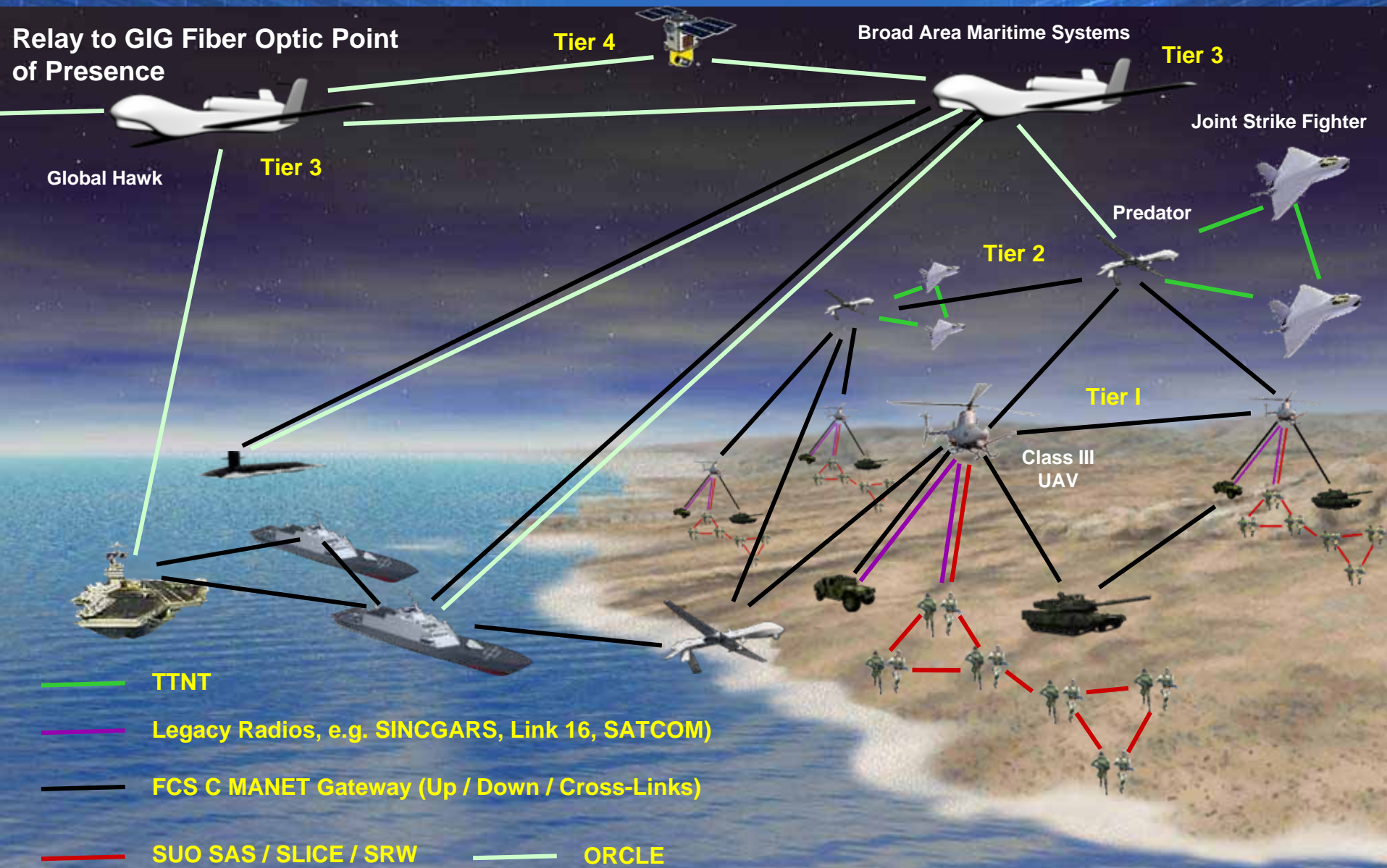
# How Do You Make This Happen: Network Gateways



**Future Combat Systems Communications Network Centric Demonstration**



# Possible Architecture Using DARPA Technologies





# Optical & RF Combined Link Experiment (ORCLE)

*Links to forces fixed and on the move*



Air-to-Air Crosslink  
FSO/RF  
>200 km  
99% Availability  
2 Gbps (average)

FSO/RF  
All Weather  
Surface to 10 km  
>95% Availability  
2 Gbps (average)

Optical Retro Reflector  
Clear Air  
>45 Mbps  
Uplink/Downlink

**Objective: Develop a hybrid free space optical/radio frequency communications system**

GIG / Fiber Optic  
Point of Presence

**Component and Technology Lab Demos: Complete**  
**Improved Availability Study: Complete**  
**Technology Maturation: Presently**  
**MOA with USAF: Signed Sep 2006**  
**Ground Link and Network Test (Air-Air and Air-Ground): Complete**  
**Air-Air-Ground Flight Demo (Primary Program Goal): Nov 2007**



# Future Combat Systems Communications



## A Dual-Rate, Mobile Ad-Hoc Network for the Maneuver Force

Mobile ad-hoc network *dynamically* reconfigures during operations to *automatically* maintain network connectivity

QoS Provides for Adaptive Communications Capabilities

System automatically schedules non-interfering communications for increased network capacity



High Band (JTRS NDL-Like)  
> 50 Mbps rate high band

Spatial re-use improves network capacity

Low Band (JTRS WNW-like)  
> 5 Mbps rate low band

Networked vehicles automatically communicate when within range – no manual configuration

Multi-Mode Connectivity Options:  
GND-to-GND, GND-to-AIR, AIR-to-AIR & AIR-to-GND

Vehicles automatically leave and join the network – no manual entry

*Network Centric Field Experiment at Fort Benning – JAN 2006*





# FCS Communications Technology Highlights



- **Assured high data rate communications:** Simultaneous high data rate networked communications in high and low bands. Adaptive data rates 72 Mbps in high band, 10 Mbps in low band. Spatial re-use through directional antennas for increased network throughput.
- **High resistance to threat jamming:** Directional antennas, supplemented by AV-OFDM waveform in low band and DSSSS in high band. Digital beam forming in low band steers nulls against jammers. Adaptive networking routes traffic around jammers.
- **High resistance to threat detectors and intercept:** Very narrow directional beams in high band; directional beams in low band, with featureless OFDM waveform.
- **Assured multi-path communications:** Low band AV-OFDM waveform integrates over frequency and time, outperforms rake receivers at low cost/weight.
- **QoS based ad-hoc mobile-mobile networking** incorporating the benefits of adaptive waveforms and smart antenna technology in both low and high bands for improved message throughput in threat and non-threat conditions.
- **Validated designs validated through relevant field demonstrations** air and ground mobile nodes including actual military robotic platforms, airborne nodes, surrogate netfires supplemented by critical laboratory modeling and simulation for validation and scalability.



# FCS C Demo 3 Go/No-Go Results



FCS Communications Go/No-Go Metrics	Demo 3 Criteria		Raytheon (FCS-C)	
20 Node Average Network Aggregate Throughput (Goodput)	<b>AJ/LPD</b>	<b>HDR</b>	<b>AJ/LPD</b>	<b>HDR</b>
Low Band	<b>200 Kbps</b>	<b>10 Mbps</b>	203 Kbps	10.3 Mbps
High Band	<b>1 Mbps</b>	<b>70 Mbps</b>	24 Mbps	50 Mbps
LPD/AJ				
Spatial - Low Band (3 dB beamwidth)	<b>45°</b>		39°	
Spatial - High Band (3 dB beamwidth)	<b>3.5° x 12° *</b>		3.5°x12°	
Processing (PG, nulling, etc.)				
Low Band	<b>40 dB</b>		41.6 dB	
High Band	<b>14 dB * (19.4 dB)</b>		19.4 dB	
Latency				
Type 1 (10% of the avg sys load)		<b>90% &lt; 200 msec.</b>		90.0%
Type 2 (30% of the avg sys load)		<b>90% &lt; 1 sec.</b>		88.8%
Type 3 (60% of the avg sys load) (Retrans 3x)		<b>90% &lt; 30 sec.</b>		98.9%
HB/LB Transition		<b>&lt;1 sec.</b>		1 sec.
Packet Delivery				
Type 1 (10% of the avg sys load)		<b>90%</b>		75.0%
Type 2 (30% of the avg sys load)		<b>90%</b>		73.6%
Type 3 (60% of the avg sys load) (Retrans 3x)		<b>90%</b>		88.3%
20 Node Network Initialization Time		<b>&lt;6 min.</b>		2 min.
Node Entry Time		<b>&lt;30 sec.</b>		10 sec.
Detect Node Exit Time		<b>&lt;10 sec.</b>		5 sec.

**Live Test under operational conditions - User level performance**

**NOTE:** Items in Red corrected upon return to lab and GO/NO GO validated in Raytheon Parking Lot



## 1. Raytheon Network Centric Radio In Operations

- Operates Like WNW would In Network Centric Operations at Tier 1 & Tier 2
- SCA Compliant, Non-Proprietary Software
  - Raytheon Will supply FCS C Waveform Given to JTRS Library as above
- High data rate LOS (including LOS airborne extensions to BLOS) networked radio system
  - >100 km Non-LOS Ranges Achievable with Airborne Relays
  - Automatic Adaptation to Lower Data Rates for Increased Range
- Automated “configuration” and Network Management

## 2. Heterogeneous Gateway Architecture Implemented In TCA Structure

- Gateways linked end-users via Sample WAN technologies
  - FCS-NC, Ku SATCOM, Inmarsat, Iridium, GlobalStar
- Gateways linked end-users via Tactical Data Radios (IP Capable)
  - EPLRS, EPLRS micro-Lite, Soldier Radio Waveform (SRW), SECNET 11
- Gateways linked end-users via Tactical Voice Radios
  - PRC 117, PRC 119, PRC 150

## 3. Complete Soldier Operation In Simulated Missions

- Initial Training in NOV/DEC 2005 at Fayetteville, TN
- Heterogeneous Gateway Operations as well as Surrogate UAV Placement for Optimum Connectivity

*Demonstrated Transformational Communications Down to the Platoon*



# FCS-C Network Centricity Demonstration

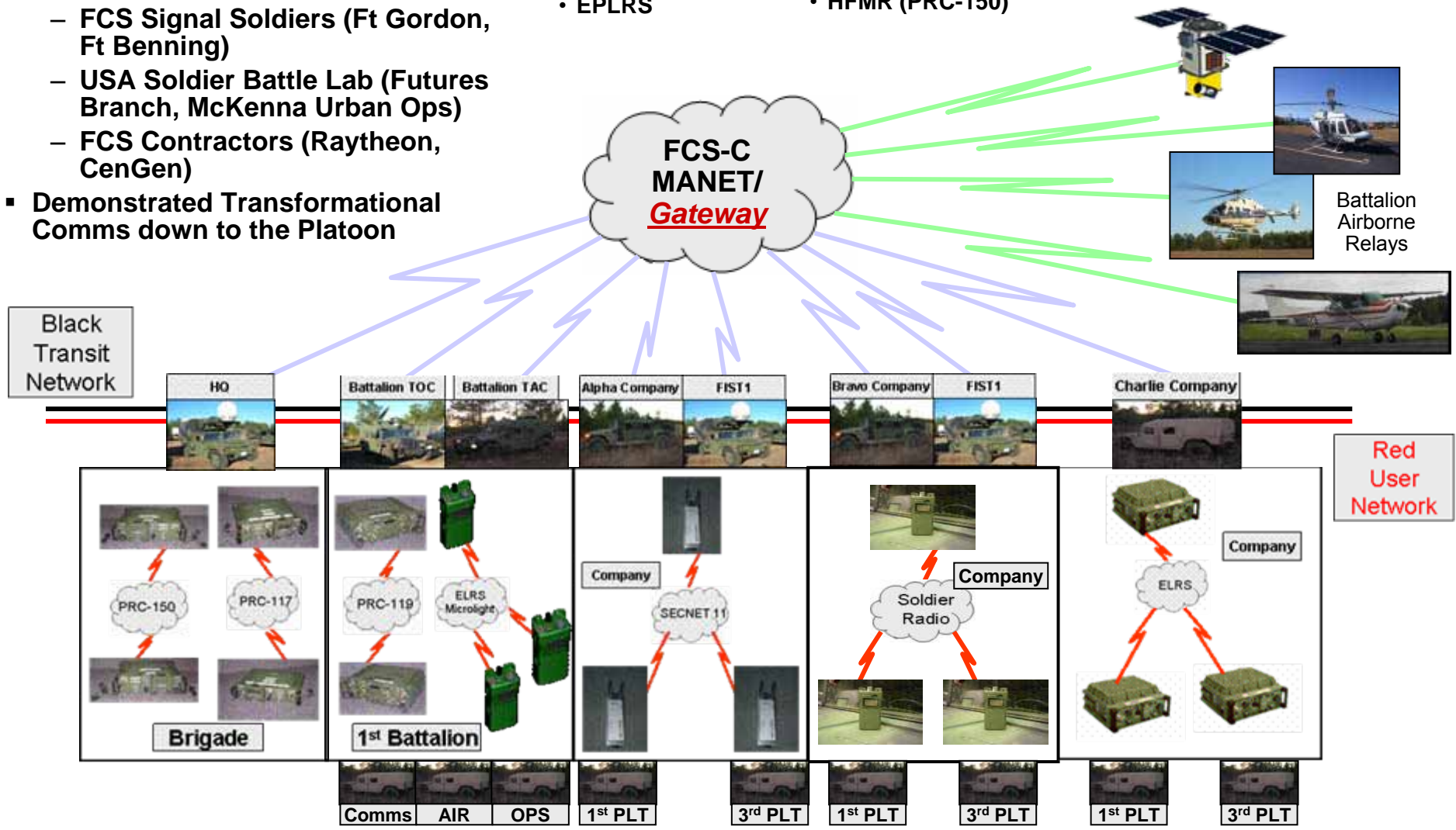
## Network Connectivity with FCS MANET & Gateway



- Network Centric Radio Operations
- Heterogeneous Gateway Architecture
- Complete Soldier Operation
  - FCS Signal Soldiers (Ft Gordon, Ft Benning)
  - USA Soldier Battle Lab (Futures Branch, McKenna Urban Ops)
  - FCS Contractors (Raytheon, CenGen)
- Demonstrated Transformational Comms down to the Platoon

### Interoperable Communications

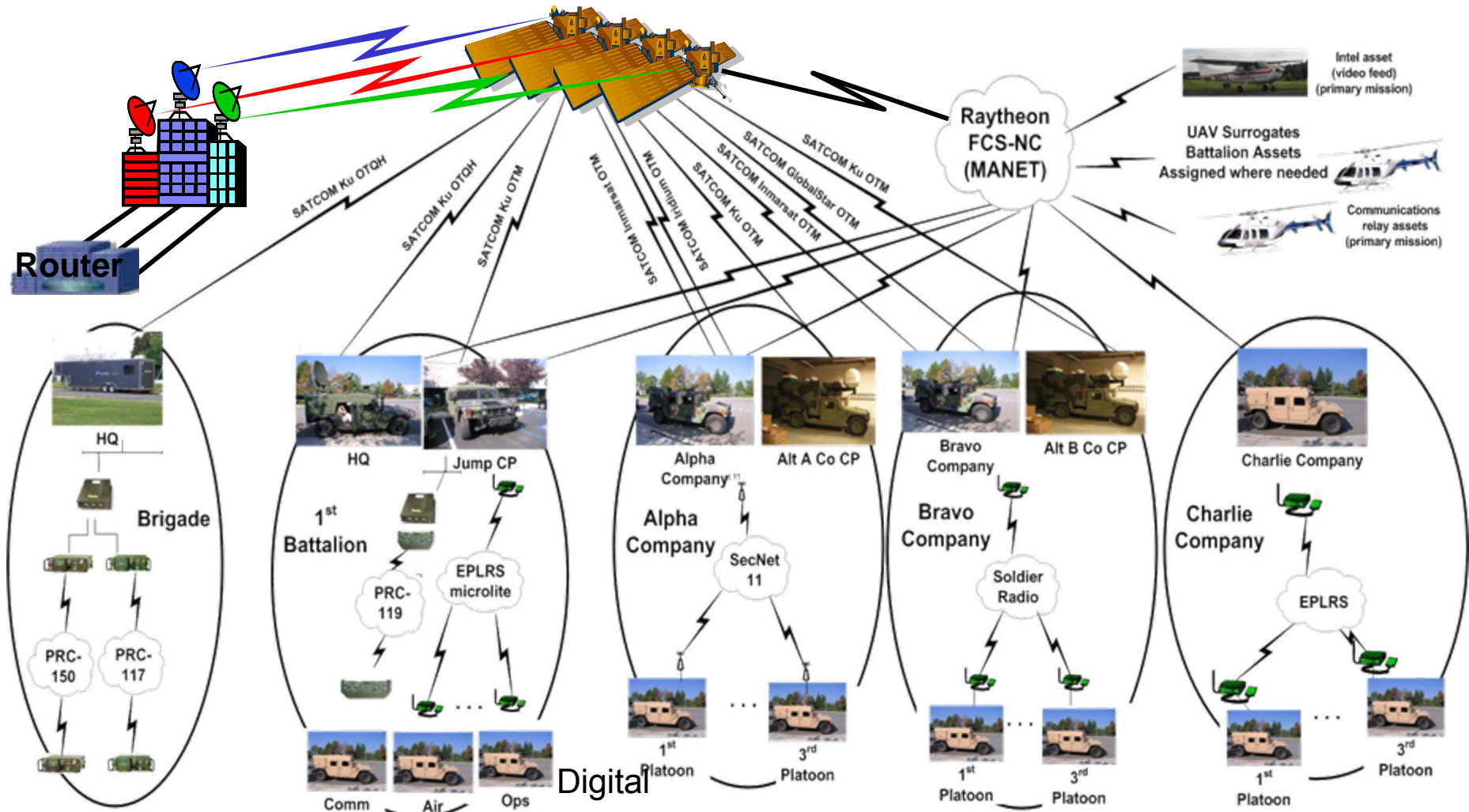
- CPOF's VoIP
- ITT Soldier Radio
- EPLRS
- HAVEQUICK I/II (PRC-117)
- SINCGARS (PRC-119)
- HFMR (PRC-150)





# Heterogeneous Network Centric Architecture

## FCS-C NC Demonstration



- **Heterogeneity between Radios and Radio-Types (Analog Voice vs Data/VoIP)**
  - Translate everything into IP (Analog Voice to VoIP)
  - Interoperate at the Network Layer (OSPF)
  - Demonstrated over 120 km-wide scenarios

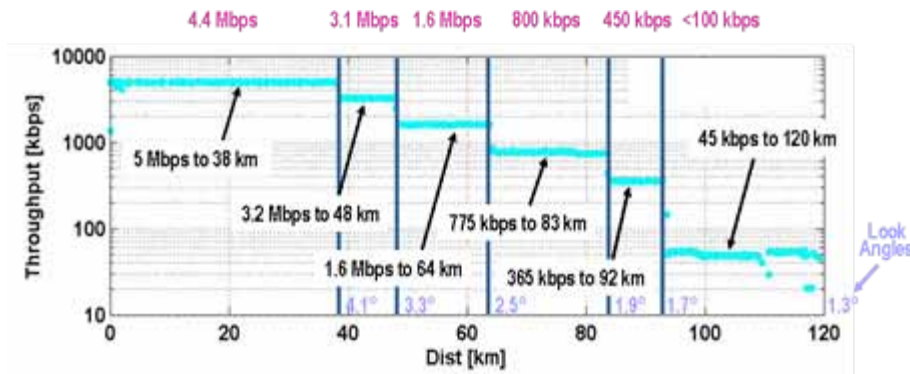


# Comparison of FSC & WNW Performance



Characteristic	Wideband Network Waveform	FCS C MANET / Gateway <sup>2</sup>
Demonstrated Max Data Rate at Max line-of-sight, point-to-point mode	<ul style="list-style-type: none"> <li>• 1 Mb/s @ ~14 miles (Expansion to 2 Mb/s is planned for summer of 2008) <sup>1</sup></li> </ul>	<ul style="list-style-type: none"> <li>• 5.5 Mb/s @ 23.6 miles</li> <li>• 1.6 Mb/s @ 39 miles</li> <li>• 775 Kb @ 51.6 miles</li> </ul>
Demonstrated Radio Interoperability with Networking	<ul style="list-style-type: none"> <li>• Demonstrated hardware running WNW simultaneously with a JTRS version of a legacy signal, which proves the feasibility of key JTRS concepts, waveform portability and simultaneous waveform operation <sup>1</sup></li> </ul>	<ul style="list-style-type: none"> <li>• Simultaneous demo at Ft Benning of MANET/Gateway communications among the following digital and analog systems: CPoF's VoIP, the ITT Soldier Radio, the Enhanced Position Location Reporting Systems (EPLRS), HAVEQUICK I/II (PRC-117), the Single Channel Ground and Airborne Radio System (SINCGARS/PRC-119) and the High Frequency MAN-PACK Radio (HFMR/PRC-150) and various SATCOM Links.</li> </ul>

Demonstrated FCS C Performance at Ft Benning



Note: The Army's Joint Network Node was not included in this comparison as JNN is not a tactical MANET system as JTRS WNW and FCS C. It is on-the-halt (Static) SATCOM (non-MANET) and is designed to be integrated into tactical backbone at Brigade fixed TOCs.

<sup>1</sup> Charlotte Adams, "Editor's Note: Reinventing JTRS", *Avionics Magazine Monthly News*, Volume 1 Issue 1, July 17, 2006.

<sup>2</sup> FCS C Network Centric Demonstration, McKenna MOUT Site, Ft Benning, January 2006

