



Advanced Wireless Technologies at DARPA

Presented to:
2002 International Symposium on Advanced Radio
Technologies

by
G. Duchak
Program Manager, Advanced Technology Office

March 4, 2002



DARPA Mission

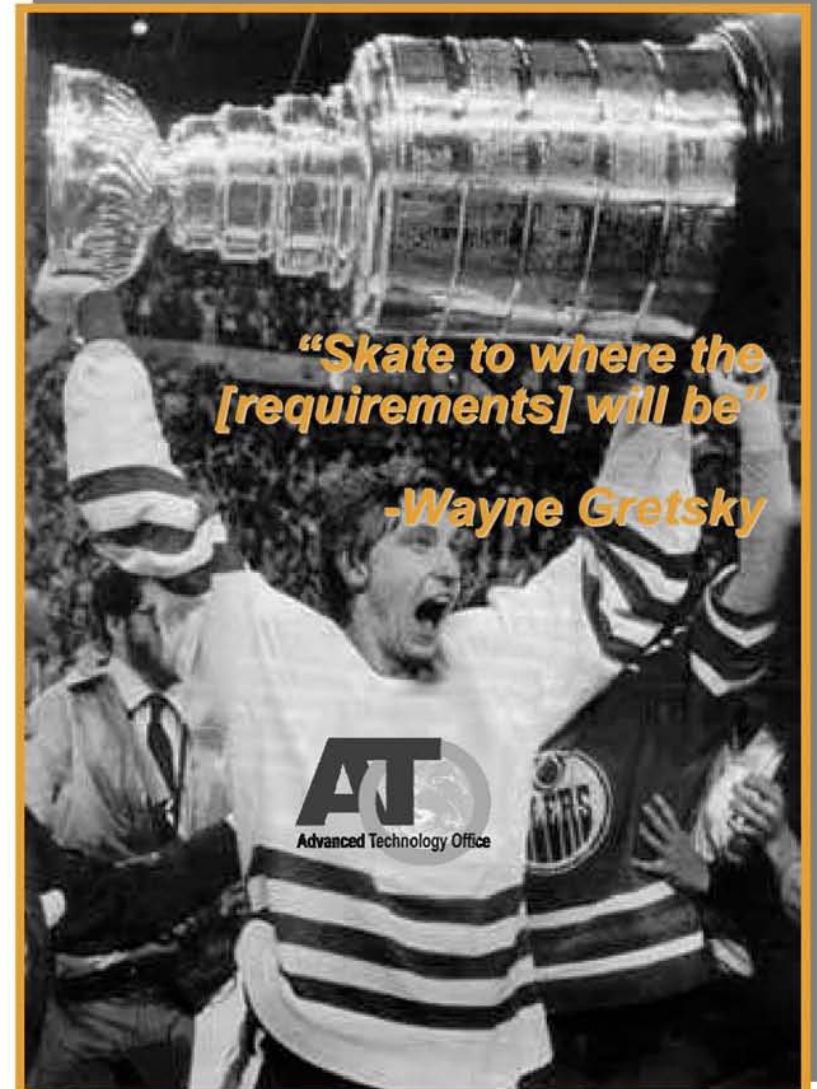
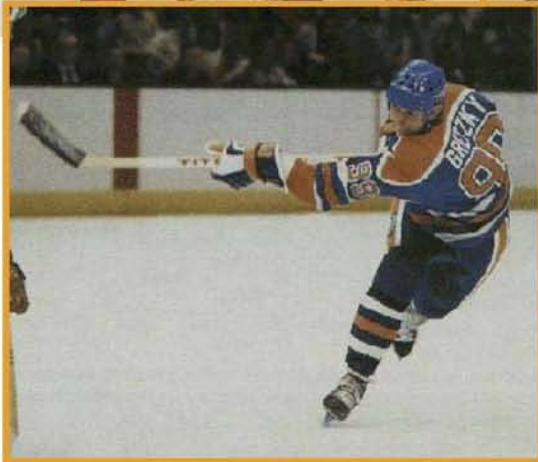
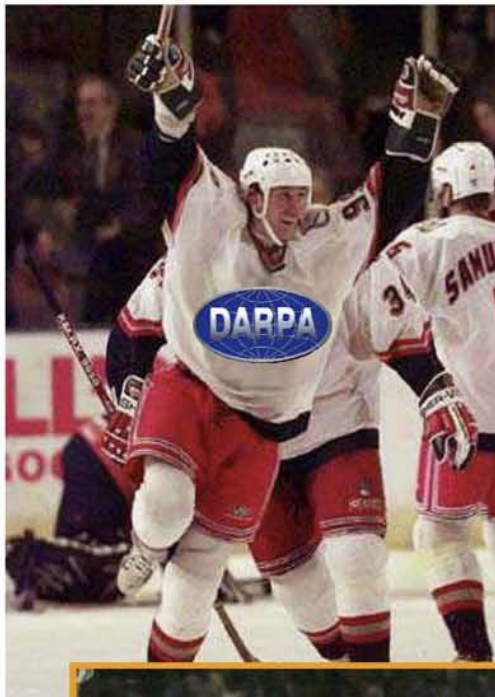


Innovation in Support of National Security

- **Solve National-Level Problems**
- **Enable Operational Dominance**
- **High Risk Technology Development, Exploitation -- *Avoid Surprise***



The Secret to Scoring





Think Differently!



Revolutionize the way we exploit RF

The Synergy of Energy

$$E=mc^2$$

- ✓ Bits are Bits & RF is RF
- ✓ Mission Functionality is determined by Software

DARPA

A billboard advertisement featuring a black and white portrait of Albert Einstein on the left. To his right, the text "The Synergy of Energy" is written in white on a dark background. Below this, the equation $E=mc^2$ is written in white. Further down, two bullet points with red checkmarks are listed: "Bits are Bits & RF is RF" and "Mission Functionality is determined by Software". A small DARPA logo is visible in the bottom left corner of the billboard image.



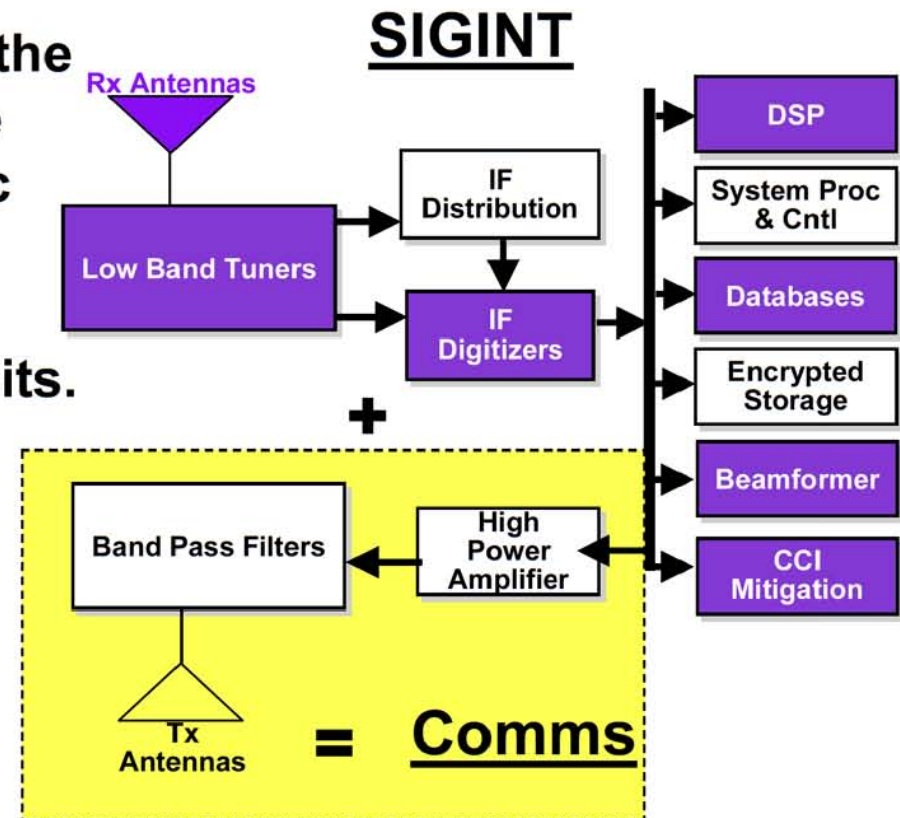
Exploiting all the RF Energy



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:

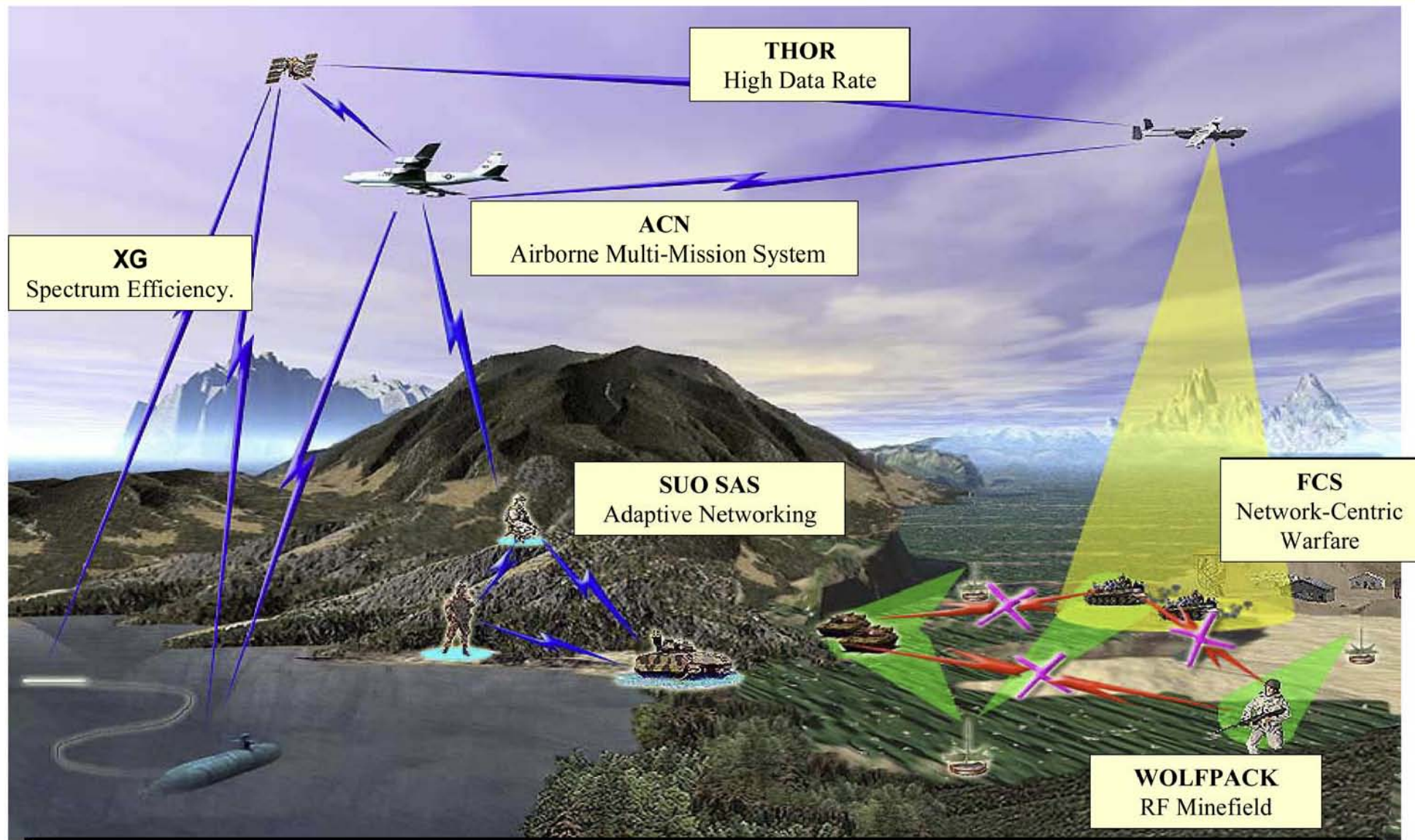
- Software definable radios
- MEMS Technologies
- High power amplifiers
- Broadband antenna advances
- Robust interference cancellation



Multi-mission capability in a single system breaks down traditional stovepipes and makes interoperability straightforward



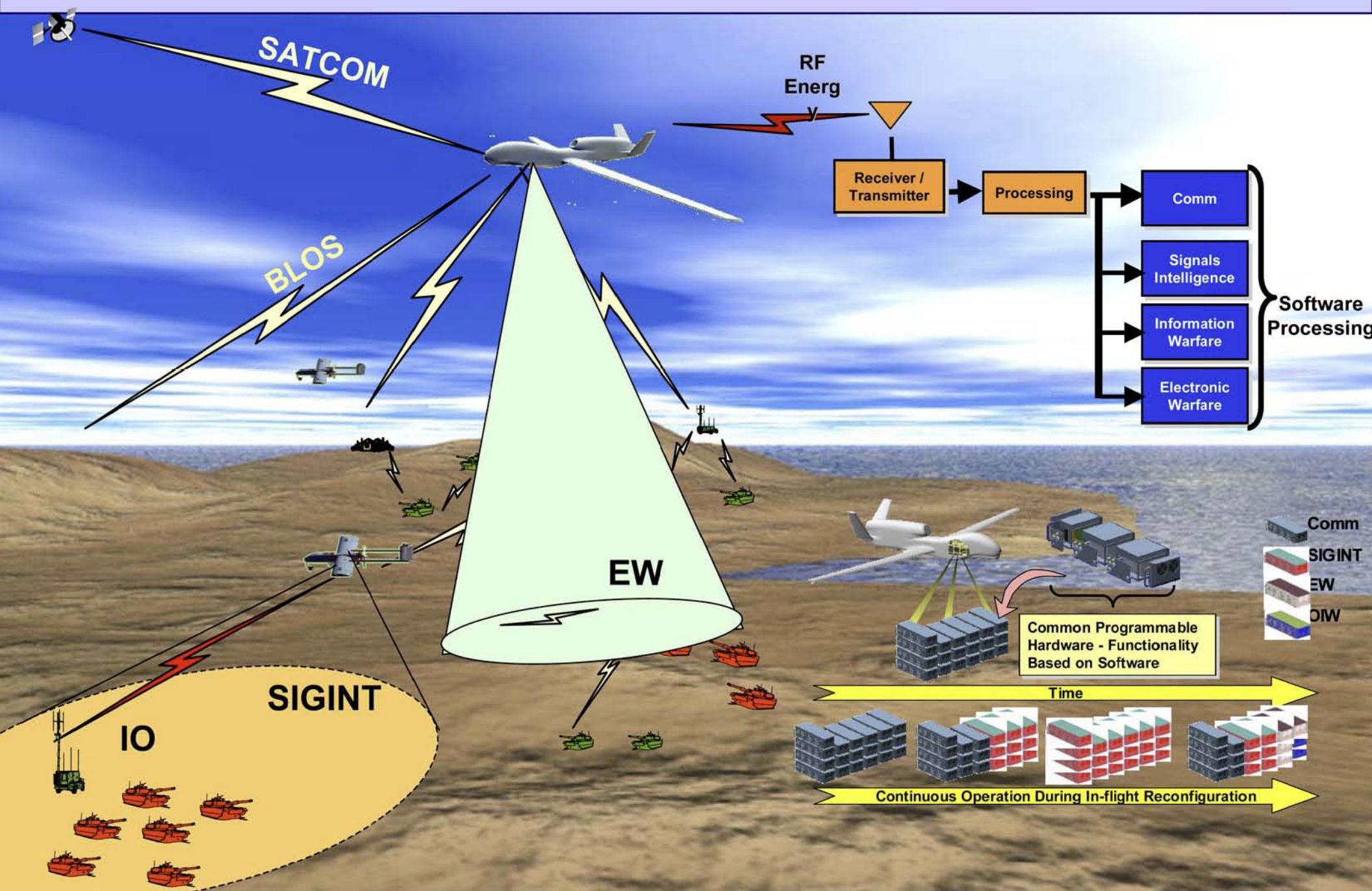
ATO Wireless Communications



***Assured communications anywhere in the world
without infrastructure and zero setup time***

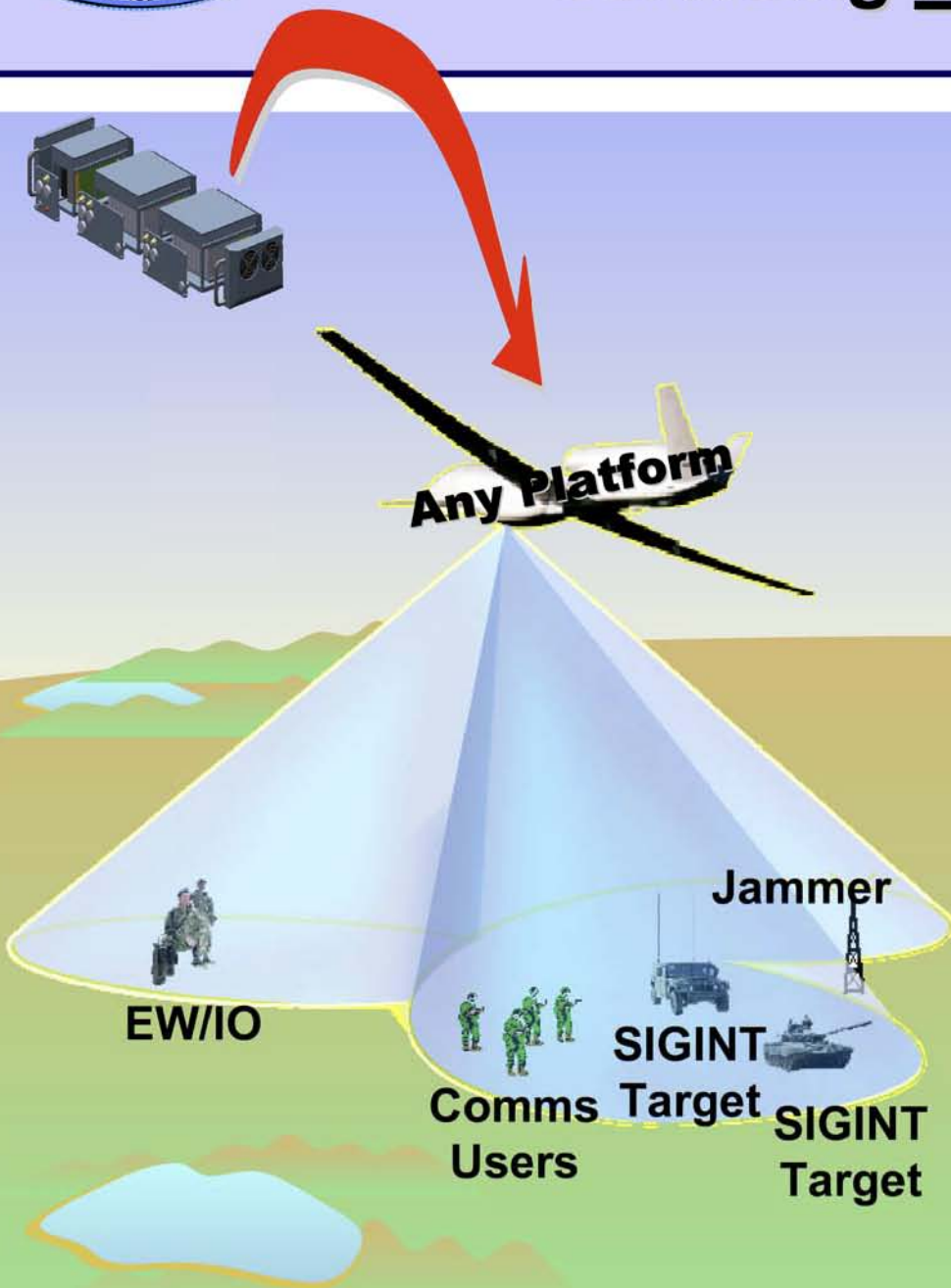


ACN Concept 2000-2002





ACN: A Single System Servicing Many Missions



Approach

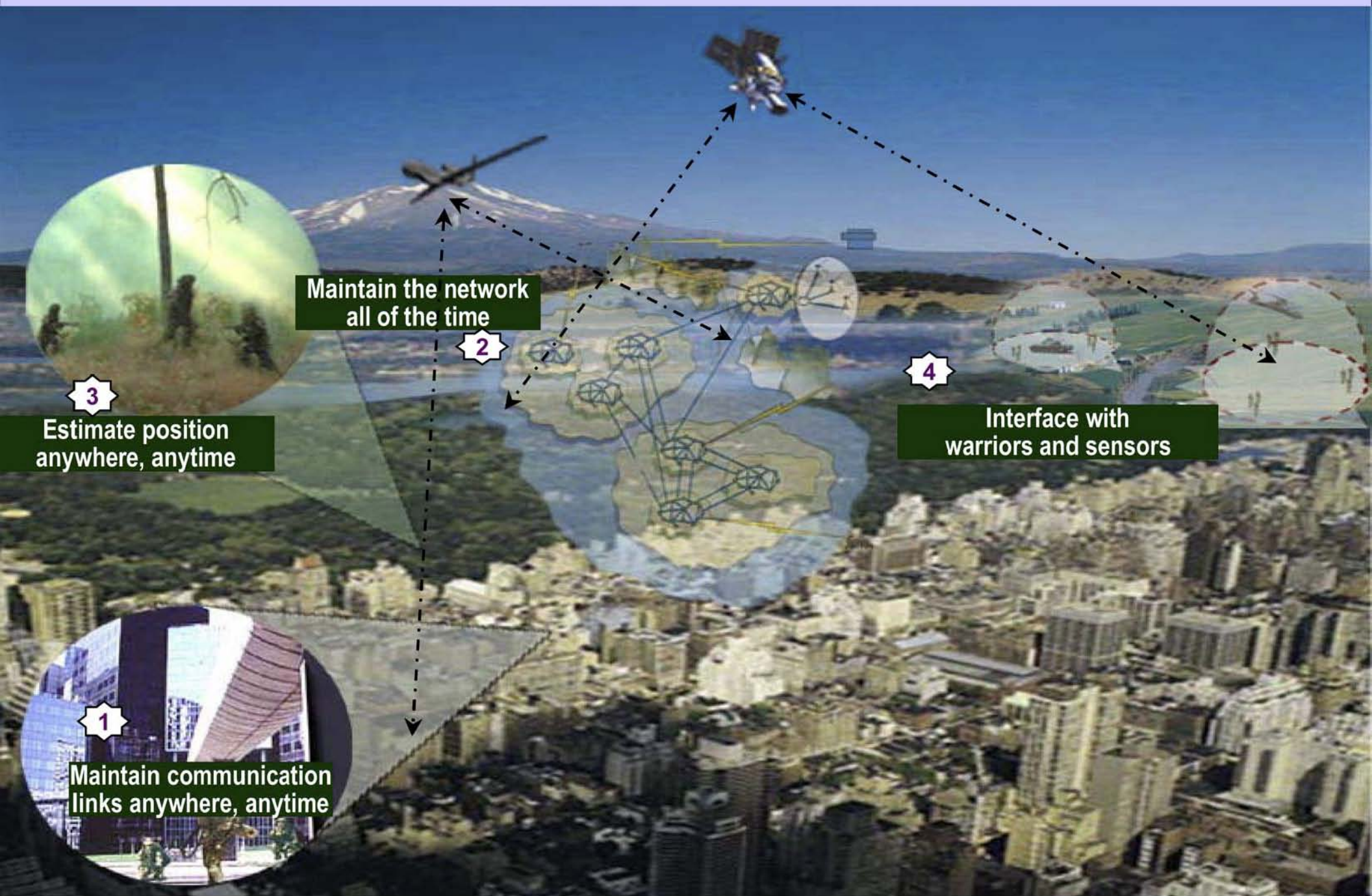
- Develop a Real-Time Programmable, Platform Agnostic, Multi-Mission (Communications, SIGINT, EW & Electronic Attack) Payload
- Develop, Mature & Demonstrate Technologies Necessary to Implement the Design.
- Demonstrate End-to-End System Design in Laboratory

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





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
- Scalable 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



SUO SAS is Built!

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



FCS-Communications



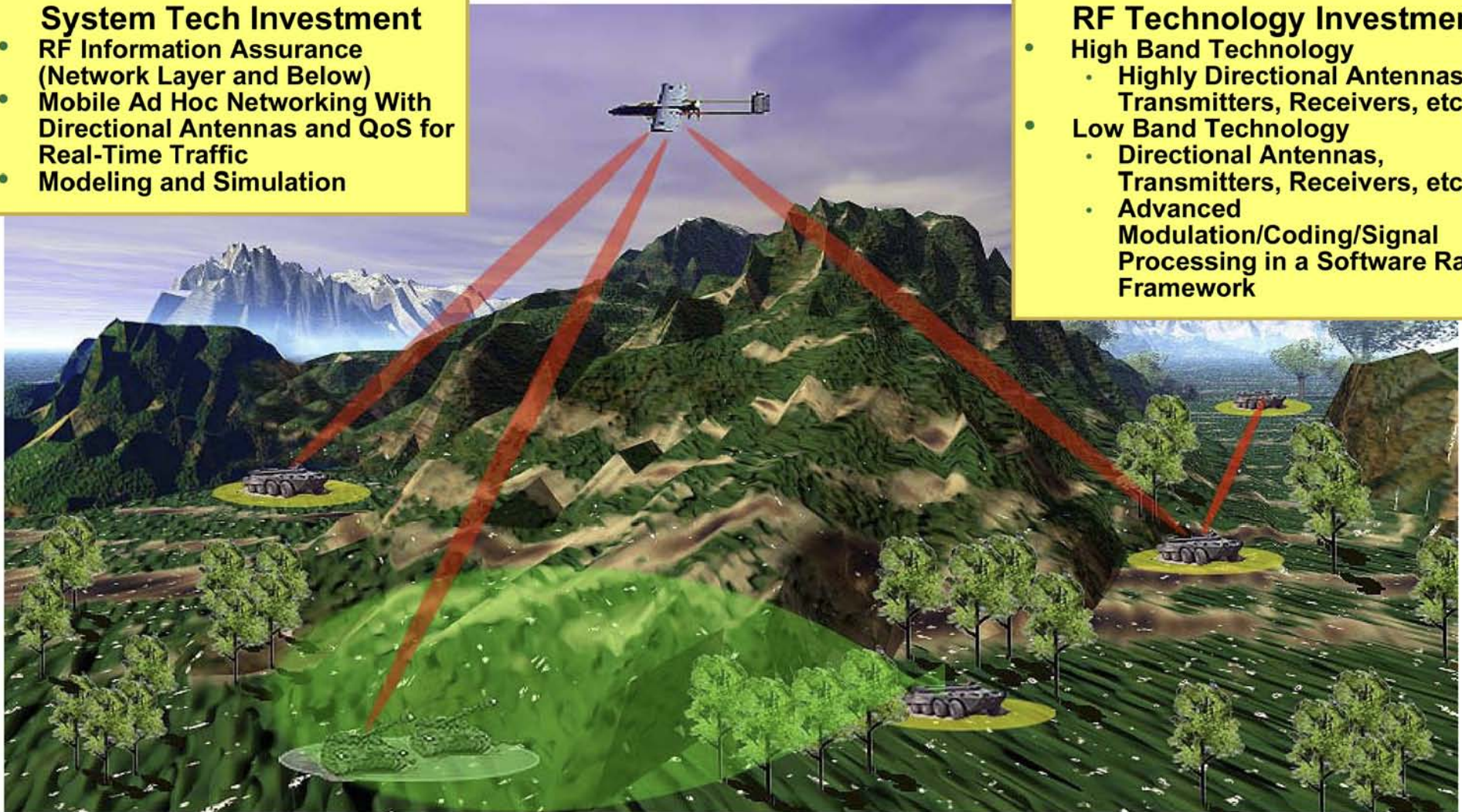
Assured communications for Army Future Combat System

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



**FCS Becomes
a Target without
Assured
Communications**



Tactical UAVs (2)



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

25 km

C2 Platform



Indirect Fire (2)



Direct Fire (2)



Troop Carriers (2)



Robotic Sensors (2)



10 km

**Unattended
Sensors (100)**



25 km

Dismounts (30)



Forward Link (A/J)

–Command and Control

- Way Points, Commands
- Target Folder Coordinates and Templates
- SA Updates
- Tele-operation
- Fire Control

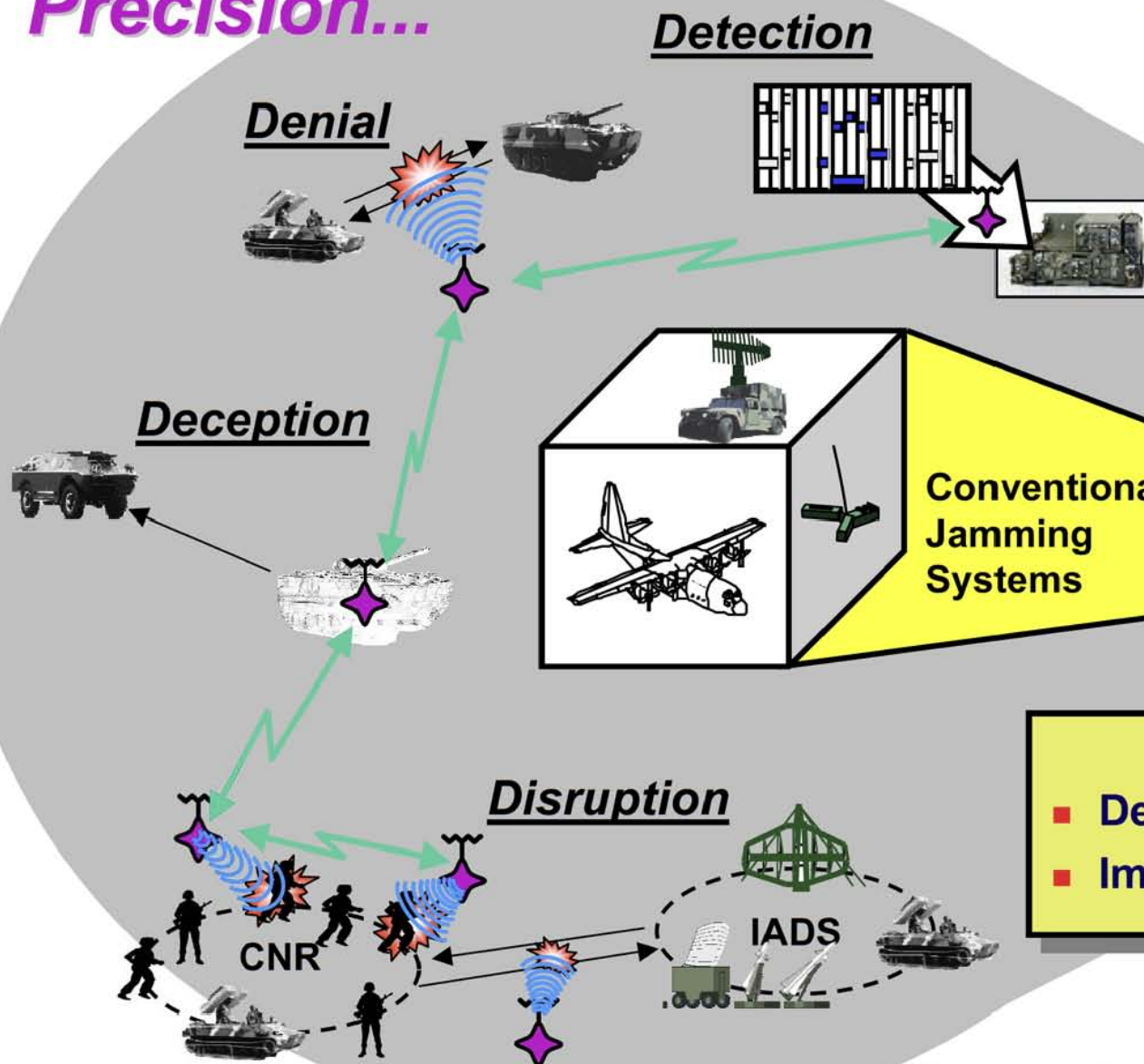


WolfPack Program Vision

Close, Distributed, Networked RF Spectrum Dominance



Precision...



Communication Service Layers

Application
Presentation
Session

Transport
Network
Data Link

Physical

"The Challenge"

- Develop technology enablers
- Implement innovative techniques

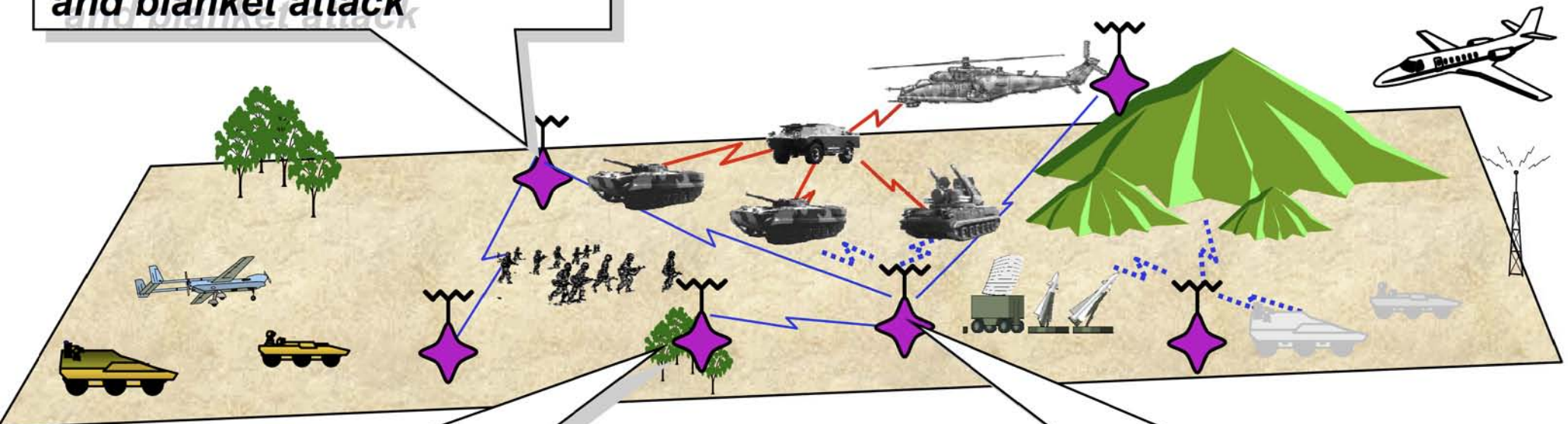
...with no Fratricide!



WolfPack Operational Concept



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

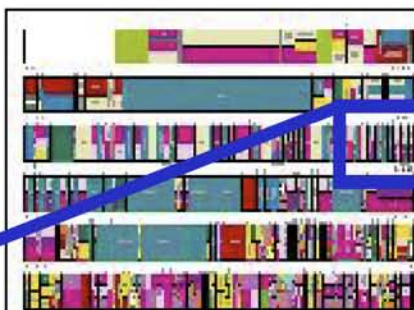
WolfPack Technology responds to advanced LPD/LPI, Packet Network Radios



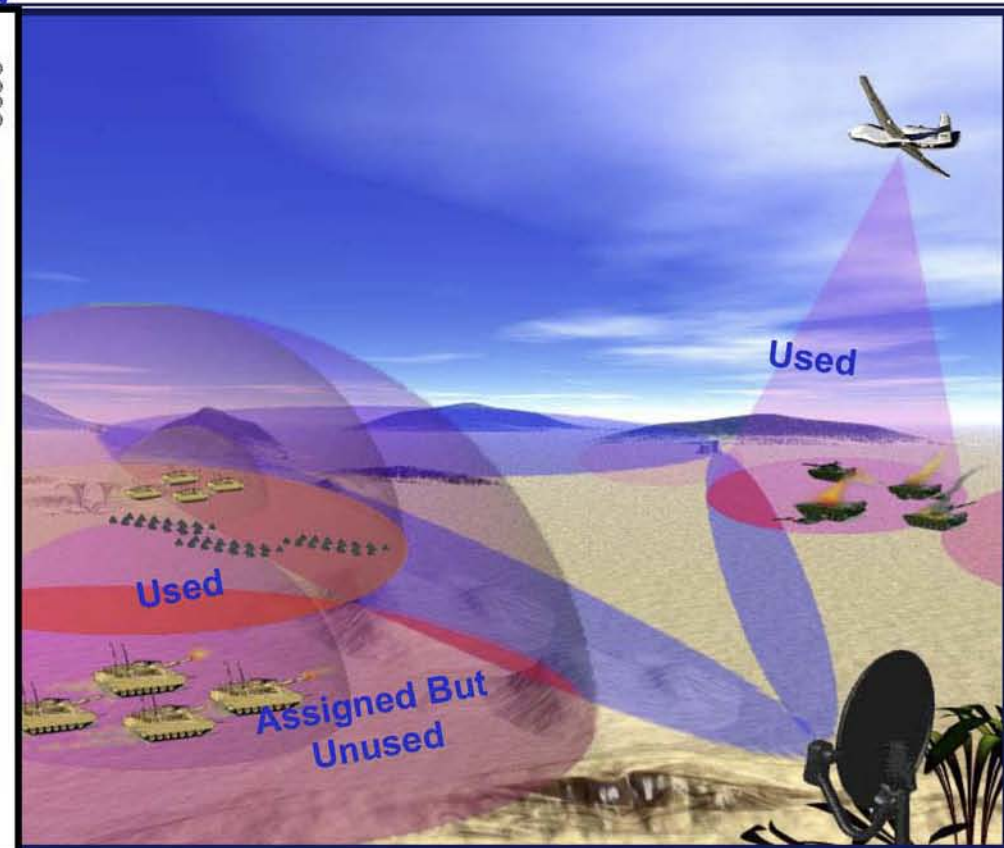
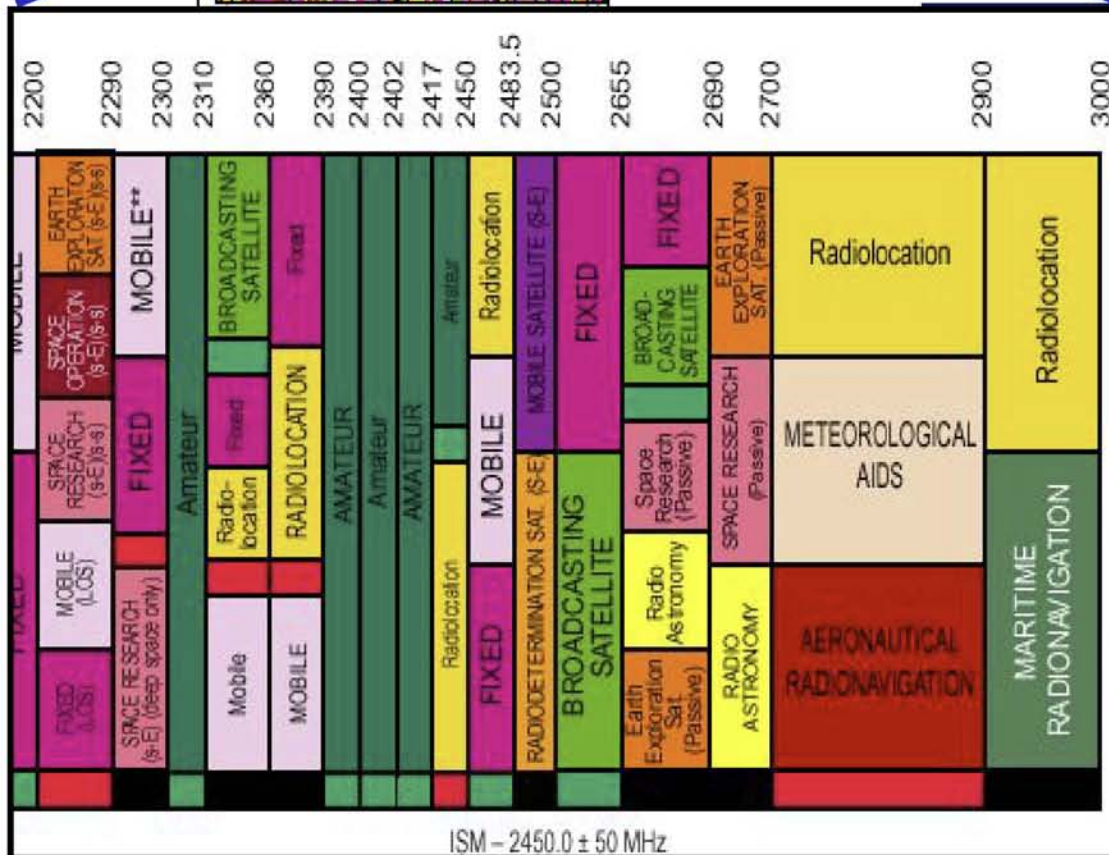
neXt Generation (XG) Communication Program



TODAY: Spectrum statically allocated

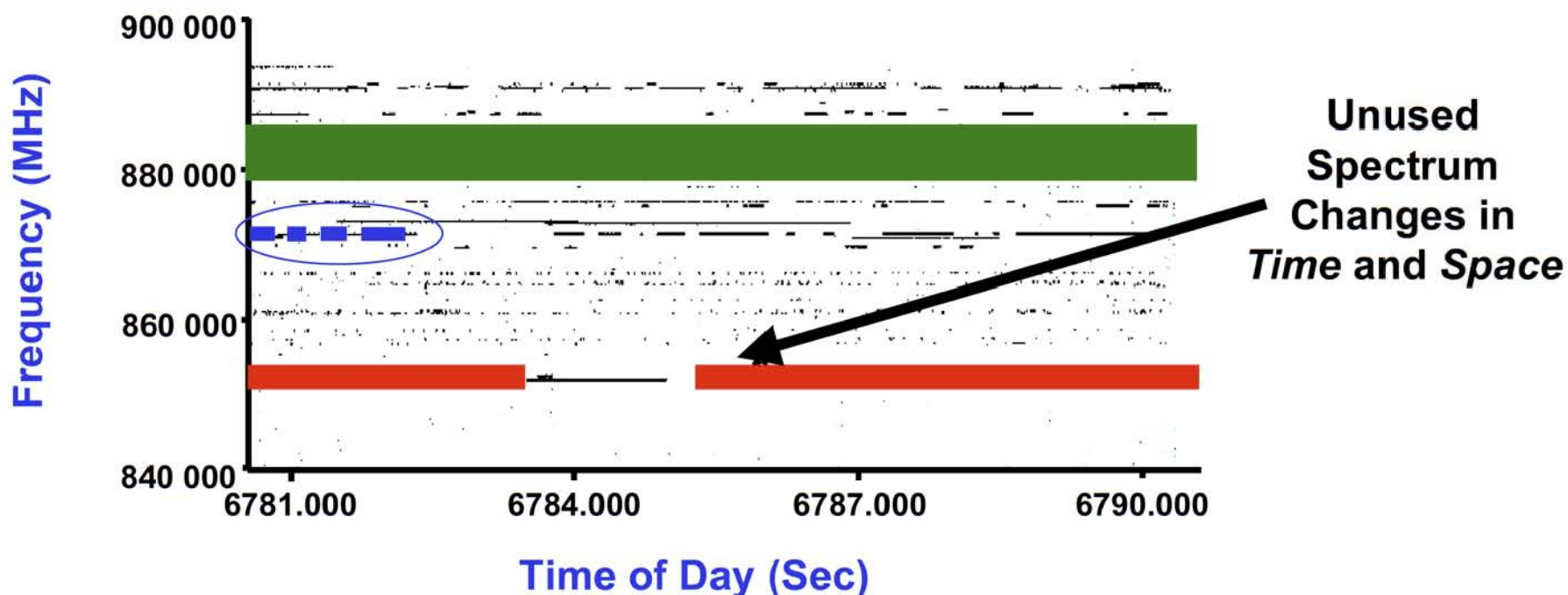


FUTURE: Dynamically allocating spectrum in frequency, space, and time may improve utilization by a factor of 10





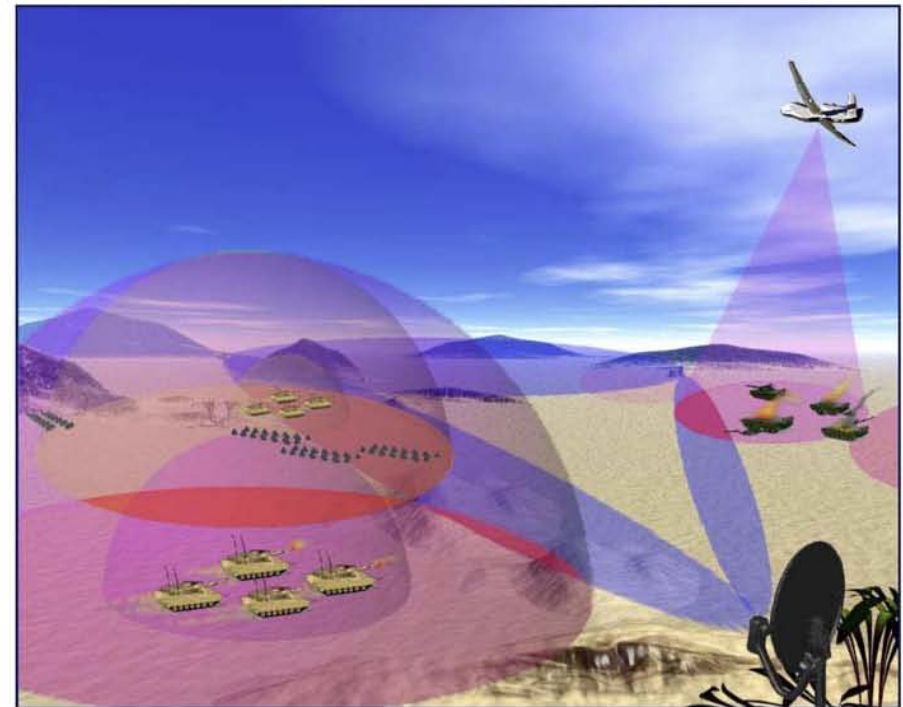
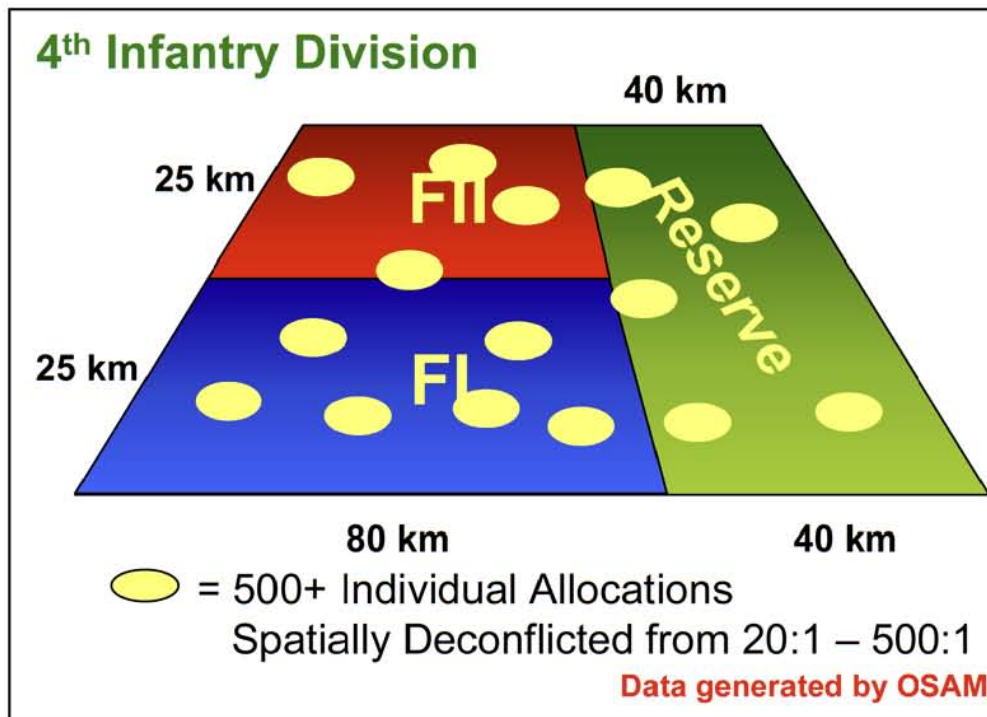
XG Initiative



- Develop both the Enabling Technology and the System Concepts to *Dynamically* Allocate Spectrum
 - Improve Efficiency ($\ll 1\%$) 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



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

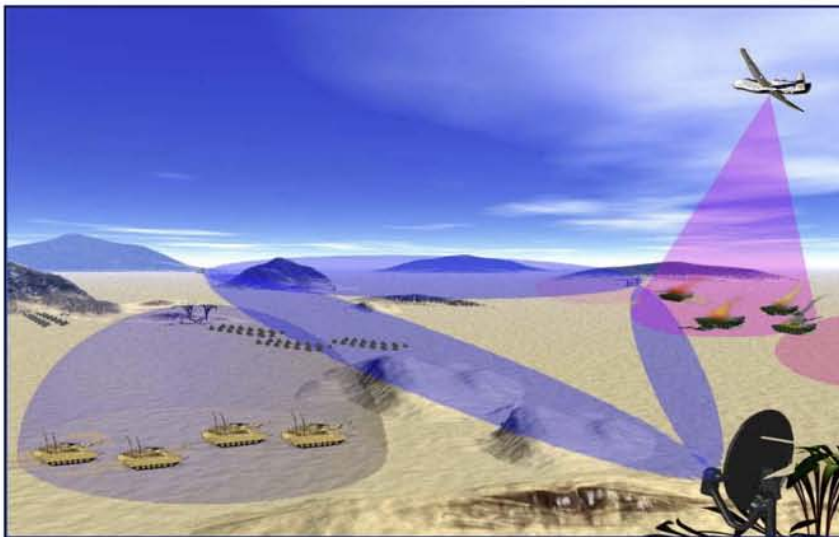
- **Allocations are Made to be Risk Adverse**
 - 99.9% Allocation Reliability
 - 97% Connection Reliability
- **Planning can Take up to Months to Deconflict**
 - e.g. Naval Group will use Same Allocations for 6 Month Deployment



XG Technology Challenges

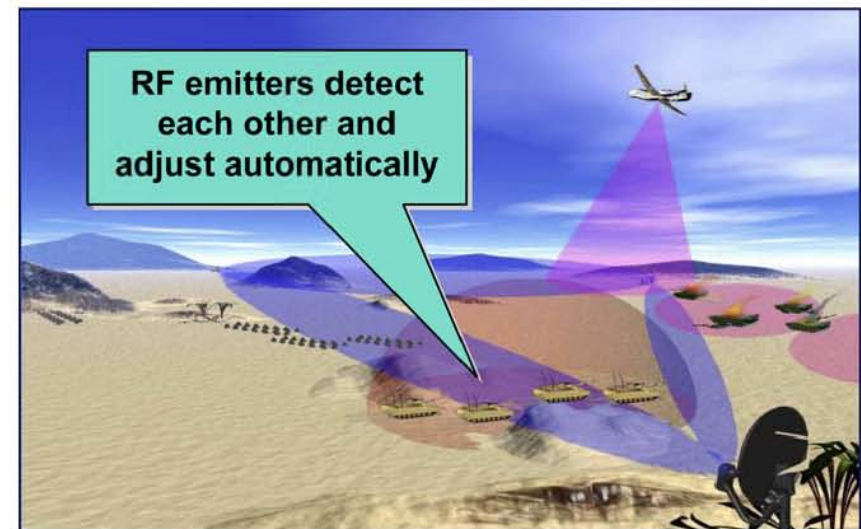


Predict or React to the Available Spectrum through Dynamic MAC Layer ...



Either Move in Frequency or Become Malleable ...

... Invest in Heterogeneous, Wideband MAC Subsystems

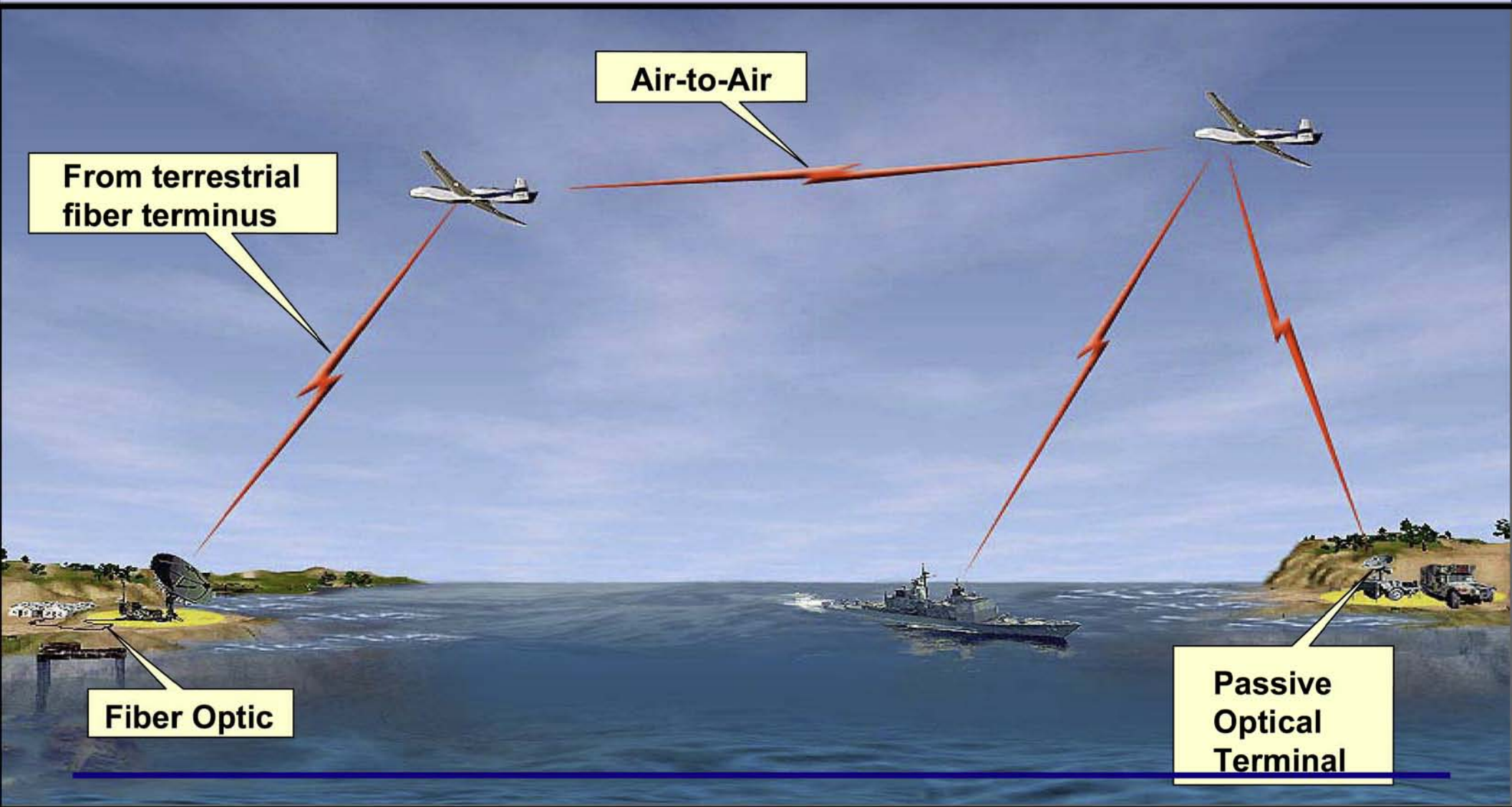


... Invest in multiple time-frequency agile waveforms

XG Requires Integration of New Control Techniques and Agile Waveforms That Balance Complexity and Capacity



Tera-Hertz Operational Reachback (THOR)



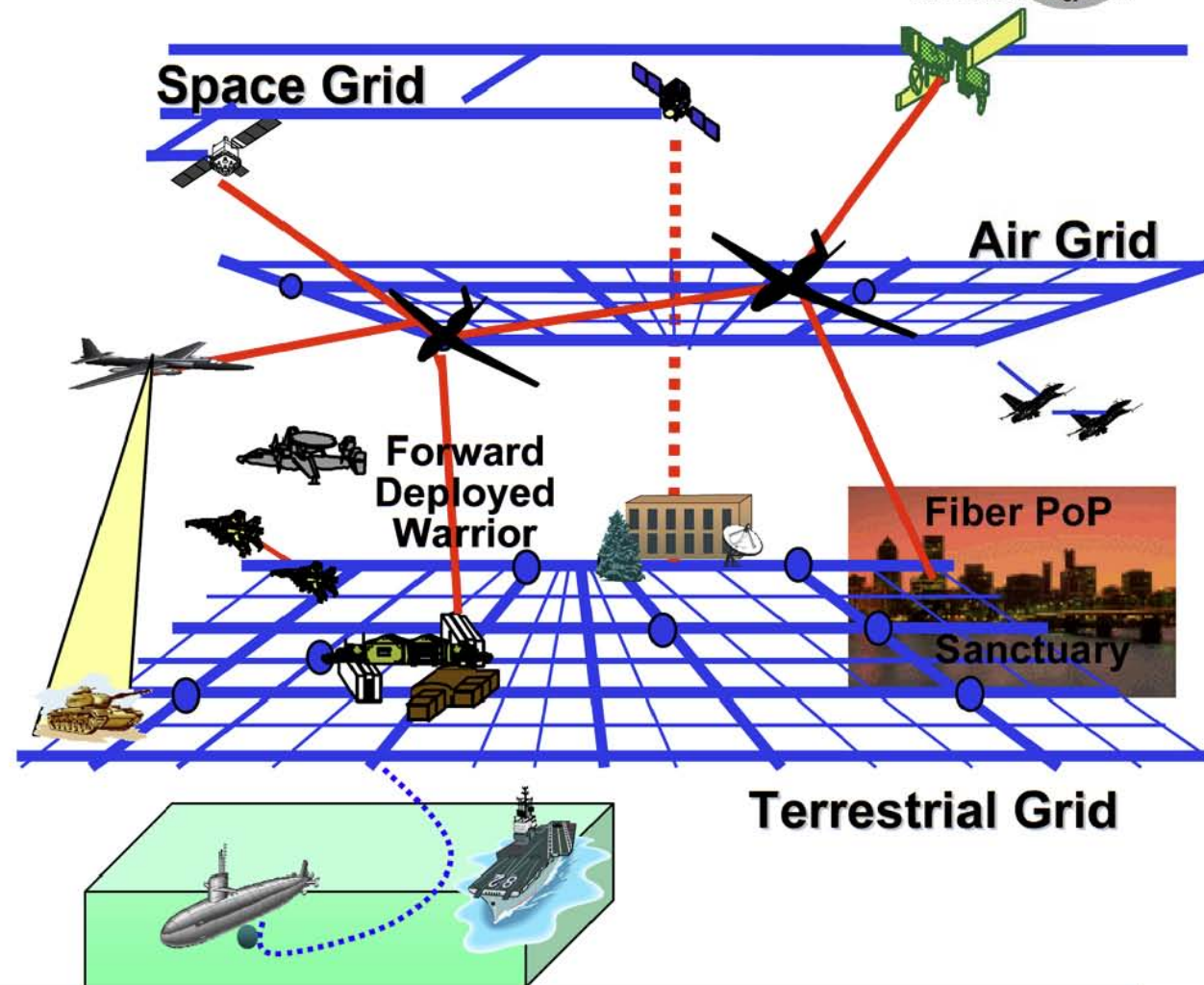
Connect the warfighter, in theater, to the fiber optic infrastructure using mobile free space optical communications



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