ANDRO Computational Solutions, LLC

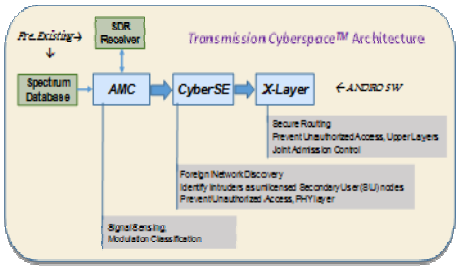
ANDRO Computational Solutions, LLC, a privately-owned company established in 1994, is dedicated to research, development, and the application of advanced computer software for a variety of applications. ANDRO's diverse portfolio includes: research and development in electromagnetic environmental effects on systems, dynamic spectrum management, spectrum exploitation, cyber-secure wireless communications, cognitive radios and software defined networking, multi-sensor and multi-target tracking, advanced radar data fusion, and sensor resource management. Located in The Beeches Professional Campus in Rome, NY, ANDRO provides research, engineering, and technical services to defense and commercial industries. The facilities house over 15,000 square feet of office space including two laboratories for R&D work on software defined radios.

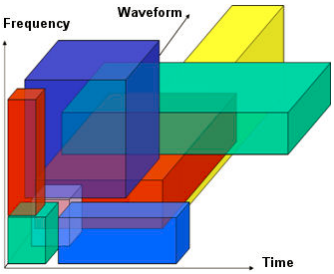
ANDRO Technologies

Cyber-Domain Spectrum Exploitation
Transmission Cyberspace (Secure Communications)
SIGINT/Cross-Layer Networking*
Automatic Modulation Classification

Dynamic Spectrum Access/Sharing
*Transmission Hyperspace™**
Spectrum Efficiency Solutions
Software Defined Radios/Networks

Cosite Analysis
*E³Expert Toolkit**
EM Environment Effects
RF Sensor Location



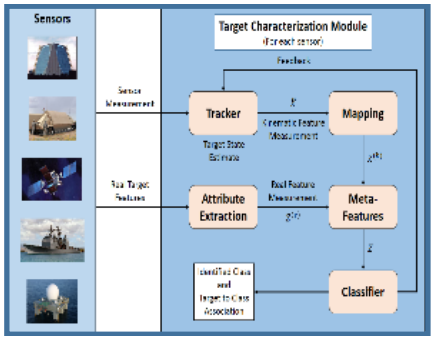


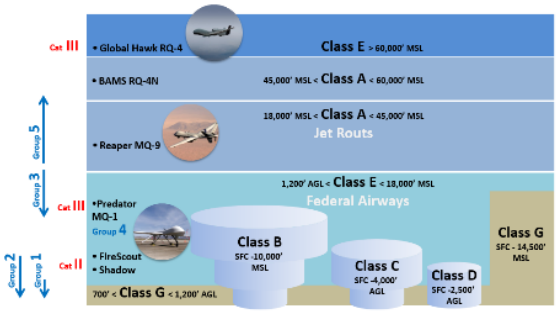
*Original R&D sponsored by AFRL/RI, Rome Research Site

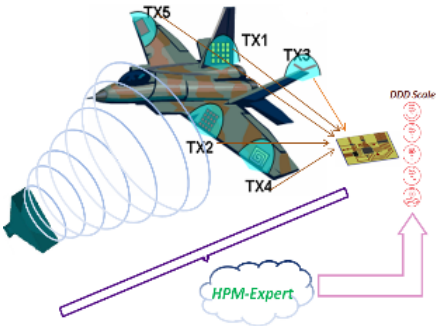
Sensor Resource Management
Automated Target Characterization
Multisensor Information Fusion

UAS/UAV Security & Safety
Interference & Link Analysis
Flight Zone Standards & Protocols

High Power Electromagnetics
Modeling & Simulation
Vulnerability Analysis/Studies







The Beeches Professional Campus
One Beeches Place
7980 Turin Road, Bldg. 1
Rome, NY 13440-1934
(315) 334-1163 P
(315) 334-1397 F
www.androcs.com
Email: ***androcs@androcs.com***

ANDRO
Computational Solutions, LLC

Vision & Mission

Our Mission is to be a globally recognized leader in advanced information, defense and security technologies within the public and private sectors through continual identification, generation and implementation of intelligently designed solutions for client specific needs.

Our Vision is to benefit mankind globally by researching, developing and deploying game-changing technologies that will advance the state-of-the-art in smart systems and intelligent software applications emphasizing novel solutions for: Software Defined Radio (SDR) and Software Defined Networking (SDN) technologies/applications; revolutionizing secure, wireless radio frequency (RF) communications including spectrum policy reform; achieving highly-specially-efficient systems; incorporating cyber-domain electromagnetic spectrum exploitation to enhance cyber security, spectrum dominance and information superiority; integrating electronic warfare (EW) and cyber defense; multisensor exploitation and sensor resource management; advanced data fusion and signal processing for target tracking; and virtually all aspects of Automatic Target Recognition (ATR) including signal intelligence (SIGINT), image intelligence (IMINT), and "big data" knowledge discovery.

E^3Expert Training Courses

Level one training course is aimed at the novice user of ANDRO's E^3Expert software. The course is designed to expose the new user to the various capabilities and features of the tool, and to facilitate the rapid and efficient use of *E^3Expert* electromagnetic problem solving tasks for specific applications of interest. The Level 2 Top Gun training is for current users of *E^3Expert* who are looking to improve their modeling skills and who want to get the most out of the software.

E^3Expert was developed under Air Force and Navy funding to provide the electromagnetic environment effects (E^3) engineer a new type of user-friendly capability to perform interactive electromagnetic interference/compatibility (EMI/C) computer modeling, simulation, and analysis of large, complex systems.

For More Information

Contact Andrew Drozd at (315) 334-1163 x101 or email *adrozd@androcs.com.*

ANDRO Media Coverage

~ Local company awarded contract with U.S. Department of Homeland Security

Video Link: http://www.cnyhomepage.com/story/rome-software-company-awarded-contract-that-will-create-jobs/d/story/4Lenb9A1nUGKciRnNZWW-w

~ Rome business grows with deal to monitor federal networks

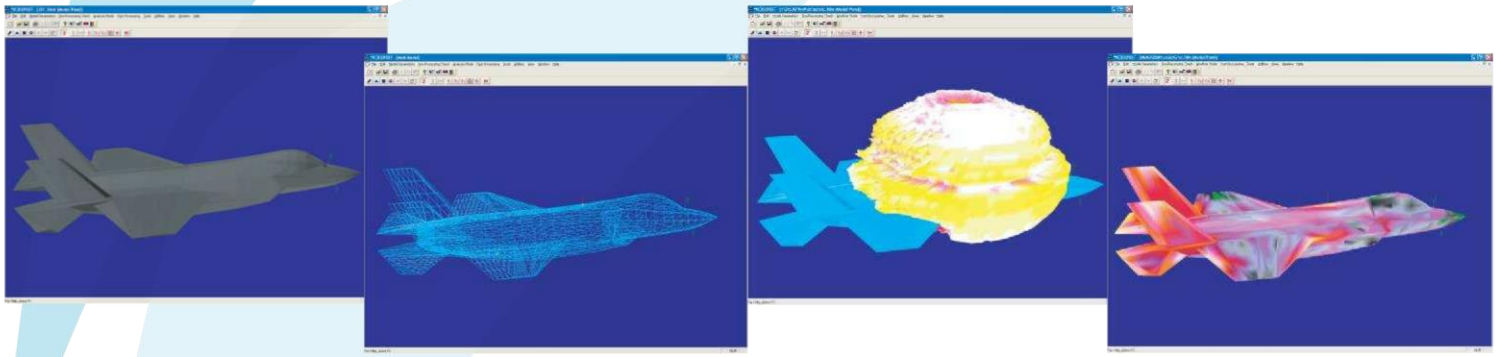
http://www.uticaod.com/news/x1783716057/Rome-business-grows-with-deal-to-monitor-federal-networks

E^3Expert

EMC Modeling & Simulation Tool

Applications

Applications of *E^3Expert* include analysis of co-located communications and radar systems, multispectral electromagnetic environment effects, antenna jamming, receiver immunity and desensitization, cable-to-cable coupling and electronics susceptibility.



Features and Capabilities

- Intelligent preprocessor which automatically generates valid CEM models from CAD data
- Multi-fidelity modeling and simulation in a single package – conservative methods and MoM/UTD physics are used to compute scattering, propagation, isolation and coupling for complex systems consisting of electronic subsystems, cables and antennas
- Employs an integrated computational electromagnetics engine which performs a whole-system baseline analysis
- Integrated with multiple numerical tools for detailed analysis of coupling for a single source-receiver pair in the frequency domain
- Average and non-average power models for baseband/RF/microwave systems including radars and mobile/wireless spread spectrum communication radios
- Nonlinear RF models to calculate receiver 3rd-order intermodulation products
- Applies rule-based techniques to determine interference rejection requirements using an expert system that ranks computed results, identifies interference frequencies, determines the cause of interference and suggests corrective actions
- Graphical post-processing utilities to enable rapid understanding and decision making
- 3D model utilities for viewing, editing and graphically manipulating CEM models
- User-friendly Windows interface
- Built-in modeling advisor

Benefits of Using *E^3Expert*

- Improvement in modeling efficiency and performance
- Reduces modeling and simulation time, effort and cost
- Helps the non-expert become a proficient CEM modeler and analyst

The Beeches Professional Campus
One Beeches Place
7980 Turin Road, Bldg. 1
Rome, NY 13440-1934

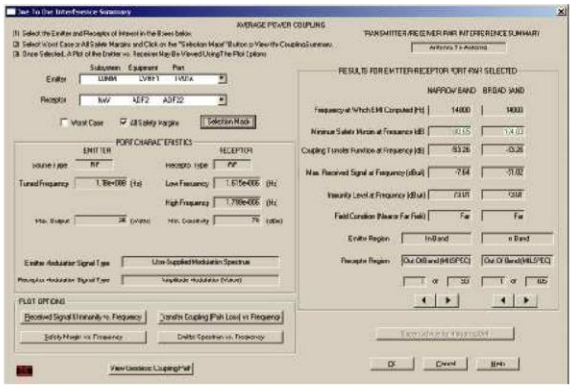
ANDRO

Phone: (315) 334-1163
Fax: (315) 334-1397
Email: androcs@androcs.com

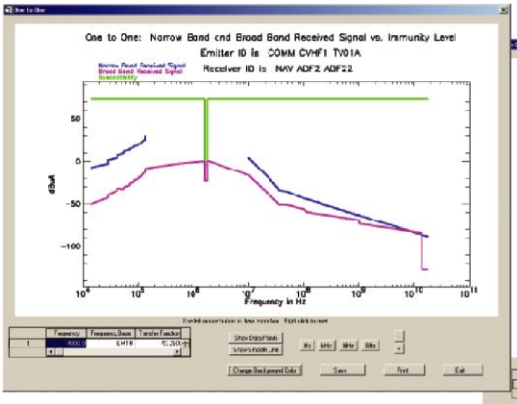
Analysis Tools

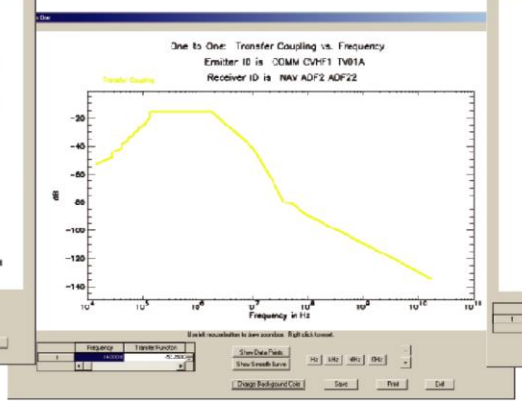
Single Transmitter to Single Receiver Analysis

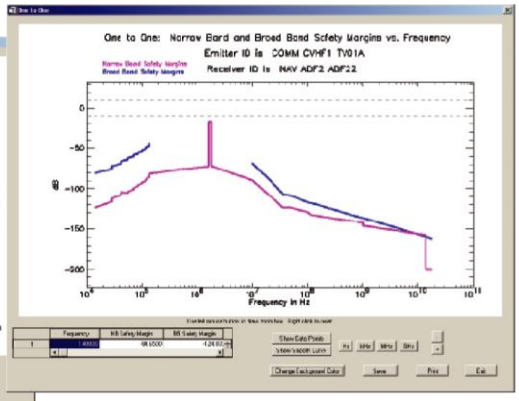
Use the One-to-One Matrix screen to determine which transmitter-receiver pairs are experiencing EMI



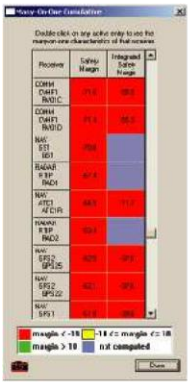
Use the Interference Summary screen to investigate the frequency, safety margin and coupling transfer function for the pair



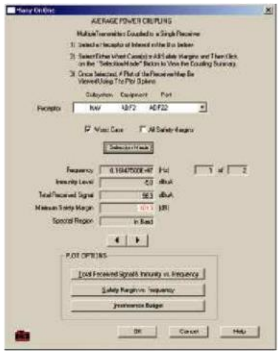


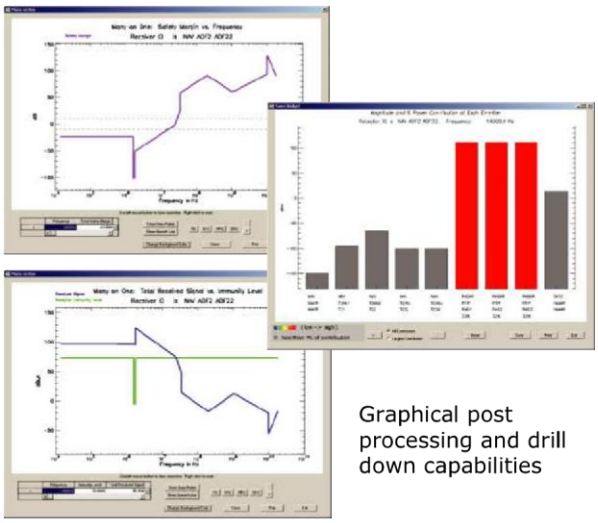


Multiple Transmitters to Single Receiver Analysis



View the cumulative results for each receiver





Graphical post processing and drill down capabilities

The plots shown here were created using arbitrary data, and do not represent the performance of actual systems.

The Beeches Professional Campus
One Beeches Place
7980 Turin Road, Bldg. 1
Rome, NY 13440-1934

Phone: (315) 334-1163
Fax: (315) 334-1397
Email: androcs@androcs.com

EXECUTIVE SUMMARY

Advanced Software Defined Radio Capabilities and Information Dominance:
Applying ANDRO's Transmission Cyberspace Solution

Introduction

This research effort is to investigate and validate Software Defined Radio (SDR) based, multi-function portable network sensing and intrusion detection algorithms suitable for small dismounted radio platforms used to support Command and Control (C2) standard sensor interfaces carried in the field and for sensor data exfiltration. A new capability called Transmission Cyberspace is proposed that will enable DoD military SDRs in the battlefield that are in close proximity to hostile foreign networks to be cognizant of their surrounding radio frequency (RF) environment. A novel and robust network discovery capability will be developed to rapidly assess the potential for RF intrusion, cyber attacks or other unauthorized access to SDRs and Cognitive Radio and Sensor Networks (CRSNs) along with implementing effective defense strategies. This will be accomplished through the application of a suite of algorithms that fundamentally exploit the multidimensional and joint orthogonal nature of the RF signal space. A hybrid class of algorithms and techniques will be used, namely: multiobjective optimization, game theory, spectrum sense and adapt, distributed detection, joint cognitive routing and spread spectrum channelization, and automated modulation classification. A unique physical (PHY) layer protection scheme is then used to thwart attacks and to augment upper layer (data, MAC, network) multi-level security methods to deny cyber attacks and to ensure secure communications and trusted network routing. These algorithms will leverage the SDR's ability to sense the presence of other wireless networks, monitor those networks and detect when and where hostile intrusion attempts might arise.

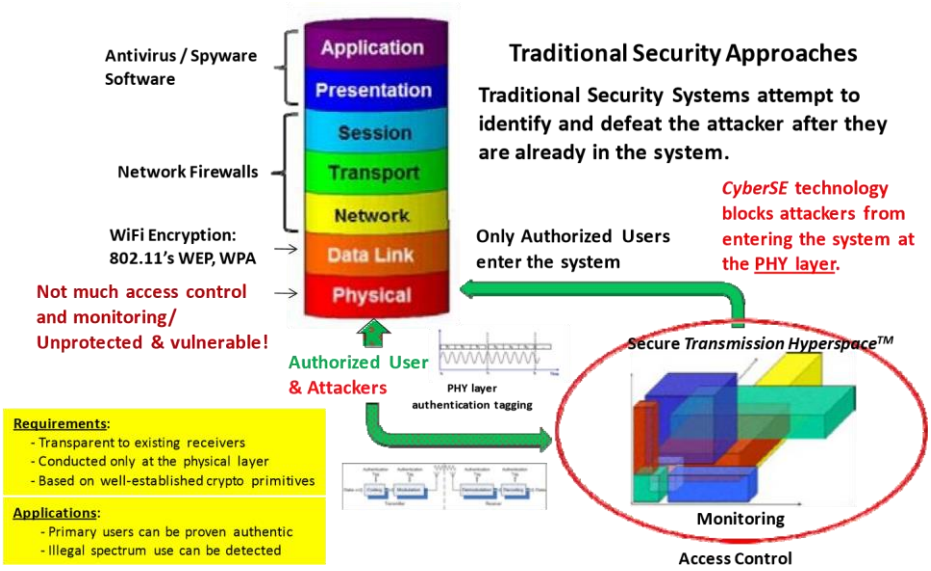
Background/Technical Problem

Dismounted and Special Forces personnel must rapidly adapt to hostile environments and need to acquire relevant operational information as quickly as possible. For instance, DoD military SDRs in the battlefield will be in close proximity to hostile foreign networks and have the potential to be cognizant of their surrounding RF environment. SDRs are poised to deliver a paradigm shift in operational awareness on the battlefield and are on the path towards the realization and deployment of Cognitive Radios that can help to generate a dynamic radiomap of the electromagnetic (EM) battlespace (likened to a weather map). Applications need to be investigated that utilize the SDR's ability to sense the presence of other wireless networks, monitor those networks and detect hostile intrusion attempts and then defend against them. This involves the development of algorithms and the implementation of strategies that support communications diversity, trusted routing, contingency planning, cognitive radio agility, environmental sensors and spectrum sensing, and the application of ad hoc network behavioral models. These models are used to study how RF effects at the physical (PHY) may impact the upper (data, MAC and network) layers and how to effectively and efficiently use this knowledge to defend our networks against unauthorized access or intrusion. In developing any practical solution to this problem for current SDR technologies, care must be given to implementing a technically feasible and cost-effective approach that leverages state-of-the-art devices and considers size, weight and power (SWAP) as well as electromagnetic interference/compatibility (EMI/C) packaging, and hardware/software integration requirements.

In this effort we fill an important technology gap by providing a better understanding of how foreign networks exploit or attempt to gain access to our communications networks to exfiltrate critical information and data. By understanding the strategies for accomplishing this, we can better arm ourselves to defend against this or any other type of disruptive RF cyber attack. Because all operational states and concepts of operation (CONOPS) cannot be practically considered during experimental simulations and testing, some uncertainties remain regarding potential vulnerabilities and how best to exploit them. In this effort we are performing a critical study of how attack strategies are formulated, where vulnerabilities may exist, and how to mitigate RF cyber attacks focusing on PHY layer intrusion/anomaly detection. The outcome of this Phase I effort will benefit advances in SDR and cognitive radio technologies to enable rapid discovery, detection and defense to a level previously not demonstrated. By applying a validated methodology in advance for determining when and where access or disruption might occur, the effectiveness of foreign network cyber attacks will be quantified and effectively diminished and we will be better prepared to face adversaries on our own terms.

Accomplishments

We are leveraging and extending our suite of technologies to solve the immediate technical problem. The purpose of this effort is to develop a TC capability that combines the *best of breed* techniques to assess network discovery and enact defensive measures. This new capability will be deployed in the dual use (military and commercial) sectors to study Cognitive Radio and Sensor Network (CRSN) utility, utilization and security in complex environments and to understand potential security breaches and risks, and apply effective defense measures. We began efforts to identify candidate algorithms and solutions for CRSNs to support the objectives of foreign network discovery, intrusion detection and cyber defense. The central concept is shown below:



Wireless Communications Network Dynamic Spectrum Exploitation for Foreign Network Discovery.

Algorithms that we are examining include:

- *ANDRO's Transmission Hyperspace™* single and multiobjective optimization algorithms.
- *ANDRO's Cyber-domain Spectrum Exploitation and Security (CyberSE)* defensive game theoretic algorithms.
- Spectrum (energy, feature) sensing algorithms and techniques to detect intruders, infiltrators, exfiltrators, primary user emulators, eavesdroppers, jamming attacks or other unauthorized network access.
- Cryptographic link signature algorithms for PHY-layer discovery and authentication in networked CRs.
- CRSN cross layer framework algorithms for joint dynamic resource allocation, routing and network security.
- Protocol design for joint dynamic spectrum allocation and secure routing using *Transmission Hyperspace™.*
- Detection of weak signals and radiomapping schemes using Distributed Automated Modulation Classification (DAMC) algorithms.

Anticipated Benefits

SDR technology is rapidly being adopted by the military as well as civilian first responders. In the near future all users of radio equipment, industry wide will demand adaptable, reconfigurable, software defined radios equipped with robust security strategies and intrusion detection software, which will be provided by Transmission Cyberspace technologies. Technology areas, acquisitions and *Programs of Record* that will benefit from this innovation include: JPEO JTRS - ACAT I.

Training Courses

Scope. Level one training course is aimed at the novice user of ANDRO's *E^3Expert* software. The course is designed to expose the new user to the various capabilities and features of the tool, and to facilitate the rapid and efficient use of *E^3Expert* to electromagnetic problem solving tasks for specific applications of interest. The Level 2 training class is for current users of *E^3Expert* who are looking to improve their modeling skills and who want to get the most out of the software.

Purpose. *E^3Expert* was developed under Air Force and Navy funding to provide the electromagnetic environment effects (E^3) engineer a new type of user-friendly capability to perform interactive electromagnetic interference/compatibility (EMI/C) computer modeling, simulation, and analysis of large, complex systems.

Objective. To give the *E^3Expert* user the necessary skills and overall proficiency in the effective application of the tool to EMI/C problem solving for specific problem sets.

Level 1:

- The Level I training class introduces users to basic theory and techniques for using *E^3Expert* for analyzing your EMC and E^3 problems.
- This training is available to anyone interested, including current customers and those wishing to evaluate the capabilities of *E^3Expert.*

Level 2:

- Attendees will receive significant amounts of individual one-on-one time with the authors of *E^3Expert.*
- Students are encouraged to bring along their specific modeling problems and questions.

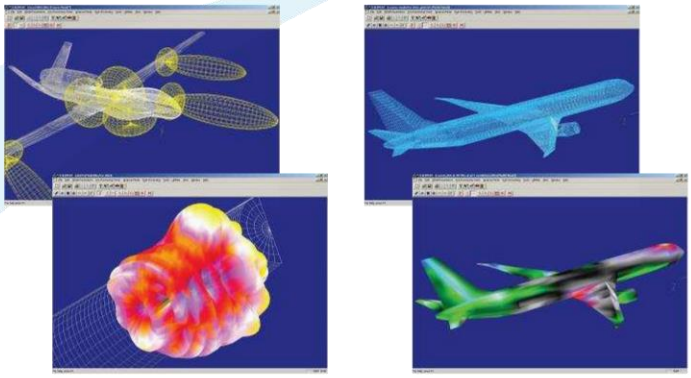
For more information
Call ANDRO Computational Solutions at (315) 334-1163, or email training@androcs.com.

The Beeches Professional Campus
One Beeches Place
7980 Turin Road, Bldg. 1
Rome, NY 13440-1934

Phone: (315) 334-1163
Fax: (315) 334-1397
Email: androcs@androcs.com

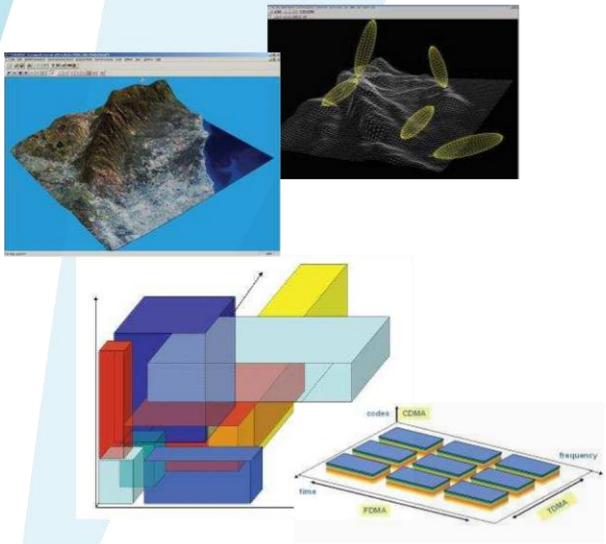
Expert System Solutions

Electromagnetic Analysis



As leaders in the development of E^3 software using expert systems, we are dedicated to developing reliable products that provide our customers with the technology they need to solve challenging and complex problems. Our main product, E^3Expert, is relevant to a variety of market segments. These include air and automobile transportation systems, telecommunications, power utilities, medical instrumentation, consumer electronics, and a variety of other government and commercial systems or products. ANDRO has provided training and consultation in the use of E^3Expert technologies and other tools. This work has been sponsored under an SBIR Phase III contract for the Naval Air Warfare Center - Aircraft Division.

Spectrum Management



ANDRO is developing and demonstrating innovative concepts for spectrum management that enable the effective and efficient joint utilization of all orthogonal EM transmission resources, including, but not limited to, time, frequency, geographic space, power control, modulation/code, smart antenna beam direction and polarization. This multi-dimensional environment is referred to as the Transmission Hyperspace (TH), a term intended to convey the notion of a multi-dimensional resource space in which each dimension allows orthogonality amongst users. This research is aimed at developing approaches that consider the multi-dimensional nature of the transmission space, the results of which are expected to garner several orders of magnitude improvement in RF resource utilization and therefore, aggregate information throughput. The research exploits optimization and orthogonality schemes as well as joint time-frequency transforms and waveform diversity that allow for multiple users while minimizing interference. This work was sponsored under an SBIR contract for the Air Force Research Laboratory, Rome Research Site and the Office of the Secretary of Defense, and the United States Congress.

The Beeches Professional Campus
One Beeches Place
7980 Turin Road, Bldg. 1
Rome, NY 13440-1934

ANDRO

Phone: (315) 334-1163
Fax: (315) 334-1397
Email: androcs@androcs.com

Dynamic Spectrum Management for Airborne Networking

Background. Current methods for RF Resource Management are confined to the realm of spectrum management. In this scheme, systems are generally assigned specific fixed pre-approved frequency bands for operation. Current command and control philosophy is mired in technologies and applications that date back over 90 years and derive from outdated narrowband, analog systems used in the early days of radio broadcasting. Current spectrum management policy underscores the point that spectrum is not scarce as much as it is inefficiently used. In reality, we are using less than 10% of the available spectrum at any one time, which means information is wasted. This inefficient use of the spectrum has led to the need for more effective and efficient tools that can provide for a "***paradigm shift***" in RF Spectrum Management. Current RF spectrum management policies have little relevance to today's digital architectures, wideband systems, dynamic networks and RF communications systems. Adaptability and flexibility across frequency, time, and other signal dimensions are necessary with today's technologies. Dynamic access and efficient RF resource management are essential to meeting future system needs. Another important aspect is the need for bridging the spectrum and network management domains to achieve *dynamic spectrum access networks*, which represents the new age of RF Resource Management. This issue of spectrum management inefficiency and better ways to harvest (exploit) spectrum have recently been in the national spotlight.

Summary. ANDRO Computational Solutions, LLC with locations in Rome, NY and at the DoD Joint Spectrum Center (JSC) facility in Annapolis, MD has developed new and novel algorithmic and computational techniques in the area of RF Resource Management for Advanced Cognitive Networks and Radios for potential applications to Airborne Networking and Communications systems.

ANDRO's new **"Transmission Hyperspace"** solution will enable the effective and efficient joint utilization of all orthogonal electromagnetic transmission resources described by a multi-dimensional resource space (i.e., assigned frequency, time, geographic space, modulation/code, polarization, signal power, energy beam direction, and other dimensions). In this notion of a multi-dimensional RF resource space, each dimension is assigned to every device that is enabled to allow orthogonality amongst users to maximize information throughput, data reliability and information sharing. Unused spectrum changing in *time* and *space* as well as other dimensions can then be controlled to preclude "collisions" that lead to suboptimal performance. Specially designed multiobjective optimization algorithms applied in a unique way are used at the network layer to achieve desired objectives such as enhancing information throughput, authorizing transmissions, denying access, assuring quality of service, reducing interference potential, etc. This approach considers and exploits the multi-dimensional nature of the transmission space and network protocol domain, the results of which are expected to garner several orders of magnitude improvement in RF resource utilization and therefore, aggregate information throughput. Initial results have shown information throughput enhancements approaching 100X.

Potential Applications. Ultimately, we will be able to effectively manage the information/data space and enhance communications efficiency by several orders of magnitude beyond today's capabilities, as well as ensure improved radio and mobile wireless device interoperability. One of the immediate potential applications of this technology can be to support the Advanced Airborne Networking (AAN) community in its efforts to institute Net-centric Operation, Objective Gateway (OG) and Enterprise Integration backbones for managing air, space and terrestrial layer communications and sensor assets. Additionally, this can lend itself to the generation of new *policy defined radio* standards as well as lead to a reformation (modernization) of national spectrum management policy. This is a "revolutionary" change in the way that the information and communications systems infrastructure will be managed in the future.

Benefits/Future Needs. This newly-evolving technology can lead to the development of next generation software and hardware technologies for the efficient utilization of the RF spectrum that can be applied to virtually any radio, sensor, or mobile wireless device and to ensure their seamless interoperability under any/all conditions. This will include: information assurance, information sharing, cyber security, operation of wireless complex networks, advanced network and radio communications systems interoperability, and newly evolving net-centric warrior and net-centric warfighter concepts that leverage the Global Information Grid (GIG) applied to the USAF's future Advanced Airborne Networking and the US Army's Future Combat Networking Systems. Agencies that are embracing this technology include the FCC, NTIA, DoD NII, DARPA, DoD Joint Spectrum Center (JSC), DHS and AFRL.

For further information contact:
Mr. Andrew Drozd at *adrozd@androcs.com* or by phone at (315) 334-1163.

The Beeches Professional Campus
One Beeches Place
7980 Turin Road, Bldg. 1
Rome, NY 13440-1934

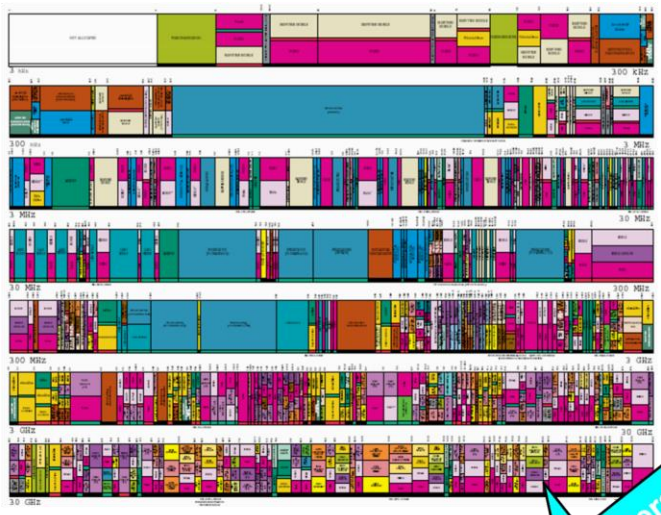
Phone: (315) 334-1163
Fax: (315) 334-1397
Email: androcs@androcs.com

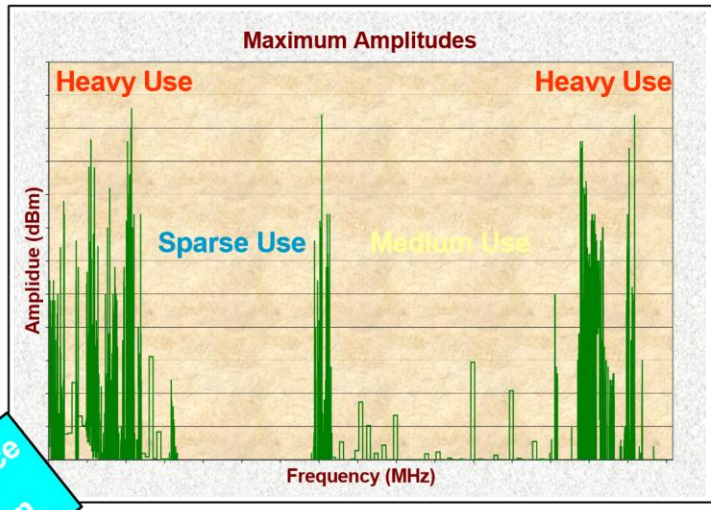
Dynamic Spectrum Access — New Directions

Transmission Hyperspace

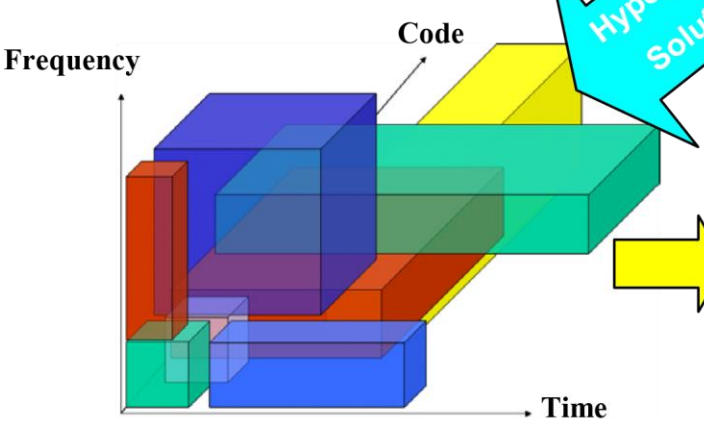
Developing the ***Technology*** and ***System Concepts*** to Harvest and Utilize Available Spectrum

All Spectrum May Be Assigned, But…Most Spectrum Is Unused!

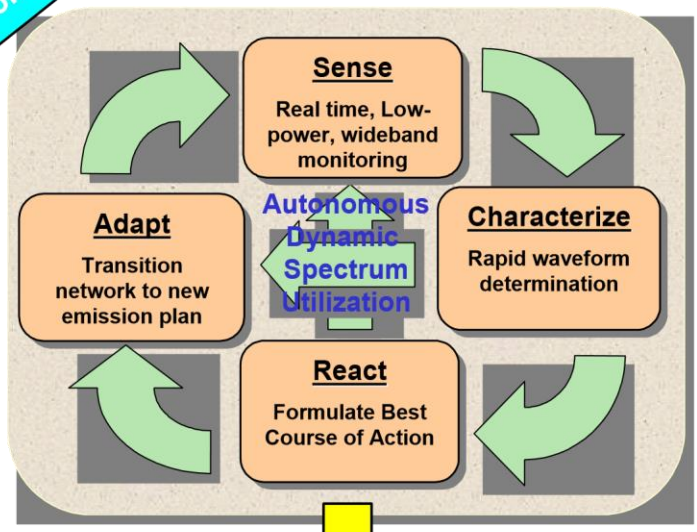




Hyperspace Solution



Transmission Hyperspace



Imagine a "cube" (in more than 3 dimensions) that constantly changes with "cells" of signals that have applied for, received, used, and returned, their transmission coordinates.
When you want to transmit, you ask for the coordinates, execute, and go off air.
Someone else fills in your cell and you get another one next time.
This represents a new direction on behalf of XG, Cognitive Radio & Networks, Policy-Defined Radio technologies and applications.

Approaching 100X+ Increase in Information Throughput

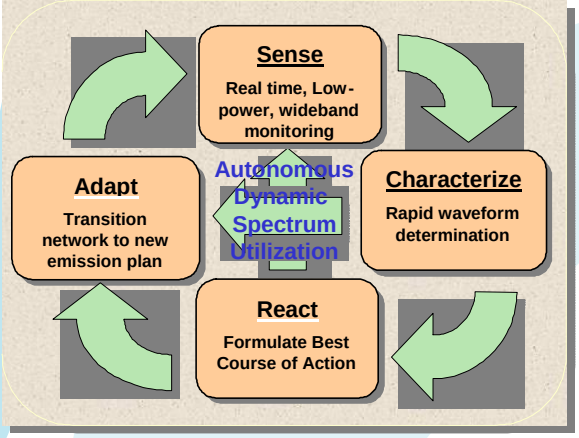
The Beeches Professional Campus
One Beeches Place
7980 Turin Road, Bldg. 1
Rome, NY 13440-1934

Phone: (315) 334-1163
Fax: (315) 334-1397
Email: androcs@androcs.com

Computational Electromagnetics Tools For Assessing Cognitive Networks & Radios

Key Capabilities:

- Dynamic Spectrum Management



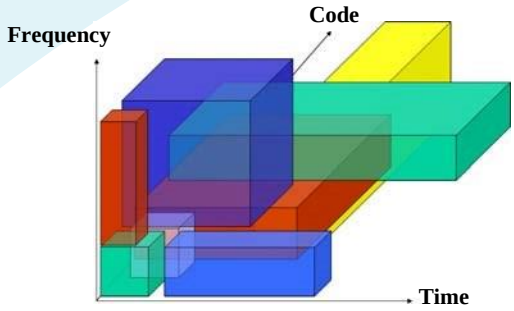
- Modeling & Simulation
  - Physical/Network Layer Modeling
  - *Systems of Systems* EM Analysis
- Co/Inter-Site EM Interference Prediction
- Antenna/Platform EM Effects
- Integrated C2 for Air, Space & Cyber

Customers & Users:

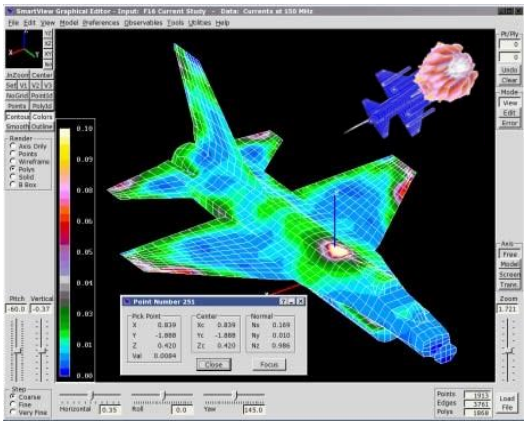
- DoD & Other Gov't
  - US Air Force/AFRL & AFSEO
  - US Navy, US Army
  - Joint Spectrum Center
  - Missile Defense Agency
  - NASA
- Commercial
  - ITT, Raytheon, Rockwell Collins ,Northrop Grumman
  - Lockheed Martin (F-35 JSF Program)
- International
  - Australian Military Defence
  - German Air Defence (EADS)
  - Israeli Air Force

Core Technologies & Products:

- *Transmission Hyperspace Optimizer*



- *E3Expert* Modeling & Simulation Toolkit



Benefits—Technology Enablers for:

- Efficient RF Resource Management
- Interoperable Communications
- Robust Information & Sensor Net Connectivity
- Cognitive Networking
- EM Interference Management
- Information Assurance
- Integrated C2 & Cyber Security

Training: *ANDRO provides Training in our E^{3}Expert and spectrum management analysis tools for users worldwide.*

The Beeches Professional Campus
One Beeches Place
7980 Turin Road, Bldg. 1
Rome, NY 13440-1934

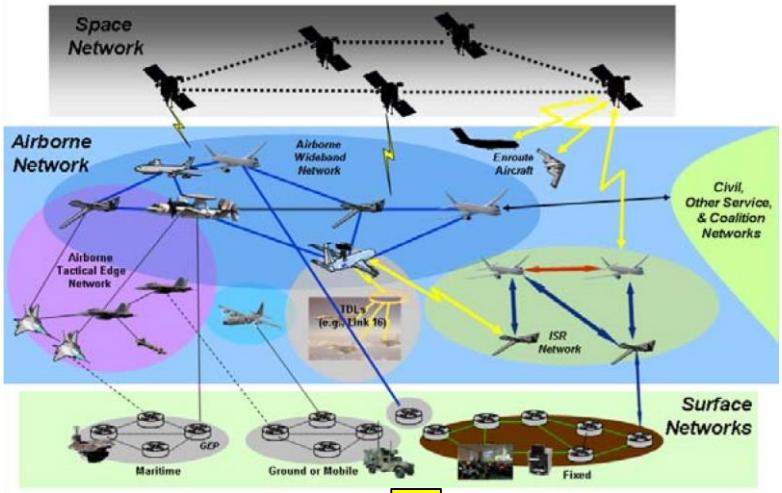
Phone: (315) 334-1163
Fax: (315) 334-1397
Email: androcs@androcs.com

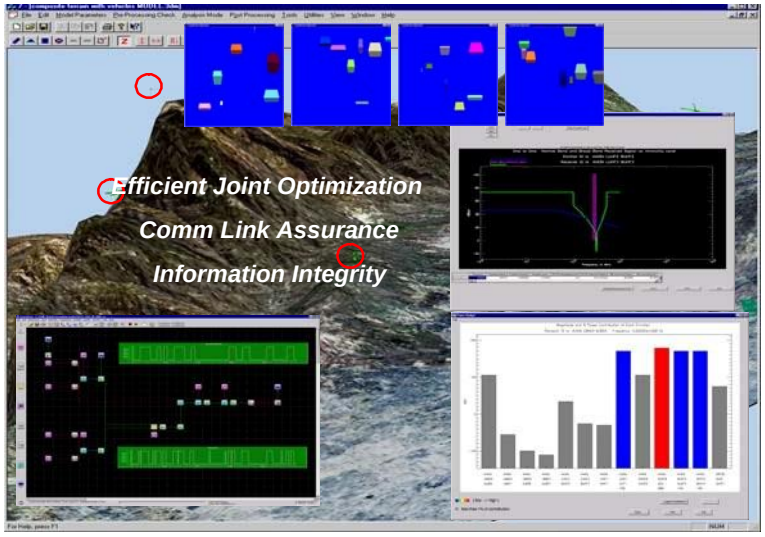
Electromagnetic Effects Analysis

The Problem:

Advanced Airborne Networks and Cross Domain Applications Need to Account for Spectrum Management/Sharing Policies and Constraints for:

- Non-interference-limited connectivity
- High information-sharing capacity
- High data reliability and throughput
- Cyber-secure cognitive networking

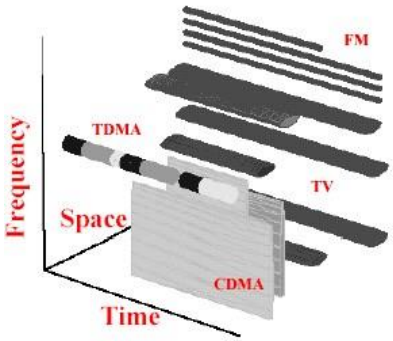


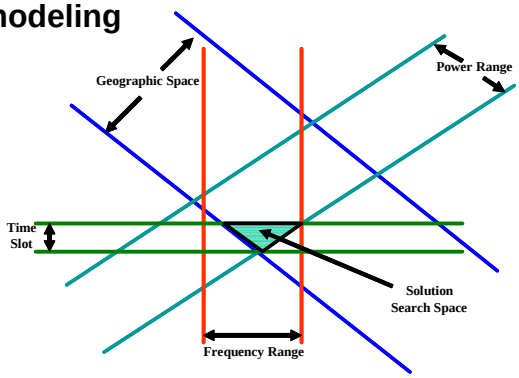


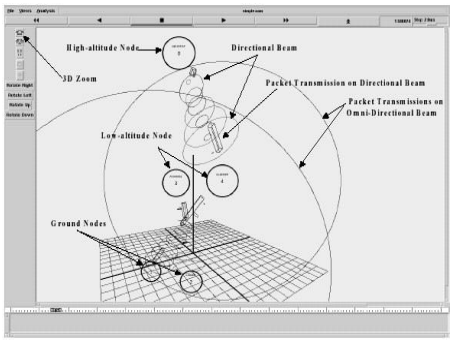
Approach: Modeling & Simulation

- Physical/network layer analysis
- Connectivity analysis
- MANET simulations
- Compute optimal solution for interference-free operation (*Transmission Hyperspace*)
- Bridging the physical and network layers

Physical layer modeling







Transmission Hyperspace approach → **Computing optimal solutions** → **MANET/Connectivity analysis**

Bridging physical layer to network domain

Results:

Interference-free cognitive networking and mobile wireless device inter-operability using optimized spectrum sharing schemes for airborne networking applications!