EW asset optimization/management
Effects based operations

Gregory Gerten
Analytical Graphics Inc.

Scott Woyak
Phoenix Integration

This Presentation is Approved for Public Release

Derived from: Internet sources

October 29th, 2007
Electronic Warfare is broken into three “stove pipes” – EA, EP, ES. Each segment is concentrated on “their effect” – not “system.” Effects based operations ensures maximum effect to the enemy, minimal effect to allied forces including intra-force fratricide.

**Optimization** (mathematics): trying to find maxima and minima of a function.
Agenda

Segment modeling
- Electronic Attack
- Electronic Protection
- Electronic Support

Effects based operations
- Navigation warfare
- Urban warfare
- Campaign analysis - MCOs

Mission based operations
- JCREW
- COTM
- AEA

Example of EW Optimization

Summary
Electronic Attack - EA

• Create an “effect” on (red) user equipment
  – “Surgical” Denial – full spectrum
  – “Undetected” Deception techniques

• Need to be able to…
  – Know effectiveness on enemy
  – Understand enemy’s effect on us
  – Predict fratricide on friendly’s

• Optimize placement / orientation / spectrum / techniques
  – Maximize effect on red
  – Minimize effect on blue/grey
Electronic Protection - EP

- 4D electronically steered arrays (ESA) gain modeling
  - Controlled reception pattern antenna (CRPA) \( \Delta t \)
  - Or fixed null/beams

- User (filtering) and signal processing (spectral) capabilities

- Sources signal power, bandwidth/frequency, and modulation/structure/encryption (TDMA, CDMA, xSK, etc.)

- Optimization of ingress/egress routes (Position / Orientation), spectral parameters, antenna types and placement
Electronic Support - ES

- 4D detection of EO, IR, RF and geolocation of these sources
  - Detection of signals
  - Location estimation
  - Fusion of multi-platform data

- TDoA, FDoA, AoA, PoA…
  - Denial threats
  - Deception threats
  - Friendly sources

- Optimization of collection routes / profiles (multi-ship) / orientation / antenna types and placement
Environmental effects

- Accuracy errors due to the environment
  - Terrain (DTED)
  - Ionosphere
  - Obscura / Multipath
  - Weather models
Optimization of effects

- Monte-Carlo simulation
  - Add probability density f(x)
  - Run multiple iterations
  - Collect statistical results

- Optimization methods
  - Gradient
  - Adaptive Surrogate
  - Genetic

- Outputs
  - Best solution
  - Carpet plots
  - Data from every run
Analysis outputs

Link budget reports and graphs

RF Coverage 2D/3D

Tip-offs and visual cues
Agenda

Segment modeling
- Electronic Attack
- Electronic Protection
- Electronic Support

Mission based operations
- JCREW
- COTM
- AEA

Effects based operations
- Navwar
- Urban warfare
- Campaign analysis - MCOs

Example of EW Optimization

Summary
JCREW Operations

• High level goals
  – Detect IED signatures
  – Ensure denial of enemy systems
  – Trigger prior to arrival

• Methods to achieve goal
  – Ground based - Convoy support
  – Airborne support
  – Intelligence data

• Fratricide possibilities
  – Navigation system “went offline” when in the “ON” position
  – Communication systems “went down momentarily”
  – “We blew up our ESM system”
Communications On The Move

• Dynamic geometry
  – Vehicle movement
  – Antenna pointing
  – Obscurations

• Comm link activity
  – System loading
  – Jamming / Noise
  – Dynamic re-routing

• System of Systems mobile ad-hoc networks
  – Integrated battlespace of “hot-spots”
  – Data shared locally as well as through the GIG
  – No longer dedicated circuits, now IP, many-of-many nodes
• Advanced system capabilities
  – “You name it – we can make it”
  – Combined EA/EP/ES system
  – Not just a “bigger electron basher”

• Divides roles and responsibilities
  – Stand-off jamming
  – Stand-in jamming
  – Escort and close-in

• Who, what, when, where
  – Need to schedule complex EOB
  – By scheduling “effects” from assets
  – EW optimizer would be nice
Segment modeling
- Electronic Attack
- Electronic Protection
- Electronic Support

Mission based operations
- JCREW
- COTM
- AEA

Effects based operations
- Navwar
- Urban warfare
- Campaign analysis - MCOs

Example of EW Optimization

Summary
• Navigation techniques
  – GNSS – space and ground
  – Inertial navigation system (INS)
  – Clocks, barometers, other sensors

• GPS may be vulnerable
  – Its easy, accurate/precise, and cheap
  – Weak signal from space and near/far problem
  – Jamming is easy (“so simple it hertz”)

• GPS used for more than position
  – GPS provide position, velocity and time
  – Doppler (aka velocity) used by many sensors
  – Time (nsec) used by many onboard systems
Urban Warfare

• “What is LOS”?
  – Little to no line of site (LOS)
  – Multipath – good and bad
  – Signal blockage and attenuation

• N-dimensional problem
  – No longer just 4D (x,y,z,t)
  – Depends on number of bounces
  – Depends on complexity of “model”

• More than one signal
  – Multiple signals of interest
  – Jammer / threat signals
  – Other “background” signals
Campaign analysis - MCOs

- Problems on steroids
  - Multiple forces (NATO)
  - All with EA/ES/EP
  - STANAG is a start

- $X^Y$ growth in complexity
  - No longer just denial assets
  - SAPs foster stove pipes
  - Left/right hand problem

- Joint services headache
  - Procurement per service
  - Requirements per SPO
  - Complaints/Needs per “CAOC”
Agenda

Segment modeling
- Electronic Attack
- Electronic Protection
- Electronic Support

Mission based operations
- JCREW
- COTM
- AEA

Effects based operations
- Navwar
- Urban warfare
- Campaign analysis - MCOs

Example of EW Optimization

Summary
Example of EW Optimization

• Variables to optimize
  – Position/Orientation of all players over time
  – Systems used (antennas/Tx/Rx/etc)
  – Spectral / signal parameters

• Constraints to choose
  – At-least this effect “there”
  – Maximize effect “here”
  – Minimize effect “there”

• Solution “space”
  – Heard of chaos theory?
  – Makes fractals look fun
  – Can there only be one?

Abbreviated steps:
1. Create AOI / targets
2. Create/import players
3. Set players positions/routes
4. Select optimization criteria
5. Run optimizer / view results
Summary

Leverage efforts across community
Program collaboration and risk reduction
EW trades and system optimization
Requirement validation and analysis
Perform effects based selection

EW asset optimization via effects based operations

- Measures of Performance
- J/S, Availability, Coverage
- Measures of Effectiveness
- Range Errors, CEP

Performance Attributes

You can do it!

---

Greg Gerten
ggerten@agi.com
(610) 653-8626
Hardware in-the-loop Simulation

Transfers the M&S scenario data/inputs into actual hardware to simulate test conditions and collect this data to determine system performance in real-time.

- Perform M&S
  - Bound the problem space
  - Create test scenarios
  - Transfer test parameters to the hardware

- Hardware
  - Import simulation parameters
  - Create signals (power, frequency, phasing, etc.)
  - Combine signals and pass to hardware under test
  - Send truth data to simulation

- Quick look Visualization
  - Import data feeds
    - Truth
    - Test Hardware
  - Calculate RT differences
  - Visualize entire scenario including environment
Communication Systems

- Modeling a transmitter
  - Frequency, Power, Data Rate, Modulation
  - Antenna, Polarization, Gains
Communication Systems

• Modeling a Receiver
  – Frequency
  – Bandwidth
  – Antenna
  – Polarization
  – Gains
Communication Environment

- Taking environment into account
  - Terrain, Urban, Masking
  - Rain, Cloud, and Fog
  - Gaseous Absorption
  - Tropospheric, Plug-ins