

Understanding & Managing Chaotic ECM Evaluation Results

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Presentation Outline

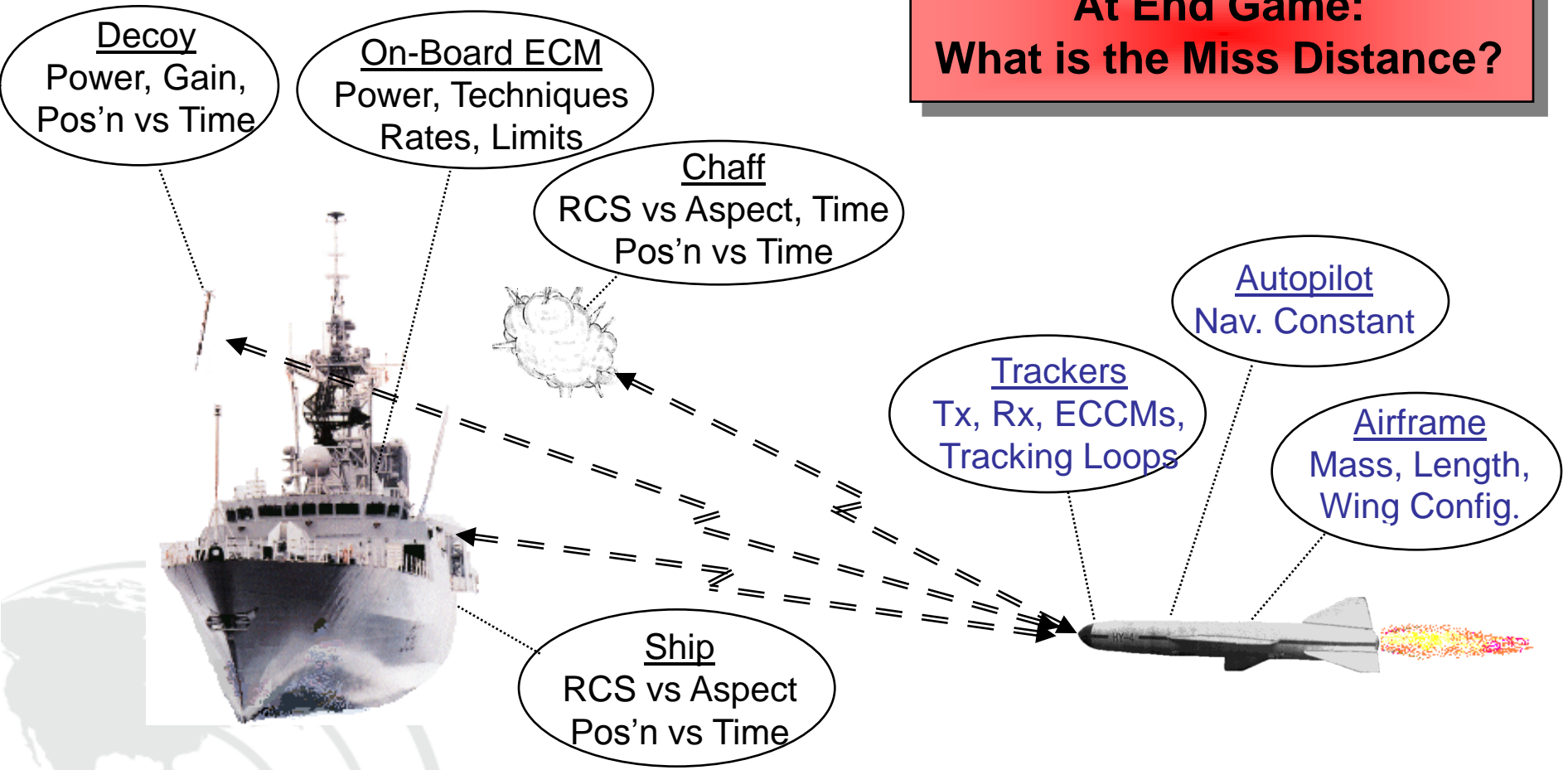
- A Brief History Of ECM System Effectiveness Test Results
- Typical ECM Test Result Variance
- Non-Linear ECM and Weapon System Interactions
- Impact of Non-Linear Interactions On Results
- Managing Chaotic Test Result Behaviour

A Brief History

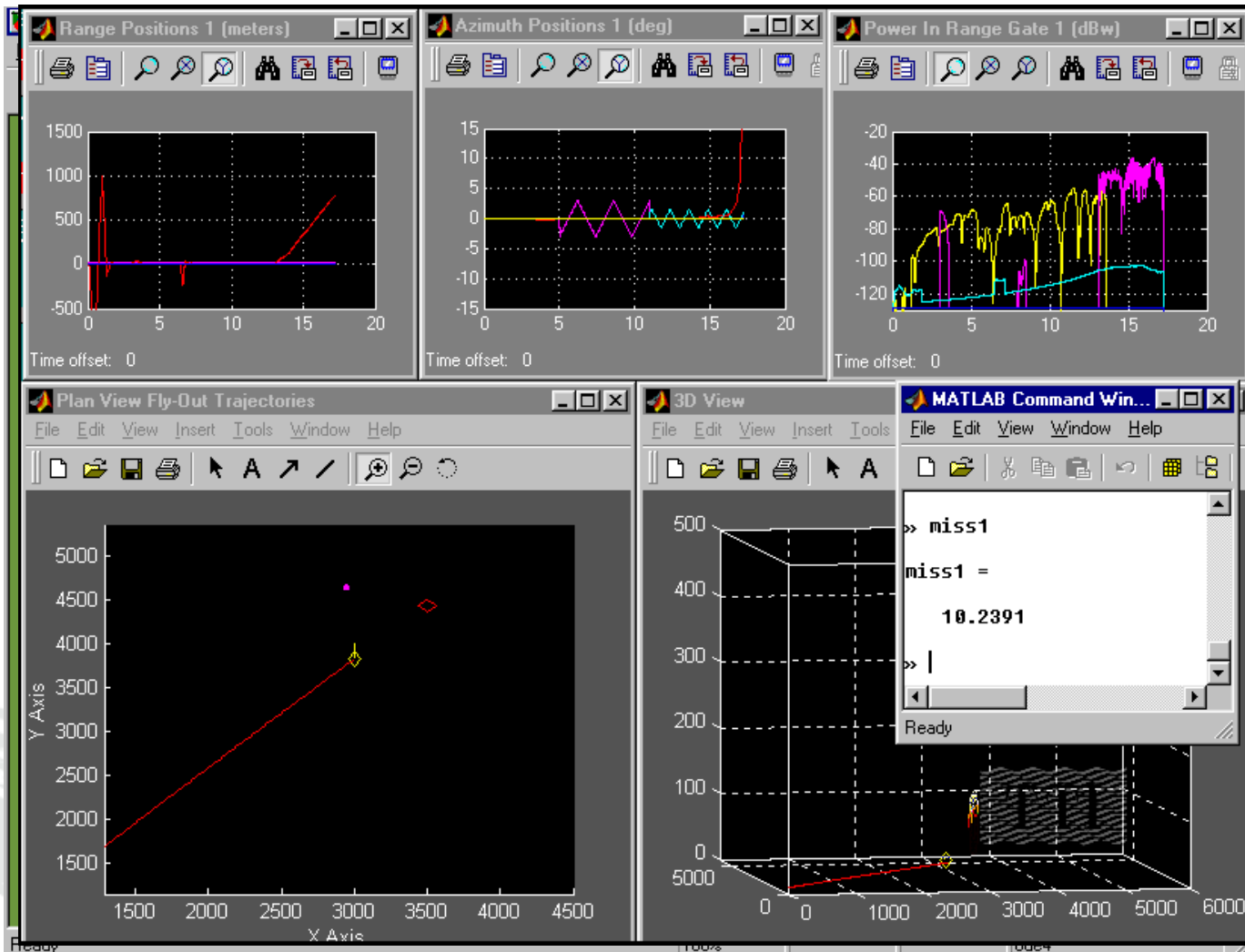
- AN/SLQ-32 Ship Protection
 - “Modifications Have Been Made At A Cost Of Over \$300 Million But The AN/SLQ-32’s Effectiveness Remains Questionable”
 - “Inadequate Testing Lead to Faulty SLQ-32 On Ships”
 - GAO/NSAID Report 93-272, 1993
- ALQ-165 Naval Aircraft Protection
 - “Key performance criteria for effectiveness were not met”
 - “Can not certify ALQ-165 (ASPJ) is effective against original requirement”
 - “The ASPJ was not operationally effective because it did not meet the requirement threshold value for increasing the survivability of an ASPJ equipped F/A-18 strike force”
 - DOT&E 1996 Annual Report
- ***Such Results Indicate Problems in Testing Jammers to Demonstrate That Their Effectiveness Meets Requirements***

ECM Performance Testing

**At End Game:
What is the Miss Distance?**



ECM Test Result Variance

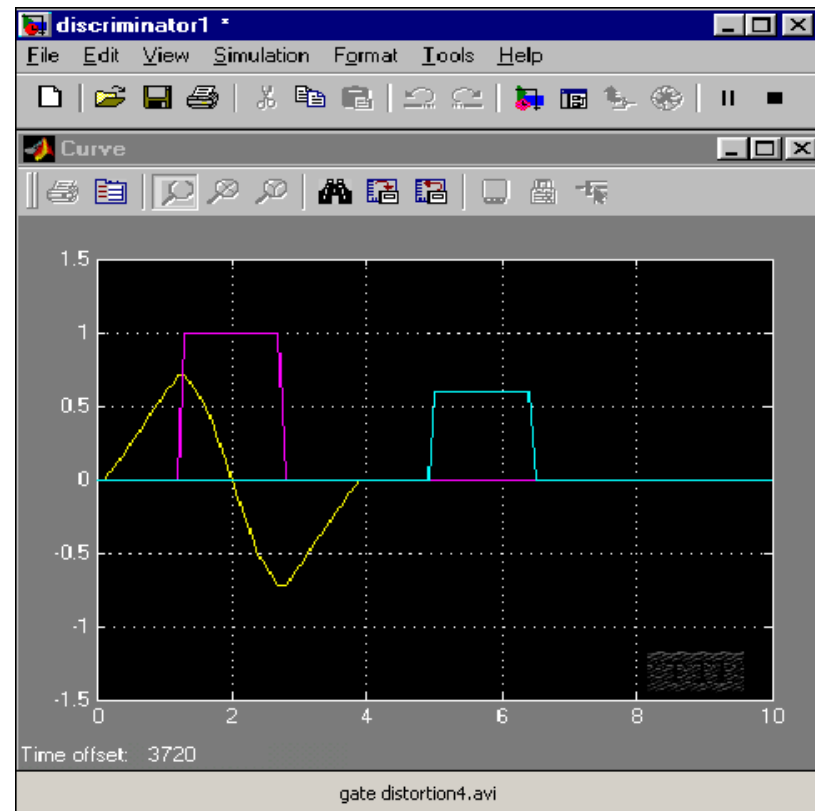


ECM Test Result Variance

Range Servo BW (Hz)	Angle Servo BW (Hz)	Miss Distance (m)
0.75	0.5	135
0.75	0.75	63
0.5	0.75	100
0.5	0.5	147
0.4	0.5	10

Non-Linear ECM & Weapon System Interactions

Demonstration Of Radar's
Range Tracking
Discriminator Distortion
With Range Gate Pull Off

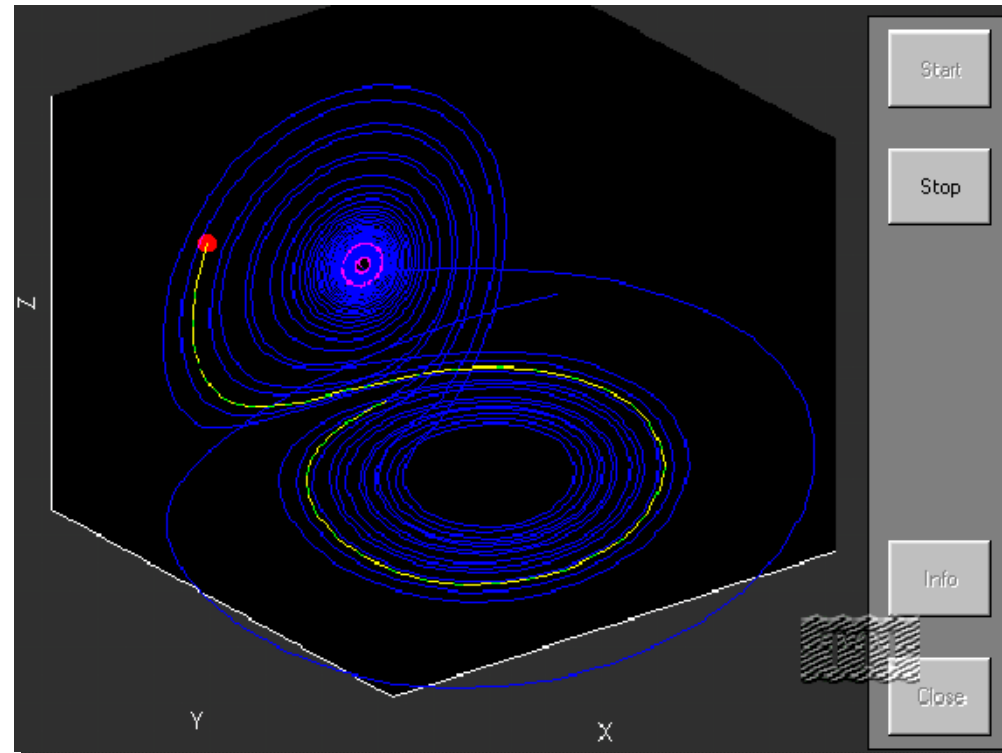


Missile Miss Distance & Chaos

- Missile Miss Distance Occurs After ***Extended Dynamic Interactions*** Between ECM And Weapon Systems
- Weapon Systems Contain Many ***Non-Linear Functions*** and Components, Such as Radar Mode Switching and Tracking Discriminators
- ECM Signals Inherently Cause Radars To Operate In Non-Linear Regions And With Non-Linear Logic And Functions
- Extended Dynamic Interactions Between Non-Linear Systems Inherently Gives Rise to ***Chaotic Behavior***
- Chaotic Behavior Means a ***Small Change in an Input Condition or Parameter Can Lead To a Large Change in Miss Distance***

What Is Chaotic Behaviour?

- Noticed by Lorenz in weather prediction studies
- Plot trajectory depends on initial conditions
- May possess “Quasi- Stable Regions”
- Plot trajectory is not repetitive
- May possess multiple “Strange Attractors”
- Final result depends on duration of interaction
- Caused by ***non-linearities in extended dynamic interactions***



Technical work reported on the impact of non-linear interactions in extended engagements:

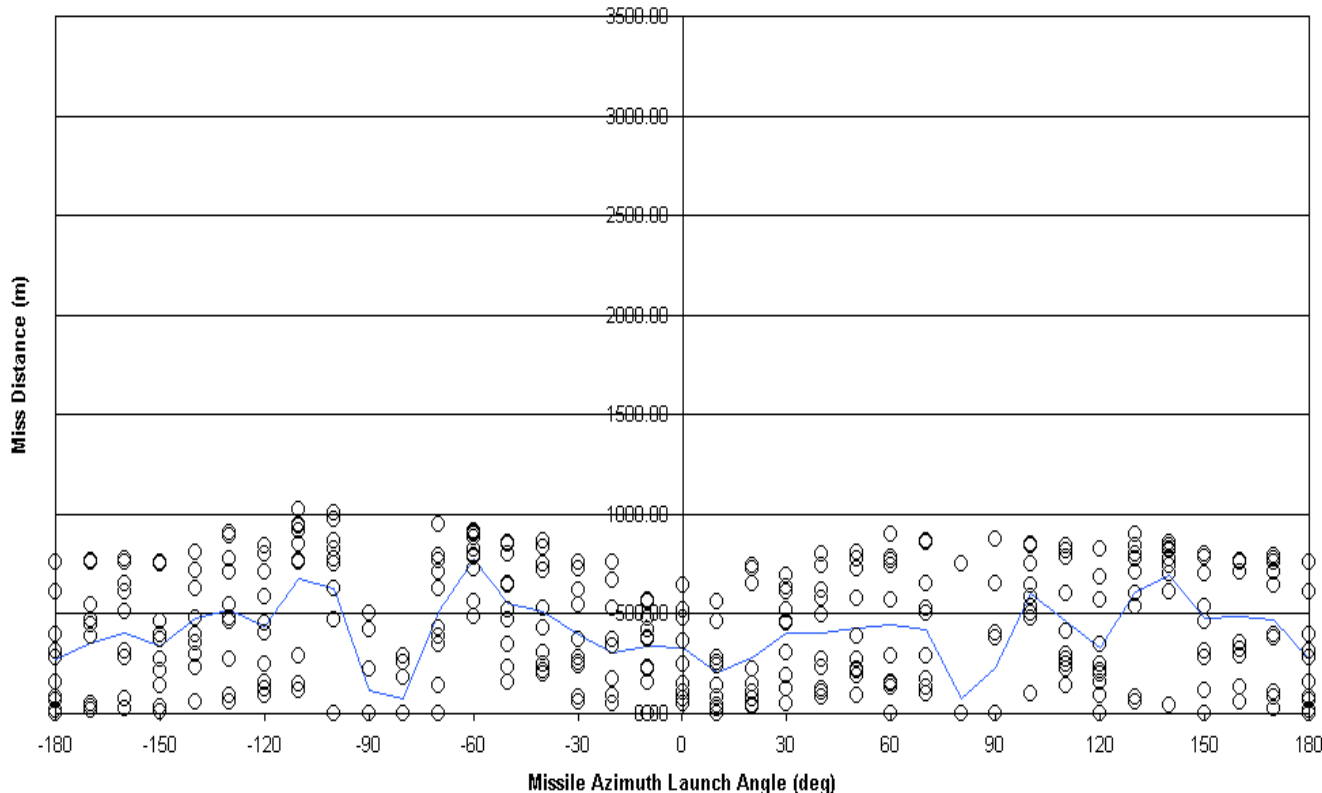
*On Threat Analysis,
On Simulation Validation,
On ECM Test and Evaluation*

➤ **One Only**

Seduction Chaff Effectiveness Test Result Variance

Miss Distance Scatter vs Missile Launch Angle

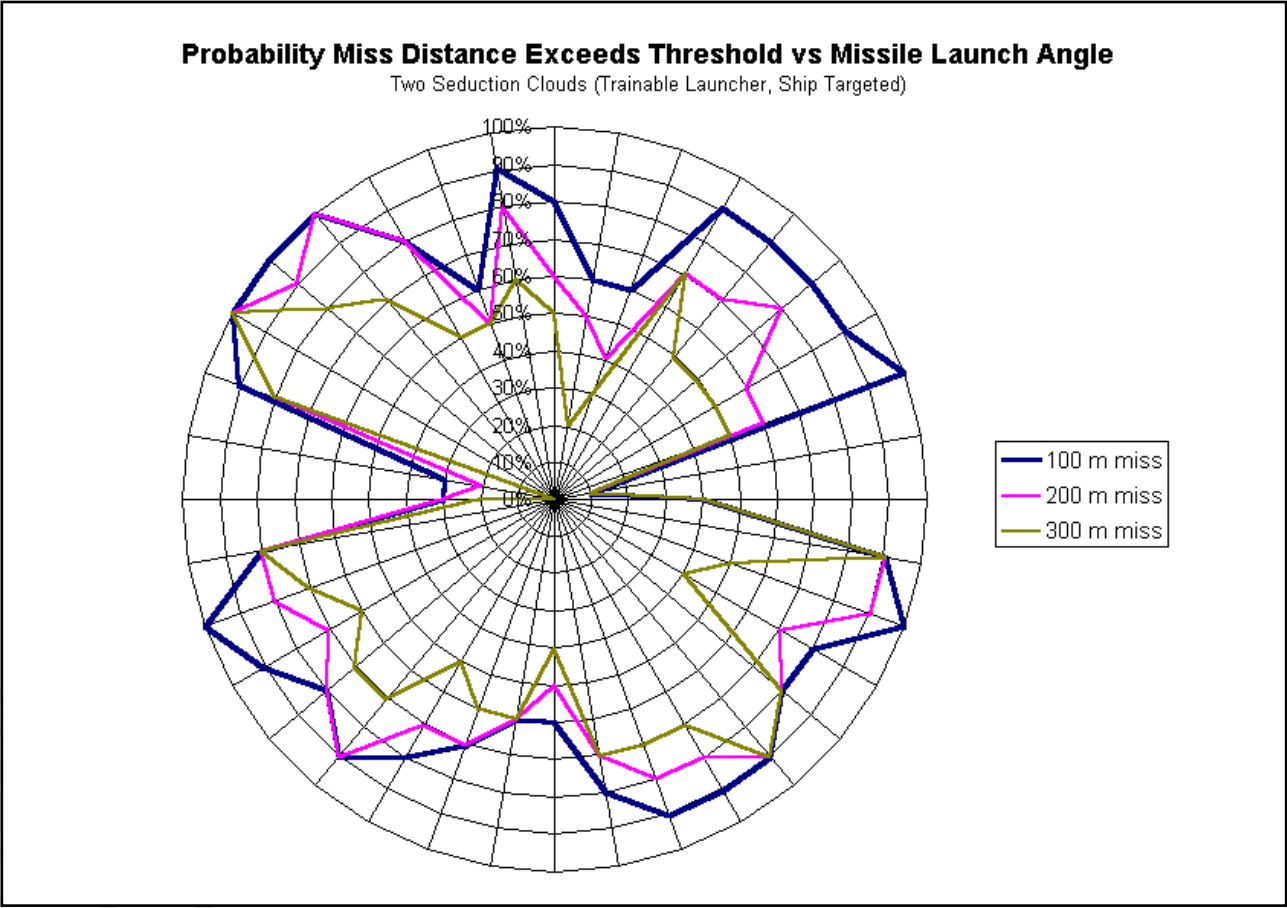
Two Seduction Clouds (Trainable Launcher, Ship Targeted)



Monte Carlo Parameters:

- Wind Speed
- Wind Direction
- Missile Turn-On Range
- Missile Yaw At Turn-On

Plotting Seduction Chaff Effectiveness



Plotting ECM Effectiveness

- Plot Miss Distance Scatter Data So That The Probability (Percentage Of Runs) Miss Distance Exceeds Pre-Selected Thresholds As A Function Of Missile Azimuth Launch Angle.
- Provides A Means To:
 - Develop Effectiveness Requirements Specifications
 - Develop Equipment Test Procedures Based on Effectiveness Specifications
 - Develop Chaff Deployment Tactics
 - Develop Ship Maneuver Tactics

Minimize Chaotic ECM Effects By:

- Conducting batch simulation runs of dynamic engagements using Monte Carlo selection of threat, ECM and engagement parameters
- Including the characterization of threat subsystems with non-linearities and narrow threat parameter ranges (within the available characterization methods)
- Including simulation-based knowledge of the impact of threat system non-linearities on the outcome of ECM engagements
- Validating models to confirm they simulate realistic non-linear & chaotic behavior

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The Beginning