

# Understanding & Managing Chaotic ECM Evaluation Results

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Dr. T.W. Tucker

Tactical Technologies Inc.

356 Woodroffe Ave.

Ottawa, Ontario, K2A 3V6

Tel: (613) 828-0775, e-mail: [info@tti-ecm.com](mailto:info@tti-ecm.com) URL: [www.tti-ecm.com](http://www.tti-ecm.com)

# Presentation Outline

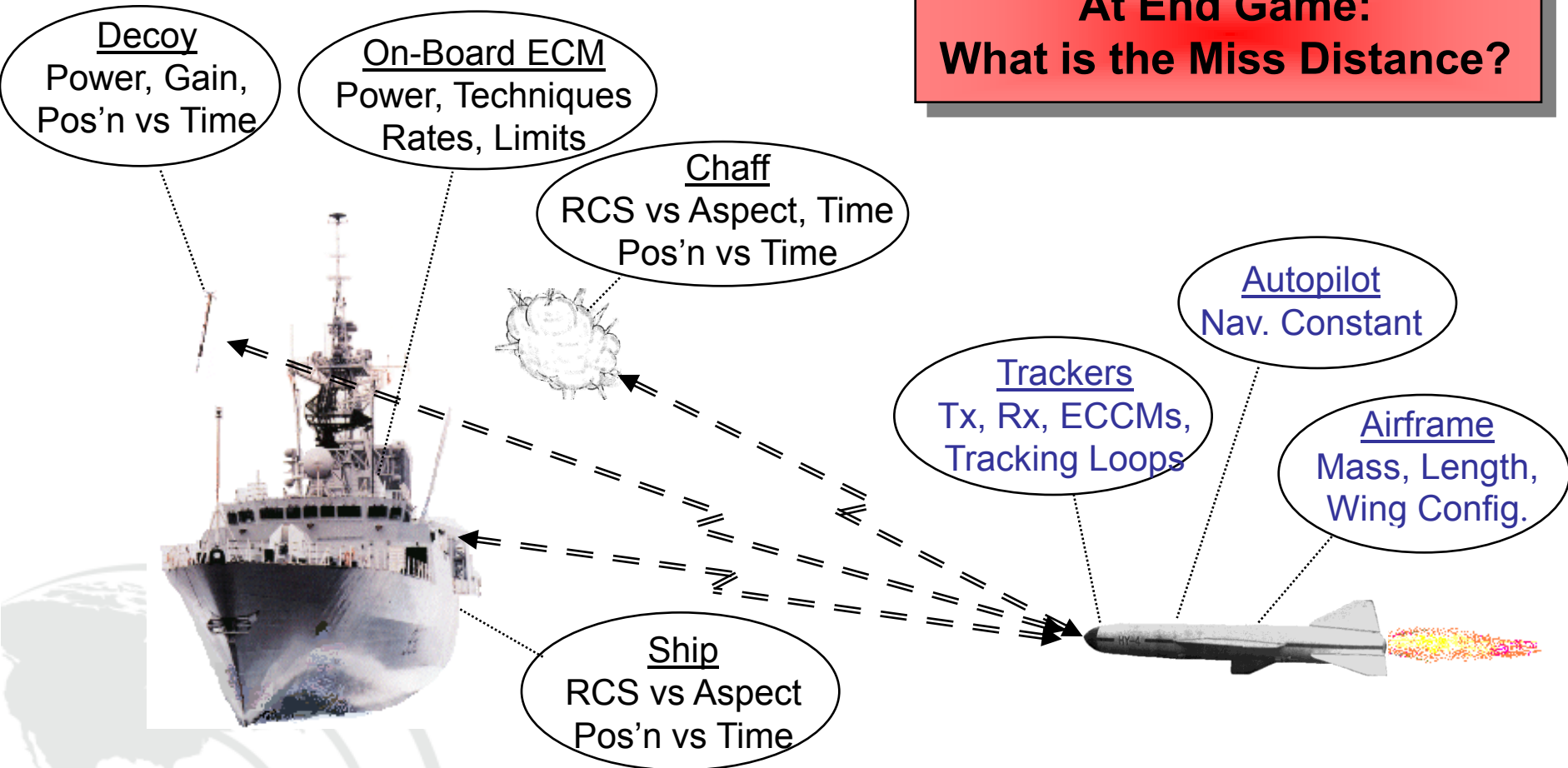
- A Brief History Of ECM System Effectiveness Test Results
- Typical ECM Test Result Variance
- Non-Linear ECM and Weapon System Interactions
- Impact of Non-Linear Interactions On Results
- Managing Chaotic Test Result Behaviour

# A Brief History

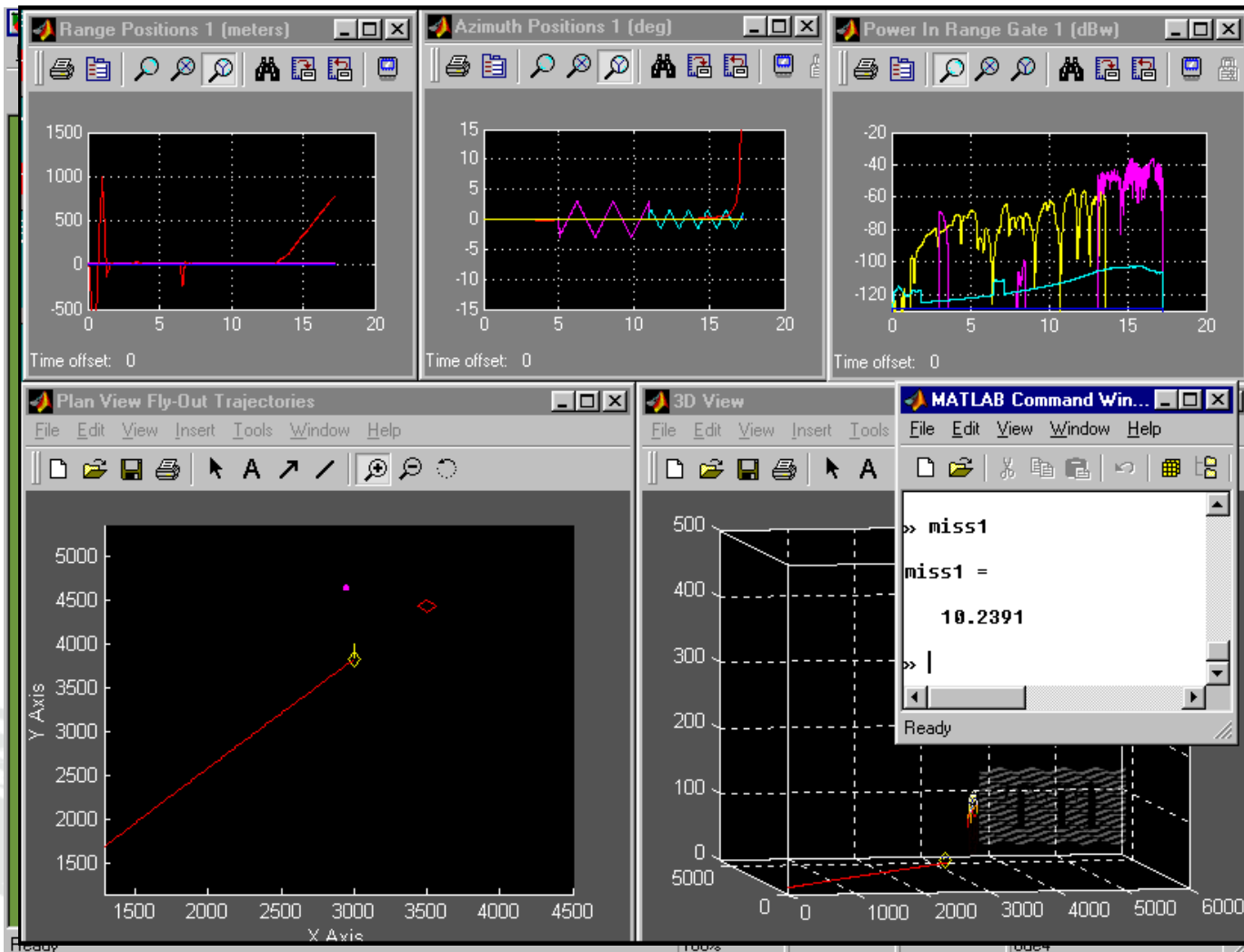
- AN/SLQ-32 Ship Protection
  - “Modifications Have Been Made At A Cost Of Over \$300 Million But The AN/SLQ-32’s Effectiveness Remains Questionable”
  - “Inadequate Testing Lead to Faulty SLQ-32 On Ships”
  - GAO/NSAID Report 93-272, 1993
- ALQ-165 Naval Aircraft Protection
  - “Key performance criteria 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

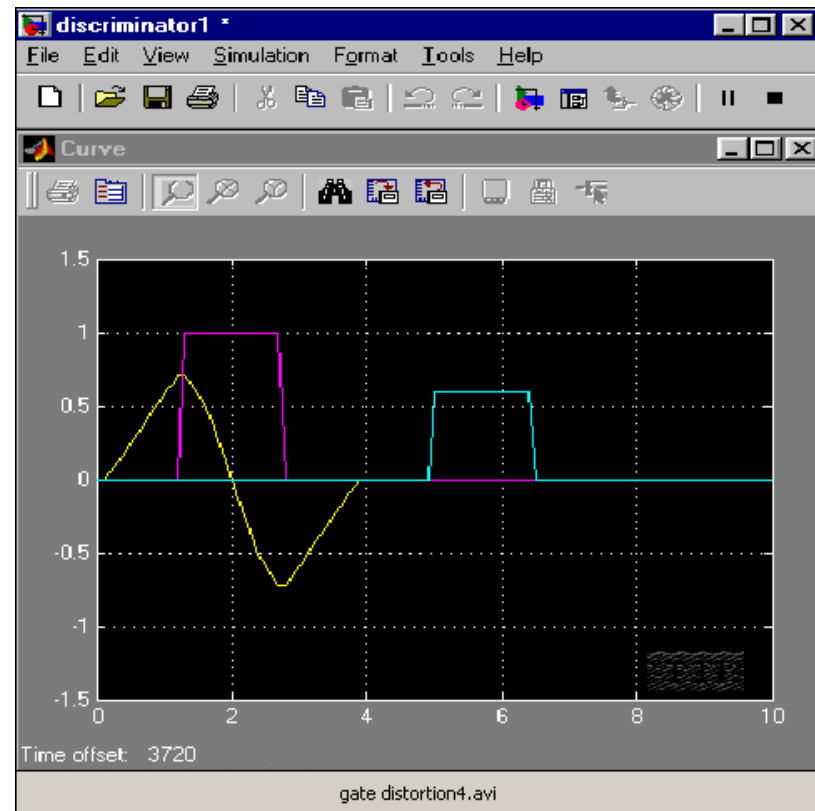


# ECM Test Result Variance

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



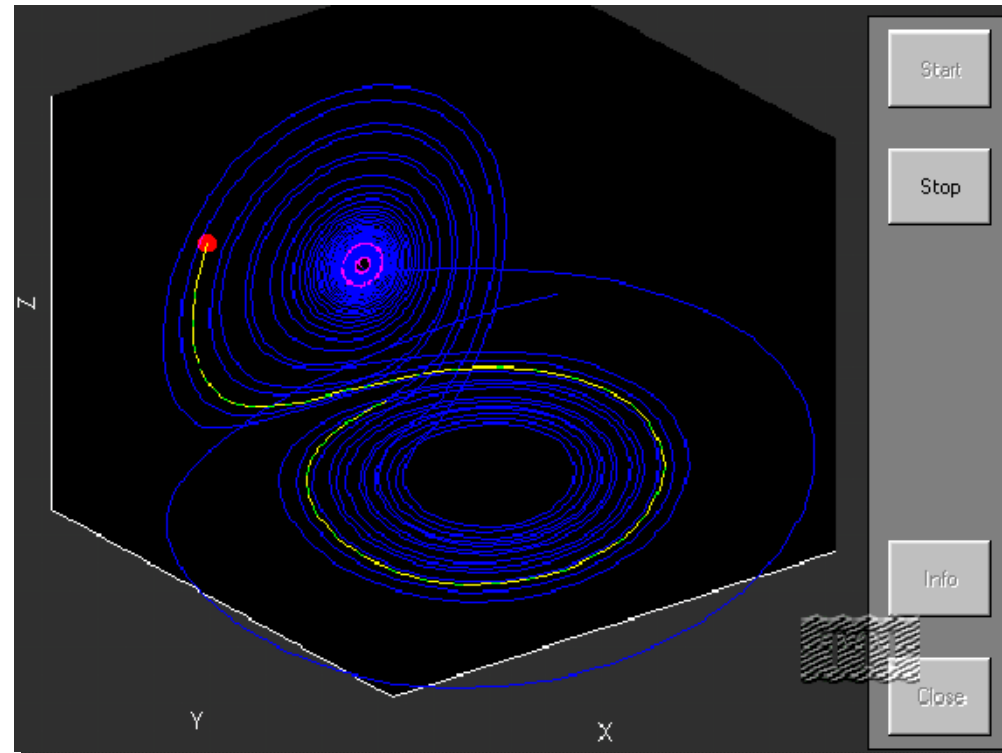
# Missile Miss Distance & Chaos

- 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:

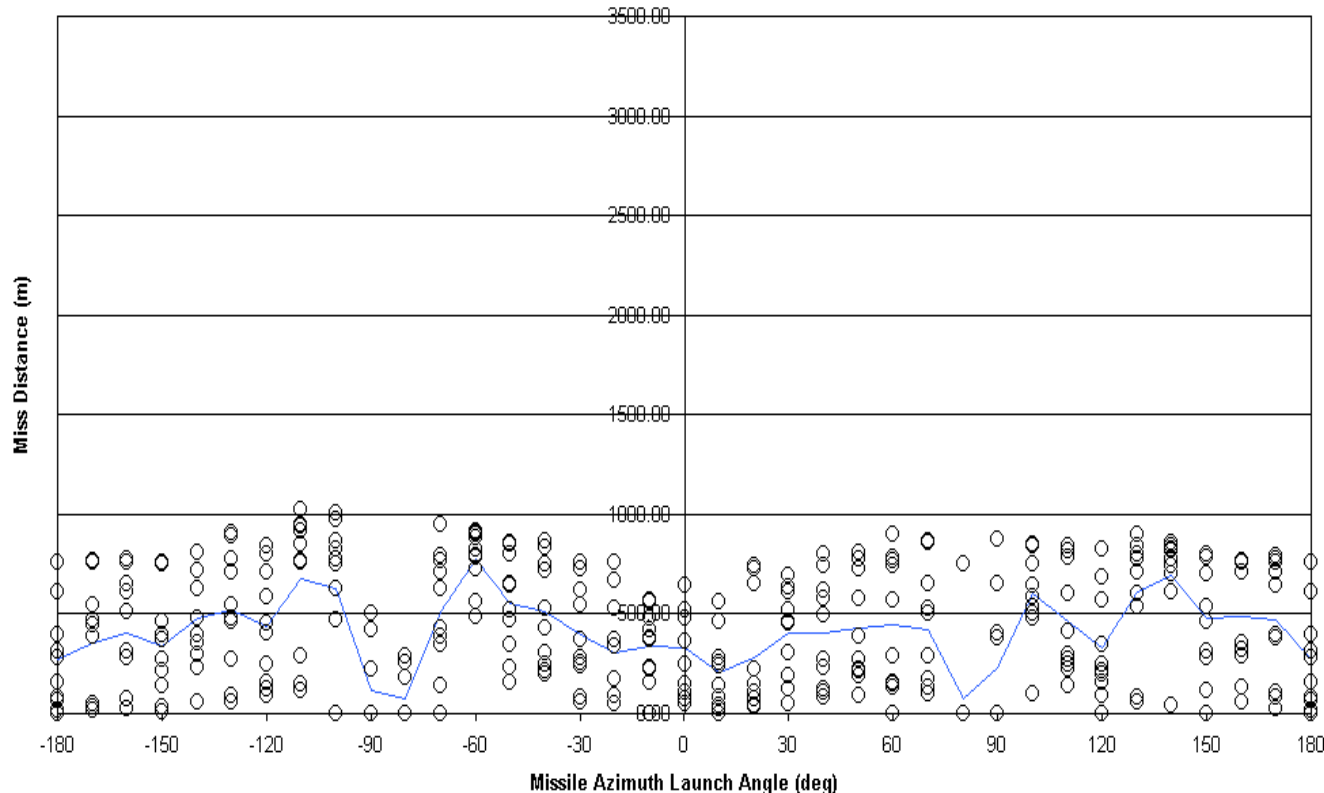
*On Threat Analysis,  
On Simulation Validation,  
On ECM Test and Evaluation*

➤ **One Only**

# Seduction Chaff Effectiveness Test Result Variance

**Miss Distance Scatter vs Missile Launch Angle**

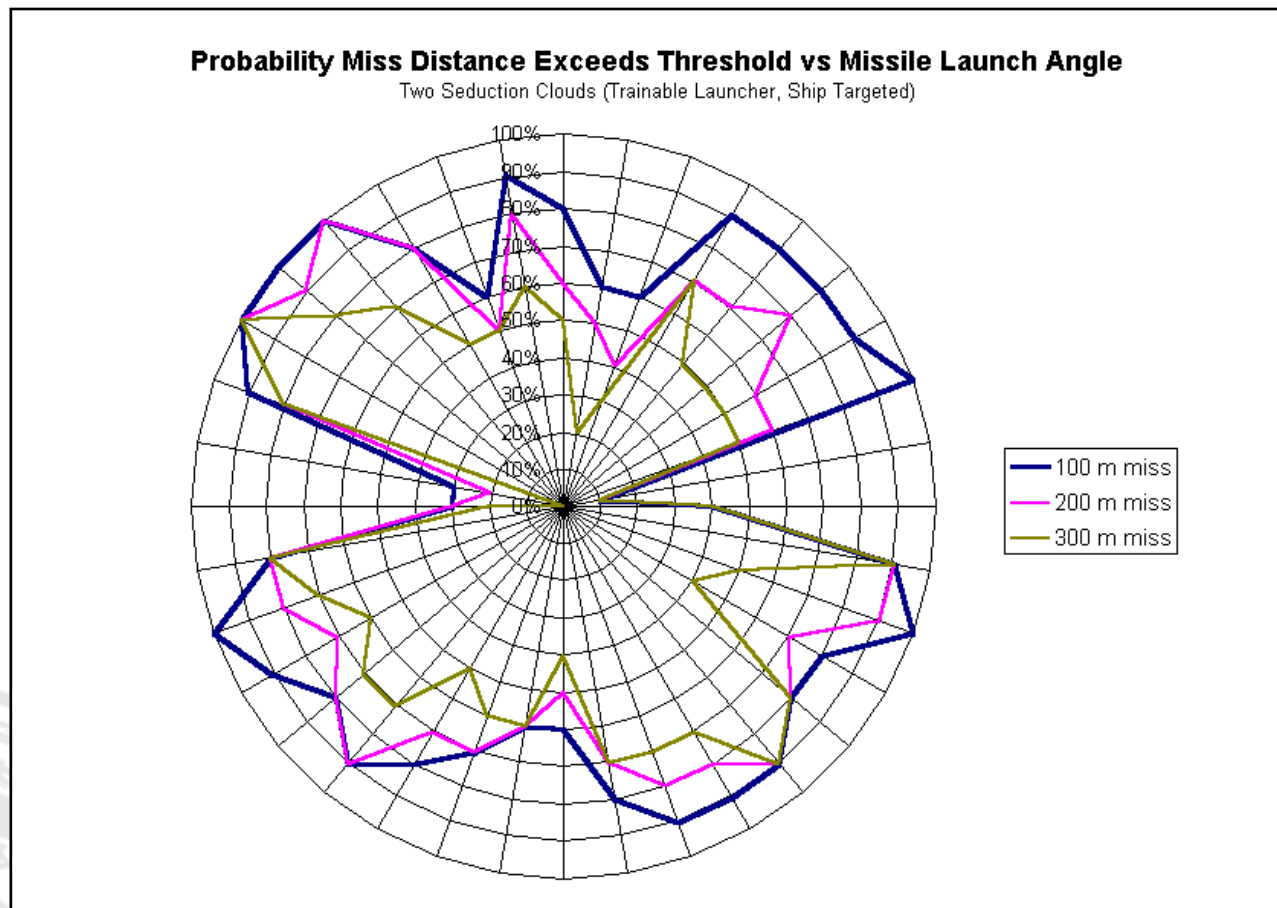
Two Seduction Clouds (Trainable Launcher, Ship Targeted)



## 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