



# *Evaluating Airliner MANPADS Protection*

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- | Engagement Characterization
- | MANPADS Characteristics
- | DIRCM Modulation For Success
- | DIRCM vs MANPADS Simulations
- | Flares vs MANPADS Simulations



# Engagement Characterization



- | Threat Weapon: Guidance and Dynamics
- | Target Platform: Signature and Maneuver
- | Countermeasures: Techniques and Tactics
- | Propagation: Attenuation vs Wavelength
- | Background Clutter
- | Engagement Geometry
- | Simulation Involves About 250 Parameters

# *Engagement Scenarios*



- | Wide Body Aircraft
  - Four Engines
  - In Take-off, Climbing at  $10^0$
  - Speed 100 m/sec,
  - AC Altitude at Missile Launch: 400 m
  
- | Missile Launch
  - Launch Range 1.4 Km
  - Terminal Velocity 600 m/s

# MANPADS Characteristics



Threat	Wave Band (microns)	Tracking Technique	Reference
SA-7 Grail	1.9-2.8 (uncooled)	<b>Spin Scan</b> (Amplitude)	Fischer et al, JED, Jan 04 Zaloga, Janes Pub, 1988
SA-14 Gremlin	1.9-4.1 (cooled)	Con Scan (Frequency)	Fischer et al, JED, Jan 04 <a href="http://encyclopedia.thefreedictionary.com/SA-14">http://encyclopedia.thefreedictionary.com/SA-14</a>
SA-16 Gimlet	2-3 & 3-5 (two colour discrimination)	Con Scan? (Frequency)	OPFOR Battle Book, Mar 98, Ch 3
SA-18 Grouse	2-3 & 3-5 (ECCM - colour discrimination)	<b>Rosette?</b>	Grossman et al, Rand Study, #1713

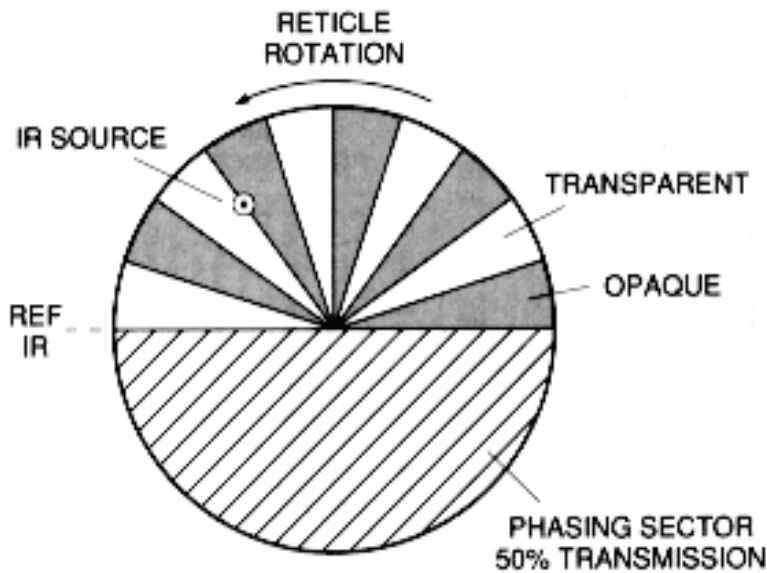


# Spin Scan Tracker

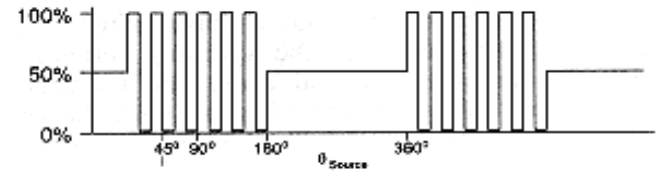


## Target Detection and Tracking

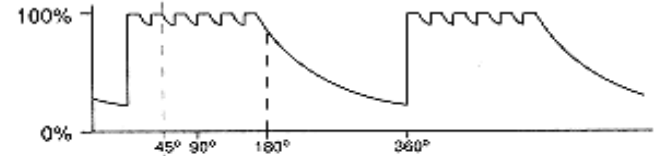
### Spinning Reticle



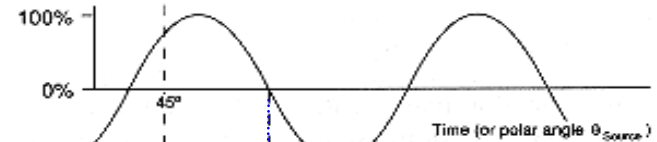
1) Carrier (chopped) signal:



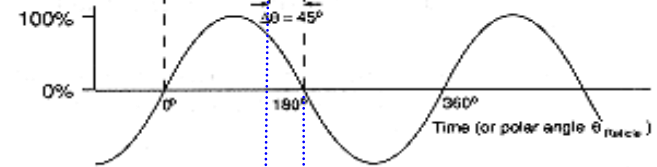
2) Envelope detector signal:



3) Envelope fundamental:



4) Reference signal:

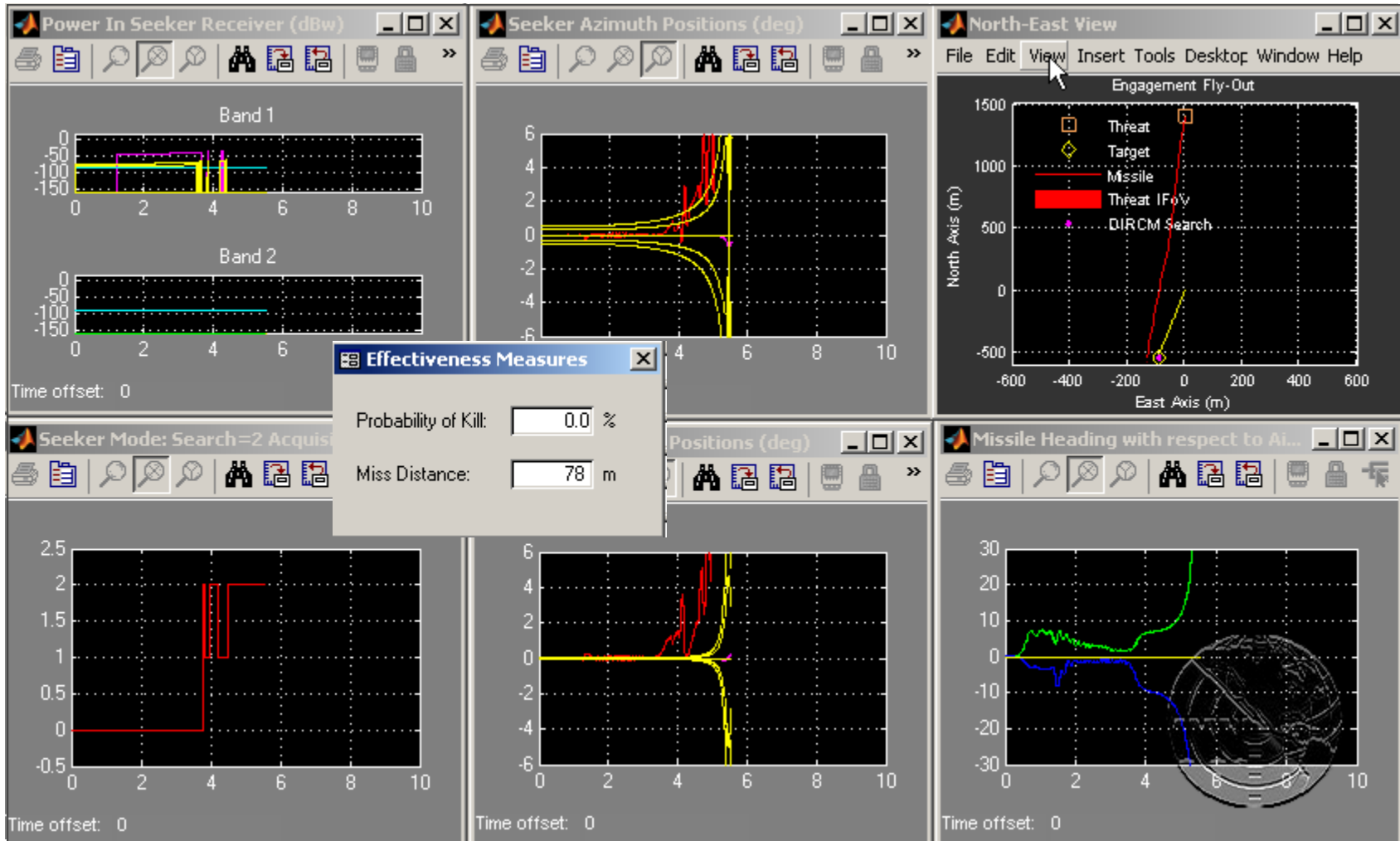


Relative Phase Determines Target Angle

Graphics: "Test And Evaluation Of The Tactical Missile" By E.J. Eichblatt

**Counter-Phase ECM Amplitude Modulation Causes Angle Error**  
**Sweeping ECM AM Frequency Can Ensure Counter-Phasing**

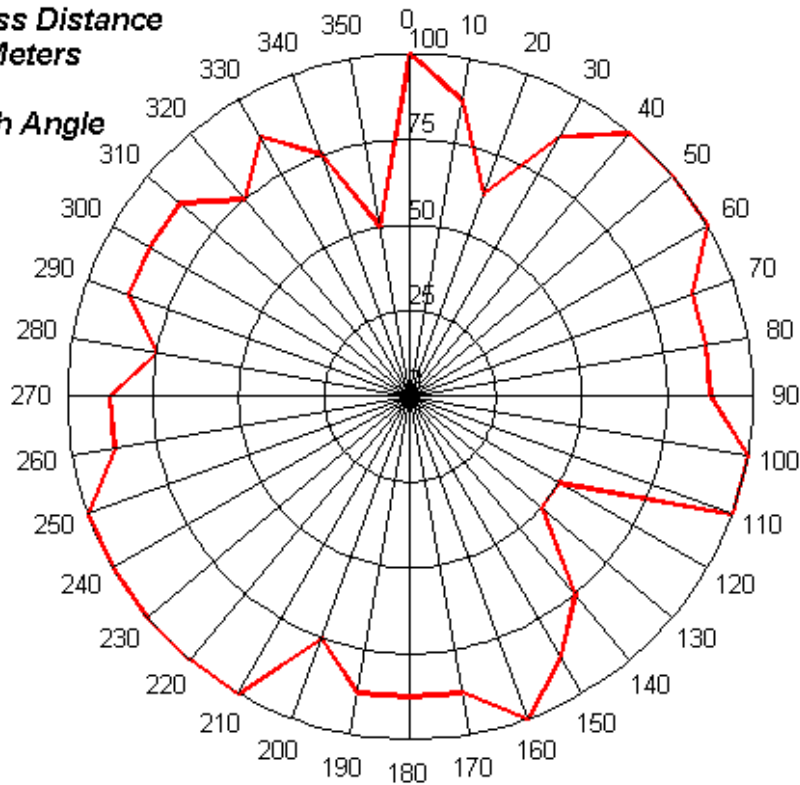
# Swept AM vs Spin Scan



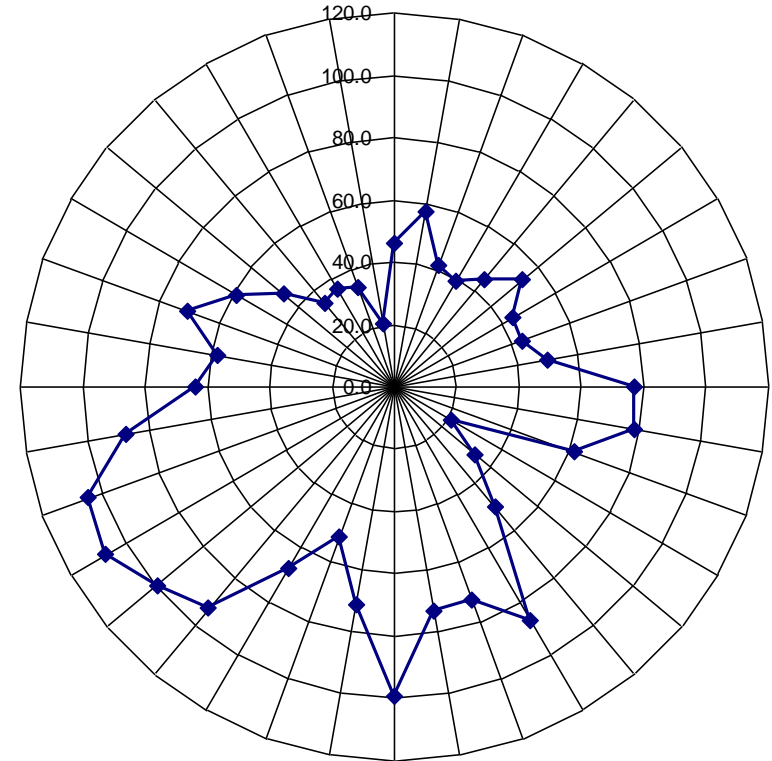
# Swept AM vs Spin Scan Effectiveness



Probability Miss Distance  
Exceeds 20 Meters  
vs  
Missile Launch Angle



Average Miss Distance (m)

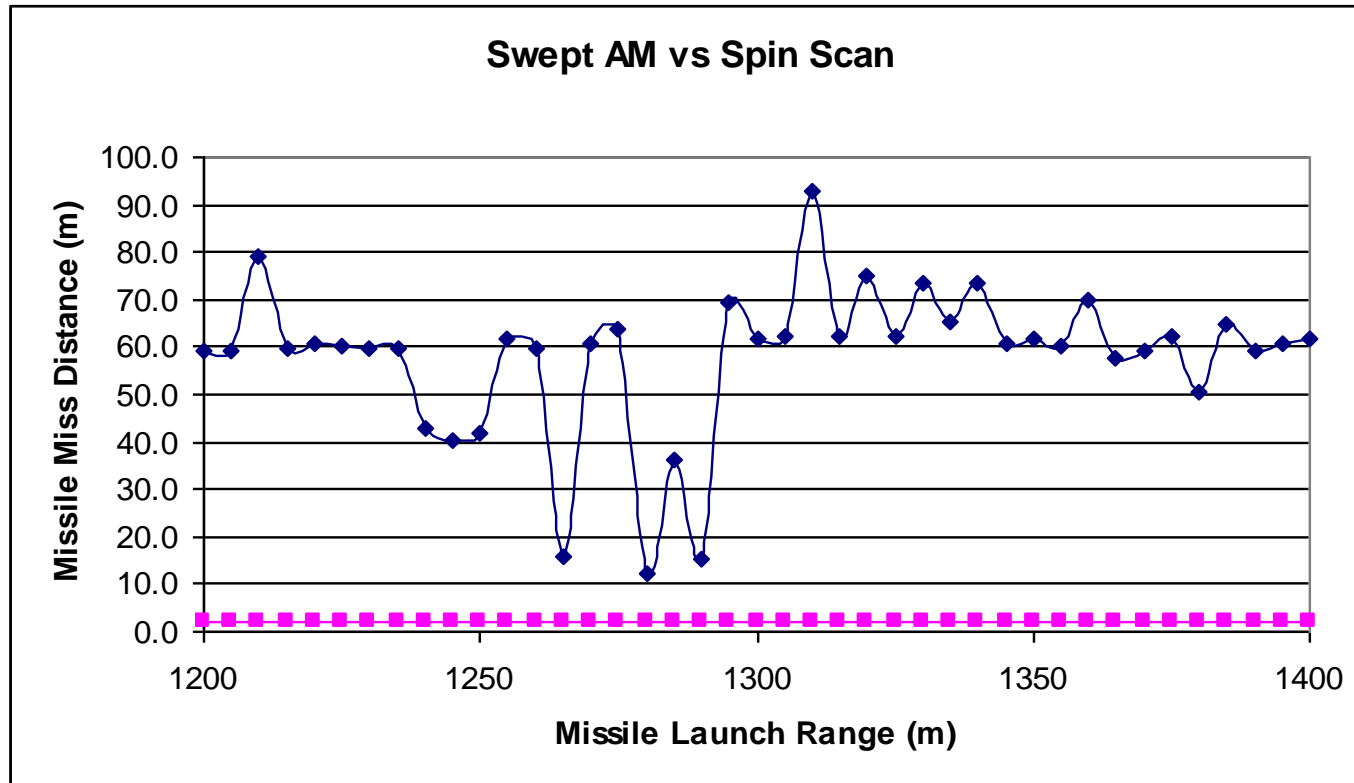




# Swept AM vs Spin Scan



Miss Distance Dependence on Missile Launch Range  
(In The Tail Chase Geometry)



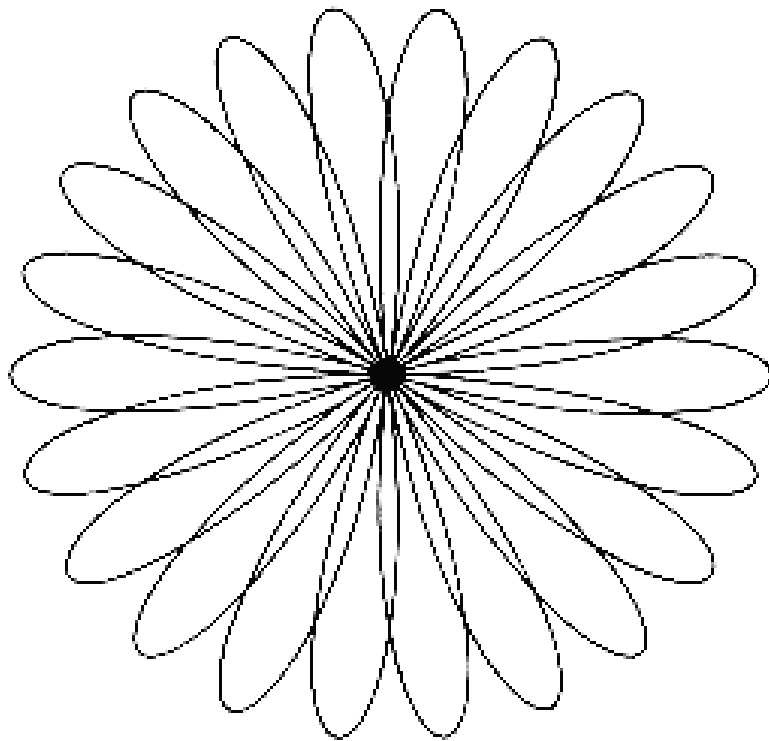
Miss Distance:  
Average = 57.9 m

Last Mode:  
100% In Search

Miss Distance Depends Somewhat on Launch Range (ie Relative AM and Spin Scan Phase)



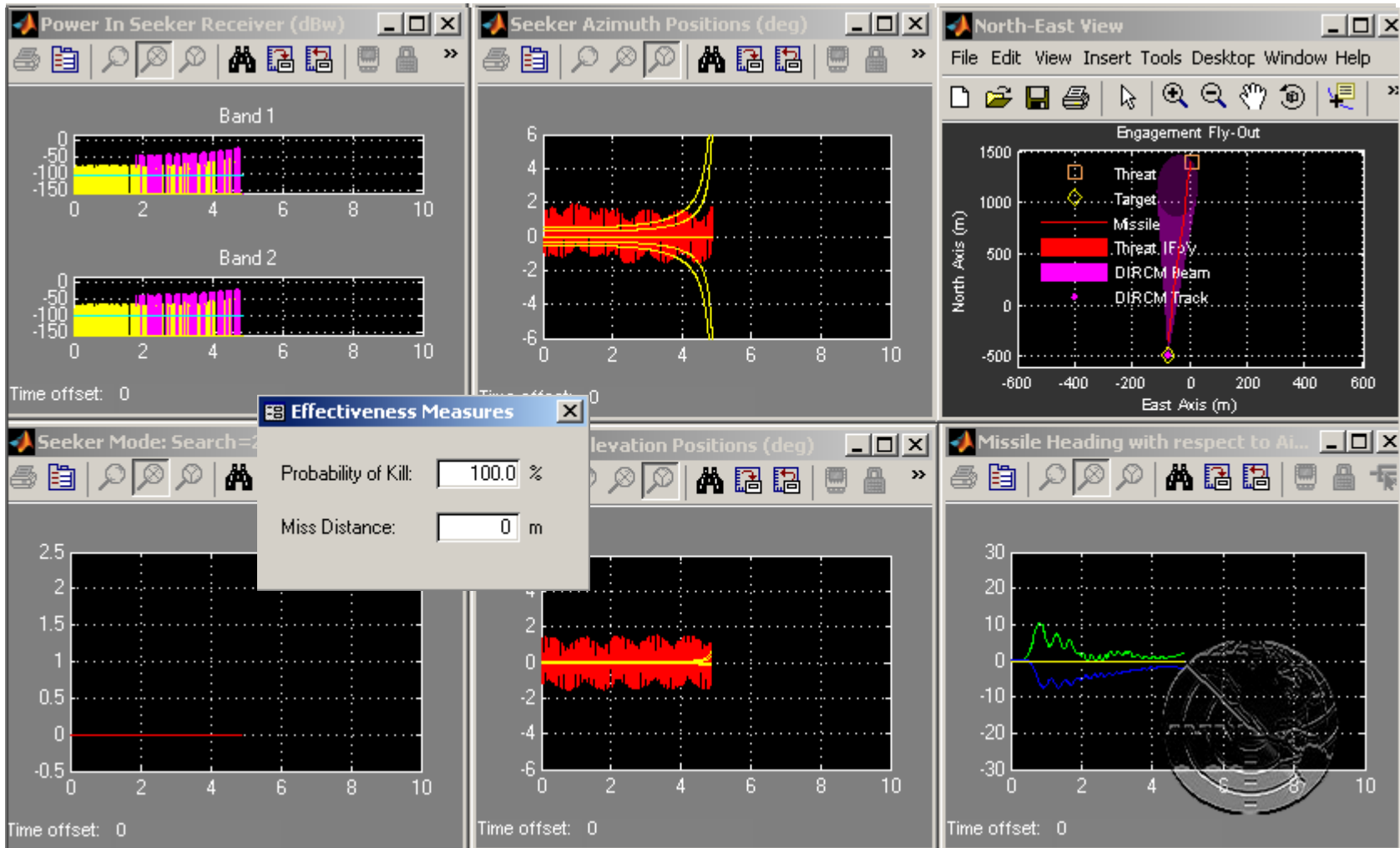
# *Typical Rosette Scans: Multiple Spinning Optics*



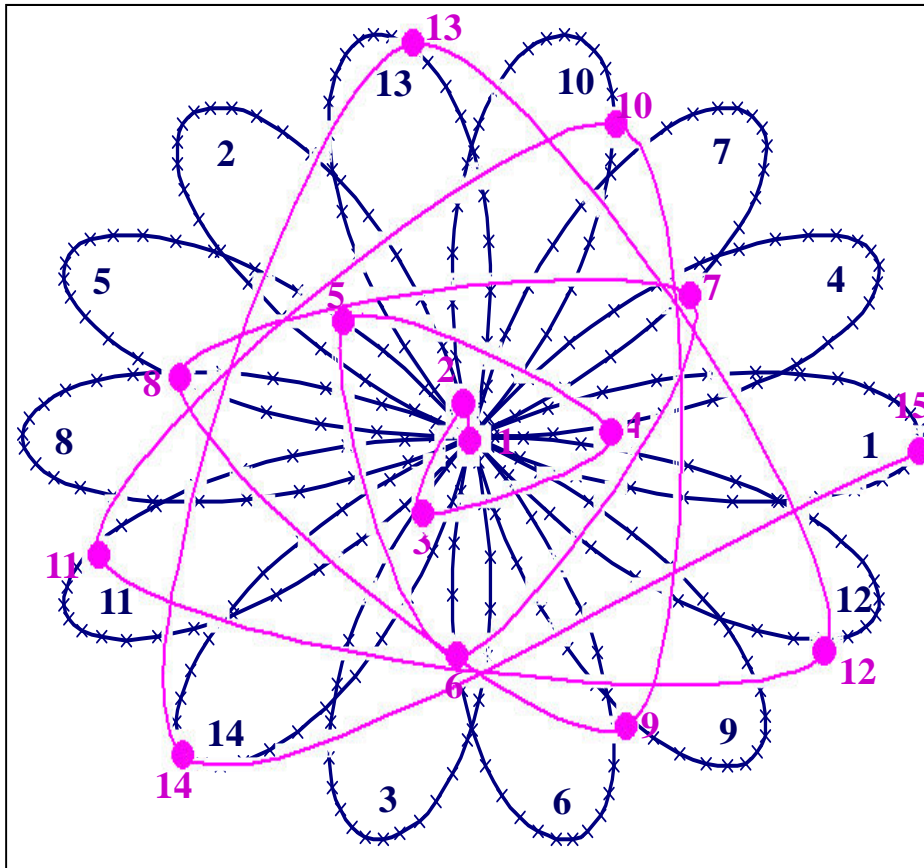
- | Track While Scan
- | Spatial Sampling
- | Quasi-Imaging
- | Digital Tracking
- | Generation Of Deceptive AM vs Digital Track Is Difficult

Graphic: "The Infra-Red Handbook" Edited By W.L Wolfe And G.J. Zessis

# Swept AM vs Rosette Engagement



# Rosette AM Deception Analysis



## Sample Rosette Characteristics

- | Two Counter-Rotating Mirrors
- | Rotation Rates = 15 & 27 Hz
- | Petal Frequency = 42 Hz
- | Rosette Frequency = 3 Hz
- | Number of Petals = 14
- | Sequence As Shown At Left

## Sample AM ECM Characteristics

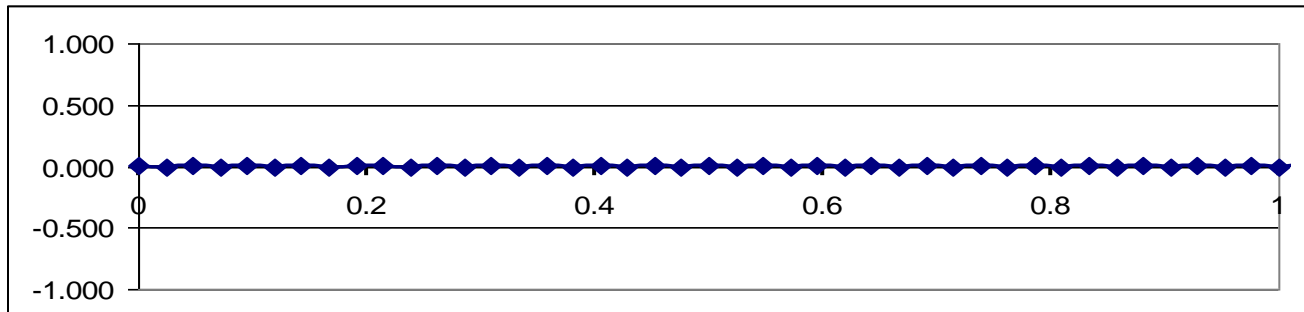
- | AM Center Frequency = 43.5 Hz



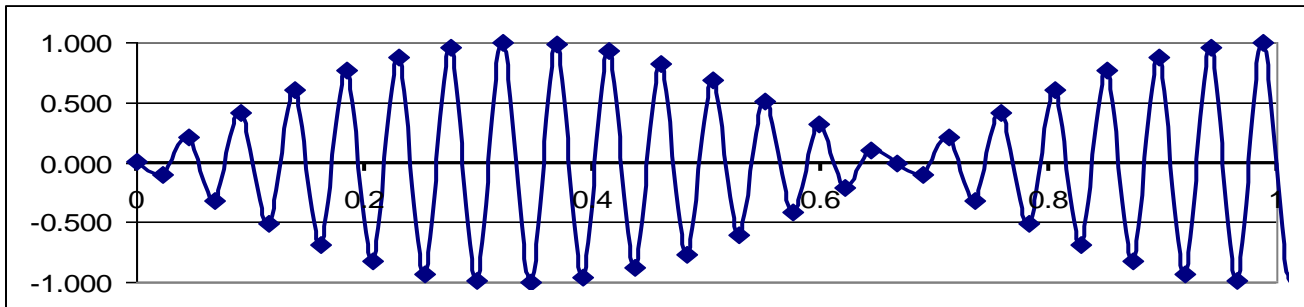
# Angle Error vs AM Frequency



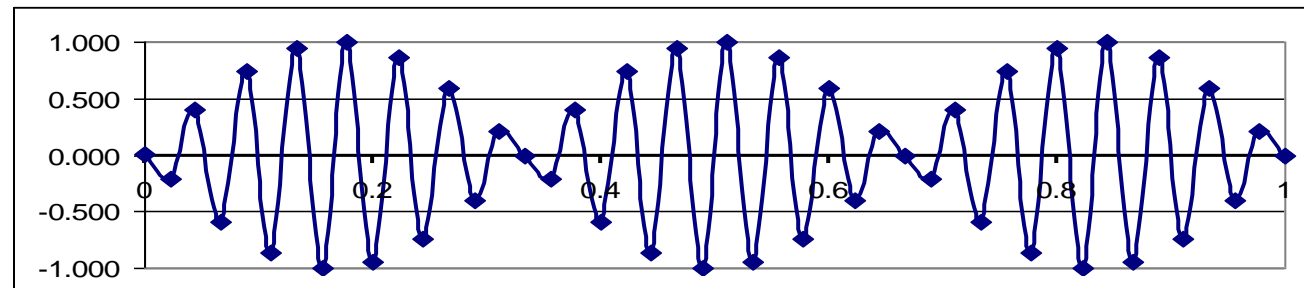
42.0 Hz



43.5 Hz



45.0 Hz



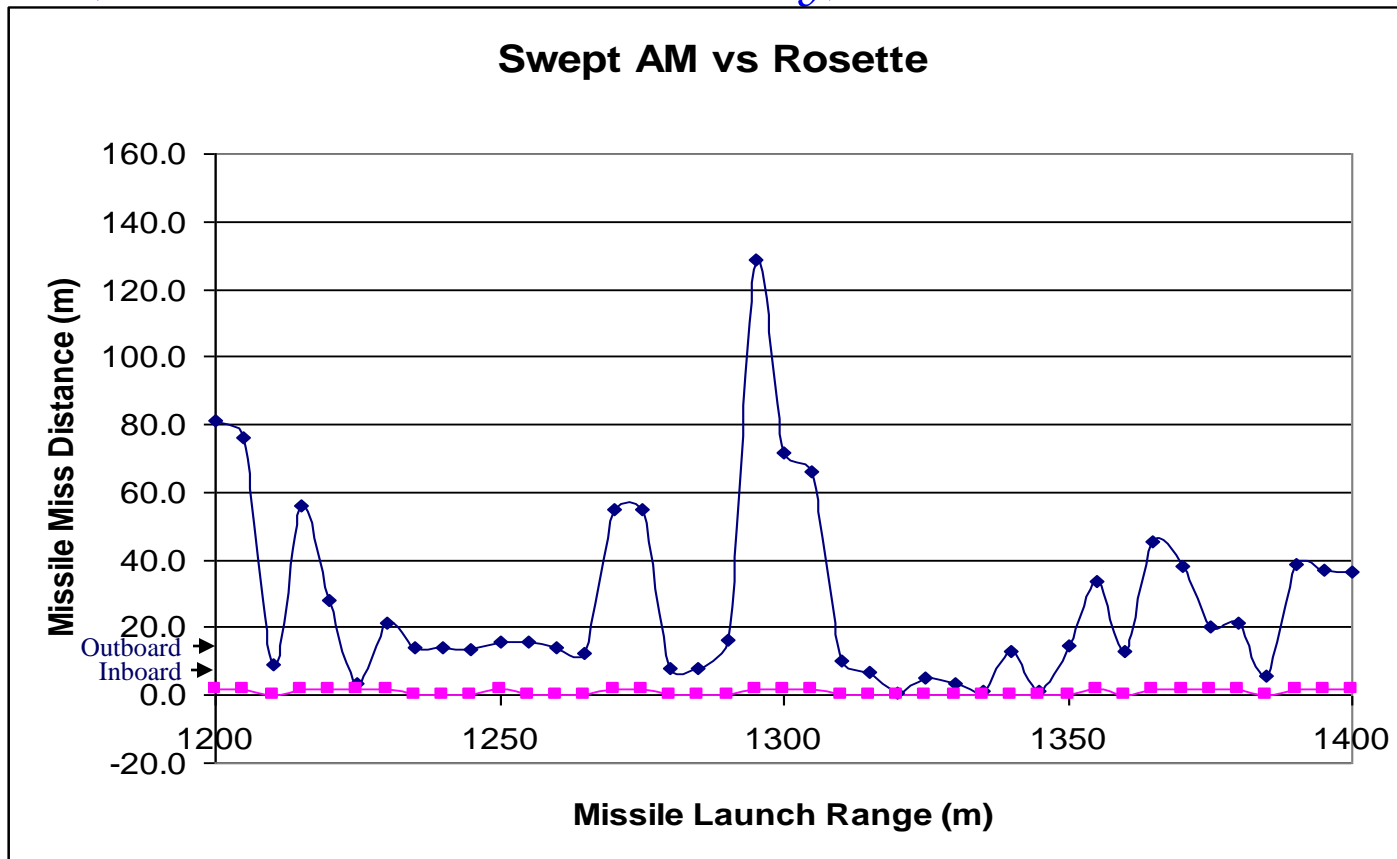
6.9% Sweep



# Swept AM (6.9%) vs Rosette



Miss Distance Dependence on Missile Launch Range  
(In The Tail Chase Geometry)



Miss Distance:  
Average = 27.5 m

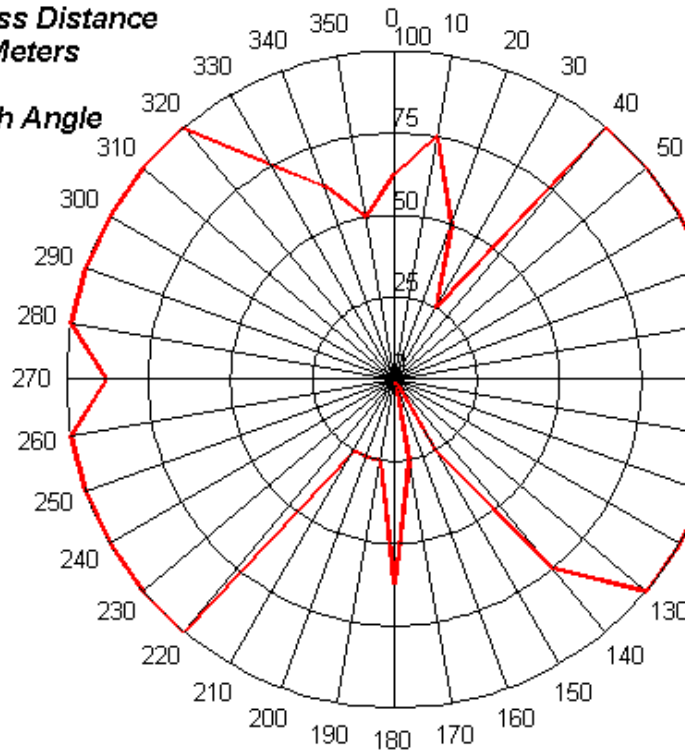
Last Mode:  
50% In Search

Miss Distance Depends Substantially on Launch Range (ie Relative AM and Rosette Phase)

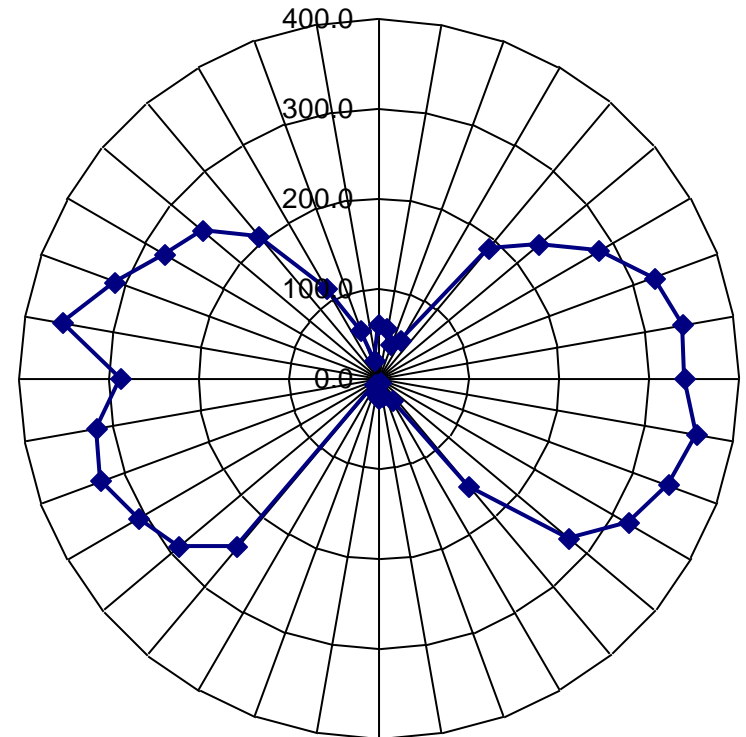
# Swept AM (6.9%) vs Rosette Effectiveness



Probability Miss Distance Exceeds 20 Meters vs Missile Launch Angle



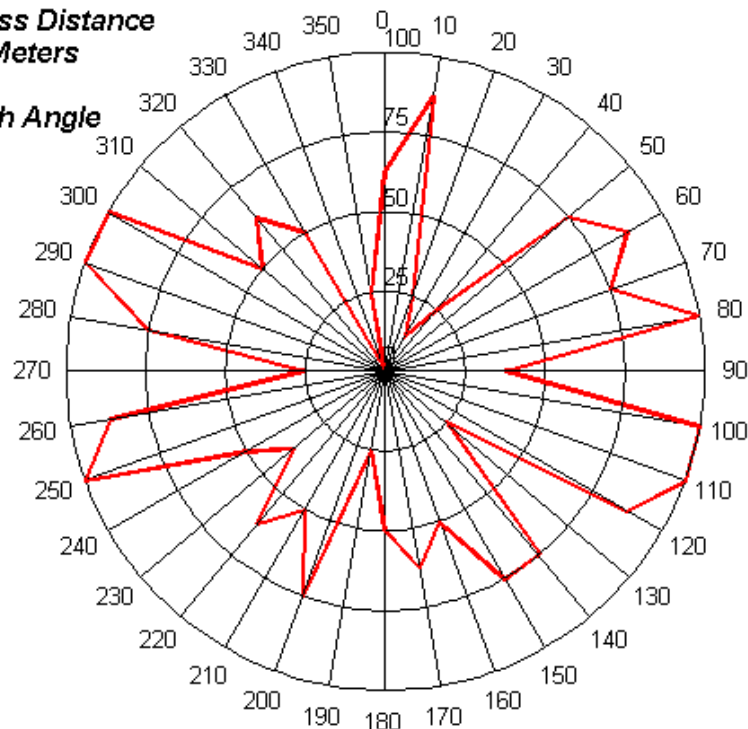
Average Missile Miss Distance (m)



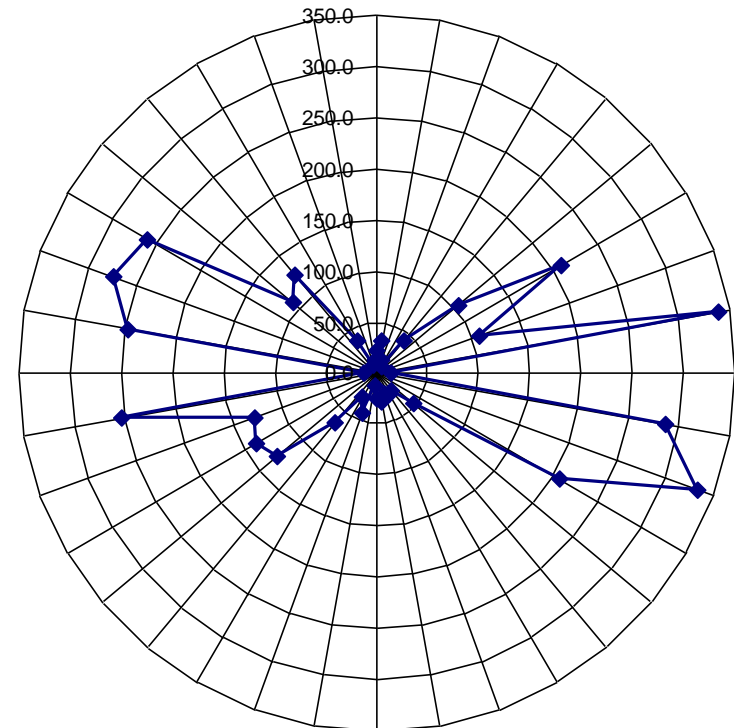
# Swept AM (2.3%) vs Rosette Effectiveness



Probability Miss Distance Exceeds 20 Meters vs Missile Launch Angle

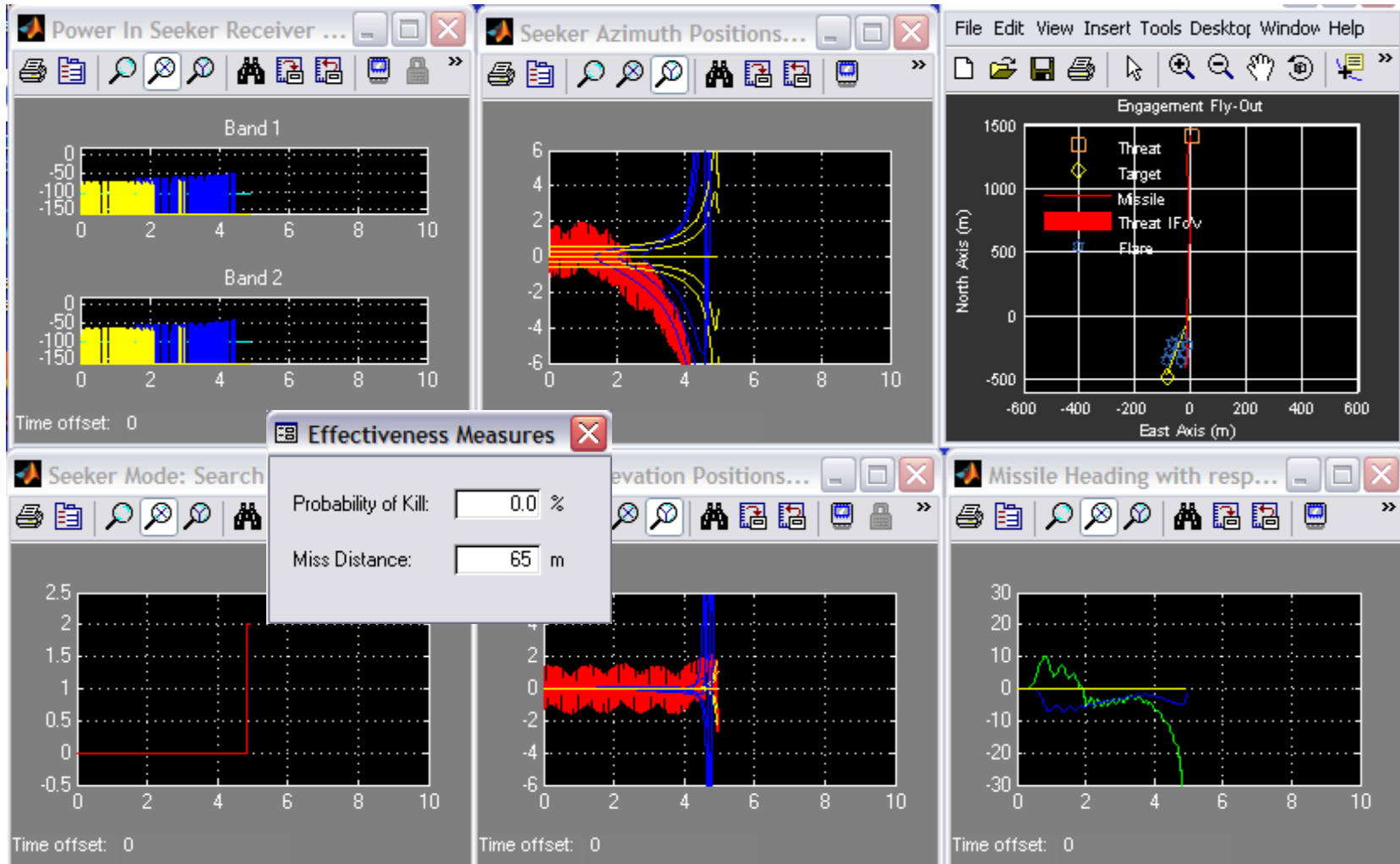


Average Missile Miss Distance (m)





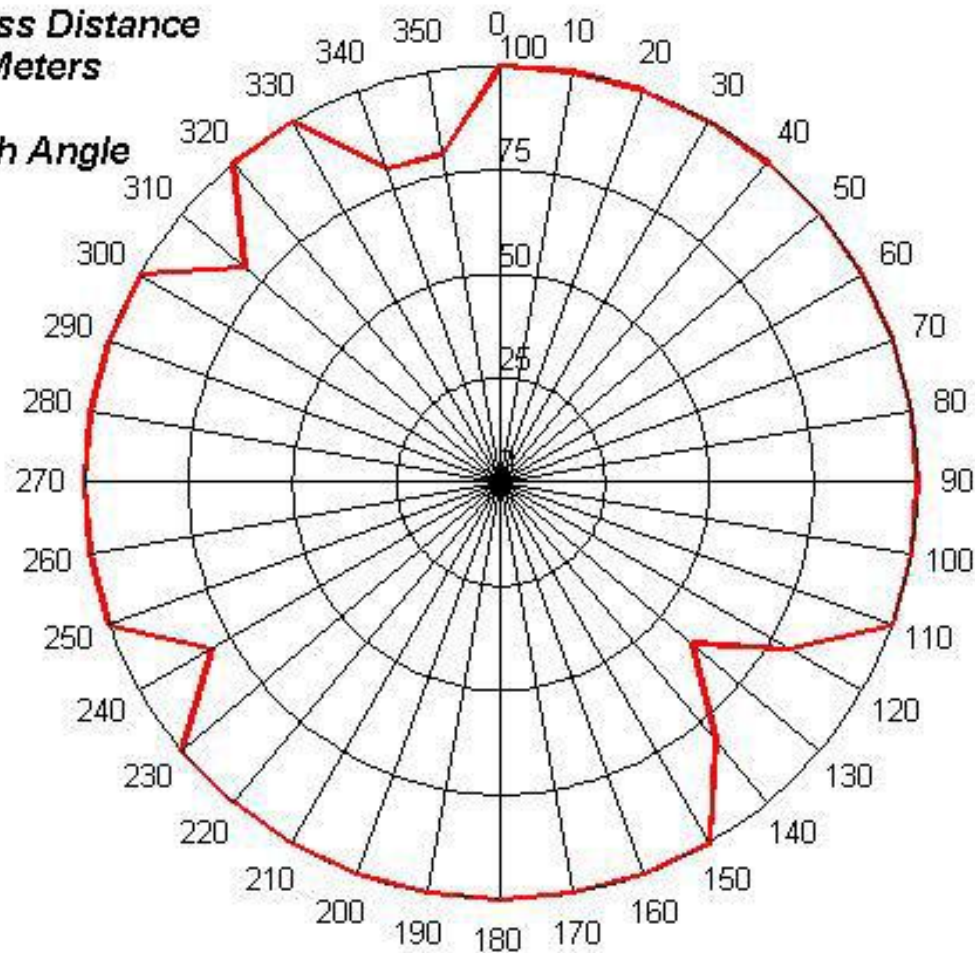
# Flares vs Rosette Engagement



# Flares vs Rosette Effectiveness



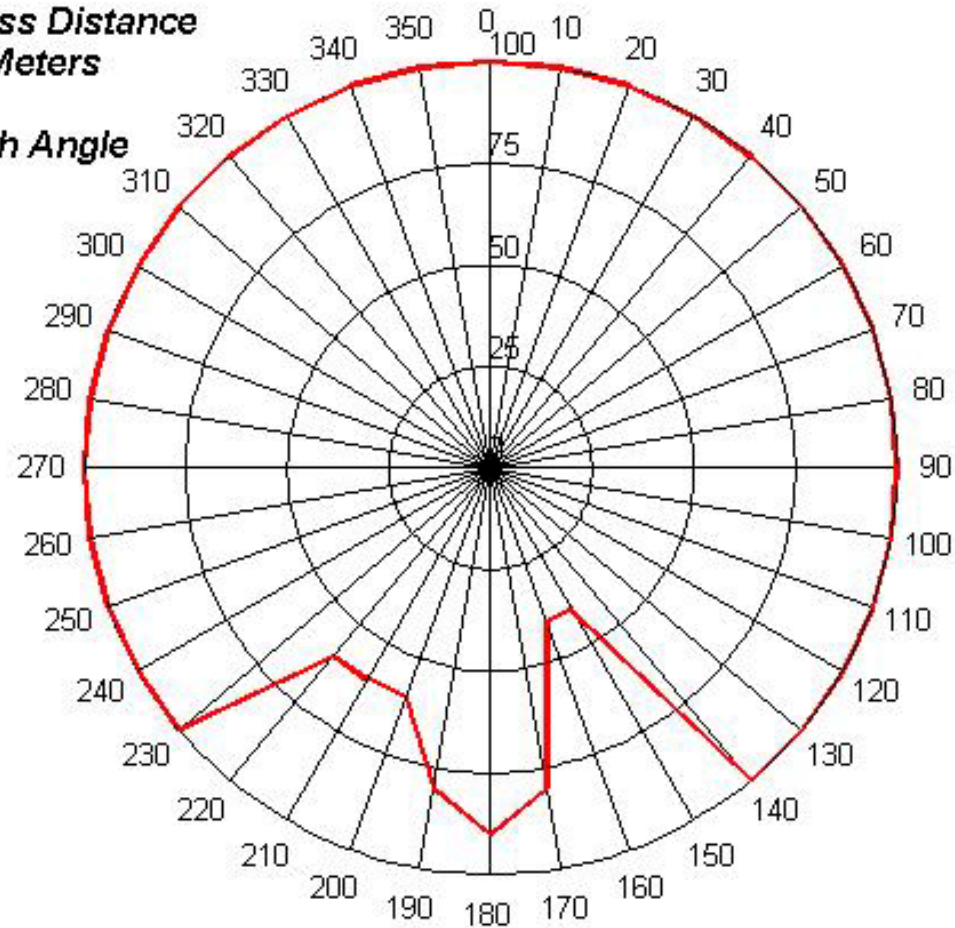
**Probability Miss Distance  
Exceeds 20 Meters  
vs  
Missile Launch Angle**



# Flares vs Spin Scan Effectiveness



**Probability Miss Distance  
Exceeds 20 Meters  
vs  
Missile Launch Angle**



# Airliner Self Protection



## | On-Board (DIRCM)

- Modulation's Success Depends on Threat's Tracking Technique
- Requires Threat Analysis Capabilities

| Defeat of Advanced Trackers May Be Difficult if DIRCM Power Is Not Sufficient to Cause Damage

## | Off-Board (Flares)

- Deployment Sequence Relative to End Game (Timing) Is Important For Success
- Success Is Engagement Geometry Dependent

| Success Is Relatively Independent Of Threat's Tracking Technique



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**Questions???**