EW-00006

ECM TECHNIQUES GENERATION

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The goal of this session is to provide a comprehensive look at functional areas of ECM system and trade-off considerations, i.e. apertures, receivers/processors, counter/measurer techniques generators, and high power sources. Also to a provide comprehensive look at techniques, i.e. generators, system architectures, interaction between jamming and radar processing, trades & drivers, and processes/tools

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INTRODUCTION

GOAL OF SESSION

. PROVIDE COMPREHENSIVE LOOK AT FUNCTIONAL AREAS OF ECM SYSTEM AND TRADE-OFF CONSIDERATIONS

- APERTURES
- RECEIVERS/PROCESSORS
- COUNTERMEASURE/TECHNIQUES GENERATORS
- HIGH POWER SOURCES

GOAL OF TOPIC

- PROVIDE COMPREHENSIVE LOOK AT TECHNIQUES GENERATORS
  - SYSTEM ARCHITECTURES
  - INTERACTION BETWEEN JAMMING AND RADAR PROCESSING
  - TRADES & DRIVERS
  - PROCESSES/TOOLS

AGENDA

SURVIVABILITY FACTORS

ECM SYSTEM ARCHITECTURES

RADAR COUNTERMEASURES

- RANGE
- VELOCITY
- ANGLE

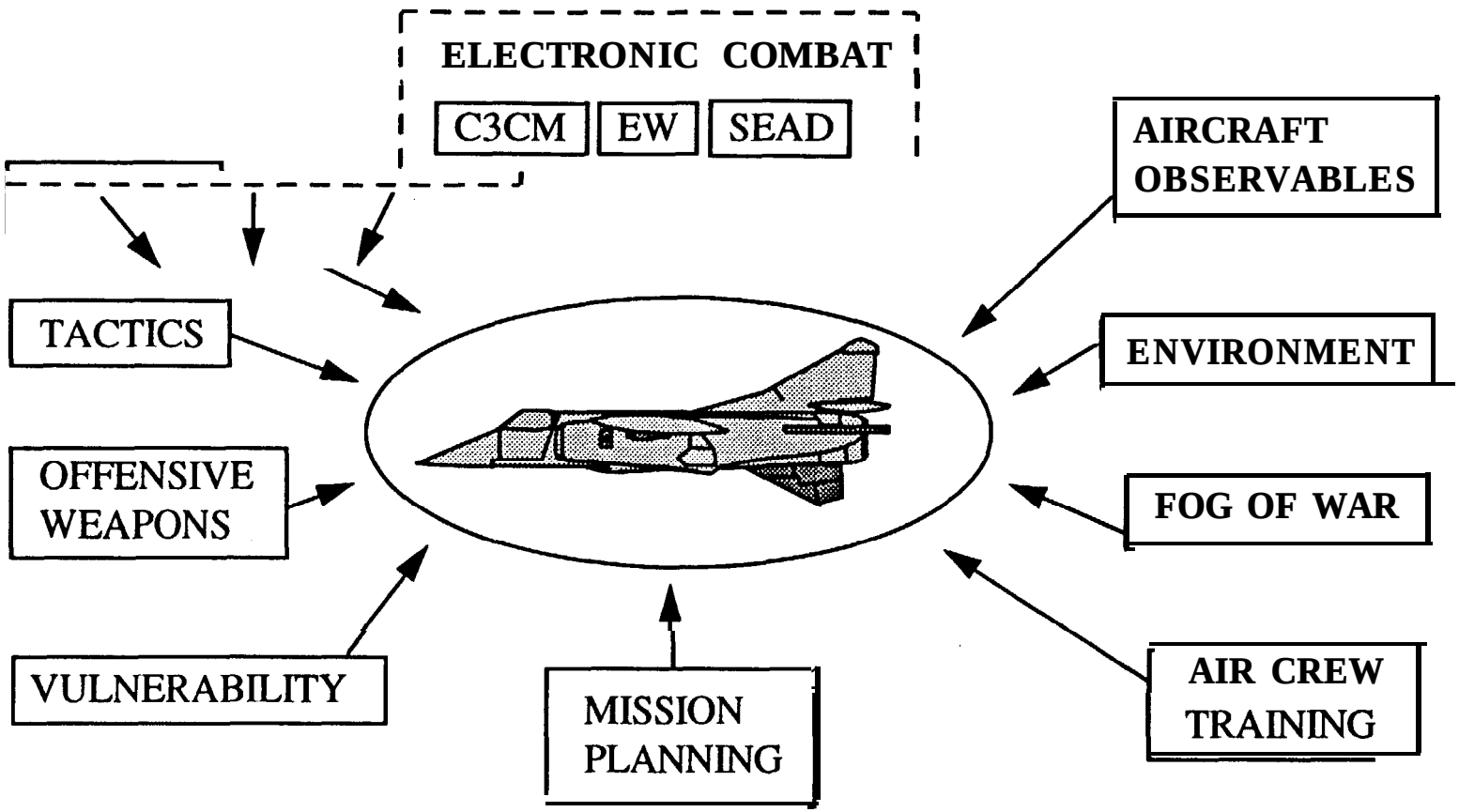
MISSILE COUNTERMEASURES

COUNTERMEASURES WRAP-UP

ECM ANALYSIS - TOOLS AND PROCESSES

AIRCRAFT SURVIVABILITY FACTORS

(EC IS A CONTRIBUTOR TO A/C SURVIVABILITY)



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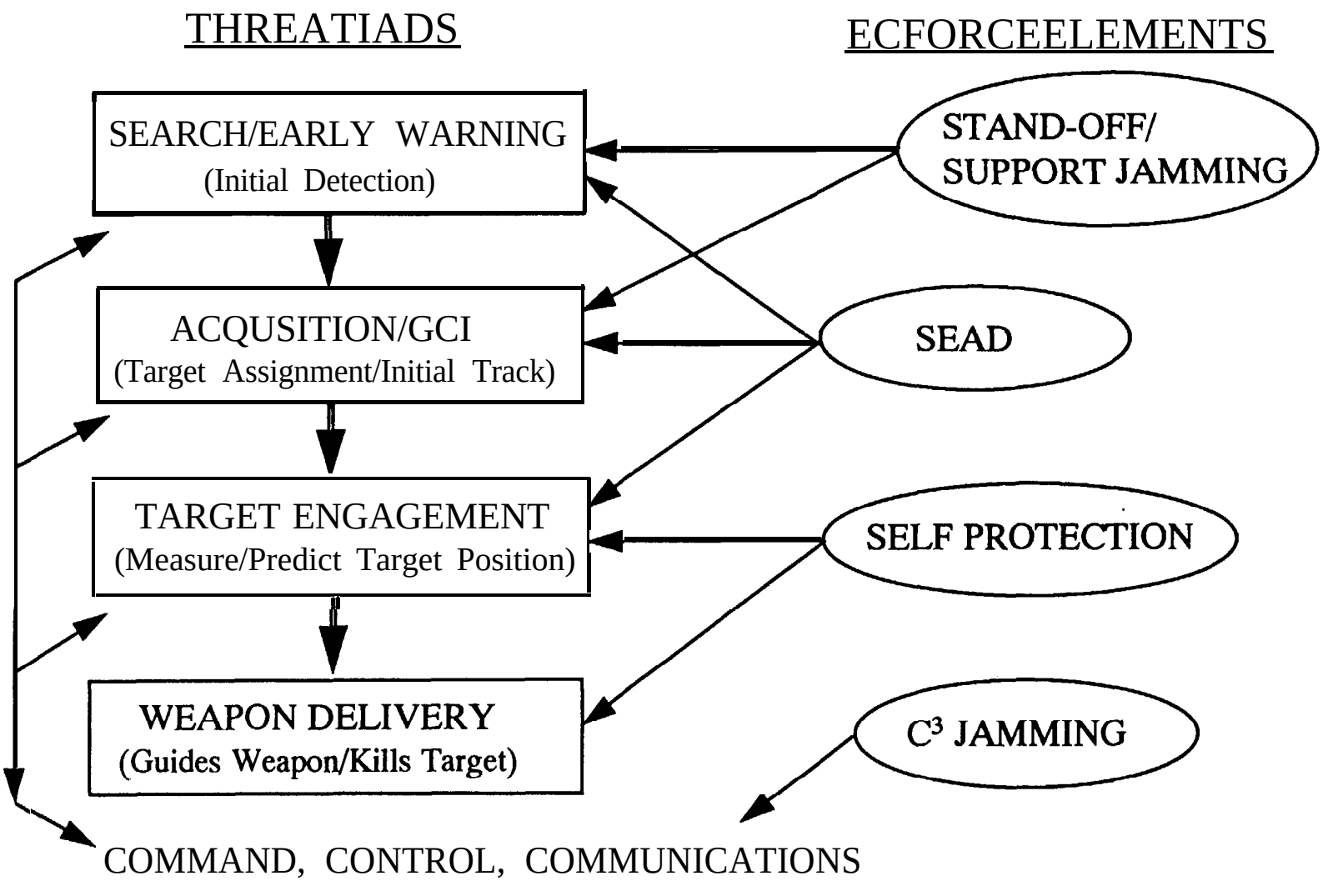
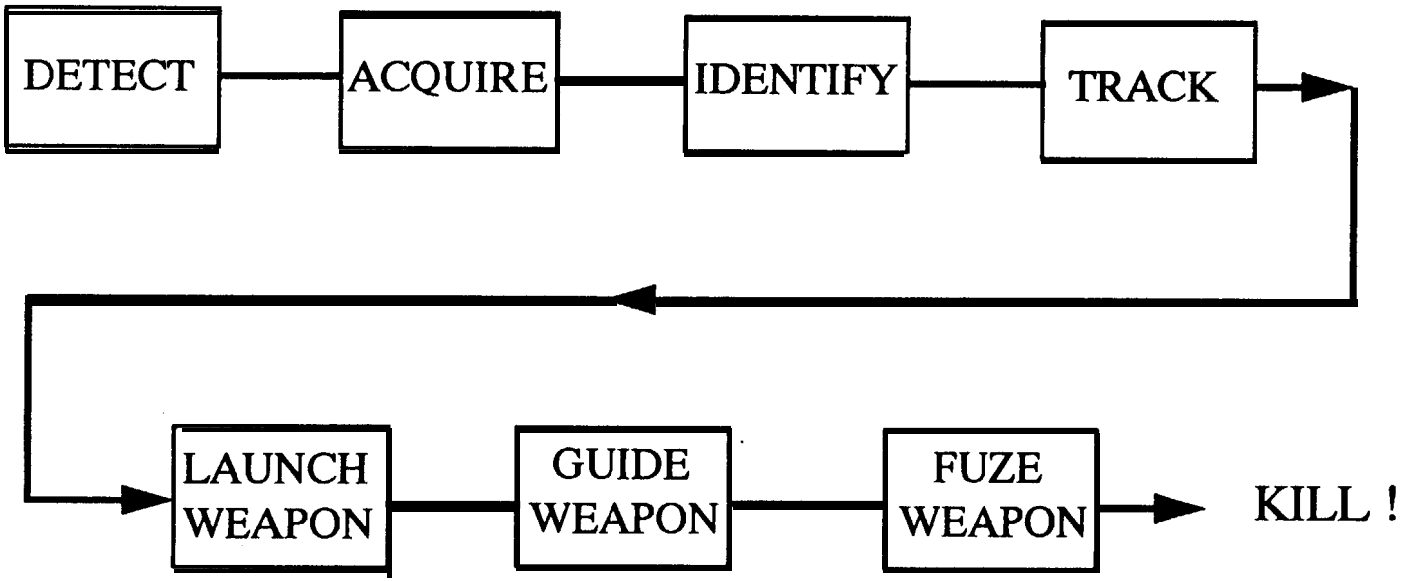


ENGAGEMENT PROCESS



SURVIVABILITY FACTORS

JAM TO SIGNAL RATIO (J/S) - SELF SCREENING

- RATIOOFJAMMERPOWERTOTARGETRETURNPOWER

J/S = f (ERP, RANGE, TARGET SIGNATURE, BANDWIDTH MATCH)

$$J/S = \frac{P_J G_J}{P_T G_T} \cdot \frac{4\pi R^2}{1} \cdot \frac{\sigma.}{1} \cdot \frac{B_T}{B_J} \qquad \text{for } B_J \geq B_T$$

WHERE:

P_J = Jammer Tx Power
G_J = Jammer Tx Antenna Gain
P_T = Radar Tx Power
G_T = Radar Antenna Gain

R = Range - Jammer to Radar
$\sigma.$ = Target Radar Cross Section
B_T = Radar Bandwidth
B_J = Jammer Bandwidth

AGENDA

SURVIVABILITYFACI'ORS

ECMSYSTEMARCHITECTURES

RADARCOUNTERMEASURES

- RANGE
- VELOCITY

*ANGLE

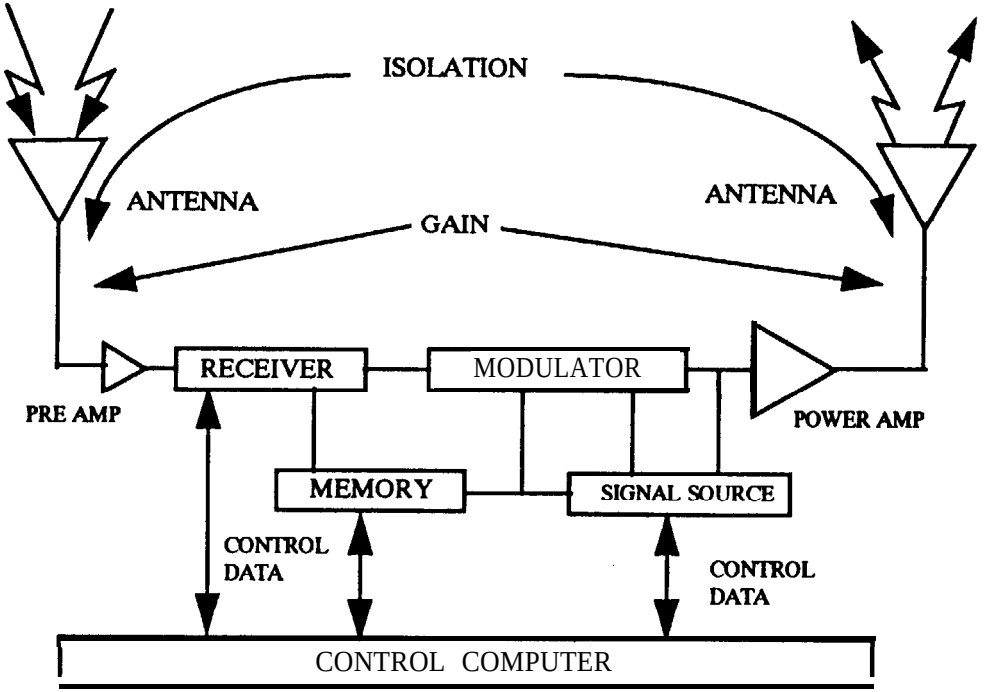
MISSILECOUNTERMEASURES

COUNTERMEASURESWRAPUP

ECMANALYSIS-TOOLSANDPROCESSES

GENERIC ECM SUITE MODEL

Receive Antenna
FOV/Beamwidth
Polarization
Gain
DF



Transmit Antenna
FOV/Beamwidth
Polarization
Gain
DF

Receiver/Processor
Environment Sorting
Parameter Measurement
(F, PRI, PW, Amp, Pol)
PRI Tracking
Frequency Tracking
Threat ID/Prioritization
Parameter Prediction

Transmitter
High Power
Multiple Signal/
Power Sharing

Modulator
Amplitude
Freq/Phase
Polarization

Memory
Technique Selection
Time Delay/Advance
Coherent Signal Replication

Signal Source
Receiver Support (e.g., LO)
Threat Frequency
Replication

ECM SYSTEM ARCHITECTURES

CONSTANT GAIN

- LINEARAMPLIFICATIONOFINPUTSIGNAL
- ELECTRONICGAIN<ISOLATION

4LLOWSRxTO"LOOKOVER"JAMMINGTOSEETHREAT

- PROVIDESCONSTANTJ/SUNTILTxSATURATION

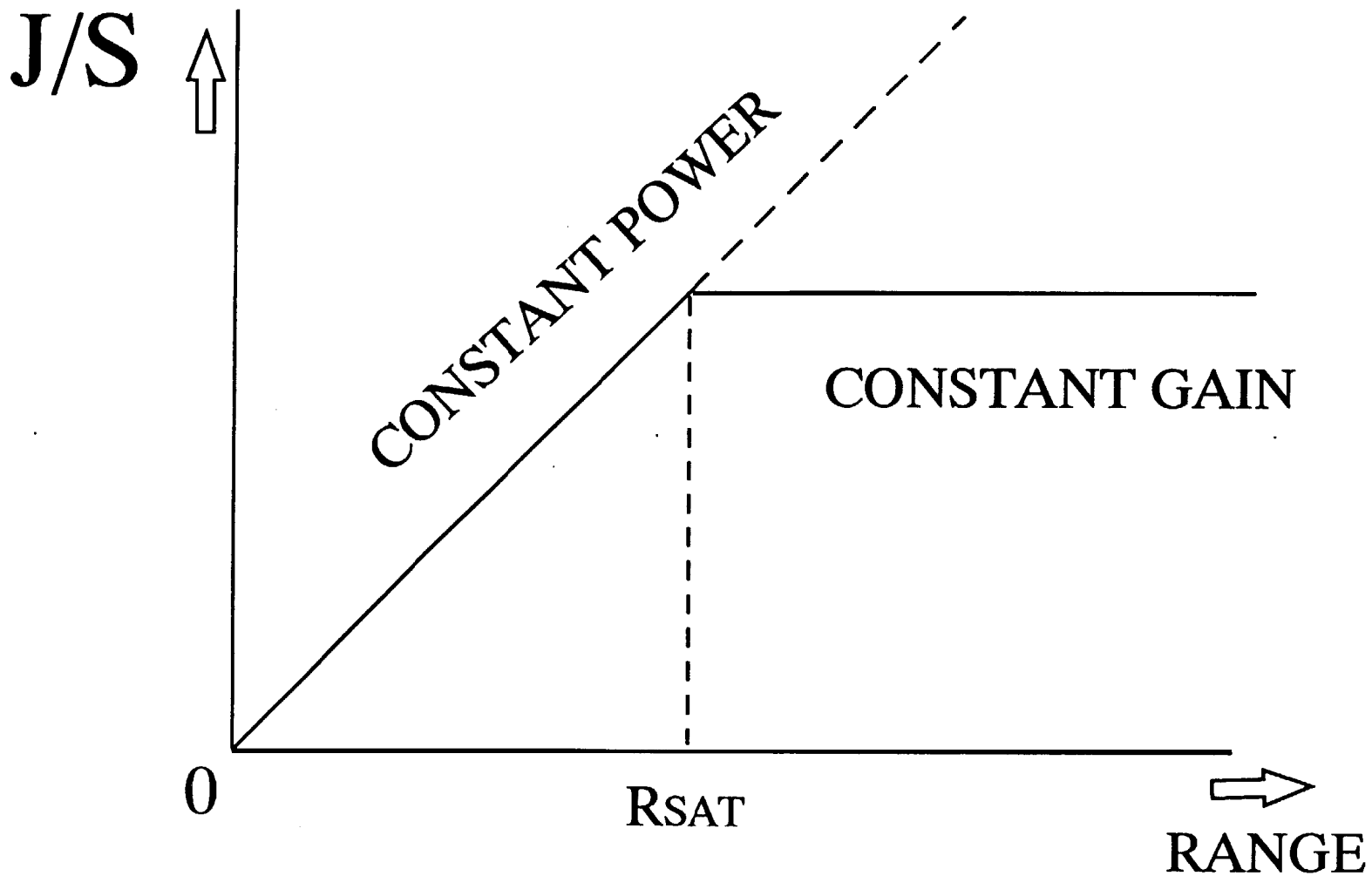
THEN DEGRADES WITH RANGE (-6dB/OCTAVE)

CONSTANT POWER

- POWER SHARING vs MULTIPLE SIGNALS
- TxOPERATESATORNEARSATURATIONREGARDLESSOFINPUT SIGNALLEVEL‘
- ELECTRONICGAINMAYBEGREATERTHANISOLATION

- TYPICALLY, Tx MUST SHUT DOWN FOR Rx TO SEE THREAT
- J/S DECREASES WITH RANGE (-6dB/OCTAVE)

ECM SYSTEM ARCHITECTURES



ECM SYSTEM ARCHITECTURES

TRADES & DRIVERS - CONSTANT GAIN

- ANTENNA ISOLATION
  - LARGE ENOUGH TO COVER TARGET RETURN TO ACCEPTABLE RANGE
  - SUFFICIENTGAINMARGINTOALLOWRECEIVERTOACQUIRE/ MAINTAINTRACKOFTHREATRADAR
  - DIFFICULTTOCOVER LARGECROSSSECTIONTARGETS

*LOOK-OVER-GAINMARGINALLOWSRECEIVERTOSEE THREATSIGNALINPRESENCEOFJAMMING

.LOOK THROUGH - SERVICE OF SPECIALIZED RECEIVERS

- SYSTEM LOSSES (CABLES, COUPLERS ETC.) WILL DEGRADE DETECTION RANGE AND J/S
- COHERENCY MAINTAINED BY MEMORIZATION/REPEATING INCOMINGSIGNAL

ECM SYSTEM ARCHITECTURES

TRADES & DRIVERS - CONSTANT POWER

- ANTENNA ISOLATION - MUST SHUT OFF Tx ON RECEIVE
- LOOKTHROUGH
  - ENOUGH TO ALLOW RECEIVERS TO ACQUIRE/MAINTAIN TRACK
  - SMALL ENOUGH TO PRECLUDE JAMMING **DEGRADATION**
- **CHOP**
  - ***TIMING**
  - SPECTRAL SPREADING
- SYSTEM LOSSES (CABLES, COUPLERS, ETC.) WILL DEGRADE RANGE AND J/S
- DIFFICULT TO ACHIEVE/MAINTAIN COHERENCY

SYSTEM APPROACH - COMBINE CONSTANT GAIN /POWER MODES

- **CONSTANTPOWERMODEVS.NON-COHERENT THREATS**
- **CONSTANTGAINMODEVSCOHERENTTHREATS**

AGENDA

SURVIVABILITYFACI'ORS

ECMSYSTEMARCHITECTSJRES

RADARCOUNTERMEASURESTECHNIQUES

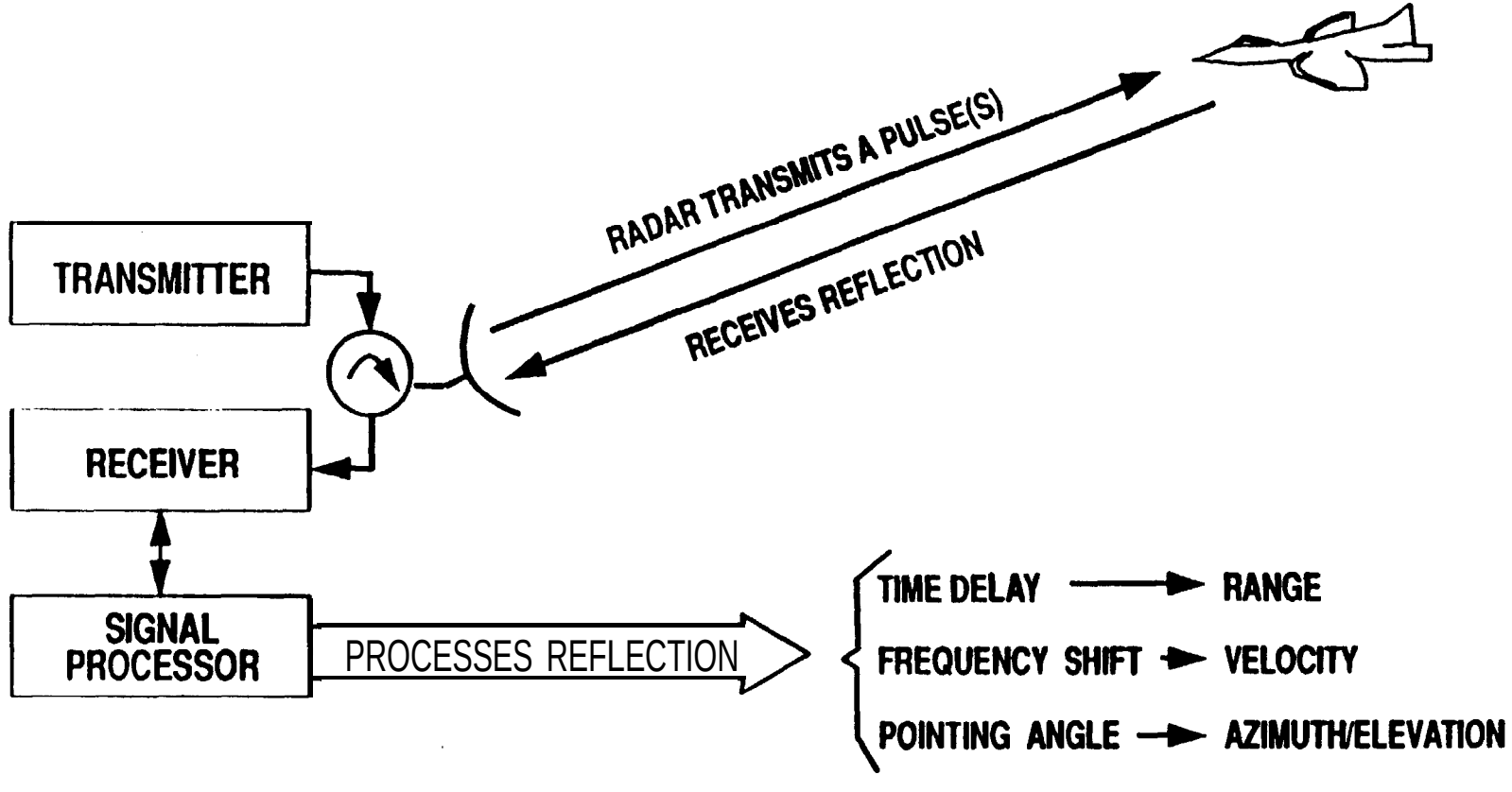
- RANGE
- VELOCITY
- ANGLE

MISSILECOUNTERMEASURES

COUNTERMEASURESWRAPUP

ECMANALYSIS- TOOLSANDPROCESSES

BASIC RADAR


RADAR TRANSMITS A PULSE(S)
RECEIVES REFLECTION
TRANSMITTER
RECEIVER
SIGNAL PROCESSOR
PROCESSES REFLECTION
TIME DELAY → RANGE
FREQUENCY SHIFT → VELOCITY
POINTING ANGLE → AZIMUTH/ELEVATION

RADARCOUNTERMEASURES

NON-COHERENT-PULSE RADAR CHARACTERISTICS

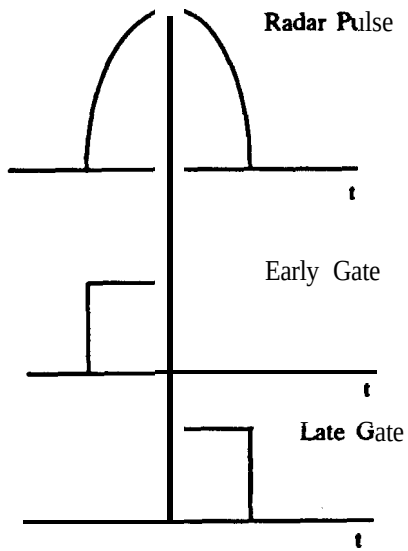
- **RANGE TRACKING**
- **PHASE INFORMATION NOT PRESERVED**
- **HIGH PEAK POWER**
  - **GROUND BASED (~ 120 dBm)**
  - **AIRBORNE (~ 100 dBm)**
- **LOW DUTY CYCLE (< 1%)**
  - **MAY HAVE NARROW PW (< 1 USEC)**
  - **LOW PRF (<SK PPS)**
- **INSTANTANEOUS BANDWIDTH (MEGAHERTZ)**

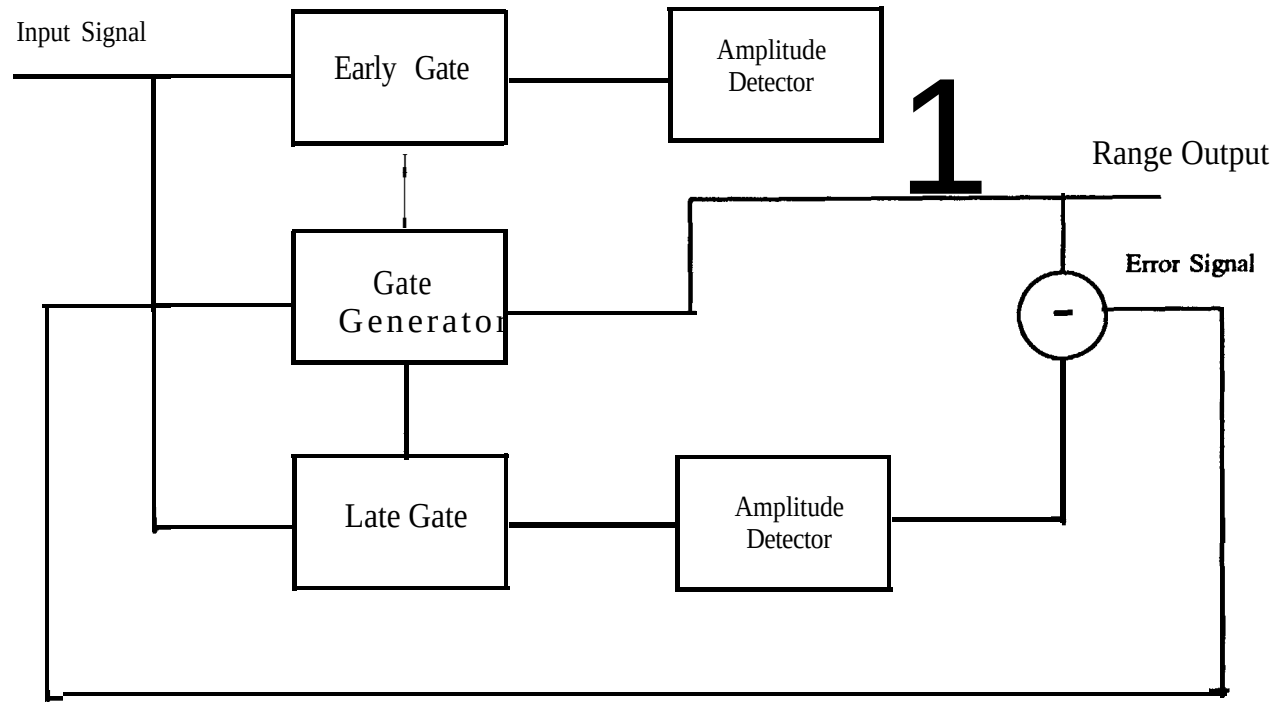
RADARCOUNTERMEASURES

RANGE TECHNIQUES VS PULSE RADAR

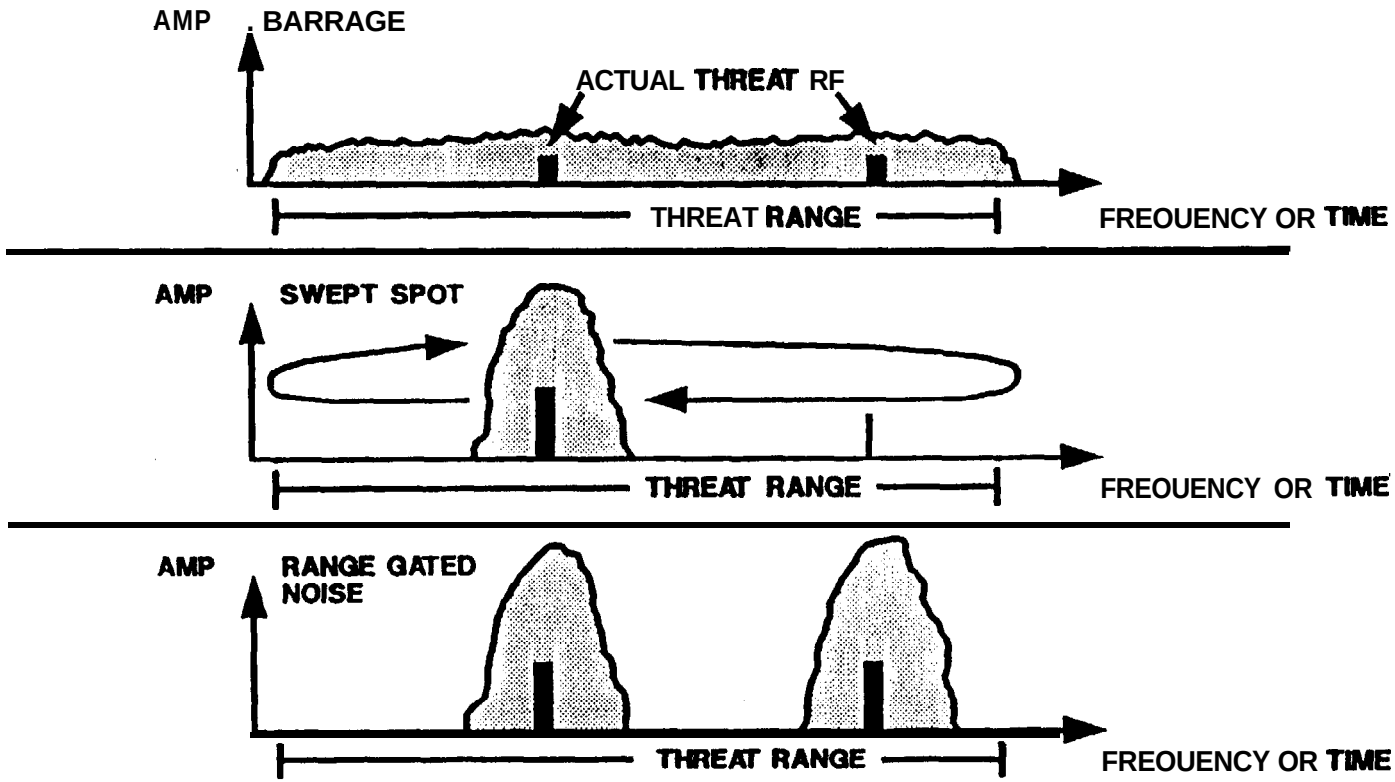
- **BROADBAND NOISE**
  - **BARRAGE (BARR)**
  - **SWEPT SPOT (SSN)**
- **POWER MANAGED NOISE**
  - **RANGE GATED NOISE (RGN)**
- **PULSE REPEATER**
  - **RANGE GATE PULL OFF (RGPO)**
- **POWER MANAGED TRANSPONDER**
  - **RANGE GATE PULL IN & OUT** (RANRAP)
  - **RANGE FALSE TARGETS (RFT)**

SPLIT GATE RANGE TRACKER

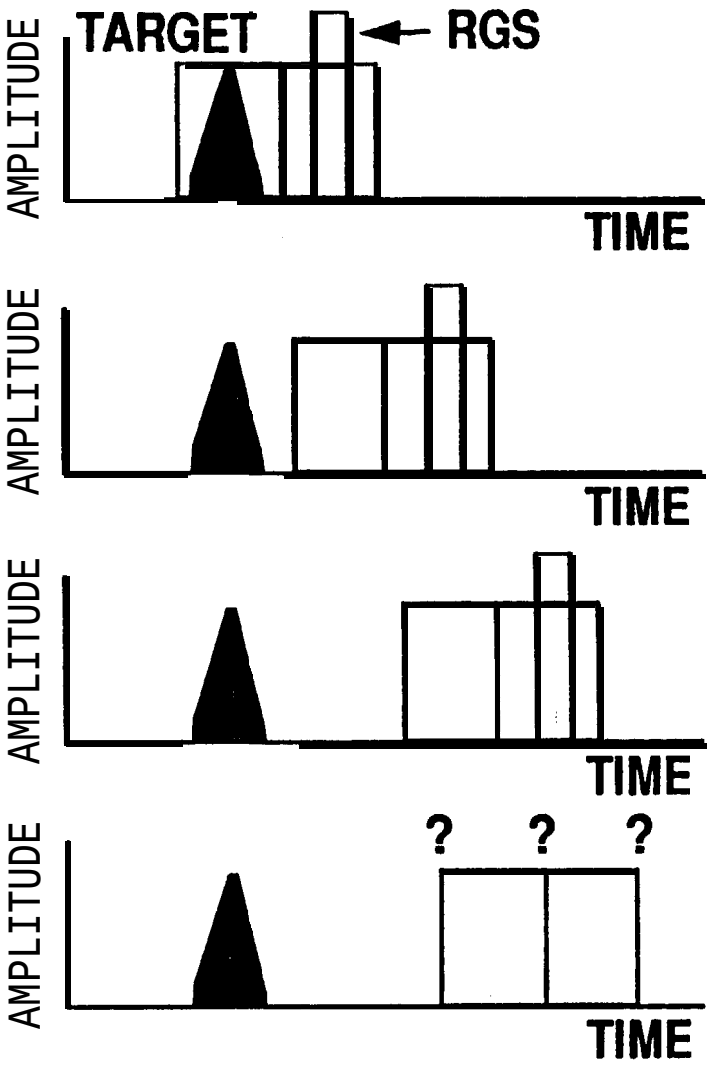




NOISE TECHNIQUES



RANGE GATE PULL-OFF TIME SEQUENCE



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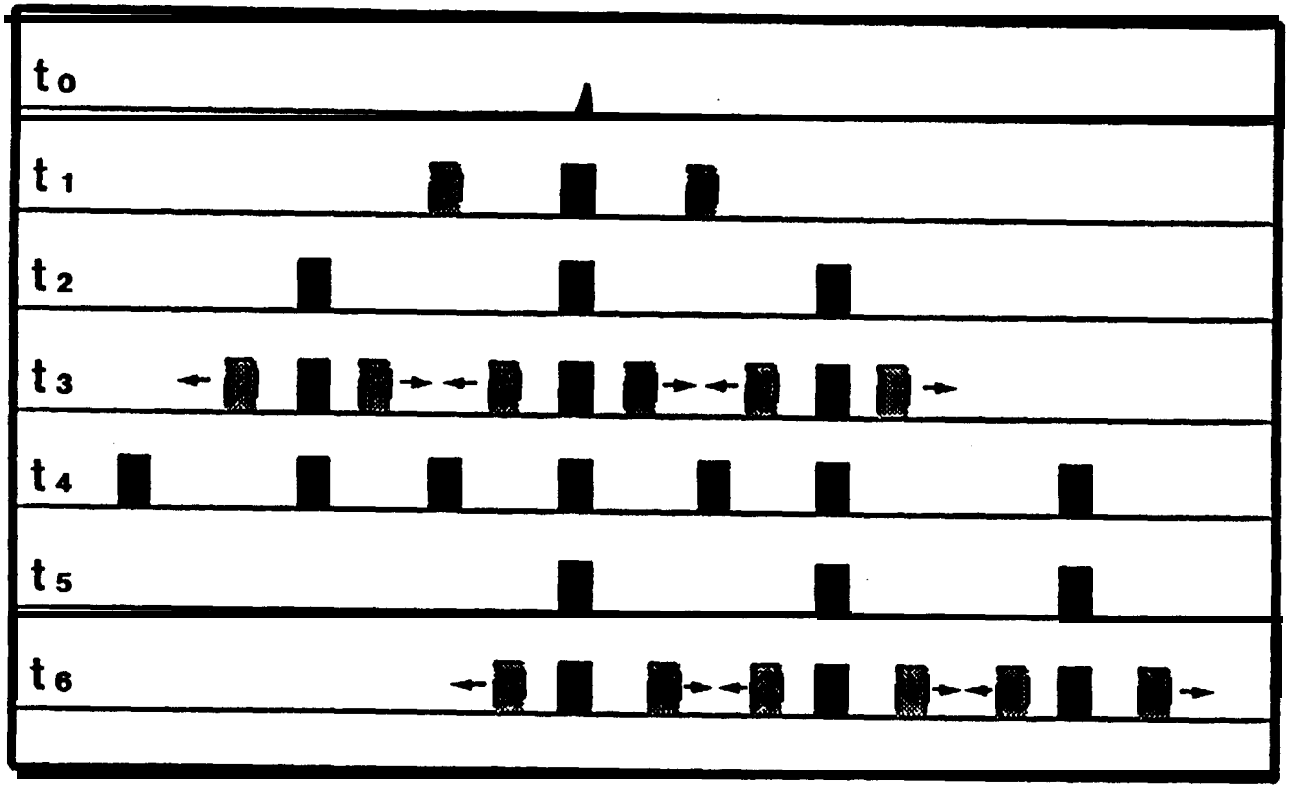
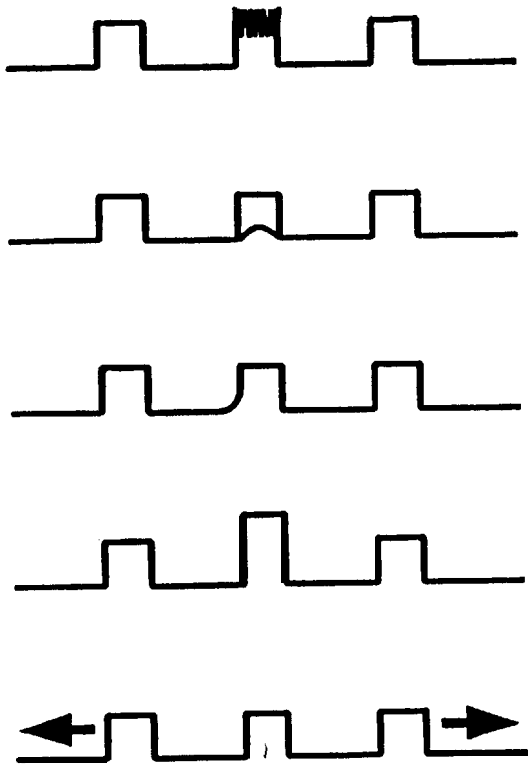
RANGE FALSE TARGETS



CUES

- FAZZBALL
- MOUSE UNDER THE RUG
- FXOHH POACH
- J/S DIFFERENCES
- RATE OF SEPARATION



RADARCOUNTERMEASURES

TRADES & DRIVERS - RANGE TECHNIQUES

- NOISE
  - FREQUENCY SET ON - ACCURACY & SETTLING TIME
  - BANDWIDTH MATCHING
  - LOOK THROUGH RATE
- REPEATER
  - CONSTANT GAIN - ISOLATION/GAIN VERSUS TARGET RCS
  - TIME DELAY THROUGH SYSTEM
  - CONSTANT POWER - CHOP RATE/SPECTRAL SPREADING
- TRANSPONDER
  - SYSTEM COMPLEXITY
  - SIGNAL SORTING/TRACKING
  - FREQUENCY/TIME SET ON ACCURACY
  - LOOK THROUGH RATE

AGENDA

SURVIVABILITYFACTORS

ECMSYSTEMARCHITECI'URES

RADARCOUNTERMEASURESTECHNIQUES

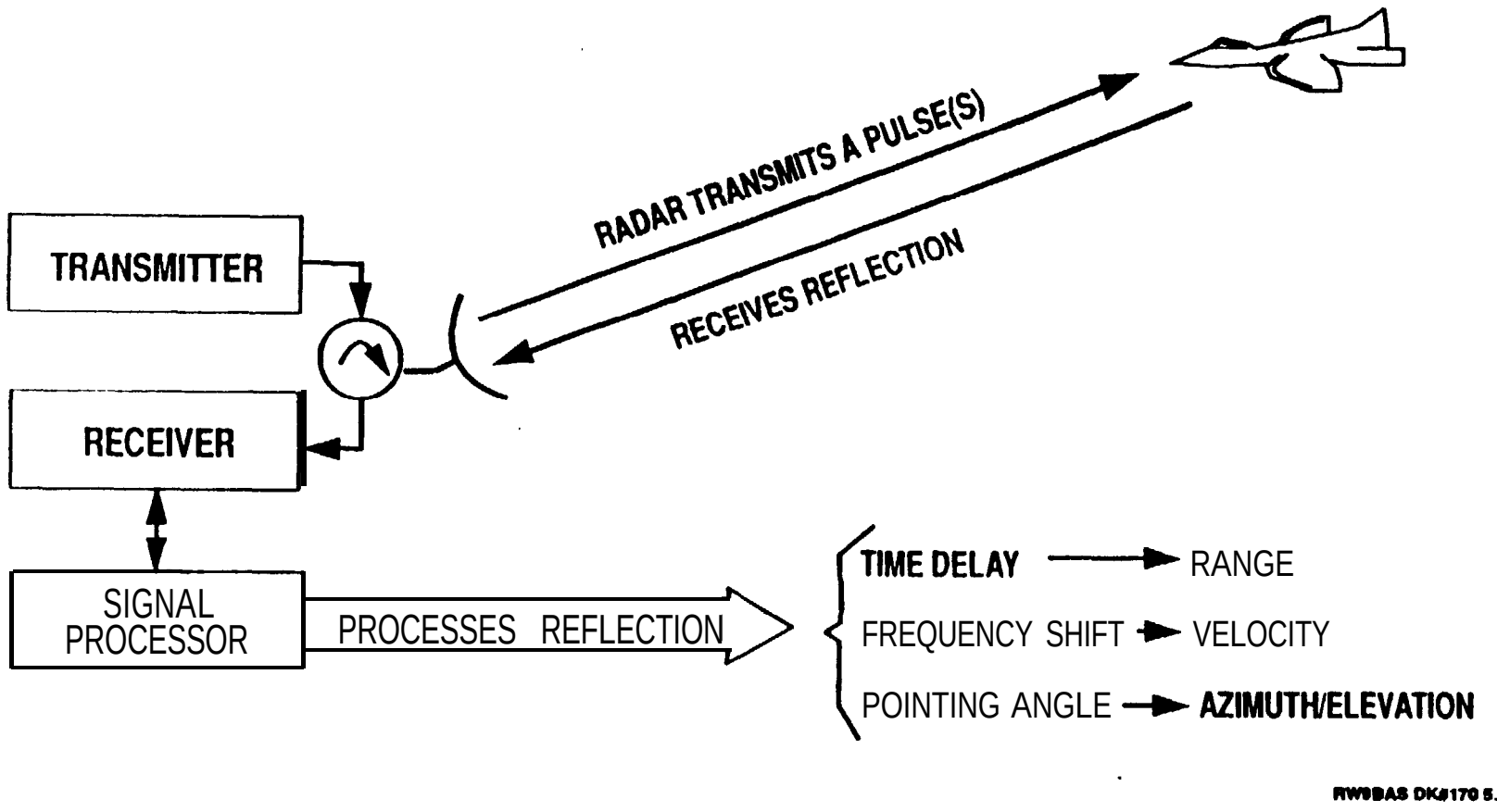
- RANGE
- *VELOCITY
- ANGLE

MISSILECOUNTERMEAURES

COUNTERMEASURESWRAPUP

ECMANALYSIS-TOOLSANDPROCESSES

BASIC RADAR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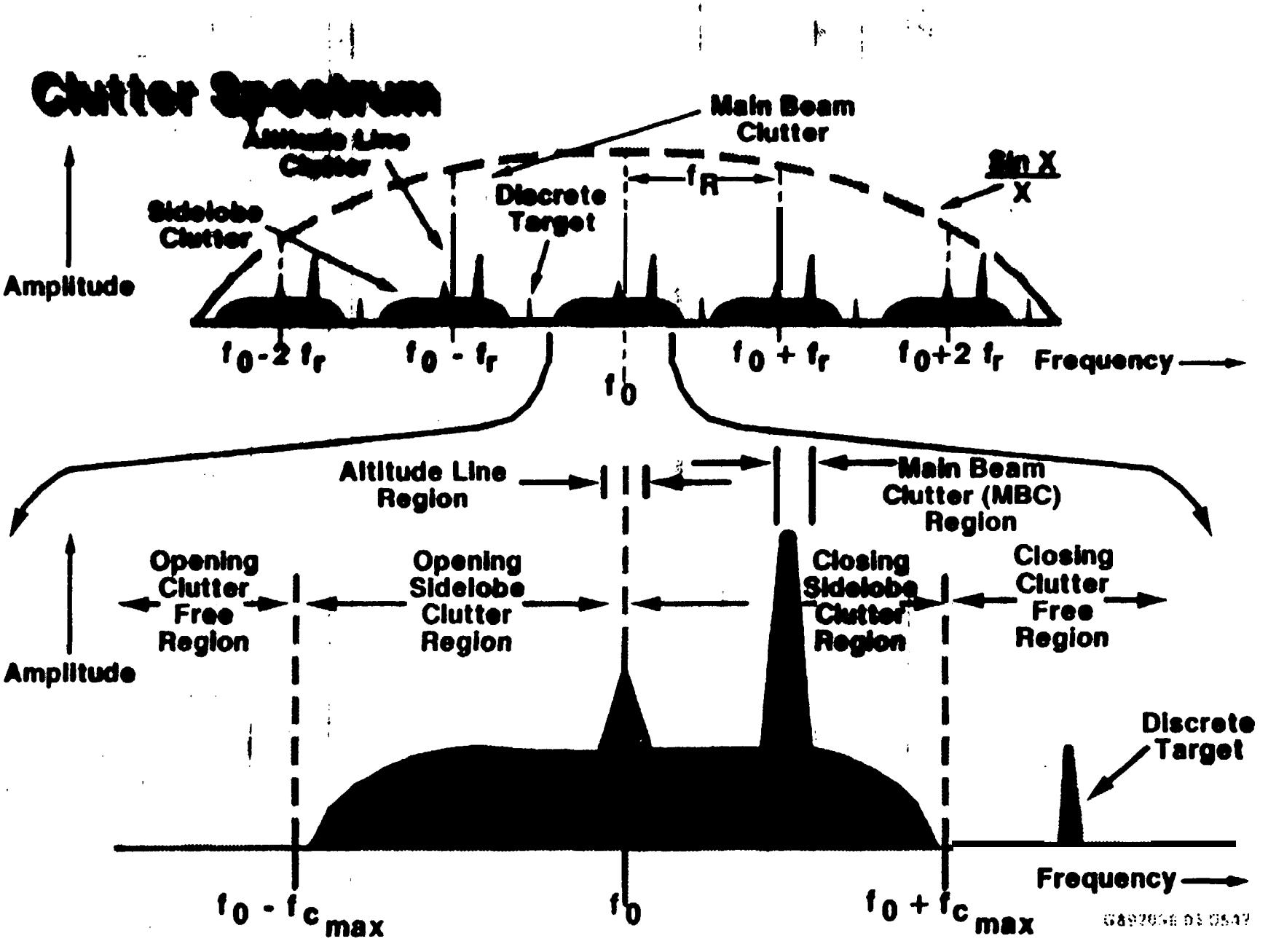
RECEIVES REFLECTION
TRANSMITTER
RECEIVER
SIGNAL PROCESSOR
PROCESSES REFLECTION
TIME DELAY → RANGE
FREQUENCY SHIFT → VELOCITY
POINTING ANGLE → AZIMUTH/ELEVATION

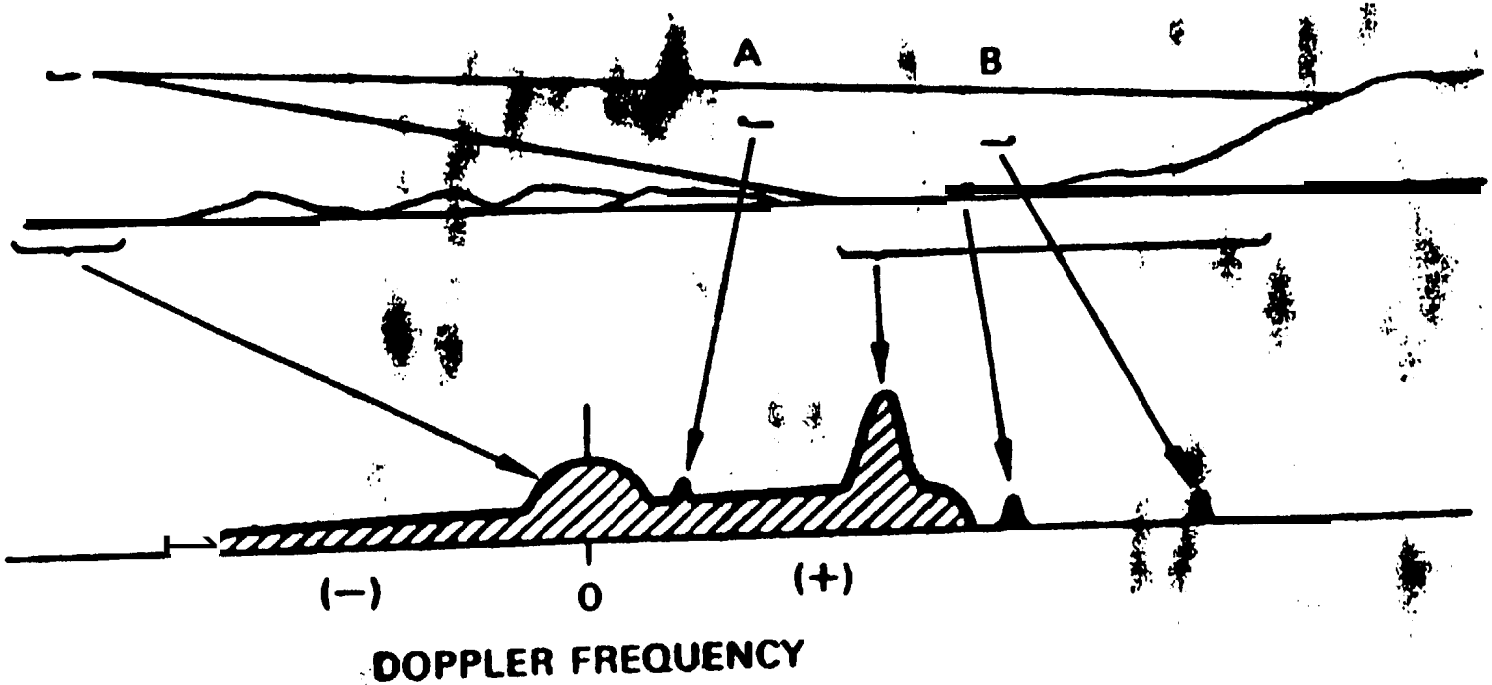
RADAR COUNTERMEASURES

DOPPLER RADAR CHARACTERISTICS

- DOPPLER SHIFT (VELOCITY) TRACKING
- COHERENT RADAR - PHASE INFORMATION PRESERVED
  - STABLE FREQUENCY SOURCE
  - PHASE DETECTOR
- HIGH AVERAGE POWER
  - GROUND BASED (~ 110 dBm)
  - AIRBORNE (~ 90 dBm)
- MEDIUM TO HIGH DUTY CYCLE (5<DC<40 % TO CW)
  - WIDE PW (1 USEC < PW < CW)
  - MEDIUM - HIGH PRF (10K-300 K PPS TO CW)
- NARROW INSTANTANEOUS BANDWIDTH (KILOHERTZ)
  - DEPENDS ON COHERENT INTEGRATION OF TARGET RETURN
  - SIGNIFICANTLY DECREASE NOISE & NON-COHERENT JAMMING EFFECTS


Clutter Spectrum
Altitude Line Clutter
Main Beam Clutter
Sidelobe Clutter
Discrete Target
f_R
Sin X / X
Amplitude
$f_0 - 2f_r$
$f_0 - f_r$
f_0
$f_0 + f_r$
$f_0 + 2f_r$
Frequency
Altitude Line Region
Main Beam Clutter (MBC) Region
Opening Clutter Free Region
Opening Sidelobe Clutter Region
Closing Sidelobe Clutter Region
Closing Clutter Free Region
Amplitude
Discrete Target
$f_0 - f_{c\,max}$
f_0
$f_0 + f_{c\,max}$
Frequency

TRUE DOPPLER PROFILE

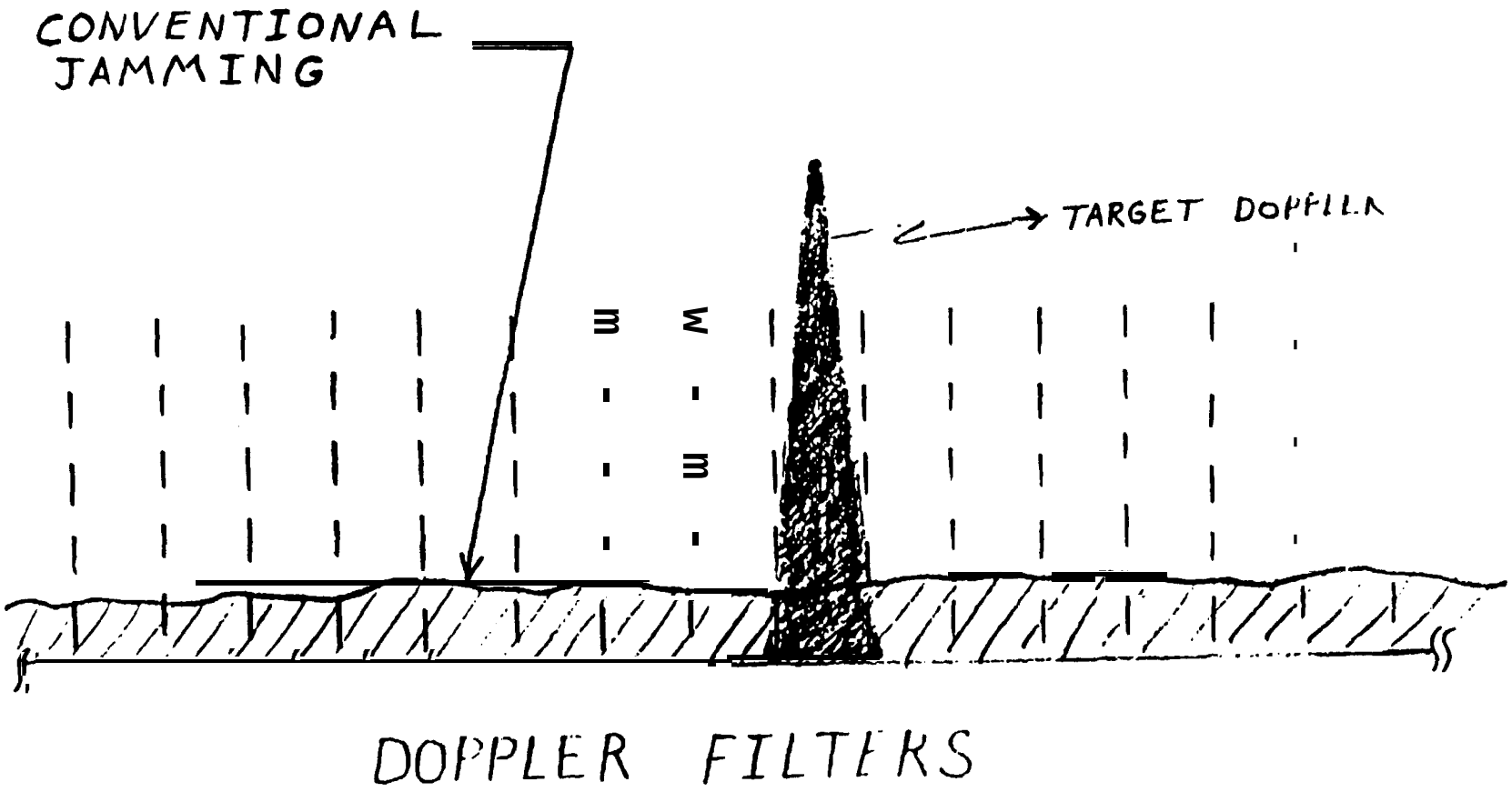


RADARCOUNTERMEASURES

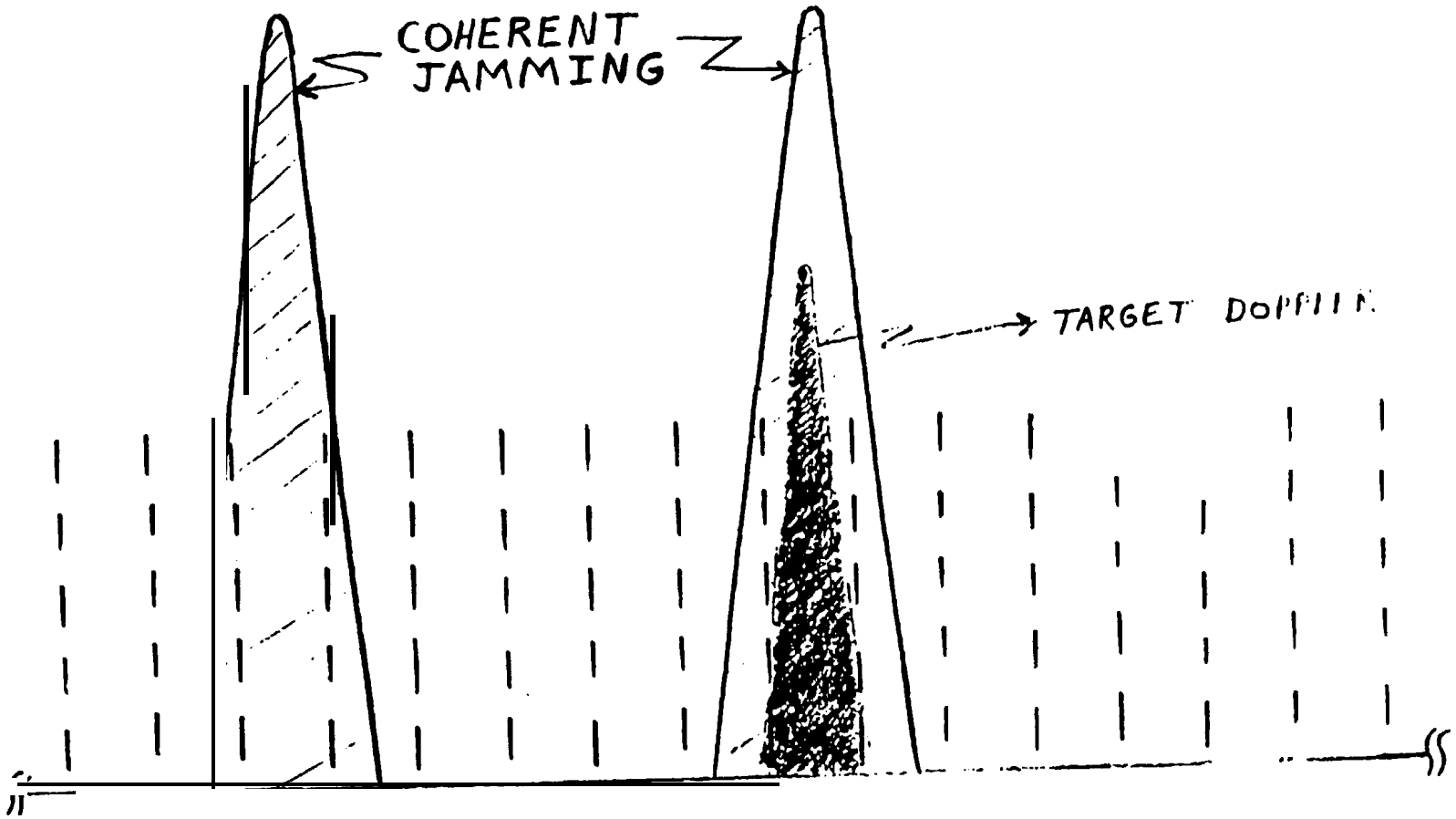
VELOCITY TECHNIQUES VS DOPPLER RADAR

- REPEATER
  - VELOCITY GATE PULL-OFF (VGPO)
    - VELOCITYFALSETARGETS(VFI')
- TRANSPONDER (DRFM TECHNIQUES)
  - COMBINEDRANGE/VELOCITYPULL-OFF
  - RANGE/VELOCITY FALSE TARGETS (R/V FT)

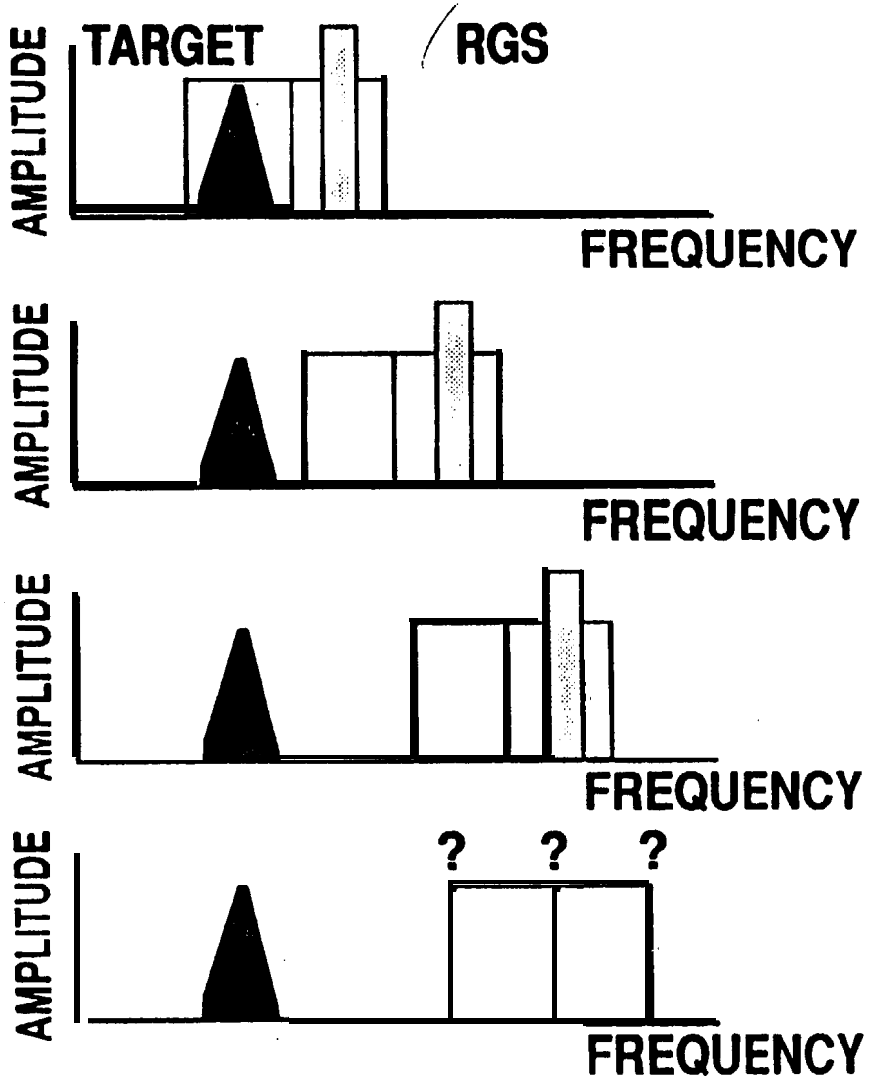
COHERENT DOPPLER CHARACTERISTICS



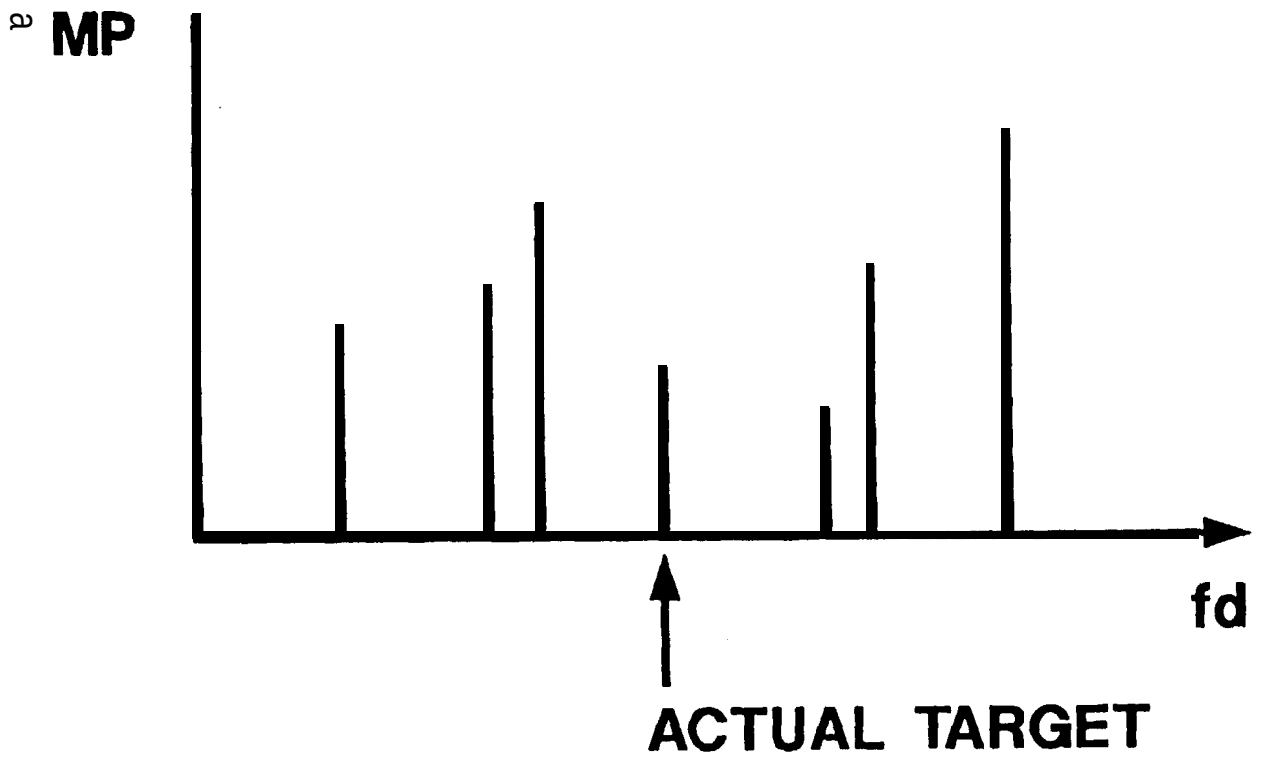
COHERENT RADAR CHARACTERISTICS



VELOCITY GATE PULL OFF TIME SEQUENCE

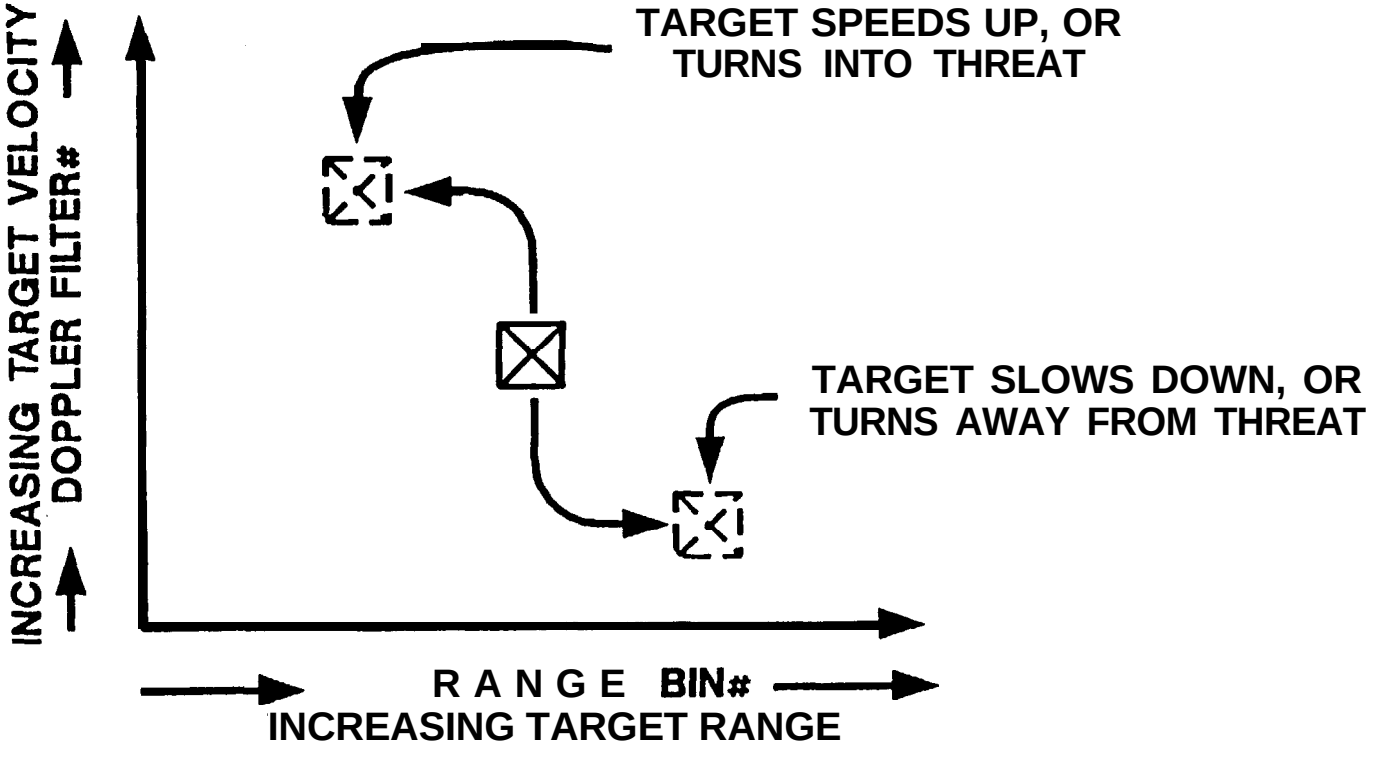


VELOCITY FALSE TARGETS



COMBINED RGPO/VGPO

COMBINED RGPO/VGPO



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RADAR COUNTERMEASURES

TRADES & DRIVERS - VELOCITY ECM

- PRESERVATION OF COHERENCY
  - ISOLATION/GAIN/ GAIN MARGIN
  - STABILITY OF UP/DOWN CONVERSION HARDWARE
  - MEMORY UPDATE RATES
- POWER (J/S)
  - BANDWIDTH MATCH
  - MODULATION LOSS
  - MULTIPLEXING LOSS (6dB PER ADDITIONAL THREAT)
- JAM CUES
  - SPECTRAL PURITY
    - QUANTIZATION NOISE/SPURS
    - UP/DOWN CONVERSION SPURS
  - JEM LINES

AGENDA

SURVIVABILITYFACI'ORS

ECMSYSTEMARCHITECTURES

RADARCOUNTERMEASURES

- RANGE
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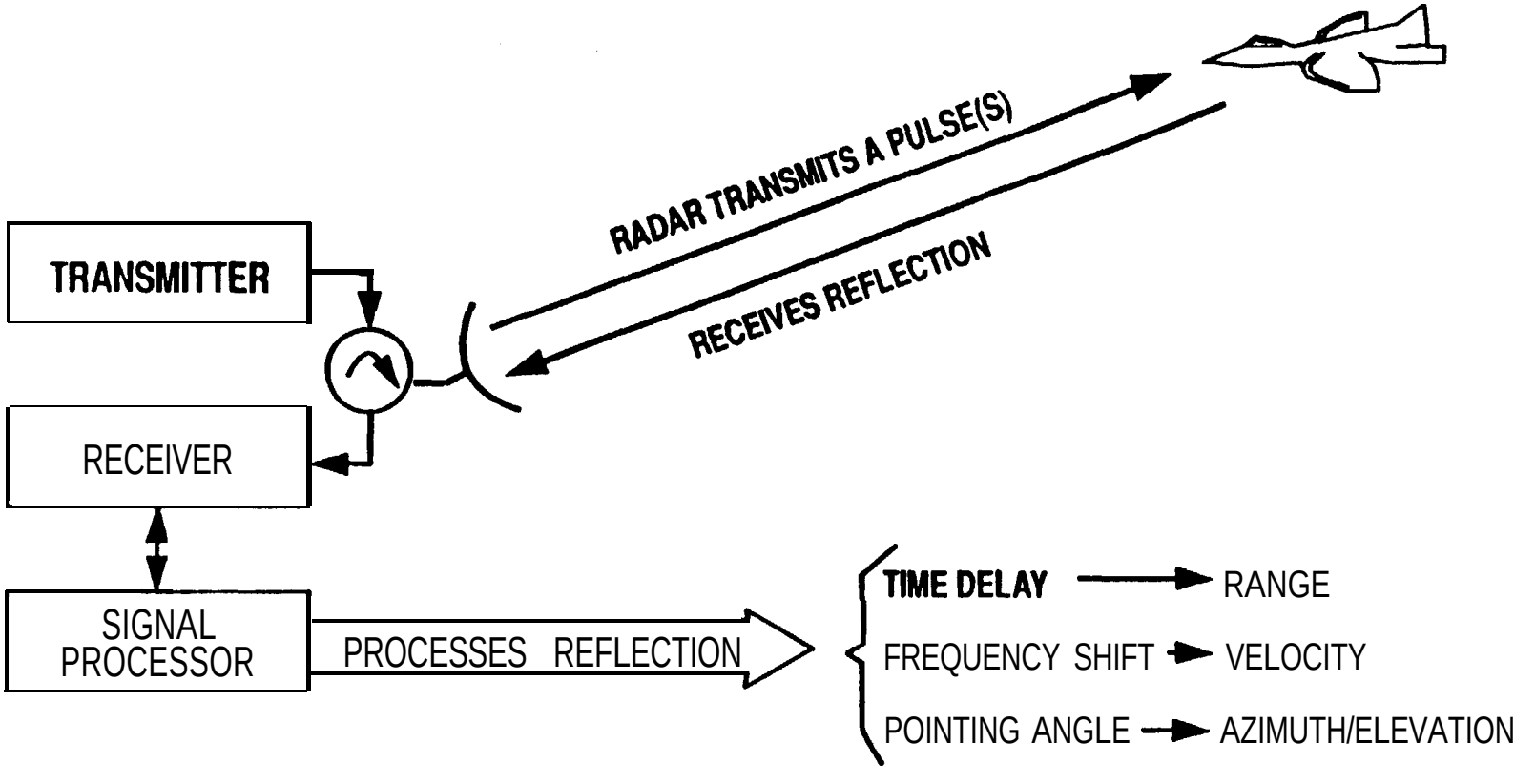
MISSILECOUNTERMEASURES .

COUNTERMEASURESVVRAPUP

ECMANALYSIS-TOOLSANDPROCESSES

BASIC RADAR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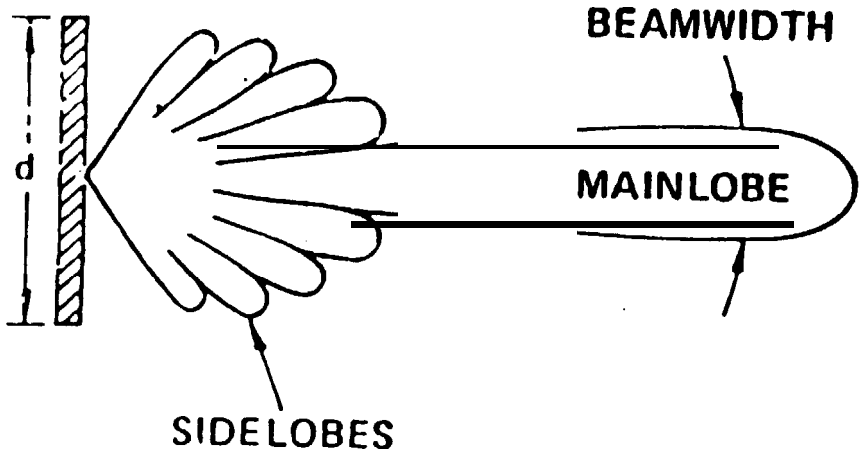
RADARCOUNTERMEASURES

ANGLE TRACKING CHARACTERISTICS

. AZIMUTH/ELEVATION TRACKING IN ADDITION TO RANGE AND/OR VELOCITY

- UTILIZES ANTENNA BEAM SHAPE FOR ANTENNA POINTING
- USE RANGE OR DOPPLER (BINS/GATES/CELLS) TO REDUCE NOISE, CLUTTER, JAMMING, INTERFERENCE TO TRACK ONLY SIGNAL
- SINGLE ANGLE CHANNEL
  - USES SINGLE ANTENNA BEAM
  - TARGET POSITION - RETURN @ MAXIMUM AMPLITUDE
  - SUSCEPTIBLE TO AMPLITUDE MODULATION ECM
  - ACTIVE/PASSIVE TRACK WHILE SCAN (TWS), CONICAL/SEQUENTIAL SCAN
- MULTIPLE ANGLE CHANNELS (MONOPULSE)
  - COMPARES MULTIPLE ANTENNA BEAMS
  - TARGET POSITION - WHERE ANGLE ERROR IS ZERO
  - NULLIFIES CONVENTIONAL AM
  - SUSCEPTIBLE TO MORE SOPHISTICATED TECHNIQUES

THE ANTENNA PROVIDES ANGLE MEASURMENT



BEAMWIDTH

$$\theta_{3\,dB} \propto \frac{\lambda}{d} = \frac{\text{WAVELENGTH}}{\text{ANT DIAMETER}}$$

AT X-BAND

$$\theta_{3dB} \approx \frac{85^o}{d}$$

(FOR TAPERED ILLUM)

$$\theta_{3\,dB} \approx \frac{70^o}{d}$$

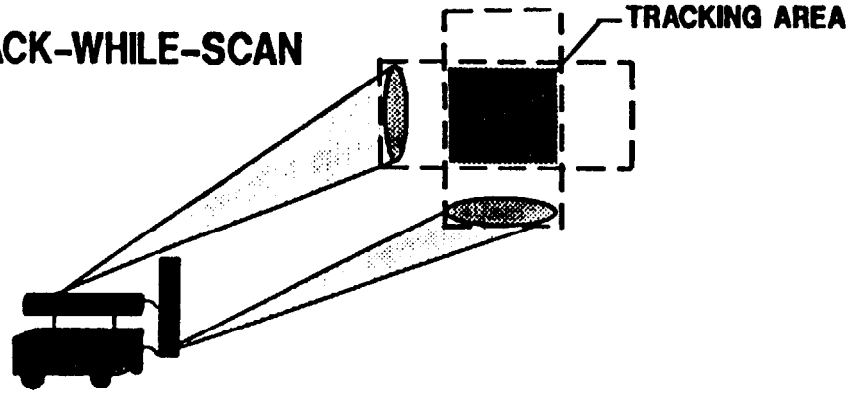
(FOR UN-TAPERED)

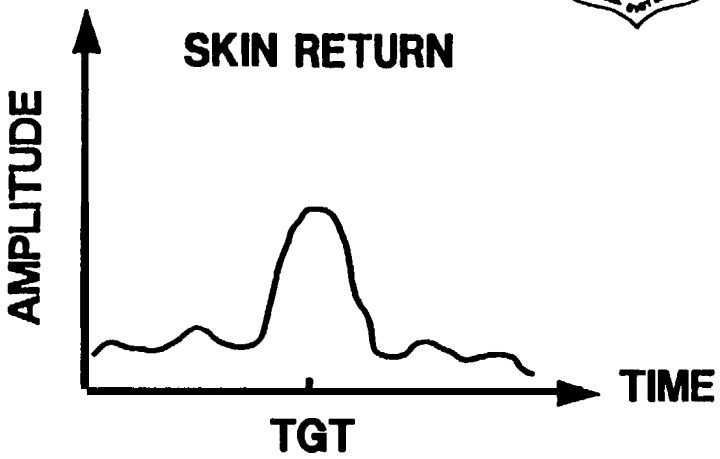
RADAR COUNTERMEASURES

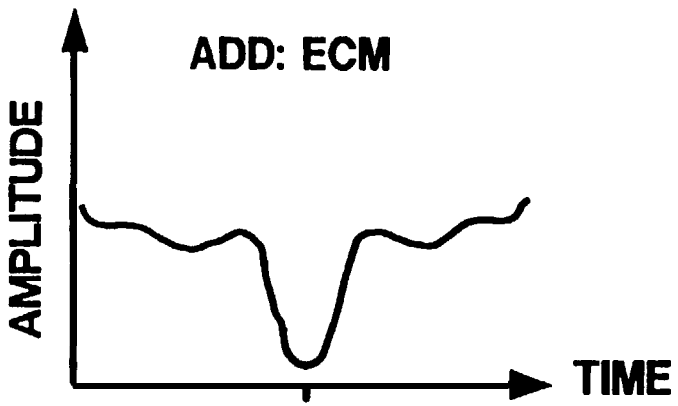
ANGLE ECM TECHNIQUES

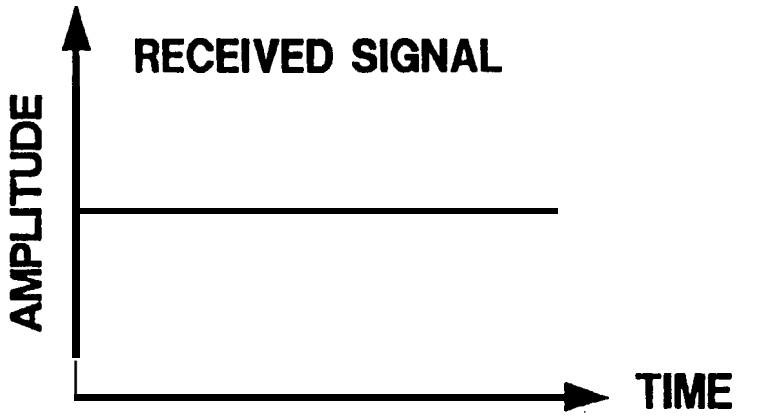
- AMPLITUDE MODULATION
  - INVERSE GAIN
  - INVERSE CONICAL SCAN
  - SWEPT SQUARE WAVE
- MONOPULSE
  - POLARIZATION
  - CROSS-EYE
  - CHAFF

INVERSE GAIN VS TRACK-WHILE-SCAN



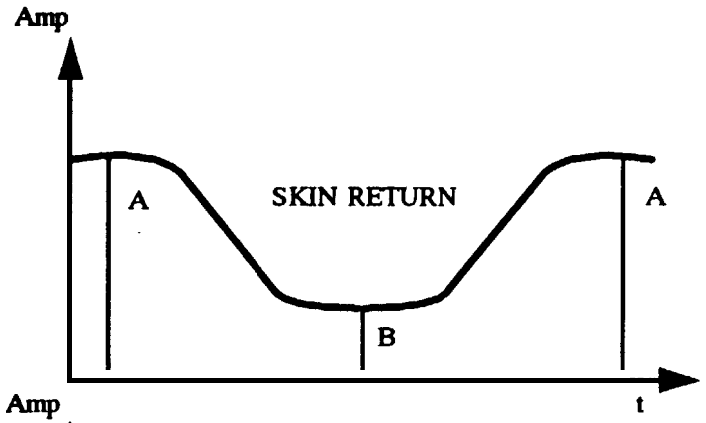


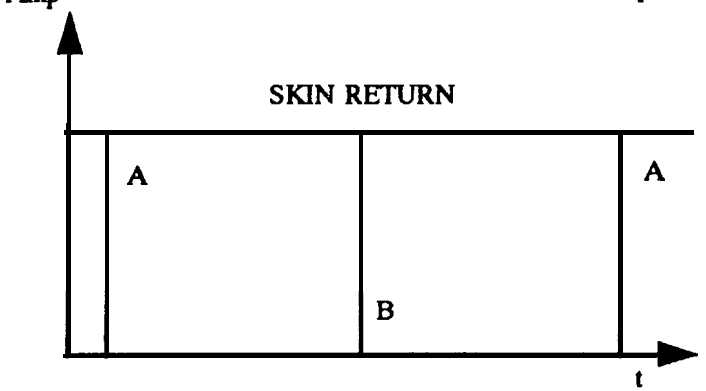


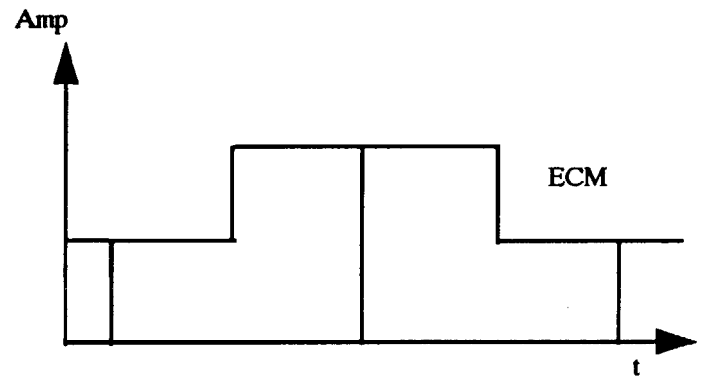


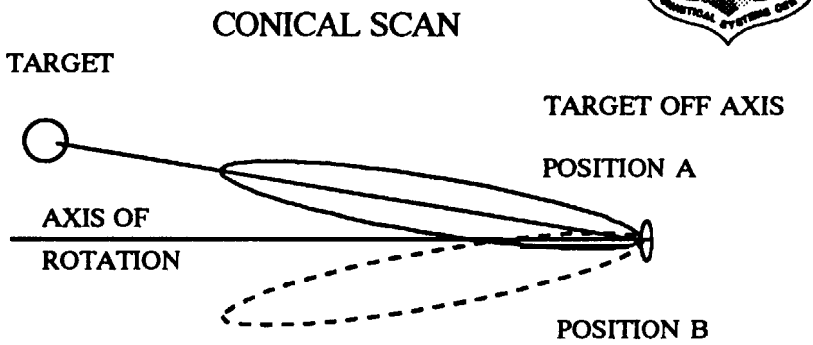
RW55INV DK#173 5.2

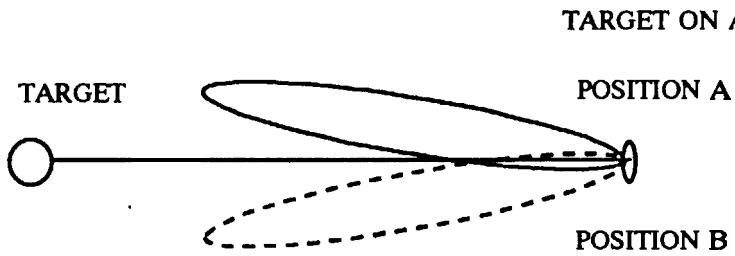
SCAN RELATED AMPLITUDE MODULATION VS CONICAL SCAN

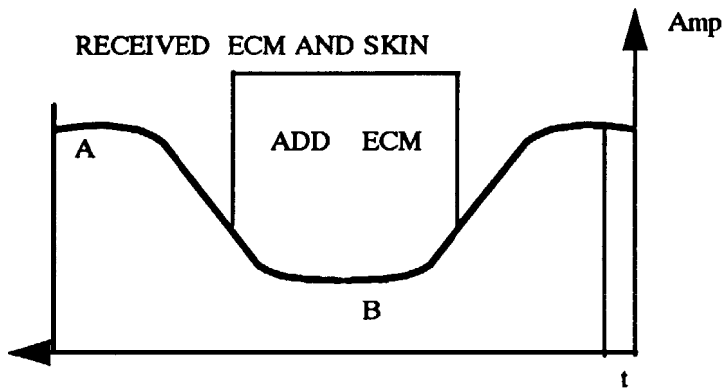




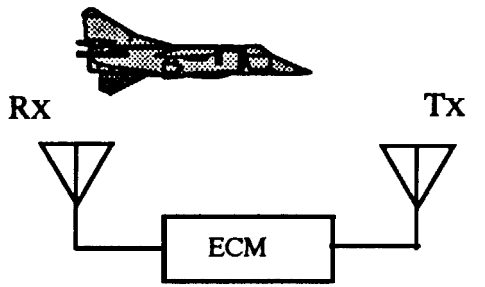


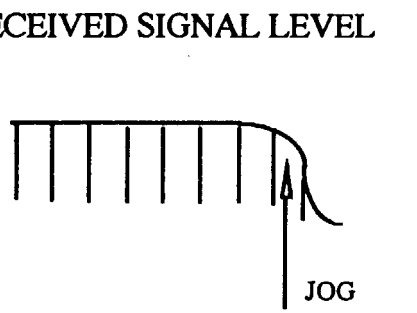


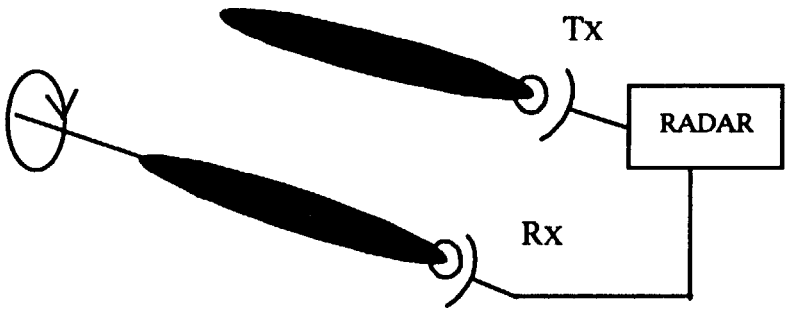




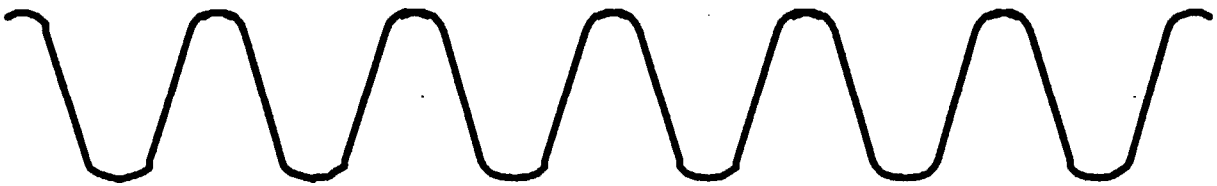
SWEPT AM VS PASSIVE SCAN







Radar Receive Scan 60 Hz



ECM 30 Hz 50 Hz 60 Hz

RADAR COUNTERMEASURES

TRADES & DRIVERS - AMPLITUDE MODULATION

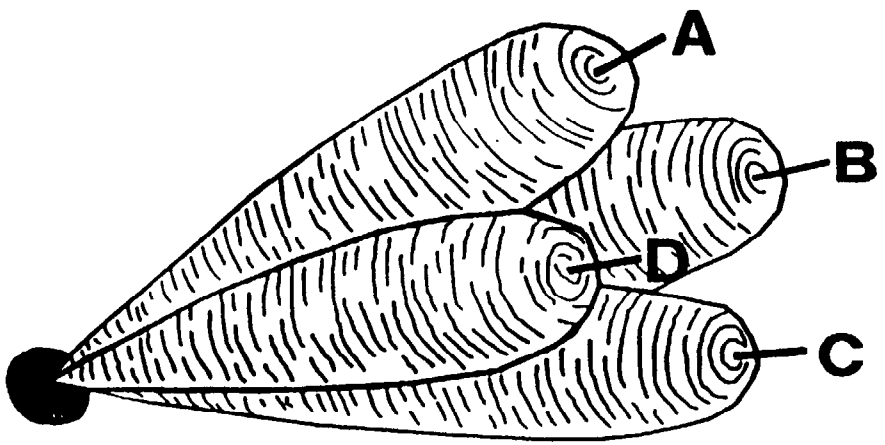
. TECHNIQUE GENERATOR COMPLEXITY

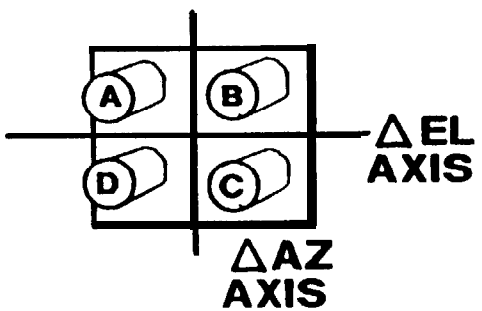
- DETECTION & TRACKING
  - SIGNAL AMPLITUDE
  - SCAN RATE & PHASE
  - DEPTH OF MODULATION
  - MONITORING OF SIGNAL AMPLITUDE (FOR JOG DETECT)
- MODULATION
  - SCAN FREQUENCY SET-ON ACCURACY
  - PHASE SET-ON ACCURACY
  - DUTY CYCLE
  - DEPTH OF MODULATION

MONOPULSE

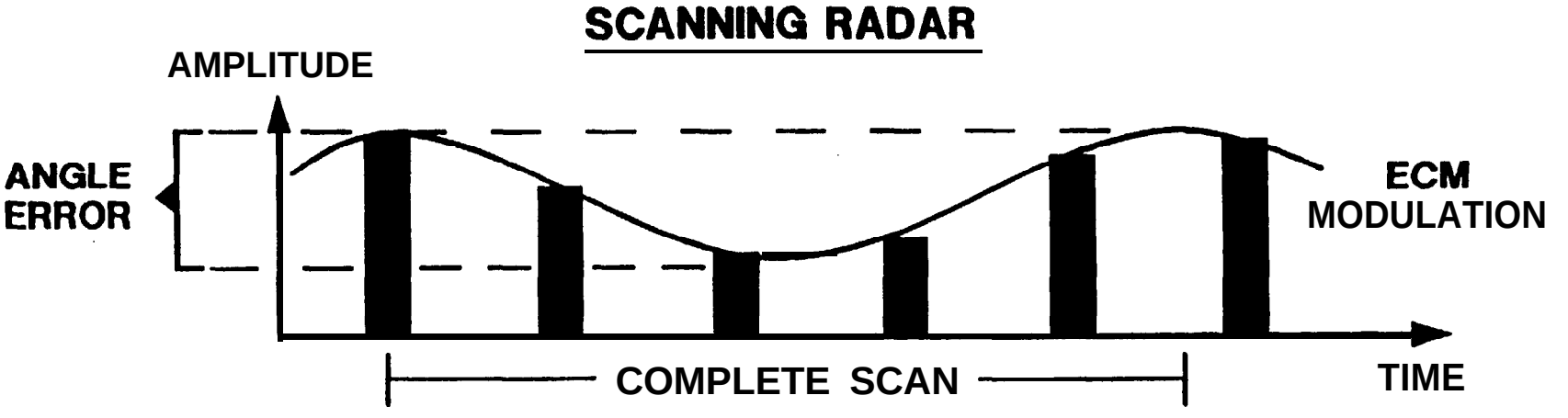
- FOUR SIMULTANEOUSLY RECEIVE BEAMS.
- ANGLE ERRORS DERIVED FROM INSTANTANEOUS BEAM COMPARISON
  - -AZIMUTH ERROR = (A + D) – (B + C)
  - -ELEVATION ERROR = (A + B) – (C + D)

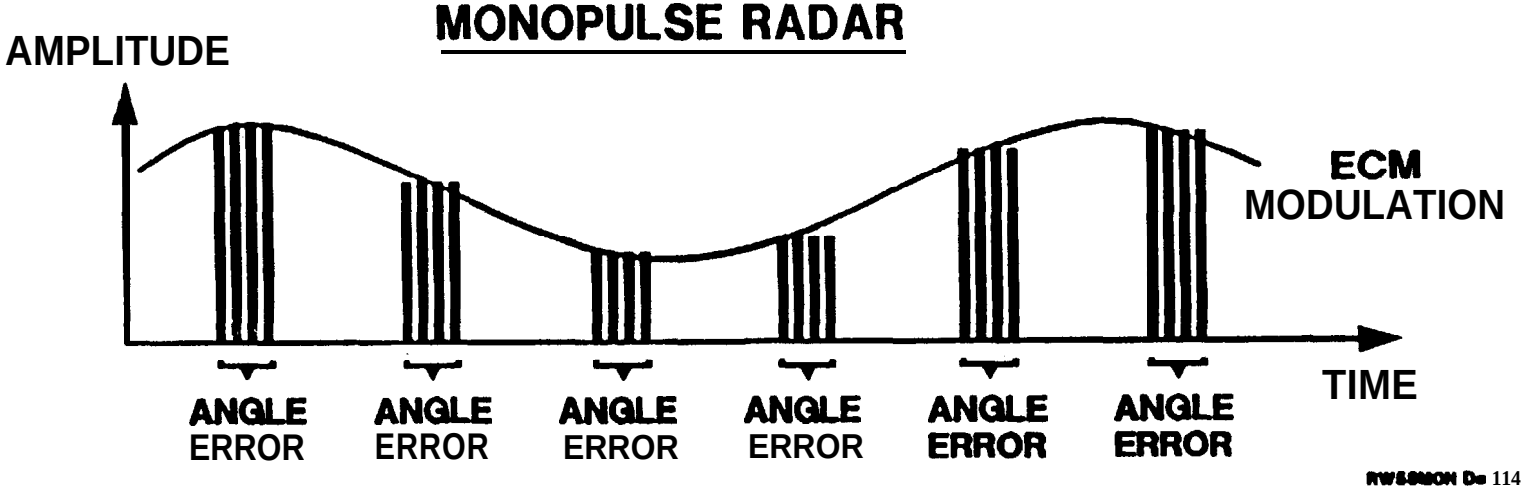
  } TIME INDEPENDENT
- TARGET BORESIGHTED WHEN A=B=C=D



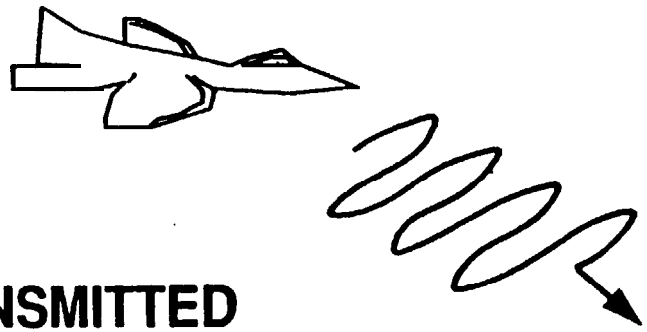


MONOPULSE IMPACTS



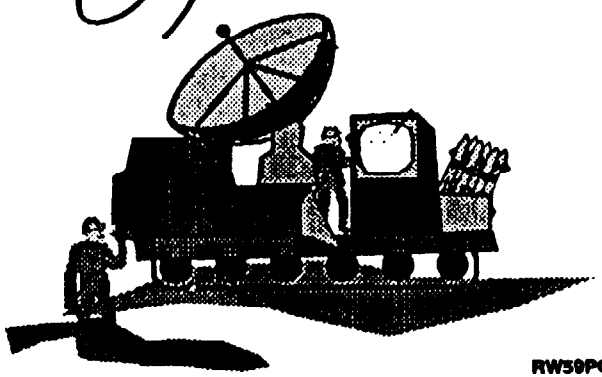


POLARIZATION



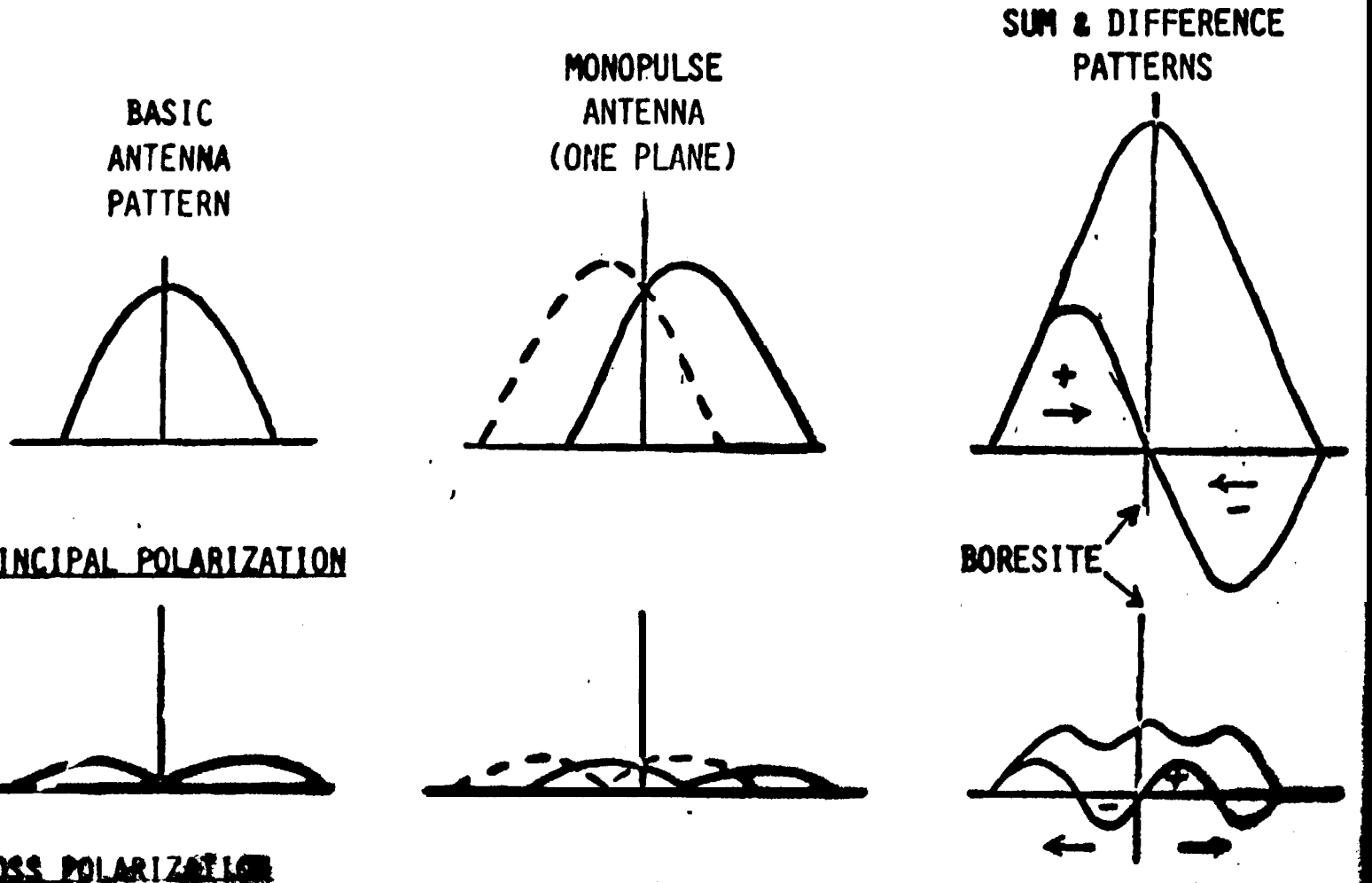
TRANSMITTED
POLARIZATION ECM
(HORIZONTAL)

TRANSMITTED
RADAR SIGNAL
(VERTICAL)



RW59POL DK# 170 5.2

POLARIZATION CHARACTERISTICS IN A MONOPULSE ANTENNA



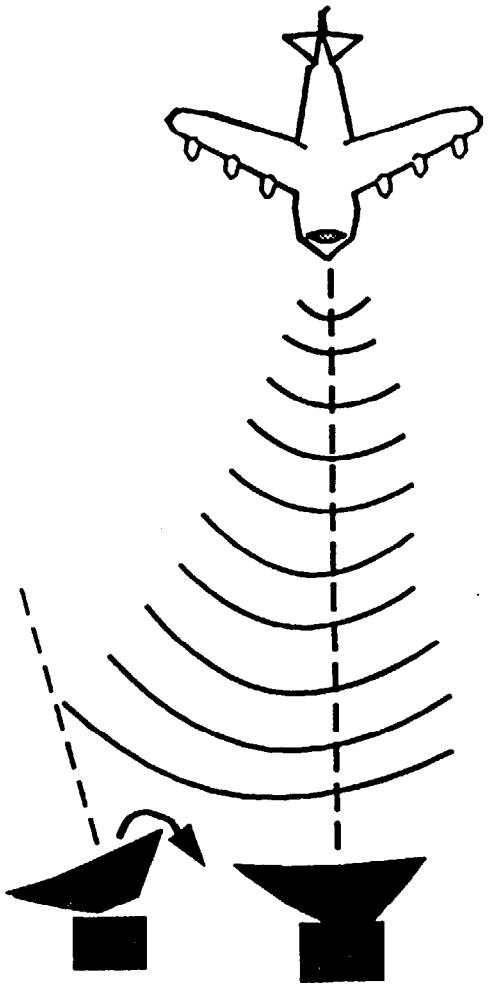
RADAR COUNTERMEASURES

TRADES & DRIVERS - POLARIZATION ANGLE ECM

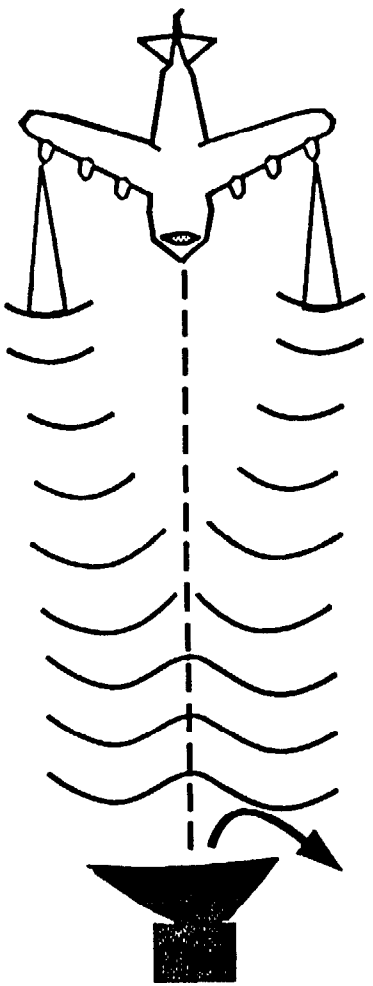
- THREAT VULNERABILITY
  - •MONO-STATIC vs BISTATIC
  - •CROSS-POLARIZATION RESISTANCE
- SYSTEM COMPLEXITY - SPECIALIZED Rx/Tx
  - • POLARIZATION UPDATE RATE
  - • LOOKTHROUGH
  - • MULTIPATH
  - • POLARIZATION SET ON ACCURACY (PURITY)
- OFTEN DEPENDENT ON RANGE OR VELOCITY PULL TO ACHIEVE INFINITE J/S

CROSS-EYE

NORMAL RADAR TRACKING



CROSS-EYE



RADAR TRIES TO ALIGN ANTENNA WITH TILTED PHASE FRONT

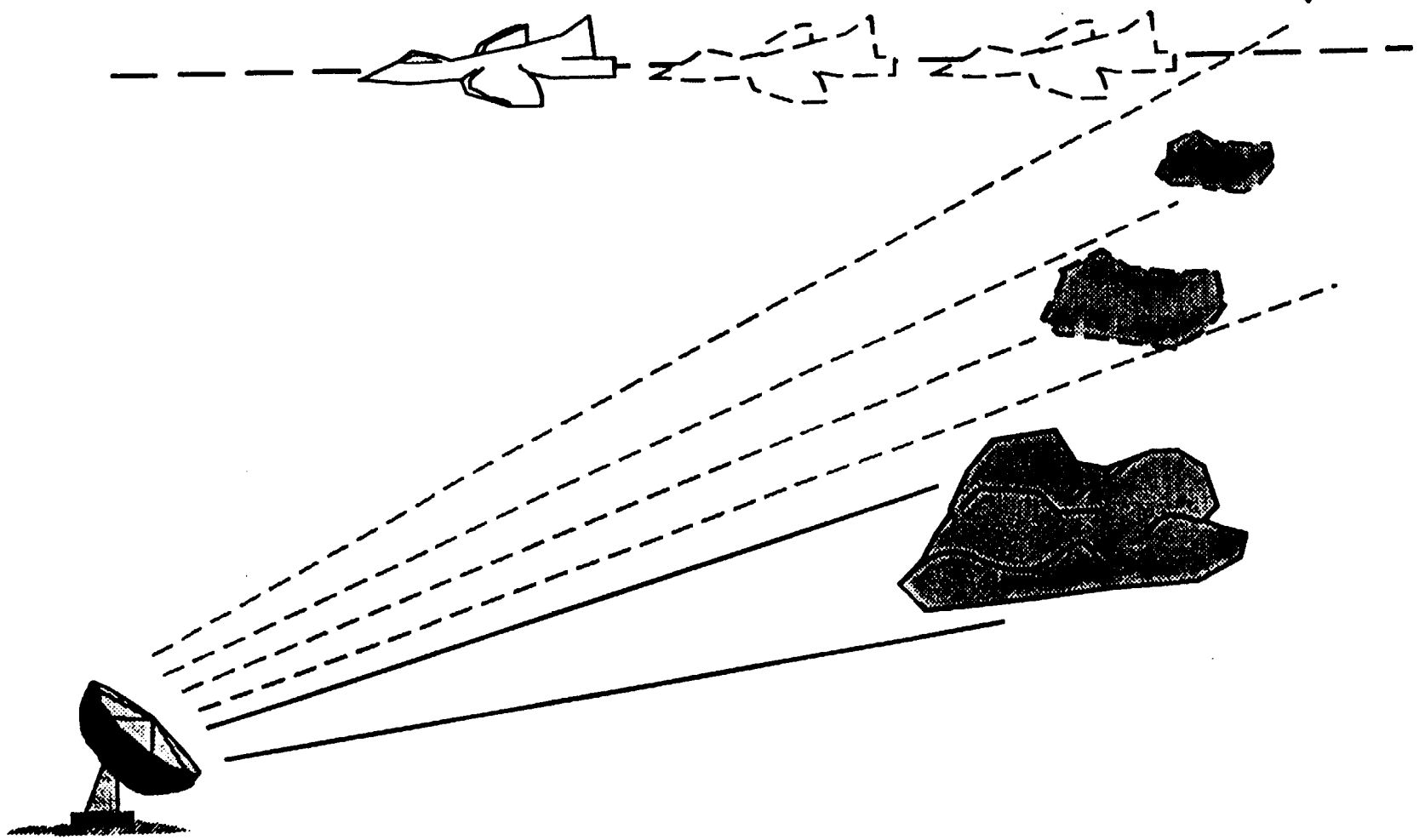
RW61CRO DK#170 5.2

RADAR COUNTERMEASURES

TRADE & DRIVERS - CROSS-EYE ANGLE ECM

- RADAR - MONOSTATIC vs BISTATIC
- SYSTEM COMPLEXITY - SP≤CIALI≥≤D Rx/Tx
  - PHASE MATCHING
  - SYSTEM DELAYS
- OFTEN DEPENDENT ON RANGE ºR VELOCITY PULL TO ACHIEVE INFINITE J/S

SELF PROTECTION CHAFF



RW64SE DKJ170

RADARCOUNTERMEASURES

TRADE & DRIVERS - CHAFF ANGLE ECM

- **DISPENSE RATE**
- **BLOOM RATE/SIZE**
- **VELOCITY OF DIPOLES VS DOPPLER TRACKERS**
- **EFFECTIVE CROSS SECTION OF CHAFF CLOUD**
- **WEATHER**
- **AIRCRAFT MANEUVER**

AGENDA

SURVIVABILITYFACTORS

ECMSYSTEMARCHITECTURES

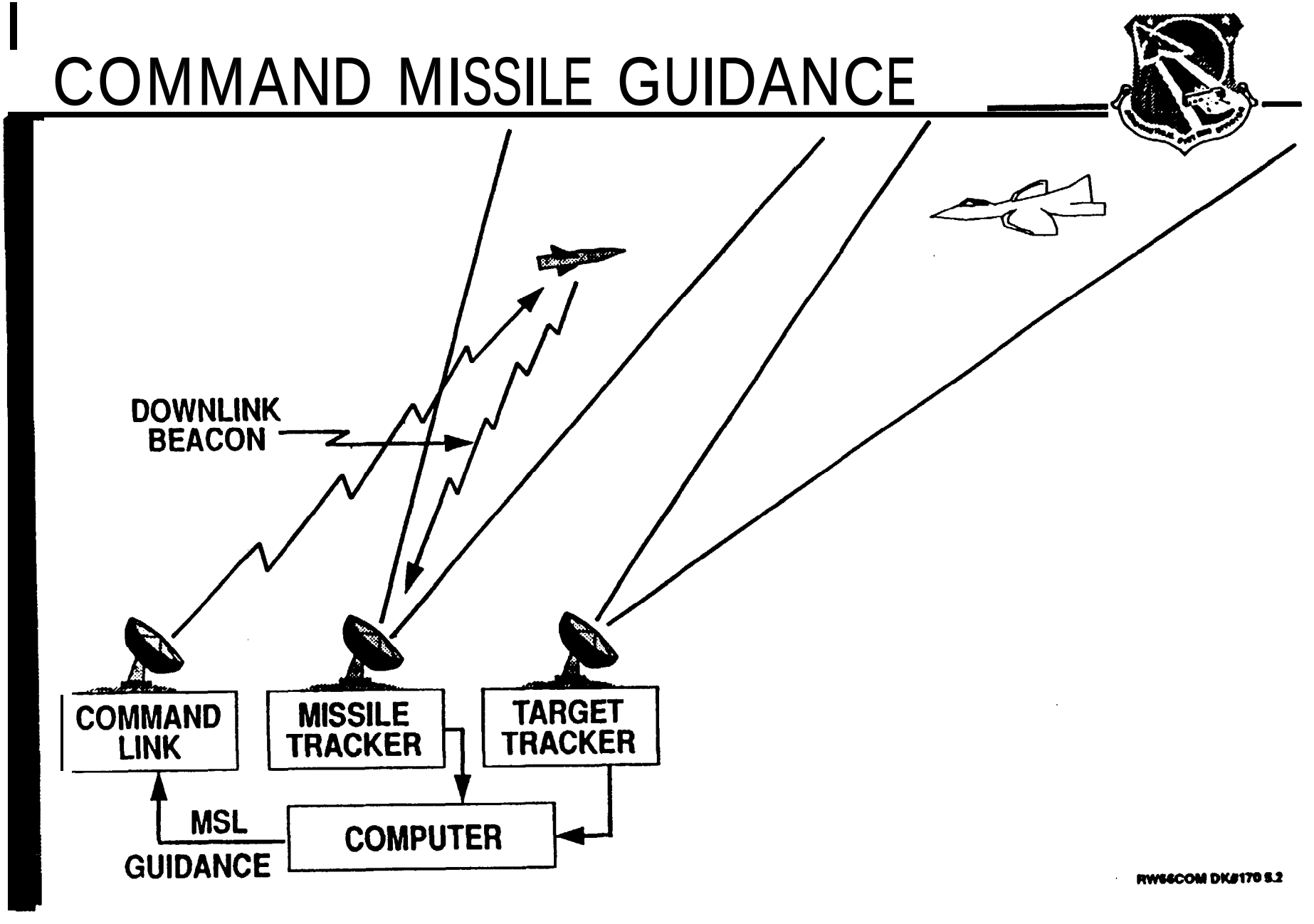
RADARCOUNTERMEASURES
- *RANGE
- VELOCITY
- ANGLE

MISSILECOUNTERMEASURES

COUNTERMEASURESWRAPUP

ECMANALYSIS-TOOLSANDPROCESSES

COMMAND MISSILE GUIDANCE



RW66COM DK#170 S.2

MISSILE COUNTERMEASURES

COMMAND GUIDED WEAPON JAMMING APPROACH:

- ATTACK MULTIPLE ASPECTS OF WEAPON SYSTEM

. FALSE TARGET POSITION VERSUS TARGET TRACK RADAR (TTR)
  - RANGE - FALSE TARGETS (RFT/RANRAP), MASKING - NOISE
  - ANGLE - ANGLE ERROR - AM, XPOL

DOWN LINK JAMMING:

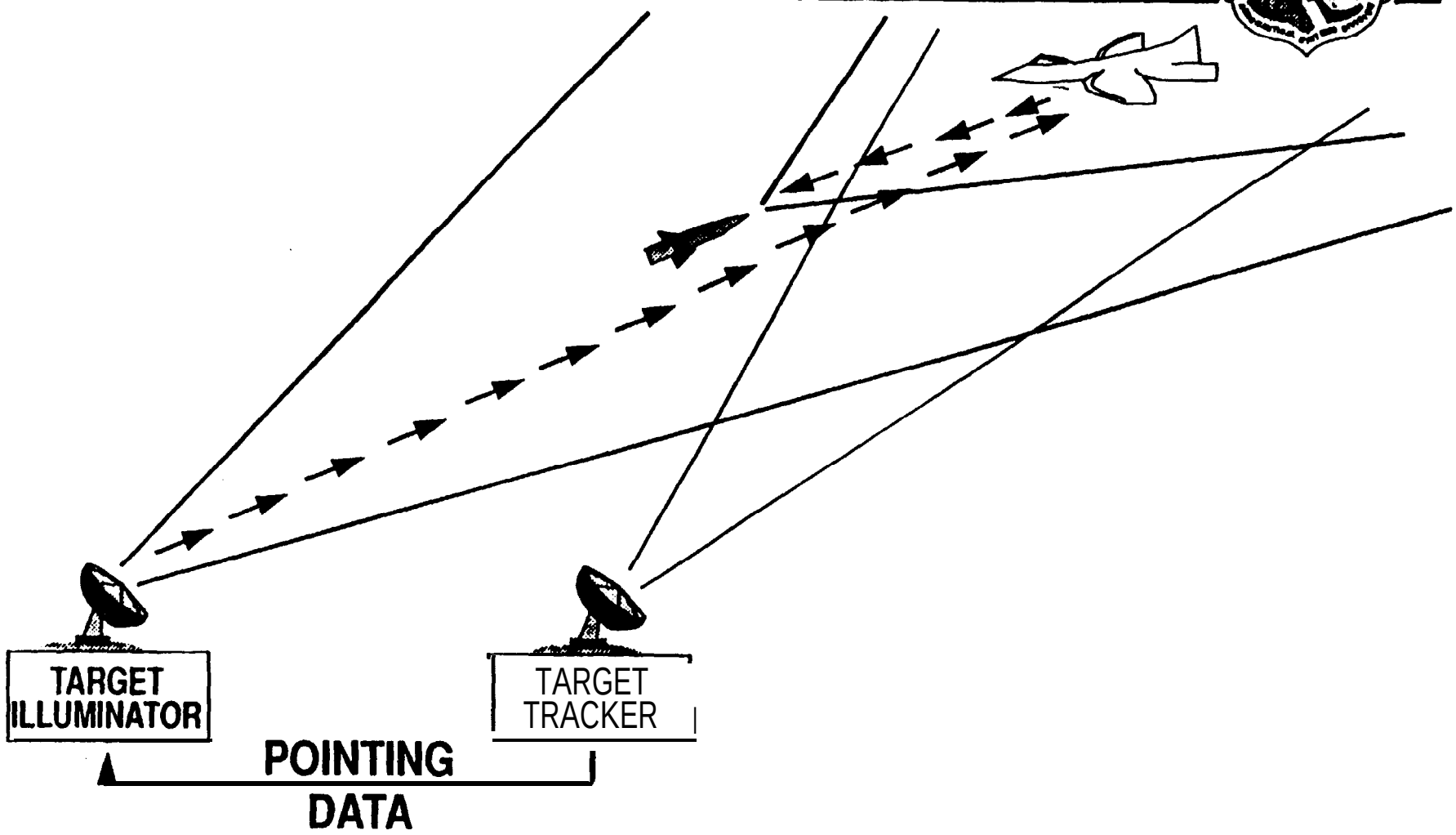
- FALSE MISSILE POSITION VERSUS MISSILE TRACKING RECEIVER
  - RANGE - FALSE RANGE POSITION
  - ANGLE - LINE OF SIGHT WITH TARGET, NOT WITH MISSILE
  - DENY MISSILE TRACK
- COMMAND LINK - (UPLINK)
  - ISSUES INCORRECT FLIGHT COMMANDS TO MISSILE
  - MISSILE FLYS TO WRONG RANGE/ANGLE FOR INTERCEPT

MISSILE COUNTERMEASURES

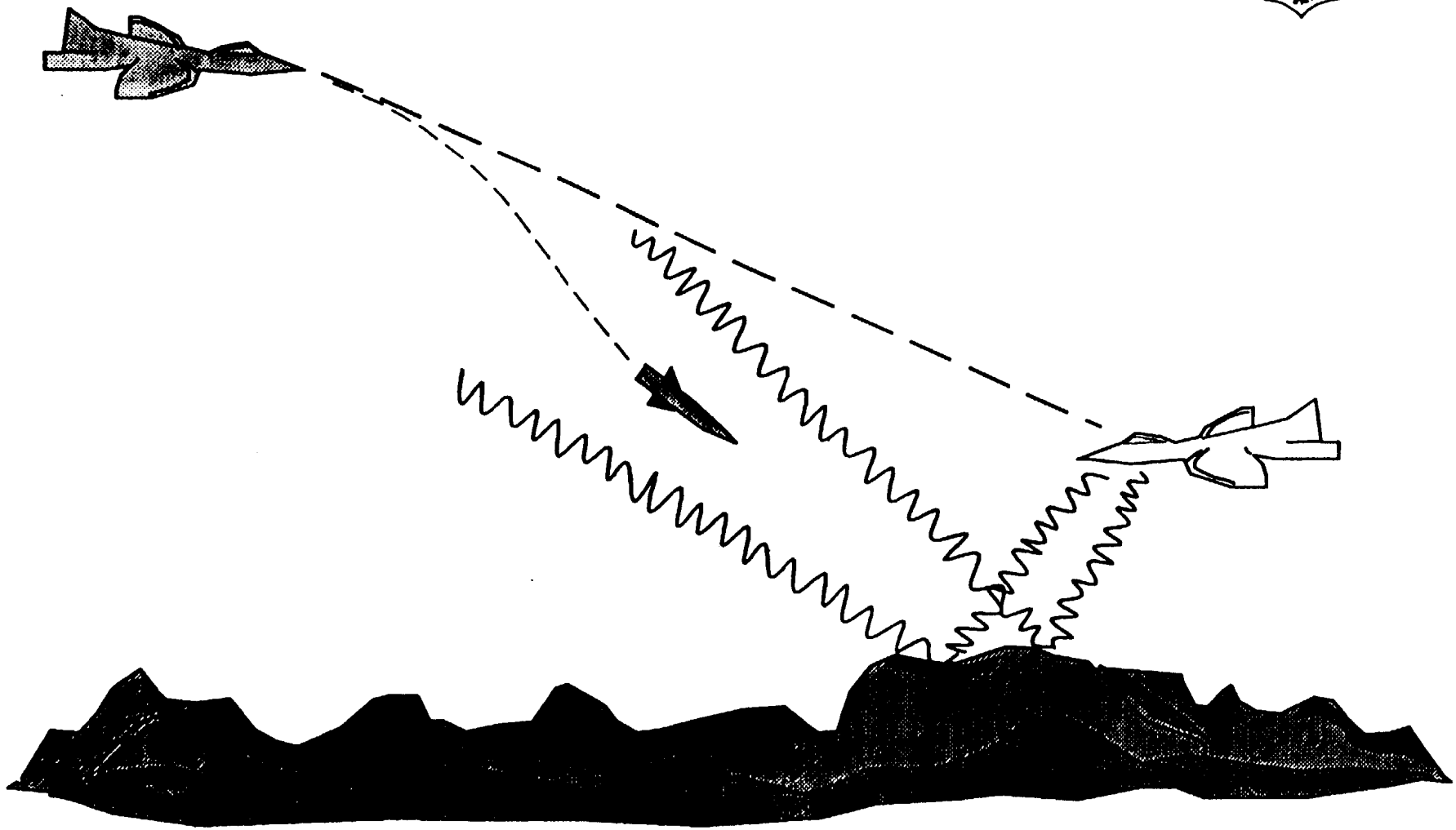
TRADES & DRIVERS - COMMAND GUIDED MISSILE CM (DOWN LINK JAMMING)

- REQUIRES HIGH POWER TO BE EFFECTIVE
  - JAM TO BEACON (J/B) RATIO
  - APRIORI KNOWLEDGE OF BEACON FREQUENCY OR ABILITY TO MEASURE BEACON FREQUENCY
- REQUIRES HIGH DUTY CYCLE FROM JAMMER @'MULTIPLE ECM PULSES FOR EACH RADAR PULSE
  - TIME/FREQUENCY MULTIPLEXING TO COVER UNCERTAINTY

SEMI-ACTIVE MISSILE GUIDANCE SYSTEM



TERRAIN B° UNCE



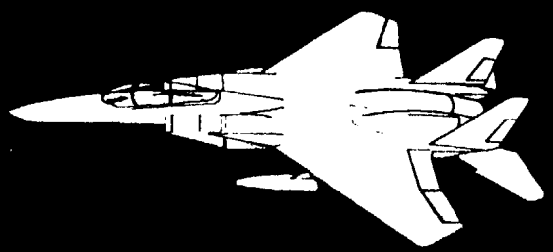
RWSOTER DK#170 5.2

MISSILE COUNTERMEASURES

TRADES & DRIVERS - TERRAIN BOUNCE MISSILE CM

- **ATTACKS SEMI-ACTIVE AND ACTIVE MISSILES**
- THREAT CAPABILITY - TWO TARGET PROCESSING/CCM
- $(J/S)_{DIRECT}$ VS $((J)_{INDIRECT}/(J+S)_{DIRECT})$
- POWER DENSITY DIMISHES WITH ALTITUDE
- ANTENNA TRADES
  - **MAINLOBE GAIN/BEAMWIDTH**
  - DEPRESSION ANGLE
  - **SIDELOBE** SUPPRESSION
- TERRAIN REFLECTIVITY
  - VARIES WITH TERRAIN TYPE
  - DOPPLER SPREAD
  - TIME DELAY

Affordable, Effective Countermeasures Against Critical RF Threats



ON-BOARD SYSTEMS	DECOY TOW LINE	OFF-BOARD DECOY
• DECOY SYSTEM •• CONTROLLER •• POWER SUPPLY •• LAUNCHER	• POWER TRANSMISSION • CONTROLLER - DECOY COMMUNICATIONS	• SELF-CONTAINED REPEATER - RECEIVE - MODULATE - AMPLIFY - TRANSMIT
THREAT WARNING SYSTEM DIRECTION OF ARRIVAL		
• TECHNIQUES GENERATOR •• RECEIVE •• MODULATE •• RF - OPTIC CONVERSION	• OPTICAL SIGNAL TRANSMISSION	•DECOY TRANSPONDER - OPTIC - RF CONVERSION - AMPLIFY - TRANSMIT

MISSILE COUNTERMEASURES

TRADES & DRIVERS - TOWED DECOY MISSILE CM

- THREAT CAPABILITY
  - TWO TARGET PROCESSING CCM'S
  - LETHAL RADIUS
  - FUSING
  - SALVO SHOT
- AIRCRAFT SIGNATURE TO BE PROTECTED

*GEOMETRY-ZONESOFNOPROTECTION

- TOWEDDECOYAERODYNAMI.CCHARACTERISTICS .
  - LAUNCH CLEARANCE
  - DEPLOYMENT / REDEPLOYMENTSPEED/BRAKING
  - REELOUT/INCAPABILITY
  - FLIGHT STABILITY
  - LINE LENGTH / DROOP
- QUANTITY TO BE CARRIED

MISSILE COUNTERMEASURES

TRADES & DRIVERS - REPEATER TOWED DECOY

- SIMPLE ARCHITECTURE
- LIMITED ELECTRONIC GAIN - DUE TO ISOLATION OF CLOSELY SPACED TRANSMIT AND RECEIVE ANTENNAS
- DOPPLER MODULATION RESULTS IN SPECTRAL SPREADING & LOSS OF J/S
- THREAT RANGE RESOLUTION LIMITS TOW LINE LENGTH
  - GEOMETRY
  - DELAY
- POTENTIAL BEACONING TO UNWANTED THREATS FOR BROADBAND OPERATION

MISSILE COUNTERMEASURES

TRADES & DRIVERS - TRANSPONDER TOWED DECOY

- COMPLEX ARCHITECTURE
  - RECEIVE/TECHNIQUE GENERATION ON BOARD
  - REMOTE TRANSMITTER
- ELECTRONIC GAIN- HIGHER DUE TO WIDE ANTENNA SEPARATION
- LONGER TOW LENGTH POSSIBLE
- GEOMETRY ISSUES REMAIN
- COMPLEX MODULATIONS POSSIBLE
  - DOPPLER
  - RANGE TECHNIQUES - OVERCOME DELAYS
- MINIMIZES BEACONING - USE OF THREAT SPECIFIC TECHNIQUES

AGENDA

SURVIVABILITYFACTORS

ECMSYSTEMARCHITECKJRES

RADARCOUNTERMEASURESTECHNIQUES

- *RANGE
- VELOCITY
- *ANGLE

MISSILECOUNTERMEASURES

WCOUNTERMEASURESWRAPUP

ECMANALYSIS-TOOLSANDPROCESSES

COUNTERMEASURES - WRAP UP

REQUIREMENTS AND STRATEGY DERIVED FROM:

- THREAT ENVIRONMENT
  - IADS - C3 VULNERABILITY
  - SIGNAL DENSITY
  - RADAR CAPABILITIES (RANGE, DOPPLER, ANGLE)
  - MISSILE CAPABILITY (CG, SA, A)
- AIRCRAFT
  - SIGNATURE
  - FLIGHT ENVELOPE

COUNTERMEASURES GOALS

- DELAY/NEGATE ALL STEPS OF RADAR/MISSILE ENGAGEMENT

COUNTERMEASURES-WRAP UP

SYSTEM ARCHITECTURE

- **ISOLATION/SYSTEM** GAIN VS TARGET RETURN
- CONSTANT GAIN VS CONSTANT POWER
- **LOOKTHROUGH,LOOKOVER,CHOP**
- COHERENCY

COUNTERMEASURES TECHNIQUES

- COUNTER RANGE, VELOCITY, AND ANGLE
- **RADAR OPERATION & ECCM'S**

@OPERATOR

- *MISSILE VULNERABILITIES AND TECHNIQUES*
  - COMMAND GUIDED
  - ACTIVE / SEMI-ACTIVE

AGENDA

SURVIVABILITY FACTORS

ECMSYSTEMARCHITECTURES

RADARCOUNTERMEASURES

- RANGE
- VELOCITY
- ANGLE

MISSILECOUNTERMEASURES

COUNTERMEASURESWRAPUP

ECMANALYSIS-TOOLSANDPROCESSES

EC ANALYSIS - TOOLS AND PROCESSES

EC ANALYSIS TASK

- **EW ENVIRONMENT - COMPLEX**
- **COUNTLESS FACTORS AFFECT EC OUTCOME**
- **MULTIPLE TOOLS AVAILABLE FOR EC TECHNIQUE ANALYSIS**

WHICH TOOL DO I CHOOSE TO HELP ANALYZE ECM TECHNIQUES PERFORMANCE?

DON'T DEFINE THE PROBLEM TO FIT THE TOOL

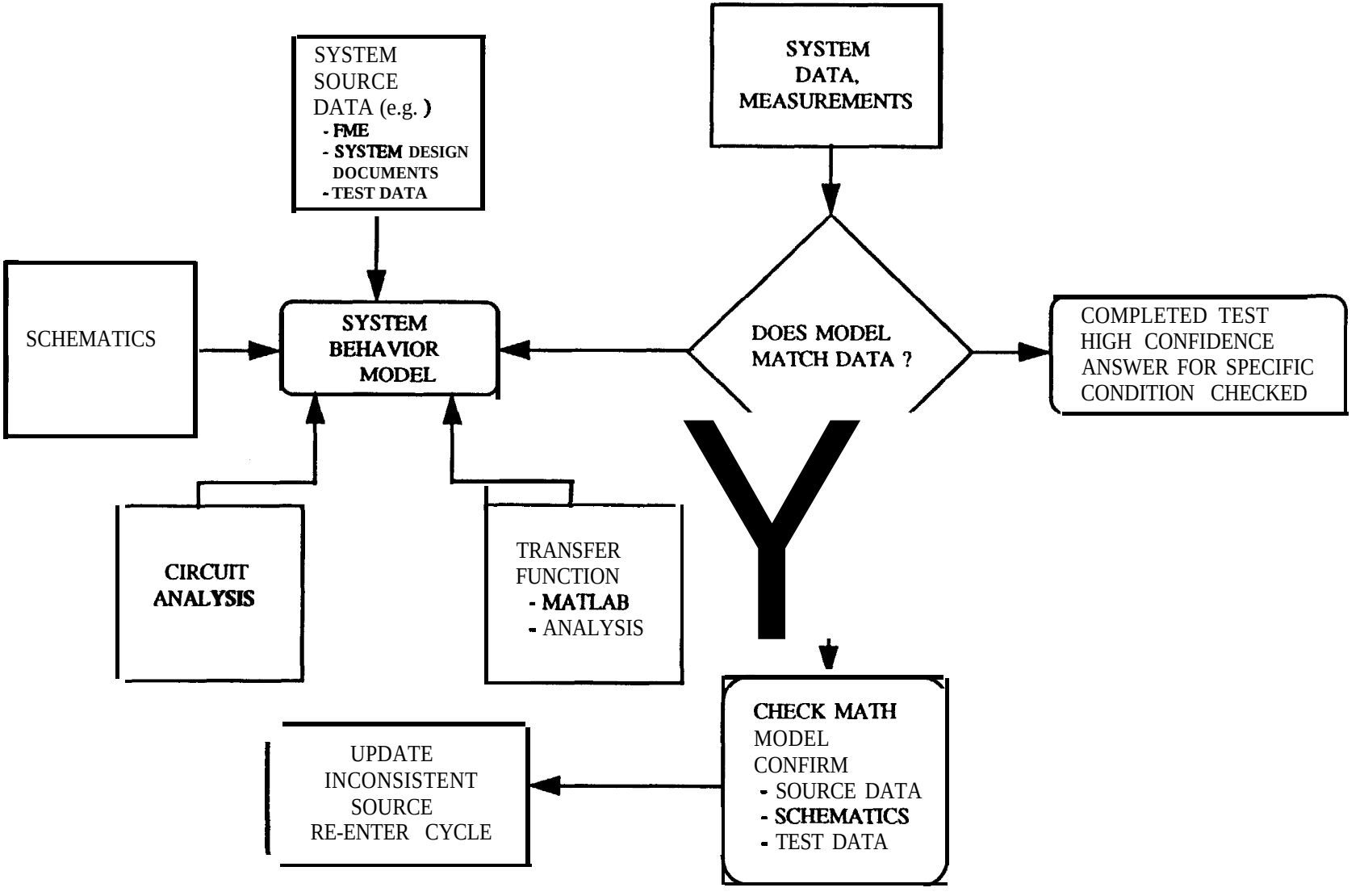
THE TOOL MUST FIT THE PROBLEM

EC ANALYSIS - TOOLS AND PROCESSES

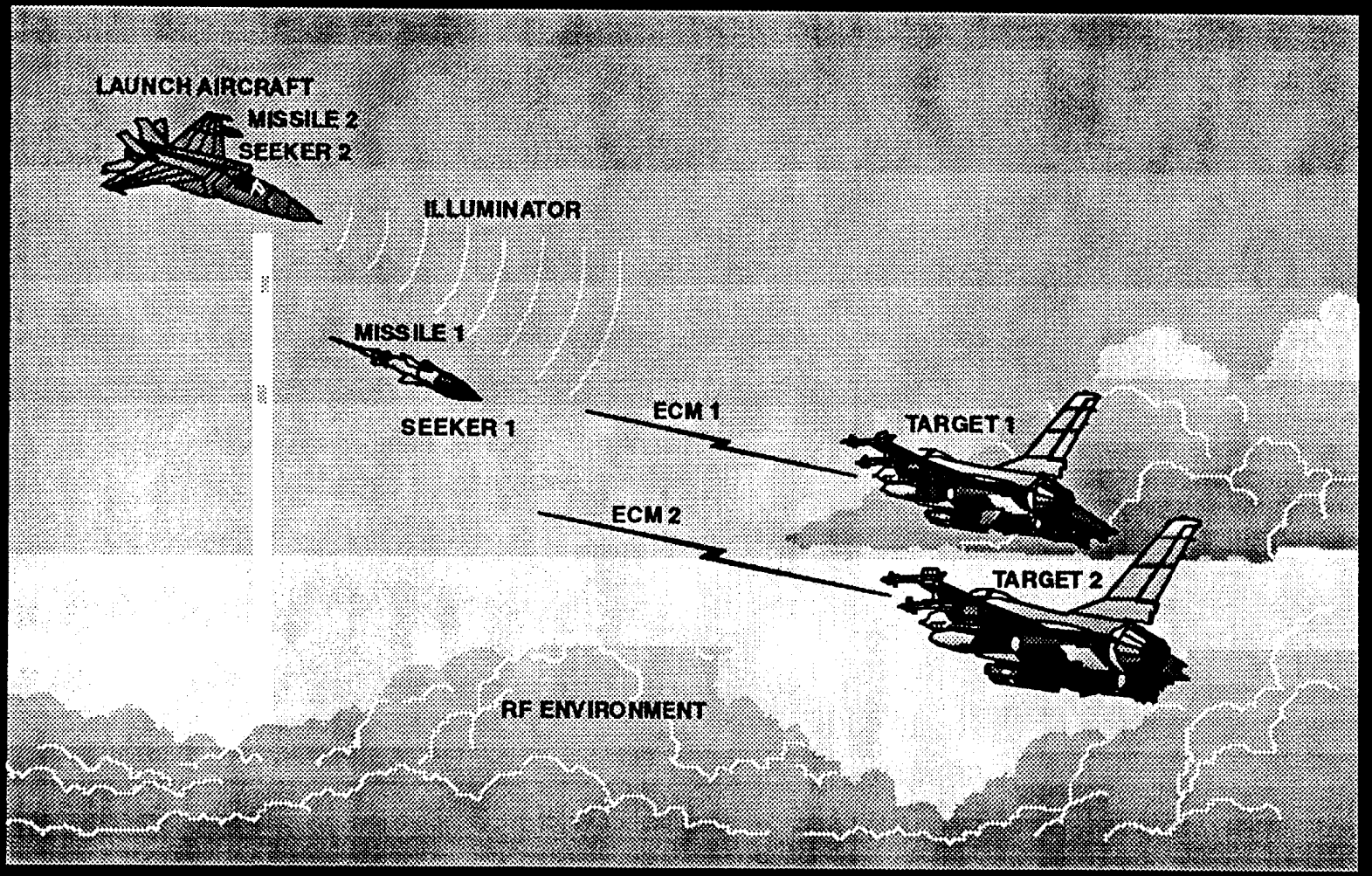
FACTORS TO CONSIDER IN TOOL CHOICE

- **UNDERSTAND WHAT IS IMPORTANT TO QUESTION BEING ASKED**
  - **NOT FEASIBLE TO CAPTURE ALL REAL WORLD VARIABLES IN A MODEL - ASSUMPTIONS ARE INHERENT - WHAT ARE THEY?**
  - **CHALLENGE - SELECT & ADEQUATELY TREAT PERTINENT VARIABLES IN THE QUESTION TO BE ANSWERED**
- **CHECK TO SEE IF IT IS THE RIGHT TOOL**
  - **MODEL MUST MATCH THE PHYSICS OF THE ISSUE**
  - **USE HARD THREAT.DATA FOR VARIABLES THAT ARE THREAT SENSITIVE**
  - **REPRESENTATION OF INTELLIGENCE DATA IN THE TOOL MUST ADEQUATELY SUPPORT ADDRESSING THE CRITICAL ISSUE**
- **UNDERSTAND THE PEDIGREE OF THE TOOL**
  - **SA-xx or MiG - zz NAMEPLATE - DOES NOT ENSURE FIDELITY**
  - **WHAT ASPECTS OF TOOL HAVE HIGH FIDELITY?**

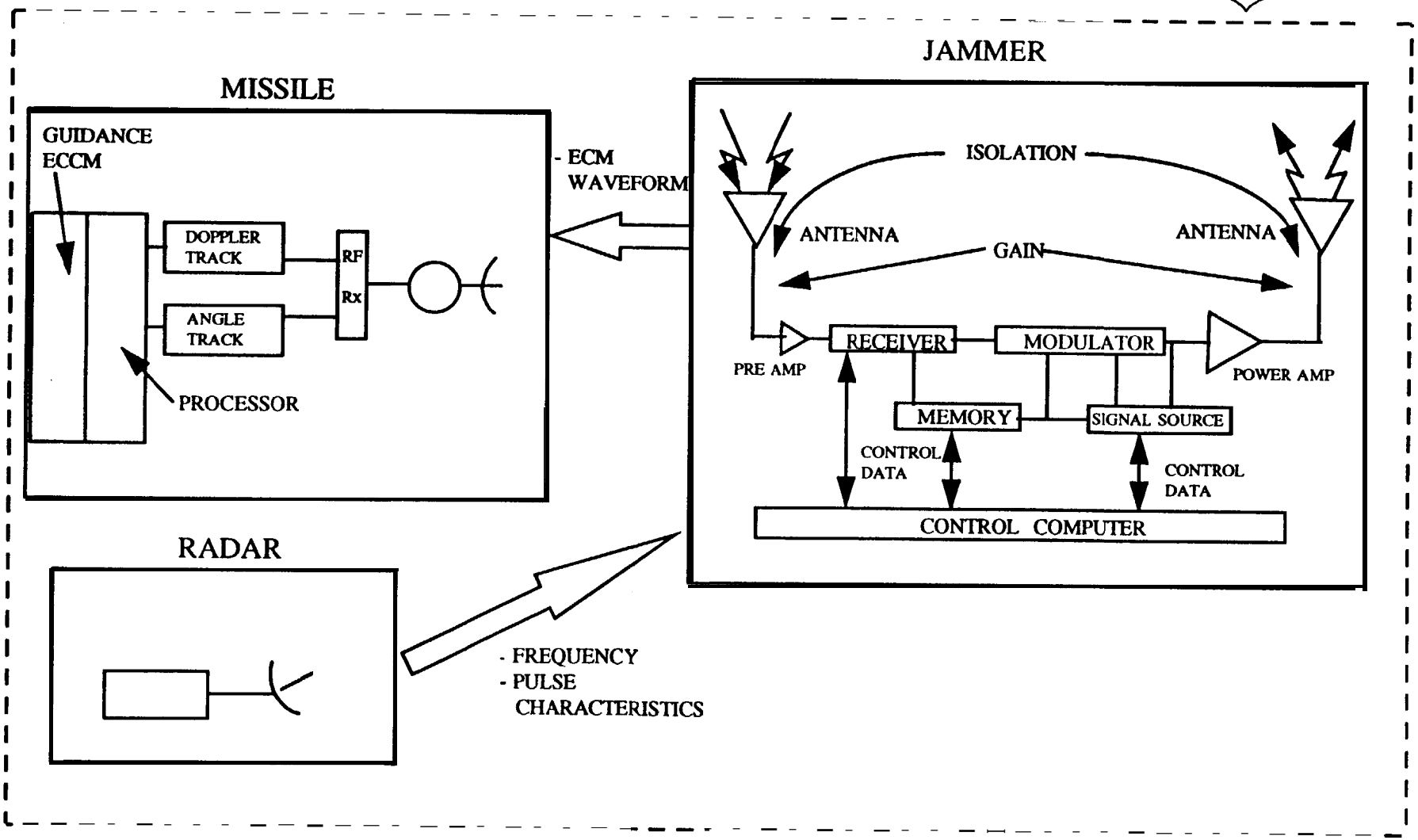
CONFIDENCE PROCESS/OUTPUTS



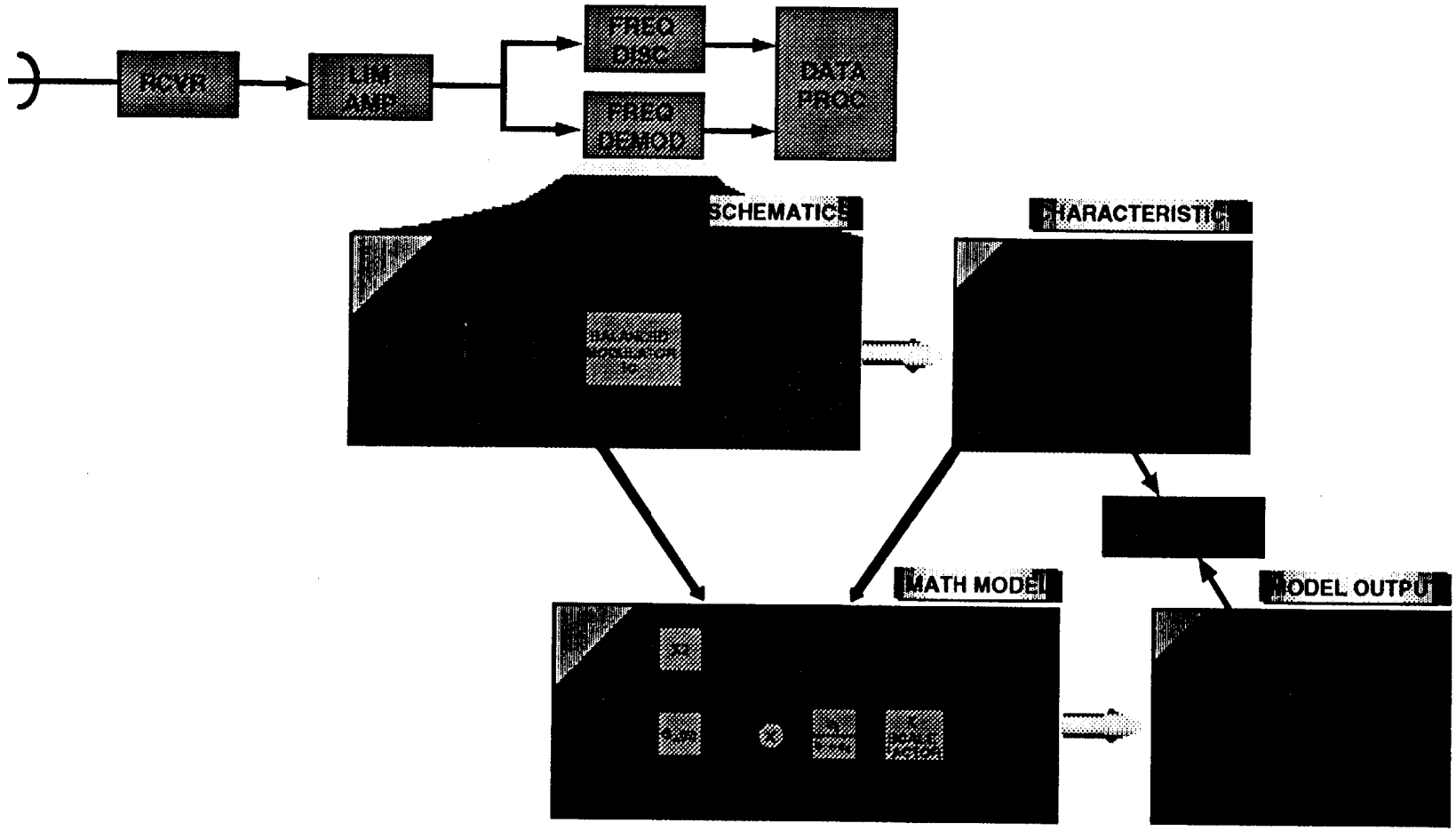
TARGET ENGAGEMENT



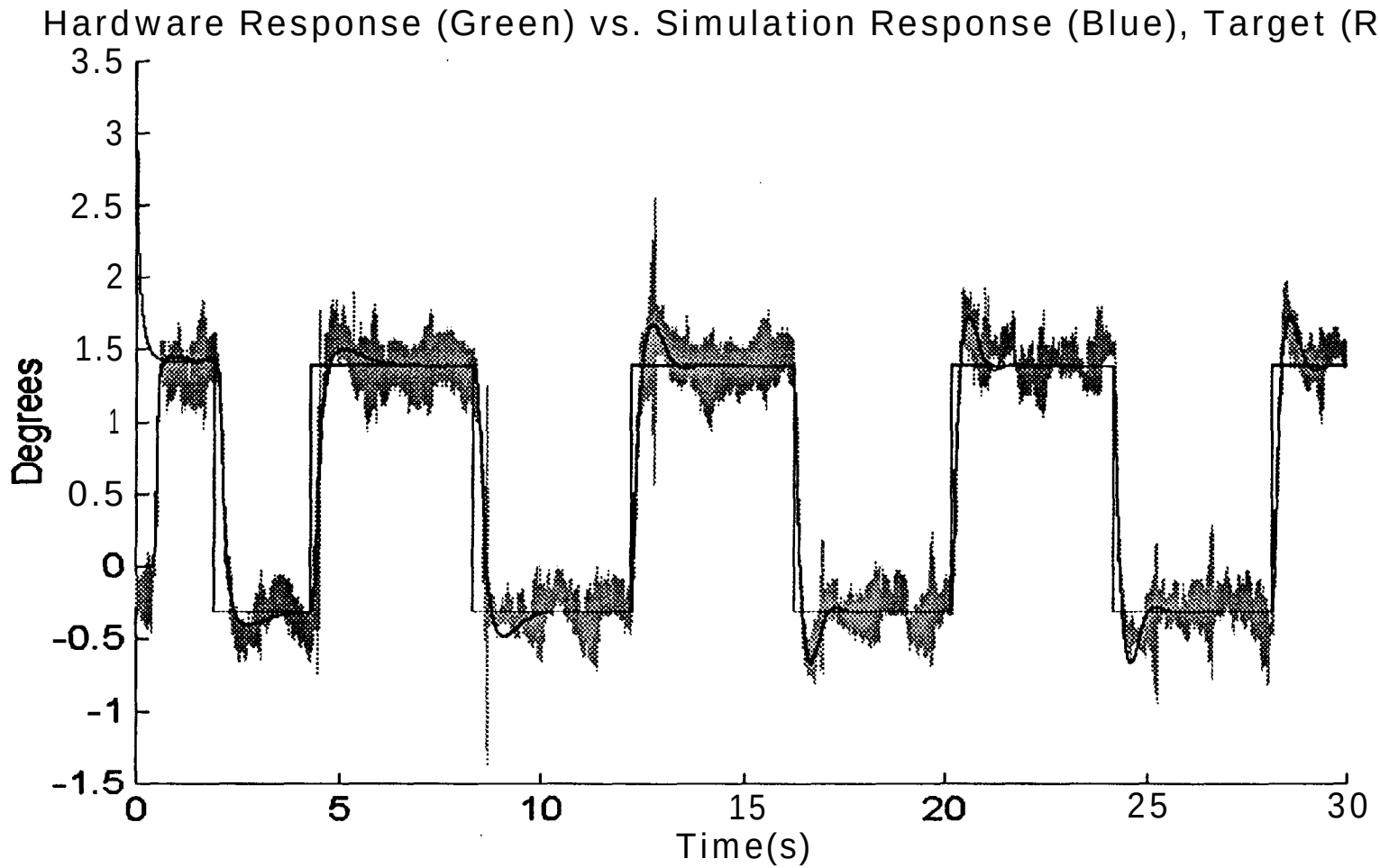
TARGET ENGAGEMENT MODEL



SUBSYSTEM RESPONSE DATA



SYSTEMRESPONSEDATA



ECMANALYSIS-TOOLSANDPROCESSES

EC EFFECTIVENESS ASSESSMENTS

- HIGH DEGREE OF COMPLEXITY - NUMEROUS VARIABLES
- UNCERTAINTY IN INPUT DATA
- **LIMITATIONS & ASSUMPTIONS IN MODELS/TOOLS**

EC TOOLS DO NOT PROVIDE ANSWERS

EC TOOLS PROVIDE INSIGHT TO INFORMED ANALYSTS IF THE TOOL, THE INPUT DATA, AND CONSTRAINTS ARE UNDERSTOOD