ECE 495 – Electromagnetic Warfare and Survivability

Block 1: Radar Fundamentals

Lesson 7: IADS Threat Radar Taxonomy

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Where We Left Off

L6 gave us antennas as patterns. L3–L5 gave us the equations.

Threats use *different* radars for *different* jobs. Knowing which is which is half of EW.

Today: the cast of characters inside an IADS — EW, ACQ, HF, GCI, TTR, AI, TIR, seekers, and fuses.

Lesson Objectives

By the end of this lesson, you will be able to:

- Name the **radar classes** in a layered IADS
- Match each class to its **band**, **PRF regime**, and **beam type**
- Map each class to the **kill-chain link** it advances
- Predict how LO changes the IADS's effective coverage at each layer

The IADS as a Layered System

- Each class trades **range for precision**; together they cover the engagement
- Information is *handed off* from class to class — breaking handoff degrades the chain
- EW and ES sensors fight at every layer

The IADS isn't one radar — it's a cast of cooperating ones.

Detection Layer: Early Warning Radars

EW radar — the long-range eyes of the IADS.

- **Band:** UHF or L — propagation, large antenna, low atmospheric loss
- **Range:** hundreds of km
- **PRF:** low — big R_u at the cost of v_u
- **Beam:** wide fan, slow rotation, 2D track only
- **Job:** detect inbound air activity, alert higher echelons

EW radars are where stealth pays its highest dividend in absolute kilometers.

Acquisition and Height Finding

ACQ provides 3D tracks for engagement. Paired **HF** can add elevation to a 2D ACQ.

- **Band:** S typical
- **Range:** long (hundreds of km), but shorter than EW
- **PRF:** low / medium
- **Beam:** fan beam ACQ + pencil-beam HF, or modern 3D ACQ
- **Job:** produce 3D tracks suitable for handoff to engagement radars

GCI sits at the C2 layer — vectors interceptor aircraft using the 3D picture.

Engagement Layer: TTR and TIR

TTR — target tracking radar, the SAM site's fire-control sensor. **TIR** — target illuminating radar for semi-active missiles.

- **Band:** X typical
- **Range:** medium (tens to a low hundred km)
- **PRF:** medium / high; often pulse-Doppler
- **Beam:** pencil, narrow HPBW, slewable
- **Job:** TTR holds the target; TIR floods it for the missile seeker

If you break the TTR-to-missile lock, the engagement is over.

Airborne and Terminal Sensors

- **AI — Airborne Interceptor** radar (fighter fire control)
  - X-band, AESA, multi-mode (search, track, scan-while-track)
- **Active seeker** on the missile itself
  - Ka or mmW for compact aperture; very high PRF; final 5–20 km
- **Proximity fuse**
  - Very short range, CW or high-PRF; triggers warhead at burst radius

EW radars find you; trackers kill you.

Mapping to the Kill Chain

Kill-chain link	Radar class	Primary band
Detect	EW	UHF / L
Track	ACQ + HF, GCI	S
Identify	ACQ multi-mode, ESM	S
Engage (cue)	TTR, AI	X
Engage (illuminate)	TIR	X
Engage (terminal)	Active seeker	Ka
Kill	Proximity fuse	mmW

- Break one row $\Rightarrow$ break the chain
- EW investments tend to attack the early rows (cheaper, higher payoff)

Today's Interactive Demo: IADS Coverage Explorer

Three coverage rings — EW, ACQ, TTR — drawn to scale around one site.

- Slide σ and watch every ring collapse together
- Read $R_{\max}$, ΔR vs legacy, and % cut off the live table
- Jump between presets: legacy, 4th-gen LO, B-21, next-gen
- Try the band-dependent B-21 preset — the rings stop collapsing together

Companion script: `L7_IADSRadarSurvey.m`

In L8 we add the missing piece: how detection actually happens (Pd, Pfa, SNR).

Quick Exercise / Type-along: Build the Three Rings

Type this with me. Three IADS classes, one range equation, $\sigma = 1$ m^2.

```
c = 3e8;  names = {'EW','ACQ','TTR'};
Pt   = [2e6   1e6   100e3];   % W
G    = [25    30    35   ];   % dBi, Gt = Gr
f    = [0.5e9 3e9   10e9 ];   % Hz
Smin = [-158  -160  -150 ];   % dBW
lam = c ./ f;  Gl = 10.^(G/10);  Sw = 10.^(Smin/10);
R = ((Pt .* Gl.^2 .* lam.^2) ./ ((4*pi)^3 * Sw)).^(1/4);
for k = 1:3
    fprintf('%-4s  R_max = %6.1f km\n', names{k}, R(k)/1e3);
end
fprintf('Detected %.1fx farther out than tracked.\n', R(1)/R(3));
```

Wrap-Up

Key ideas:

- IADS is a cascade of radar classes, each doing one job
- Band + PRF + beam tell you the class and the kill-chain link
- LO buys absolute km at the EW / ACQ layers; engagement layers still close in

Next lesson:

- **L8: Detection theory** — SNR, P_d, P_{fa}, integration gain
- Pre-flight quiz for L8 due before class