



ECE 495 – Electromagnetic Warfare and Survivability

Block 3: IR EW and Signature Management Lesson 24: IR Countermeasures

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L23 introduced the hunters: **reticle seekers** that track a chopped point of energy, **imaging seekers** that track a shape, and the passive sensors that cue them.

Today we fight back. *How do you beat a sensor that emits nothing?*

This lesson is a **duel**: every countermeasure we play, the seeker answers. We end where the duel stands today — imaging seekers versus lasers.

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

- Classify IRCM by the **four ways** to attack the optical track: starve it, clutter it, deceive it, damage it
- Explain **flare seduction** with the J/S contest and the tracking-gate timeline
- Describe the **IRCCM cues** — trajectory, spectral, intensity — that kill flares
- Argue why modern seekers pushed IRCM toward **DIRCM** and **suppression**

Four Ways to Attack the Optical Track



Every IRCM in this lesson is one of four moves against the seeker's information:

- **Starve it** — reduce the signature J so the track never starts (suppression)
- **Clutter it** — add competing sources so the right one is unclear (flares, decoys)
- **Deceive it** — inject false information into the tracker (seduction, DIRCM)
- **Damage it** — overload or destroy the detector with directed energy

The target is not the missile — it is the missile's information.

A flare offers the reticle seeker a **better point of energy** — and the seeker takes it:

- Pyrotechnic (MTV) or special-material decoys, burning **hotter** in-band
- The contest: the flare wins while $J_{\text{flare}}/J_{\text{tgt}} > 1$ with margin *inside the gate*
- **Seduction**: dispensed after lock, the flare drags the gate off the target
- Smart dispensers sequence size, timing, and direction per threat

Seduction assumes the missile is already tracking. Pre-emptive tactics attack earlier:

- **Distraction** — decoys out *before* the seeker locks: it acquires a flare, not the aircraft
- **Dilution** — many credible targets at once: the shooter must engage them all
- Pre-emptive flaring burns the magazine fast — **magazine depth** is a KPP
- Rise time, peak intensity, burn time, and spectral match fill out the scorecard

The Seeker's Answer: Three Cues That Kill a Flare

A flare is a lie, and lies have tells. Modern seekers check three of them:

- **Trajectory** — the flare decelerates and falls away; aircraft do not fly like that
- **Spectral** — at ~ 2000 K the flare is hotter than any tailpipe; a **two-color** ratio flags it
- **Intensity** — the flare's signature *jumps* in a fraction of a second; real ones do not
- Any tell trips the logic: freeze the gate on the original track and ignore the newcomer

Check: the Imaging Seeker Ends the Flare Era



Against a modern **Band IV** threat, the duel tilts hard:

- An **imaging seeker** sees two objects separate — and simply keeps tracking the one shaped like an aircraft
- Two-color and kinematic logic reject conventional flares even without a full image
- Flares still earn their ride against the huge inventory of **legacy reticle** threats
- But against the newest MANPADS, expendables alone are a losing hand

You cannot out-shout a seeker that can see shapes.

If the seeker ignores decoys, attack the seeker itself — with light:

- A **missile warning system** detects the launch and cues a turret onto the seeker
- A **modulated laser** shines into the seeker's own optics, feeding it false tracking error
- The goal is **optical break lock**: drive the gate off the aircraft, and keep it off
- Earlier **lamp** jammers radiated blindly; lasers add power, precision, tailoring

The Quiet Move: Suppress the Signature



The duel's cheapest victory is the one that never starts — attack J at the design table:

- **Plume** — mix exhaust with cool bypass air; shape nozzles to shred the hot core
- **Hot parts** — bury the engines, mask line-of-sight to the nozzle, avoid afterburner
- **Skin** — low-emissivity finishes push the L22 skin term down
- L23's rule prices it: cut J and every seeker's $R_{\max}$ shrinks as $\sqrt{J}$

For the B-21, this is not a pod on a pylon — it is the airframe itself.

Where This Is Headed: the Other Signature

Block 3 now pivots from the IR signature to its **RF twin**:

- Everything we did to J — rank, aspect, suppress — has a radar-side analog in **RCS**
- L25 builds it: RCS as **geometric cross section** $\times$ **reflectivity** $\times$ **directivity**
- The same duel logic returns: the radar's $\sigma^{1/4}$ is the RF version of our $\sqrt{J}$
- By L28 we fuse them: a survivable aircraft manages *every* signature at once

Quick Exercise / Type-along: Call the Duel



For each engagement, name the **CM play** and the seeker's **answer**. Call it out.

1. A 1970s reticle MANPADS locks onto a helicopter's stern
2. A Band IV imaging MANPADS is launched at a transport on departure
3. An IRST-cued fighter closes on a strike package at night
4. A B-21 planner asks which IRCM to *add* for a deep-penetration mission

Today's interactive demo.

- Model the target's intensity and a flare's **rise-and-burn** curve after dispense
- Model the pair **separating** and find when they no longer share the tracking gate
- The **seduction window**: from when the flare out-shines the target to gate exit
- Then slow the flare's rise time and watch the window collapse — *that is the KPP*

Companion script: L24_FlareSeduction.m

In L25 we cross to the RF side: the physics of radar cross section.

Key ideas:

- IRCM is four moves on the seeker's information: **starve, clutter, deceive, damage**
- A flare wins while $J_{\text{flare}}/J_{\text{tgt}} > 1$ *inside the gate* — rise time and geometry set the window
- IRCCM tells — **trajectory, spectral, intensity** — ended the flare's easy era
- The modern duel is **DIRCM** vs imaging seekers, atop signatures suppressed by design

Next lesson:

- **L25: RCS Physics** — geometric cross section, reflectivity, and directivity
- Pre-flight quiz for L25 due before class