



ECE 495 – Electromagnetic Warfare and Survivability

Block 3: IR EW and Signature Management Lesson 28: Multi-Spectral Signatures

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L27 finished the RF story: **RAM** buys down the echo, and **EMCON** hides the one signature you choose to radiate.

But radar was never the only sensor watching. The aircraft is still **seen**, **heard**, and — most stubbornly — **felt** in the infrared.

Today we gather every band that is left, then ask the question that decides survivability: *when a defender can use all of them at once, which one gives you away?*

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

- Place an aircraft's signature across the **visual**, **acoustic**, and **EO/IR** bands
- Fuse L22's **five IR components** with the other bands into one picture
- Apply the **loudest-band rule**: detection is the union across bands
- Prioritize signature investment **across the spectrum** — the Project 3 argument

The Visual Band: the Oldest Sensor



Before any receiver, there is the **human eye** — and it still works:

- **Contrails:** engine water vapor freezes into a persistent, sky-wide arrow pointing straight at you
- **Glint:** bright specular flashes off the canopy, edges, and flat panels
- **Paint and finish:** low-reflectance schemes cut the contrast the eye lives on
- Counter with **tactics and finish**, not coatings: avoid contrails, kill the glint

The Acoustic Band: Loud Down Low



Engines and airflow make noise — but sound is a **slow, lossy** messenger:

- It travels at ~ 340 m/s and fades fast: geometric spread plus atmospheric absorption
- **Low-altitude** penetrators, helicopters, and UAS are heard first by acoustic arrays
- For a **high-altitude** B-21 the slant range is long, so acoustic is a *minor* band
- Near the deck, the ear and ground sensors still cue the other bands

Everything from L22 is still glowing — the **five components** return:

- Three **emitters** (hot parts, plume, skin) and two **reflectors** (sun, sky/earth)
- **MWIR** carries the plume and hot parts tail-on; **LWIR** carries the all-aspect skin
- **IRST** and **FLIR** (L23) read all of it passively — there is no emission to intercept
- Thermal crossover hides the LWIR skin twice a day; the MWIR plume does not care

Passive IR is the sensor that never has to transmit.

Each sensor sees a **different aircraft** — and picks a different loudest part:

- **Radar** sees geometry; **IR** sees heat; the **eye** sees contrast; the **ear** hears engines
- No single band is the whole story — each vantage crowns a different contributor
- A modern IADS **fuses** them: RWR, IRST, EO, and acoustic cues, cross-referenced
- Beat one band and the defender simply **leans on another**

The Fusion Rule: Found at the Loudest Band

If *any* band crosses its detection threshold, you are found. So the range that matters is the **largest**, not the average:

$$R_{\text{det}} = \max_b R_b \quad \implies \quad \text{the loudest band sets your survivable range}$$

- Detection is a **union**: the defender needs only one band to succeed
- Reducing a **quiet** band changes nothing — until it becomes the limiter
- Your worst band, not your best, decides how close you can fly

You are only as quiet as your loudest band.

L26 swept the RCS budget **loudest-first**. The same discipline now spans *bands*:

- Cut the limiter and the **next band inherits** the problem — re-plan and repeat
- Over-investing past the next limiter is wasted weight, money, and maintenance
- Some floors resist coatings: the **eyeball** (contrail, glint) and, tail-on, the **plume**
- Survivability is a **balanced package** across the spectrum, not one heroic band

Where This Is Headed: the Whole Block, and the Project

Step back — Block 3 was one argument in three movements:

- **L21–L24:** the IR story — physics, five components, seekers, and countermeasures
 - **L25–L27:** the RF story — RCS, shaping, RAM, and EMCON
 - **L28:** every band fused — and the rule that the loudest one wins
 - **Project 3:** a B-21 variant trade against an IR MANPADS and a surveillance radar
- L29 is the work day. Bring the loudest-band rule — it is the project's core argument.

Quick Exercise / Type-along: Name the Loudest Band



For each case, name the **band that gives the aircraft away** and the **fix** that would help. Call it out.

1. A B-21 at high altitude in cold, humid air, in daylight, over an EO-cued IADS
2. A helicopter hugging the terrain on a night infiltration
3. A fighter in afterburner, tail-on to anIRST, on a moonless night
4. An LO bomber with world-class RCS and no plume management, tail-on

Today's Interactive Demo: the Loudest Band



Today's interactive demo.

- Give **one aircraft four bands**: radar, IR, visual, and acoustic
- Find the **loudest band**: the largest detection range is the one that finds you
- Spend 10 dB on the **wrong** band and watch detection *not move*
- Spend it on the **loudest** band and watch the limiter **jump** to the next

Companion script: L28_LoudestBand.m

In L29 this rule drives Project 3: which investment actually buys survivability?

Key ideas:

- **Visual** (contrails, glint, paint) and **acoustic** (mostly low-altitude) round out the non-RF bands
- **EO/IR** is the persistent band: L22's five components, read passively byIRST and FLIR
- **Fusion rule:** $R_{\text{det}} = \max_b R_b$ — you are only as quiet as your loudest band
- Signature management is a **balanced, loudest-first budget** across the whole spectrum

Next lesson:

- **L29: Project 3 work day** — the B-21 IR/RCS signature trade study
- Pre-flight quiz for L29 due before class