



ECE 495 – Electromagnetic Warfare and Survivability

Block 3: IR EW and Signature Management Lesson 26: The Aircraft RF Signature

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L25 gave you the physics: $\sigma = A_{\text{geo}} \times \Gamma \times D$, plates spike, **corners betray**, and the **median** prices the pattern.

Today we walk the airframe. *Where do the echoes actually come from — and what did the designer do about each one?*

This is L22's move on the RF side: find the **contributors**, rank them, and hand each a **verdict**.

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

- Name the major **RF signature contributors** on an aircraft and the physics that makes each loud
- Assign each contributor its design verdict: **shape**, **mask**, **treat**, or **manage**
- Explain **planform alignment** and why flying wings take it to the limit
- Argue the **loudest-first** budget discipline using σ_{tot} and the fourth-root law

Contributor	Why it is loud (L25)	Verdict
Inlets, exhausts, cockpit	cavity multi-bounce	mask
Radome and antennas	built to radiate	treat
Wing/body speculars, junctions	plates and corners	shape
Edges and surface waves	diffraction	shape + treat
Gaps, seams, panels, stores	small corners everywhere	manage

- Five families of echo, four verdicts — the rest of the lesson is one frame per verdict

Shape It Away: Send the Energy Elsewhere



Shaping attacks D — the echo goes *somewhere*, just not home:

- Slope and blend every surface — no flat plate or **right angle** faces the threat
- **Planform alignment**: force every edge and seam into a *few* shared orientations
- Aligned edges stack their spikes into a handful of narrow **butterfly lobes** — pointed away from the nose
- The flying wing is the endgame: few edges, few lobes, no tail-body corners

You cannot delete the energy — you choose where to send it.

Mask It: Hide the Things That Cannot Be Shaped



Some contributors are cavities by function — you cannot slope an engine face:

- **Inlets:** serpentine ducts deny line-of-sight to the compressor; top-mounted inlets shield from below
- **Screens and vanes** block the cavity where a duct cannot bend enough
- The **cockpit** is a cavity full of corners — a conductive coat keeps the wave out
- **Exhausts:** shielded, flattened nozzles — the same hardware fixes IR (L24) and RF

Treat It: the Parts That Must Radiate



The radar, antennas, and edges cannot be deleted — so we compromise:

- An antenna built to radiate is built to **echo** — flush, conformal apertures limit it
- **Frequency-selective radomes**: transparent in the ship's own band, a shaped wall to everyone else
- **Edges** keep their diffraction — edge treatments and RAM soak it up (that is L27)
- Until then: point the loud face away and radiate on *your* terms (EMCON, also L27)

The last dBs are not designed in — they are *maintained* in:

- Every gap and panel edge is a small corner; **serrations** push returns off-normal
- External stores are RCS catastrophes — carry **internal** or stay home
- Surface condition counts: chipped coatings and proud fasteners own the nose sector
- This is why LO fleets live with **signature checks** — the test never ends

Sixty years of LO design compress into a short list:

- **No right angles** to the threat — corners retroreflect (L25)
- **Align the edges** — few orientations, few lobes, none in the nose sector
- **Hide the cavities** — inlets, cockpits, and bays never show their insides
- **Curve continuously** — early designs faceted because 1970s codes only priced flat panels; modern curvature kills the facet spikes too
- **Sweat the details** — seams, fasteners, and stores set the floor the shaping bought

Contributors add in linear space — and the sum has a tyrant:

$$\sigma_{\text{tot}} \approx \sum_i \sigma_i \quad R_{\text{max}} \propto \sigma_{\text{tot}}^{1/4}$$

- One +10 dBsm corner beside a −20 dBsm airframe *is* the signature
- So LO design is a **budget**: every contributor under the line, loudest first
- The fourth root prices it: −20 dB of median RCS keeps a third of the reach
- This budget logic is exactly how Project 3 should argue

Fix the loudest scatterer — the rest is rounding error.

Where This Is Headed: Buying the Last dBs

Shaping did the heavy lifting. What it cannot fix, **materials and discipline** must:

- **RAM**: absorb what shaping could not redirect — edges, seams, inlet lips
- **Polarization tricks**: exploit how edges and wires favor one polarization
- **EMCON**: the loudest thing on a stealth aircraft is its own transmitter
- L27 closes the RF story; L28 fuses every signature into one target

Quick Exercise / Type-along: Deliver the Verdict



For each finding on a notional LO design review, call the verdict — **shape**, **mask**, **treat**, or **manage** — and the fix.

1. The vertical tail meets the fuselage at 90°
2. The compressor face is visible straight up the inlet
3. The satcom antenna returns strongly at threat frequencies
4. Post-maintenance, a weapons-bay door sits 3 mm proud
5. The wing leading edge flashes at one narrow azimuth

Today's interactive demo.

- Give a notional airframe six edges, each throwing an L25-style **specular lobe**
- Build the **unaligned** design: six orientations, spikes scattered around the compass
- Re-group the same edges into **two** shared orientations and rebuild the pattern
- Compare: how much of the compass is loud, and *what happened at the nose?*

Companion script: L26_PlanformAlignment.m

In L27: RAM, polarization, and EMCON — buying the dBs shaping left behind.

Key ideas:

- Five families — cavities, antennas, speculars, edges, seams — each with a **verdict**
- **Shape** redirects; **mask** hides cavities; **treat** tames radiators; **manage** holds the floor
- **Planform alignment** stacks edge spikes into few lobes pointed away from the nose
- $\sigma_{\text{tot}} \approx \sum \sigma_i$: the **loudest scatterer owns the signature** — budget and fix loudest-first

Next lesson:

- **L27: RAM, Polarization, and EMCON** — materials and discipline buy the last dBs
- Pre-flight quiz for L27 due before class