



ECE 495 – Electromagnetic Warfare and Survivability

Block 3: IR EW and Signature Management Lesson 29: Project 3 Work Day

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Your group is the B-21 signature-management cell.

Product: a prioritized package of signature investments that buys the most survivability against a three-band threat, chosen inside a fixed budget.

- Everything you need is in L25–L28: the loudest-band rule, RCS scaling, IR intensity
- Handout, signature CSV, investment menu, and starter are posted
- Results presentations at L30 — 10 minutes, 5 of Q&A, everyone speaks

You cannot buy every band. Spend where the limiter is.

The Scenario: Three Bands, One Aircraft

The target area is watched in three bands at once:

Threat	Band	Detects
Surveillance radar (EWR)	VHF	2 m ² at 90 km
Fire-control radar (TTR)	X	0.03 m ² at 45 km
MANPADS seeker (IR)	MWIR	300 W/sr at 8 km (lethal 6)

- Baseline B-21 nose-on: $\sigma_{\text{VHF}} = 2 \text{ m}^2$, $\sigma_{\text{X}} = 0.03 \text{ m}^2$, stern $J = 300 \text{ W/sr}$
- Radars illuminate you **nose-on**; the MANPADS engages **tail-on**

Each threat turns a signature into a detection range through a Block-3 law:

$$R_{\text{radar}} = R_{\text{ref}} \left(\frac{\sigma}{\sigma_{\text{ref}}} \right)^{1/4} \quad R_{\text{IR}} = R_{\text{ref}} \sqrt{\frac{J}{J_{\text{ref}}}}$$

- The defender needs only **one** band, so detection is the largest: $R_{\text{det}} = \max_b R_b$
- Reducing a **quiet** band does nothing until it becomes the limiter
- The fourth root is harsh: it takes ~ 12 dB of RCS just to *halve* a radar's range

This is L28 made operational: find the limiter, then spend on it.

Seven investments on the menu; a budget that cannot buy them all:

$$\sum \text{cost} \leq 10 \quad \sum \text{weight} \leq 5$$

- At baseline the **VHF radar** is loudest (90 km) — and RAM barely touches VHF
- Only planform realignment and structural low-band treatment move VHF, and both cost dearly
- Spend it all on the limiter and the **MANPADS** is still lethal at the target

The whole project lives in that trade. Defend your package.

1. **Signature-to-detection pipeline** — signature + package to three ranges to R_{det} ; verify on the starter
2. **Budget optimization** — search the menu under the caps to minimize R_{det}
3. **The terminal threat** — spend on the MANPADS or not, and defend that trade
4. **Aspect** — how R_{det} changes nose-on vs tail-on; a heat map earns the bonus
5. **Recommendation** — one slide: what to buy first, and what you left on the table

The starter gives you a working pipeline for the simplest case:

- Reads `B21_SignaturePattern.csv` and the `SignatureMenu.csv`
- Scores **one example package** (X-band RAM + plume) with the loudest-band rule
- Plots the **fourth-power trade**: what a decibel of RCS actually buys

Example File: `L29_Project3Starter.m`

The example package leaves you found at ~ 85 km by the VHF radar. Beat it within the same budget.

Today's Battle Rhythm



- **First 10 min** — groups assigned, claim a whiteboard, read the handout together
 - **Next 30 min** — divide the work: pipeline, budget search, aspect, recommendation
 - **Last 10 min** — regroup: what's done, what's blocked, who owns what before L30
- I am floating between groups — pitch me your loudest band and your package early.

Name the limiter before you spend a single point.

Before you leave:

- Pipeline verified against the starter's baseline ($R_{\text{det}} \approx 90$ km)
- A first package chosen — and checked against the cost and weight caps
- Task owners assigned through L30

Next lesson:

- **L30: Project 3 results presentations** — slides + code due before class
- **HW3 due** at the start of L30
- **Quiz 3** (open book) in class, tied to your project work