

DRAGONFLIES WITH RAILGUNS

Rob Tow

Nova Lux, New Mexico, USA, Sol III

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The Expanse is the best physics-aware space combat on television; every ship on screen is missing the same thing; radiators. Stefan–Boltzmann is not negotiable. A real gunship would look less like a sleek missile and more like an armored spine carrying vast thermal wings, folding them to fight and running a heat clock against time.

Dragonflies with railguns!

I enjoyed the novels and the tv series *The Expanse* a great deal. The latter is easily the best physics-aware space combat ever put on television. The writers clearly did their homework on inertia, reaction mass, spin gravity, and railguns.

But every time a ship appears on screen I find myself thinking the same thing. Because physics.

Where are the radiators?

Space is thermally brutal. There is no air. No convection. No cooling wind. Every joule of waste heat must leave the ship by radiation alone, governed by the Stefan–Boltzmann law. That law is not negotiable. Even a modest hundred-megawatt power system running radiators around six hundred kelvin requires thousands of square meters of emitting area.

Which means a real gunship would *not* look like a sleek missile. It would look like an armored spine with enormous thermal wings. A dragonfly with a railgun.

The *Rocinante* as shown on screen is a tidy dart. A real one would instead be an engineering object. A long structural spine wrapped around a reactor and mostly filled with propellant. The crew habitat would be a small armored capsule buried near the center of mass, separated from the drive by both shielding and distance. Distance is

cheap radiation protection. Everything aft would be propulsion machinery. Reactor, exhaust structure, pumps, injectors, power conversion hardware. Immediately forward of that sits shadow shielding so the crew does not spend the voyage bathing in neutron flux. Fusion drives make neutrons. Lots of them.

Then come the tanks. Large ones. Fast ships are not weapons with fuel. They are fuel with a few weapons attached. The rocket equation looms here. Care of Tsiolkovsky.

The railgun would likely run along the central spine because structure matters when you are throwing kilogram projectiles at several kilometers per second. A railgun is not just a gun. It is a pulse-power installation. Capacitor banks, switching gear, heavy buss bars, cooling loops. Every shot dumps heat and electrical stress into the ship.

Which brings us back to radiators. A realistic *Rocinante* would carry large deployable radiator panels on booms extending away from the hull so they can see cold space. Thin dark sheets quietly glowing in infrared while coolant loops carry heat away from reactor, weapons, electronics, and life support.

They would also be perfect targets. Large ones. So the moment combat begins those panels retract or fold against the hull. At that instant the ship becomes a sealed thermodynamic problem. Every reactor cycle, every railgun shot, every thruster pulse is now heating a system that cannot easily shed the energy. Heat gets dumped into internal stores that can briefly hold joules.

This creates a constraint that most space opera politely ignores; space battles would run on a heat clock.

The ship enters combat with a finite thermal budget. Coolant mass, heat sinks, phase-change materials, perhaps blocks of lithium or other thermal storage media. While the fight lasts the ship is spending not just ammunition and delta-v, but also temperature margin.

Run too long and the electronics cook, rails distort, seals fail,

coolant boils, and the crew slowly roasts inside their own machinery. Of course not; but think budget. Kinda like a WWII submarine and CO₂.

There is also a subtler possibility that almost never appears in fiction: directional radiators. This is a fun area I have been exploring in designing a LEO and cis-Lunar fictional gunboat for a near future young adult series of stories.

Radiation is not perfectly isotropic if you engineer it. A warship could mount radiator surfaces designed to preferentially emit heat into a particular hemisphere. Panels angled and shielded so that most of the infrared leaves one side of the ship. That does two useful things. First, it allows the ship to reject heat while keeping its cold side facing the enemy. In other words, the vessel can continue cooling while presenting its armored aspect toward the threat. Kinda stealthy.

Second, it allows the radiators to be partially shielded behind armor or propellant tanks from incoming fire. The ship essentially hides its fragile thermal organs behind its own bulk while still dumping heat into open space. Directional radiators would not solve the problem. They would merely make the problem tactically more manageable.

So a realistic gunship has two physical forms, *as a transformer*.

Cruise configuration: long, awkward, radiator wings extended, tanks full, quietly glowing in infrared like a mechanical insect. But louder in certain directions.

Combat configuration: radiator wings folded or partially shielded, outer tanks jettisoned, armor presented toward the threat axis, and the whole vessel running hot while trying to end the fight before its own waste heat does the job. Minutes, not days. Point defense guns would sit on armored sponsons with autonomous fire control because interception windows are measured in milliseconds and in-

coming fragments may be traveling several kilometers per second. Sensors would be distributed across the hull because any single aperture is fragile. The crew would see the outside world through instruments, never windows.

The whole machine would look less like a naval vessel and more like a cross between a launch vehicle upper stage, a submarine, and a chemical plant.

Which, frankly, makes it more interesting. Because in a real fight the captain would not only ask: “How much propellant do we have?” They would also ask: “How many seconds of full-power combat remain before we must break contact and unfold the radiators?”

That is the missing physics in most space opera.

And if someone ever does build a warship that actually obeys thermodynamics, it will not resemble a sleek rocket. It will be an armored spine carrying vast fragile thermal wings, angled to throw their heat into the dark. Wings it can fold and then dart to kill.

A dragonfly heat engine that happens to carry weapons.

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