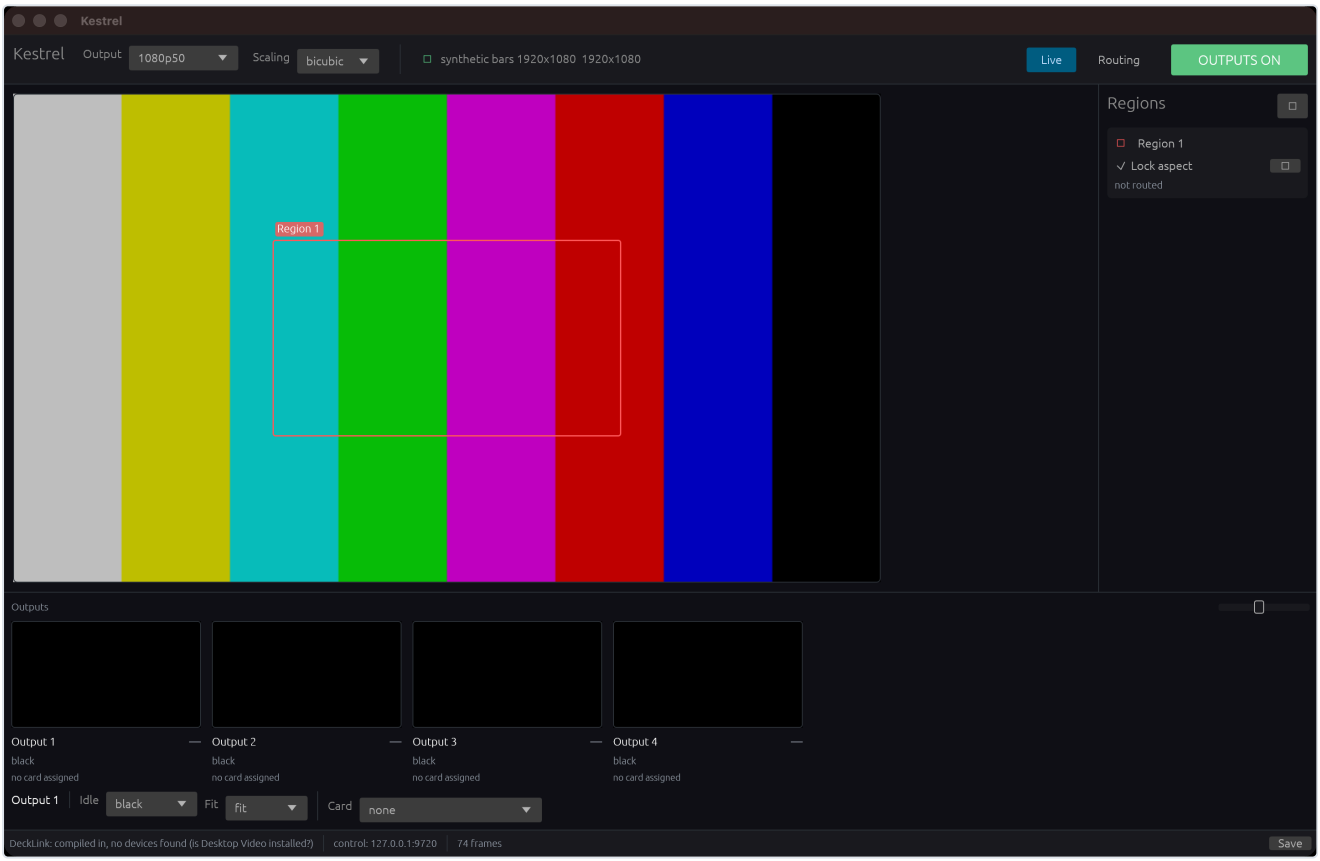
Kestrel user guide

One wide shot in, several tighter shots out.

Kestrel takes a single video input — typically a locked-off wide of a stage — lets you draw any number of **regions of interest** on it, and sends each region back out of a Blackmagic DeckLink, cropped and scaled to the output raster. A kestrel hovers over a wide field and picks out one thing at a time; so does this.



The operator window on its own synthetic bars — one region drawn on the wide, four outputs black because no DeckLink is in this machine, the control server listening. Captured from the build on this Mac by window: the first time the layout has been looked at rather than served.

> **Before you rely on this:** the GPU path is verified by **pixel readback** (14 tests, including a raster whose rows need padding), the control API end to end, and the Companion module against a really-running Kestrel — with 49.99 fps sustained at 1080p50 with the GUI open.
>
> **No DeckLink has ever been connected to this code.** Every line of SDI — capture, playback, pre-roll, format detection, profile handling — is written against the SDK headers and is unproven here. **Windows and Linux have never been run.**
>
> This codebase was created with AI assistance, directed and reviewed by a human author.

The rule everything else follows

Every output produces a frame, every frame, always.

Not "every routed output". An SDI output that *stops* is an output the switcher downstream has to re-lock, and re-locking costs frames on air. So:

- An output with **nothing routed** to it carries its **idle fill** — legal black by default, or bars, or the whole input as a confidence feed.
- The **global outputs kill** blacks every output at once and **leaves every crosspoint intact**. The signals keep running; nothing downstream notices anything but the picture.
- **Losing the input blacks the routed outputs rather than freezing them.** A frozen last-good frame looks live to anyone watching, which is worse than black.
- An output with **no card assigned** is still planned and still rendered. It simply has nowhere to go.

Everything you might otherwise read as odd behaviour — a kill that does not clear routing, black rather than a freeze — is that rule.

Running it

```
kestrel-gui
```

With no DeckLink in the machine it runs on generated colour bars with a sweeping marker, and everything except the SDI works — regions, routing, the matrix, the Companion module, the previews. That is deliberate: build the show's layout on a laptop, then take it to the rack.

Headless, for a rack:

```
kestrel run --http 0.0.0.0:9720
```

And to see what the machine has:

```
kestrel devices
```

The screen

- **A large preview** of the input, with the regions drawn on it and draggable.
- **A row of output previews** along the bottom, each showing exactly what is on that wire, with a **scale percentage** saying how far the source is being blown up. That percentage is the

number to watch — it is what tells you a region has been pushed past what the source can stand.
- **A crosspoint matrix** — regions down the side, outputs across the top — on its own tab.

SDI support is opt-in at build time

The DeckLink SDK is a free but licence-gated download and is not ours to redistribute, so nothing from it is vendored. Point the build at your copy:

```
DECKLINK_SDK_DIR="/path/to/Blackmagic DeckLink SDK 12.9" cargo build --release
```

SDK **11.0 or newer**. Without one the build succeeds and reports `DeckLink: not compiled in` — which the app is careful to distinguish from `no devices found`, because the two have completely different fixes.

Profiles, which is the thing that wastes an afternoon

A multi-sub-device card presents all its sub-devices whatever profile it is in, and the ones the profile has switched off support no display modes at all.

A DeckLink Duo 2 in its two-sub-device profile shows four sub-devices of which two are dead — and an attempt to open one of those **looks exactly like a broken card**.

Kestrel wants one input and several outputs at once, which on a Duo 2 means the **four-sub-device half-duplex profile**. `kestrel devices` says which sub-devices are inactive and why, and the UI greys them out with the reason rather than showing an empty menu.

Control API

HTTP for commands, a WebSocket for pushed state.

`GET /api/state`	the whole state
`WS /ws`	the same, pushed when it changes
`POST /api/route`	`{"output":1,"roi":2}`, or `"roi":null` to clear
`POST /api/output/enable`	`{"enabled":false}` or `{"toggle":true}`
`POST /api/roi`	create; `POST` / `DELETE /api/roi/{id}` to edit or remove
`POST /api/output/{id}`	label, idle fill, fit mode

> **A refused command comes back as HTTP 200 with `ok:false` and a populated `error`. Check the body, not the status code.**

> **There is no authentication.** Anyone who can reach the port can re-route every output and kill them all. Keep it on a management interface.

The Stream Deck end is companion-module-kestrel.

How a frame gets across

Four GPU stages, all fragment shaders:

1. **decode** — UYVY to full-raster RGB, BT.709 limited range, chroma **interpolated** rather than nearest-sampled. Once per *captured* frame.
2. **crop** — a rectangle of that, scaled to the output raster, Catmull-Rom bicubic or bilinear. Once per output per *output* frame.
3. **fill** — black or bars, for an output carrying nothing.
4. **pack** — RGB back to UYVY, into a half-width target whose rows are exactly the byte layout DeckLink wants.

Stage 4 is why **the CPU never touches a pixel** — it only copies rows out of a mapped buffer. Everything intermediate is linear, never sRGB: these pixels arrived over SDI already encoded, and a gamma re-encode on the way through would shift every colour on the output.

If something is wrong

Symptom	Cause
`DeckLink: not compiled in`	The build had no SDK. Different problem from no devices found.
A sub-device will not open, card looks broken	Wrong profile. On a Duo 2, use four-sub-device half-duplex. `kestrel devices` says which are inactive.
An output went black rather than freezing	The input was lost. That is deliberate — a frozen frame looks live.
Killing outputs did not clear my routing	Also deliberate. The crosspoints stay; only the picture goes.
A command returned 200 and did nothing	Read `ok` and `error` in the body.
The output is soft	Check the scale percentage under that output preview.