FLY LIKE AN EAGLE

BUILD A QUADCOPTER FROM SCRATCH

WHO IS THIS GUY?

I'M LOÏC

@loicvigneron

loic@spin42.com


SPIN42

THE IDEA

I WANTED TO FIND SOMETHING TO CHILL OUT

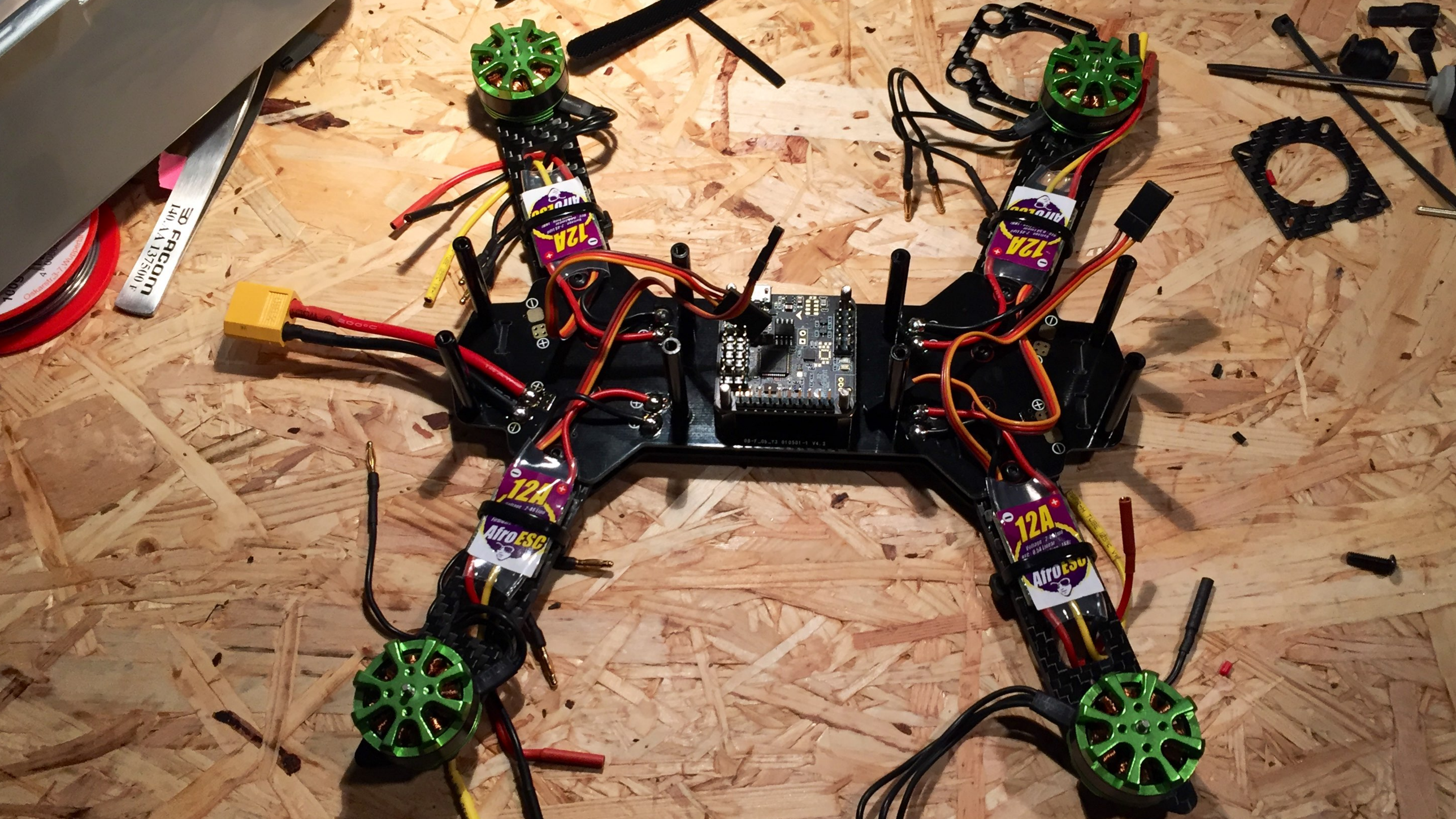
BIGGEST DRONE RACE

WORLD DRONE PRIX DUBAI

1st prize: $250,000

THE IDEA

THAT'S MY GAME!
LET'S BUY ONE


FACOM
12A
AfroESC

THE IDEA

I WANTED TO KNOW HOW IT WORKS.
LET'S BUILD ONE.

WHAT TO BUILD & FOR WHOM?

DON’T BUILD FOR /DEV/NULL

UNDERSTANDABLE

HUMAN FRIENDLY/ READABLE SOURCE CODE. WELL SEPARATED BUILDING BLOCKS

EXTENDABLE

EASY TO CONNECT HARDWARE, 3D PRINTED PIECES

DESIGN CHOICES

BUILDING BLOCKS

EVERYTHING TOGETHER

FURTHER WORK

DESIGN CHOICES

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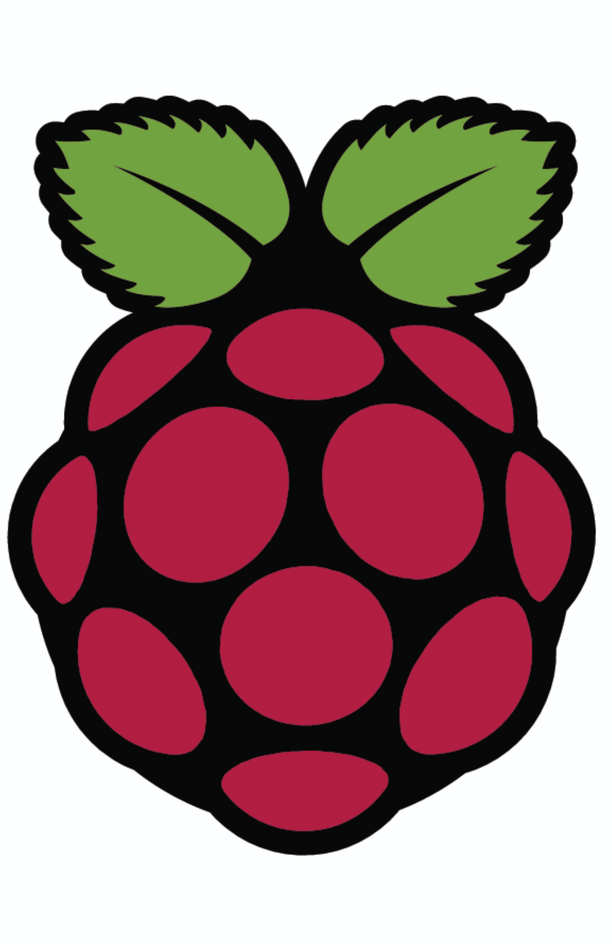
FURTHER WORK

Compute unit

Tools



Raspberry PI 3

Affordable

1GB memory

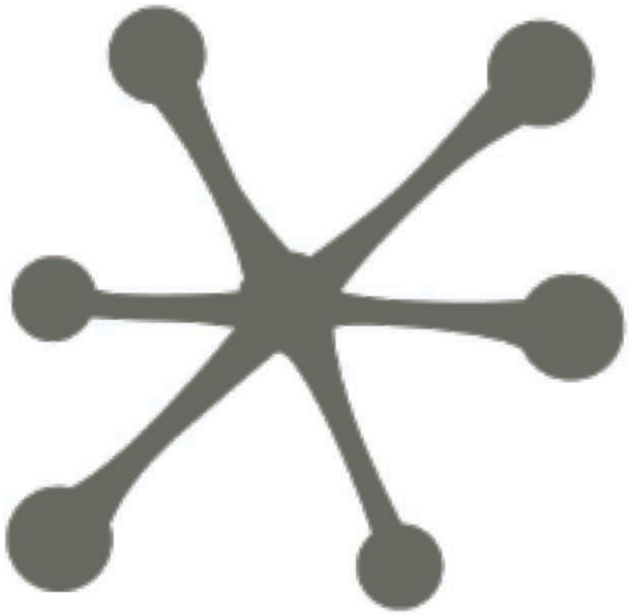
64bits Quad Core 1.2Ghz

17 GPIO (I2C, UART, ...)

Wifi

Compute unit

Tools



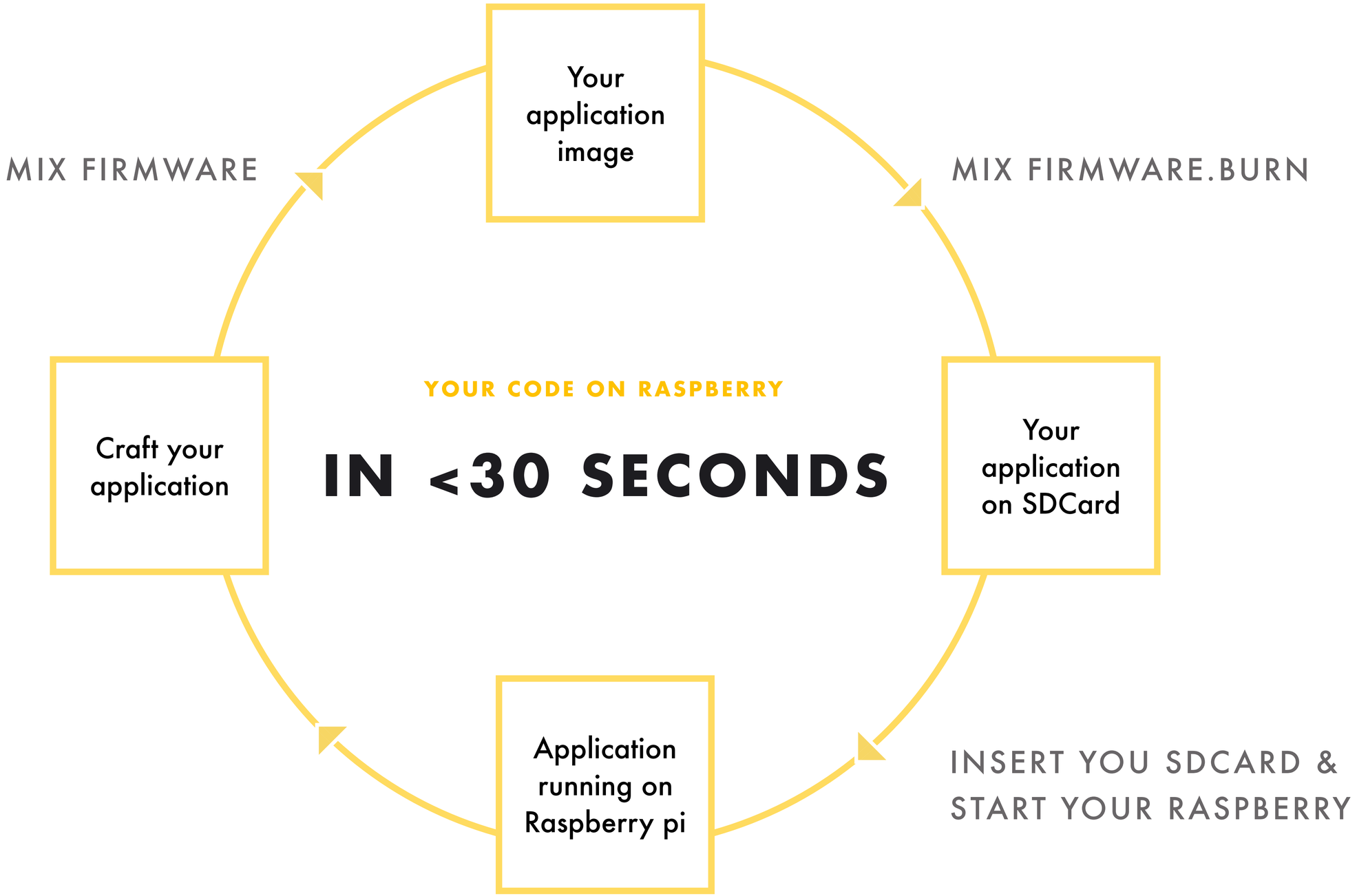
Nerves

Frameworks : Handle networks, I/O, ...

Tooling : Cross compiling tools for specific platform

Platforms : boot cross compiled linux directly to Erlang VM

DESIGN CHOICES



DESIGN CHOICES

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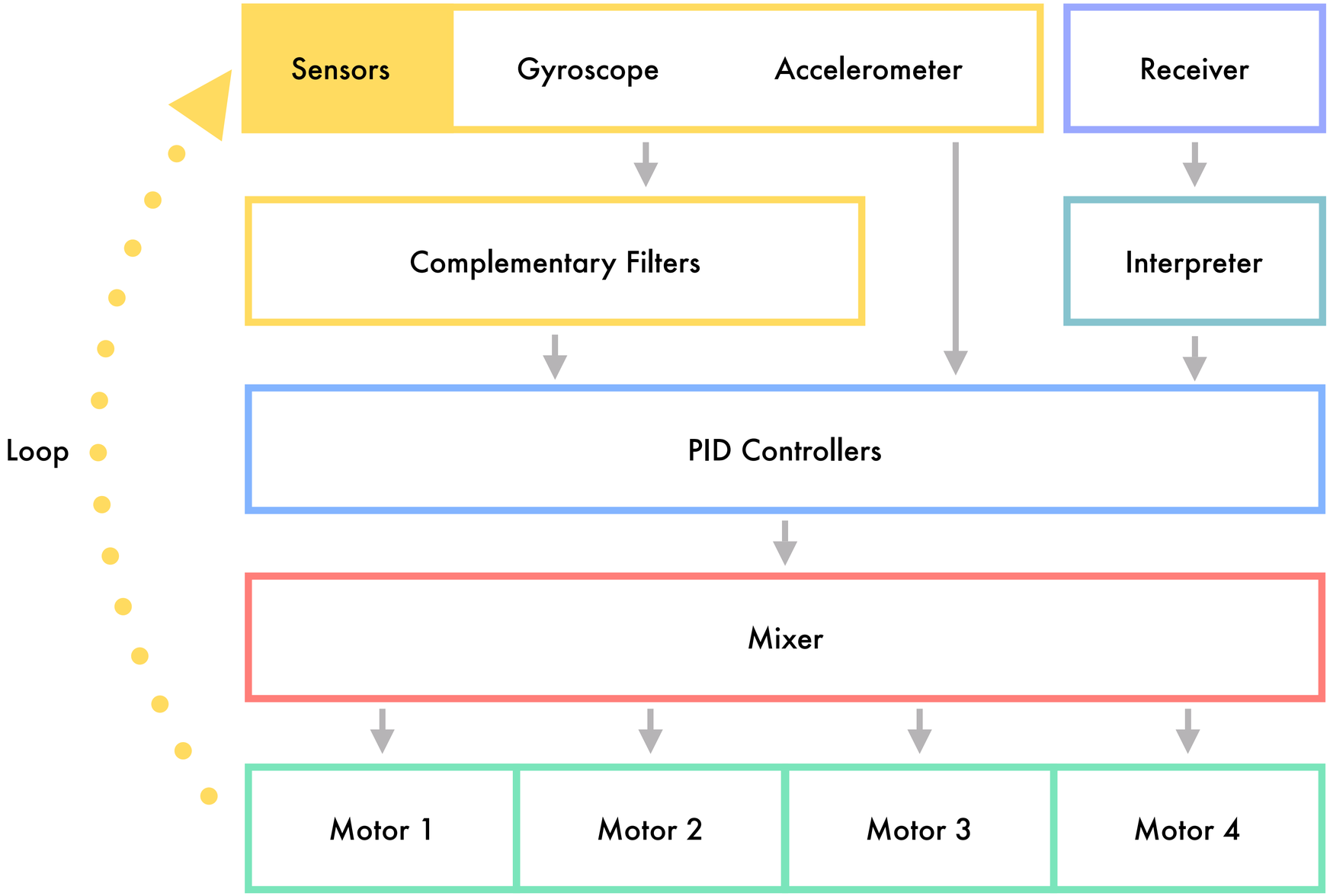
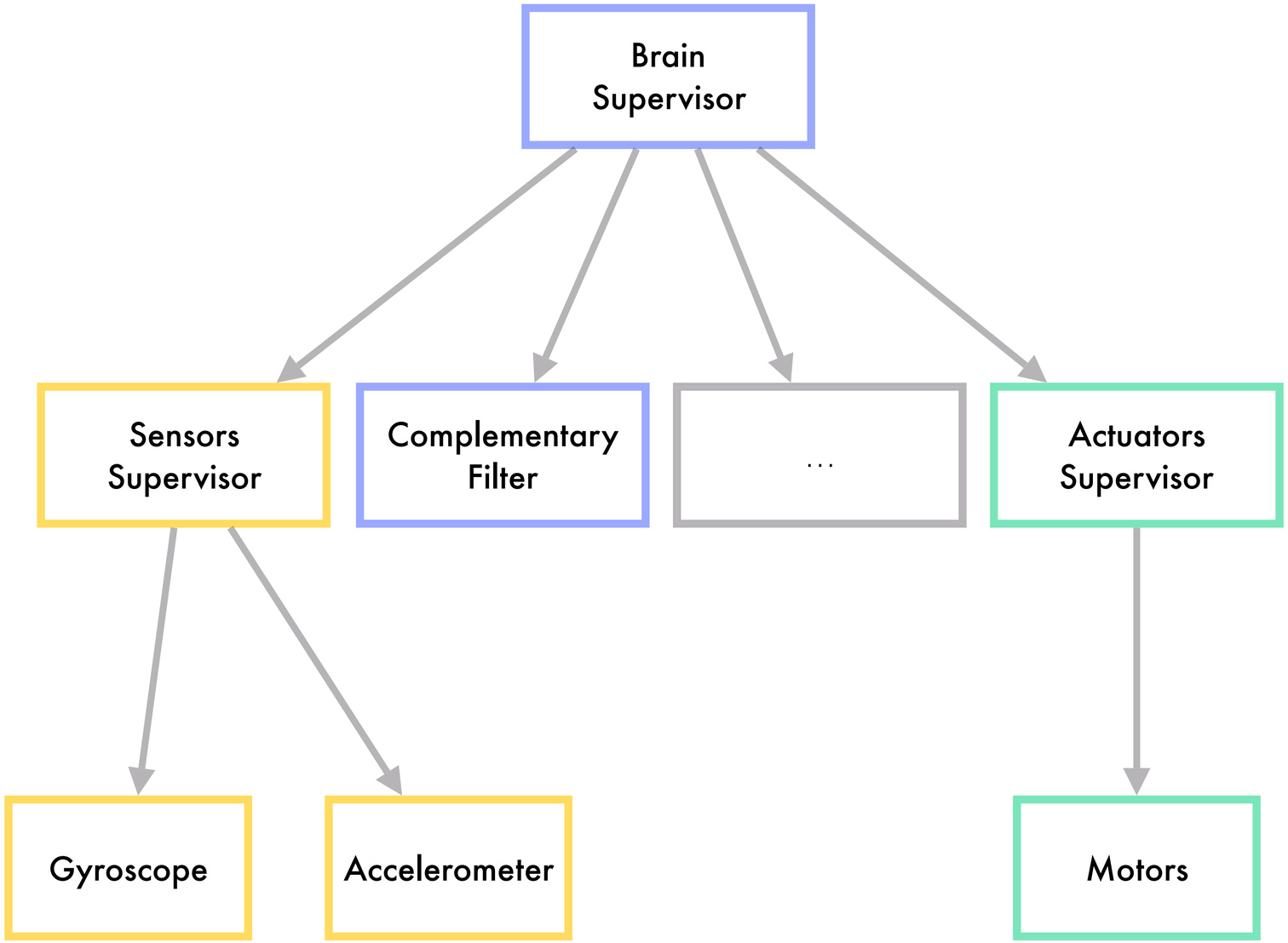
BUILDING BLOCKS



IT'S JUST A TREE

- Each component is a GenServer
- Components grouped under supervisors



```
config :brain, :sensors, [
  Brain.Sensors.Magnetometer,
  Brain.Sensors.Accelerometer,
  Brain.Sensors.Gyroscope
]
config :brain, Brain.Sensors.Gyroscope,
  driver: Drivers.L3GD20H
```

config.exs

sensor_supervisor.ex

```
defmodule Brain.Sensors.Supervisor do
  use Supervisor

  def init([]) do
    children = Application.get_env(:brain, :sensors) |> Enum.map(fn sensor_module ->
      sensor_configuration = Application.get_env(:brain, sensor_module)
      driver_module        = sensor_configuration[:driver]
      worker(sensor_module, [driver_module])
    end)
    supervise(children, strategy: :one_for_one)
  end
end
```

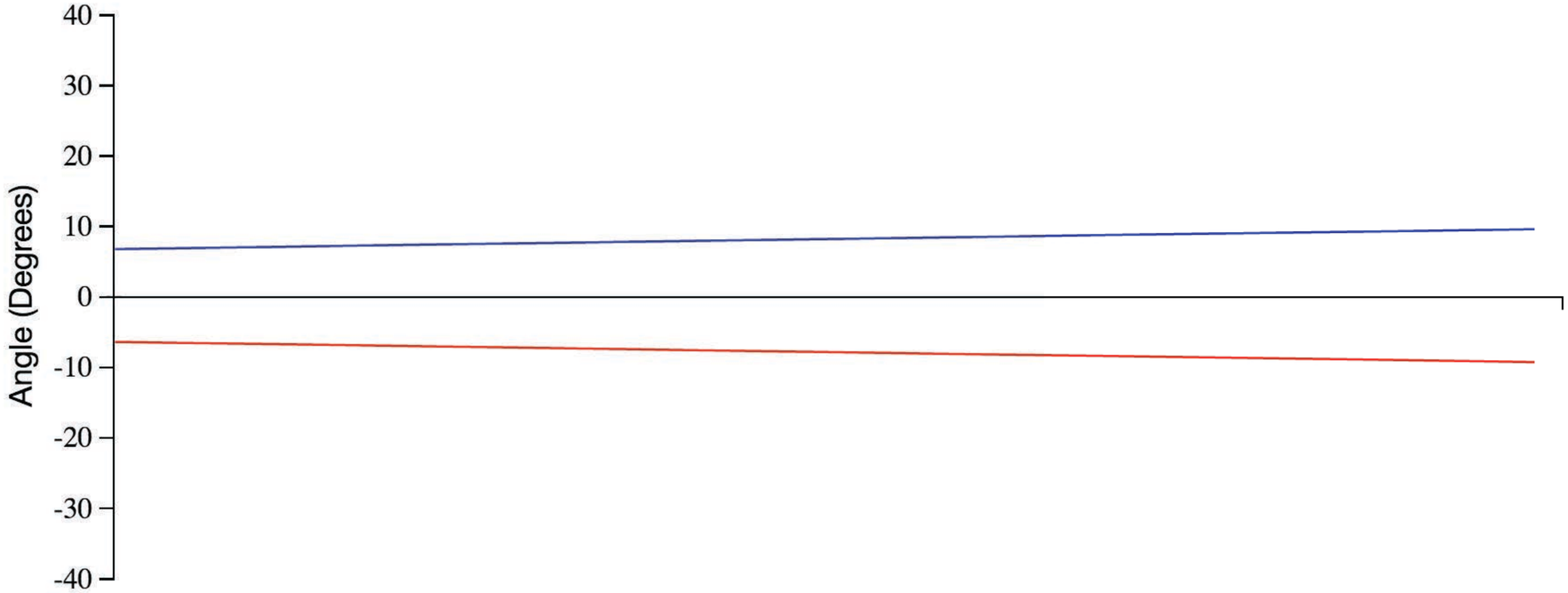
SENSORS

GET THE QUADCOPTER TILT

GYROSCOPE

Measures the angular speed (degrees/seconds)

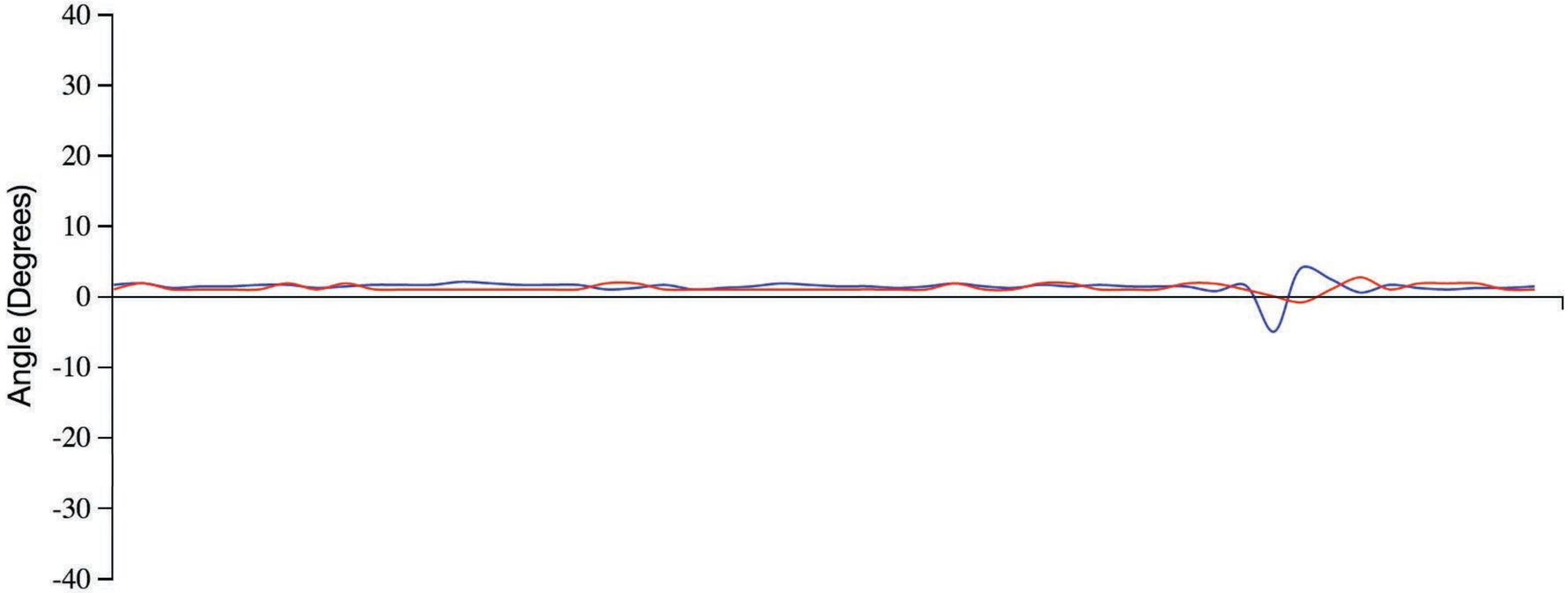
Its values drift with time



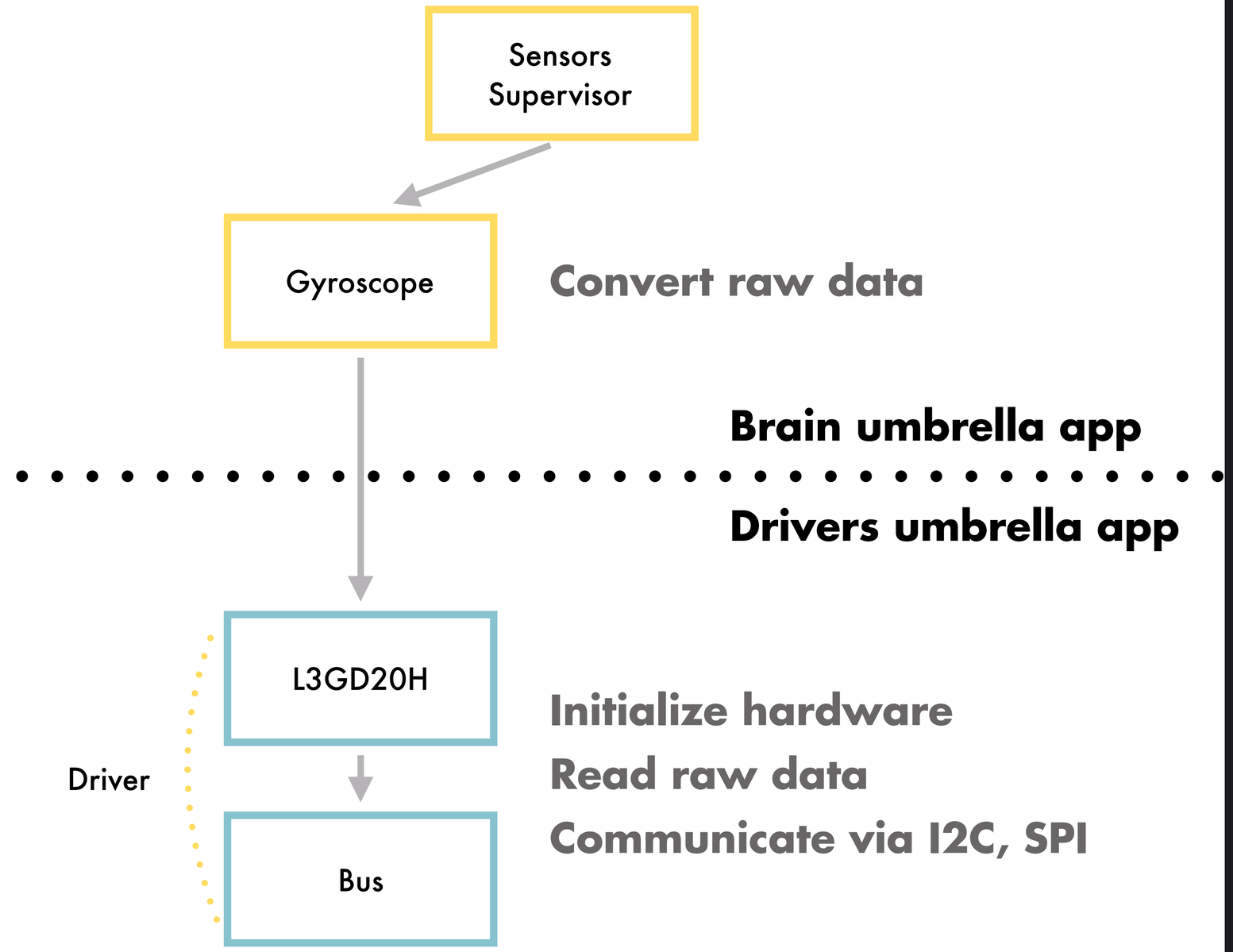
ACCELEROMETER

Measures the acceleration (g)

It is highly sensible to vibrations



BUILDING BLOCKS



IN PRACTICE

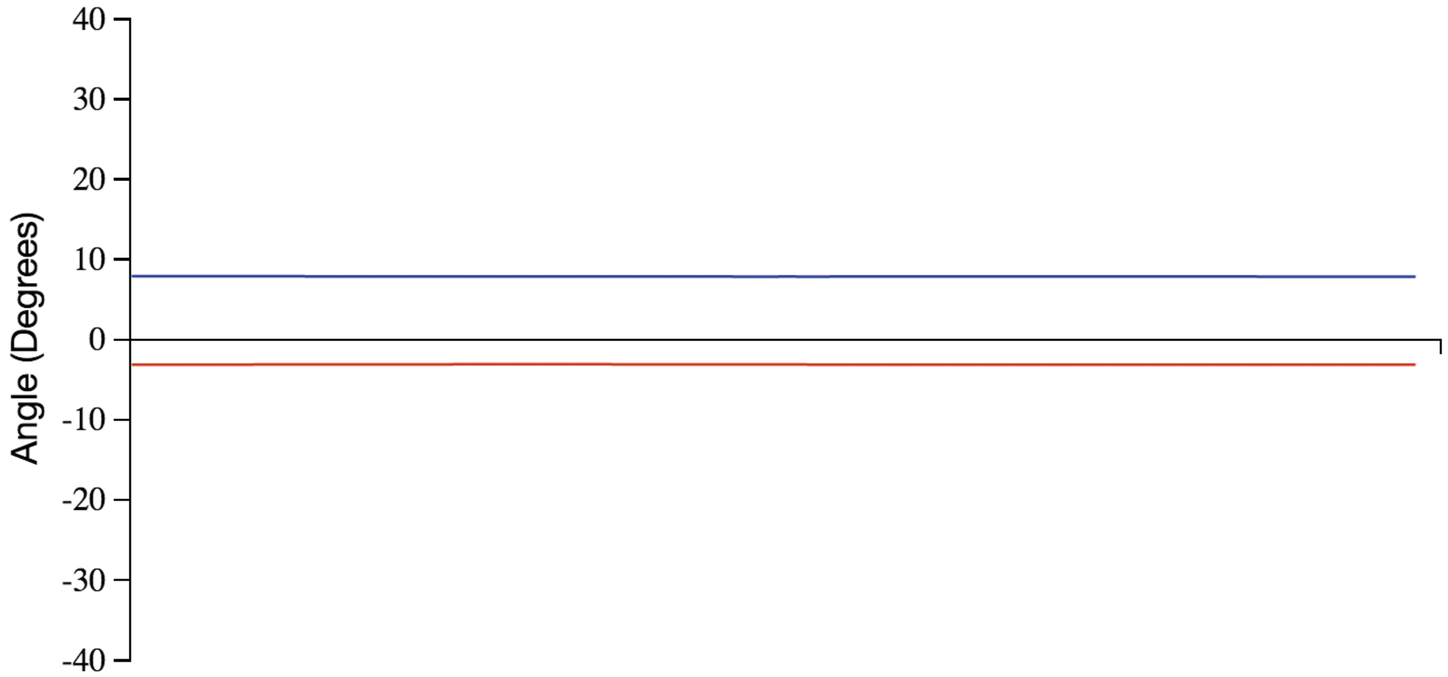
- Separate drivers and business logic
- Allow to switch driver for each sensor
- **elixir_ale** to handle communication

COMPLEMENTARY FILTER

Computes precise measure of the quadcopter tilt

Compensates accelerometer noise and gyroscope drift

angle = α * (gyroscope) + (1 - α) * accelerometer



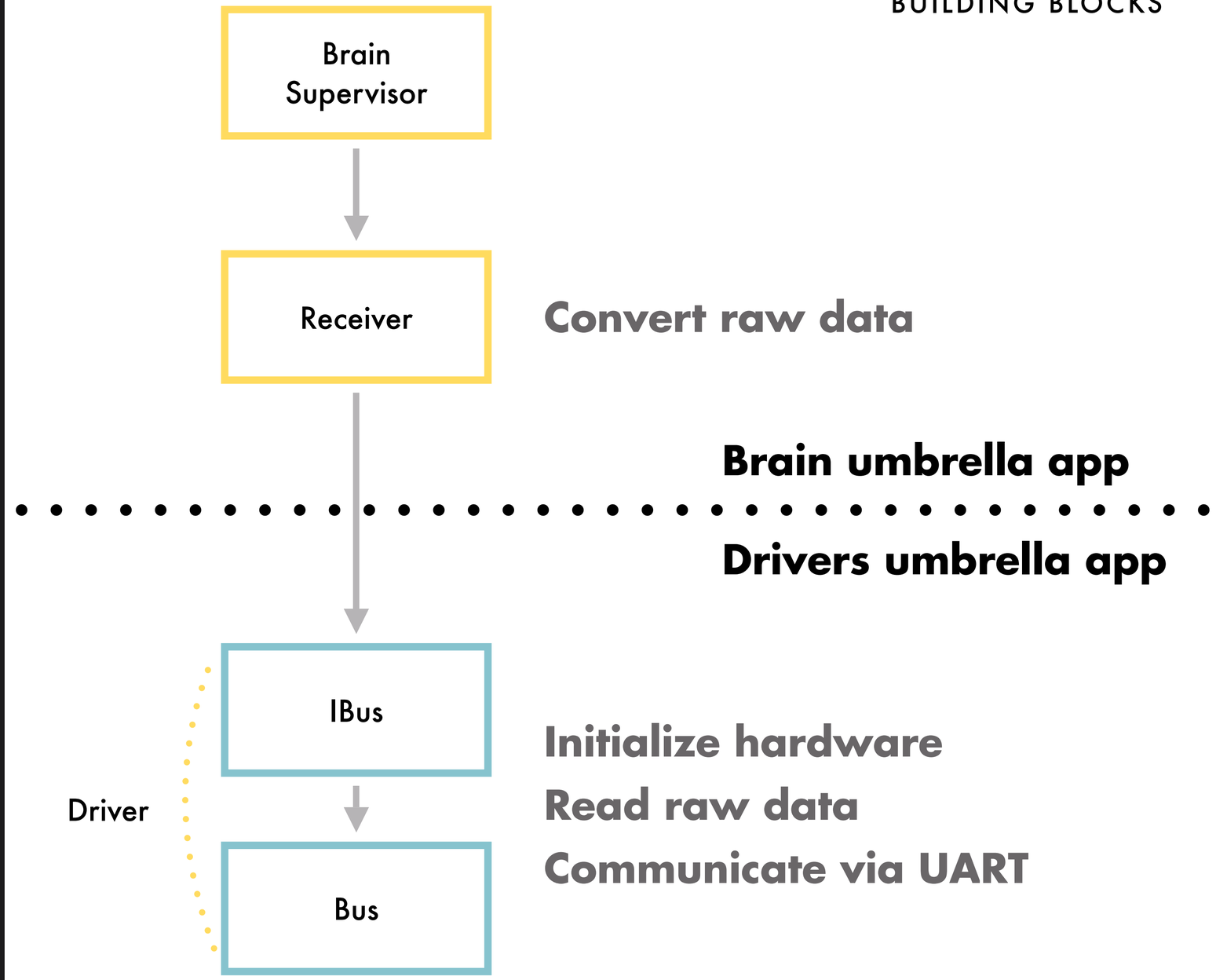
RECEIVER

RECEIVES COMMAND SENT BY USER TRANSMITTER

<<6, 0, 0, 1, 0, 0, 0, 255, 0, 0, 0, 2, 0, 0, 0, 255, 255>>

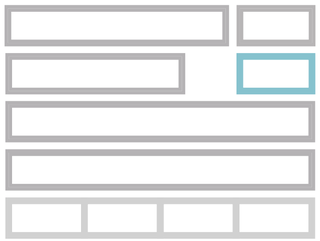
IN PRACTICE

- Same logic as sensors
- **nerves_uart** for serial communication

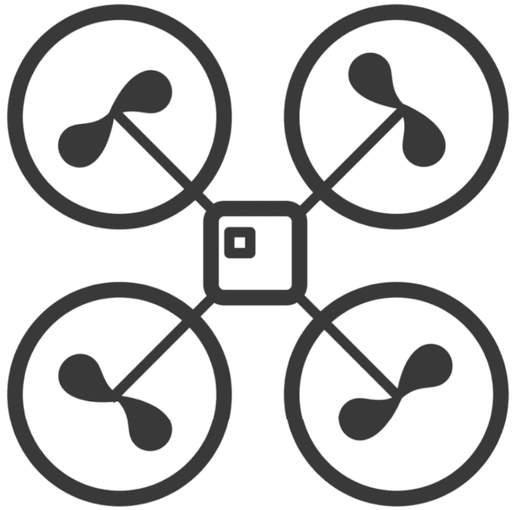


INTERPRETER

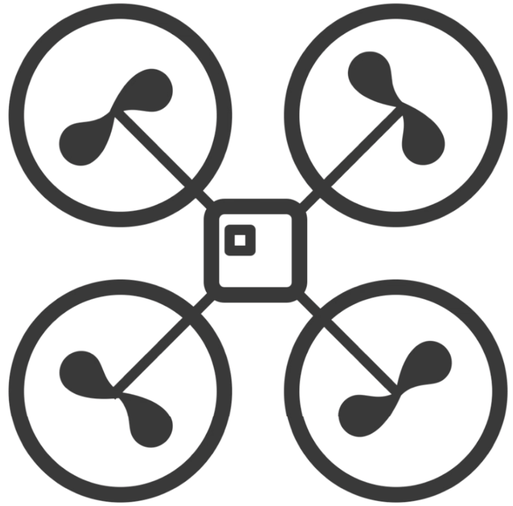
CONVERTS RECEIVER CHANNELS VALUES TO SET POINTS



RATE MODE

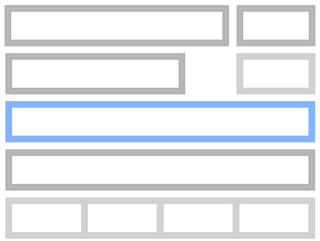


ANGLE MODE

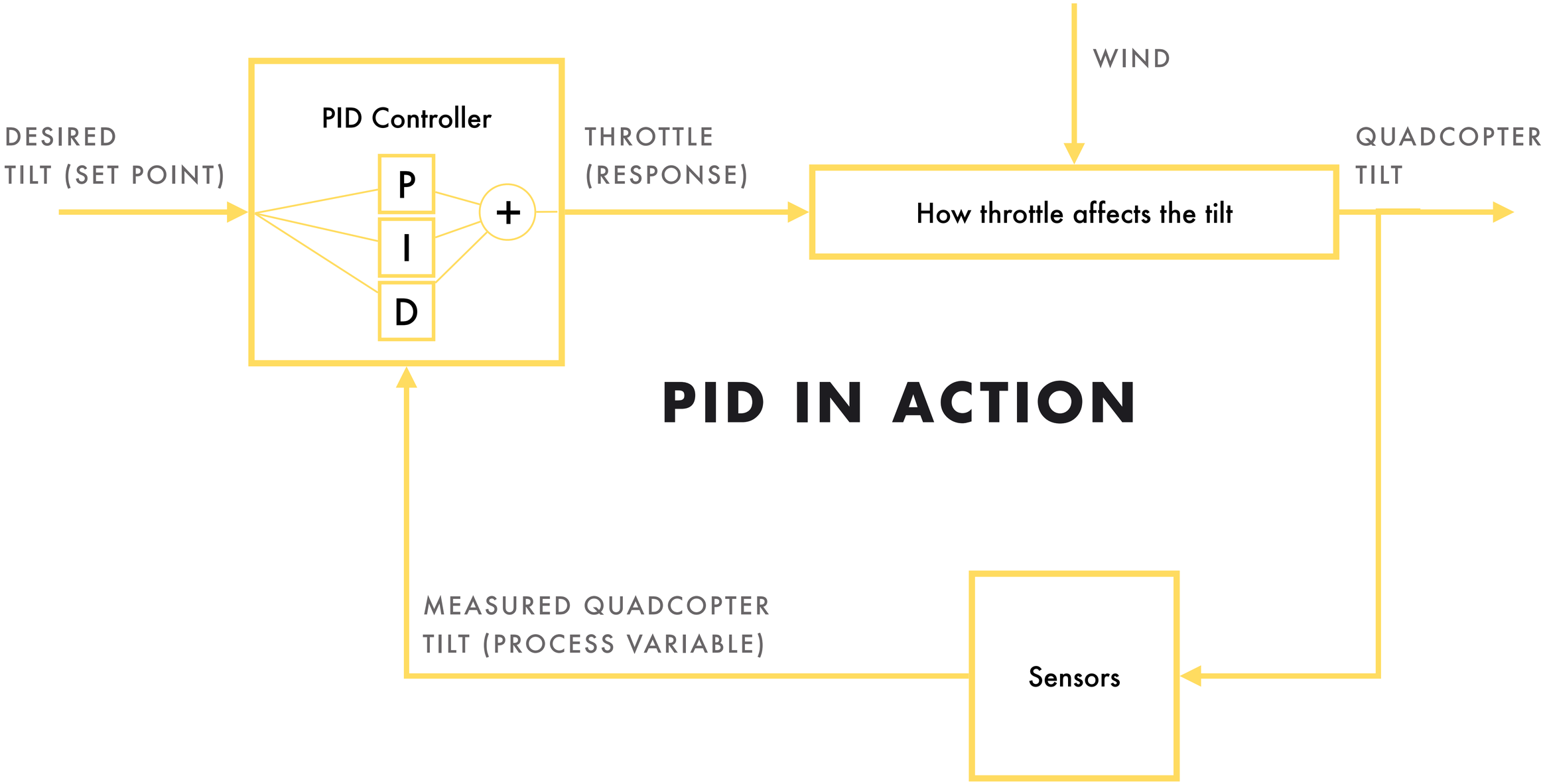


PID CONTROLLER

CONTROL LOOP FEEDBACK MECHANISM



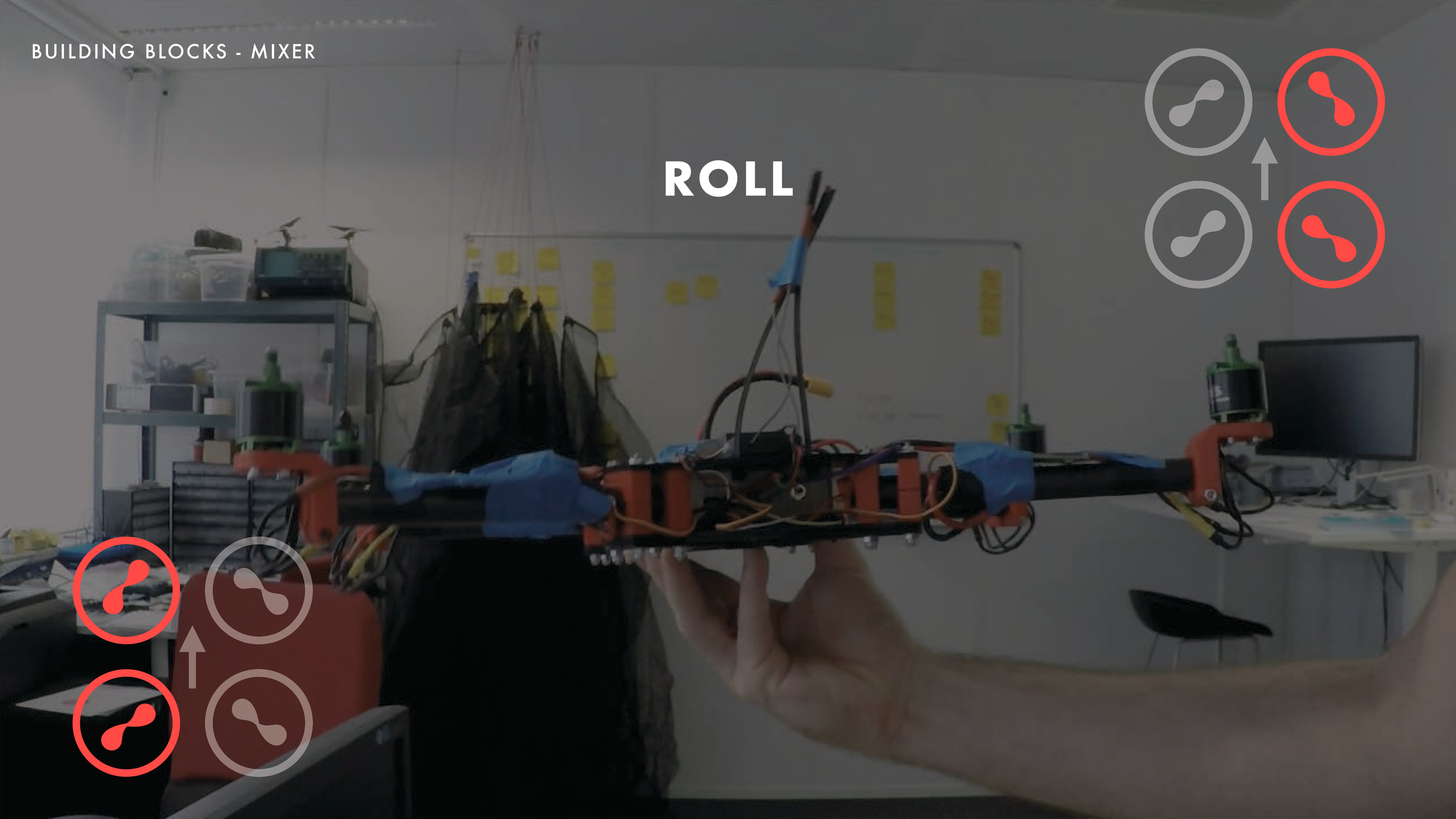
BUILDING BLOCKS - PID CONTROLLER



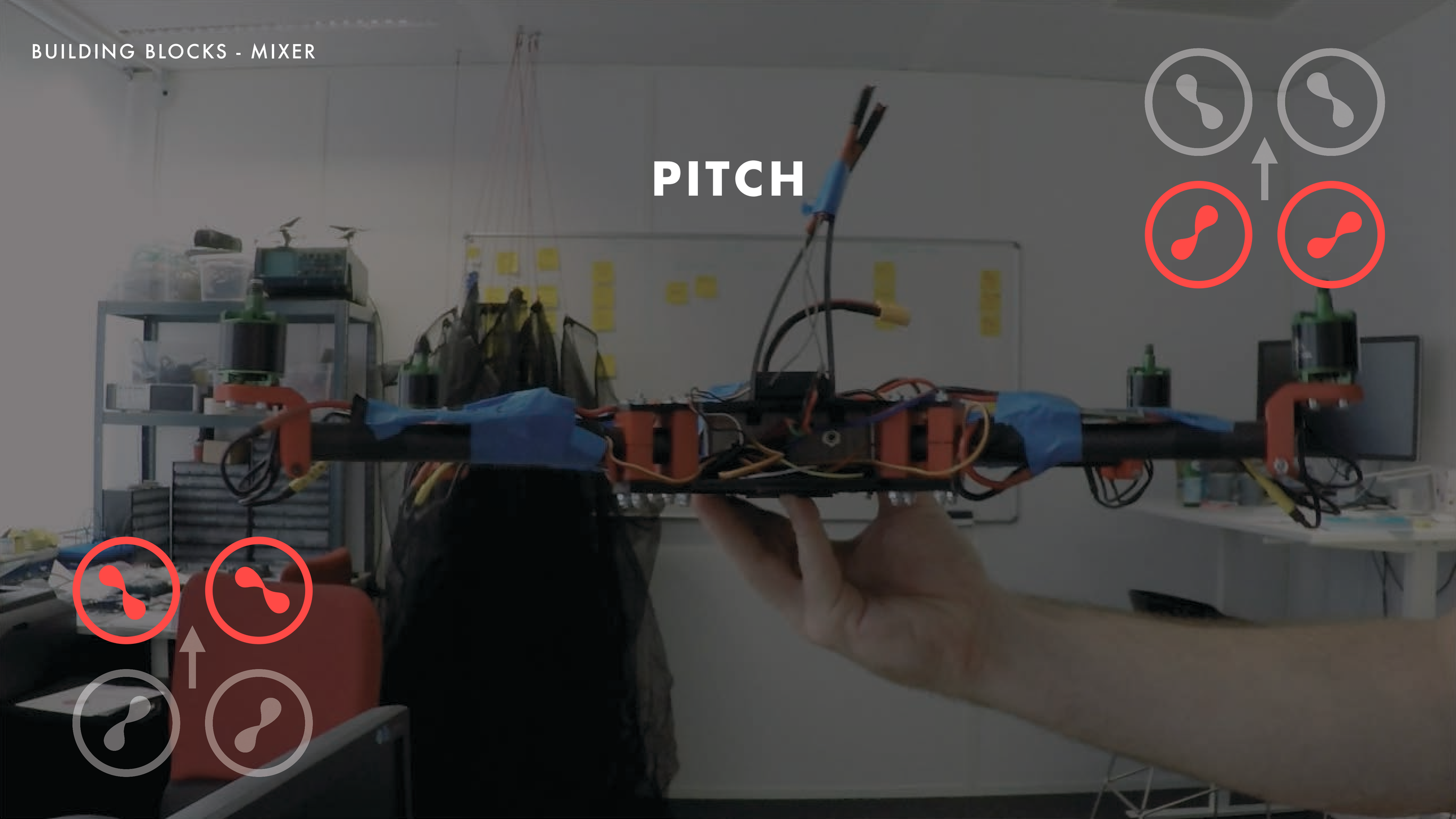
MIXER

COMPUTES THE SPEED TO APPLY TO EACH MOTOR

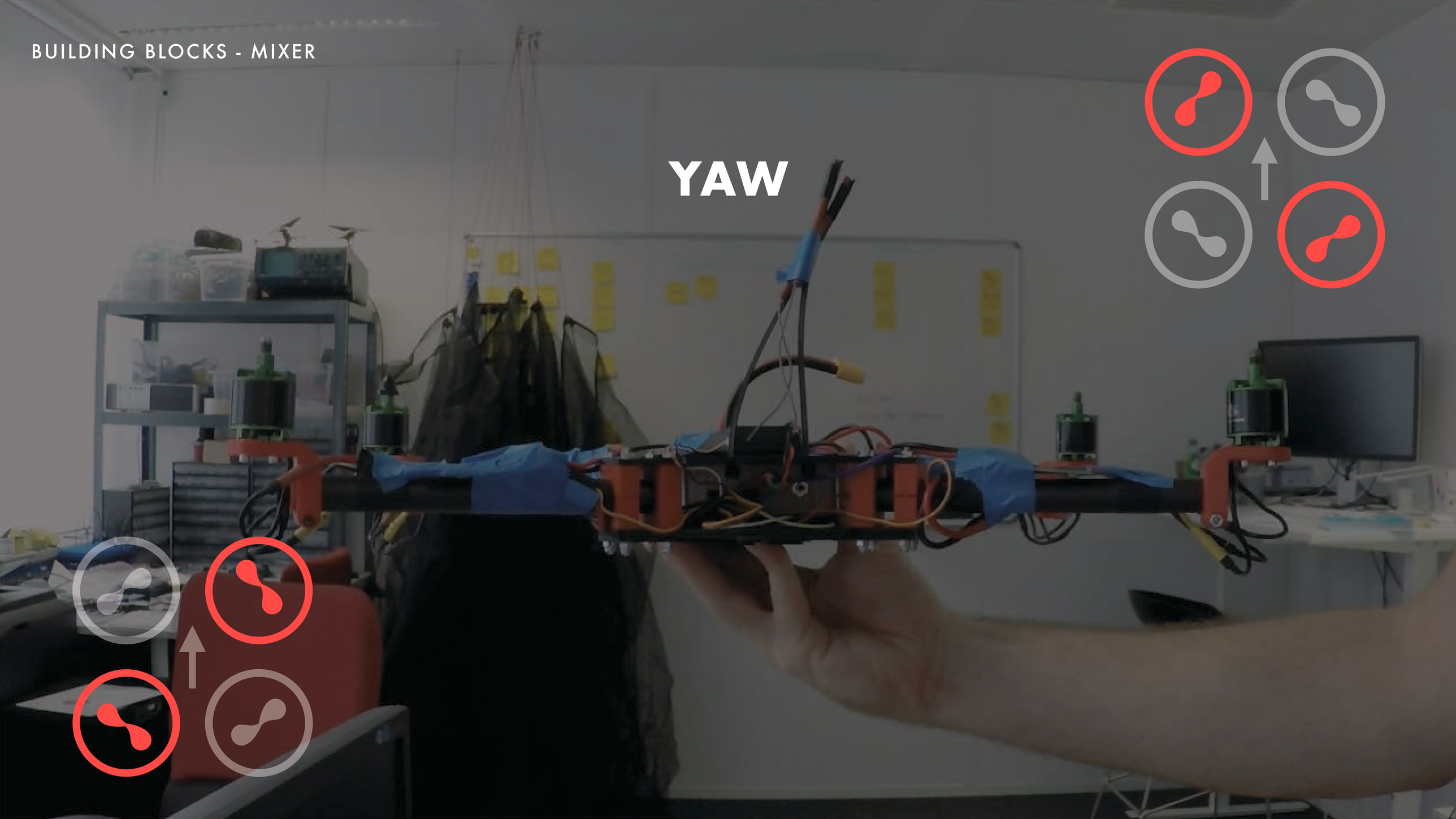
ROLL



PITCH



YAW



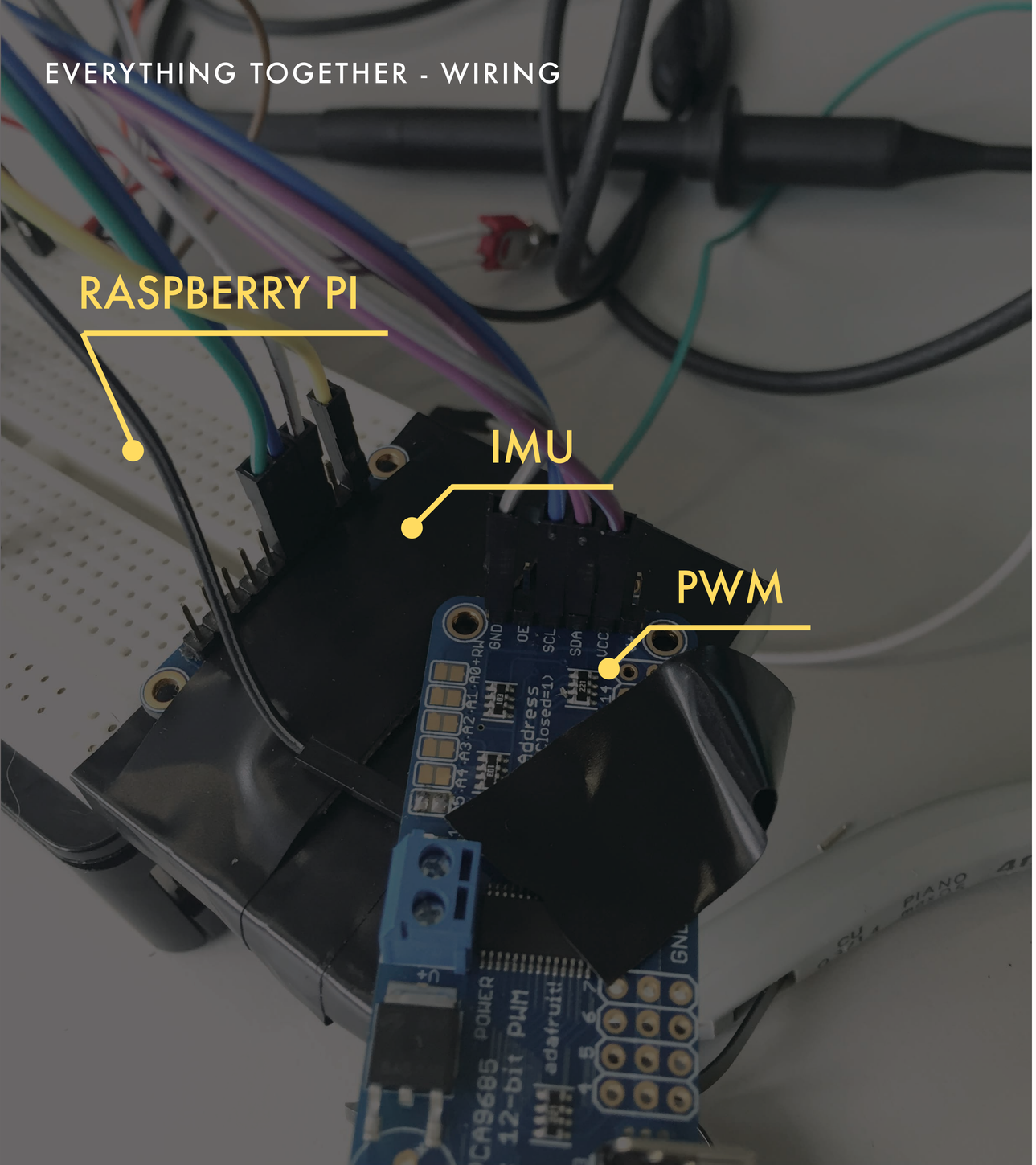
DESIGN CHOICES

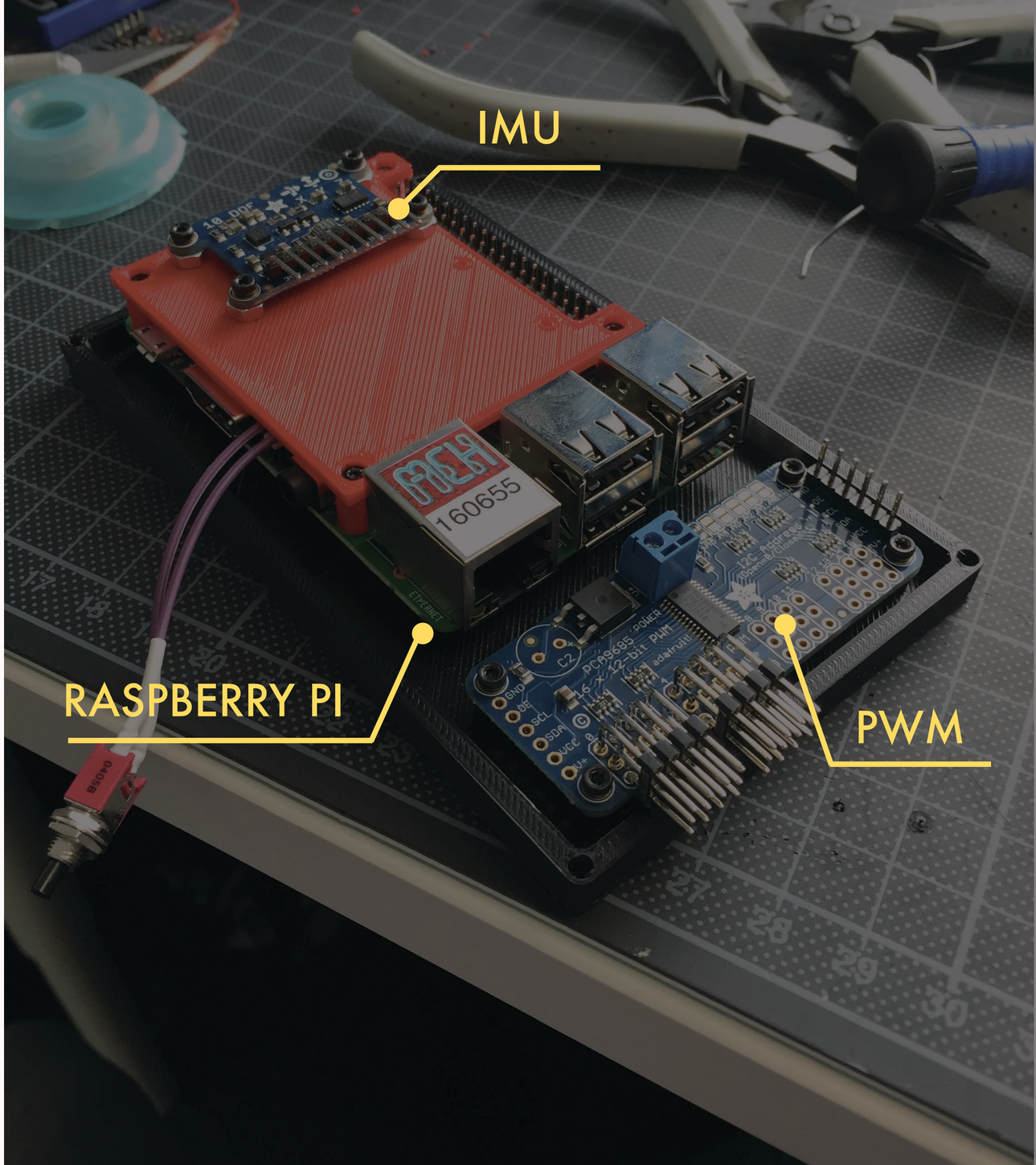
BUILDING BLOCKS

EVERYTHING TOGETHER

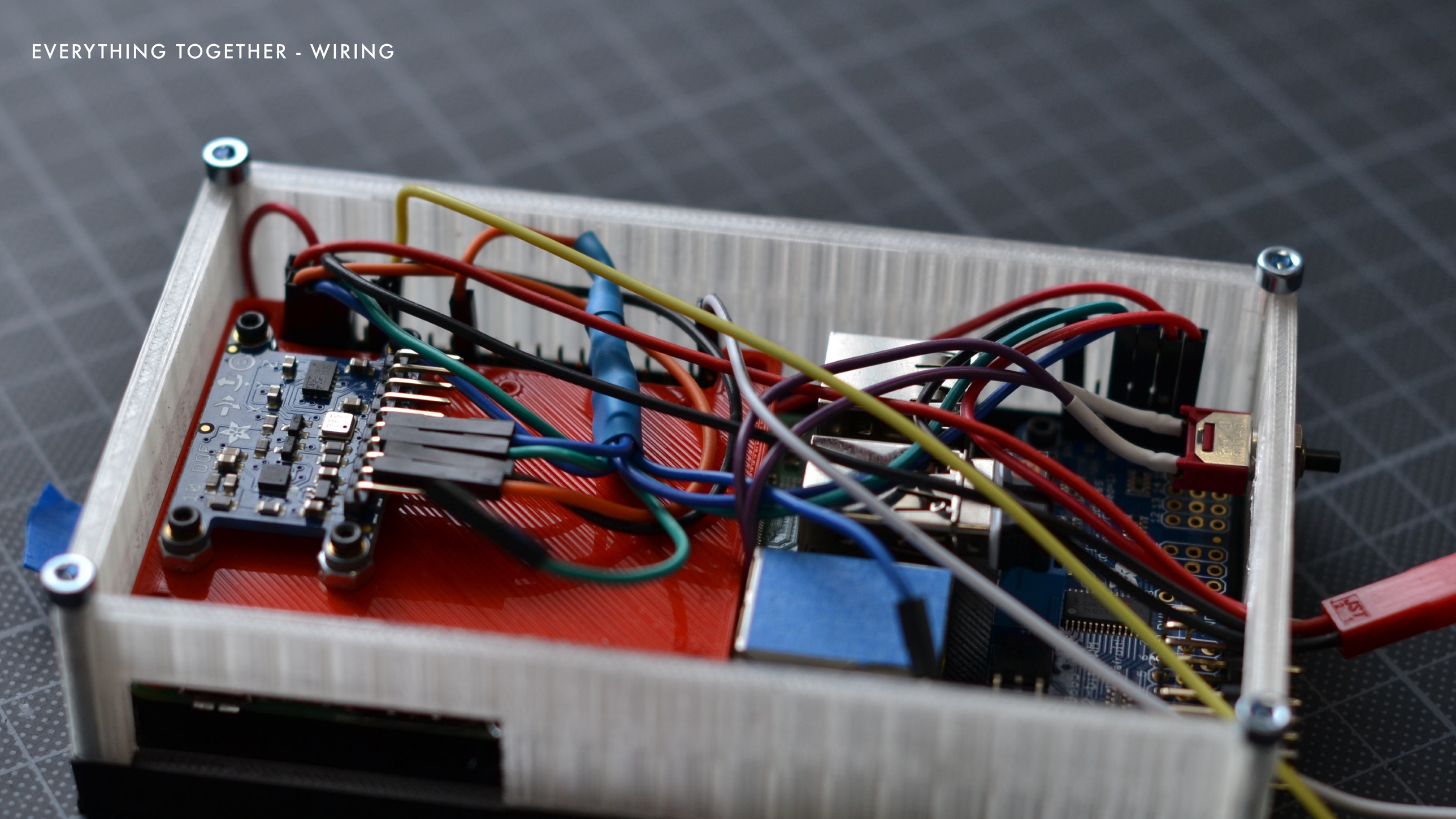
FURTHER WORK

EVERYTHING TOGETHER - WIRING

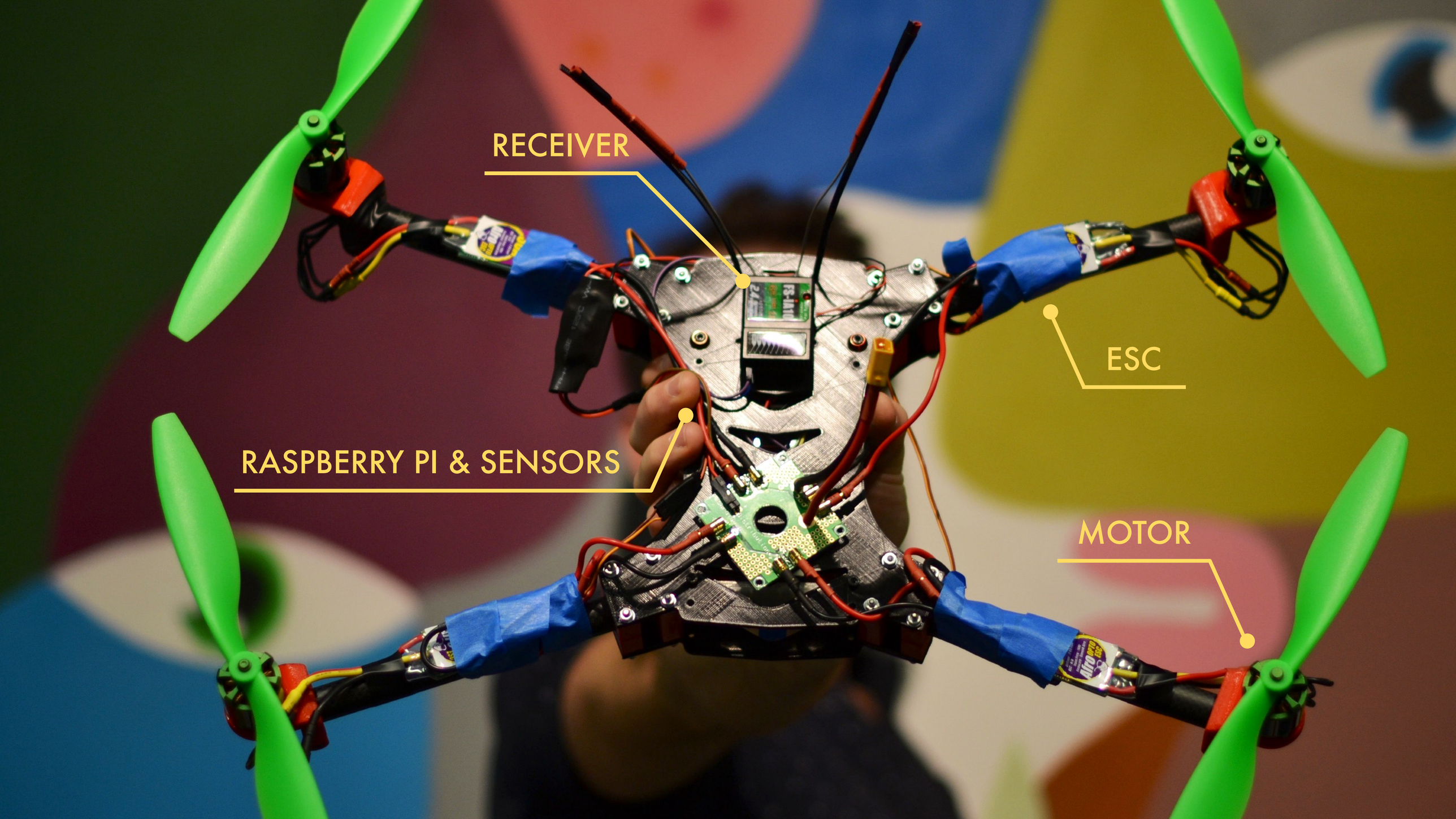


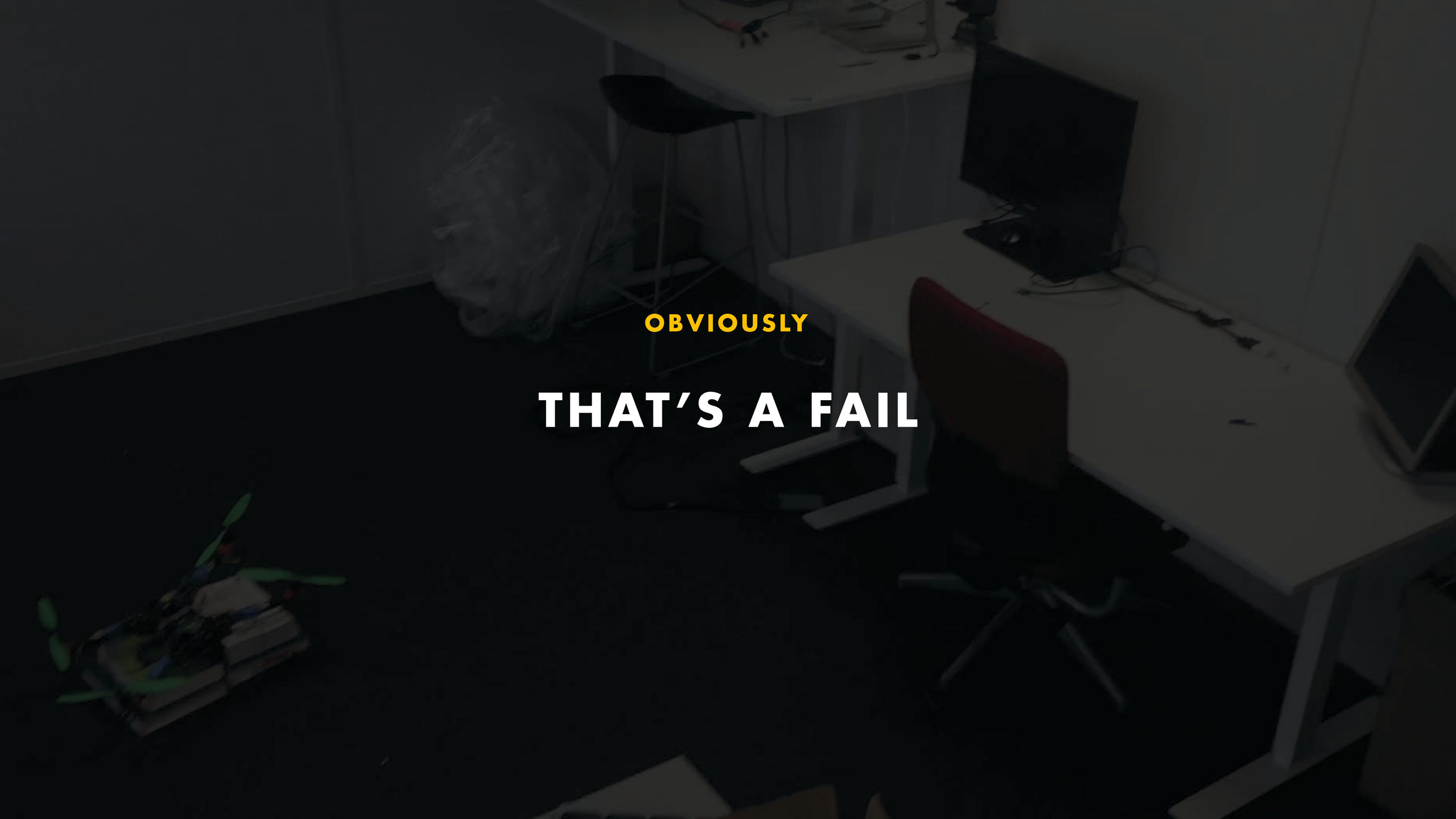


EVERYTHING TOGETHER - WIRING



EVERYTHING TOGETHER - WIRING


RECEIVER
ESC
RASPBERRY PI & SENSORS
MOTOR



OBVIOUSLY

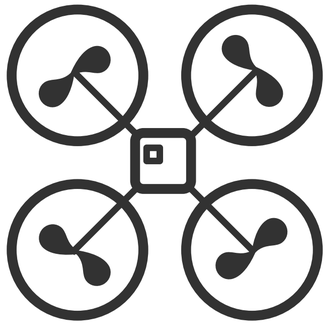
THAT'S A FAIL

DEBUGGING

REDUCE THE FEEDBACK LOOP

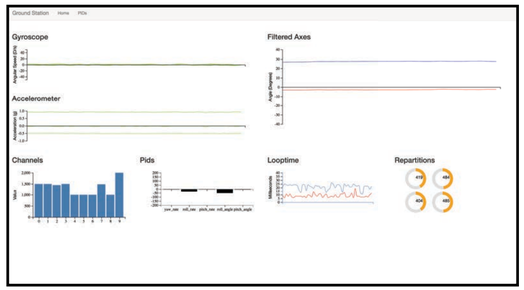
BLACKBOX

Collects data of each quadcopter components



Quadcopter

Phoenix Socket



Ground Station

Quadcopter Sensor

```
def handle_call(:read, _from, %{driver_pid: driver_pid} = state) do
  {:ok, data} = GenServer.call(driver_pid, :read)
  BlackBox.trace(__MODULE__, Process.info(self())[:registered_name], data)
  {:reply, {:ok, data}, state}
end
```

1

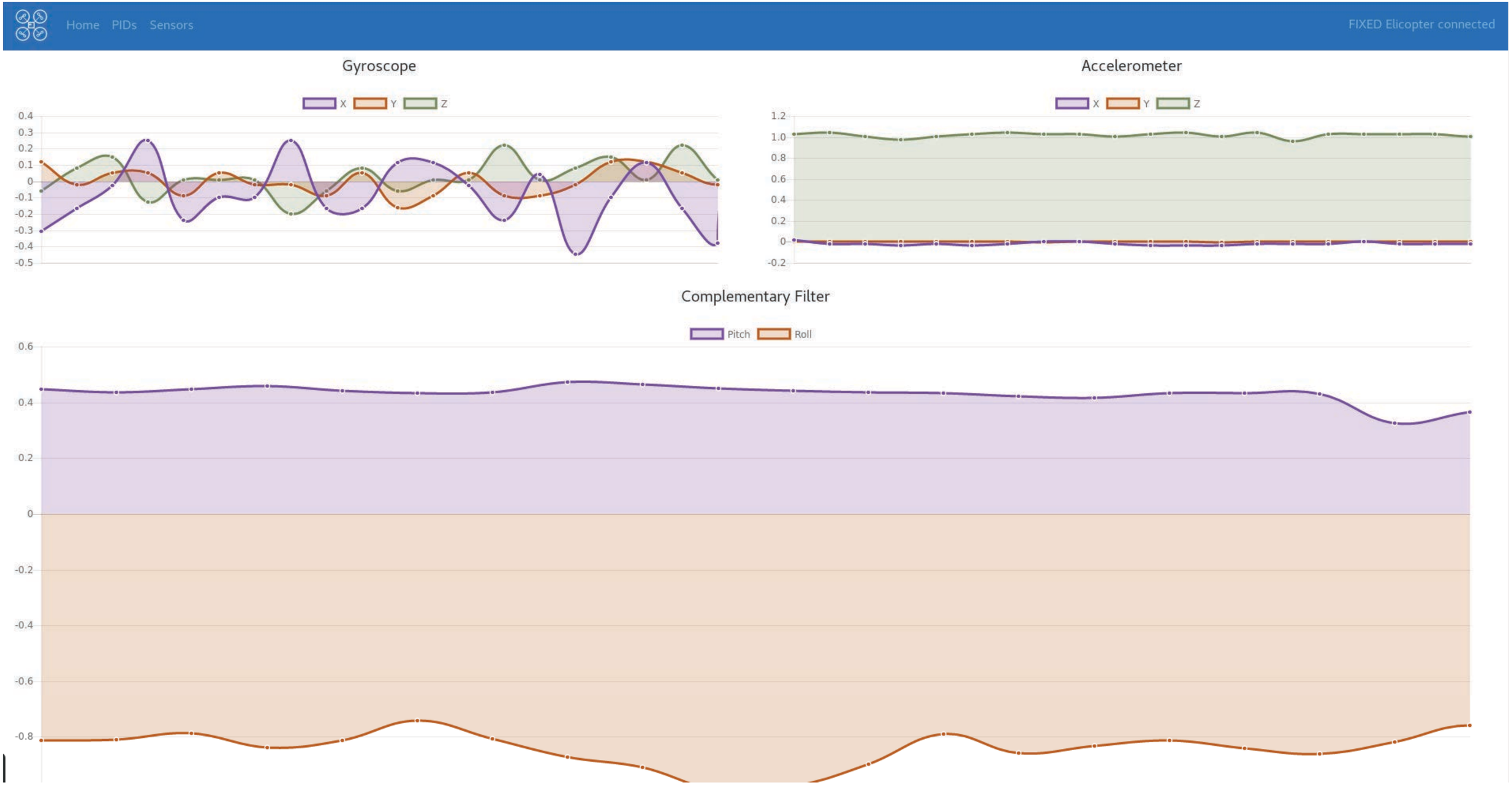
Blackbox

```
def handle_cast({:trace, key, data}, %{loops_buffer: loops_buffer} = state) do
  [last_loop | previous_loops] = loops_buffer
  last_loop                    = [{key, data} | last_loop]
  if length(previous_loops) >= @loops_buffer_limit do
    previous_loops = previous_loops |> Enum.drop(-1)
  end
  {:noreply, %{state | loops_buffer: [last_loop | previous_loops]}}
end

def trace(module, process_name, data) do
  event = case {module, process_name, data} do
    {Brain.Loop, _process_name, data} ->
      {:trace, :loop, data}
    {_, process_name, data} ->
      {:trace, process_name |> Module.split |> List.last |> Macro.underscore, data}
  end
  GenServer.cast(__MODULE__, event)
end
```

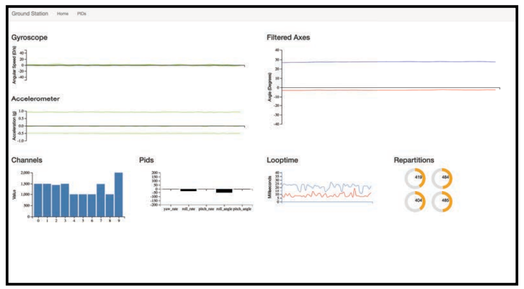
2

EVERYTHING TOGETHER - BLACKBOX



API

Tunes quadcopter in real time



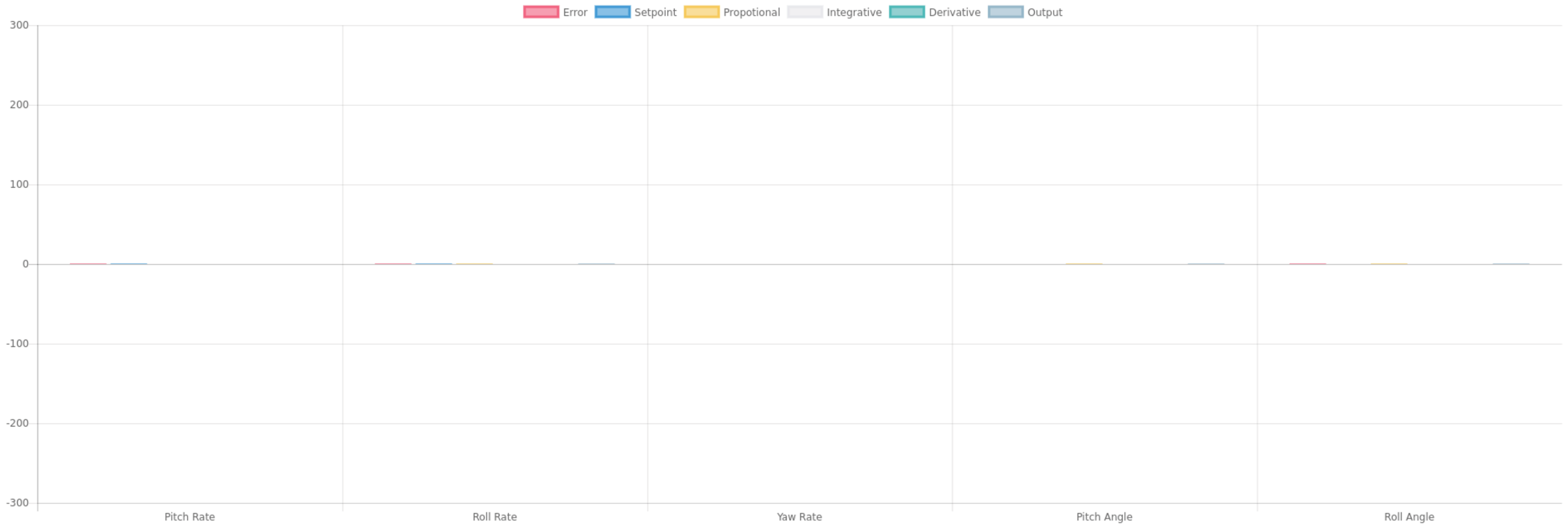
Ground Station

Phoenix REST API

Quadcopter

EVERYTHING TOGETHER - COMMANDER

Home PIDs Sensors FIXED Elicopter connected



Controllers

Name	kp			ki			kd			Minimum Output	Maximum Output
RollAnglePIDController	-	1.5	+	-	0	+	-	0	+	-400	400
PitchAnglePIDController	-	-1.5	+	-	0	+	-	0	+	-400	400
YawRatePIDController	-	1.7	+	-	0	+	-	0	+	-500	500
RollRatePIDController	-	0.7	+	-	0	+	-	0	+	-500	500
PitchRatePIDController	-	0.7	+	-	0	+	-	0	+	-500	500

SSDP DISCOVERY

- No need to change the IP address in the code
- **nerves_ssdp_server**
- **nerves_ssdp_client**

Quadcopter

1

```
def advertise_ssdp do
  name = Application.get_env(:brain, :name)
  {:ok, _name} = Nerves.SSDPServer.publish(name, "elicopter",[
    port: Application.get_env(:api, Api.Endpoint)[:http][:port]
  ])
end
```

Host

```
defp discover do
  Logger.info("Discovering Elicopters...")
  nodes      = Nerves.SSDPClient.discover
  elicopters = nodes |> Enum.filter(fn ({_name, info}) ->
    case info do
      %{host: _, st: "elicopter"} -> true
      _ -> false
    end
  end)
  {:ok, elicopters}
end
```

2

HTTP FIRMWARE UPDATE

- Use SSDP discovery
- No need to plug or remove the SD Card
- Auto reboot
- **nerves_firmware_http**


```
defmodule Mix.Tasks.Firmware.Upgrade do
  use Mix.Task
  require Logger
  def run(_) do
    {:ok, _pid}        = HTTPoison.start
    {:ok, _pid}        = Nerves.SSDPClient.start(nil, nil)
    {:ok, elicopters} = discover()
    {elicopter_name, elicopter_info} = elicopters |> List.first
     Logger.info("Found #{elicopter_name} at #{elicopter_info[:host]}.")
    build()
    upload(elicopter_info[:host])
    Logger.info("Firmware updated!")
  end

  defp discover do
    …

  defp build do
    …
  end

  defp upload(host) do
    Logger.info("Upload firmware...")
    firmware_update_url = "http://#{host}:8988/firmware"
    firmware_path       = Path.absname("_images/rpi3/brain.fw")
    HTTPoison.request!(
      :post, firmware_update_url, {:file, firmware_path},
      [{"Content-Type", "application/x-firmware"}, {"X-Reboot", "true"}],
      [timeout: 30_000, recv_timeout: 30_000]
    )
  end
end
```

1

2

3

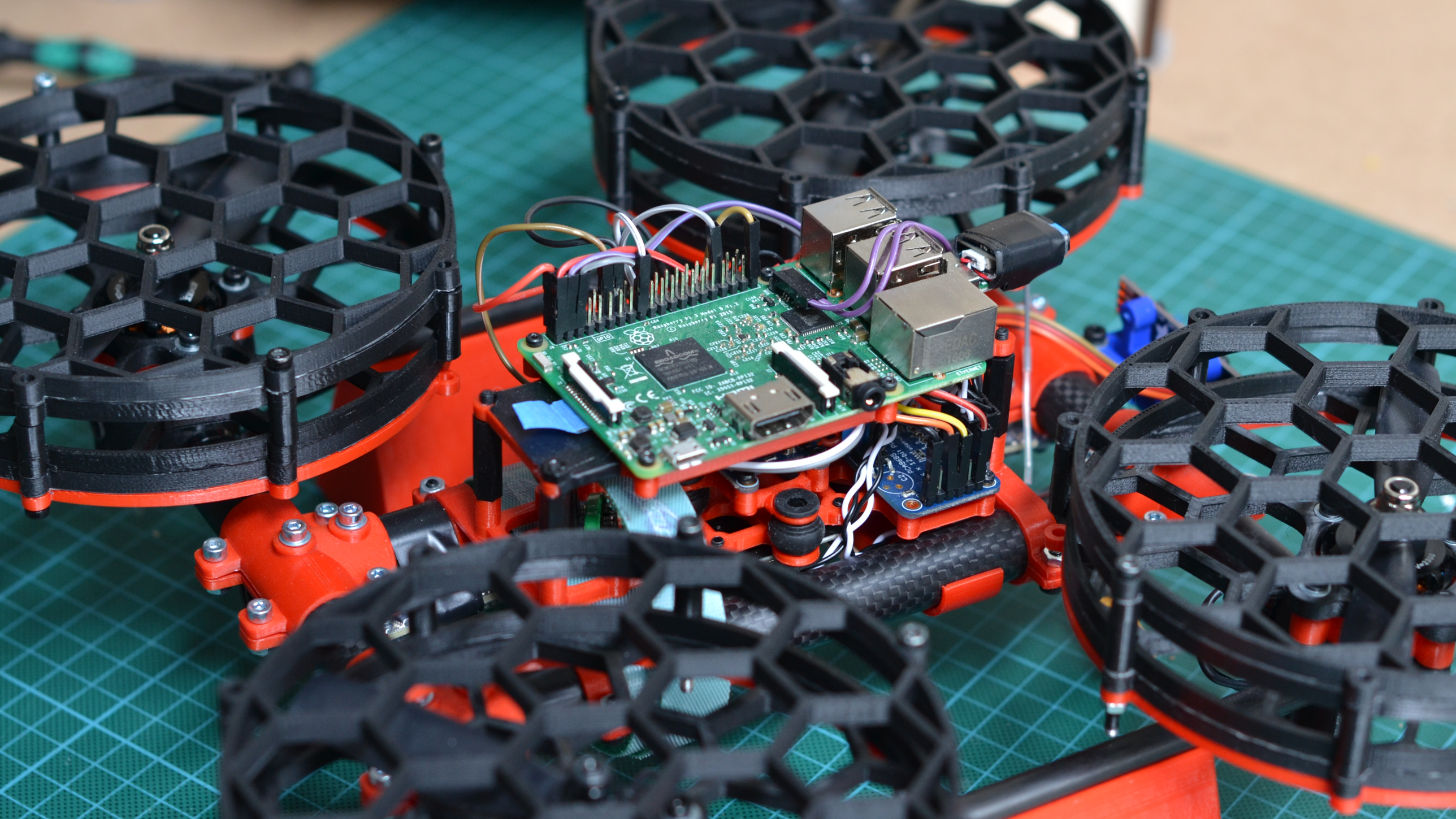
PREPARE A SAFE DEBUGGING ENVIRONMENT

THE RESULT

AFTER SOME TUNING...


VIC
TO
RY!


DEPRECATED



DESIGN CHOICES

BUILDING BLOCKS

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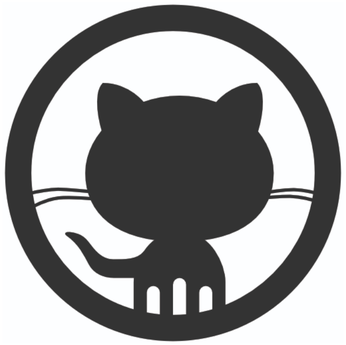
FURTHER WORK

IMPROVE

INNOVATE

OPEN SOURCE PROJECT

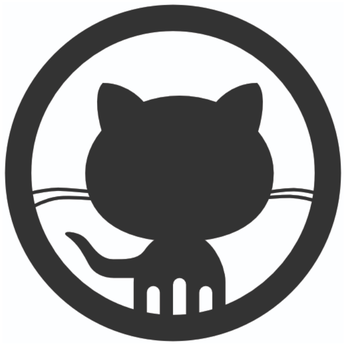
DRAWINGS AND CODE ON GITHUB



GITHUB.COM/ELICOPTER

ElixirConf™ EU

THANKS



GITHUB.COM/ELICOPTER

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