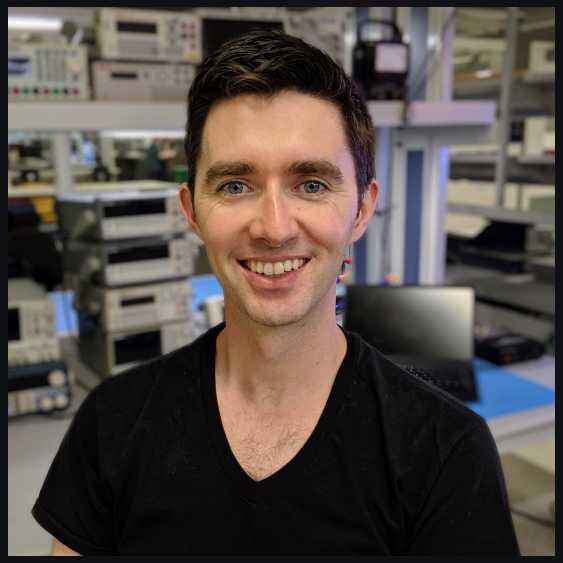
What Chip Shortage?

How We Use Zephyr for Truly Modular Hardware

Chris Gammell & Mike Szczys

About Chris



Chris Gammell

@chris_gammell on twitter

- Developer Relations Lead at Golioth
- 20 years hardware development
- Worked at places like ABB, Samsung, Supplyframe, Keithley, Hologram
- Most recently was a hardware and firmware consultant.

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About Mike

Mike Szczys

@szczys on twitter

- Developer Relations Engineer at Golioth
- 15 years of firmware experience
- Previously: Editor in Chief of Hackaday

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Golioth is a device management platform

(and more)

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Who is this talk for?

Zephyr Beginners

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Zephyr Veterans looking for help during the chip shortage

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Anyone interested in hardening their supply chain by introducing *Swappability*

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Swappability (interoperability):

- The ability to trade one temperature sensor for another temperature sensor.
- The ability to trade a temperature sensor for LIDAR.
- The ability to trade network interfaces to (cellular → WiFi) for easier testing.
- The ability to trade microcontrollers within a family or even between manufacturers.

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Why bother with flexibility?

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Part shortages

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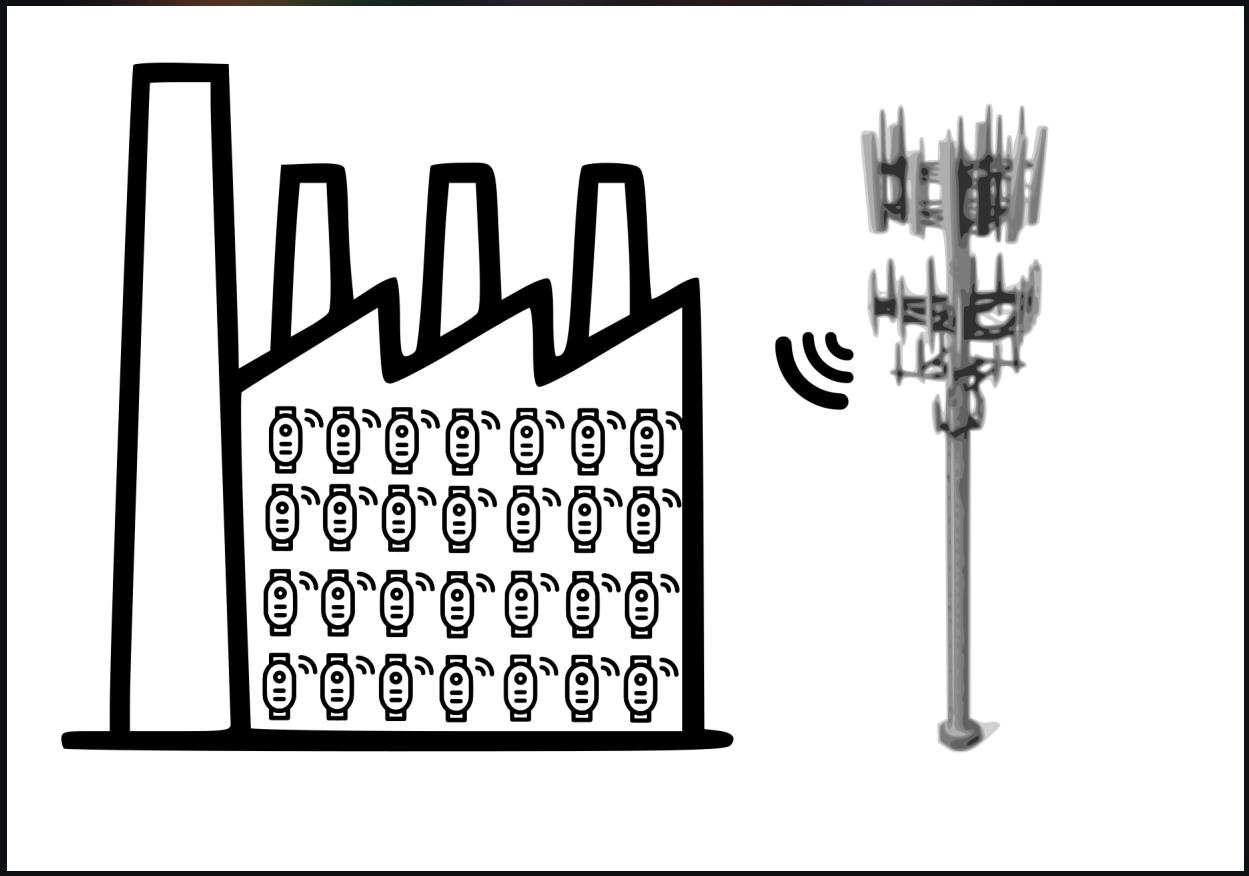
On-the-ground issues



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Different customers, same design

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What is the Aludel Hardware?

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Standard Enclosure

Easily purchased from multiple vendors, widely available

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Swappable faceplates

Each customer gets a tailor-made hardware look

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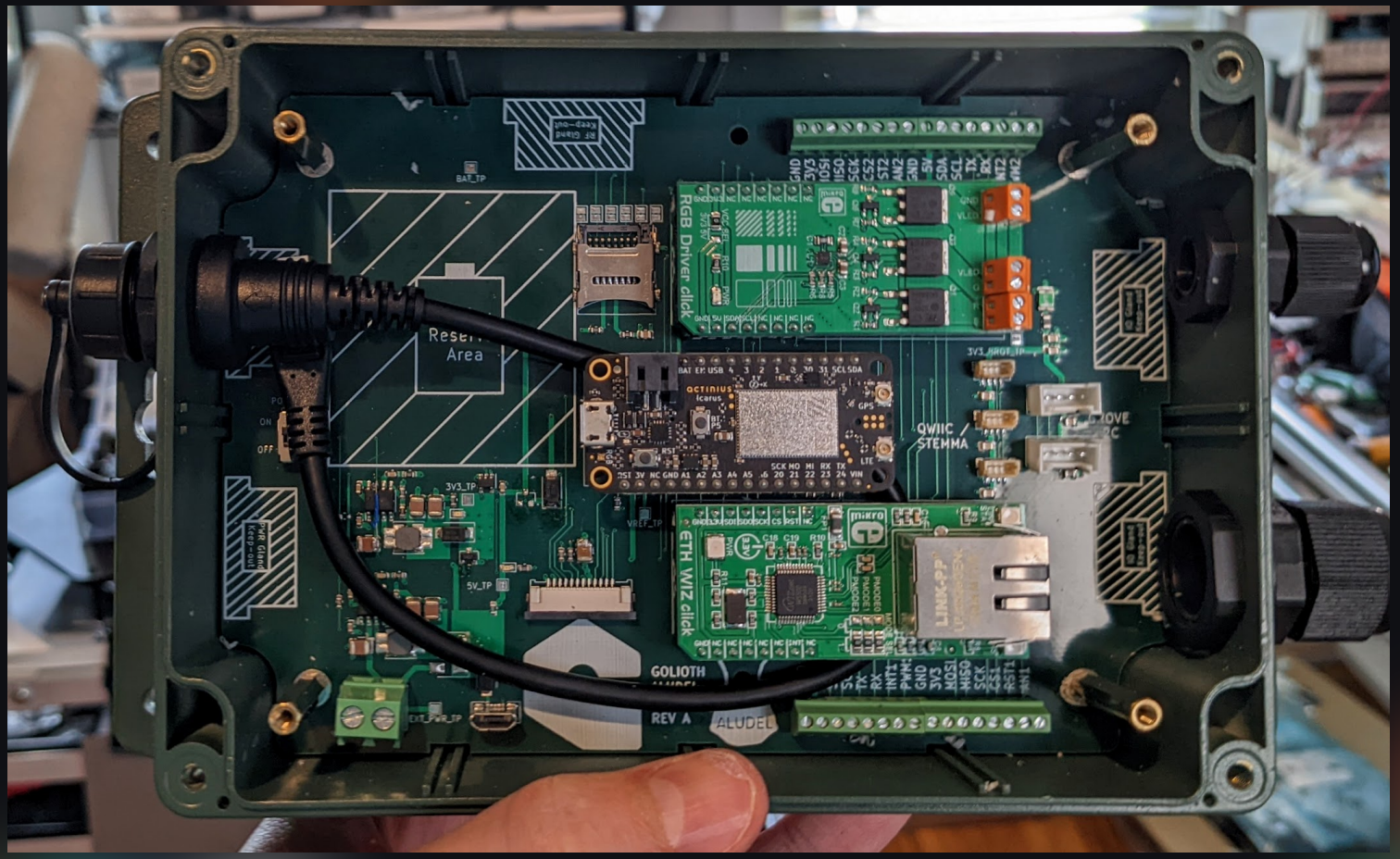
Internal Standards

Off-the-shelf modules made interchange possible



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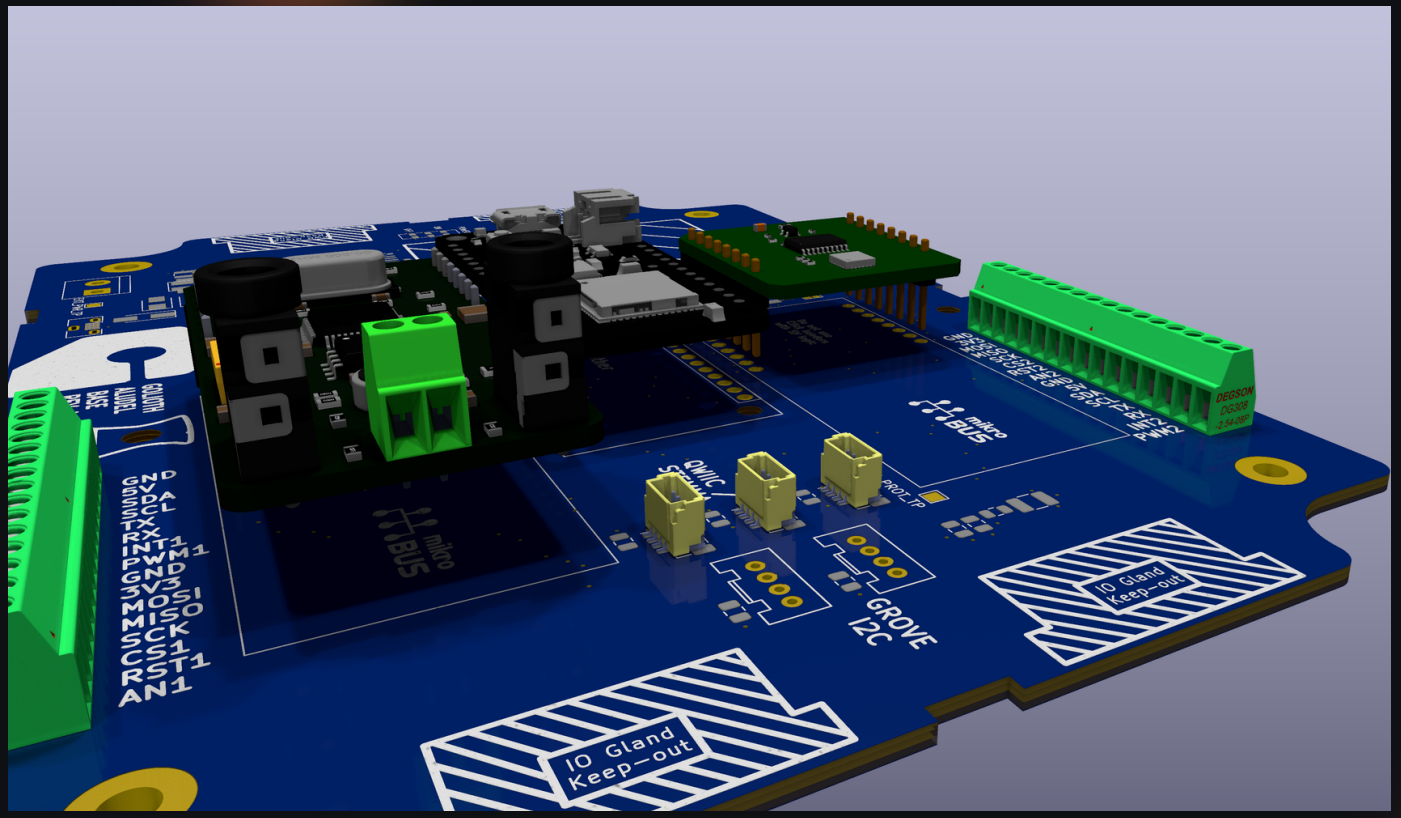
Terminals Blocks

Standard industrial option for connecting components



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Glands, Glands, Glands

Industrial IoT needs to think about water/dust ingress

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Plans, Plans, Plans

Future plans include more power options and fine control

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What is the Aludel Software?

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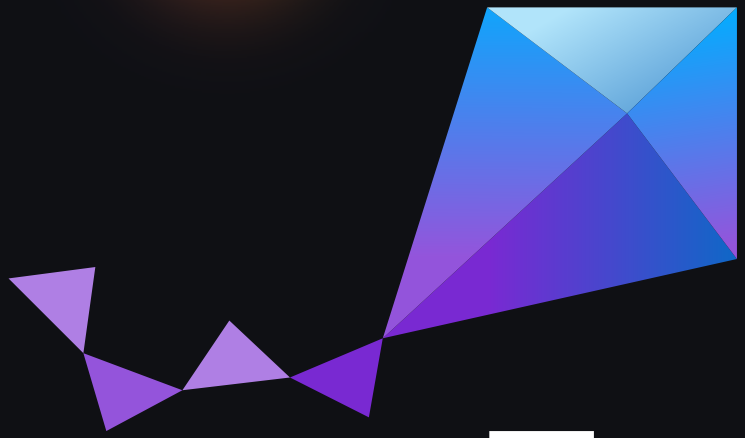

Zephyr™

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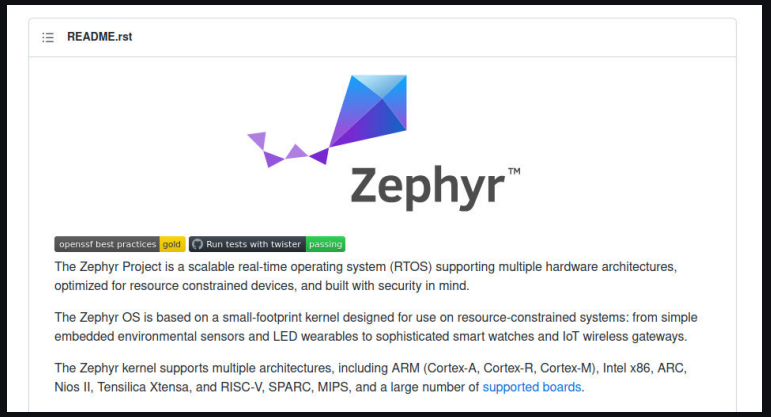
Flavors of Zephyr

Zephyr

(vanilla)



nRF Connect

(still Zephyr, but it tastes a bit like Nordic)

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Device Tree

boards > adafruit_feather_stm32f405.overlay > ...

```
&i2c1 {
    bme280@76 {
        compatible = "bosch,bme280";
        reg = <0x76>;
        label = "BME280_I2C";
    };
};

&spi2 {
    compatible = "st,stm32-spi";
    status = "okay";
    cs-gpios = <&gpioc 5 GPIO_ACTIVE_LOW>, <&gpiob 9 GPIO_ACTIVE_LOW>, <&gpioc 7 GPIO_ACTIVE_LOW>;
    test_spi_w5500: w5500@0 {
        compatible = "wiznet,w5500";
        label = "w5500";
        reg = <0x0>;
        spi-max-frequency = <10000000>;
        int-gpios = <&gpioc 4 GPIO_ACTIVE_LOW>;
        reset-gpios = <&gpioa 6 GPIO_ACTIVE_LOW>;
    };
};

/ {
    aliases {
        aludeli2c = &i2c1;
        pca9539int = &interrupt_pin0;
    };
    gpio_keys {
        compatible = "gpio-keys";
        interrupt_pin0: int_pin_0 {
            gpios = < &gpiob 8 GPIO_ACTIVE_LOW >;
            label = "Port Expander Interrupt Pin";
        };
    };
};
```

Everything kind of just works, but...

```
if (IS_ENABLED(CONFIG_GOLIOTH_SAMPLE_WIFI)) {
    LOG_INF("Connecting to WiFi");
    wifi_connect();
}

#if IS_ENABLED(CONFIG_NET_L2_ETHERNET)
if (!IS_ENABLED(CONFIG_WIFI_ESP32))
{
    LOG_INF("Connecting to Ethernet");
    struct net_if *iface;
    iface = net_if_get_default();
    net_dhcpv4_start(iface);
}
#endif
```

Some conditionals for specialized code (Ethernet DHCP, ESP32 as AT modem)

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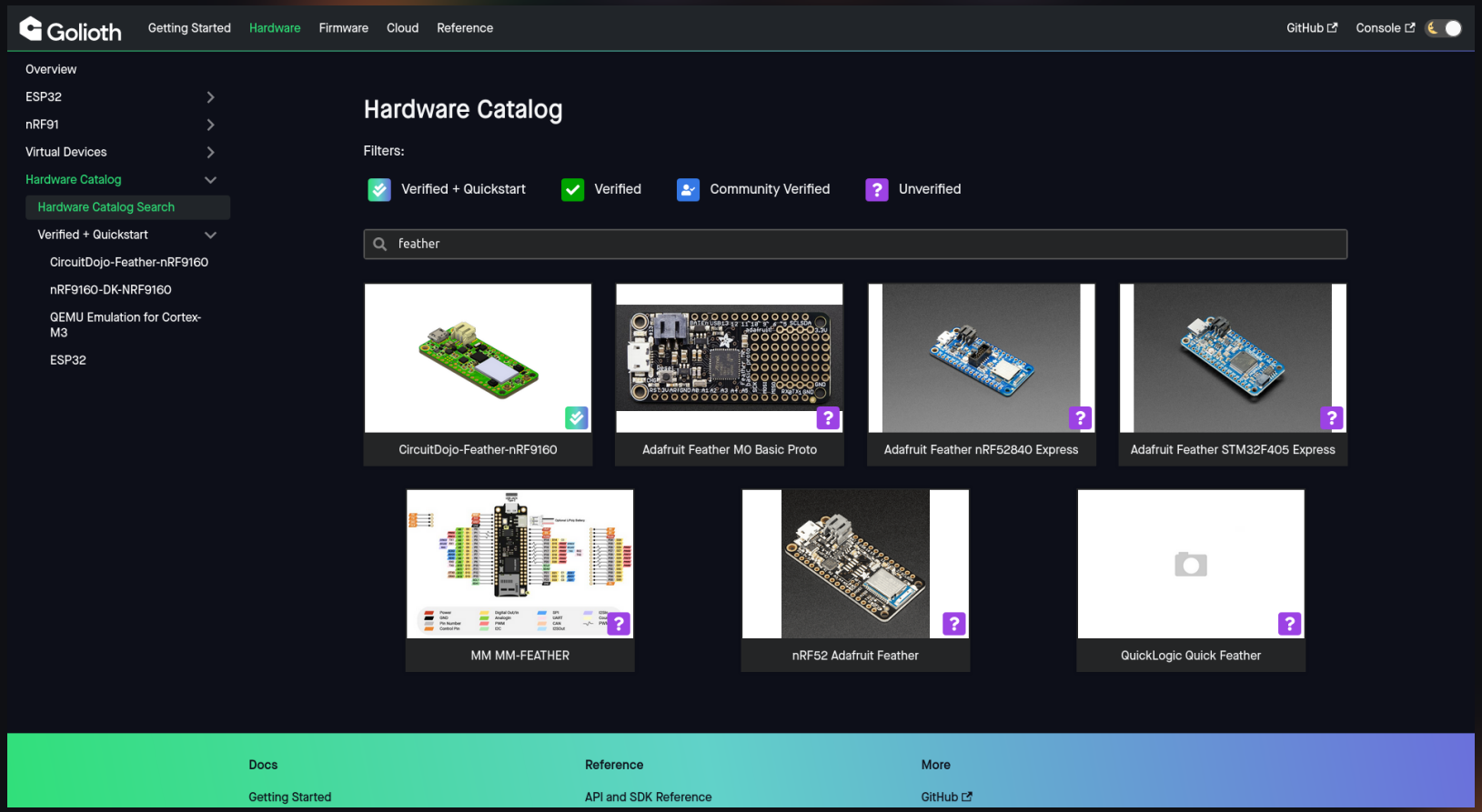
Zephyr support for 'Feather'



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Overlay and Conf Files

Chosen on the board level

- The Feather footprint has good support
  - Circuit Dojo nRF9160 (Cellular)
  - Adafruit Feather nRF52840 (Ethernet)
  - Sparkfun Thing+ STM32f405 (Ethernet)
- Others have related board support:
  - Adafruit Feather ESP32 (WiFi)

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<board>.conf files

boards > adafruit_feather_nrf52840.conf

```
CONFIG_SPI=y
CONFIG_NET_L2_ETHERNET=y
CONFIG_ETH_W5500=y
CONFIG_ETH_W5500_TIMEOUT=1000
CONFIG_NET_DHCPV4=y
CONFIG_NET_MGMT=y

CONFIG_GPIO=y
CONFIG_I2C=y

CONFIG_UART_CONSOLE=n
CONFIG_RTT_CONSOLE=y
CONFIG_USE_SEGGER_RTT=y
```

<board>.overlay

boards > circuitdojo_feather_nrf9160_ns.overlay

```
1  &i2c1 {
2      bme280@76 {
3          compatible = "bosch,bme280";
4          reg = <0x76>;
5          label = "BME280_I2C";
6      };
7  };
8
```

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Overlay files can remap for board variations

```
15  &i2c0 {
16      status = "okay";
17      clock-frequency = <I2C_BITRATE_STANDARD>;
18      sda-pin = <23>;
19      scl-pin = <22>;
20
21      bme280@76 {
22          compatible = "bosch,bme280";
23          reg = <0x76>;
24          label = "BME280_I2C";
25      };
26  };
```

Remap pins

Or you can define your own DTS files for custom boards

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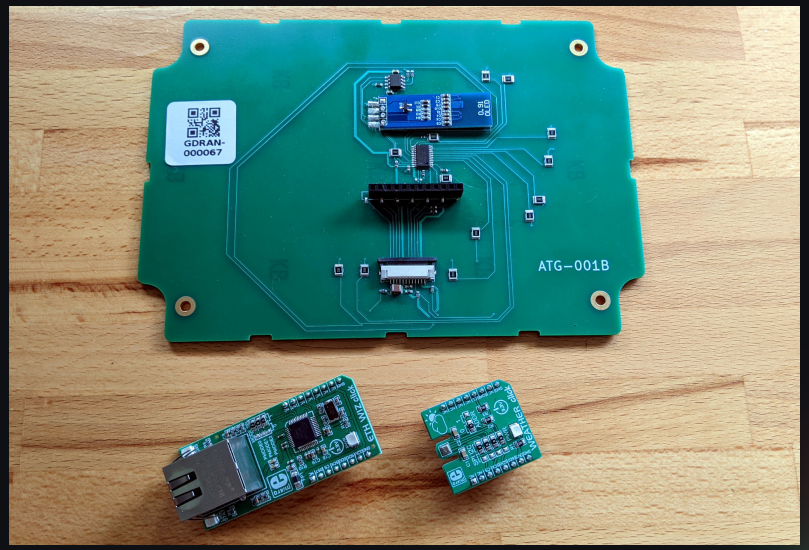
Sensors and Add-Ons

- Examples:
  - BME380 Weather sensor (built-in)
  - W5500 Ethernet module (built-in)
  - AW9523 i2c port expander (direct)



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Sensors need to be added to the overlay file for every microcontroller variant

```
&i2c0 {
    apds9960: apds9960@39 {
        compatible = "avago,apds9960";
        status = "okay";
        reg = <0x39>;
        label = "APDS9960";
        int-gpios = <&gpio0 26 (GPIO_ACTIVE_LOW | GPIO_PULL_UP)>;
    };
};
```

```
&i2c1 {
    apds9960: apds9960@39 {
        compatible = "avago,apds9960";
        status = "okay";
        reg = <0x39>;
        label = "APDS9960";
        int-gpios = <&gpio0 13 (GPIO_ACTIVE_LOW | GPIO_PULL_UP)>;
    };
};
```

```
&i2c1 {
    apds9960: apds9960@39 {
        compatible = "avago,apds9960";
        status = "okay";
        reg = <0x39>;
        label = "APDS9960";
        int-gpios = <&gpioa 4 (GPIO_ACTIVE_LOW | GPIO_PULL_UP)>;
    };
};
```

```
&i2c0 {
    apds9960: apds9960@39 {
        compatible = "avago,apds9960";
        status = "okay";
        reg = <0x39>;
        label = "APDS9960";
        int-gpios = <&gpio0 4 (GPIO_ACTIVE_LOW | GPIO_PULL_UP)>;
    };
};
```

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```
arduino_header: connector {
        compatible = "arduino-header-r3";
        #gpio-cells = <2>;
        gpio-map-mask = <0xffffffff 0xffffffc0>;
        gpio-map-pass-thru = <0 0x3f>;
        gpio-map = <0 0 &gpioa 0 0>,    /* A0 */
                   <1 0 &gpioa 1 0>,    /* A1 */
                   <2 0 &gpioa 4 0>,    /* A2 */
                   <3 0 &gpiob 0 0>,    /* A3 */
                   <4 0 &gpioc 1 0>,    /* A4 */
                   <5 0 &gpioc 0 0>,    /* A5 */
                   <6 0 &gpioa 3 0>,    /* D0 */
                   <7 0 &gpioa 2 0>,    /* D1 */
                   <8 0 &gpioa 10 0>,   /* D2 */
                   <9 0 &gpiob 3 0>,    /* D3 */
                   <10 0 &gpiob 5 0>,   /* D4 */
                   <11 0 &gpiob 4 0>,   /* D5 */
                   <12 0 &gpiob 10 0>,  /* D6 */
                   <13 0 &gpioa 8 0>,   /* D7 */
                   <14 0 &gpioa 9 0>,   /* D8 */
                   <15 0 &gpioc 7 0>,   /* D9 */
                   <16 0 &gpiob 6 0>,   /* D10 */
                   <17 0 &gpioa 7 0>,   /* D11 */
                   <18 0 &gpioa 6 0>,   /* D12 */
                   <19 0 &gpioa 5 0>,   /* D13 */
                   <20 0 &gpiob 9 0>,   /* D14 */
                   <21 0 &gpiob 8 0>;   /* D15 */
};
```

Zephyr Shields as a workaround

- Shield file calls out the &arduino_header abstraction
- Caveat: the header must be mapped in the board.dts file (can't be mapped in an overlay)

```
&i2c0 {
    apds9960: apds9960@39 {
        compatible = "avago,apds9960";
        status = "okay";
        reg = <0x39>;
        label = "APDS9960";
        int-gpios = <&arduino_header 0 (GPIO_ACTIVE_LOW | GPIO_PULL_UP)>;
    };
};
```

```
# From the root of the zephyr repository
west build -b None your_app -- -DSHIELD="x_nucleo_idb05a1 x_nucleo_iks01a1"
```

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Don't forget to Document

nrf52840 feather with w5500 Ethernet

```
west build -b adafruit_feather_nrf52840 . -D OVERLAY_CONFIG=credentials.conf -p
```

1. Connect via the J-Link programmer
2. `west flash`
3. View the serial output using JLinkRTTViewer

stm32f405 feather with w5500 Ethernet

```
west build -b adafruit_feather_stm32f405 . -D OVERLAY_CONFIG=credentials.conf -p
```

This one cannot be programmed when plugged into the Aludel.

1. Remove the feather from Aludel
2. Plug into USB, hold the `BT0` button and tap the reset button
3. `west flash`

Circuit Dojo Feather (nrf9160)

Make sure to use the Golioth **NCS** SDK (the Nordic "flavor") to build for this board.

```
west build -b circuitdojo_feather_nrf9160_ns . -D OVERLAY_CONFIG=credentials.conf -p
```

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Case Study 1:

Your Sensor Is Out Of Stock

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Prototype

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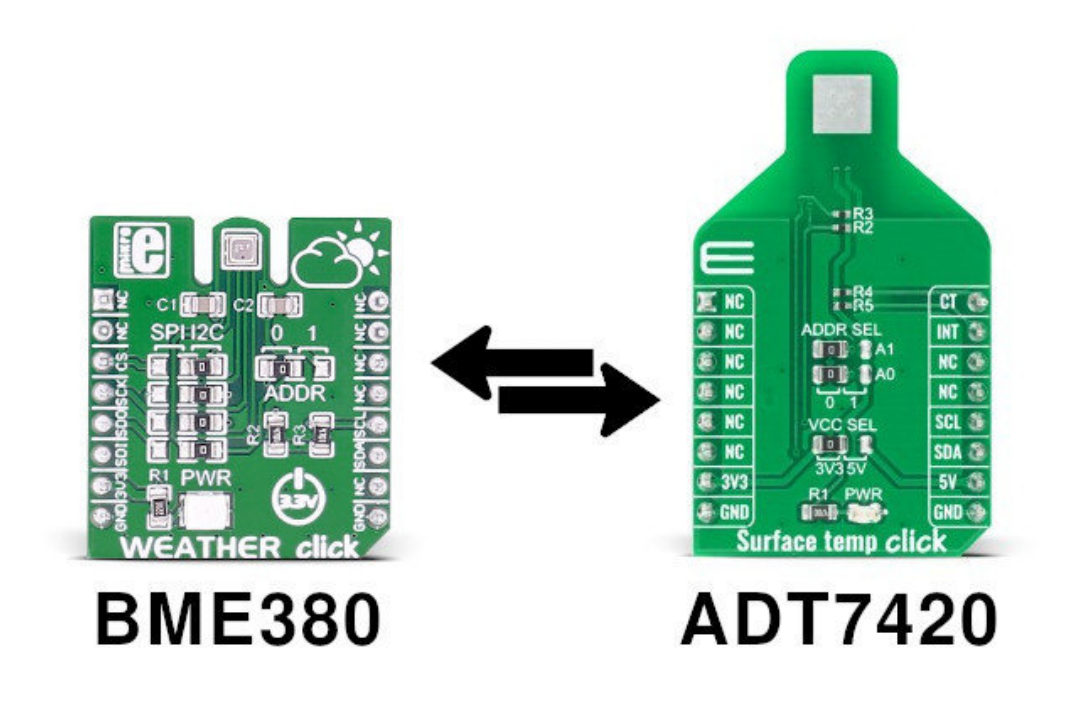
Switch out the click board



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Switch out a bit of the code

- <yourboard>.overlay - if there are new pins
- prj.conf - if there are new settings
- main.c - or wherever calls the sensor

Apply Blockchain AI algorithm in order to generate NFT and apply using 5G programming methods

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Nah, we're done

(also, people talk like that?)

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Assumptions

- You checked that you can actually buy the new sensor
- Your chosen replacement is in-tree and has the same output variable like "ambient temperature"

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Taking it to production

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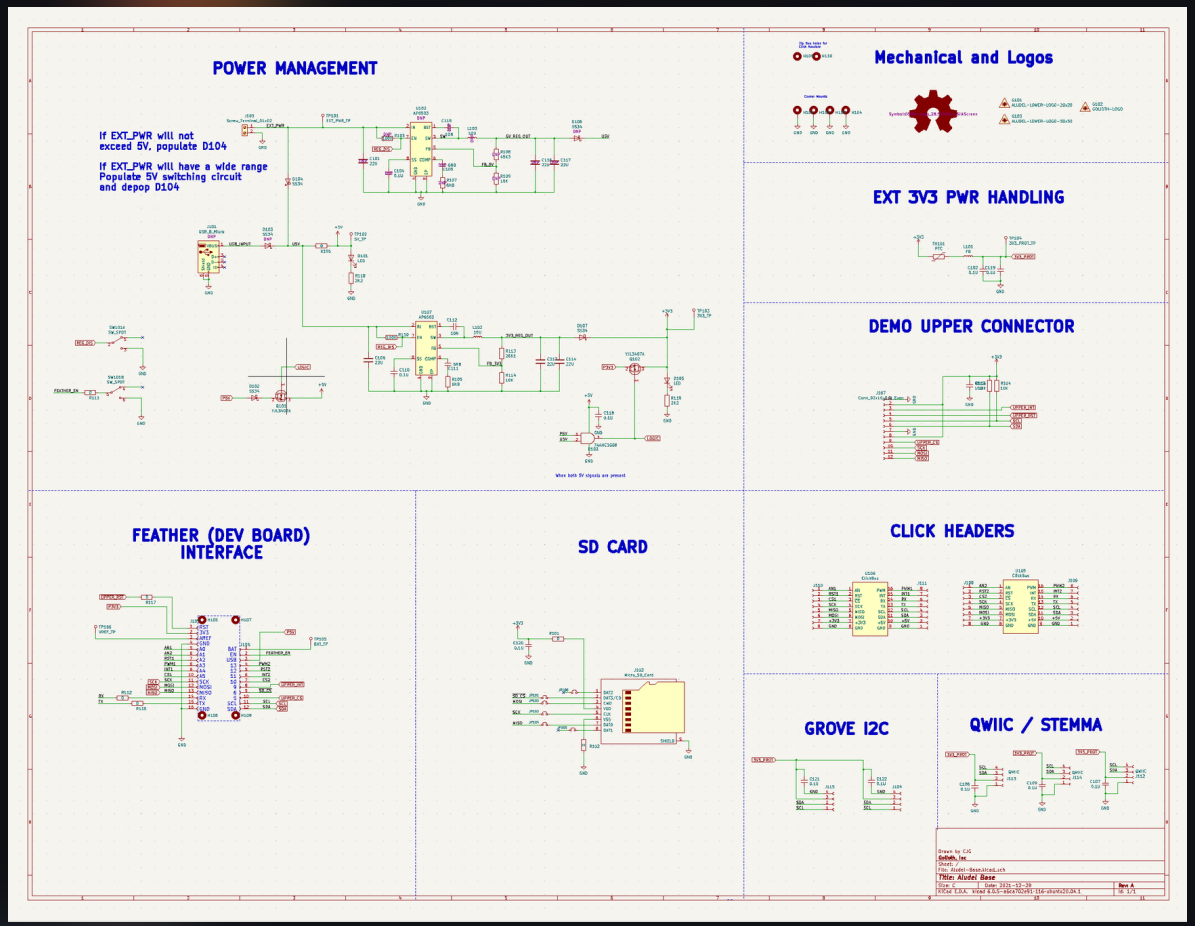
Design in the new sensor

(it's really really in-stock...right?)



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Problem: Manage different versions of FW with devices already in the field

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Organize your devices using a device management platform

- At Golioth we use a flat tagging system to organize different hardware versions.
- Great for targeting firmware updates.
- Understand what your device contains at a glance.

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Case Study 2:

Your Micro Is Out Of Stock

SparkFun Thing Plus - STM32

DEV-17712 ROHS

$32.50

Volume sales pricing

We do not currently have an estimate of when this product will be back in stock. **Notify Me**

Note: If this item is available for backorder it is subject to price changes at any

guarantee time frame for shipping or availability.

\- 1 +

BACKORDER

Quantity discounts available

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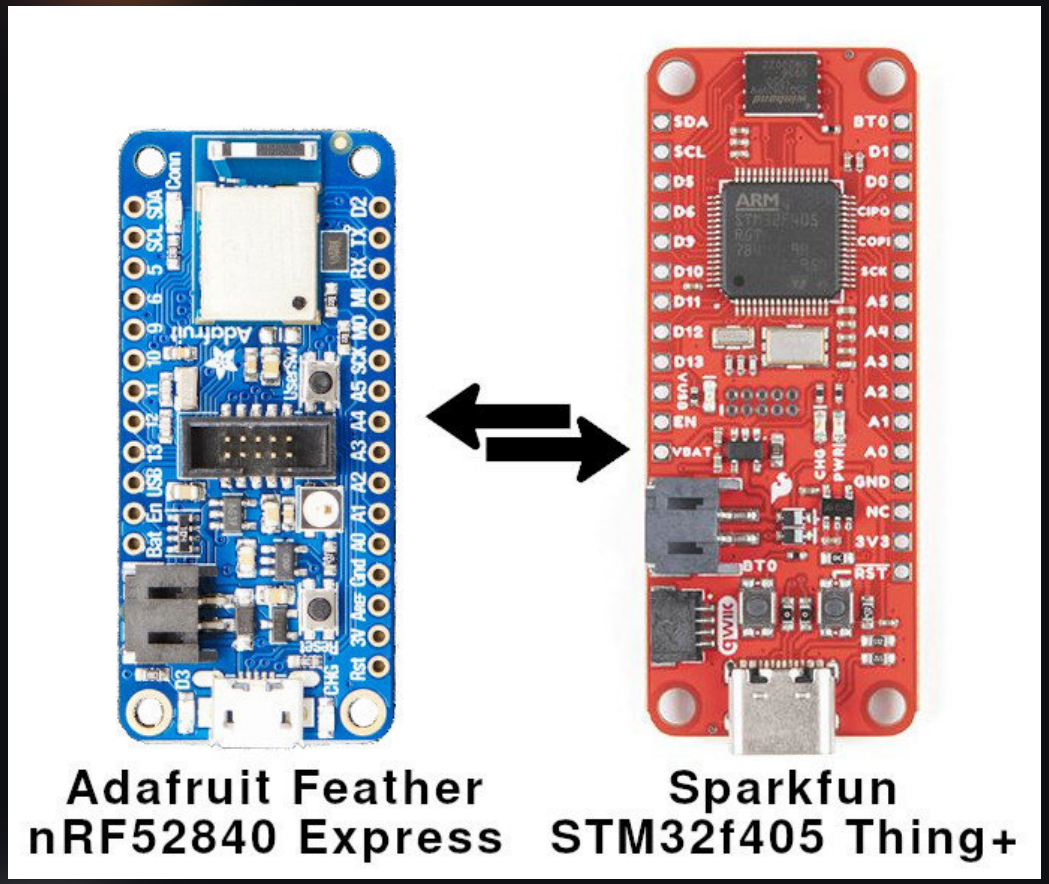
Switch out the Feather board



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If no Feather exists...

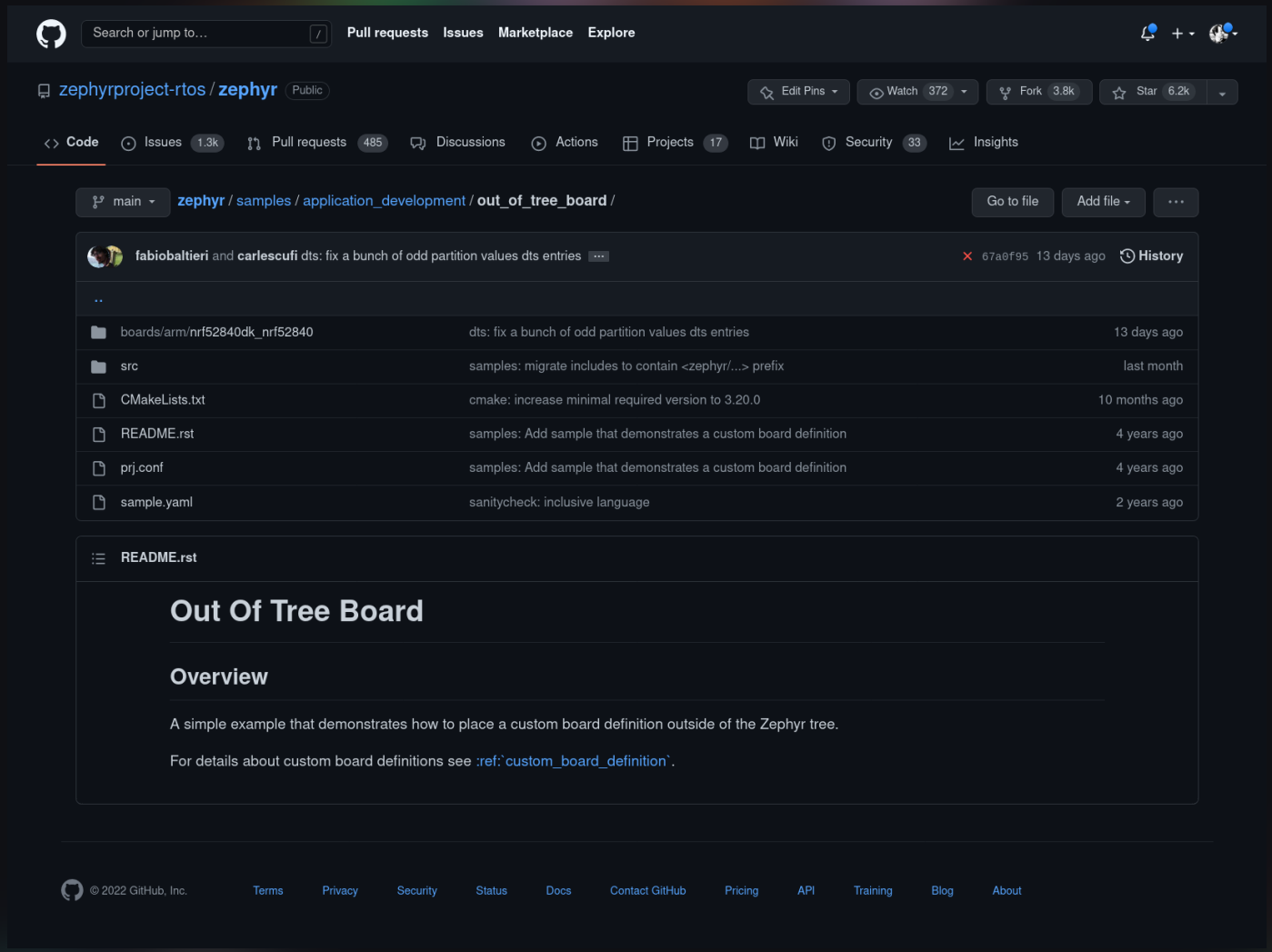
make one!

Switch out more of the code

If a similar board exists in the Zephyr tree:

- <yourboard>.conf - apply new board settings
- <yourboard>.overlay - map the pin functions
- prj.conf and main.c should not need to change

zephyr/samples/application_development/out_of_tree_board



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"But I'm not using the Aludel"

or

I'm making a single board product

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Most devices bound for production will be cost, space, and power optimized.

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Each of the interfaces on the Aludel represents a block on a finished product

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Your schematic/layout blocks can approximate these systems

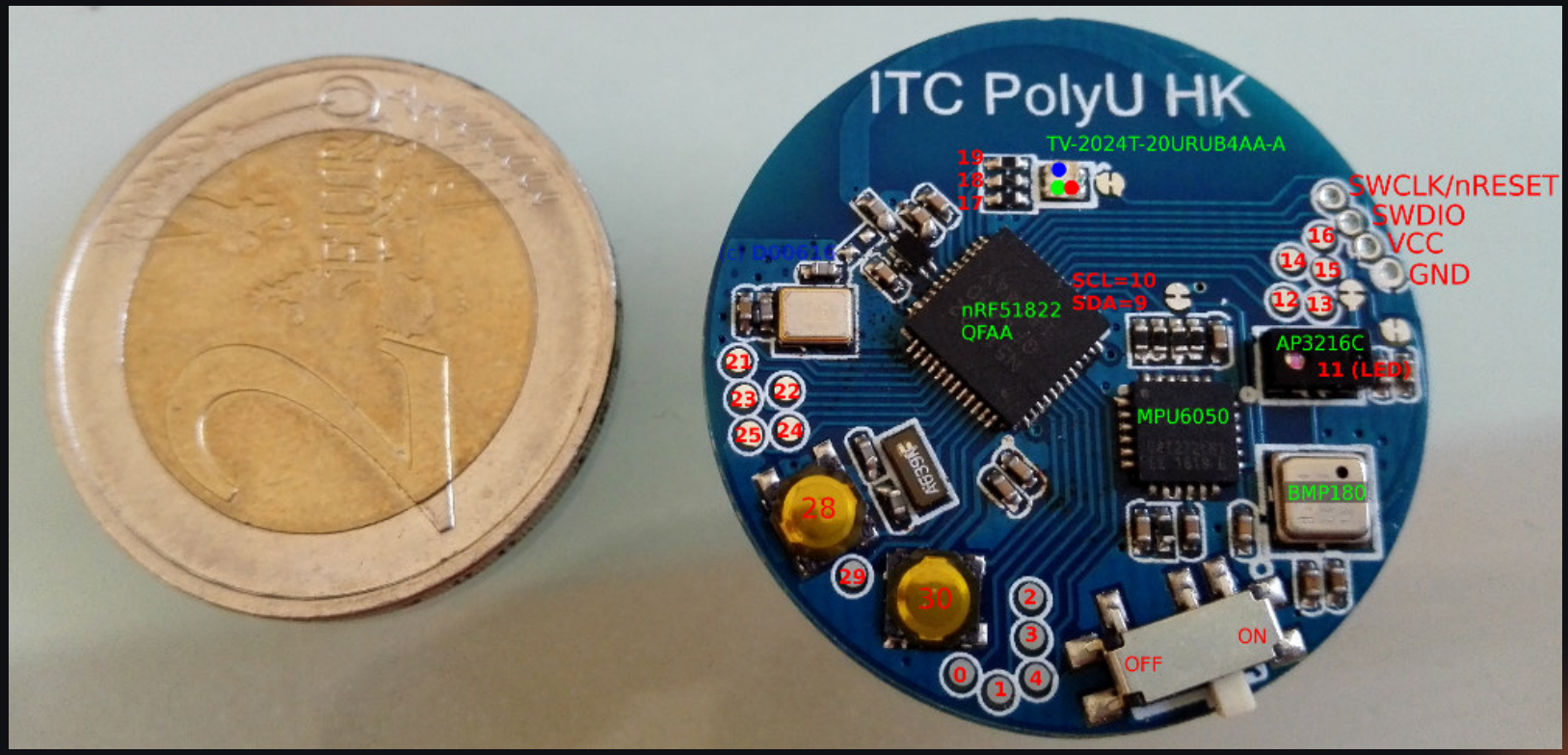

Image Source: https://bit.ly/3mkucGR

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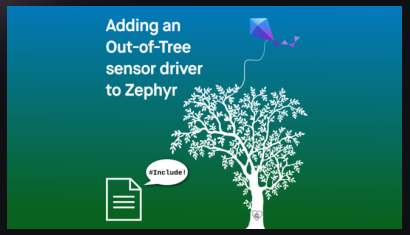
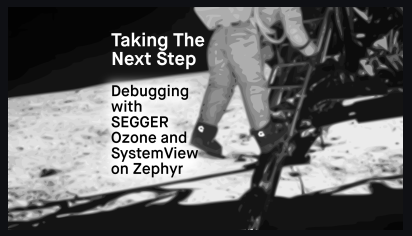
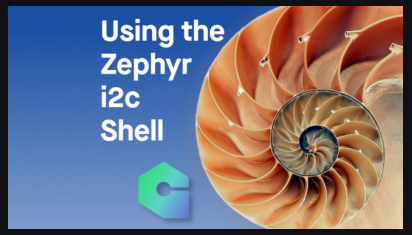
What have we learned?

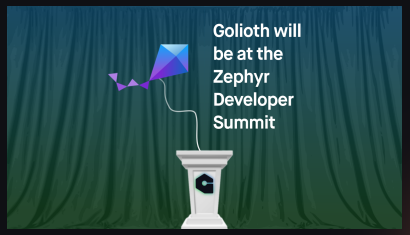
- Plan for the worst by designing in flexibility and modularity.
- Balance flexibility and modularity with the reality of your design constraints.
- Zephyr's abstracted interfaces allows HW and FW engineers to react to problems in the supply chain.

We write about Zephyr a LOT









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