Zephyr® Project

Developer Summit 2022

June 8-9, 2022

Mountain View, CA + Virtual

Laird CONNECTIVITY

Memfault

Design a scalable, maintainable low power LTE IoT Gateway

With Laird Connectivity, Memfault & Zephyr

Presented by:

Tyler Hoffman - Co-founder, Memfault

Andrew Ross – Senior Product Manager, Laird Connectivity

Designing a scalable, maintainable, low power LTE IoT gateway with Laird Connectivity, Memfault, and Zephyr

Tyler Hoffman - Co-founder, Memfault

Andrew Ross – Senior Product Manager, Laird Connectivity

Agenda

Introductions

Laird Connectivity Introduction

Gateway Applications

Memfault Introduction

Laird + Memfault Combined

Q&A

Introductions: Andrew Ross from Laird Connectivity

Andrew Ross, Senior Product Manager at Laird Connectivity, responsible for IoT Device and Module products offering Wi-Fi & Cellular solutions.

Andy is based in California, and has more than 20 years of experience in wireless technology, having spent time at Quatech, B+B SmartWorx, and Silex Technology before Laird Connectivity. He has led projects to develop IoT solutions with major partners such as Infineon (Cypress), GE, and Qualcomm over his career.

Andrew Ross
Senior Product Manager
Laird Connectivity

Introductions: Tyler Hoffman from Memfault

Tyler Hoffman
Co-founder
Memfault

Passion: developer tools and infrastructure for embedded engineers and companies

Previously a Firmware Engineer @ Pebble & Fitbit
Split time between writing firmware and building internal services to help monitor millions of devices

Now working at Memfault building tools for hardware companies

Can find my thoughts and content on Memfault's Interrupt blog (interrupt.memfault.com)

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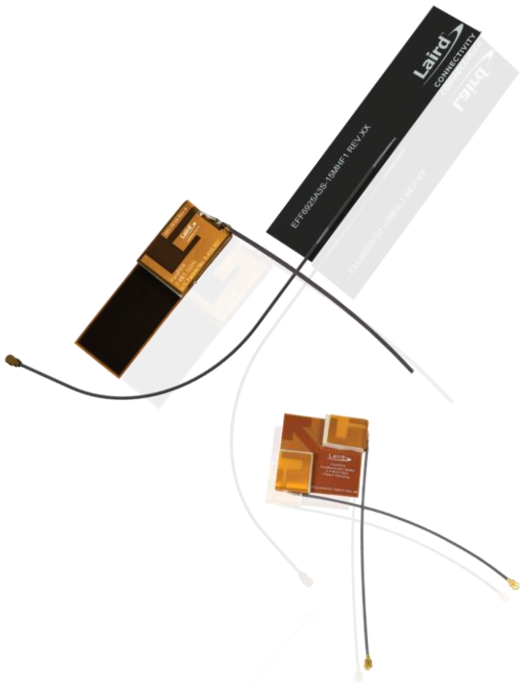
Laird simplifies Wireless Connectivity

Wireless Modules

IoT Devices

Internal Antennas



Sentrius™ MG1xx Micro-Gateway

Cloud Ready
Securely connect your wireless Bluetooth sensors over a low-power LTE connection to cloud services like Cumulocity IoT

NB-IoT LTE-M

LTE-M + NB-IoT
Latest 3GPP standards in a single SKU

Fully Integrated
SIM card, power management, and low-cost connector interface, all fully certified

Pre-integrated, low-cost embedded antennas with external options including Laird Connectivity's Revie LTE-M & NB-IoT antennas

Bluetooth 5 including LE Long Range

Bluetooth® 5

Embedded Memfault agent integrated into operational firmware.

Memfault

Embedded RTOS from Zephyr Project running on nRF52840 SoC

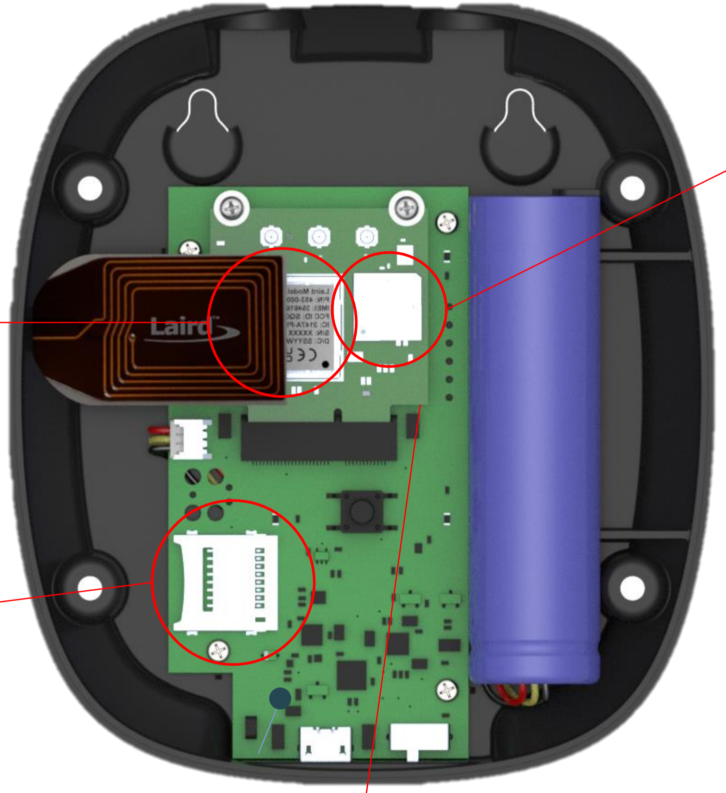
Memfault FC Industry Canada CE SIERRA WIRELESS NORDIC SEMICONDUCTOR altair semiconductor AT&T verizon Laird™ CONNECTIVITY

Sentrius MG100 Hardware Overview

Cost Optimized
Fully functional BT to Cellular micro-gateway, with development environment for customer applications.

LTE-M + NB-IoT
Latest 3GPP standards
using Sierra Wireless 7800 radio

Expansion
Supports integrated microSD card for data buffering



Long Range BT with Zephyr
Nordic nRF52840 SoC provides long range BLE connectivity and Gateway controller running Zephyr on Cortex M4 core.

Fully Integrated
- SIM card
- Antenna (Cellular, NFC)
- Micro-USB (Power & Debug)
- Power Switch
- Back-up Battery
- Power Management
- Status LED’s

Certified module core
Built around the Laird Connectivity Pinnacle 100 Cellular/BT module.

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Sentrius MG100 Hardware Overview

Processing Engine

Nordic nRF52840 SoC

- 64 MHz Cortex-M4 with FPU
- 1 MB Flash, 256 KB RAM
- 2.4 GHz Transceiver
- 2 Mbps, 1 Mbps, Long Range
- Bluetooth Low Energy, Bluetooth mesh
- ANT, 802.15.4, Thread, Zigbee
- +8 dBm TX Power
- 128-bit AES CCM, ARM CryptoCell
- UART, SPI, TWI, PDM, I2S, QSPI
- PWM
- 12-bit ADC
- NFC-A
- USB 2.0

nRF Connect SDK

nRF Connect SDK is a scalable and unified software development kit for building products based on all our nRF52, nRF53 and nRF91 Series wireless devices. It offers developers an extensible framework for building size-optimized software for memory-constrained devices as well as powerful and complex software for more advanced devices and applications. It integrates the **Zephyr RTOS** and a wide range of samples, application protocols, protocol stacks, libraries and hardware drivers.

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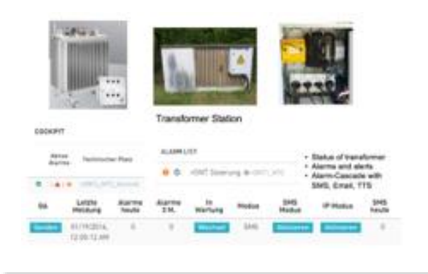
- Laird Connectivity Introduction
- **Gateway Applications**
- Memfault Introduction
- Laird + Memfault Combined
- Q&A

Use cases across verticals (illustrative)

Smart, connected products

Industrial IoT

Grid element monitoring

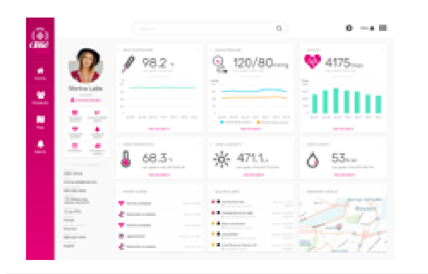


Utility metering

Sensing & observations

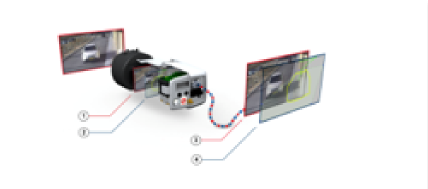
Conveyor in auto manufacturing

Patient monitoring



Logistics & asset tracking

Surveillance & security

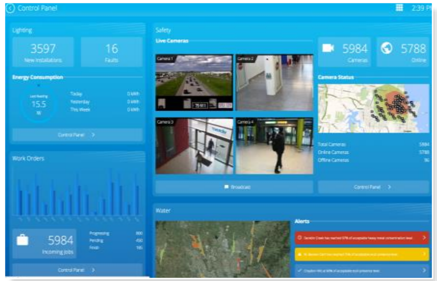


Metadata collection for people and vehicle counting & events

Medical equipment

Traffic monitoring / safety

Smart city



Retail / vending telemetry

Intelligent building

What's your business?

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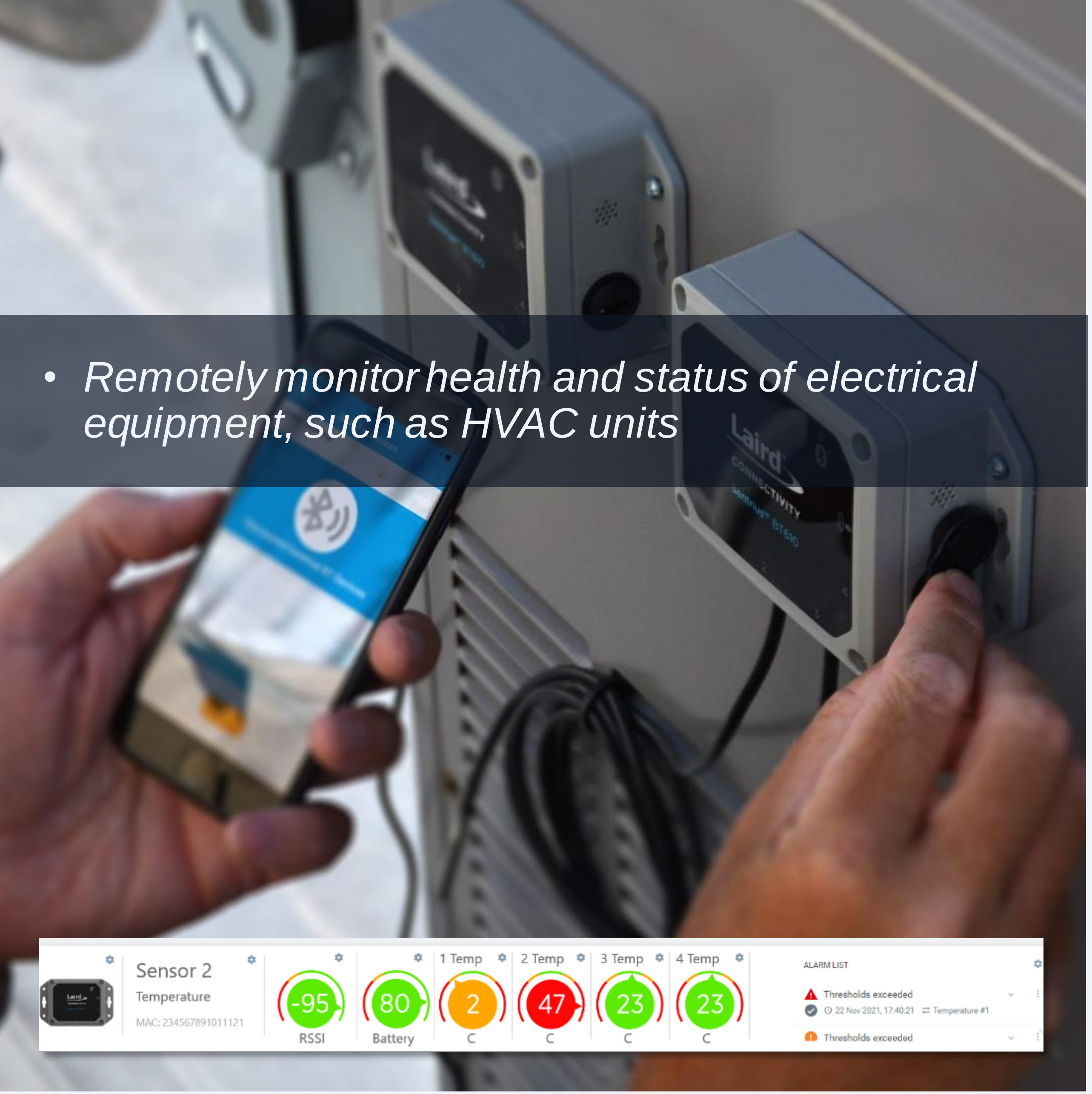
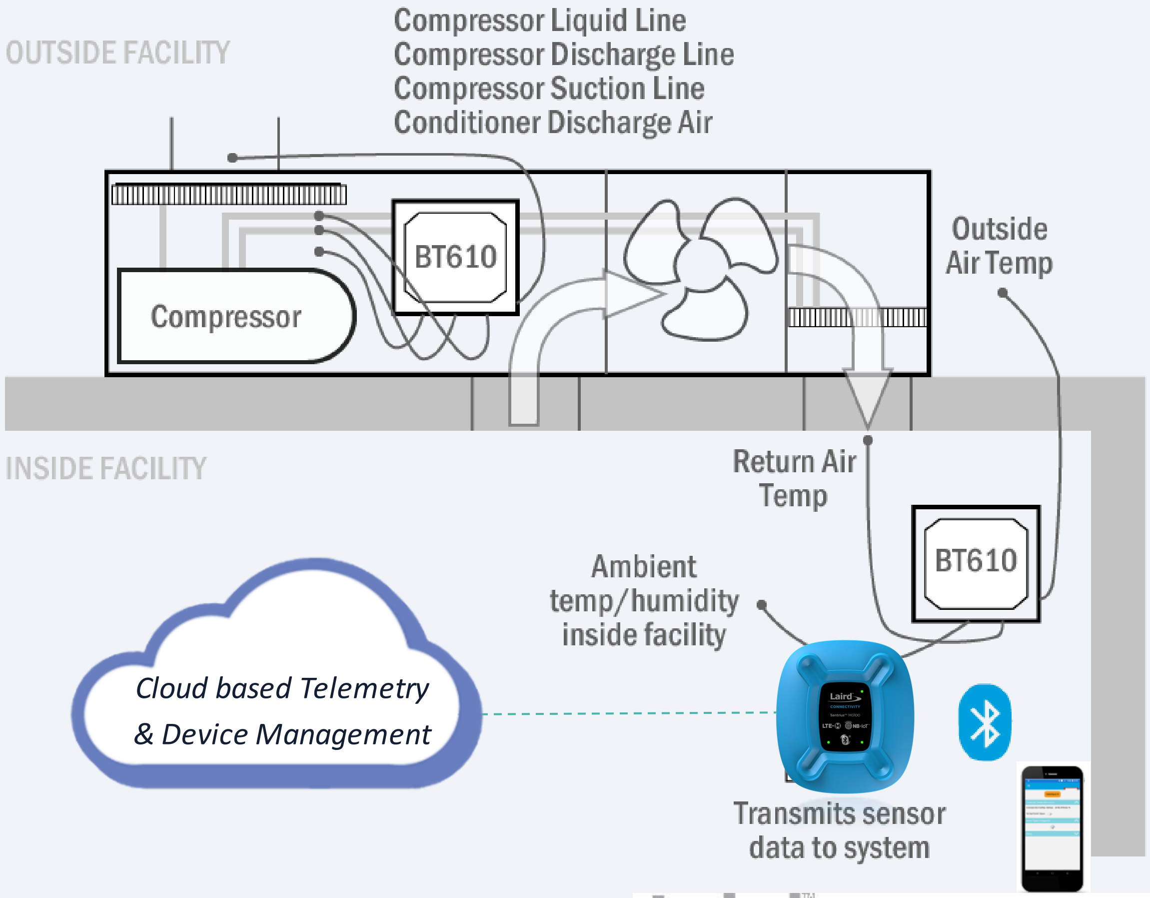
Use Case Example
HVAC Monitoring

Sentrius™ BT610 + Thermistors offers remote temperature monitoring with low response lag



- *Remotely monitor health and status of electrical equipment, such as HVAC units*



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The Easy Button: In Action

Not just selling it, living it!

Furnace
Temperature Monitoring

Water Heater
AC Current Sensing

Complete & Scalable IoT Solution

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Why remote debug?

Do you really need to be able to debug a device remotely?

- Simple answer – YES!
- Why did it make sense for Laird Connectivity and the MG100?
    - Low hardware cost solution drives cost of ownership focus toward similar model
        - Having on-site maintenance and debug does not fit with the product model
    - Laid Connectivity provides a premium support service
        - Not practical to have FAE team travel to remote locations
    - Scalability of solution means high volume deployments
        - Device management and remote telemetry solutions part of the total solution
        - Increases the need for remote (more efficient) solutions for maintenance and debug
- Memfault supported the nRF52840, running Zephyr and provided the functionality we needed to provide the product support we felt was required on the product
- Laird Connectivity initially implemented Memfault as a support tool on the product
- Customers saw the value and have subsequently taken the product support on themselves.

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Remote Debugging is critical

More and more happening outside of firmware

- Building a device is hard
- Scaling to 1000's of devices **is harder**
- Software & device-collected data is becoming more important
- Firmware engineers were not prepared for the complexity
- End up building, logging and monitoring infrastructure and scaling it to demand

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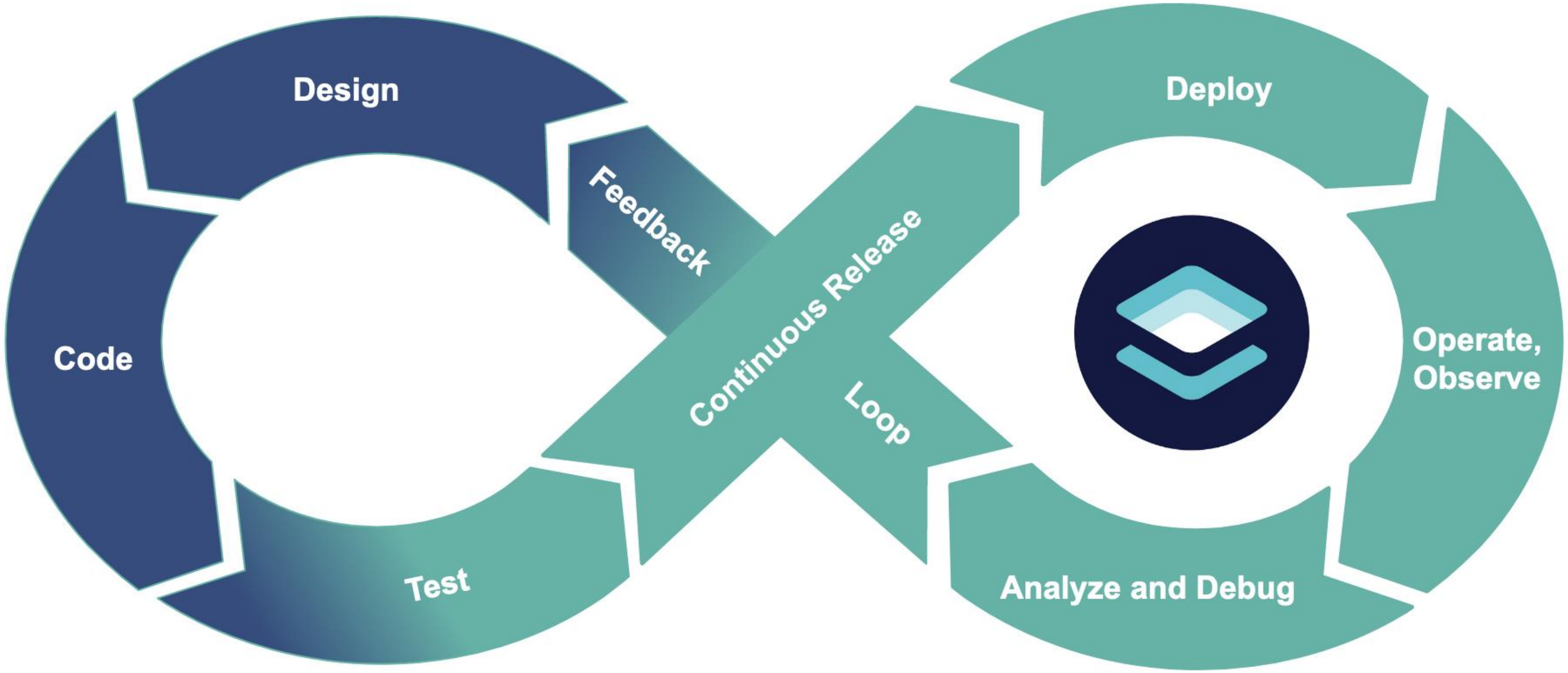
Help **Hardware Teams** Build Better **Software**



Memfault

- Works on any ARM or ESP32* MCUs with Zephyr OS
- C-SDK with connectivity agnostic data transport
- Simple drop-in integration for Zephyr

Remotely debug issues with coredumps, events and logs

Continuously monitor devices in production with metrics

Deploy OTA updates safely with staged rollouts and targeted device groups

Zephyr Panics

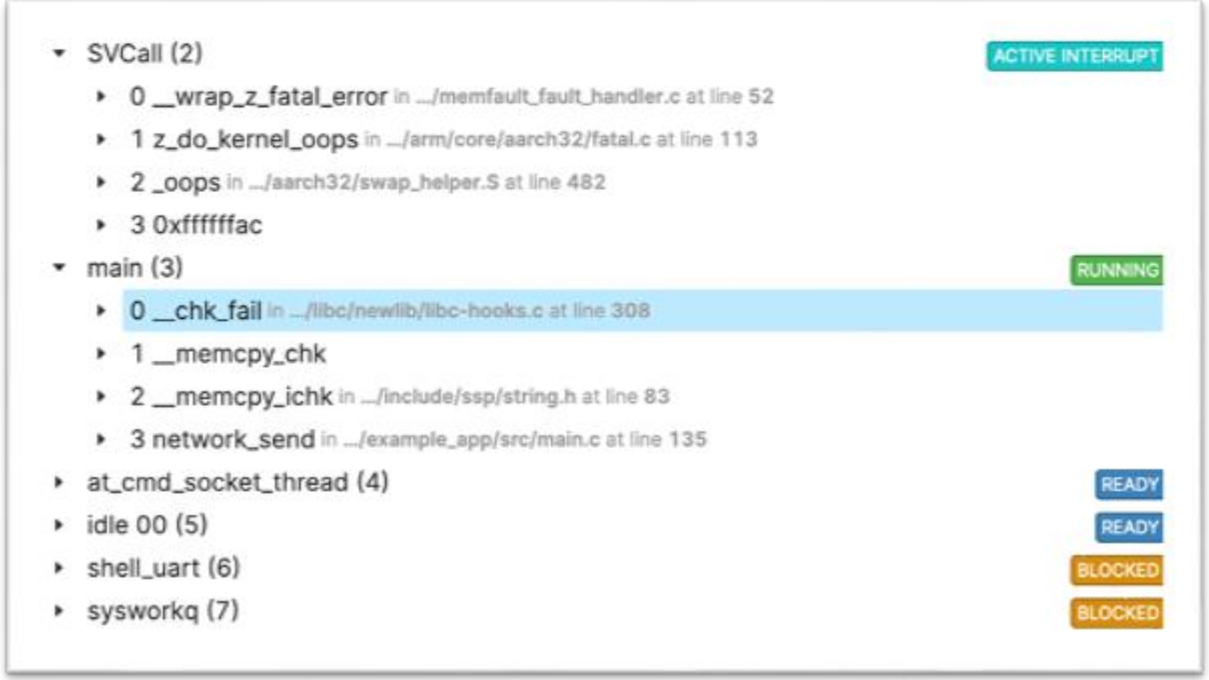
```
[00:26:12.826,782] <err> os: ***** BUS FAULT *****
[00:26:12.832,153] <err> os:   Instruction bus error
[00:26:12.837,738] <err> os: r0/a1:  0x00000001  r1/a2:  0x200150c1  r2/a3:  0x00000000
[00:26:12.846,343] <err> os: r3/a4:  0x0badcafe r12/ip:  0x00000001 r14/lr:  0x0001a6cb
[00:26:12.854,919] <err> os:  xpsr:  0x60000000
[00:26:12.860,107] <err> os: s[ 0]:  0x00000001  s[ 1]:  0x00000001  s[ 2]:  0x00000001  s[ 3]:  0x00000001
[00:26:12.870,422] <err> os: s[ 4]:  0x00000001  s[ 5]:  0x00000001  s[ 6]:  0x00000001  s[ 7]:  0x00000001
[00:26:12.880,737] <err> os: s[ 8]:  0x00000001  s[ 9]:  0x00000001  s[10]:  0x00000001  s[11]:  0x00000001
[00:26:12.891,052] <err> os: s[12]:  0x00000001  s[13]:  0x00000001  s[14]:  0x00000001  s[15]:  0x00000001
[00:26:12.901,367] <err> os: fpscr:  0x00000000
[00:26:12.906,524] <err> os: r4/v1:  0x00000001  r5/v2:  0x000135af  r6/v3:  0x2001abf8
[00:26:12.915,130] <err> os: r7/v4:  0x2001ac00  r8/v5:  0xfffffffc  r9/v6:  0x00000001
[00:26:12.923,736] <err> os: r10/v7: 0x00000001  r11/v8: 0x00029f38    psp:  0x2001ab38
[00:26:12.932,342] <err> os: EXC_RETURN: 0xffffffac
[00:26:12.937,835] <err> os: Faulting instruction address (r15/pc): 0x0badcafe
```

Memfault Hooks into Fault Handler

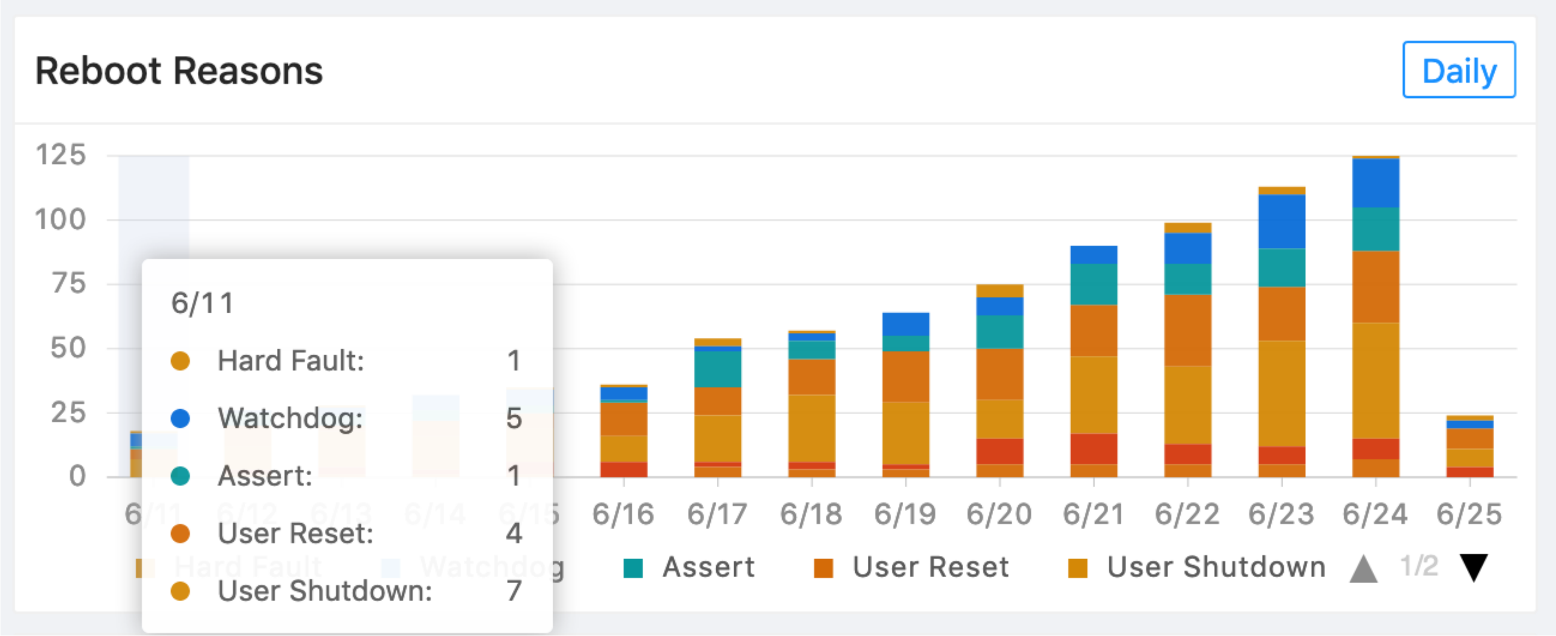
```c
// zephyr/arch/arm/core/aarch32/cortex_m/fault.c
void z_arm_fault(uint32_t msp, uint32_t psp, uint32_t exc_return,
    _callee_saved_t *callee_regs)
{
  // ...

}
```

Capture & Investigate Coredumps Remotely

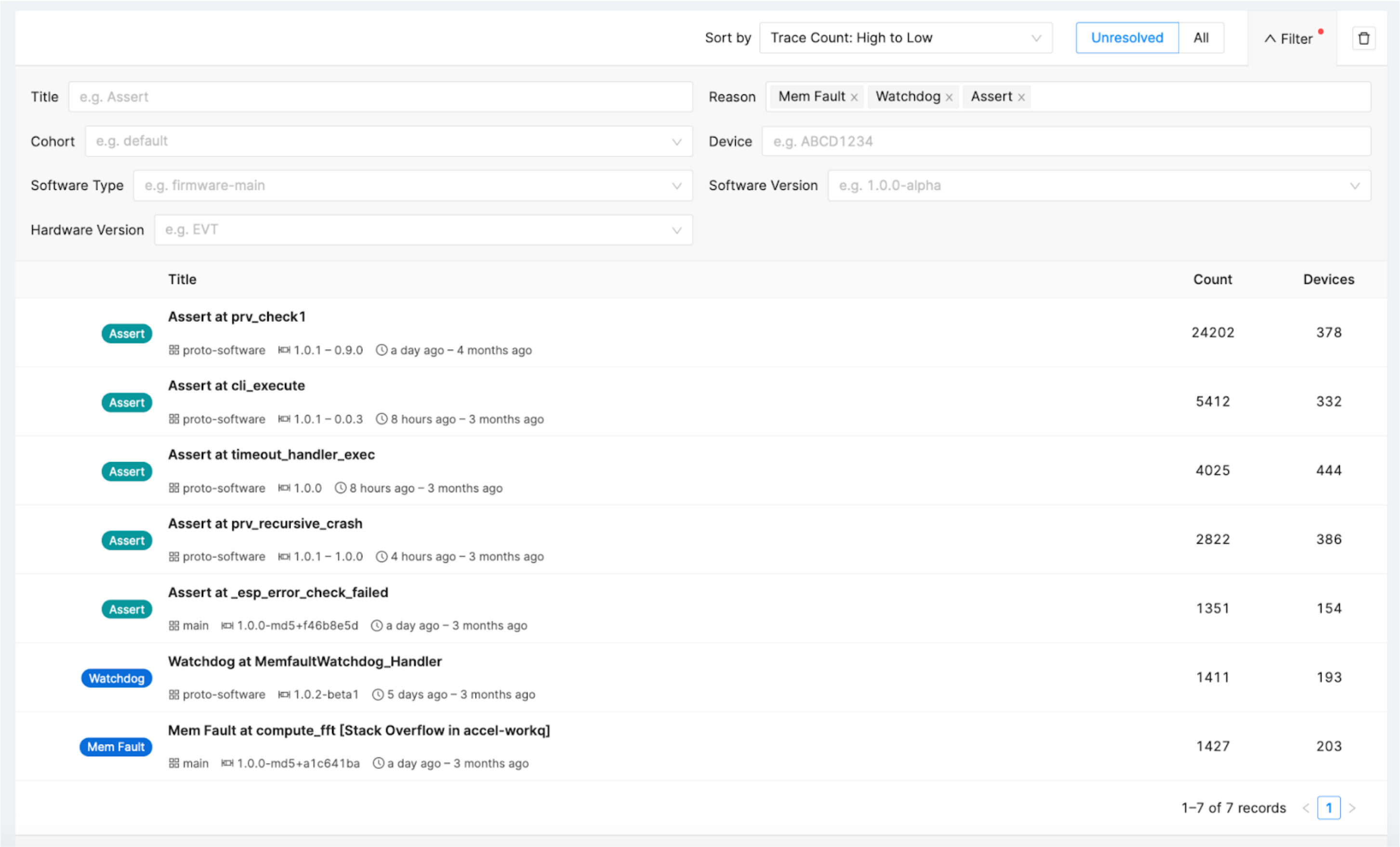


Tracking Reboot Reasons



One of the best indicators of fleet health

Issue Dashboard



Determine what is worth fixing easily

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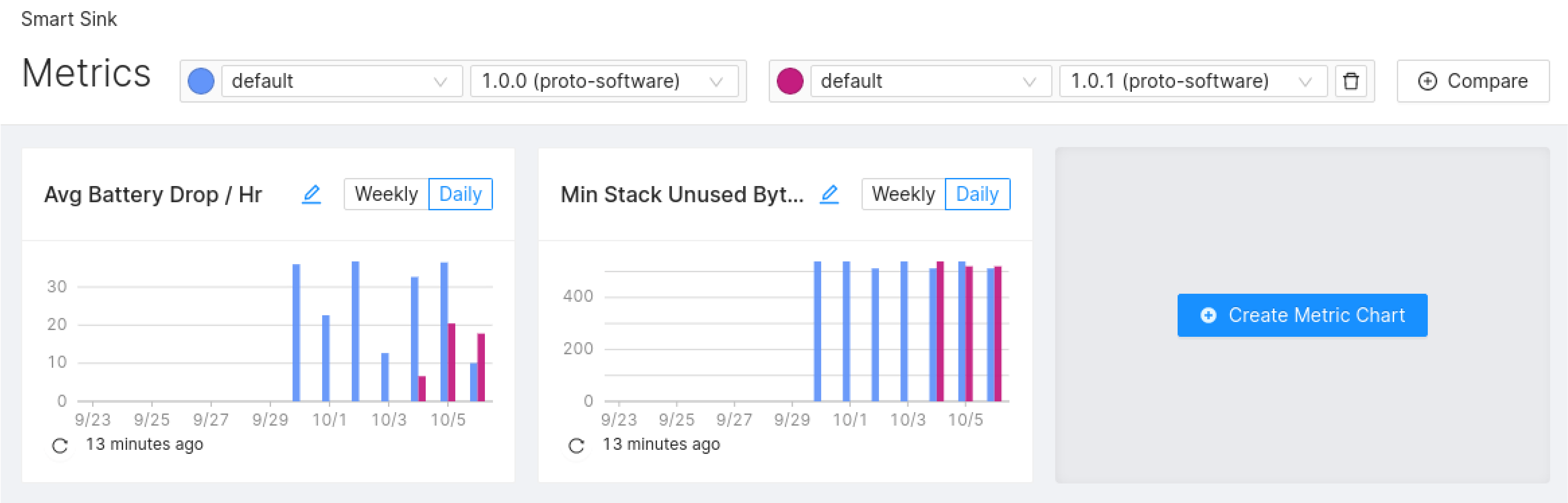
Firmware Metrics

- Not all issues result in crashes!
- Difficult to nearly impossible to debug
    - Poor battery life
    - Performance issues
    - Connectivity regressions
    - Hardware failures

- Many, many factors impact the above problems
    - CPU & task utilization
    - RF environment & location
    - Operating temperature and conditions
    - Data being transferred
    - Hardware silently degrading

We need to be able to measure then compare these metrics between devices and software versions and over time

Comparing Metrics by Firmware Version



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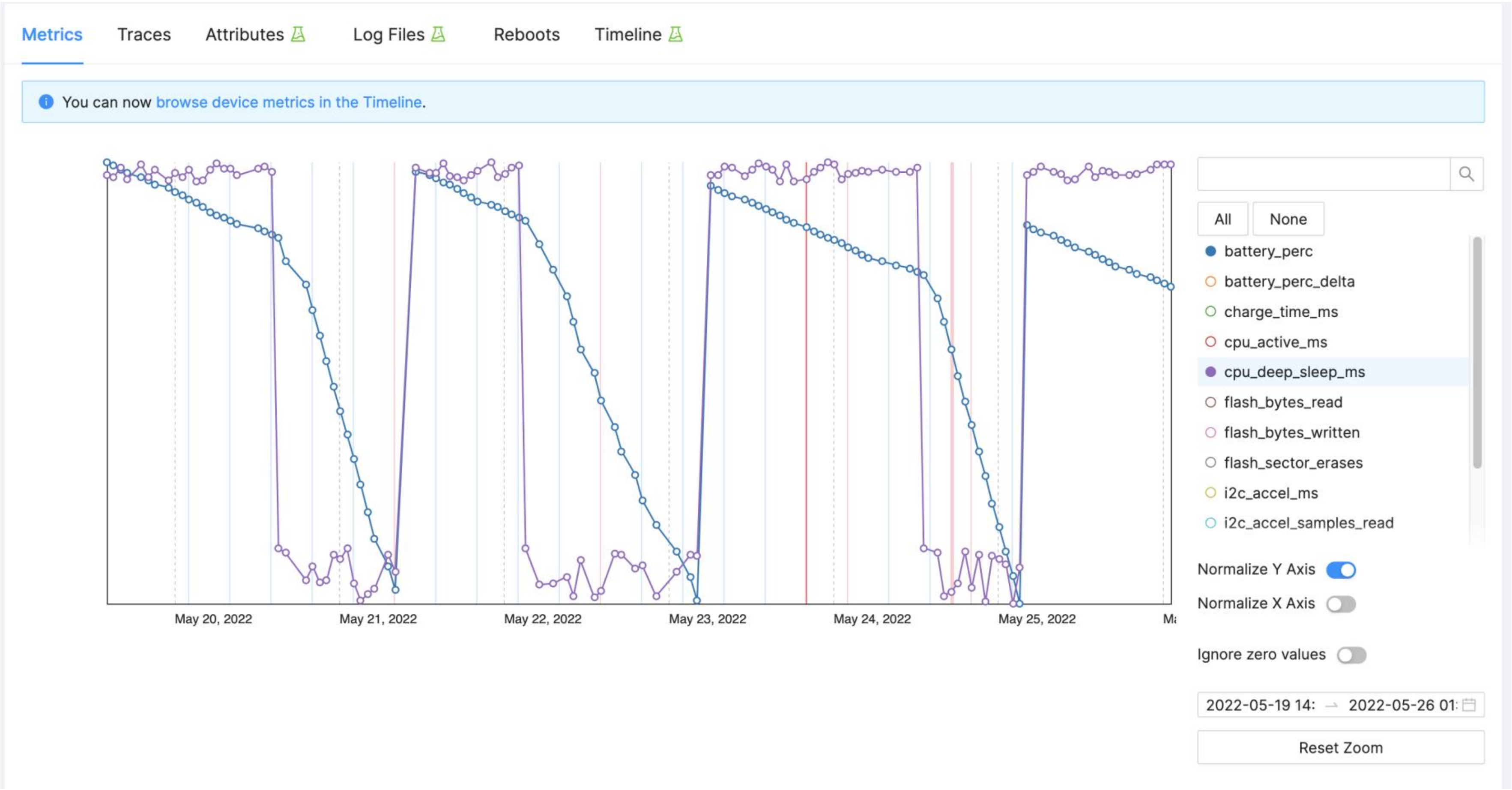
Comparing Metrics on a Device



Memfault Integration Hooks

Traces and Errors Device Behavior	Metrics Device Performance	Compact Logs Device Story	Delivery Releases
Hard Faults	CPU Utilization	Application	Rollout Control
Watchdogs	Battery Performance	System	Version Matrix
Stack Overflows	Heap Utilization	Peripheral	Adoption Rate
Memory Faults	Connectivity Statistics		Comparative Performance
Software Asserts	RTOS Statistics		Attributes
Connectivity Faults	Flash Statistics		
Bus Faults	Alerting		

Memfault Integration Specifics

west.yml

```
[ ... ]
    - name: memfault-firmware-sdk
      url: https://github.com/memfault/memfault-firmware-sdk
      path: modules/memfault-firmware-sdk
      revision: master
```

prj.conf

```
CONFIG_MEMFAULT=y
CONFIG_MEMFAULT_HTTP_ENABLE=
```

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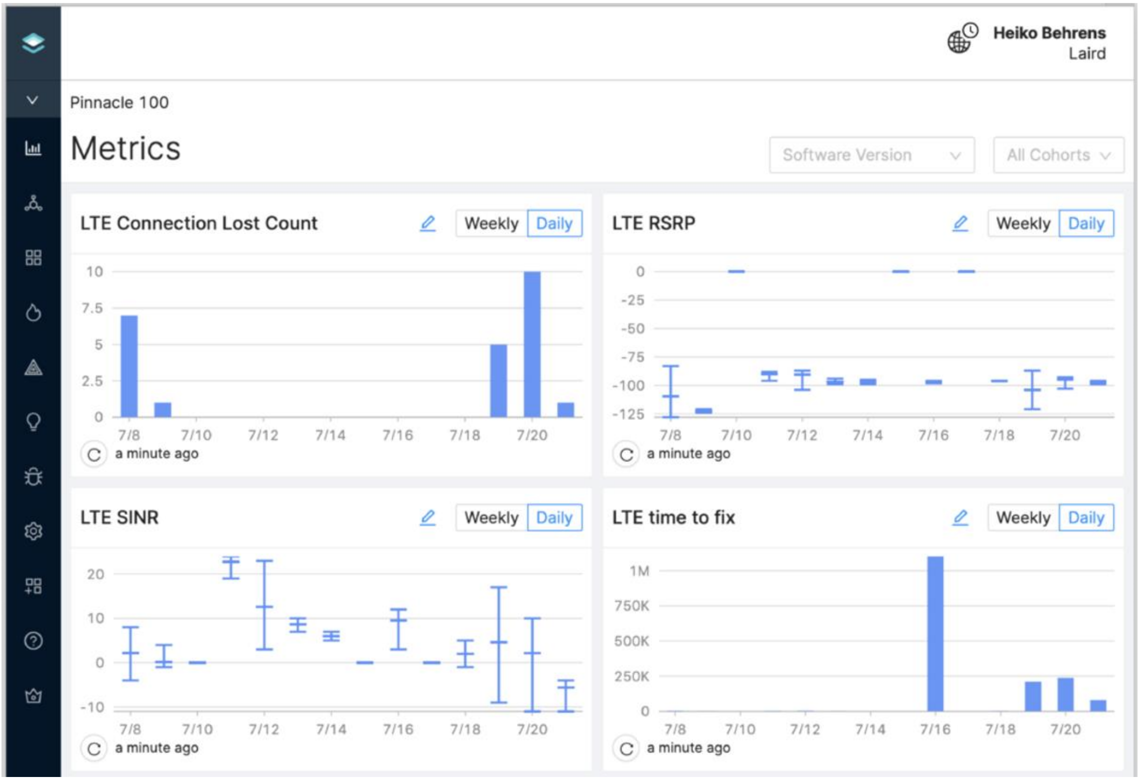
Memfault + Laird Integration

- Memfault included by default in Laird's platform
- Just add Memfault API key
- Coredump collection, device metrics, and OTA all integrated
- All Zephyr + Memfault features supported, as well as:
    - Default metric charts to track LTE performance
    - Integration improves with updates on both sides



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Laird + Memfault Success Story: Xylem

- Large, water treatment company
- Using the MG100 in part due to ease of use and long-range Bluetooth
- Wrote their own firmware on top of Laird's platform
- Saw Laird engineers using Memfault. Wanted it!
- Successfully using Memfault in internal trials to great success

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Q&A?

Come to our booth!

info@lairdconnect.com

hello@memfault.com