Zephyr Project:

Unlocking Innovation with an Open Source RTOS

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Zephyr Project

• **Open source** real time operating system
• **Vibrant Community** participation
• Built with **safety and security** in mind
• **Cross-architecture** with broad SoC and development board support.
• **Vendor Neutral** governance
• **Permissively** licensed - Apache 2.0
• **Complete**, fully integrated, highly configurable, **modular** for **flexibility**
• **Product** development ready using LTS includes security updates
• **Certification** ready with Auditable

Open Source, RTOS, Connected, Embedded
Fits where Linux is too big

Zephyr OS

- 3rd Party Libraries
- Application Services
- OS Services
- Kernel
- HAL

THE LINUX FOUNDATION PROJECTS
Products Running Zephyr Today

- Grush Gaming Toothbrush
- hereO Smartwatch
- Proglove
- Rigado IoT Gateway
- Distancer
- Ellcie-Healthy Smart Connected Eyewear
- Intellinium Safety Shoes
- GNARBOX 2.0 SSD
- Adero Tracking Devices
- Anicare Reindeer Tracker
- Sentrius
- GEPS
- Point Home Alarm
- RUUVI Node
- HereO Core Box
- Safety Pod
Zephyr Supported Hardware Architectures

- Cortex-M, Cortex-R & Cortex-A
- X86 & x86_64
- 32 & 64 bit
- Xtensa

Coming soon:
- SPARC
- OpenPOWER
Native Execution on a POSIX-compliant OS

- Build Zephyr as native Linux application
- Enable large scale simulation of network or Bluetooth tests without involving HW
- Improve test coverage of application layers
- Use any native tools available for debugging and profiling
- Develop GUI applications entirely on the desktop
- Optionally connect to real devices with TCP/IP, Bluetooth, and CAN
- Reduce requirements for HW test platforms during development
POSIX API on Zephyr

Provides familiar API to non-embedded programmers, especially to Linux developers

Enable re-use (portability) of existing libraries based on POSIX APIs

- Provides efficient subset appropriate for small (MCU) embedded systems
- POSIX API subset is increasingly popular operating system abstraction layer (OSAL) for IoT
- Supports subsets of PSE51, PSE52, and BSD sockets API

https://docs.zephyrproject.org/latest/guides/portability/posix.html
Board Support – 200+ and growing

<table>
<thead>
<tr>
<th>Board</th>
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<tbody>
<tr>
<td>Arduino Due</td>
<td>Nucleo 103RB</td>
<td>Adafruit Feather</td>
<td>Nucleo64 L476RG</td>
<td>Nucleo F411RE</td>
<td>NRF91 pca10090</td>
<td>Nucleo F334R8</td>
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<td>Minnowboard</td>
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<td>Nucleo 401RE</td>
<td>Vega Board</td>
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<td>STM3210c</td>
<td>Atmel SAM E70</td>
<td>NRF51</td>
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<td>NXP FRDM K64F</td>
<td>NRF52</td>
<td>Seed Carbon</td>
<td>TI Launchpad Wifi</td>
<td>BBC Microbit</td>
<td>STM32373c</td>
<td>Redbear BLE Nano</td>
<td>96b Neon Key</td>
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<td>STM32 Olimexino</td>
<td>STM Mini A15</td>
<td>Seeed Nitrogen</td>
<td>ARM V2M Beetle</td>
<td>Zedboard Pulpino</td>
<td>NXP FRDM-KW41Z</td>
<td>SiFive HiFive1</td>
<td>NXP LMX RT1050</td>
</tr>
</tbody>
</table>

http://docs.zephyrproject.org/boards/boards.html
Development Boards Shipping with Zephyr Today

- Nordic Thingy91
- Phytec Reel Board
- Icarus (Adafruit Feather) - Actinius
- Antmicro Badge
- Phytec Link Board BASE
- Electronuts Papyr
Architecture

- Highly Configurable, Highly Modular
- Cooperative and Preemptive Threading
- Memory and Resources are typically statically allocated
- Integrated device driver interface
- Memory Protection: Stack overflow protection, Kernel object and device driver permission tracking, Thread isolation
- Bluetooth® Low Energy (BLE 5.1) with both controller and host, BLE Mesh
- 802.15.4 OpenThread
- Native, fully featured and optimized networking stack

Fully featured OS allows developers to focus on the application
Native IP Stack

- Build from scratch for Zephyr
  - Using Zephyr native kernel concepts
- Dual mode IPv4/v6 stack
  - DHCP v4; IPv4 autoconf; IPv6 SLAAC; DNS; SNTP
- Multiple network interfaces support
- Time Sensitive Networking support
  - 802.1QAV API
  - 802.1AS (gPTP, generalized Precision Time Protocol)
- BSD Sockets-based API
  - TLS/DTLS supported via setsockopt call
  - RAW socket support for IP and non-IP traffic
- Supports IP offloading
  - Transparent for application using Socket API
- Compliance and security tested
  - >500 automated tests for TCP level using commercial products like IWL Maxwell Pro
Zephyr Networking Features

High-Level Protocols
- CoAP v1
- MQTT Client v3.1.1
- HTTP
  - As of Zephyr 2.0 server is implemented using CivetWEB library
  - Native HTTP client
  - Websocket client
- SOCKS5
- LWM2M
- Thread
  - Supported by OpenThread project

Supported technologies
- Ethernet
- Ethernet over USB
- WiFi with IP offload
- IEEE 802.15.4 with 6Lo
- Bluetooth LE with 6Lo
- CANbus with 6Lo
- PPP
Bluetooth Host and Mesh

- Bluetooth 5.1 compliant
- Low Energy & experimental Bluetooth Classic
- Multiple HCI transports
- Qualified (as of 1.14.1) for LE and Mesh
- Can be built separately or combined with the controller
- Active community developing upcoming standards
- Mesh & GATT reference stack in Bluetooth SIG training materials
Bluetooth Low Energy Controller

Second-generation open source BLE software Controller:

- Bluetooth 5.1 compliant and qualified (v1.14.1)
- Split design with Upper and Lower Link Layers
- Support for multiple BLE radio hardware architectures
  - Nordic nRF5 on Arm Cortex-M
  - VEGAboard on RISC-V
  - Proprietary radios (downstream only)
- Support for both Big and Little-Endian architectures
- Asynchronous handling of procedures in the ULL
- Enhanced radio utilization (99% on continuous 100ms scan)
- Latency resilience: Approx 100uS vs 10uS, 10x improvement over 1st gen
- CPU and power usage: About 20% improvement over 1st gen
- Multiple advertiser and scanner instances
Zephyr USB Device Stack

- Supports multiple MCU families (STM32, Kinetis, nRF, SAM, …)
- USB 2.0 support
- Full and High speed support
- Supported classes:
  - CDC ACM, ECM, EEM
  - RNDIS
  - HID
  - Mass Storage
  - Bluetooth
  - Device Firmware Update
- Tight integration with the RTOS
- Flexible descriptor instancing
- Native execution support for emulated development on Linux
- WebUSB support
Zephyr OS: Long Term Support (LTS - 1.14)

It is:
- Product Focused
- Current with latest Security Updates
- Compatible with New Hardware: We will make point releases throughout the development cycle to provide functional support for new hardware.
- Tested: Shorten the development window and extend the Beta cycle to allow for more testing and bug fixing
- Supported for 2 years

It is not:
- A Feature-Based Release: focus on hardening functionality of existing features, versus introducing new ones.
- Cutting Edge
Zephyr OS: Long Term Support (LTS - 1.14)

Delivering bug fixes and latest security updates!
An auditable code base will be established from a subset of the Zephyr OS LTS.

- Code bases will be kept in sync.
- More rigorous processes (necessary for certification) will be applied to the auditable code base.

Processes to achieve selected certification to be:

- Determined by Safety Committee and Security Committee
- Coordinated with Technical Steering Committee
Standards Under Consideration

Coding for Safety, Security, Portability and Reliability in Embedded Systems:
  • [MISRA C:2012](#), with [Amendment 1](#), following [MISRA C Compliance:2016](#) guidance
  • SEI CERT C and [JPL](#) (Jet Propulsion Laboratory California Institute of Technology) used as reference

Functional Safety:
  • [IEC 61508: 2010](#) (SIL 3 initially, eventually though like to get to SIL 4)
    • Broadest for robotics and autonomous vehicle engineering companies. Reference for other standards in Robotics domain.
    • [Sampled Certifications derived from IEC 61508](#): Medical: IEC 62304; Auto: ISO 26262; Railway: EN 50128

Others:
  • Medical: FDA 510(K), ISO 14971, IEC 60601; Industrial: UL 1998, ??
Building in Safety for LTS → Auditable


- Initial target was decided by Governing Board to be **IEC 61508** (it is a common basis for others standards that the members care about)

- Build on Coding Practices have been **documented** for the project to establish more general **Coding Guidelines**

- Following all Best Practices for **project quality** as defined by CII
  - [https://bestpractices.coreinfrastructure.org/projects/74](https://bestpractices.coreinfrastructure.org/projects/74)

- Leveraging Automation to **prevent regressions**:
  - Weekly Coverity Scans to detect bad practices in imported code
  - MISRA scans being incorporated, to evolve to conformance and address issues.
  - Looking for open source as well as commercial tooling to help here.
Zephyr OS: Development

• **Quality** is a mandatory expectation for software across the industry.

• Assumptions:
  • Software Quality is enforced across Zephyr project members
  • Compliance to internal quality processes is expected.

• **Software Quality** is not an additional requirement caused by functional safety standards.

• Functional safety considers Quality as an existing pre-condition.
Zephyr OS: Initial Certification Focus

Scope will be extended to include additional components as determined by the safety committee.

Some of the modules under consideration for the next iteration include: POSIX, Crypto, IPC, Flash, etc.
System Configurations

Safety and security can apply to all these configurations
Zephyr Project Roadmap

LTS 1
- User-space and Memory Protection Support
- Logging and Shell infrastructure
- Timer and Tick-less overhaul
- BSD Socket based networking

2019
- MISRA-C Compliance
- Commercial Compiler Support and IDE Integration
- Multi Core / SMP
- Bluetooth® Split Link Layer
- Advanced Power Management

2020
- E2E Cloud Integration
- Sound/Audio Capabilities
- Next Gen Bluetooth Technologies
- Quality Standards Compliance
- Certifiable Code Base

2021
- Functional Safety Certification
- Security Certification

Accelerated Path
- Functional Safety Certification
- Quality Standards Compliance
Secure Coding Practices have been documented for project.
Zephyr Project registered as a CVE Numbering Authority with MITRE.
Security Working Group has vulnerability response criteria publicly documented
  - addressed weaknesses and vulnerabilities already
“Gold” Best Practices for projects as defined by CII
  - https://bestpractices.coreinfrastructure.org/projects/74
Leveraging Automation to prevent regressions:
  - Weekly Coverity Scans to detect bad practices in imported code
  - MISRA scans being incorporated, to evolve to conformance and address issues.
Vulnerability Alert Registry

● For Embargo to work, product makers need to be notified early so they can remediate

● Created [Vulnerability Registry](#) for vendors to register to receive these alerts for free

● Goal: Zephyr to fix issues within 30 days to give vendors 60 days before publication of vulnerability
Aims: Crypto Drivers

- Same API for different implementations
  - Provided by hardware
    - Atmel ATAES132A
  - Provided by software
    - TinyCrypt small footprint
    - mbed TLS feature-rich
Aims: FIPS 140-2/3

- Common for “cryptographic modules”
- Generally, certifies products
- But certification of auditable helps that process
- Focus is on crypto operations
Aims: Secure Boot

Today:
• MCUboot supported by Zephyr
  • Bootloader with revertible upgrades
  • Signed images against public key in ROM
  • Used by TF-M as part of story

Future:
• Upgrade story
• SUIT
Zephyr Ecosystem

Zephyr OS
- The kernel and HAL
- OS Services such as IPC, Logging, file systems, crypto
- SDK, west, tools and development environment
- Additional middleware and features
- Device Management and Bootloader

Zephyr Project
- Scheduler
- Kernel objects and services
- Low-level architecture and board support
- Power management hooks and low level interfaces to hardware
- Platform specific drivers
- Generic implementation of I/O APIs
- File systems, Logging, Debugging and IPC
- Cryptography Services
- Networking and Connectivity
- Device Management

Zephyr Community
- 3rd Party modules and libraries
- Support for Zephyr in 3rd party projects, for example: micro-ROS, Tensorflow LITE, Micropython, Jerryscript
- High Level APIs
- Access to standardized data models
- High Level networking protocols
Zephyr Project Governance

**Goal:** Separate business decisions from meritocracy, technical decisions

### Governing Board
- Decides project goals and strategic objectives
- Makes business, marketing and legal decisions
- Prioritizes investments and oversees budget
- Oversees marketing such as PR/AR, branding, others
- Identifies member requirements

### Technical Steering Committee
- Serves as the highest technical decision body consisting of project maintainers and voting members
- Sets technical direction for the project
- Coordinates X-community collaboration
  - Sets up new projects
  - Coordinates releases
  - Enforces development processes
  - Moderates working groups
- Oversees relationships with other relevant projects

### Community
- Code base open to all contributors, need not be a member to contribute.
- Path to committer and maintainer status through peer assessed merit of contributions and code reviews
- Ecosystem enablement

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**Governing Board**
- Financial & Policy Oversight
- Marketing Oversight
- Safety Oversight
- Security Oversight
- Kernel & Subsystem Maintainers

**Technical Steering Committee**
- Security Architect
- Safety Architect
- Architecture Maintainers

**Contributors**
- Individual Contributor
- Member Organizations
- Supporting Organizations

**Community**
- Kernel & Subsystem Maintainers
- Security Oversight
- Safety Oversight
- Individual Contributor
- Architect Maintainers
- Security Architect
- Safety Architect
- Architecture Maintainers
- Member Organizations
- Supporting Organizations
- Others

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**Architect**
- Security
- Safety

**Contributors**
- Individual Contributor
- Member Organizations
- Supporting Organizations
- Others

**Governing Board**
- Financial & Policy Oversight
- Marketing Oversight
- Safety Oversight
- Security Oversight
- Kernel & Subsystem Maintainers

**Technical Steering Committee**
- Security Architect
- Safety Architect
- Architecture Maintainers

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**Goal:** Separate business decisions from meritocracy, technical decisions

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# Zephyr in RTOS Landscape 2020/07/24

## Total Contributors

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<tr>
<th>Rank</th>
<th>RTOS</th>
<th>#</th>
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<tbody>
<tr>
<td>1</td>
<td>Zephyr</td>
<td>726</td>
</tr>
<tr>
<td>2</td>
<td>mbed OS</td>
<td>605</td>
</tr>
<tr>
<td>3</td>
<td>RT-Thread</td>
<td>284</td>
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## Total Commits

<table>
<thead>
<tr>
<th>Rank</th>
<th>RTOS</th>
<th>#</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Zephyr</td>
<td>42,557</td>
</tr>
<tr>
<td>2</td>
<td>nuttX</td>
<td>37,798</td>
</tr>
<tr>
<td>3</td>
<td>RIOT</td>
<td>30,552</td>
</tr>
</tbody>
</table>
Upstream Commits in Last Year

- 10,000+
- 5000+
- 2000+
- 500+
- >50

Logos of various operating systems and platforms: Zephyr, RIOT, Amazon FreeRTOS, RT-Thread, TinyOS, MBED OS, TIZEN RT, AliOS Things, mynewt, freeRTOS, Contiki NG, Contiki.
2 weeks of traffic to github.com/zephyr code repository as of 2020/06/23
Growing a Diverse Community!

Lifetime project participation

- **Authors**
  - 2016/2: 80
  - 2020/7: 726

- **Commits**
  - 2016/2: 2,806
  - 2020/7: 42,557

- **Boards**
  - 2016/2: 4
  - 2020/7: 200+

Company Participation over the last 12 months
Zephyr.org Web Traffic in Last Year
Vibrant, Active & Global Community

> 4300 Followers on Twitter

> 1500 Active on Slack

> 325 Members in WeChat Group
Zephyr Participation Information

Orientation:
  • https://www.zephyrproject.org/developer-resources/#how-to-contribute
  • https://docs.zephyrproject.org/latest/contribute/index.html

Github:
  • https://github.com/zephyrproject-rtos/zephyr

Mail Lists:
  • https://lists.zephyrproject.org/g/main

Slack:
  • https://tinyurl.com/y5glwylp
Member Information

Why Become a Member?

• Industry Leadership
• Fast track to Technical Steering Committee Participation
• Help shape the Zephyr Certification Program
• Marketing Opportunities
• Member Networking Opportunities within the Zephyr Project
• Learning and Engagement

Join Today:
https://www.zephyrproject.org/become-a-member/

<table>
<thead>
<tr>
<th>Meeting Schedule</th>
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<tbody>
<tr>
<td>Technical Steering Committee</td>
<td>Weekly, Wednesdays</td>
</tr>
<tr>
<td>Marketing Committee</td>
<td>Bi-weekly, Mondays</td>
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<tr>
<td>Security Committee</td>
<td>Bi-Weekly, Thursday (members only)</td>
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<tr>
<td>Safety Committee</td>
<td>Bi-Weekly, Tuesday (members only)</td>
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<tr>
<td>Governing Board</td>
<td>Monthly (Platinum members only)</td>
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