

The Civil Infrastructure Platform



— CIVIL —
INFRASTRUCTURE
— PLATFORM —

Overview

Civil infrastructure systems are the very heart of modern societies: Technical systems are ubiquitously responsible for supervision, control, and management of infrastructure that supports human activities such as:

- Electric power generation and transport, oil and gas distribution
- Water and wastewater management
- Communications and transportation systems
- Healthcare infrastructure and devices
- Collections of buildings that make up urban and rural communities



These networks deliver essential services, provide shelter and support social interactions and economic development. As requirements for reliability, connectivity and feature-richness increase, the amount of software needed to implement and maintain such systems has grown to unprecedented levels.

Linux plays a key role in such endeavors. In contrast to more consumer-oriented embedded appliances where Linux and the associated ecosystem are firmly established as the primary choice, civil infrastructure systems provide unique challenges in terms of safety, security and reliability requirements, or long-term availability for multiple decades. The Civil Infrastructure Platform (CIP) Project, hosted by The Linux Foundation, is driven by some of the world's most innovative industry leaders such as Codethink, Cybertrust, Hitachi, Moxa, Plat'Home, Renesas, Siemens and Toshiba. Together, CIP project members work together to develop a base layer – a set of industrial grade core open source software components, tools and methods to create Linux-based embedded systems that meet the safety, reliability and other requirements of modern societal infrastructure.

Motivation

CIP is part of a natural progression of the open source trend in many industries that turns passive software consumers into active contributors, boosting the outcome that those involved in the initiative get through open collaboration: Software-intensive, complex base systems that do not create differentiating value for products, yet need to be provided by each and every manufacturer, are jointly developed, extended and maintained. The results of this collaborative development are provided as open source software (OSS). Within CIP, special focus is given to two particular items:

- Providing a basis for the implementation of safety-critical systems using standard Linux components whenever possible.
- Delivering super long-term support (envisioned duration: 15+ years) of selected versions of the Linux kernels and the most crucial system components and tools.

Of course, these very ambitious goals can only be fully realized if many companies and organizations join the effort!

Besides taking care of the key focus points, CIP believes that the following factors are essential to ensure the success of the initiative.

1. Collaboration

Participants share development efforts around those components that have become a commodity part of any Linux-based layer used in the industry in order to:

- Improve the quality and reliability of the components.
- Share and distribute maintenance costs.
- Collaborate with industries with similar needs.

By sharing development efforts, CIP members can focus more effort on differentiation factors, and can create products with overall improved quality, functionality and reliability.

2. Work closely with the upstream community

Learning from those who actually develop, and participating in the development of code is the best way to:

- Reduce the learning curve to widely adopt Linux-based systems internally.
- Become successful contributors to projects considered key by members and influence them according to what the industrial needs are for end-user centric projects.
- Learn from other industries, organizations and developers how common problems have been solved before and how to face new ones in the future.

3. Contribute back

CIP understands that open source thrives on a proper balance of giving and taking. Contributing back to the ecosystem is not only an essential aspect of being a good open source citizen, but has been long known to make sense from a business perspective. Our main motivation for contributing back to the open source community is to fuel the outcome of our investment:

- Sharing code knowledge, experiences and costs to ensure the sustainability of open source, not just as an ecosystem and development model but also as a viable product base for the civil (social) infrastructure industry.
- Influencing key players to make a difference in essential industrial grade areas like testing, safety critical features and security practices.

Base Layer Requirements

While CIP intends to utilize the existing Linux ecosystem as far as possible, several requirements are unique to the considered fields and do usually not play any substantial role in consumer or server products. CIP will ensure these requirements are met by extending and modifying the kernel and other crucial base layer components, of course always in discussion with the individual communities. The following two salient needs distinguish civil infrastructure projects from most other applications:

Industrial Grade

A bug in a mobile phone that unexpectedly quits a phone call or requires a reboot is a nuisance to the user. A similar bug in a brake control system, a signal-box or a light-signalling system can cause severe harm to people, including loss of lives. CIP thus needs to ensure that its base layer is of the highest industrial quality, which necessitates:

- **Reliability:** Uninterrupted operation over very extended periods of time is the rule, not the exception.
- **Functional safety:** Civil Infrastructure systems are often cyber-physical in that they interact with the external world, sometimes using very heavy machinery. The platform must provide an appropriate basis so that higher layers can ensure that people will not be harmed. This is only possible when the base components are combined into appropriate software architectures.
- **Security:** The increasing use of IT technologies in industrial systems, together with a strong trend towards more and more connectivity in IoT components, increases the possible attack surfaces for criminals. Ensuring reliability and safety is of course only possible when systems cannot be tampered with by unauthorised third parties. Information security, system hardening, identification of relevant fixes, backporting of these fixes, and sound mechanisms to distribute security updates to systems that may be deployed in the harshest and most unusual conditions are therefore among the core concerns of CIP.
- **Real-time capabilities:** Automation and control tasks appear abundantly in industrial settings, and deterministic response times are often required in this context. Since there are already multiple approaches of how to extend Linux with real-time capabilities, CIP will not develop individual solutions, but will ensure cooperation with or provide sponsorship for the respective projects. In particular, CIP is a sponsor of the Linux Foundations Real-Time Linux initiative that will establish real-time extensions in standard Linux kernels.

Sustainability

Infrastructure products face product life-cycles of 10 to 60 years. Software components also need to keep up with such life-cycles. The CIP project helps to build sustainable systems at sustainable costs with the following means:

- Reduce overall development costs by:
 - Enabling short development cycles using state-of-the-art approaches established by OSS communities.
 - Using solid and tested generic open source components.
- Make maintenance costs predictable (and small) by minimising the number of regression problems by extensive, central testing and by providing components prepared for further certification.

- Provide a solid, conservative update strategy: Give advice on when firmware updates are unavoidable, and provide software architectures that prevent the need for constant updates as much as possible. Consider security not just by backporting security patches or by reducing the attack surface of the CIP system, but by directly embedding security considerations at process and design levels.

To achieve these goals in a long-term sustainable way, the CIP project cooperates closely with the Debian LTS effort, which aims to extend the lifetime of all Debian stable releases to more than 5 years. CIP's support will maximize interoperability, security and LTS for open source software for embedded systems within Debian.

Platform

CIP aims to build and maintain a pre-production base layer—CIP Core—of industrial quality that all members can share to implement commercial products. Building a civil infrastructure platform requires more than just a kernel. It also requires:

- Key software components: Linux kernel, bootloader, shell, utilities and key libraries are included in the CIP base layer and will be provided with appropriate updates and backports over the platform's lifetime. Real-Time capabilities are important to the project, so we work closely with the Preempt-RT community, and maintain a CIP version of the real-time patch set.

A newly established group of maintainers, assisted by key Linux kernel developers, ensures that competencies for super-long-term maintenance are available in the long run, and that the project is capable of simultaneously providing multiple supported kernel versions.

- Reproducibility and traceability: It is not possible to maintain a system without also maintaining those key tools that are used to produce that system from scratch, together with the associated metadata. Among other things, a complete tool chain that continues to work for decades is crucial. Achieving traceability requires CIP to produce the platform through a transparent process in which inputs, outcomes, tools and states are kept for future inspection, ensuring that CIP software and processes can be trusted in the future.

The CIP project provides financial sponsorship to the “Reproducible Builds” project to ensure that the required functionality is not only available, but becomes an integral part of many software components.

- Debugging and maintenance: Regardless of how old a system is, new bugs will crop up. Packages to debug the system and perform basic maintenance actions need to be provided. For an industrial quality base layer, maintainability is a core factor in every decision at every stage of its design and production. CIP understands that this effort is shared with upstream communities.

Civil infrastructure software does usually not operate in cloud deployments, but runs on real embedded hardware that can be tough to debug and maintain. The “Board at Desk” software released by the project eases the challenges by providing engineers with a ready-to-go local test environment for embedded boards based on LAVA and kernelci.

CIP will publish the selected software packages and tools that form the Civil Infrastructure Platform and commits to following open source development and delivery practices using OSS licenses and an upstream first policy. All components will be verified to work on selected industrial hardware reference platforms. This enables interested parties to establish complete hardware/software solutions in minimal time that can be used as basis for vendor-specific product innovation.

More Information

The project’s website, www.cip-project.org, provides more information and also describes options for corporate membership and community participation.

Find the latest version of this white paper online:

www.cip-project.org/thecivilinfrastructureplatform

