THE LINUX FOUNDATION
PROJECTS

CIVIL
INFRASTRUCTURE
PLATFORM

Debian on
Civil Infrastructure Systems

Yoshitake Kobayashi, CIP TSC chair

DebConf17, 12 August 2017

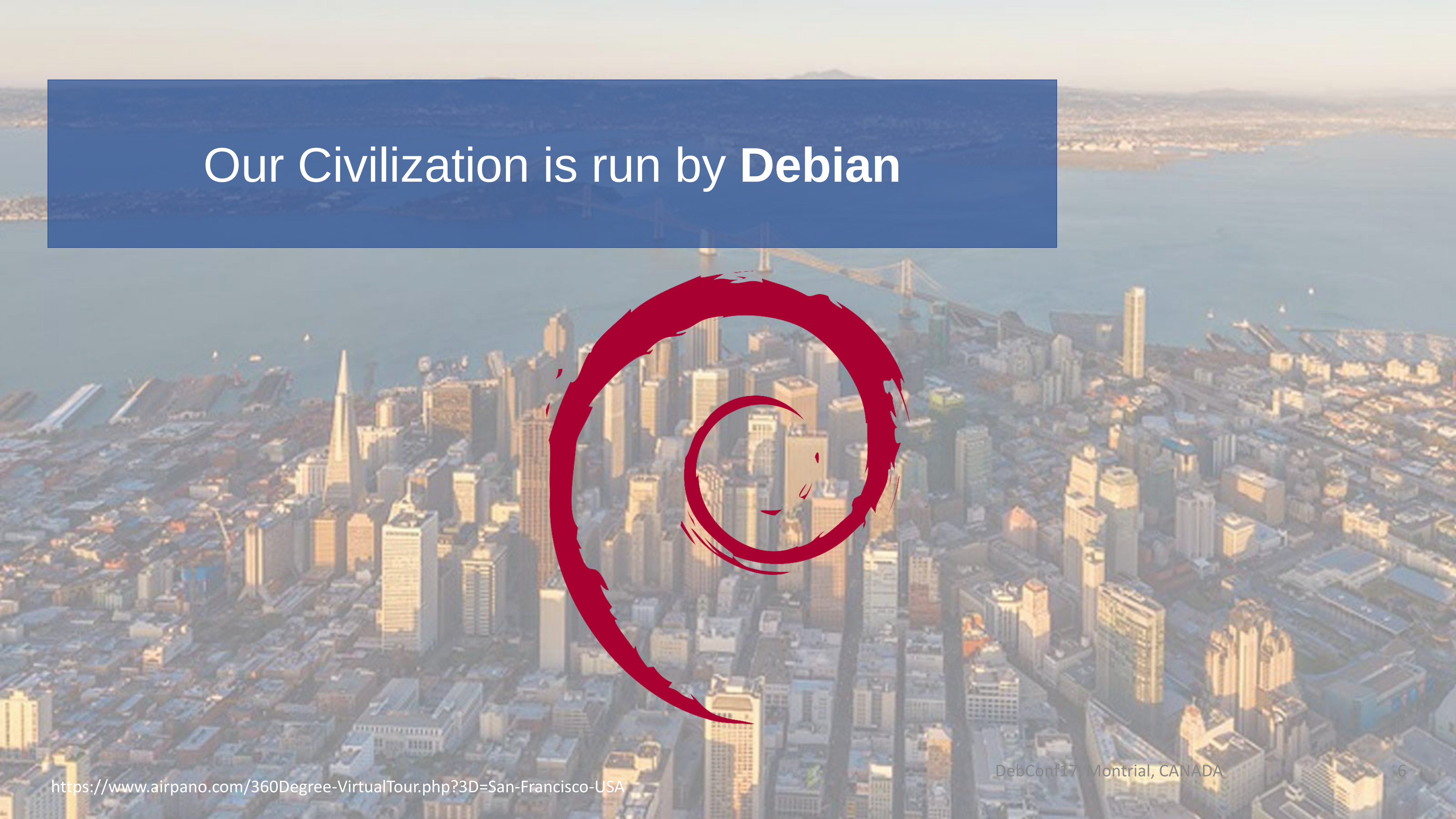
What is CIP?

- One of the most conservative open source project in the Linux Foundation
- One of the most important project for our civilization

Our Civilization is run by Linux

https://www.airpano.com/360Degree-VirtualTour.php?3D=San-Francisco-USA

Our Civilization is run by **Debian**



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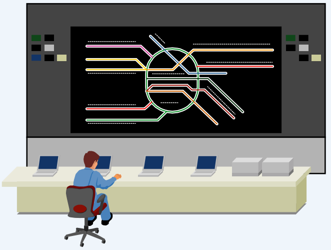
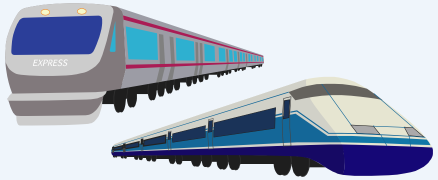
Transport



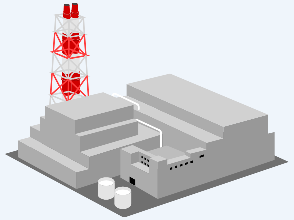
Rail automation



Vehicle control

Automatic ticket gates

Energy



Power Generation

Turbine Control

Industry

Industry automation

CNC control

Industrial communication

Others

Healthcare

Building automation

Broadcasting

https://www.airpano.com/360Degree-VirtualTour.php?3D=San-Francisco-USA

CIP members are interested in Debian

Why Debian is one of the most important distribution?

- Large community-driven ecosystem
- To ensure “free software only” in “main”
- License checks / discussions (debian-legal@lists.debian.org)
- CPU architecture support (x86, ARM, PPC64, …)
- Popular in embedded (Raspbian, Armbian, …)
- Long-term support (Debian-LTS)
- Scales up and down
- Successfully used in several of our products

There are issues to be solved…

https://www.airpano.com/360Degree-VirtualTour.php?3D=San-Francisco-USA

A Railway System:

25-50 years products life-cycle

with very reluctant nature for product update and upgrade of hardware and base software platform

Image: http://www.deutschebahn.com/contentblob/10862328/20160301+Stw+M%C3%BClheim+Innenansicht+1+(1)/data.jpg

Railway Example

3 – 5 years development time

2 – 4 years customer specific extensions

1 year initial safety certifications / authorization

3 – 6 months safety certifications / authorization for follow-up releases (depending on amount of changes)

25 – 50 years lifetime

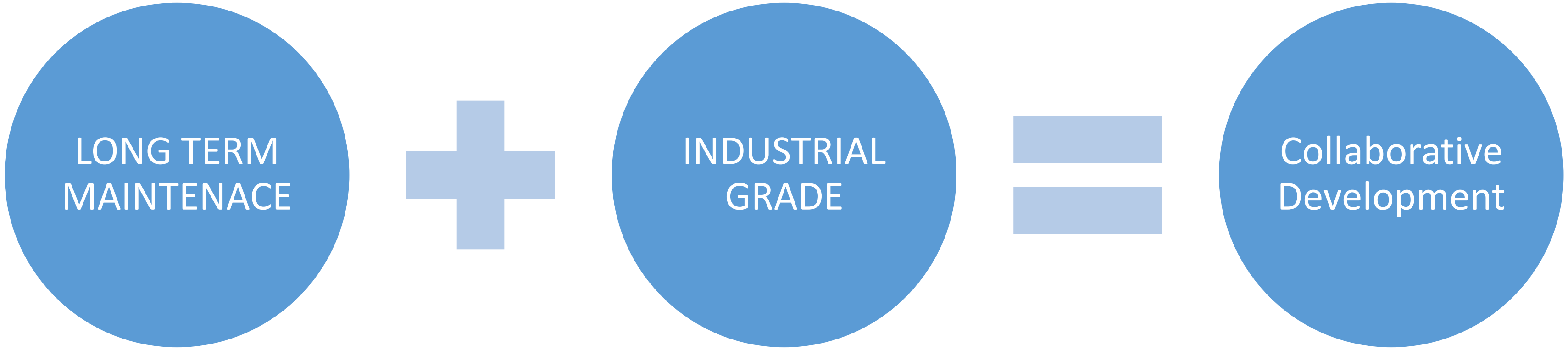
Image: http://www.deutschebahn.com/contentblob/10862328/20160301+Stw+M%C3%BClheim+Innenansicht+1+(1)/data.jpg

The Problems we face …

- The systems that support our modern civilization need to **survive for a VERY LONG TIME.** Until now the corresponding industrial grade super long term maintenance has been **done individually by each company**.

- These systems not only have to survive for a long time, they must be "**INDUSTRIAL GRADE**" (robust, secure and reliable). And at the same time the industry will also need to **catch up with the latest technology trends**

The Solutions we need …



LONG TERM MAINTENACE

INDUSTRIAL GRADE

Collaborative Development

- **<u>We need a Collaborative framework </u>**to maintain the same open source based system for many, many, many years to keep it secure, robust and reliable.
- AND most importantly, we need to do this collaboratively in the **upstream communities**, not locally.

CIP is our solution…

Establishing an <u>Open Source Base Layer</u> of industrial-grade software to enable the use and implementation of software building blocks for Civil Infrastructure Systems

https://www.cip-project.org/

CIVIL
INFRASTRUCTURE
PLATFORM

What is CIP?

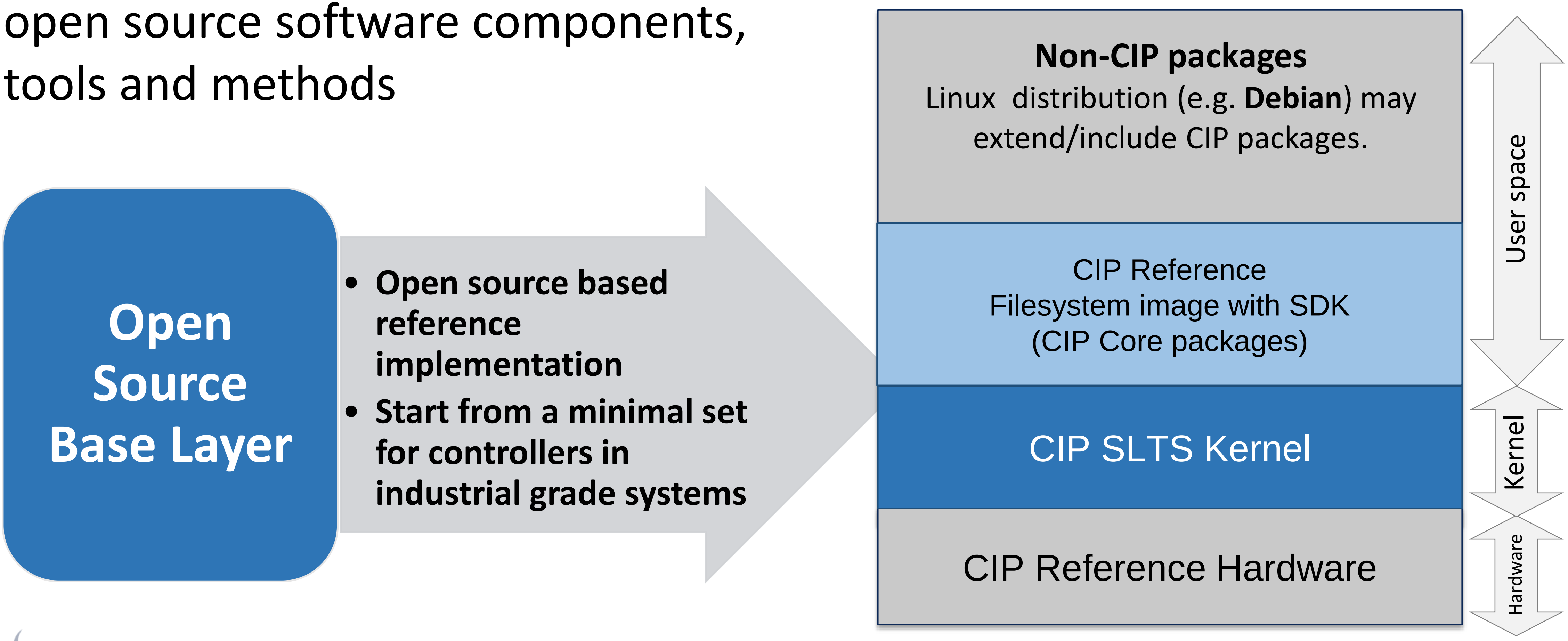
- One of the most conservative open source project in the Linux Foundation

- CIP aims to
  - Provide an **open source base layer** for CIP related embedded systems
  - Work closely with the upstream community

- CIP **does not** aim to
  - Create a new Linux distribution

What is “Open Source Base Layer (OSBL)”?

- OSBL is a set of industrial grade core open source software components, tools and methods



Open Source Base Layer

- **Open source based reference implementation**
- **Start from a minimal set for controllers in industrial grade systems**

Non-CIP packages
Linux distribution (e.g. **Debian**) may extend/include CIP packages.

CIP Reference
Filesystem image with SDK
(CIP Core packages)

CIP SLTS Kernel

CIP Reference Hardware

An example of minimal package set for CIP base layer

CIP will start with a minimal set of packages. “CIP kernel” and “CIP core” packages run on hardware.

Candidates for initial component set

CIP Kernel

CIP Core Packages

- Kernel
  - Linux kernel + backported patches
  - PREEMPT_RT patch
- Bootloader
  - U-boot
- Shells / Utilities
  - Busybox
- Base libraries
  - Glibc
- Tool Chain
  - Binutils
  - GCC
- Security
  - OpenSSL

Keep these packages for Reproducible build

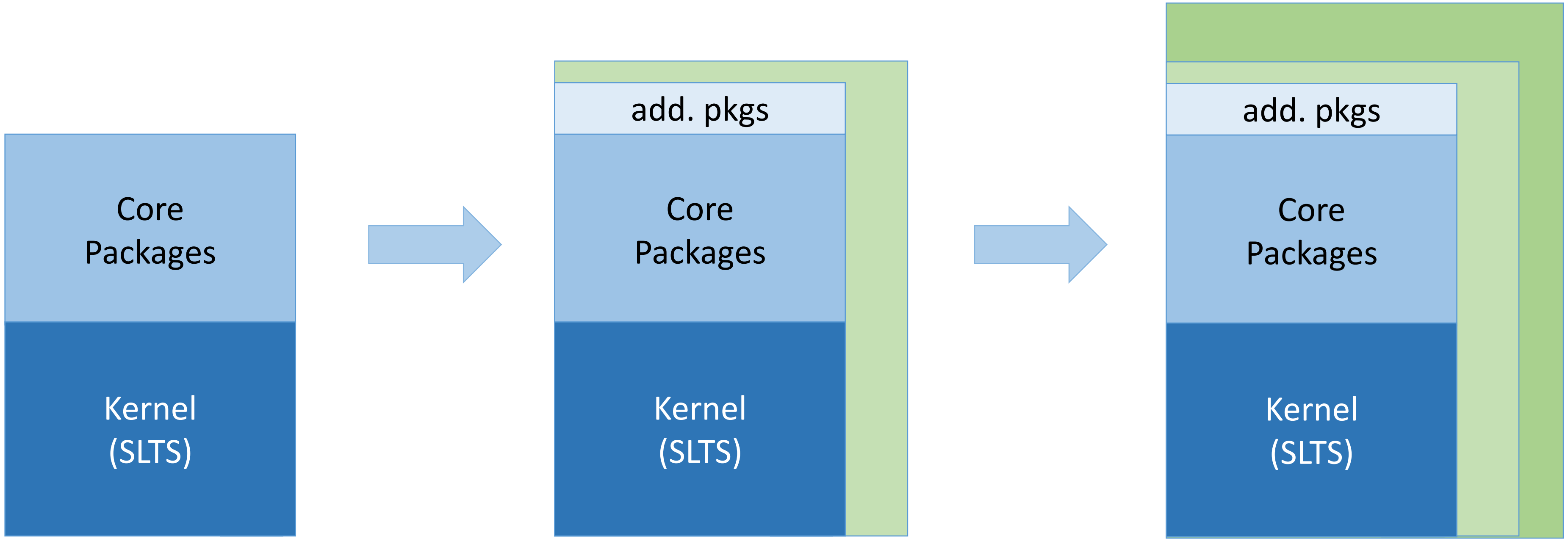
Dev packages

- Flex
- Bison
- autoconf
- automake
- bc
- bison
- Bzip2
- Curl
- Db
- Dbus
- Expat
- Flex
- gawk
- Gdb
- Git
- Glib
- Gmp
- Gzip
- gettext
- Kbd
- Libibverbs
- Libtool
- Libxml2
- Mpclib
- Mpfr4
- Ncurses
- Make
- M4
- pax-utils
- Pciutils
- Perl
- pkg-config
- Popt
- Procps
- Quilt
- Readline
- sysfsutils
- Tar
- Unifdef
- Zlib

NOTE: The maintenance effort varies considerably for different packages.

Development plan

CIP will increase the development effort to create a industrial grade common base-layer



Phase 1:

- Define supported kernel subsystems, arch.
- Initial SLTS component selection
- Select SLTS versions
- Set-up maintenance infrastructure (build, test)

Phase 2:

- Patch collection, stabilization, back port of patches for CIP kernel packages
- Support more subsystems
- Additional core packages

Phase 3:

- Domain specific enhancements, e.g. communication protocols, industrial IoT middleware
- Optionally: more subystems
- Optionally: more core packages

Using Debian on Civil Infrastructure Systems

How we use Debian for embedded systems

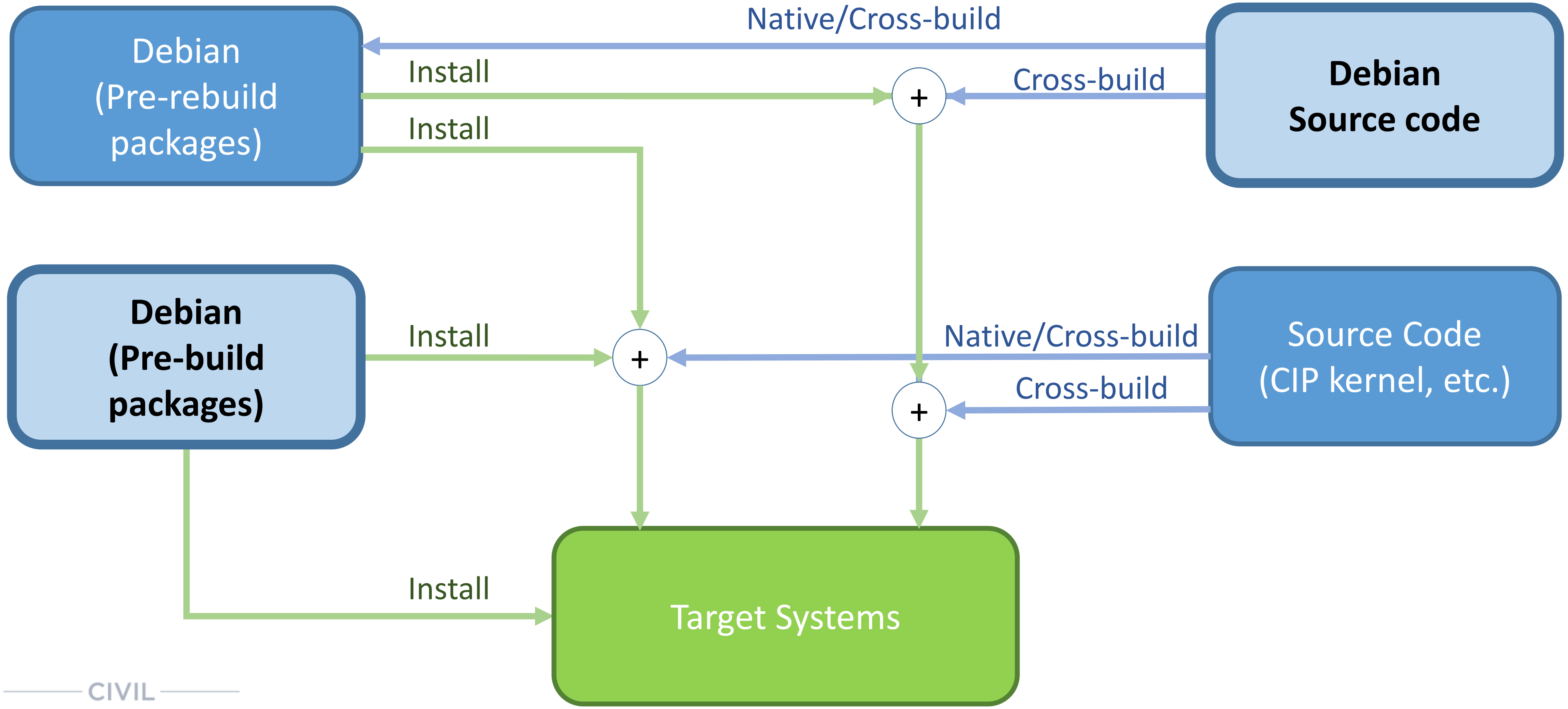
- Customization
  - Kernel
    - Change kernel options
    - Change Linux kernel version
    - Modify the kernel source code
  - Packages
    - Change compile option
    - Change package dependencies

- Tests
- Documentation
  - Open source software licenses compliance
  - Export control classification

CIVIL INFRASTRUCTURE PLATFORM

Creating Debian-based images for embedded systems

- There are several way to create Debian-based images for embedded systems



CIVIL INFRASTRUCTURE PLATFORM

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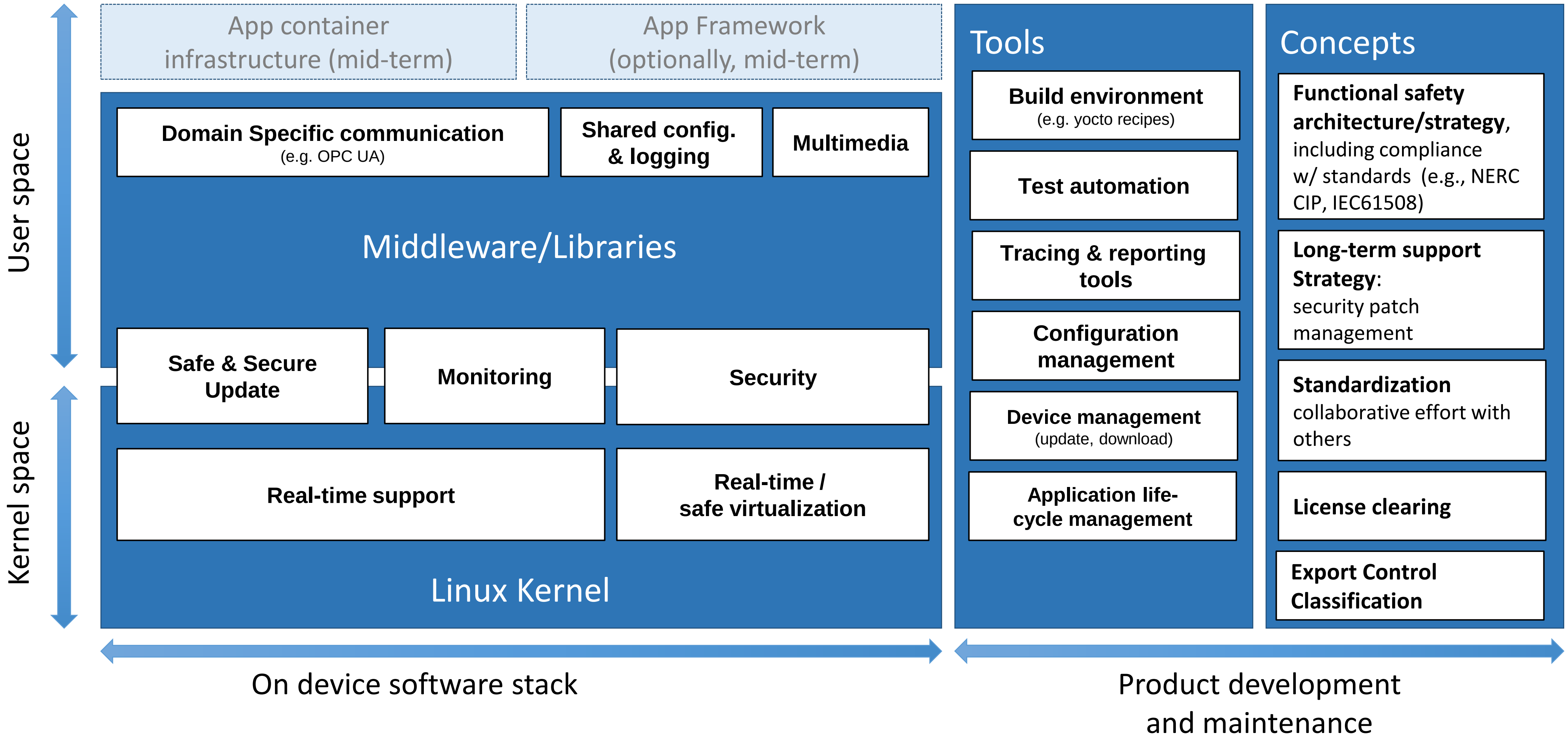
- To ensure “free software only” in “main”
- License checks / discussions (debian-legal@lists.debian.org)
- CPU architecture support (x86, ARM, PPC64, …)
- Popular in embedded (Raspbian, Armbian, …)
- Long-term support (Debian-LTS)
- Scales up and down
- Successfully used in several of our products
- CIP does not want to re-invent the wheel

CIP current scope and status

Scope of activities



User space

Kernel space

App container infrastructure (mid-term)

App Framework (optionally, mid-term)

Domain Specific communication (e.g. OPC UA)

Shared config. & logging

Multimedia

Middleware/Libraries

Safe & Secure Update

Monitoring

Security

Real-time support

Real-time / safe virtualization

Linux Kernel

Tools

Build environment (e.g. yocto recipes)

Test automation

Tracing & reporting tools

Configuration management

Device management (update, download)

Application life-cycle management

Concepts

Functional safety architecture/strategy, including compliance w/ standards (e.g., NERC CIP, IEC61508)

Long-term support Strategy: security patch management

Standardization collaborative effort with others

License clearing

Export Control Classification

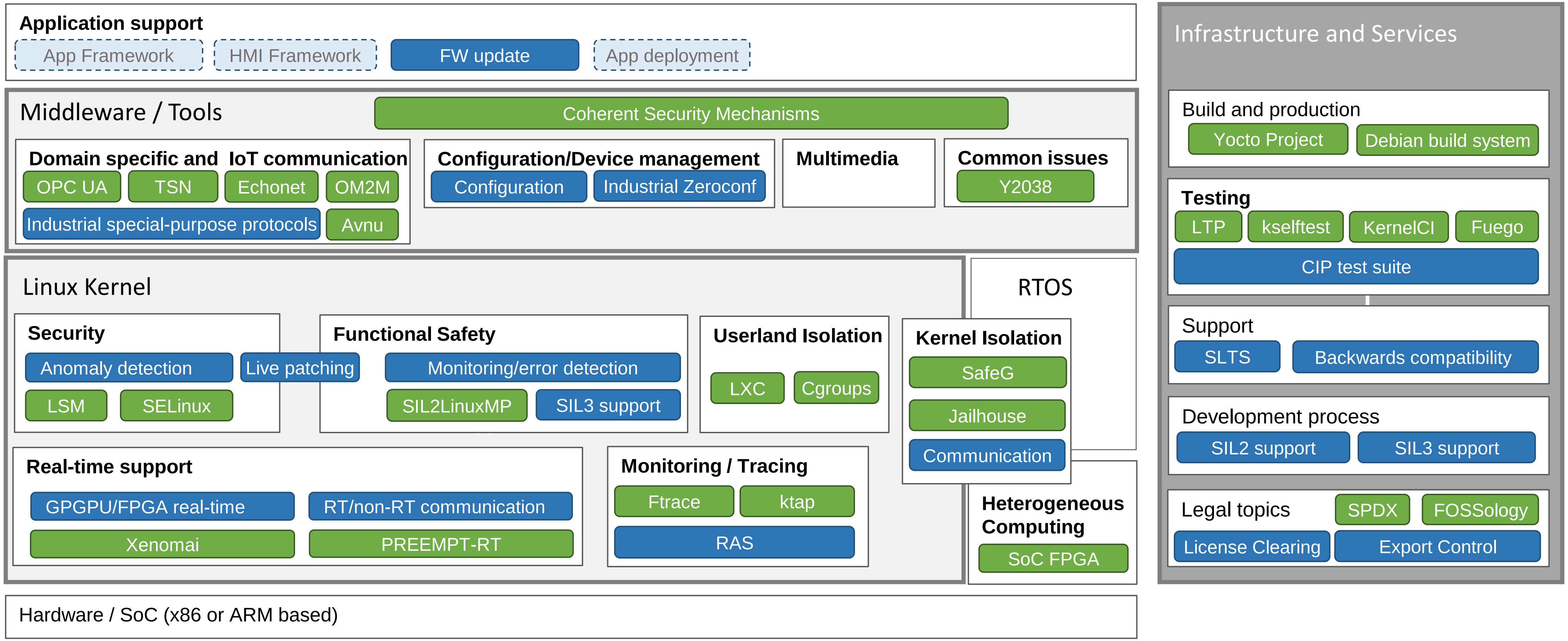
On device software stack

Product development and maintenance

CIVIL INFRASTRUCTURE PLATFORM

Technical topics and related projects (Feb. 2017 version)

** Topics will be added or removed to reflect CIP technical interests*



Application support
App Framework, HMI Framework, FW update, App deployment

Middleware / Tools
Coherent Security Mechanisms

Domain specific and IoT communication
OPC UA, TSN, Echonet, OM2M, Industrial special-purpose protocols, Avnu

Configuration/Device management
Configuration, Industrial Zeroconf

Multimedia

Common issues
Y2038

Linux Kernel

Security
Anomaly detection, Live patching, LSM, SELinux

Functional Safety
Monitoring/error detection, SIL2LinuxMP, SIL3 support

Userland Isolation
LXC, Cgroups

Kernel Isolation
SafeG, Jailhouse, Communication

Real-time support
GPGPU/FPGA real-time, RT/non-RT communication, Xenomai, PREEMPT-RT

Monitoring / Tracing
Ftrace, ktap, RAS

RTOS

Heterogeneous Computing
SoC FPGA

Hardware / SoC (x86 or ARM based)

Infrastructure and Services

Build and production
Yocto Project, Debian build system

Testing
LTP, kselftest, KernelCI, Fuego, CIP test suite

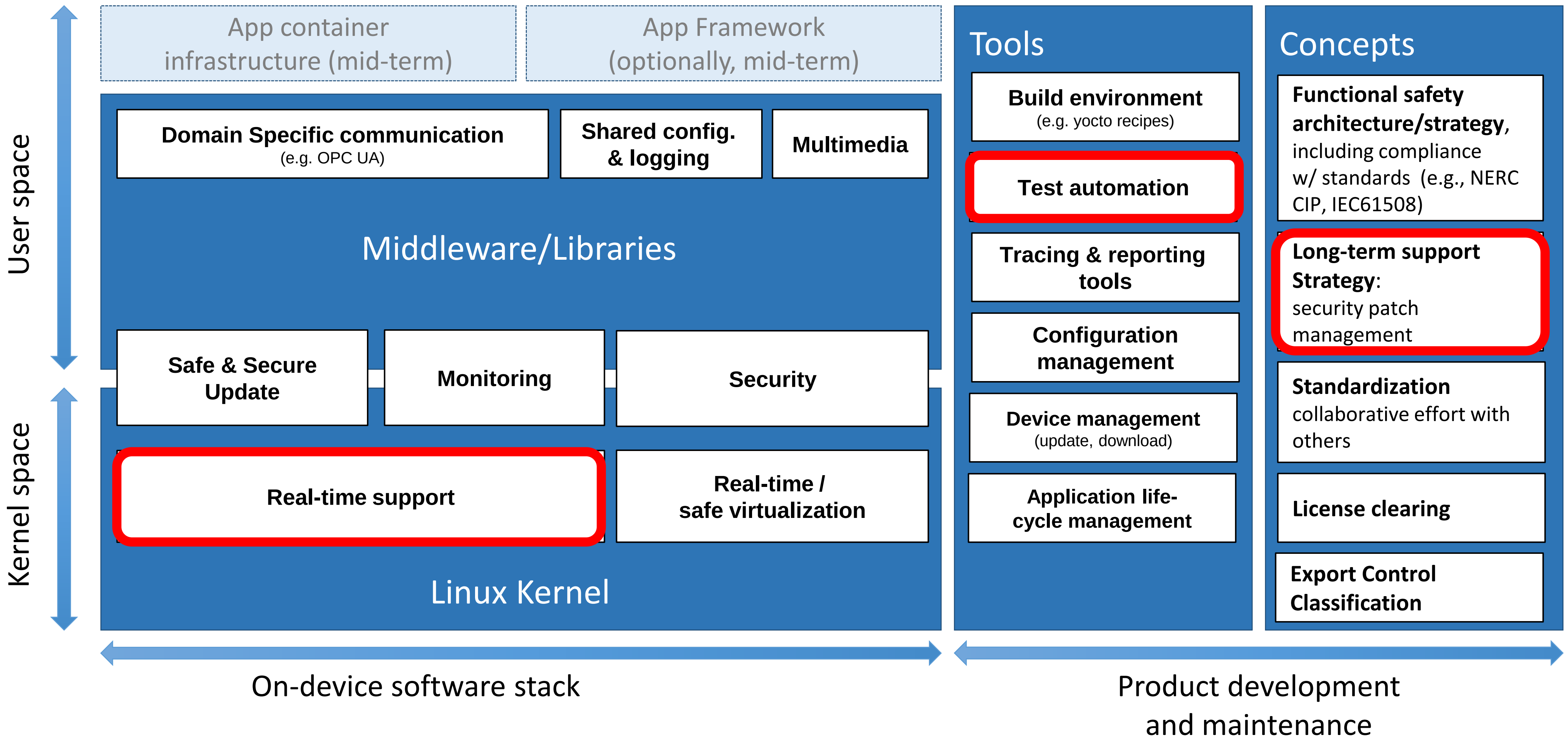
Support
SLTS, Backwards compatibility

Development process
SIL2 support, SIL3 support

Legal topics
SPDX, FOSSology, License Clearing, Export Control

Legend: To be specified / implemented by CIP; Integration / cooperation

Scope of activities



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Export Control Classification

On-device software stack

Product development and maintenance

Current status of CIP base layer development

- CIP SLTS kernel development
  - Decide the CIP kernel version and maintainer
    - 4.4 is the first CIP kernel. maintainer
    - **Ben Hutchings is the initial CIP-kernel maintainer**
  - Define a kernel maintenance policies
    - https://wiki.linuxfoundation.org/civilinfrastructureplatform/cipkernelmaintenance
  - Start maintenance
    - Linux 4.4.75-cip6 released on 3rd July 2017
  - Created a CIP kernel test framework, **Board at Desk (B@D)**

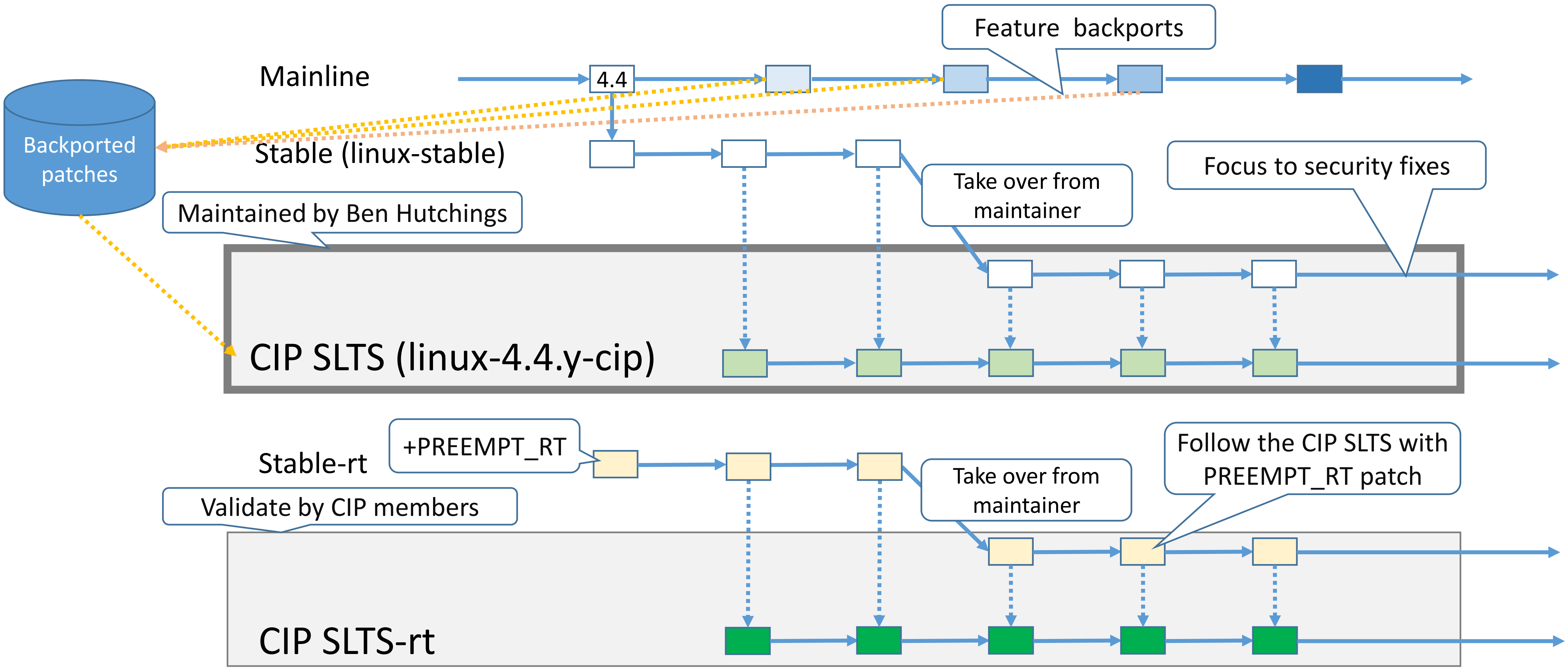
- CIP core package development
  - Define an initial component set
  - Define component version
  - Contribute to upstream project
  - Start maintenance for SLTS

CIP SLTS Kernel Development

Overview of CIP SLTS kernel

- Kernel trees
  - CIP SLTS (linux-4.4.y-cip)
    - Official CIP SLTS kernel tree based on linux-stable.git
      - https://git.kernel.org/cgit/linux/kernel/git/bwh/linux-cip.git/
    - Maintainer: Ben Hutchings
    - Linux 4.4.75-cip6 released on 3rd July 2017
  - CIP SLTS+PREEMPT_RT (will be separately maintained by CIP members)
    - CIP kernel tree based on linux-stable-rt and patches from CIP SLTS
    - Validation will be done by CIP
- Maintenance period
  - 10 years and more (10-20 years)

CIP SLTS Kernel development trees (4.4.x)



Feature backports
Mainline
4.4
Backported patches
Stable (linux-stable)
Take over from maintainer
Focus to security fixes
Maintained by Ben Hutchings
CIP SLTS (linux-4.4.y-cip)
+PREEMPT_RT
Stable-rt
Take over from maintainer
Follow the CIP SLTS with PREEMPT_RT patch
Validate by CIP members
CIP SLTS-rt

CIP’s participation in the Real-time Linux Project

- CIP has become a Gold Member of the Real Time Linux Project

- What’s next
  - Work together with the RTL Project
  - A CIP member is working to become the maintainer of 4.4.y-stable-rt, the base version of the CIP Kernel.

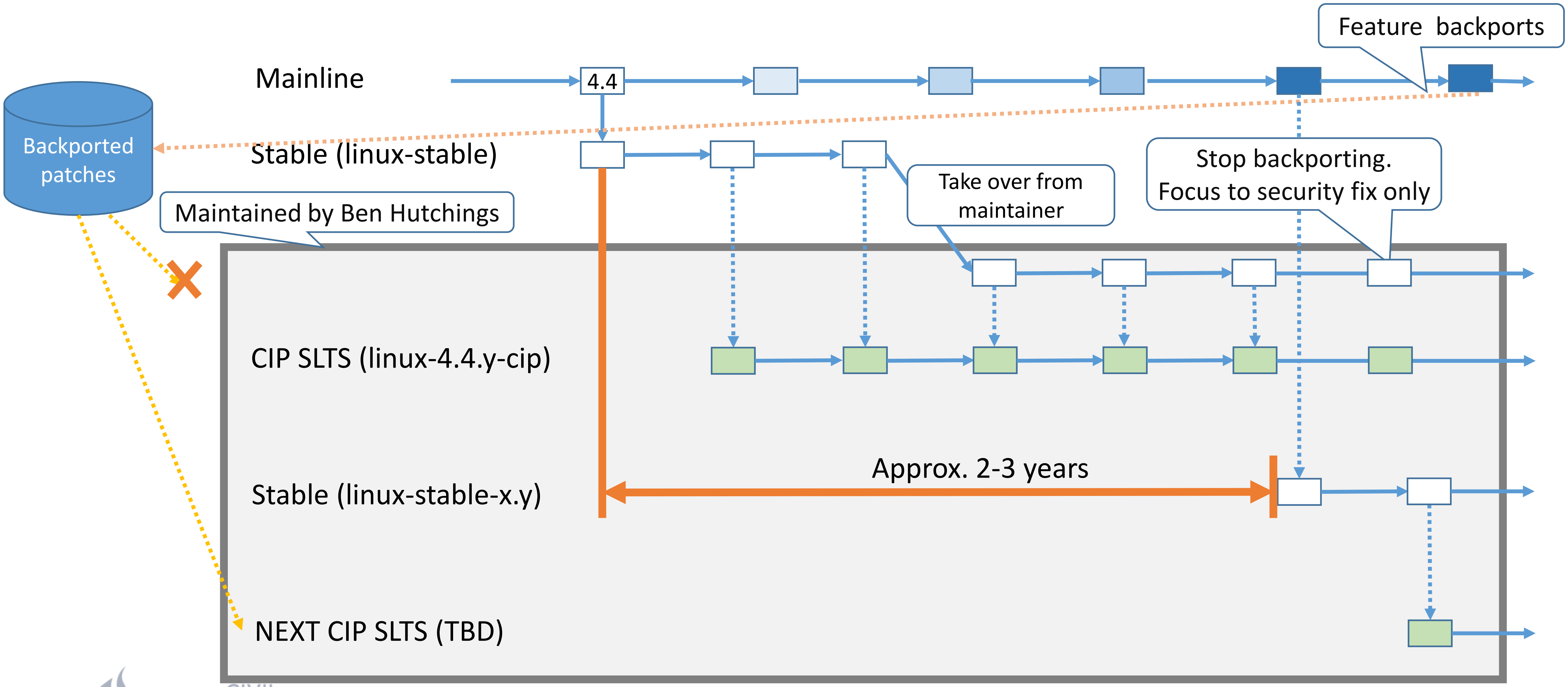
- More information
  - https://wiki.linuxfoundation.org/realtime/rtl/start

CIP SLTS Kernel development

- Kernel maintenance policy
  - https://wiki.linuxfoundation.org/civilinfrastructureplatform/cipkernelmaintenance
  - Follow the stable kernel development rule as the basis
  - Feature backports are acceptable
    - All features has to be in upstream kernel before backport to CIP kernel
    - **CIP has “Upstream first” policy**
  - Validation will be done by CIP test infrastructure and/or members

- Current backported features on 4.4.y-CIP
  - Kernel Self Protection Project related features
    - Address Space Layout Randomization for user space process (ASLR)
    - GCC’s undefined behaviour Sanitizer (UBSAN)
    - Faster page poisoning
  - Board support patches for Renesas RZ/G

NEXT CIP SLTS Kernel (TBD)


Feature backports
Mainline
4.4
Backported patches
Stable (linux-stable)
Take over from maintainer
Stop backporting.
Focus to security fix only
Maintained by Ben Hutchings
CIP SLTS (linux-4.4.y-cip)
Approx. 2-3 years
Stable (linux-stable-x.y)
NEXT CIP SLTS (TBD)

Out-of-tree drivers

- In general, all out-of-tree drivers are unsupported by CIP
- Users can use CIP kernel with out-of-tree drivers
    - If a bug is found in such a modified kernel, users will first demonstrate that it exists in the CIP kernel source release in order for the CIP maintainers to act on it.

CIP Kernel testing

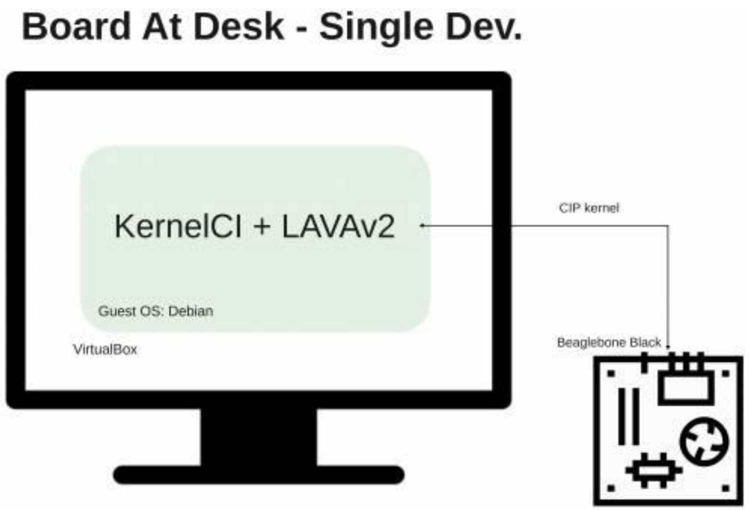
Milestones of CIP testing and current status

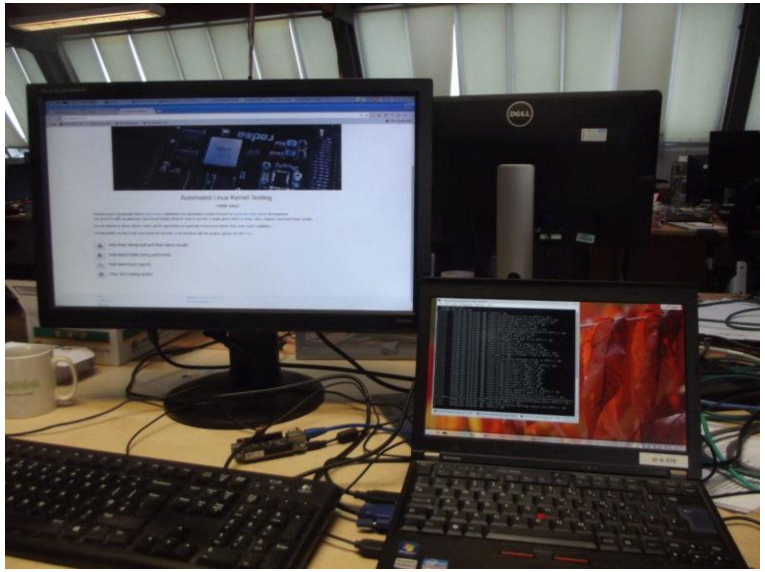
1. Board at desk - single dev
   - A setup that allows a developer to test the CIP kernel on the CIP selected hardware platform connected locally to her development machine using kernelCI tools.
2. CIP kernel testing
   - Test the CIP kernel on a regular basis and share the results with other CIP community members.
3. Define kernel testing as a service within CIP
   - Define the testing environment within CIP assuming that, in some cases, some members may share the tests, test results or laboratories while others may not.
4. From kernel testing to system testing
   - Once the testing environment has been ready and works for the kernel, explore how to extend it to the entire CIP platform.

https://wiki.linuxfoundation.org/civilinfrastructureplatform/ciptesting

CIP testing

- Goal
  - Create and publish a VM image that contains KernelCI & LAVA
  - Single developer can test the CIP kernel (or any other kernels)
- News
  - **B@D v0.9.1 has been released on 30th May at OSSJ 2017**
    - https://www.cip-project.org/news/2017/05/30/bd-v0-9-1
  - Download the VM or deploy the environment through Vagrant
    - https://wiki.linuxfoundation.org/civilinfrastructureplatform/cipdownload
  - Check the tools and software packages included in this release.
    - https://wiki.linuxfoundation.org/civilinfrastructureplatform/ciptestingboardatdesksingledevfeaturepage
    - The CIP testing team has invested a significant effort in writing step by step instructions to deploy, configure and run tests.
- Check the source code involved
  - https://gitlab.com/cip-project/cip-testing/board-at-desk-single-dev/tree/master





CIP testing: next steps

- During the coming months the team will focus on:
  - Defining how tests should look like.
  - Defining how results should be shared.
  - Increasing the test coverage of the CIP Kernel

- More updates at Embedded Linux Conference Europe 2017 this October

CIP Core Package Development

Current status of the Base layer development

1. Define an initial component set

2. Define component version
3. Contribute to upstream project
4. Start maintenance for SLTS

Current status of the Base layer development

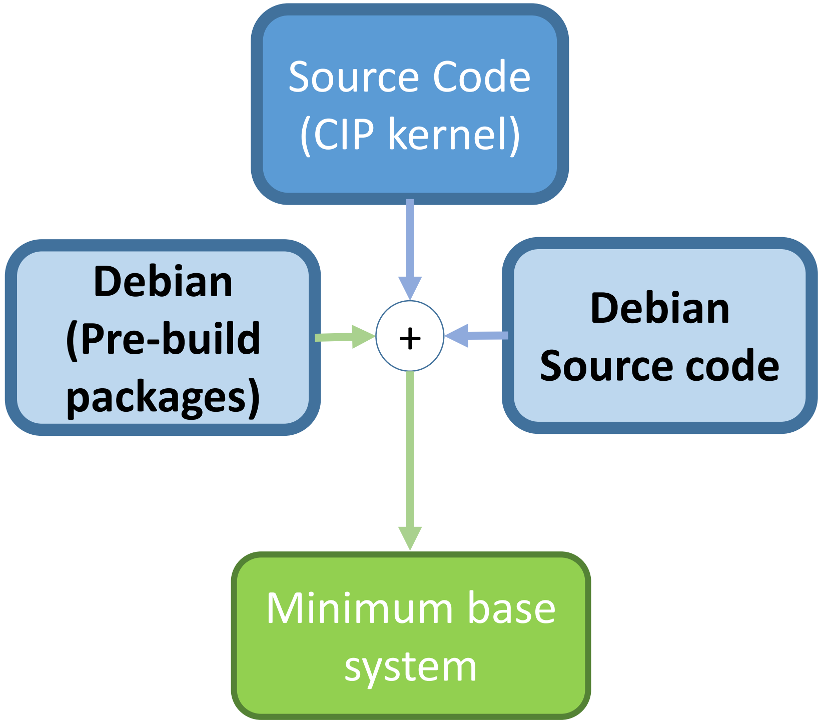
1. Define an initial component set

1.5 Talk to open source communities

2. Define component version
3. Contribute to upstream project
4. Start maintenance for SLTS

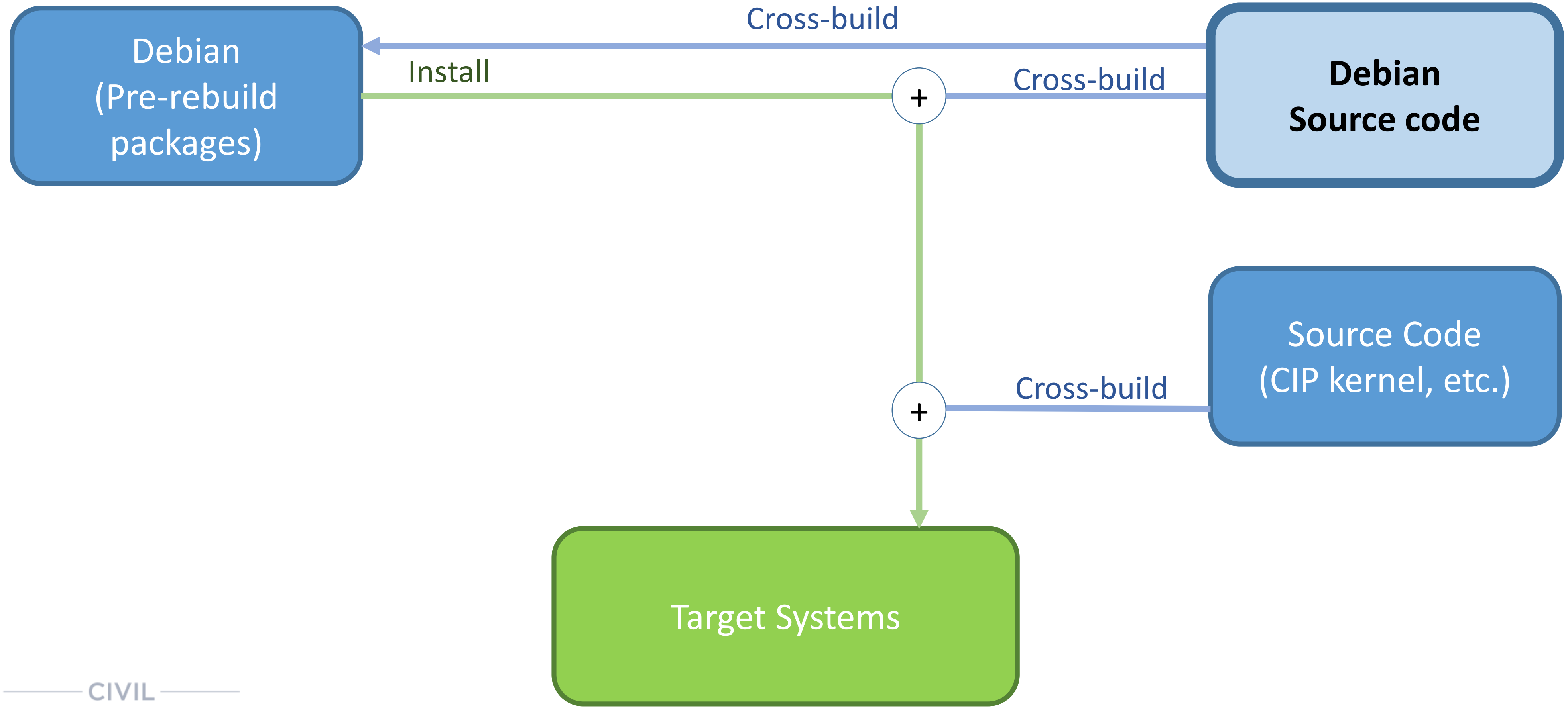
CIP Project X

- **Started an incubation project for the minimum base system**
  - This project will provide a way to test the installable image
- **Goal**
  - **Input:** Debian sources/binaries and cip kernel
  - **Build mechanism:** bitbake and/or Debian build system
  - **Output:** Minimum deployable base system image for testing
- **Current status**
  - Minimal rootfs can be build for the following hardware
    - Renesas RZ/G1M (iwg20m)
    - BeagleBone Black
    - Cyclone-V
    - QEMUx86
- **Source code**
  - https://gitlab.com/cip-playground/project-x



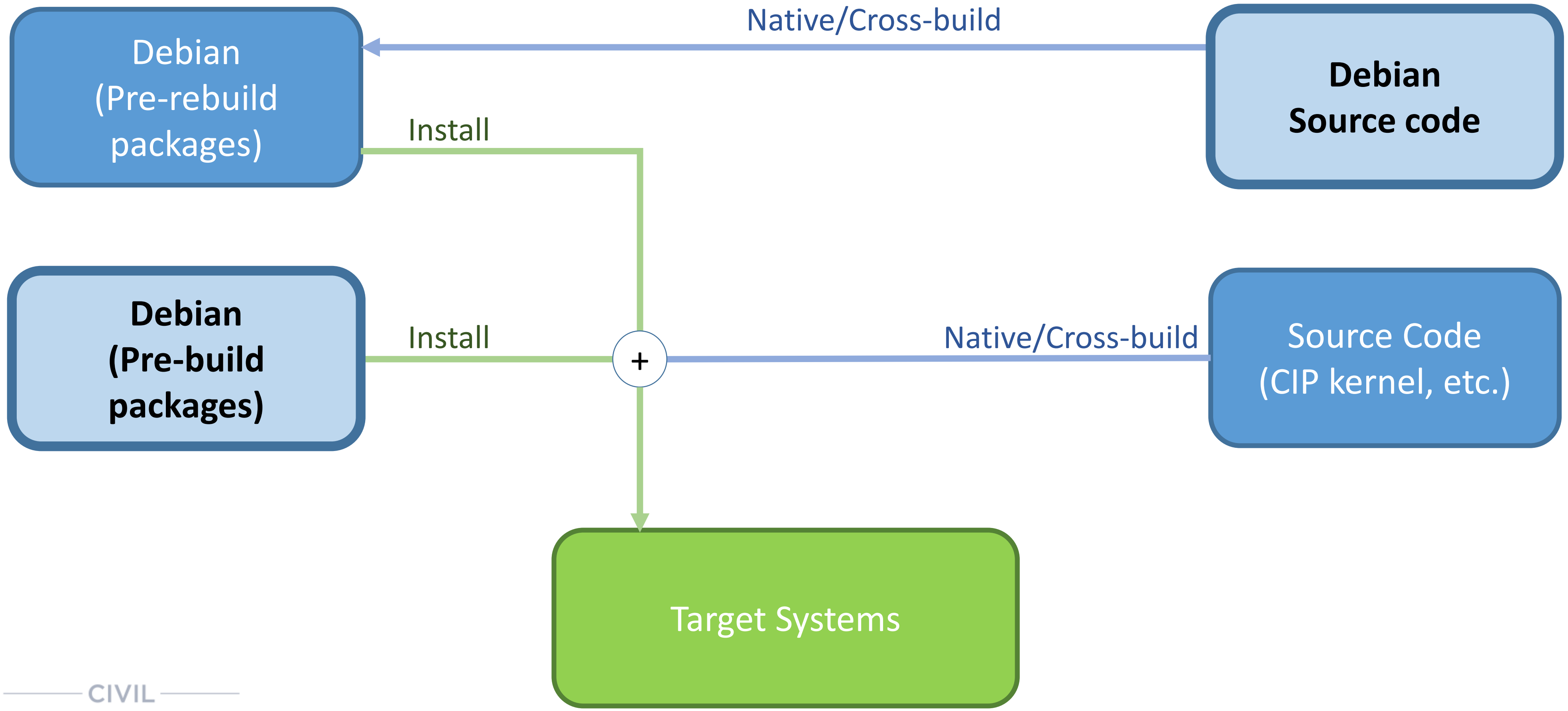
Creating Debian-based image by Project X (Current status)

- Deby https://github.com/meta-debian/meta-debian



Creating Debian-based image by Project X (Other options)

- ISAR https://github.com/ilbers/isar
- ELBE https://elbe-rfs.org/



Native/Cross-build
Debian (Pre-rebuild packages)
Debian Source code
Install
Debian (Pre-build packages)
Install
+
Native/Cross-build
Source Code (CIP kernel, etc.)
Target Systems

What’s next with Debian?

Gaps and Common Goals = Chance to work together

Debian

Support

- Term: 3+2 years by Debian-LTS
- Num of pkgs: 67776

Build

- Should support native build
- Working on cross build packaging (Debian-cross)
- Reproducible build

OSS license compliance

- DEP-5 adoption is ongoing

Testing

- Packages has to be tested
- autopkgtest

CIP requires

Support

- Term: 10+ years
- Num of pkgs: 10+ (minimum)

Build

- Need to have both native and cross build
- Binary / Source code should be managed and reproducible

OSS license compliance

- Generate reports automatically
- Easy to redistribute

Testing

- All packages should be tested in timely manner

Chance to collaborate with Debian

- **Longer** term maintenance for limited number of packages
- Contributing to **Debian-cross**
- Exchange and share the **license review results**
- Contributing **test cases** to upstream

Summary

- **Our Civilization is run by Debian**
- CIP members are interested in Debian
  - Goal of Debian is shipped free software
  - Package license policy of Debian is valuable
    - This information is valuable for us
  - Successfully used in several of our products
- CIP has started an incubation project ‘Project X’ based on Debian
- Gaps and Common Goals become a good chance for collaboration

Contact Information and Resources

To get the latest information, please contact:

- CIP Mailing list: cip-dev@lists.cip-project.org

Other resources

- CIP Web site: https://www.cip-project.org
- CIP Wiki: https://wiki.linuxfoundation.org/civilinfrastructureplatform/
- CIP Source codes
  - CIP GitLab: http://www.gitlab.com/cip-project
  - CIP kernel: git://git.kernel.org/pub/scm/linux/kernel/git/bwh/linux-cip.git

CIP whitepaper

- Year One Update + Whitepaper Release
  - https://www.cip-project.org/blog/2017/05/31/cip-year-one-update-whitepaper-release

- Everyone can download the whitepaper
  - https://wiki.linuxfoundation.org/_media/civilinfrastructureplatform/whitepaper_short.pdf

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 endeavours. 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) Initiative, hosted by the Linux Foundation and driven by the world's leading manufacturers of civil infrastructure systems, aims at providing 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.

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Thank you!

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Questions?

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