How open source projects approach functional safety

Xen, Zephyr & Linux (ELISA)

Nicole Pappler, AlektoMetis
Philipp Ahmann, Robert Bosch GmbH
Credits to: Stefano Stabellini, AMD/Xilinx

Aerospace · Automotive · Linux Features
Medical Devices · OS Engineering Process
Safety Architecture · Systems · Tools

Whoami - Philipp Ahmann

Product Manager for Embedded Open Source

Chair of the Technical Steering Committee
Lead of the Systems Working Group

Member of the Inaugural Advisory Board

OSS enthusiast and promoter

About Nicole

AlektoMetis
...we enable digital innovation.

Professional History:
Been working in production maintenance, automotive, ECU software development
All my projects had some safety criticality
Started to focus on Functional Safety about 12 years ago

Currently:
Tech consulting as part of AlektoMetis
Supporting my customers regarding Functional Safety, Security & compliant use of open source
Involved in some projects:

- Zephyr (Functional Safety Manager)
- ELISA (Medical & Systems Group)
- FuSa for SPDX SIG
- OpenChain (3rd party certification with TÜV SÜD)

What else?
Not good with remembering names and faces
GitHub, Discord, etc: @nicpappler

ELISA
ENABLING LINUX IN SAFETY APPLICATIONS

What is Functional Safety?

Definition of Safety

The freedom from unacceptable risk of physical injury or of damage to the health of people, either directly, or indirectly because of damage to property or the environment.

Definition of Functional Safety

The part of safety that depends on a system or equipment operating correctly in response to its inputs.
Detecting potentially dangerous conditions, resulting either in the activation of a protective or corrective device or mechanism to prevent hazardous events or in providing mitigation measures to reduce the consequences of the hazardous event.

ELISA
ENABLING LINUX IN SAFETY APPLICATIONS

In Functional Safety you expect:

That the software:

- does behave as specified,
- does not interfere or impair other system components
- and all possible erroneous events are addressed somehow or somewhere.

And you have sufficient evidence to prove this.

ELISA
ENABLING LINUX IN SAFETY APPLICATIONS

Example OSS projects approaching functional safety

Linux:

ELISA
ENABLING LINUX IN SAFETY APPLICATIONS

RTOS:

Zephyr™

Virtualization/Hypervisor:

Xen Project

THE LINUX FOUNDATION

ELISA
ENABLING LINUX IN SAFETY APPLICATIONS

Project Members

Platinum Members

ANALOG DEVICES, antmicro, Google, intel, Meta, NORDIC SEMICONDUCTOR, NXP, oticon life-changing technology, Qualcomm Innovation Center, ZEISS

Silver Members

ac6, ARDUINO, avnystem, Baumer, Baylibre, blues, golioth, infineon, irnas, Laird CONNECTIVITY, Linaro, Memfault, percepio, RENESAS, SILICON LABS, STERNUM, synopsys, TII Technology Innovation Institute, Texas Instruments

Zephyr™

PROJECT MEMBERS

AMD XILINX, arm, aws, epam, VATES, XenServer

Xen Project

Premier Members

BOEING, Red Hat

General Members

AISIN, arm, 斑马智行 Powered by AIOS, BOSCH, Codethink, Elektrobit, HUAWEI, LINUTRONIX, 上汽集团 SAIC MOTOR, SUSE, SUZUKI, WNDRVR

ELISA
ENABLING LINUX IN SAFETY APPLICATIONS

Members from Mobility and related industries

No real Mobility or Aerospace member.

Hardware driven:
Mainly Microcontroller and sensor manufacturer.

Zephyr™

Mobility supplier.

Originated in server.
Approaching embedded.
No car manufacturer.

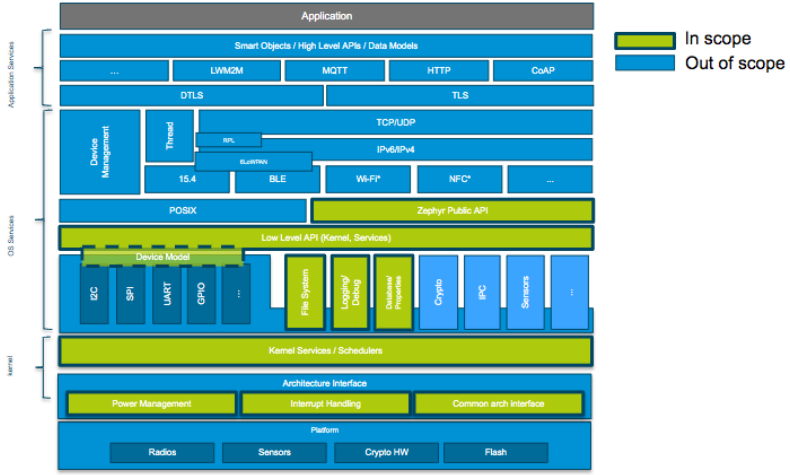
(Large non-project member community)

Xen Project

Mobility & Aerospace system provider

ELISA
ENABLING LINUX IN SAFETY APPLICATIONS

Zephyr



https://www.zephyrproject.org/introduction-of-coding-guidelines-for-zephyr-rtos/

- Targeting safety certification from the beginning of the project
- Certification artifacts and safety manual for premium members only
- Safety working group started recently to enable better collaboration
- Naturally, safety awareness in community is limited due to heavy “non-safety” use cases and many unrelated modules.
- Rich ecosystem with strong support for various HW and certain benefits on Linux.
- Posix compatible

Zephyr™

ELISA
ENABLING LINUX IN SAFETY APPLICATIONS

Xen

- Since Xen for embedded security working group was started in parallel (in 2010)
- Security & isolation are project's top priority
- Real-time scheduling.
- Rigorous Quality Process. Full commit traceability.
- Commits are tested with 2 CI loops.
- Widely adopted in critical production environment: (Data center, Desktop & Embedded)
- AMD works on making Xen safety-certifiable
- Continuous certification in mind.
- Phase 1: Certification Concept Approval
- Phase 2: Final Assessment.

Linux

- Open source software superlative.
- Largest community, largest source base.
- Made for flexibility and wide use cases.
- Spread over whole world and in space.
- Several attempts with certification path.
- Gains again momentum for high performance products (e.g. SDV*)
- Prominent open space examples: SIL2LinuxMP and ELISA

*SDV: Software-Defined-Vehicle

Limitations! The OSS projects collaboration …

- *cannot* engineer your system to be safe.
- *cannot* ensure that you know how to apply the described processes and methods.
- *cannot* create an out-of-tree system for safety-critical applications. (continuous process improvement argument!)
- *cannot* relieve you from your responsibilities, legal obligations and liabilities.

But…

Projects provide a path forward and peers to collaborate with!

ELISA
ENABLING LINUX IN SAFETY APPLICATIONS

Certification financing

Platinum members

AMD/Xilinx

Integrators
(like RedHat)

Zephyr™

Xen Project

ELISA
ENABLING LINUX IN SAFETY APPLICATIONS

Fully open vs. Pretty open

Recently started safety-wg for better collaboration.

New life to activity due to openness.
Example: requirements tool (StrictDoc)

Some results remain “behind the scenes” for premium members

Zephyr™

Discussions are open (to participate you need to have a copy of “Misra-C”)

Misra-C, documentation and other parts are open source and upstream.

Safety manual and other safety artifacts will be made commercially available via AMD/Xilinx

Xen Project

Completely open to everyone.

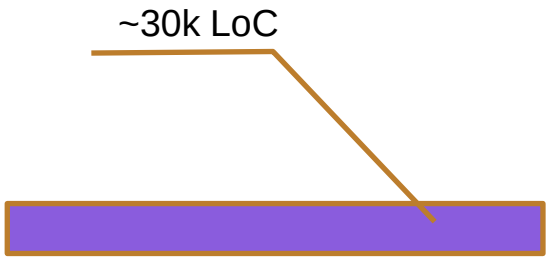
Focus is on tools, kernel improvements, documentation and processes.

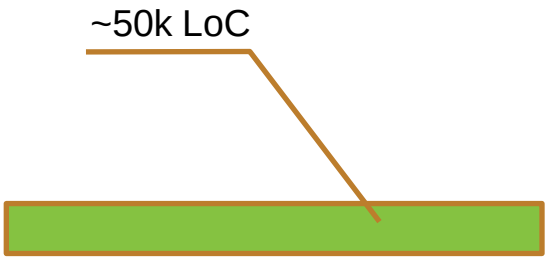
Outcome enables other integrators to build their products around Linux.

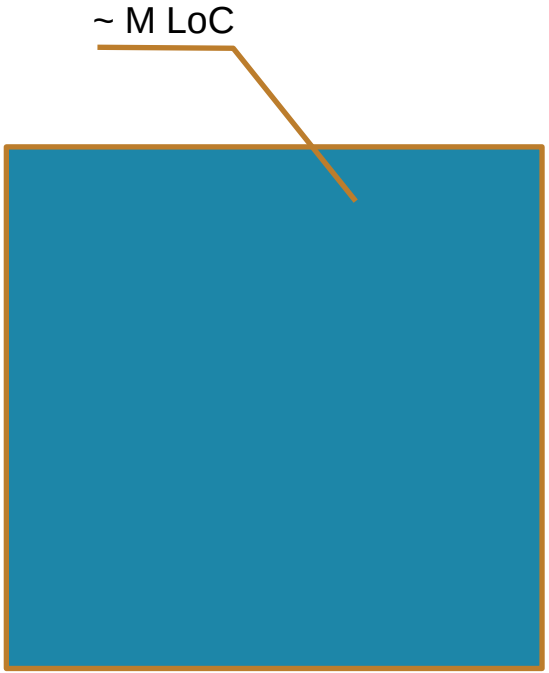
ELISA
ENABLING LINUX IN SAFETY APPLICATIONS

Code Complexity/Size

Due to smaller (upstream) code size,
it can be easier to certify Xen or Zephyr.
Also, complexity/features may be decreased/stripped
(no L2 caches or dynamic memory allocation)







Zephyr™

Xen Project

ELISA
ENABLING LINUX IN SAFETY APPLICATIONS

Trainings

Provide(d) IEC 61508 training by TÜV SÜD for project members (some contributors/maintainers have official safety training)

The safety committee (and safety working group) mainly consist of experienced safety experts.

Misra-C trainings for project contributors via Bugseng sponsored by AMD.

Mainly 1 safety expert, many engineers with safety in mind and practical product experience

Special topic webinars within ELISA.

No direct ISO26262 or IEC61508 trainings for ELISA members.

Many experienced safety experts within ELISA project.

Zephyr™

Xen Project

ELISA
ENABLING LINUX IN SAFETY APPLICATIONS

Challenges: Linux in safety critical systems

The Linux kernel has:

- Large Development Ecosystem
- Security Capabilities
- Multi-Core Support
- Unmatched Hardware Support
- Many Linux Experts at all levels available

Traditional safety-critical OS has:

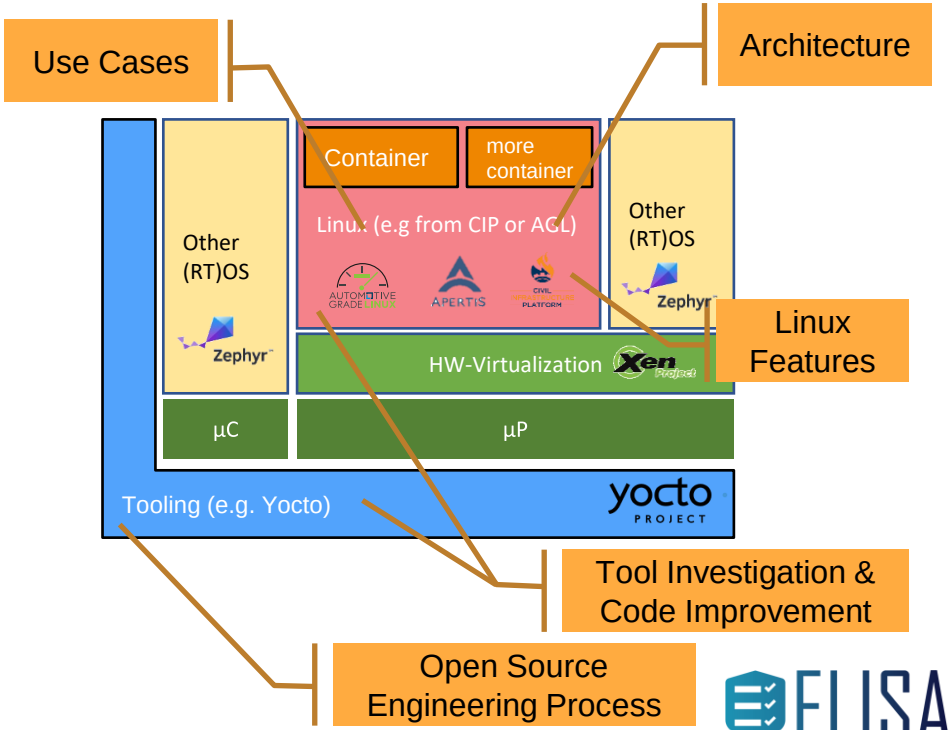
- Hard Real-time Capabilities
- Proven Safety-compliant Development Process
- …

Can these differences be tackled?

ELISA
ENABLING LINUX IN SAFETY APPLICATIONS

ELISA Working Groups - Fit in an exemplary system

- **Linux Features, Architecture** and **Code Improvements** should be integrated into the reference system directly.
- **Tools** and **Engineering process** should serve the reproducible product creation.
- **Medical, Automotive, Aerospace** and future WG use cases should be able to strip down the reference system to their use case demands.



ELISA
ENABLING LINUX IN SAFETY APPLICATIONS

The mission of the project is to define and maintain a common set of elements, processes and tools that can be incorporated into Linux-based, safety-critical systems amenable to safety certification.”

The scope of the project includes software and documentation development under an OSI-approved license supporting the mission, including documentation, testing, integration and the creation of other artifacts that aid the development, deployment, operation or adoption of the project.”

from the technical charter

ELISA
ENABLING LINUX IN SAFETY APPLICATIONS

Safety Critical Systems

“Assessing whether a system is safe, requires understanding the system sufficiently.”

- Understand your system element within that system context and how it is used in that system.
- Select system components and features that can be evaluated for safety.
- Identify gaps that exist where more work is needed to evaluate safety sufficiently.

ELISA
ENABLING LINUX IN SAFETY APPLICATIONS

Safety Element out of Context (SEooC)

Element that can prove it has sufficient evidence,

- can be integrated to a safety relevant system,

- target system is unknown during the SEooCs development.

Actually: Element of assumed context

- Provides a product with safety critical properties within a defined (functional) scope
- Provides information how it needs to be integrated
- Ships with a Safety Manual

Obligations!

- Scope and capabilities of the SEooC must match with the final system’s safety needs!
- If the system safety is insufficient, a safety SEooC will not safe you!
- Adherence to the Safety Manual!

Community challenges for all projects

Bring the argument of „OSS is not behaving like commercial software“.

Less influence on maintainers
(positive & negative – no traditional supplier management).

Harder to train/direct developers (but some Xen community members got Misra-C trainings and Zepyhr members IEC 61508 trainings).

Liability of a community? (but commercial provider may be liable – insurance)

Development process: Requirements, traceability, v-model,… mapping safety integrity standards

ELISA
ENABLING LINUX IN SAFETY APPLICATIONS

Interactions between the communities

- Open source projects focusing on safety-critical analysis

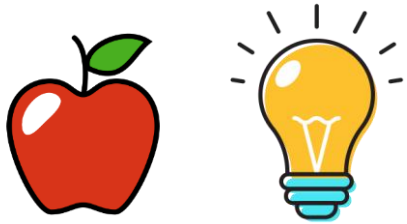
Xen Project Zephyr™

- Open source projects with safety-critical relevance and comparable system architecture considerations

AUTOMOTIVE GRADE LINUX SOAFEE SDV Eclipse Software Defined Vehicle

- Further community interactions

yocto PROJECT SPDX Linaro



"If you have an apple and I have an apple and we exchange these apples then you and I will still each have one apple
But if you have an idea and I have an idea and we exchange these ideas, then each of us will have two ideas

— George Bernard Shaw

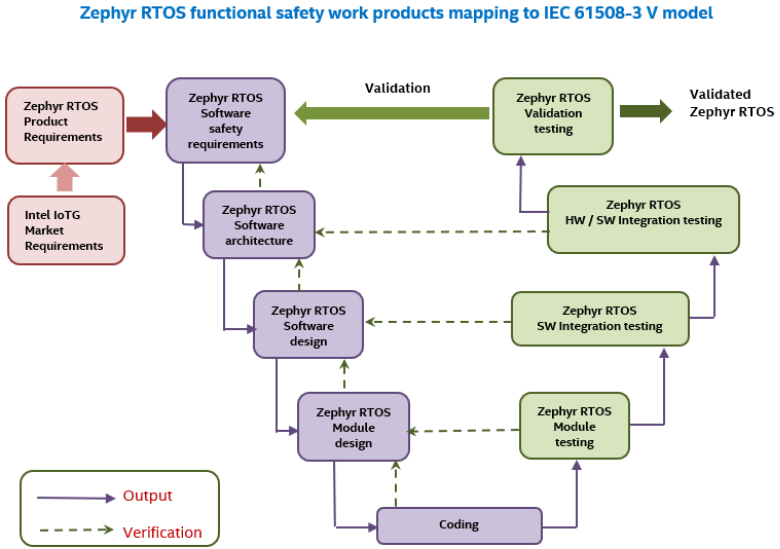
ELISA
ENABLING LINUX IN SAFETY APPLICATIONS

Zephyr – Compliant Development: V-Model

It is a challenge to map a stereotypical open-source development to the V-model

- Specification of features
- Comprehensive documentation
- Traceability from requirements to source code
- Number of committers, commits and information known
- Test coverage metrics

Provide the evidence that open source developed items can map to compliance and meet all requirements



ELISA
ENABLING LINUX IN SAFETY APPLICATIONS

What’s happening in Zephyr now…

Safety Committee

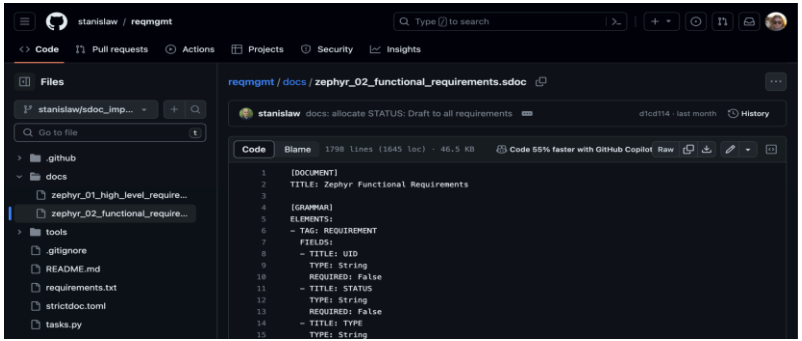
- Safety Certification strategy decisions
  - scope of certification
  - certification standards
  - certification timeline
- Assessment and audit specific tasks
- Owner of certification artefacts
- Participation limited to the project’s platinum members, the safety architect and the functional safety manager

Safety Working Group

- Enabling safety qualifications/certifications in the project
- Working on created the required documentation and evidences
  - Setting up requirements management tooling
  - Creating/deriving and documenting requirements
- Open to everyone to participate

ELISA
ENABLING LINUX IN SAFETY APPLICATIONS

Snapshot: Current Requirements Work



- Used tooling: StrictDoc (https://github.com/strictdoc-project/strictdoc)
- Decision on UIDs for requirements (will be generated by StrictDoc)
- Hierachical structure of requirements that works for the project
- WIP: capturing requirements in StrictDoc

ELISA
ENABLING LINUX IN SAFETY APPLICATIONS

Join the talk on Sunday

https://fosdem.org/2024/schedule/event/fosdem-2024-3211-application-of-the-spdx-safety-profile-in-the-safety-scope-of-the-zephyr-project/

ELISA
ENABLING LINUX IN SAFETY APPLICATIONS

Recommendations for new contributors

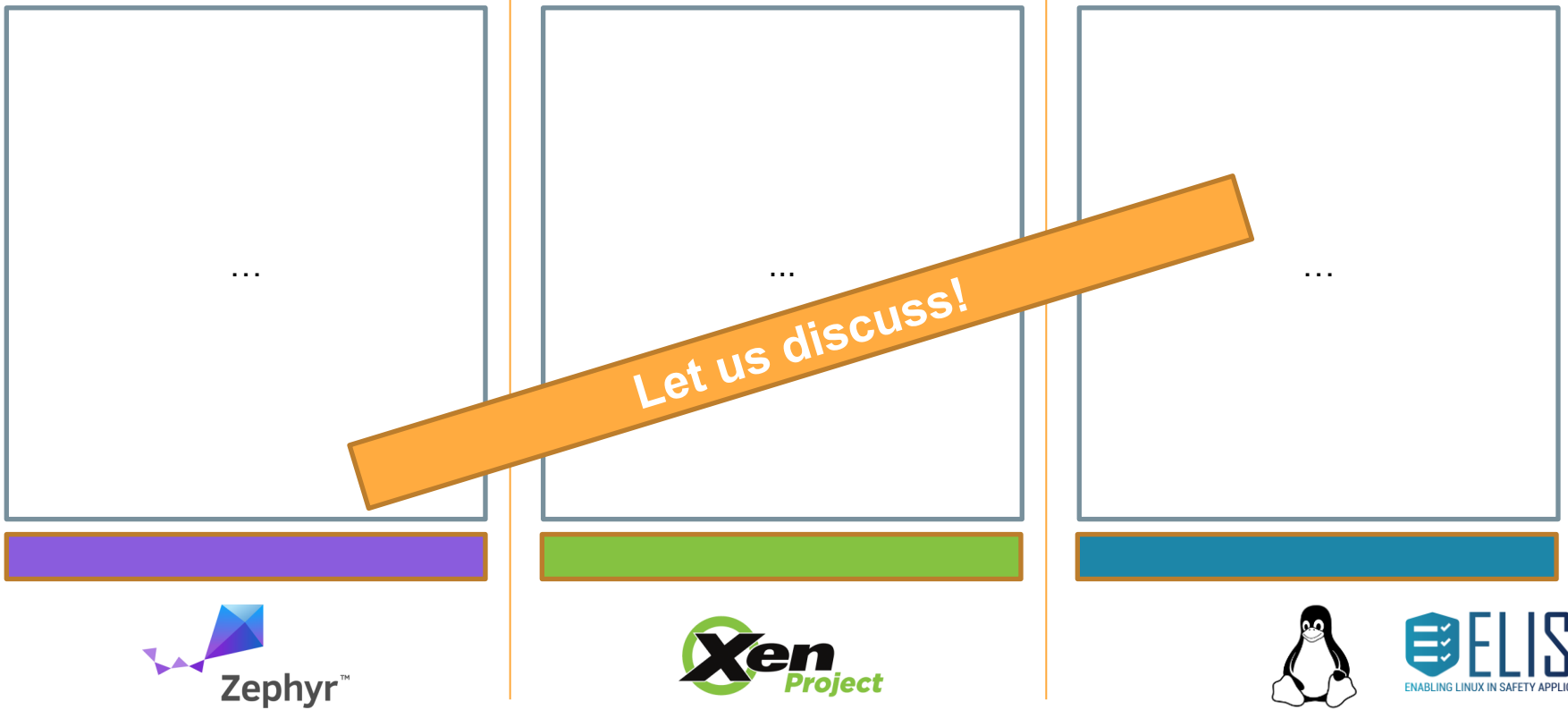
- Just show up – All presented projects are open for the adaptation of new use cases, input, domain-specific working groups etc.

- Share Safety Best Practice: Functional and structural expectations of the component used in the context of the entire system

- Become an OSS evangelist: Open source can already be used in a variety of safety contexts. Knowledge of the actual structure and potential is very scarce in the field of assessors, notified bodies and related authorities.

ELISA
ENABLING LINUX IN SAFETY APPLICATIONS

Bet on certification (if and when)?!



ELISA

ENABLING LINUX IN SAFETY APPLICATIONS

Aerospace · Automotive · Linux Features · Medical Devices

OS Engineering Process · Safety Architecture · Systems · Tools

Thank you.

Getting involved with ELISA

https://elisa.tech

https://github.com/elisa-tech

https://lists.elisa.tech

https://www.youtube.com/@elisaproject8453

ELISA
ENABLING LINUX IN SAFETY APPLICATIONS

Getting involved with Zephyr

https://www.zephyrproject.org

https://www.github.com/zephyrproject-rtos

https://lists.zephyrproject.org

https://chat.zephyrproject.org

ELISA
ENABLING LINUX IN SAFETY APPLICATIONS

Getting involved with Xen

https://www.xenproject.org

https://github.com/xen-project

https://xenproject.org/help/mailing-list/

https://xenproject.org/help/matrix/

ELISA
ENABLING LINUX IN SAFETY APPLICATIONS