Safety Critical
Special Interest Group

1st session

February 28th 2024

Your Chair

Verena Beckham

- At Codeplay since 2006

- Background in SW Engineering (compilers)

- VP of Safety Engineering since 2020

- Focused mostly on automotive

- Chair of SYCL SC Exploratory Forum / WG since 2022

- Proposer of this SIG

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Enabling AI & HPC To Be Open, Safe & Accessible To All

Established 2002 in **Edinburgh, Scotland**.

Grown successfully to around 100 employees.

In 2022, we became a **wholly owned subsidiary** of Intel.

Committed to expanding the **open ecosystem** for heterogeneous computing.

Through our involvement in oneAPI and SYCL governance, we help to **maintain and develop** open standards.

Developing at the forefront of **cutting-edge research**.

Currently involved in two research projects - **SYCLOPS** and **AERO**, both funded by the Horizon Europe Project.

Agenda

- Introduction the UXL Foundation

- Introduction to this SIG

- Relationship to other groups

- Round of introductions – Verena first

- Next steps for the SIG

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Welcome to the Unified Acceleration (UXL) Foundation!

Mission

- Build a **multi-architecture multi-vendor software ecosystem** for all accelerators
- **Unify** the heterogeneous compute ecosystem **around open standards**
- Build on and expand **open-source projects for accelerated computing**

Use case focus: AI, HPC, Edge AI and Edge Compute

Software Challenges for Accelerator Computing

- Heterogeneous architectures are multi-vendor

- Significant investment to migrate software to new hardware

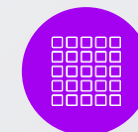- Need an open standard way to develop software for accelerators

Application Workloads Need Diverse Hardware

| Scalar | Vector | Matrix | Spatial |

Middleware / Frameworks

Languages & Libraries

| CPU | GPU | FPGA | Other Accel. |

Hardware Challenges for Accelerator Computing

- Software developers demand a standard way to target processors

- Huge investment is required to deliver a software platform for new hardware architectures
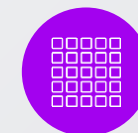
Application Workloads Need Diverse Hardware

Scalar **Vector** **Matrix** **Spatial**

Middleware / Frameworks

Languages & Libraries

CPU **GPU** **FPGA** **Other Accel.**

Unified Acceleration Foundation
Steering Members

arm

FUJITSU

Google Cloud

Imagination

intel

Qualcomm

SAMSUNG

vmware by Broadcom

www.uxlfoundation.org

Governance

Joint Development Foundation governance under Linux Foundation

SIGs: AI, Hardware, Language, Math, Safety Critical

Working Groups: Specification, Open Source

Join Us:

Participate in SIGs and Working Groups

UXL Foundation Structure

Technical Steering Committee

Special Interest Groups

Working Groups

Open Source Projects
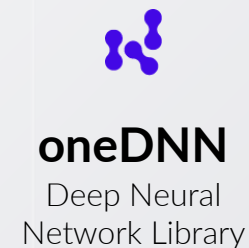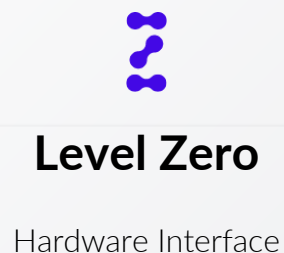oneCCL, oneDAL, oneDNN, oneDPL, oneMKL, oneTBB

Specification
oneAPI Specification

Unified Acceleration Foundation

oneAPI Specification and Projects

- **Initial contribution:** oneAPI Specification & Open Source Projects

oneAPI
Specification

Level Zero

Hardware Interface

oneDPL
Data
Parallel C++ Library

oneDNN
Deep Neural
Network Library

oneCCL
Collective
Communications Library

oneDAL
Data
Analytics Library

oneTBB
Threading
Building Blocks

oneMKL
Math
Kernel Library

Approach

The founding companies are seeding the project with highly valuable contributions to open-source libraries

Working Groups

Specification WG – defining an open standard for accelerated libraries

Open Source WG – coordinating community contributions and feedback
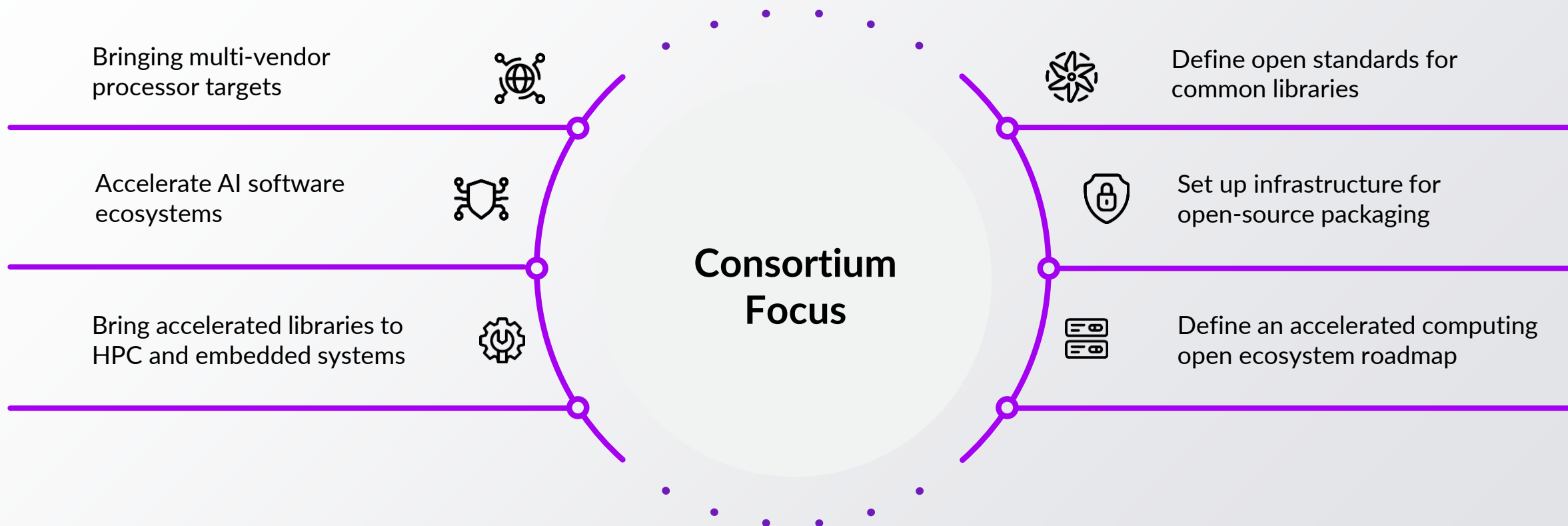
The group will work to drive the development of an open ecosystem for accelerated computing based on the fundamentals of open standards and open source

Project governed by the Joint Development Foundation (JDF), a part of the Linux Foundation

Technical Goals

Open specifications, APIs, open source for AI and HPC, Edge Compute, and Edge AI

Bringing multi-vendor processor targets

Accelerate AI software ecosystems

Bring accelerated libraries to HPC and embedded systems

Consortium Focus

Define open standards for common libraries

Set up infrastructure for open-source packaging
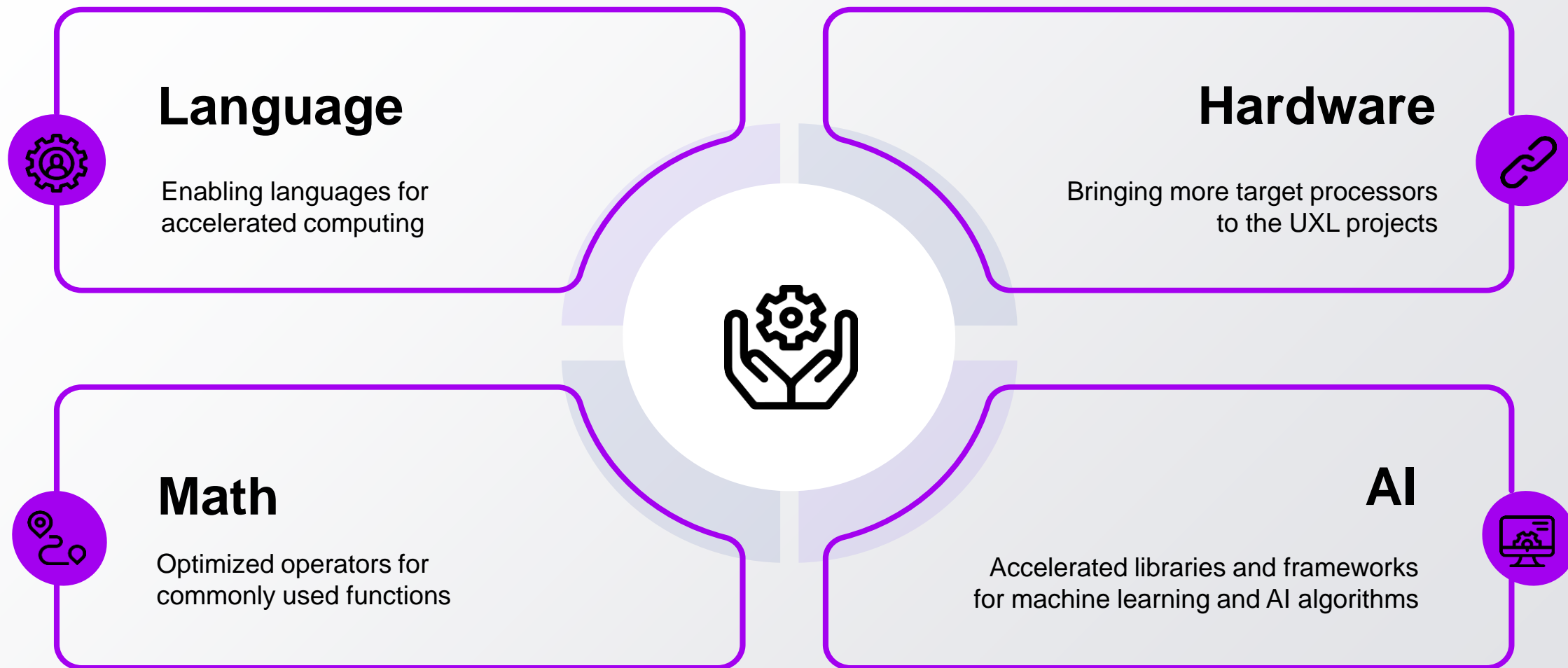
Define an accelerated computing open ecosystem roadmap

Unified Acceleration Foundation
Existing Ongoing Collaborations

- **Fujitsu:**
  oneAPI Deep Neural Network Library (oneDNN); oneAPI Data Analytics Library (oneDAL) optimizations for Arm processors

- **Google Cloud:**
  oneDNN optimizations for Intel processors

- **Argonne, Lawrence Berkeley & Oakridge:**
  DPC++, oneMKL and oneDNN used on Intel, Nvidia and AMD GPUs

- **GROMACS:**
  SYCL and oneAPI used to target multi-vendor architectures

Other UXL Foundation SIGs

Language

Enabling languages for accelerated computing

Hardware

Bringing more target processors to the UXL projects

Math

Optimized operators for commonly used functions

AI

Accelerated libraries and frameworks for machine learning and AI algorithms

Join The UXL Foundation

Steering Member
$20k*

- Seat on the Steering Committee
- Voting Rights
- Define the direction of the foundation

General Member
$5k*

- Working Group Voting Rights
- Influence Working Group direction
- Co-marketing

Contributor Member
$0

- Participate in Working Groups
- Contribute to the specification
- Contribute to the projects

membership@uxlfoundation.org

www.uxlfoundation.org

* plus Linux Foundation membership

Agenda

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- **Introduction to this SIG**
- **Relationship to other groups**
- Round of introductions – Verena first
- Next steps for the SIG
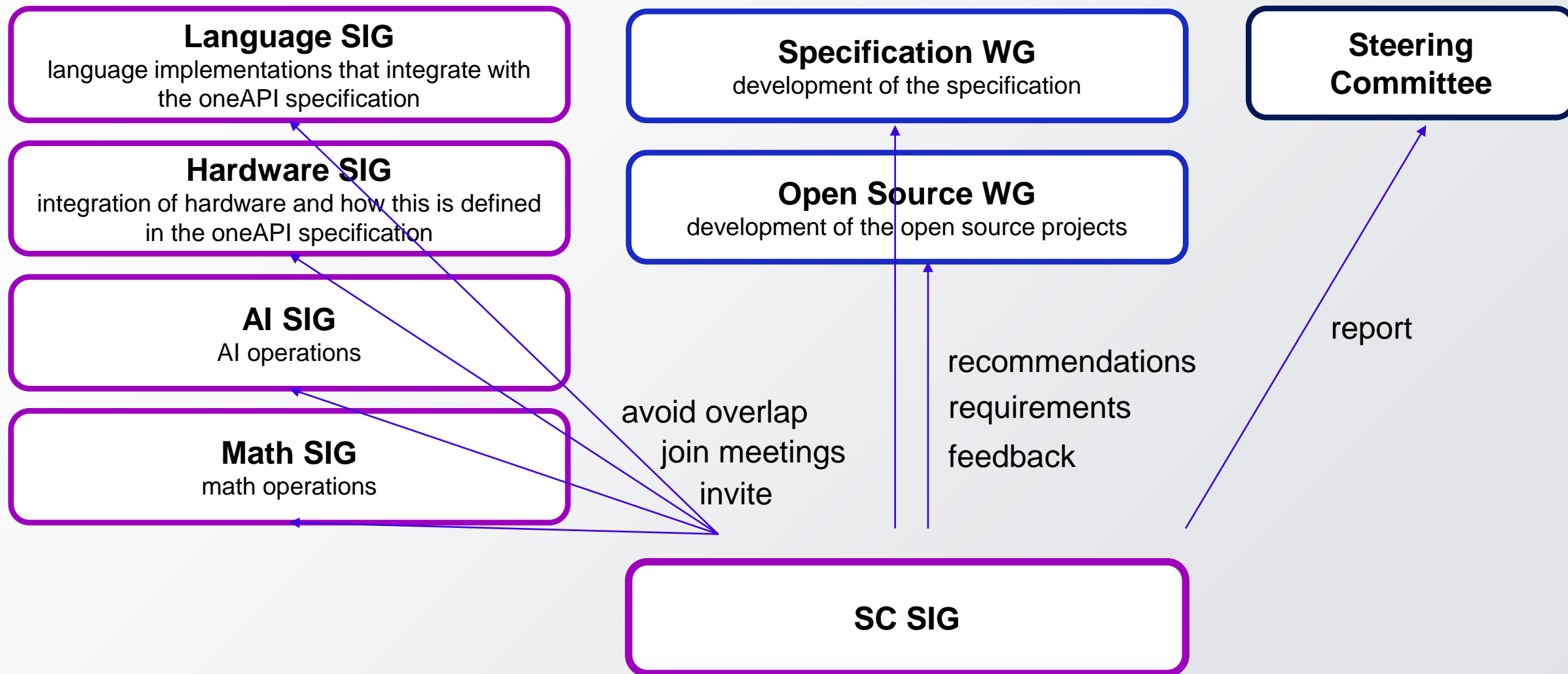
Safety Critical SIG

Aim:

Enable/accelerate integration of UXL projects into safety critical systems

The Special Interest Groups are open to anyone and bring together industry experts to help guide the oneAPI specification and open-source projects.

SIG activities include the following:

- *Open technical discussions relevant to specific technologies and the oneAPI specification*

- *Helping review and presentation of proposals*

Relationship to Other Groups

Language SIG
language implementations that integrate with the oneAPI specification

Hardware SIG
integration of hardware and how this is defined in the oneAPI specification

AI SIG
AI operations

Math SIG
math operations

Specification WG
development of the specification

Open Source WG
development of the open source projects

Steering Committee

avoid overlap
join meetings
invite

recommendations
requirements
feedback

report

SC SIG

www.uxlfoundation.org

Why?

- Safety-critical industries (automotive, avionics, medical, etc.) increasingly require *acceleration* of software, due to
  - Rising popularity of **AI** algorithms
  - Proliferation of **heterogeneous** computing
  - Increasing demand for **performance**

What?

- Based on SYCL 2020
- Modifications to ease safety-certification
  - Of the implementation of the standard
  - Of the SYCL application

Industry safety-critical standards include
RTCA DO-178C (avionics) | ISO 26262 (automotive)
IEC 61508 (industrial) | IEC 62304 (medical)

Simplified
Runtime can be more easily certified

Robust
Comprehensive error handling
Removal of ambiguity
Clarification of undefined behaviour

SYCL|SC™
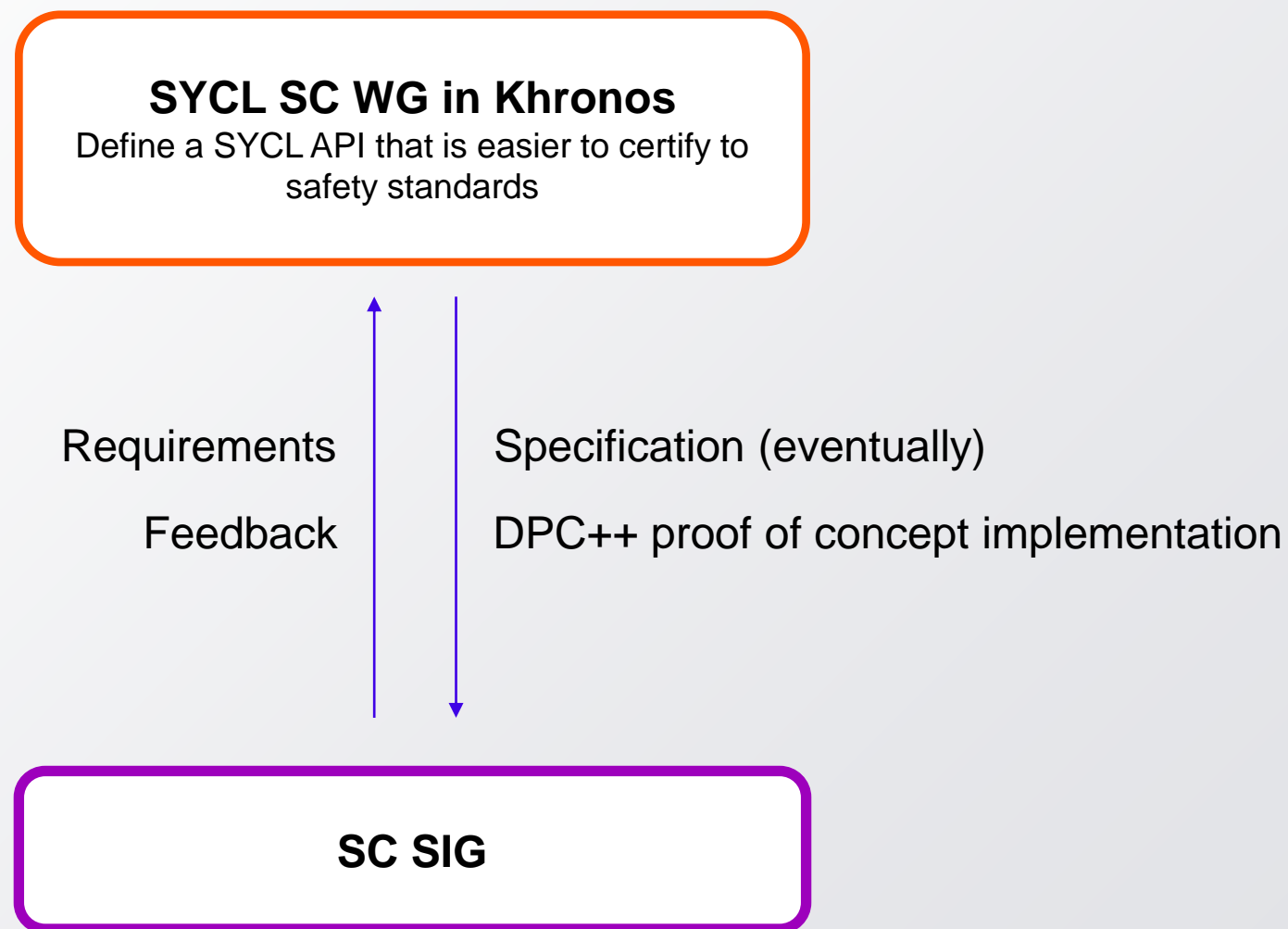
Deterministic
Predictable execution time
Predictable results

Interested?
Visit www.khronos.org/syclsc
Contact sycl_sc-chair@lists.khronos.org
Join the Working Group

Relationship to Other Groups (2)

SYCL SC WG in Khronos
Define a SYCL API that is easier to certify to safety standards

Requirements   Specification (eventually)

Feedback   DPC++ proof of concept implementation

SC SIG

Rules of the SIG

DO NOT share any confidential information or trade secrets with the group

DO keep the discussion at a High Level

The roadmap is decided by the SIG

- Focus on the meeting's agenda topics
- Suggest agenda topics!
- Present on relevant topics
- Suggest guest invitations

Chair elections will happen at some point in the future

Quarterly meetings & mailing list & Slack

Links

Membership portal: https://lists.uxlfoundation.org/g/Safety-Critical-SIG

Mailing list: Safety-Critical-SIG@lists.uxlfoundation.org

Slack: https://join.slack.com/t/uxlfoundation/shared_invite/zt-2b1tm2frp-GZY~JBngtXo5xRrcgFrV6Q

Meeting minutes:
https://github.com/uxlfoundation/foundation/tree/main/safety-critical

UXL Foundation: http://www.uxlfoundation.org

OneAPI repository: https://github.com/oneapi-src

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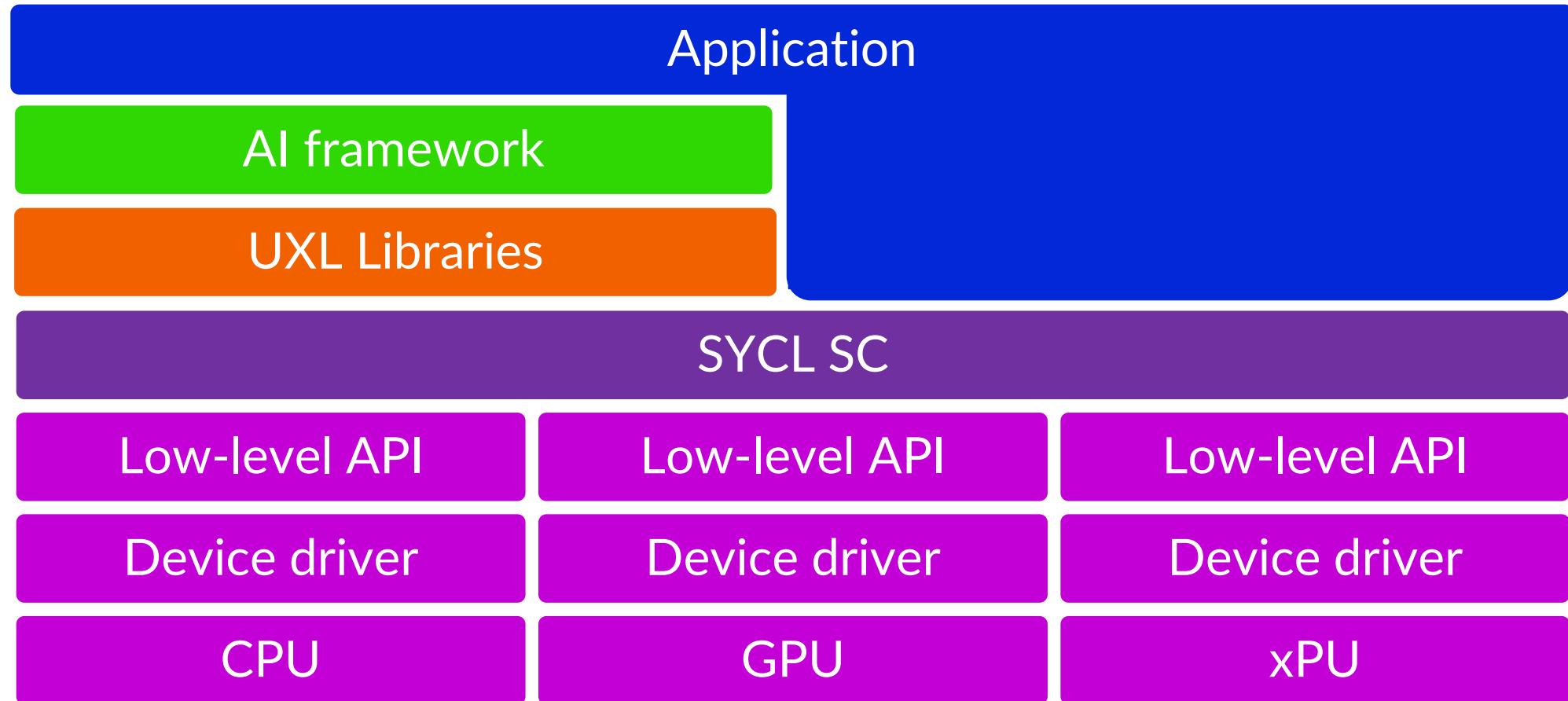- Next steps for the SIG

Interests

- SYCL

- Automotive mostly

- Higher safety levels (not just QM)

Vision

- oneAPI in vehicles on the road to accelerate ADAS and AD on centralised compute

- Safe implementations of SYCL SC based on DPC++, for a range of HW

- UXL libraries: ported to SYCL SC & qualified/certified

- Safe AI SW ecosystem

- Community combines efforts
  - Sharing best practice
  - Contributing to open-source
  - Sharing templates/fragments of certification artefacts

Safety of the Stack

Application		
AI framework		
UXL Libraries		
SYCL SC		

Vulkan SC?
Safe Level 0?

Low-level API	Low-level API	Low-level API
Device driver	Device driver	Device driver
CPU	GPU	xPU

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Immediate Problems

- Reviewing oneAPI design proposals
  - Potential impact on SC use cases!
  - I need to represent all of SC
  - I need to send a lot of emails

- oneAPI design targeted mostly at HPC
  - Decision makers have little understanding of SC/embedded requirements
  - Priority: Performance

- Interested companies asking, "How could we integrate this into our system?"
  - I repeat myself a lot
  - I don't have all the answers/experience

Safety Advantages of SYCL

Device-agnostic

- Reduces overheads of safety analysis and testing over generations

Abstraction

- Developers can focus on the safety, instead of low-level data/dependency management
- Optimisation strategies can be quickly tried out, hence WCET is reduced more quickly
- Clear interfaces between layers of the stack, supporting separation of concerns and improving testability

Industry standard

- Encourages independent tools to be developed
- Facilitates verification by comparison
- Industry scrutiny ensures higher confidence in the safety
- More likely to attract the research community

C++ based

- Guidelines already exist (Misra C++:2023)
- Skilled engineers available, many training options
- Existing (qualified) CPU compiler can be used
- Ecosystem of qualified tools exist – automates a lot of ISO 26262-6 recommended development methods

Single source

- Type-safety across host & device boundary

Safety Advantages of UXL

Ecosystem

- Existing ecosystem, including libraries & tools
- Can get started immediately, make safe later

Open-Source

- More eyes on source code means fewer bugs

Widely-Used

- More implementations/use means more opportunities to detect bugs
- Can benefit from others' bug fixes

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Opportunity

- UXL Foundation is still young and malleable
- UXL processes not finalized
- History of code relatively clean (mostly Intel)

Verena's Aims for the SIG

- Ensure UXL projects fit into an SC system
- Allow UXL projects to be more easily made safe / safety-certified according to standards
- Make SC requirements more visible to decision makers
- Provide companies a place to discuss issues / exchange ideas
- Collectively improve UXL processes
- Ideally: Collaborate on documentation, testing, templates for safety artefacts
- Ideally: Collaborate on implementations of (safe) libraries

Safety Concerns

- Allow UXL projects to be made safe
  - Allow difficult-to-certify features to be removed
  - Favour designs that maximise offline work
  - Avoid modules that are complex/large
  - Follow coding standards, e.g. MISRA C++:2023
  - Extensive testing, including coverage checking
  - Documentation (of design, use)
  - Solid development processes

- Allow an application using UXL projects to be safe
  - APIs follow coding standards
  - APIs allow applications with predictable timing properties
  - Enable certified tools to be used in development

System Concerns

- Integration with domain-specific OSs and RTOSs
- Targeting of / Optimising for relevant embedded devices
- Integration with sensors
- Integration with the system, e.g. multiple different accelerators
- Integration with other software in the system, e.g. sharing processors/accelerators safely
- Cyber security

Ideas

- Improve processes – ASPICE?
- Improve testing
- Improve static analysis
- Improve specifications to ease Qualification
- Collect historical evidence
  - Requirements
  - Design descriptions
- Qualification kit for DPC++
- Qualification kit for libraries?

ELISA
https://elisa.tech/

- Same aim
- Similar issues?
- Much bigger scope

ELISA
ENABLING LINUX IN SAFETY APPLICATIONS

About   Membership   Community   News & Events   Resources   Join Now

Advancing Open Source Safety-Critical Systems

The Enabling Linux In Safety Applications (ELISA) project aims to make it easier for companies to build and certify Linux-based safety-critical applications – systems whose failure could result in loss of human life, significant property damage or environmental damage. ELISA members are working together to define and maintain a common set of tools and processes that can help companies demonstrate that a specific Linux-based system meets the necessary safety requirements for certification.

Ferrocene Rust Compiler
https://ferrous-systems.com/blog/officially-qualified-ferrocene/

- Ferrous Systems qualified a Rust compiler (Ferrocene)
- Ferrocene is open source
- Branch from the official Rust compiler
- Qualification Kit is open source (?)
- Licenses provided by Ferrous Systems at a cost

Round of Introductions

- Why did you join the SIG?
- What part are you/your company interested in?
- What do you hope to get out of the SIG?

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Review - Summary

The Safety Critical SIG hosts discussions and presentations on functional safety topics as relating to the UXL specification and implementation. The aim of the SIG is to enable or accelerate integration of UXL elements into safety critical systems, targeting markets such as automotive and avionics.

https://github.com/uxlfoundation/foundation/blob/main/safety-critical/README.rst

Corrections?

Task – High Level Plan for 2024

- What do we want to achieve?

Call to Action

What could you contribute?

- Use cases?
- Samples?
- Code?
- Experts?
  - E.g., FuSa experts to do analysis
  - E.g., Open-source experts to give advice
- Experience reports?
- Lessons Learnt from other groups (e.g. ELISA)?

Who are we missing?

- Companies/Individuals we should invite?
  - Participate
  - Speak
- Collaborations we should initiate?
- Conferences we should attend?

UXL
Unified Acceleration Foundation

Feedback

- Any comments?
  - On the organization/running of the SIG?

Thank you for attending!

- Minutes will be uploaded to https://github.com/uxlfoundation/foundation/tree/main/safety-critical

- Contact me with agenda suggestions: verena@codeplay.com

- Forward invitations to others to join the SIG

- Continue discussion via mailing list: Safety-Critical-SIG@lists.uxlfoundation.org and Slack

- Join UXL on LinkedIn: https://www.linkedin.com/groups/14241252/