

OpenVX Town Hall Meeting

Framing the Future of Image and Sensor Processing

March 26, 2025

This webinar will begin at 07:00 am PDT



**WEBINARS
& MEETUPS**



Wednesday, March 26th Agenda

Welcome and Introductions

Khronos Updates

- Neil Trevett, NVIDIA

Overview of Use Cases and Recent Updates to OpenVX

- Kiriti Nagesh Gowda, AMD and Khronos OpenVX Working Group Chair

OpenVX for Automotive: Accelerating Vision Processing Across Diverse Sensors

- Raphael Cano, Bosch

OpenVX 2.0: Framing the Future of Vision and Sensor Processing

- Raphael Cano, Bosch

Open questions and discussion



Kiriti Nagesh Gowda,
AMD and Khronos OpenVX Working
Group Chair



Neil Trevett, NVIDIA



Raphael Cano,
Bosch



**WEBINARS
& MEETUPS**

KHRONOS
GROUP

OpenVX Core

Base Features

Essential Extensions

Custom / Target Nodes

Vision Nodes

Enhanced Vision Nodes

Neural Network Nodes

Real-time Nodes

Extensions

OpenVX
TM

TOWN HALL DISCUSSION

**Framing the Future of
Image and Sensor Processing**

Khronos Connects Software to Silicon



KHRONOS
GROUP

Non-profit Standards Consortium
creating open, royalty-free standards

Focused on runtime APIs and file formats
for 3D, XR, AI, vision, and
parallel compute acceleration

Member-driven, open to any company

Founded in 2000

~ 160 Members | ~ 40% US, 30% Europe, 30% Asia

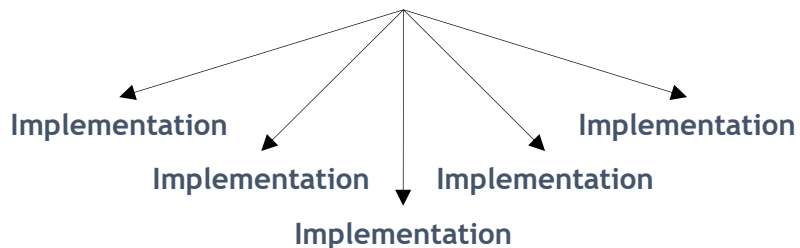
Open Standards and Open Source

Open Standards

INTEROPERABILITY via precisely specified (and conformance tested) COMMUNICATION

E.g., software to hardware, client to server

Open Standard = Shared Specification



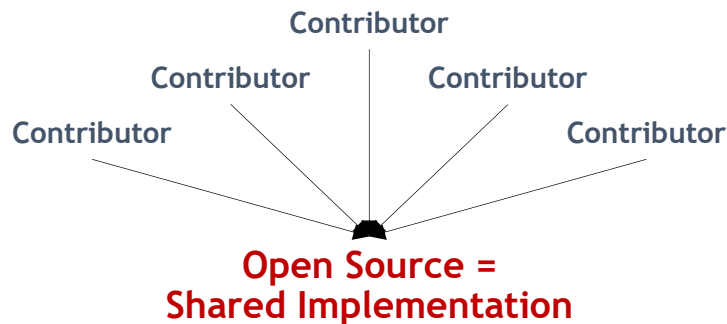
A technology can be widely deployed to meet multiple market needs without fragmentation

Often used for **HARDWARE** APIs to enable healthy competition between diverse implementations

Open Source

Collective collaboration to share engineering effort

Under a well-defined Contributor License Agreement



Consistency and transparency through a single openly available implementation

Often used for **SOFTWARE** libraries & languages when no advantage to competing over multiple implementations

Open standards often use **open source** for tooling & sample implementations

Khronos Active Standards

GPU Processing

Desktop, Mobile, Web
Low and high-level



Parallel Compute

Machine Learning
Vision Processing



Spatial Computing

Augmented & Virtual Reality
Camera Control



3D Asset Formats

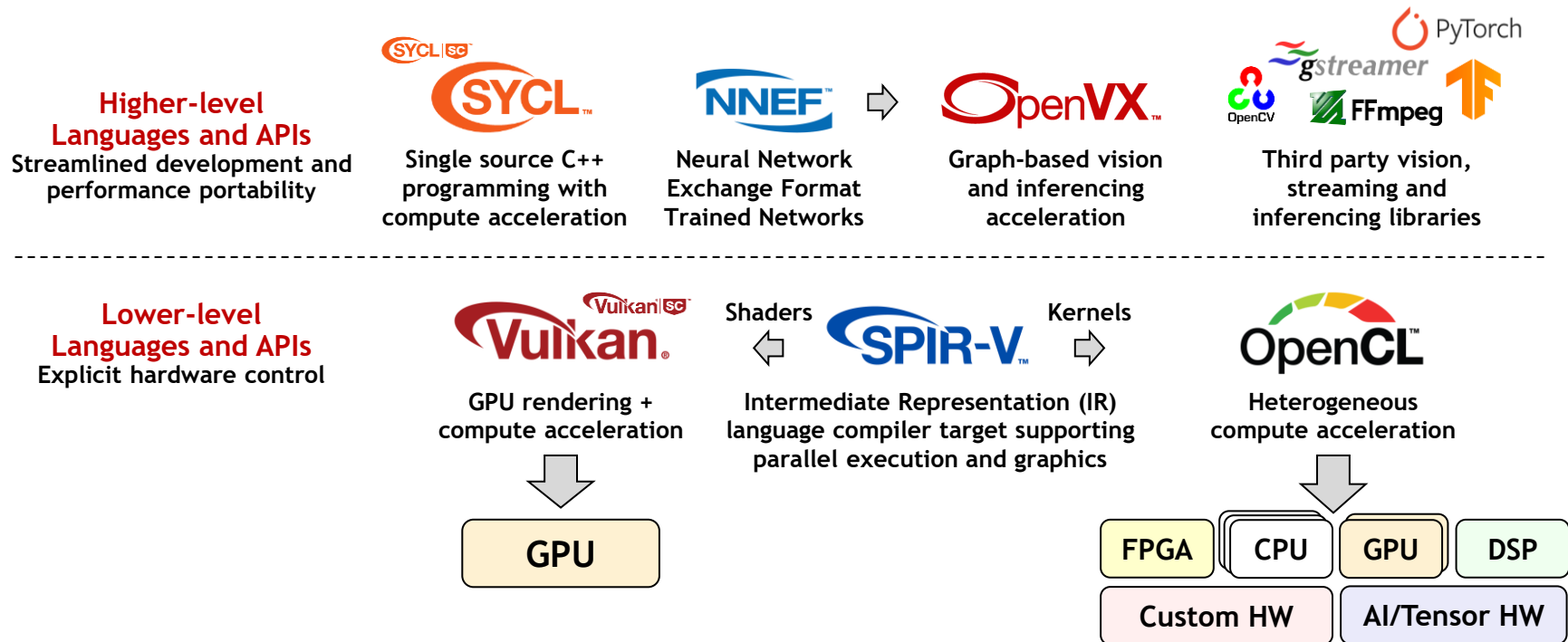


Safety Critical APIs

Khronos Compute Acceleration

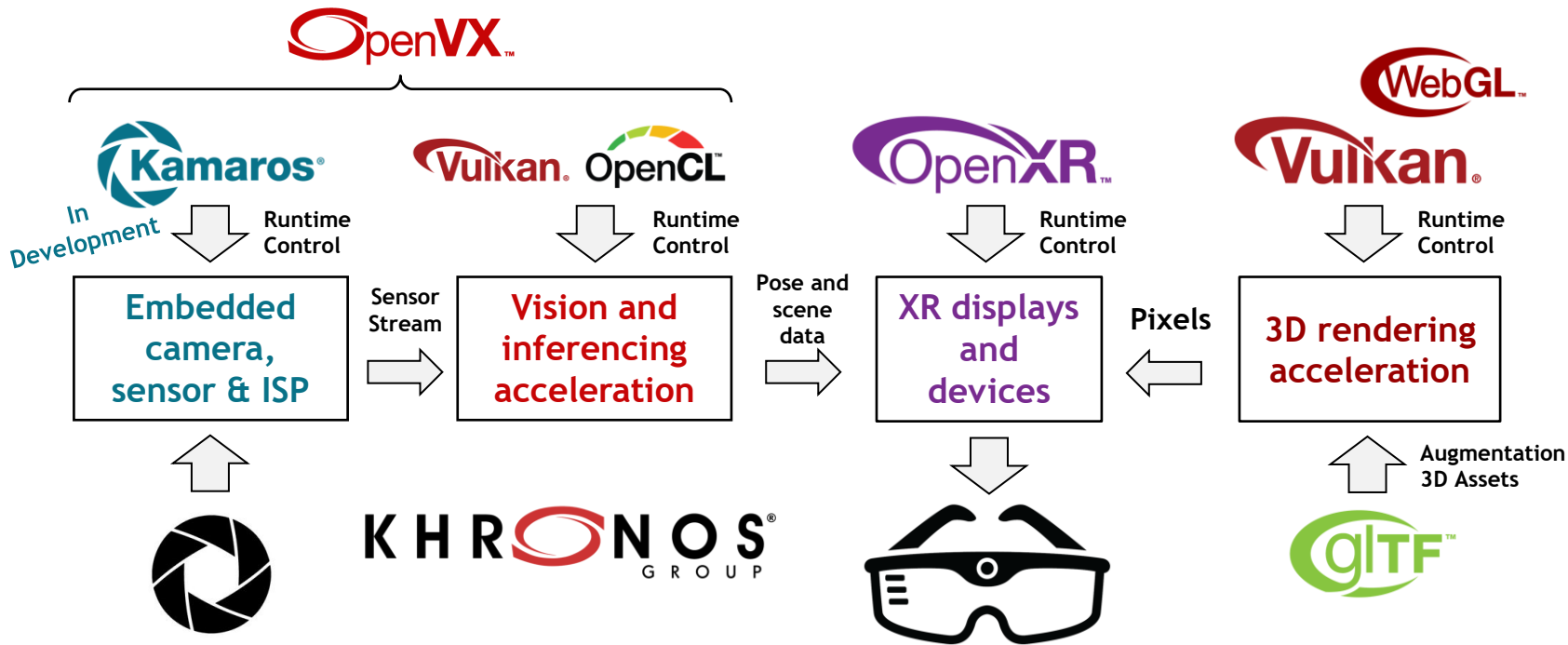
Choice of programming models to meet the needs of diverse developers

Higher-level applications, libraries, and languages and APIs often use lower-level standards



Khronos Spatial Computing APIs

OpenVX can provide control over dataflow between lower-level functional blocks



Call for Input and Participation

- Please help ensure OpenVX meets your needs and requirements!
 - Your participation and feedback is very welcome
- Any company is welcome to join Khronos to directly influence API design and evolution
 - www.khronos.org/members/
 - Email memberservices@khronosgroup.org
- More information on OpenVX and all Khronos APIs
 - <https://www.khronos.org/>





Town Hall

Kiriti Nagesh Gowda

March 2025

Computer Vision - it's increasingly relevant

The idea that computer vision might be irrelevant likely stems from a few misconceptions, but here's why it's not just relevant—it's critical to the future of AI and automation.

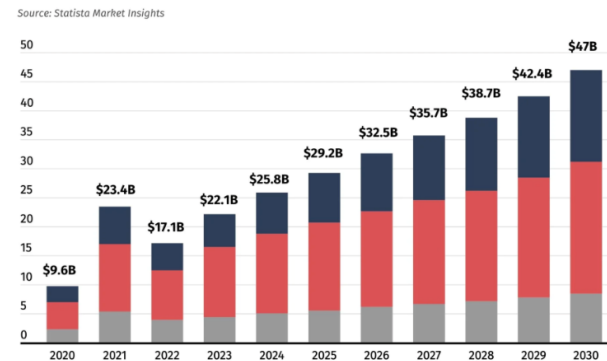
- **CV is More Than Just "Classic" Image Recognition:**
 - Vision Transformers (ViTs)
 - Multimodal AI (GPT-4V, LLaVA) merges vision with language, enabling AI to "see" and reason about images.
- **Real-World Applications Are Exploding:**
 - Autonomous Vehicles
 - Medical Imaging
 - Robotics
- **New Challenges = New Opportunities:**
 - Efficient Edge AI
 - 3D & NeRF (Neural Radiance Fields)
 - Video Understanding – Real-time analysis for security, sports analytics, and content moderation.

Computer Vision - it's increasingly relevant

- Computer vision is far from just a trend
- It's a foundational technology enabling AI to interact with the visual world.
- As long as cameras and visual data exist, CV will remain critical in shaping the future of automation, AI, and human-computer interaction.

Computer Vision Market Growth

Market size of the computer vision market from 2020 to 2030, by segment (in billion U.S. dollars)



<https://www.edge-ai-vision.com/2024/05/computer-vision-market-to-grow-by-81-and-hit-a-47-billion-value-by-2030/>



 **for automotive systems**

The "OpenVX" logo consists of a red stylized ring followed by the text "OpenVX" in a red, sans-serif font. The "VX" is in a bolder weight than "Open".

Cano Raphael-Robert Bosch GmbH
March 2025

Agenda

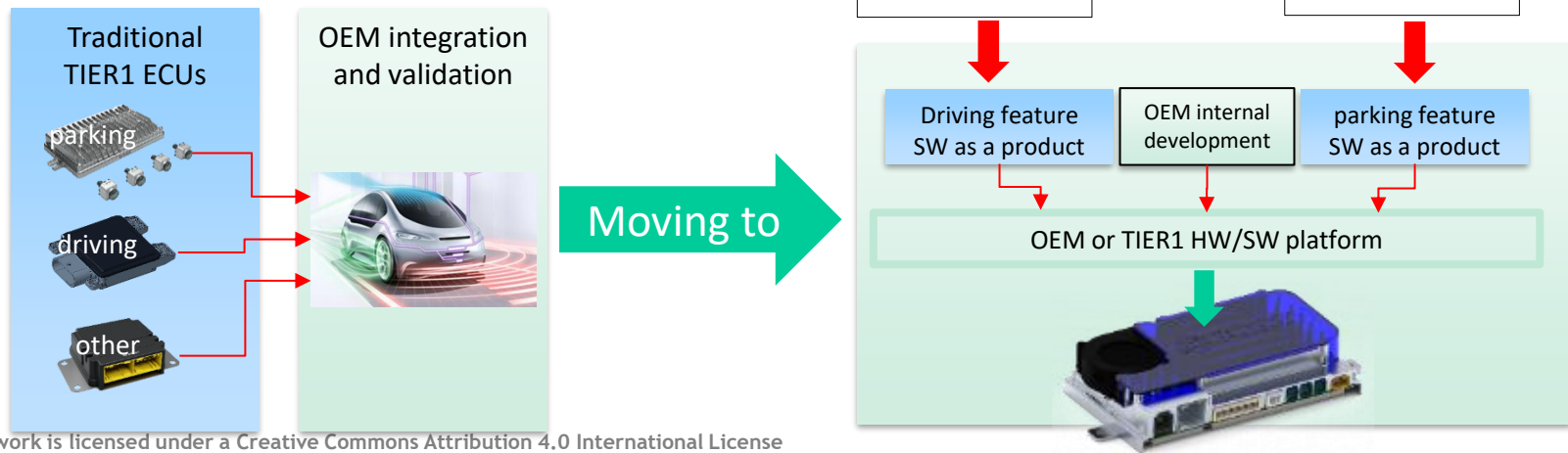
- Automotive technologies and complex use cases
- Automotive: A new business model
- How can OpenVX help TIER1 and OEMS (and SoC vendors) ?
- OpenVX concepts
- The Future of OpenVX: The road to version 2.0

Automotive technologies and use cases

- **Technologies/sensors used in automotive domains**
 - Ultrasonic, radar, lidar and video sensors
- **Automotive use cases cover a lot of different situations which can be split into these domains**
 - Manoever-Stack
 - Driver monitoring / interior camera
 - Convenient cameras like trailer / tailgate etc.
- **All these functions require different image pipelines like:**
 - Video streams suited for computer vision (different ISP setting and formats)
 - Video streams suited for human vision (different ISP settings and formats)
 - Different stream based on different type of sensor (IR stream)

A New business Model for the Automotive Industry

- Over the past few years and the emergence of the SW defined vehicle, the market has shifted from multiple dedicated (black-box) ECUs for parking, driving, and other functions to a centralized ECU that consolidates these functionalities.
- This transition has led to a restructuring of the development and integration models for the OEM / TIER1 and TIER2



Bosch Adaptation to this New Situation

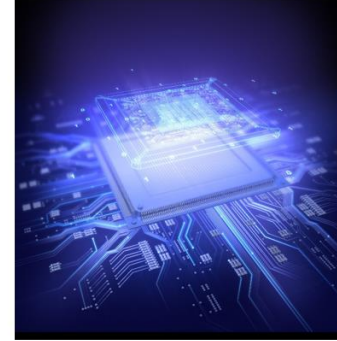
Tailored computing solution

Our approach enables customer tailored computing solutions based on the underlying modular construction kit



No SoC lock-in

Based on our flexible electronic concept we can integrate SoCs of various vendors to avoid SoC lock-in effect



ECU and system competence

We as Bosch bring in comprehensive know-how and series-proven experience both on ECU and system level

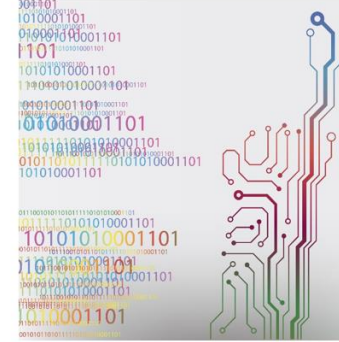
Modular electro-mechanic concept

Based on our modular electro-mechanical concept we can offer single ECU solutions as well as multi-ECU rack integration



Customer and 3rd party SW support

Our flexible integration platform supports Bosch SW as well as customer and 3rd party SW solutions



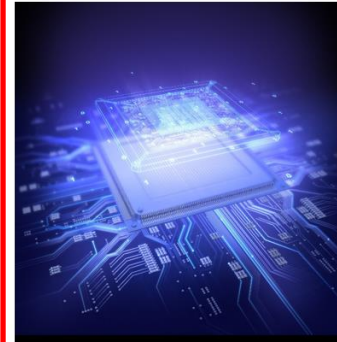
How does OpenVX help TIER1 and OEMS ?

- Royalty-free open standard API that is reliably accelerated by hardware vendors and tightly defined conformance tests.
- Targeted at low-power, real-time applications including mobile and embedded platforms.
- Portability across diverse heterogeneous processors, including ISPs, dedicated hardware, DSPs and DSP arrays, GPUs, multi-core CPUs, and more.

2

No SoC lock-in

Based on our flexible electronic concept we can integrate SoCs of various vendors to avoid SoC lock-in effect



ECU and system competence

We as Bosch bring in comprehensive know-how and series-proven experience both on ECU and system level

OpenVX™

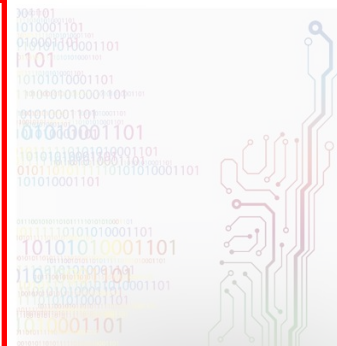
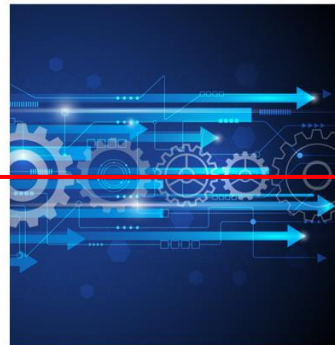
Modular electro-mechanic concept

Based on our modular electro-mechanical concept we can offer single ECU solutions as well as multi-ECU rack integration

1

Customer and 3rd party SW support

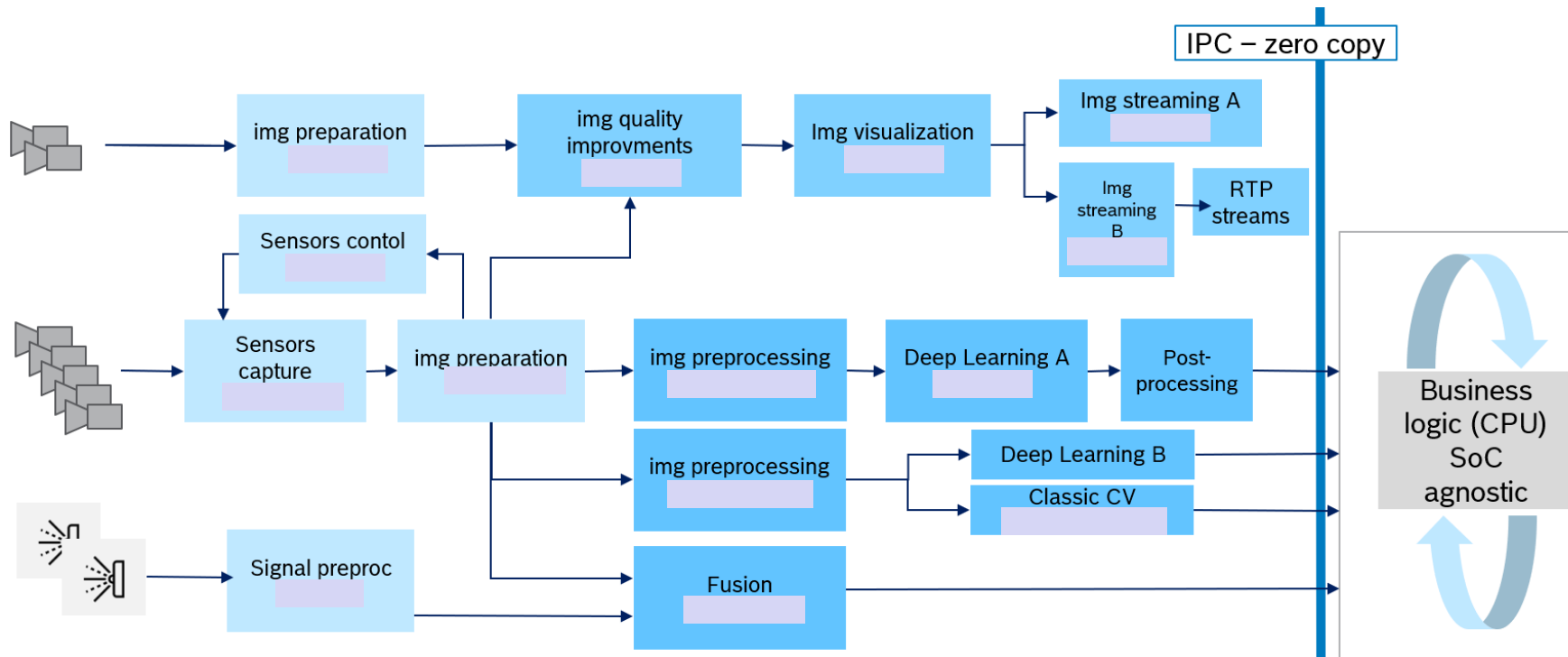
Our flexible integration platform supports Bosch SW as well as customer and 3rd party SW solutions



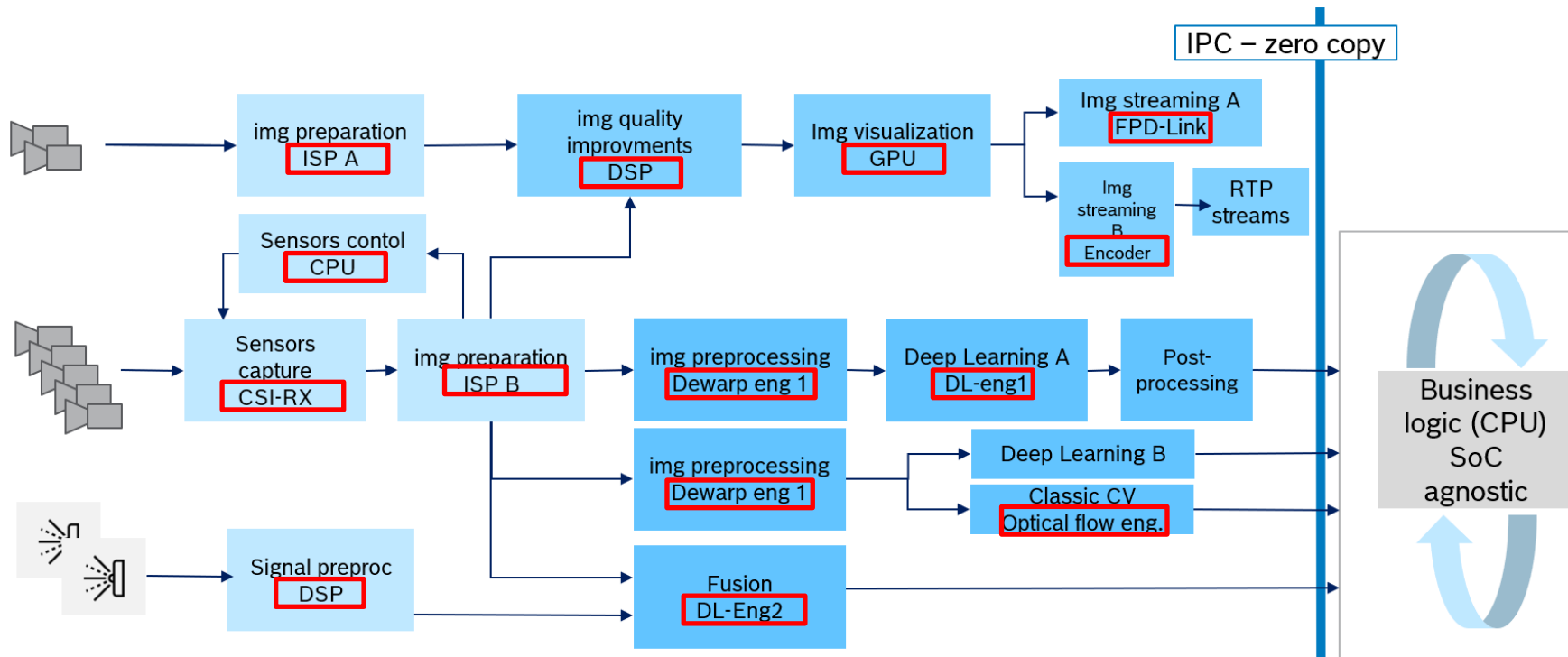
Automotive technologies and use cases

- **No Soc lock-in**
 - For TIERx: Ability to (fast) transition to a new hardware platform based on OEM requirements.
 - For OEMs: Flexibility to switch (fast) to a new SoC, enabling cost savings and dual sourcing.
 - For SoC vendor: Provides a platform to showcase hardware capabilities within the same ecosystem.
- **Customer and third-party SW integration**
 - Facilitates integration by providing a standardized interface.
 - Library Integration: Enables validation and testing processes for library integrations.
 - Reduced Complexity: Mitigates and reduces integration complexity
- **Cross-Generation Compatibility: Builds and capitalizes across system generations by providing mechanisms and standards**
 - See next slide for a typical automotive use case and how we solve it using OpenVX

Typical data pipelines used in our projects

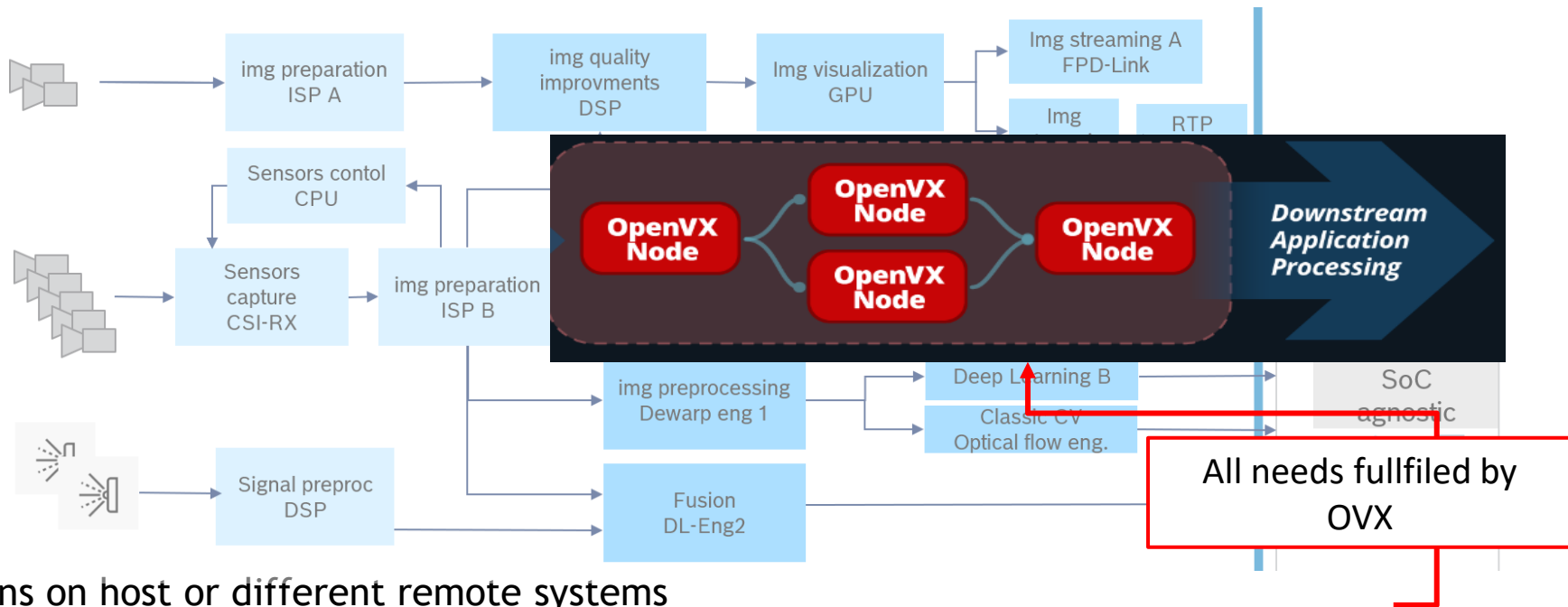


Typical data pipelines used in our projects



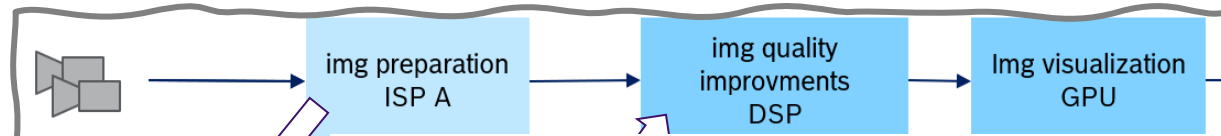
Data pipelines are spread across various HWAs, cores, and subsystems

OpenVX Concepts: Nodes and Graphs



- Each
 - U
 - Runs on host or different remote systems
- All blocks/nodes may run in parallel and form a graph
- All computations run fast with minimal interactions with the host (CPU) system

OpenVX concepts: No SoC lock-in / ease of integration

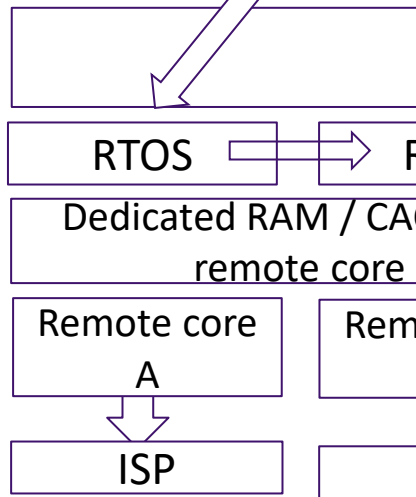


- **No Soc lock-in !**

- Pipelines (graphs) remain the same across different SoC (same “functional” need)
- Only kernels implementation differs (if needed)

- **Decomposing data pipelines into nodes allows for:**

- Supplier Flexibility: Nodes can be delivered by different suppliers.
- Independent Validation: Each node can be validated separately, outside of the entire graph.
- IP Protection: IP can be protected by using binaries if necessary.



OpenVX concepts: Capitalize across system generations

- Every automotive applications (and beyond) should
 - Meet safety and security goals
 - Be portable by re-using the same code base / documentation and quality artefacts
 - Be robust and reliable
 - Offer mechanisms for error detection and recovery
 - These requirements are complex and time consuming to develop!
 - Reusing these concepts across SoC and system generations is a smart approach.
- OpenVX provides the API and a stable platform to achieve this!**
- You can have the best AI algo, if the data are not available it does not help!

OpenVX concepts: Capitalize across system generations

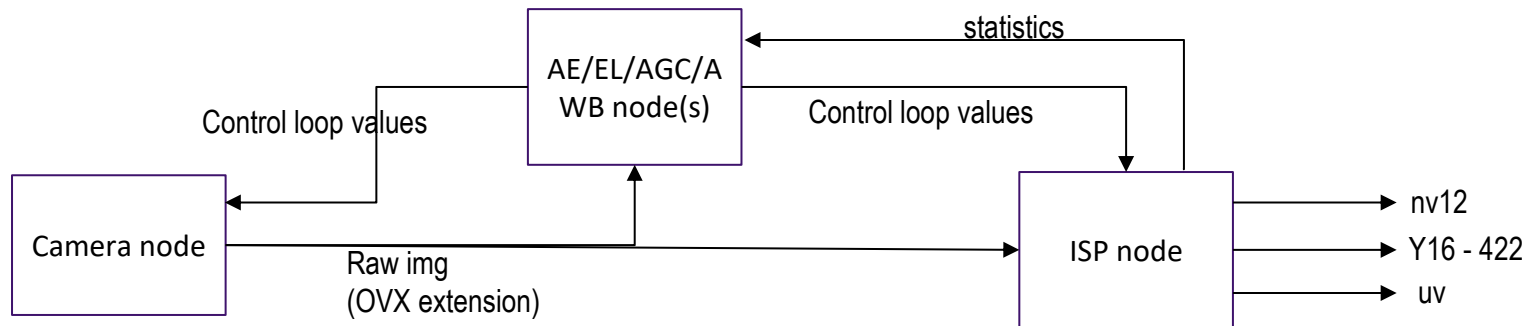
- Here are a few examples of OVX features that help achieve safety and security goals
- ***Lightweight Implementation:*** OVX can be lightweight, making it suitable for ASIL validation.
- ***Conformance Tests:*** OVX provides conformance tests to ensure the robustness and correctness of the framework.
- ***Clear Separation:*** There is a clear split between the framework and the application, ensuring freedom from interference.
- To provide reliability:
- ***Standardized API:*** The standardized API allows you to build on a stable foundation, enabling code improvement across product generations and SoCs.
- ***Error Detection and Recovery:*** OVX offers various mechanisms for error detection and recovery, including node errors, graph timeouts, latency checks, and node diagnostics.
- ***Custom Extensions:*** You can create your own extensions and propose them to the Working Group!

OpenVX & Kamaros: Similar approaches

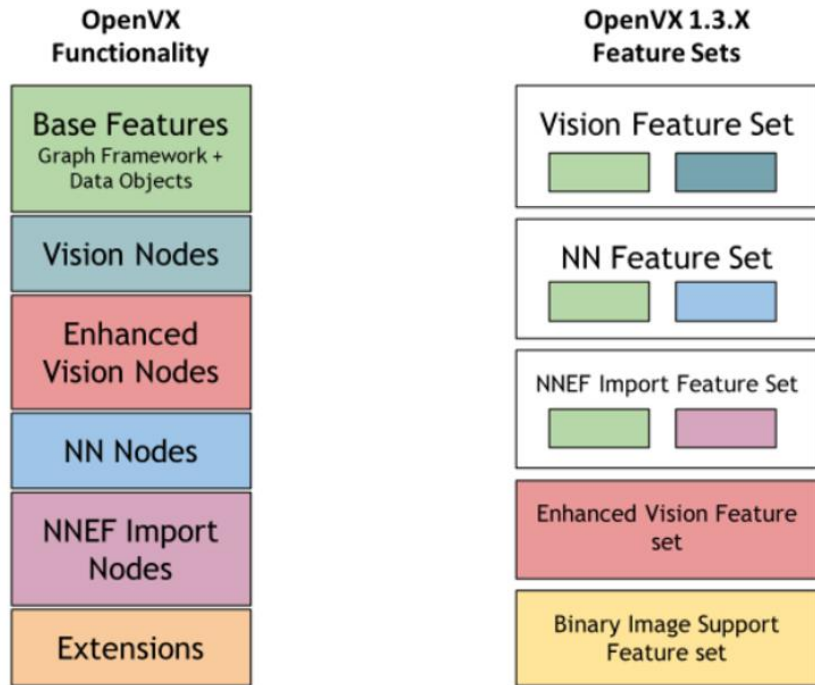
- As shown in the previous slides, OVX uses nodes and graphs
- This concept fits perfectly to model a camera interface



Combine standardized and user nodes to build a (custom) pipeline based on custom camera and ISP settings and customer defined outputs



The Future of OpenVX: Current Situation



OpenVX 1.3.x

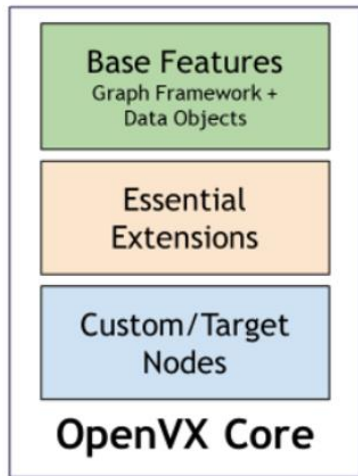
already offers various conformance models. However, to achieve conformance, you must implement at least one of the additional packages (such as vision nodes or NN nodes) along with the base features.

With version 2.0, we aim to simplify this model

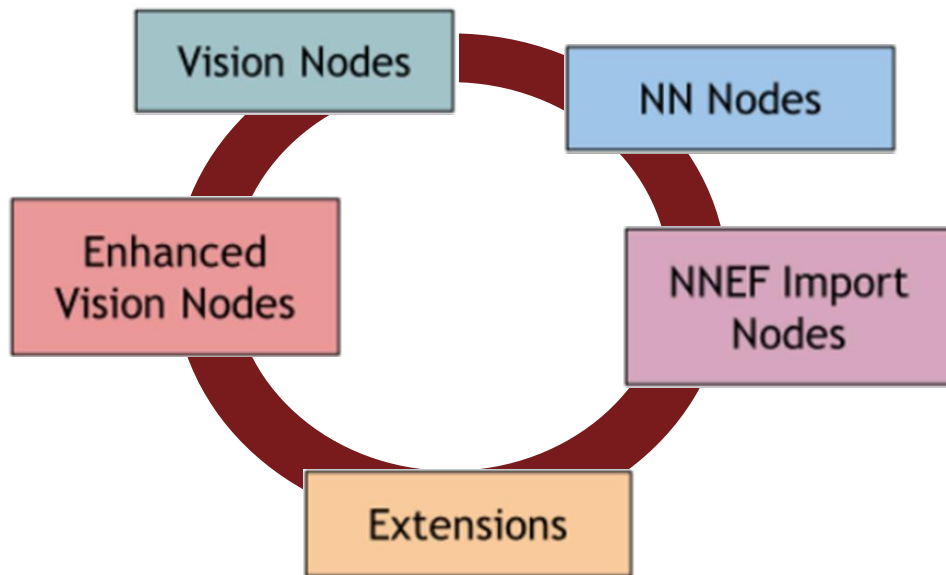
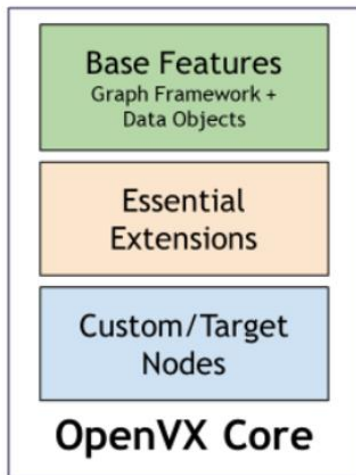
OpenVX 1.3.X implementations need to include Base Features plus at least one of Vision/NN/NNEF feature sets

The Future of OpenVX: Version 2

By simplifying and reducing the conformance process
OVX2.0 focusses on the framework feature **ONLY**:
the OpenVX core



- **Core Framework Improvements:** Building on OpenVX 1.3.1 by integrating essential extensions within the core spec
- **Focus on User-Defined and Generic Workloads:** Not focusing on video but on any kind of sensor data and HWAs processing, the vision nodes and other features being removed from the core
- **Low Barrier to Entry:** streamline the conformance process, enabling faster adoption for developers and hardware vendors alike. *(and why not proposing a portable reference implementation of it)*
- **Extensive Conformance Testing:** OpenVX 2.0 will include comprehensive conformance tests to ensure reliability and consistency across implementation(s).



OpenVX Core

Base Features

Essential Extensions

Custom / Target Nodes

Vision Nodes

Enhanced Vision Nodes

Neural Network Nodes

NNEF Import Nodes

Extensions

OpenVX™

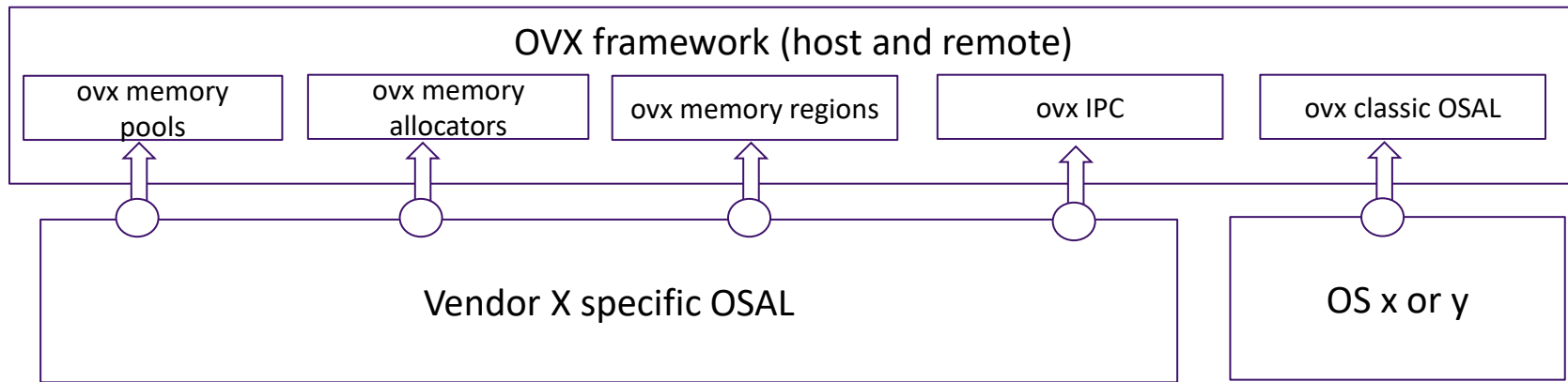
Framing the Future of Image and Sensor Processing

<https://www.khronos.org/blog/framing-the-future-of-image-and-sensor-processing-with-openvx>

One more thing ...

OpenVX & Open Source

- With this focusing on framework feature with version 2.0 and considering the most of the SoC chips share the same HW infrastructure:
 - They all have performance and efficiency cores
 - They all have multiple dedicated HW accelerators
- Running on the same POSIX OS (Linux and QNX)
- We could propose a portable sample implementation which could fit most of the SoC vendors.





Get Involved: Embrace this standard and contribute to its improvement.

Your involvement is crucial for the industry, not just automotive, to define a framework and standard that enables us to:

Build reliable and secure systems

Reduce time to market and development costs

Enhance systems and features across SoC and product generations

With a robust standard in place, you can focus on innovation!

Any company is welcome to join Khronos to influence standards development

<https://www.khronos.org/members/>

memberservices@khronosgroup.org

More information on any Khronos APIs

<https://www.khronos.org/>

A recording of this presentation will be available at
<https://www.khronos.org/events/openvx-framing-the-future-of-vision-and-sensor-processing>

For more information on OpenVX, please visit
<https://www.khronos.org/openvx/>



**WEBINARS
& MEETUPS**

