THALES
Building a future we can all trust

R&T computing challenges for operational AI in future critical systems

Thierry Collette, Ph.D

Chief Program Officer, cortAIx Labs

www.thalesgroup.com

Building a future we can all trust

Thales 2024 key figures

83,000
employees

68 countries
A global footprint

More than €4 bn*
* including €1,1 bn
in self-funded R&D

€20.6 bn
revenues

Thales's mission

EMPOWER CUSTOMERS
TO FACE THEIR DECISIVE MOMENTS
WITH CONFIDENCE

Critical decision chain

Detection and data gathering → Data transmission and storage → Data processing and decision-making

Technologies to make the world safer, greener and more inclusive

SAFER

Protecting people from physical and cyber threats

Air defence solutions for Ukraine

PARADE drone countermeasures system for large events

GREENER

Reducing our customers' environmental impact and building solutions to observe and understand climate phenomena

Pureflyt Flight Management System selected by Airbus

Major contributor to 5 of the 6 new Copernicus missions

MORE INCLUSIVE

Supporting universal access to basic rights (right to a legal identity, access to digital technology)

SATRIA satellite connecting 17,500 Indonesian islands

Voice Payment Card for blind and visually impaired people

Major player in Research & Development

Listed 12 times in the

Top 100 Global Innovators™ The rankings revealed. — Clarivate™

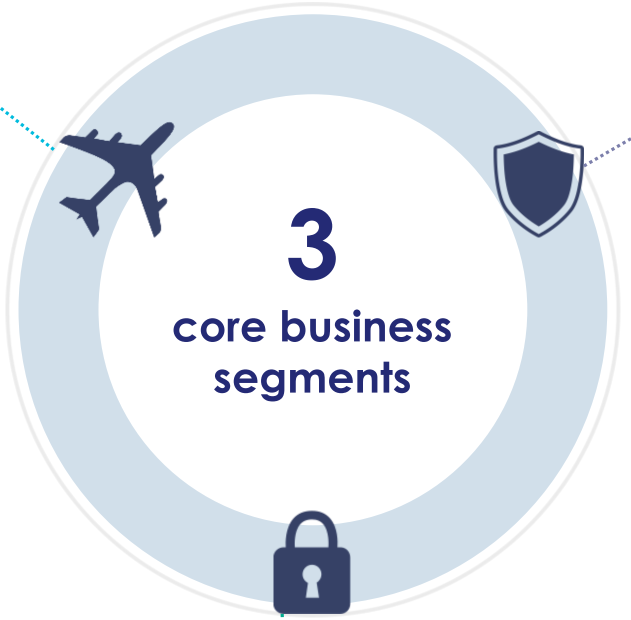
More than **40%** of Thales employees working in R&D

Intellectual property portfolio including **21,000 patents**

R&D

- Connectivity
- Artificial intelligence
- Neuroscience
- Open-source hardware
- Cloud & edge computing
- Quantum

Three core business segments



Aerospace

- Civil and military avionics
- Air traffic management
- Space programmes

Defence

- Air
- Naval
- Land
- Critical infrastructure

Cyber and Digital

- Cybersecurity
- Digital identity and biometrics

ENTERPRISE CUSTOMERS

GOVERNMENTS

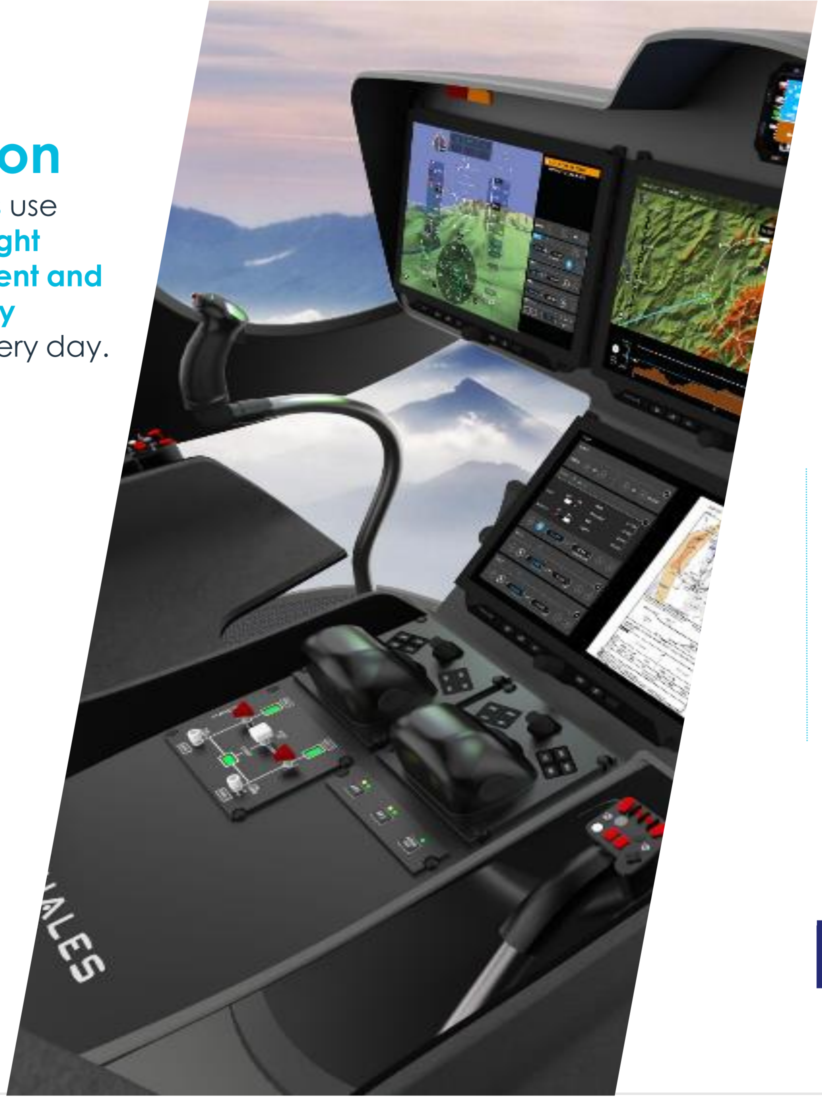
INSTITUTIONS

CITIES

Aerospace

2 million
passengers use Thales **in-flight entertainment and connectivity systems** every day.

Thales Alenia Space provides
50% of the pressurised volume of the **International Space Station.**



2/3 of the world's aircraft rely on Thales equipment to **take off and land**.

With projects such as **FlytX**, Thales is developing **flight path optimisation solutions** to reduce aircraft **CO_2 emissions by 10%**.

Defence

50+ countries
rely on Thales equipment to protect their **populations** and **territorial integrity**.

800,000+
Thales tactical radios in service in **more than 50 countries.**

Thales systems and equipment account for close to **25%** **of the total value** of the **Rafale combat aircraft**.

Thales is deploying **collaborative combat** solutions to **augment the capabilities of soldiers, vehicles and sensors in real time**.

Cyber & Digital

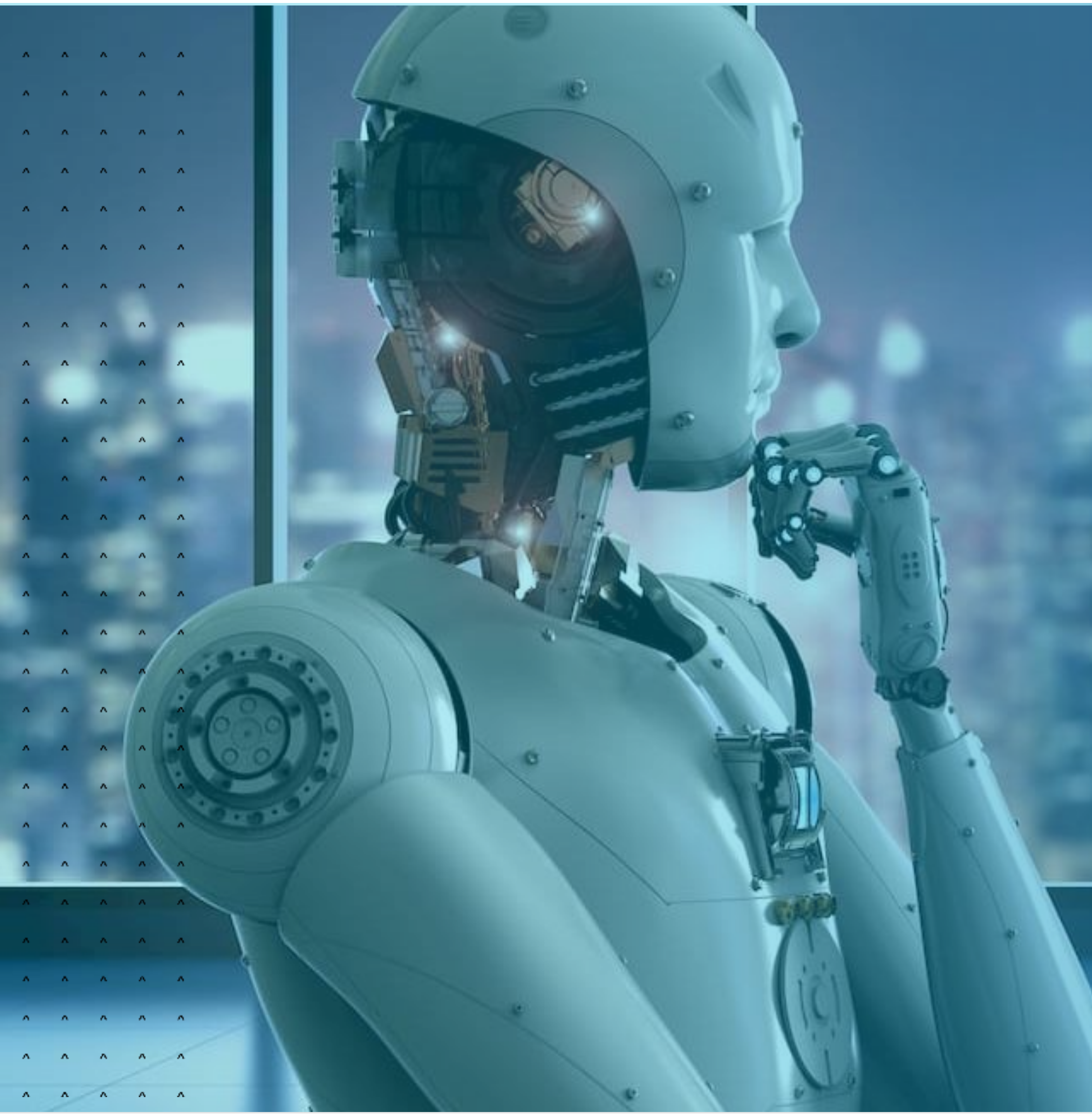
30,000+
companies use our technologies to manage identities and secure data.

$5 trillion
interbank fund transfers secured every day.

300+
government programmes for official identity, biometrics and law enforcement.

The **acquisition of Imperva** makes Thales one of the **world's top five cybersecurity providers** and affirms the Group's **leadership ambitions** in this market.

Artificial Intelligence: ability to process information by artificial means



- **Perceive** rich, complex, subtle information
- **Learn, Adapt** within a dynamic environment
- **Abstract** to create new meanings
- **Reason** to plan and decide
- **Act** to achieve a rational goal

"Artificial Intelligence is the science of making machine do things that would require intelligence if done by man" ***Marvin Minsky***

In critical systems, ordinary AI does not work

"Is this a CAT?"

VS

« Friend or Foe? »

Impact of wrong decisions, performance threshold, technological environment

Highly specialized functions
Critical missions
Standards and ethical rules

Continuous operations
Complex systems-of-systems
AI re-training for performance

In critical systems, ordinary AI does not work

Non-critical systems

Data availability - Profusion of commercial & personal data

Free data exploitation - Open data

Persistent, cloud-based resources - Large data centers, unconstrained energy consumption

Error tolerance - Fake results, Hacked AI

VS

Critical systems

Data scarcity - Operational & industrial data

Controlled data access - Sovereign & classified data requiring specific access rights

Field & edge deployment - Limited data, power, energy, bandwith…

No room for error - Trustworhy AI, Cyberprotected AI

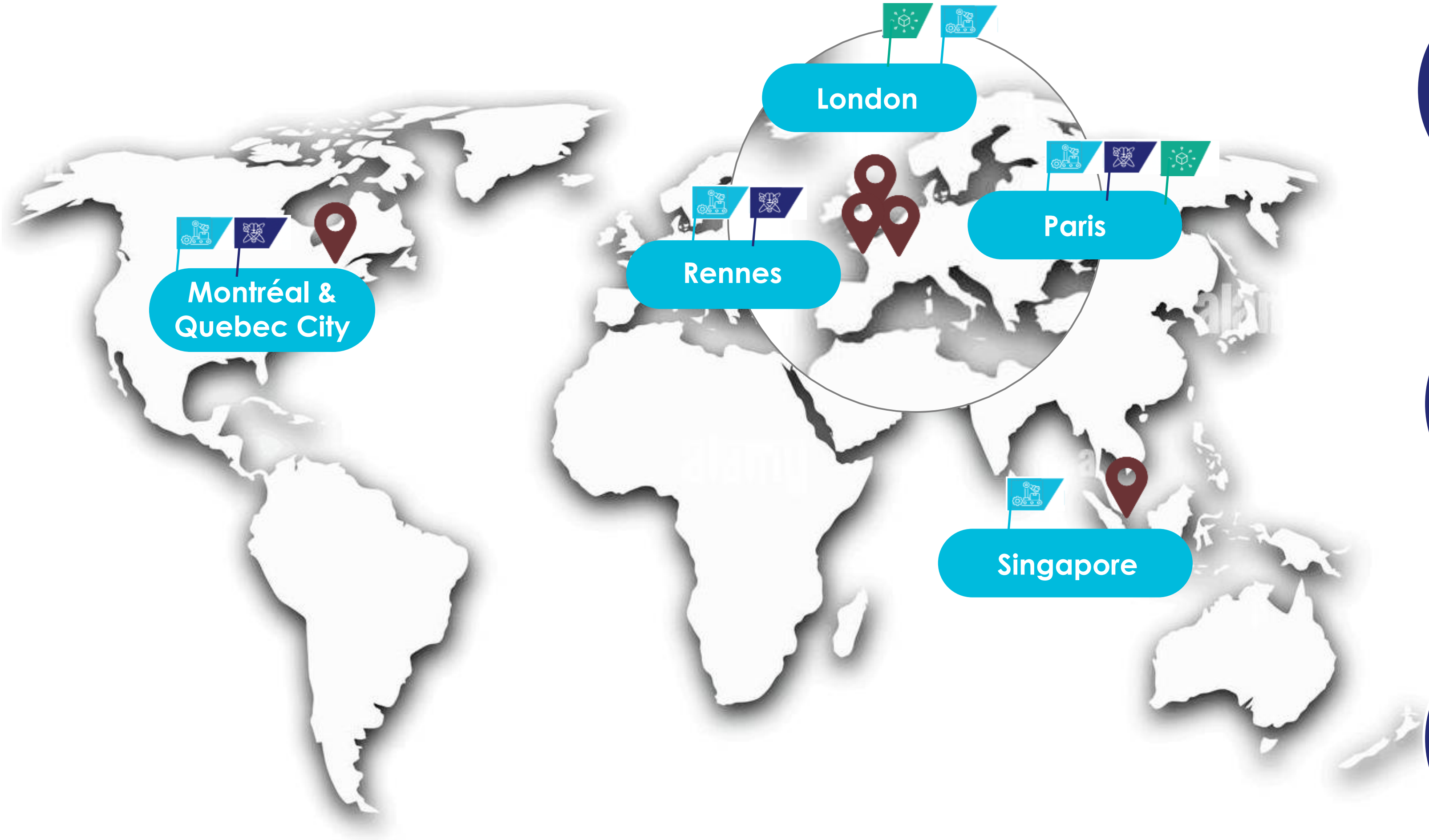
Constrained deployment, development & re-training
Sovereign AI, engineering excellence, agility

cortAIx

Artificial Intelligence for Critical Environments

A **cross-organization workforce** that **accelerates and expands AI technology integration** **to provide customers operating in critical environments with robust, superior and trustworthy AI solutions**

CortAIx | An international organization focused on Value & Delivery

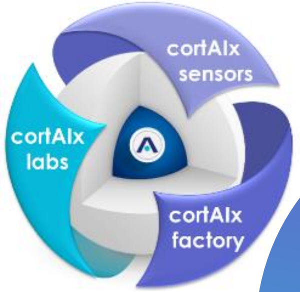


600+
AI Experts

5 Sites
Sharing common practices and processes

200 Patents
Covering full spectrum of AI technologies

CortAIx – 3 pillars to deliver end-to-end AI superiority



Factory

Integrates AI-powered sensors & groundbreaking algorithms into **systems of systems** to create differentiating capabilities and **accelerate their operational deployment** on the field

Sensors

Leverages on cutting-edge applied technologies to **embed AI at the heart of sensor processing**, reaching **multiplying effects** in field performance & efficiency

Labs

Advances **AI research,** develops superior and **trustworthy algorithms** and enabling technology adoption for critical environments

RT&I, POC | *Prototype / Demonstrator* | *Productization* | *Industrialization* | *In Service Support*

cortAIx Labs is focusing on 3 RT&I Streams

AI tech. & algo.

- **Hybrid Knowledge & Reasoning** (DL, RL, Agentic AI, GenAI, xINN…)
- **Decision support, planning, optimization**
- **Modelling & Simulation** (Incl. Adaptive digital twins)
- **Sensors' data processing**
- **Quantum technologies** (Incl. computing, sensing, networks…)

Trustworthy AI

- **Trustworthy AI Engineering**
- **Trustworthy Systems and platforms**
- **AI ⇔ Cybersecurity** (Inc. Friendly hackers)

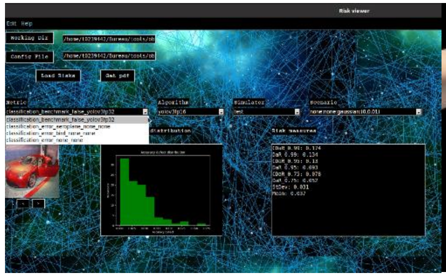
AI (in) Systems

- **Embedded AI**
- **Distributed AI** (Incl. AI ⇔ Network)
- **Computing Platforms/ Architectures, Edge computing**

Some Key Technologies

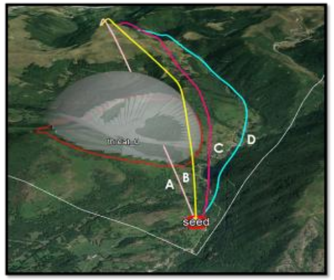
Trustable AI

- Explainable AI
- AI validation tools
- Interaction & Gen AI
- GINN (Geometrics Informed NN)




Embedded AI & Edge Computing :

- High performance computing
- Low power @ IoT & Edge
- Embedded Cyber Security
- Determinism & safety for critical system
- Neural networks & learning algorithms
- OpenHW (RISC-V & OCP)

Optimization & Decision

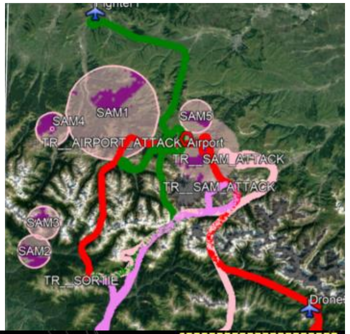
- Optimization algorithms
- Decision aid tools

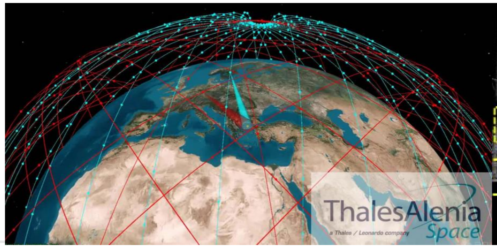
Distributed Architectures & Algorithms

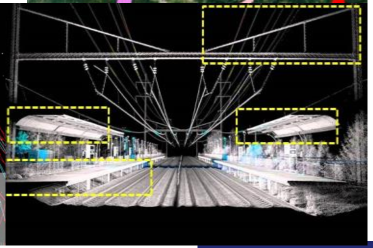
- Distributed AI (Multi Agent, RL …)
- Continuum & distributed computing
- Time Sensitive Networks


Quantum Computing

- Mastering noise impact
- Online QC





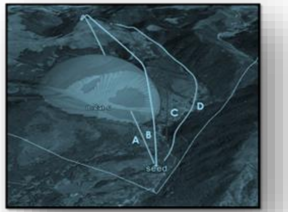


Tools & Methods for Safe and Secure

- Formal methods
- Safety analysis tools
- Cybersecurity analysis method and pen testing platform

Thales cortAIx Labs cutting edge technologies – Some examples

SWARM OF DRONES



COHORT: mission planning, drone coordination, distributed decision

Learning Scout is an AI based UAVs swarm controller that has learned its complex mission through simulations.

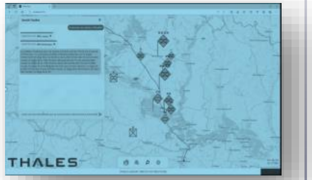
FORMAL METHODS FOR CODE VERIFICATION

Smard card EAL7 certificate issued by ANSSI after evaluation by LETI (CESTI)

AI AUGMENTED PHONY

Embedded AI algorithms to reduce background noise in real time and improving audio compression

GENERATIVE AI FOR MISSION CRITICAL SYSTEMS



Generative AI components dedicated to Mission Critical Systems such as C4I.

EDGE COMPUTING PLATFORM FOR AI

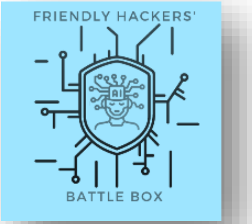
ODYSSAI

Secure, modular and energy-efficient computing solution based on open standards

OPEN HARDWARE: RISC-V

Thales member of the OpenHW group and RISC-V fondation. Since 5 years, strong contribution to the Open HW group on the CVA6 IP for FPGAs and ASICs

FRIENDLY HACKERS



Cyber for AI/Attacking and Securing AI. Ensuring trust of an AI component is essential. This covers Machine Learning, as well as Symbolic AI and Hybrid AI

ASSETS ▶	MYRIAD	SE-Star	COHORT	Battle Box

AI for Defence Systems by THALES

cortAIx Labs is focusing on 3 RT&I Streams

AI tech. & algo.

- **Hybrid Knowledge & Reasoning** (DL, RL, Agentic AI, GenAI, xINN…)
- **Decision support, planning, optimization**
- **Modelling & Simulation** (Incl. Adaptive digital twins)
- **Sensors' data processing**
- **Quantum technologies** (Incl. computing, sensing, networks…)

Trustworthy AI

- **Trustworthy AI Engineering**
- **Trustworthy Systems and platforms**
- **AI ⇔ Cybersecurity** (Inc. Friendly hackers)

AI (in) Systems

- **Embedded AI**
- **Distributed AI** (Incl. AI ⇔ Network)
- **Computing Platforms/ Architectures, Edge computing**

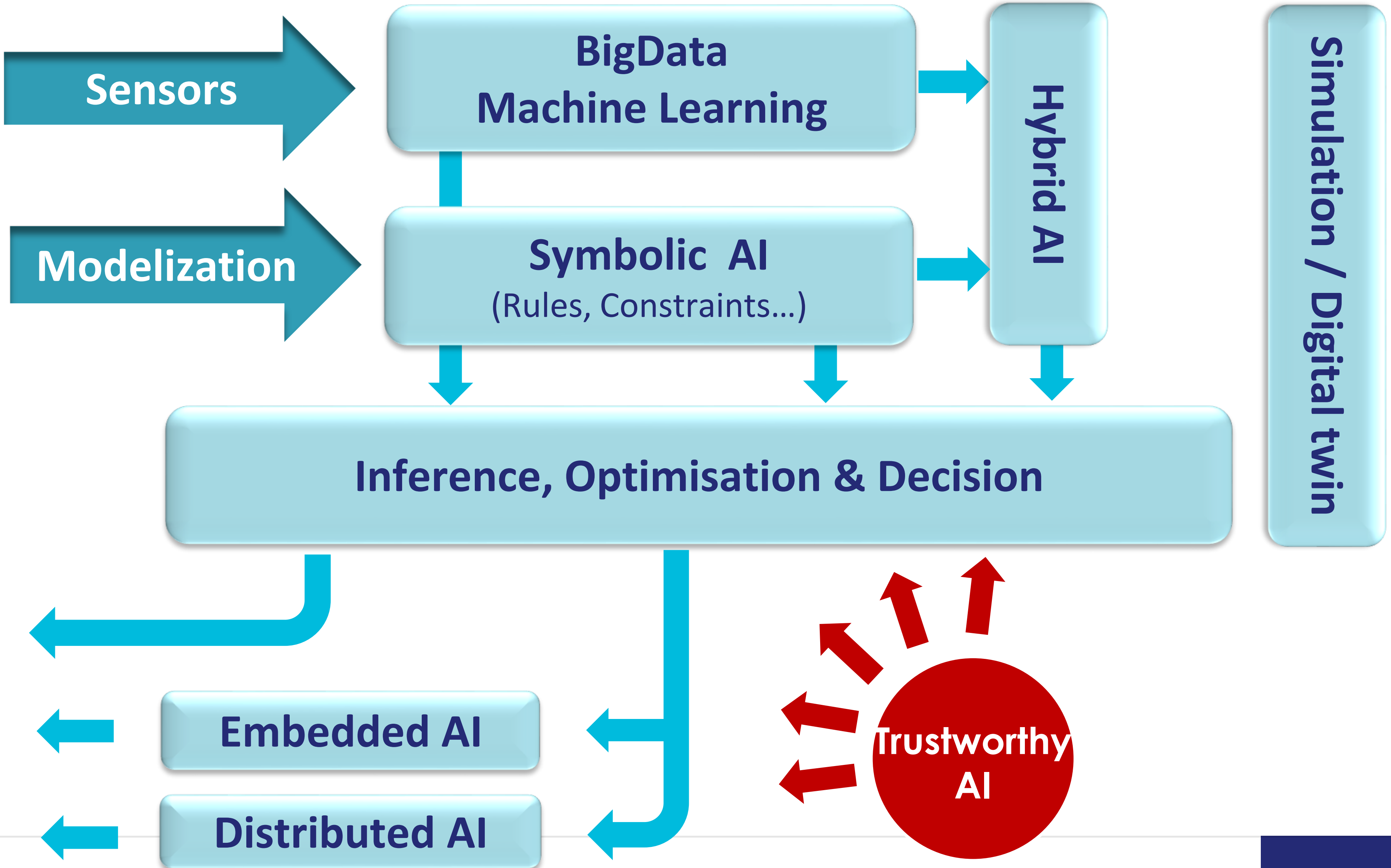
Challenges in AI algorithms

Maritime defense

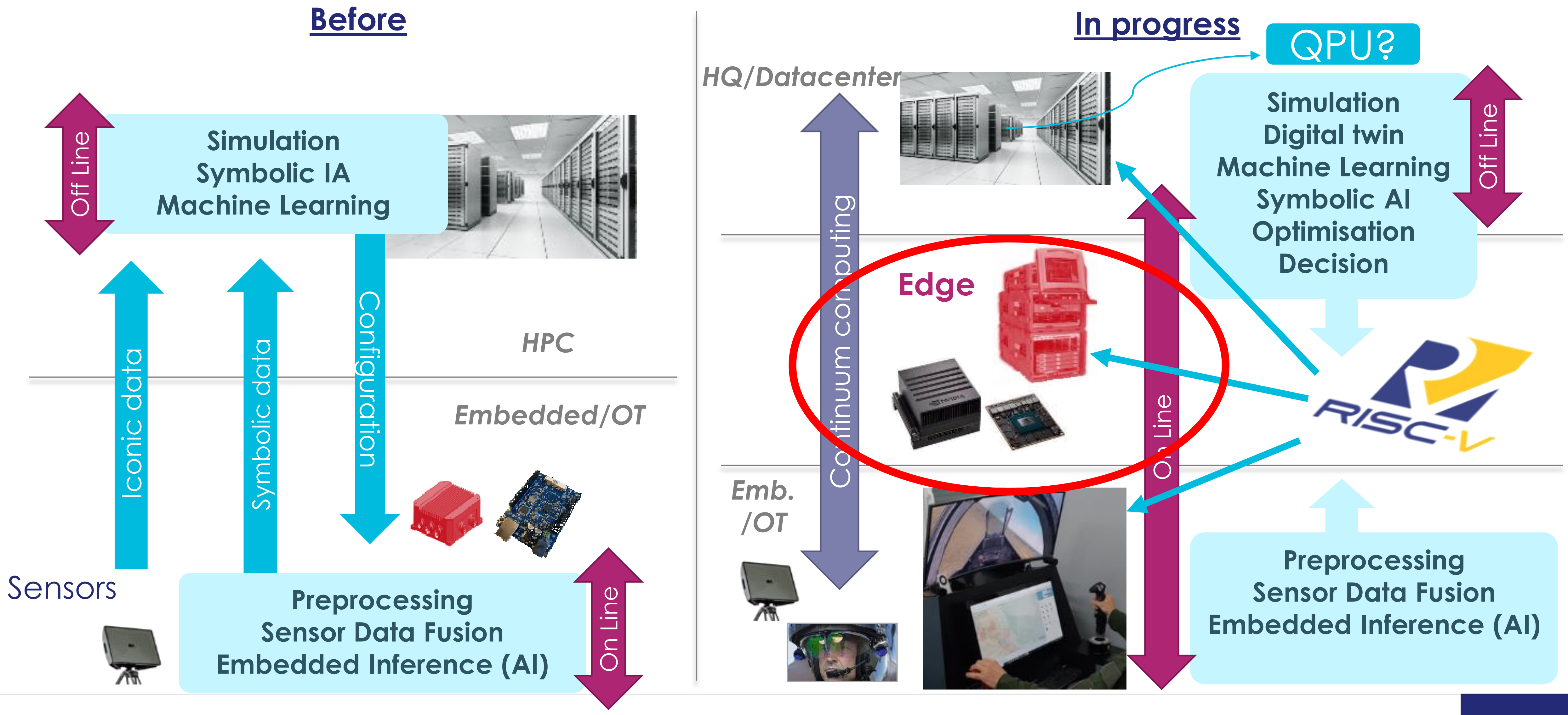
Collaborative combat

UxV

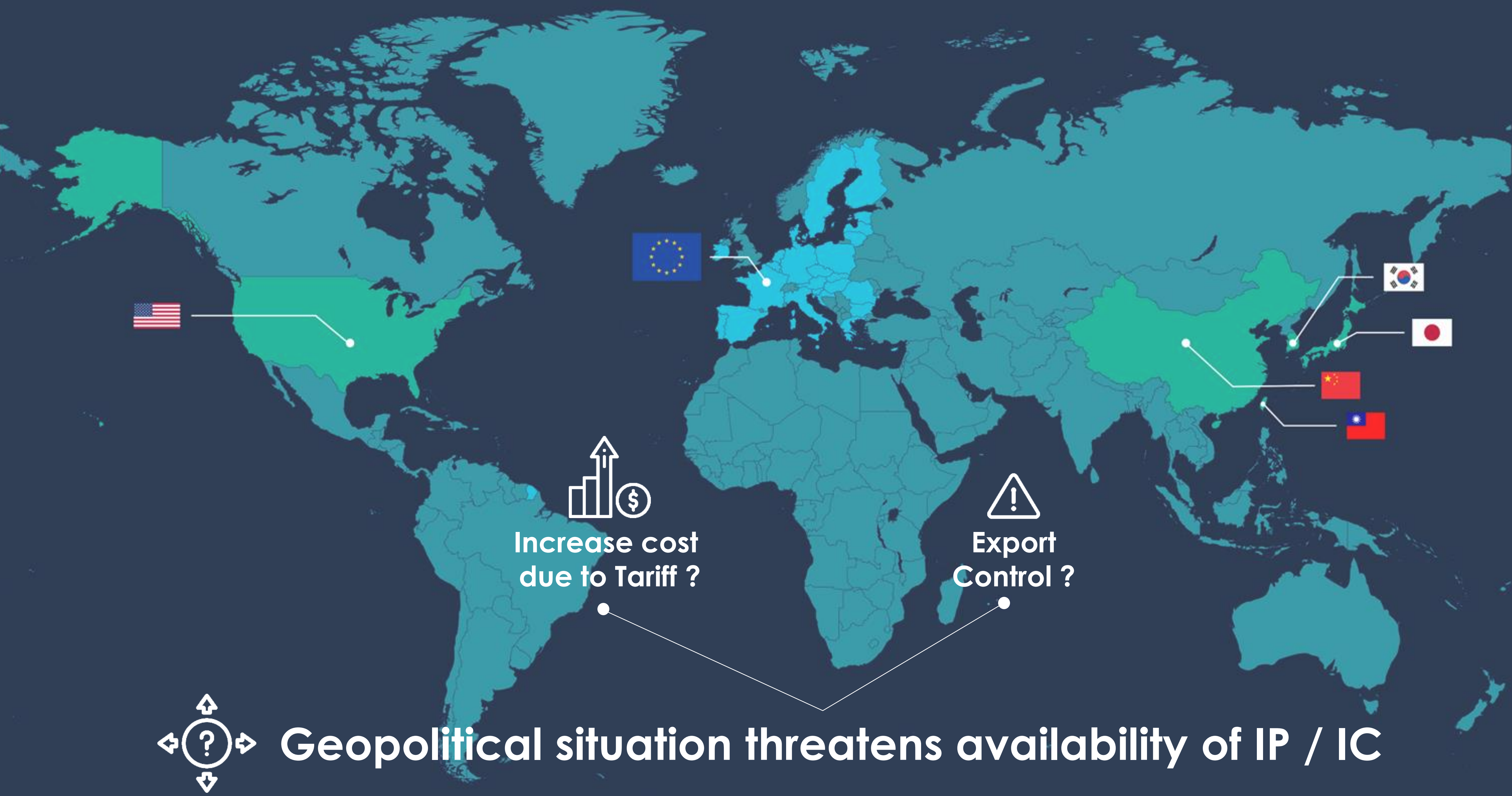
Aerian Traffic Control



Exemple of R&T challenges for vertical IT – OT convergence



Geopolitical situation threatens availability of IP / IC



Digital Sovereignty

Safe
Secure

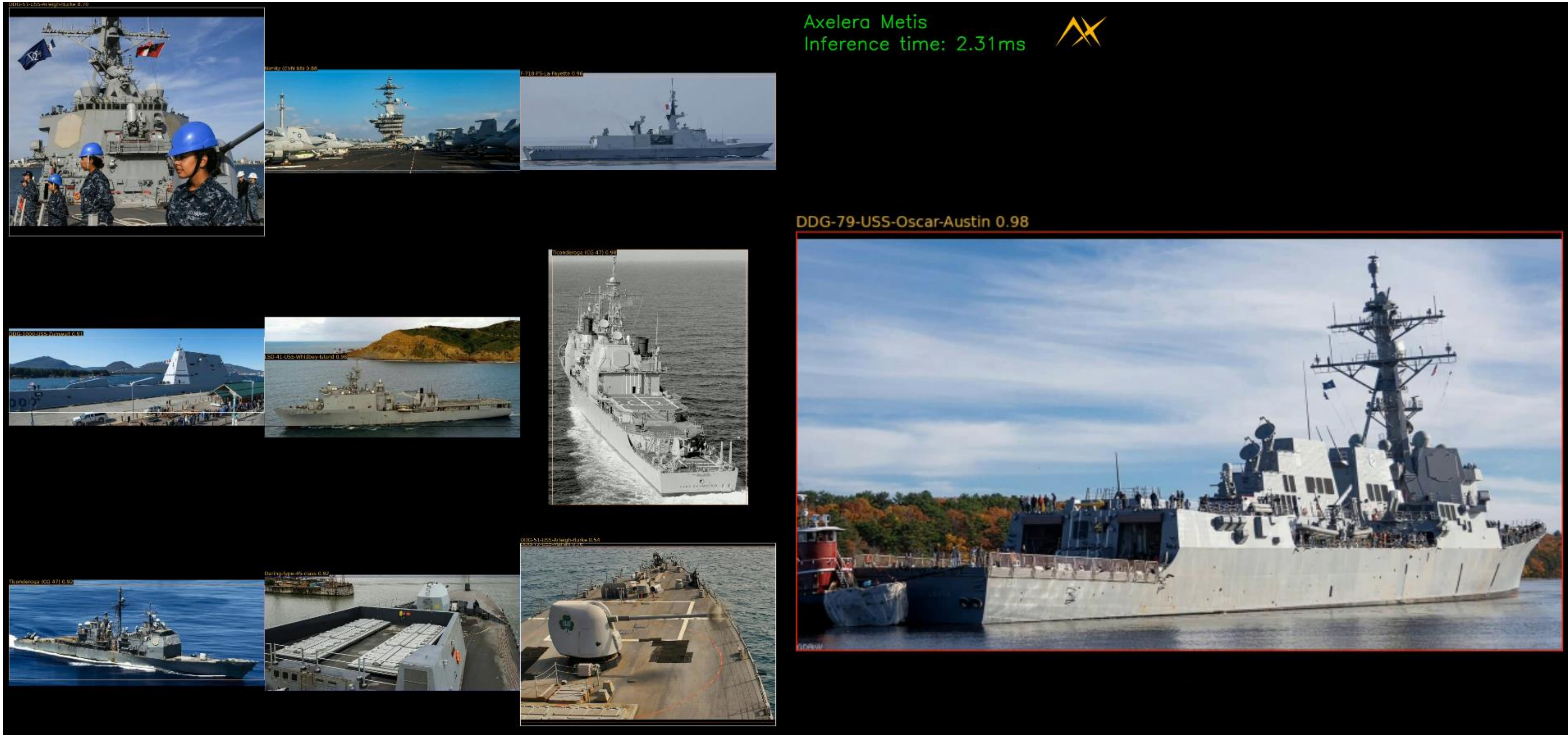
Open
Source HW

Independent

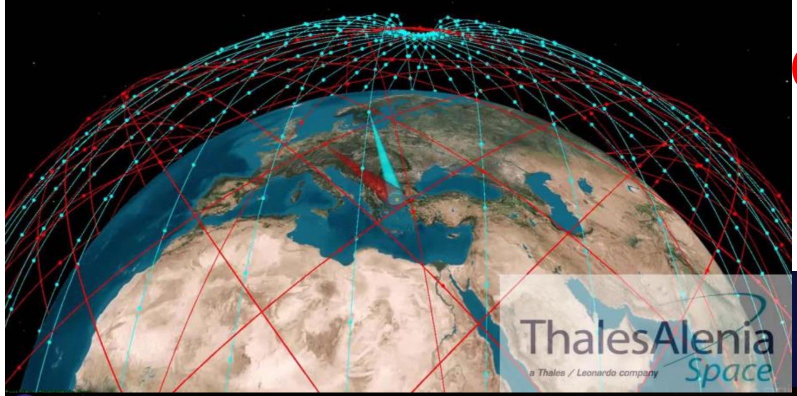
Thales Innovation

Industrial Grade CVA6 µController released as Open Source

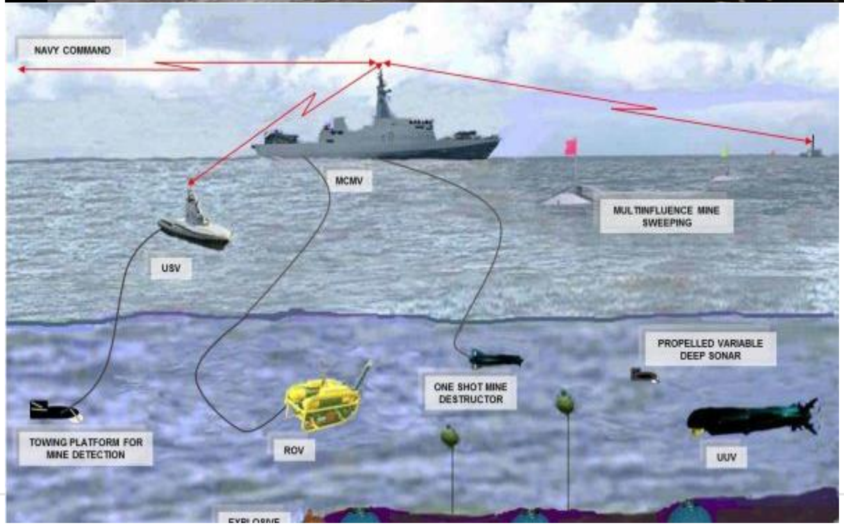
- **CV32A60X**: Low area and High performance CVA6 Core
- 100% Verified, Sovereign, ready for integration into silicon products (TRL5) !
- ***Focus on your Added Value IP / Differentiator, CVA6 comes as a commodity***


Axelera Metis
Inference time: 2.31ms
DDG-79-USS-Oscar-Austin 0.98

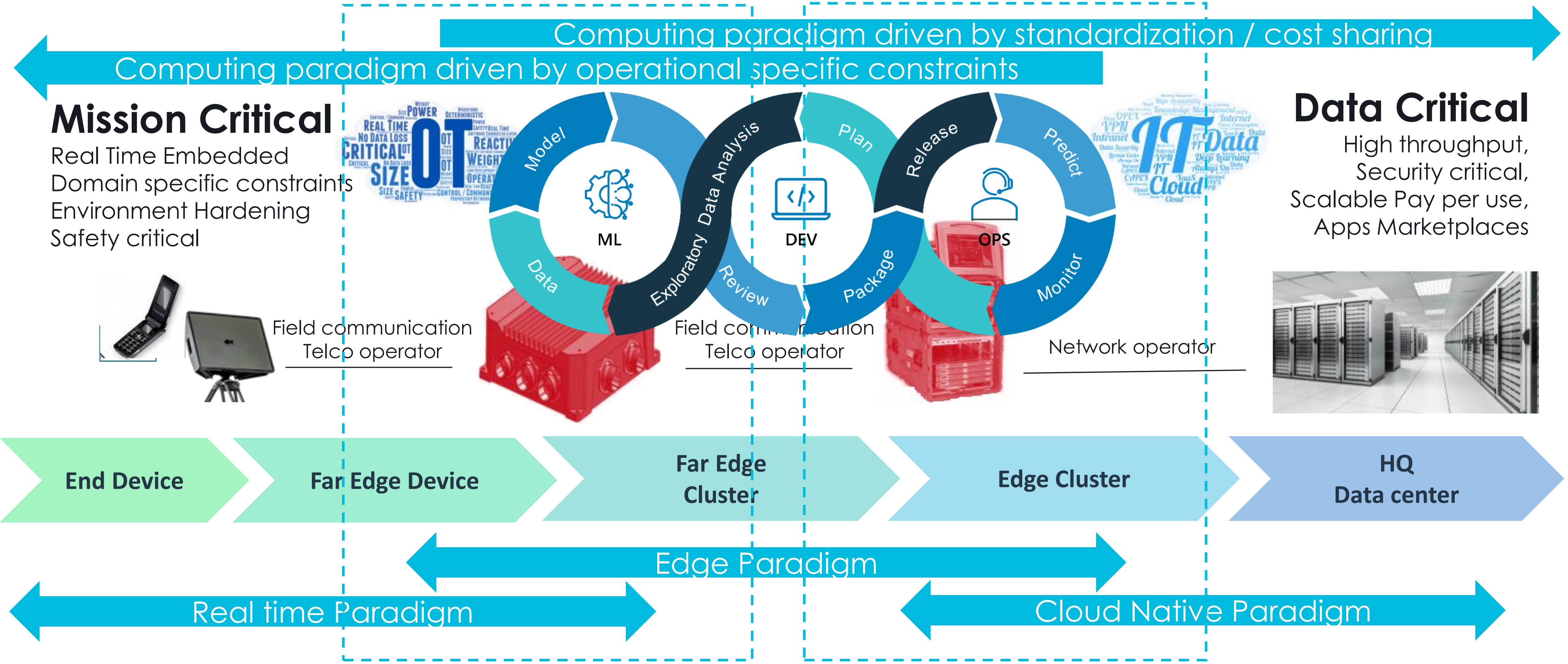
CONTINUOUS & TRUSTABLE COMPUTING SOLUTIONS



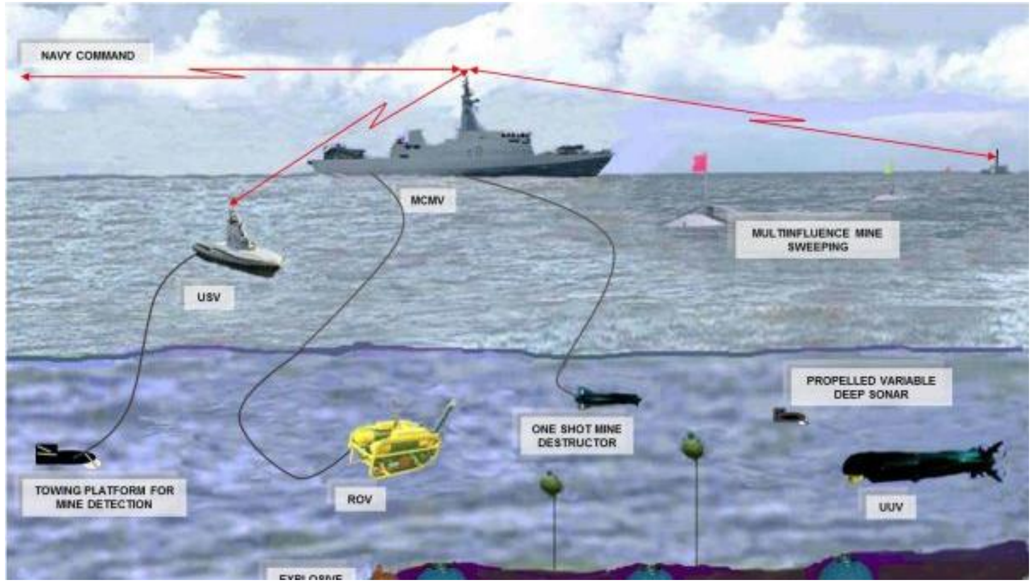
- Cloud-Edge-IoT
- Interconnection
- Autonomy
- Cybersecurity
- Low Power
- Safety

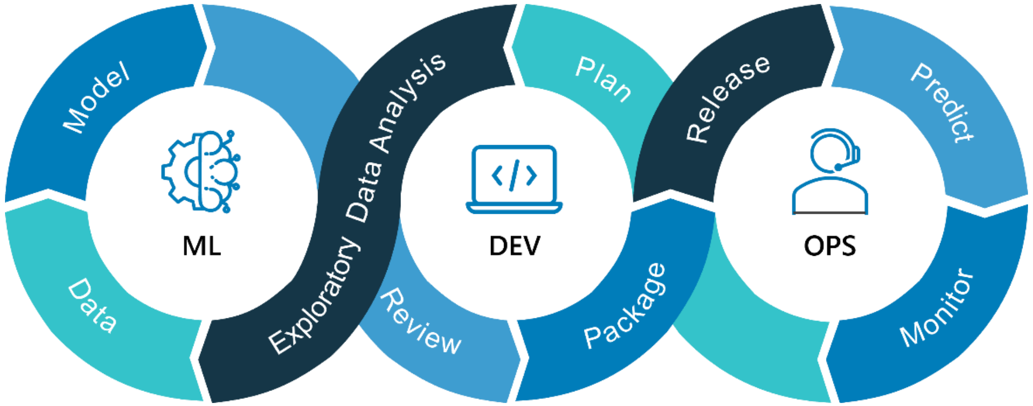


Critical Decision Chain & IT/OT convergence



New Challenges for the Edge





✓ Level of AI :

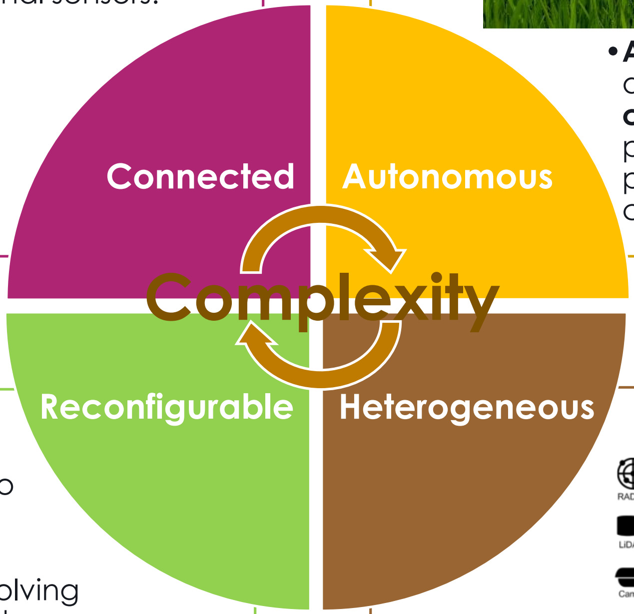
- Engineering Level : The Edge must collect the data (Off line MLOPS)
- On Board off line applications : MLDEVOPS abilities at the Edge (Edge Cluster)
- On Board In line applications : CI/CD-MLDEVOPS abilities at the Edge (Far Edge + Edge Cluster)

✓ Level of Infrastructure :

- OSS SW stack
- Containerized applications
- Continuum in 2D
- Determinism for some applications (Sensor driven)
- Cybersecurity at all levels
- SWAP optimization
- Continuous Integration / Continuous Deployement

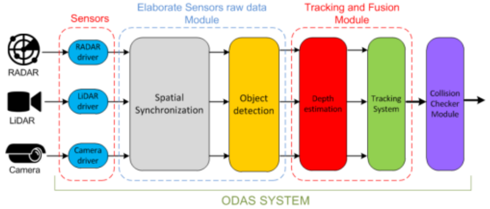
Technical Innovation Challenging Critical Real-Time EDGE systems

- **Connected** real-time systems will be included into **heterogeneous infrastructures**, where the software running into its internal computers is connected to other computers, databases, web interfaces, or even to external sensors.



- **Autonomous** systems lead to a dramatically increasing demand of **connectivity** capacities and processing power that can only be provided by **heterogeneous** computing platforms.

- **Dynamic** reconfiguration is key to respond to needs of autonomy
- Multiple **static** configurations involving **heteregeneous** SW functions and suppliers
- On-demand **upgrades** and **customization** is the key to the future of the **connectivity**



- Heterogeneous **functions domains** on heteregeneous **hardware** architecture provided by heteregenous **parties** and operating in heteregeneous **environements**

Modular Open HW approach in order to optimize the energy efficiency

> Design of a modular software-defined Edge computer (ODYSSAI)

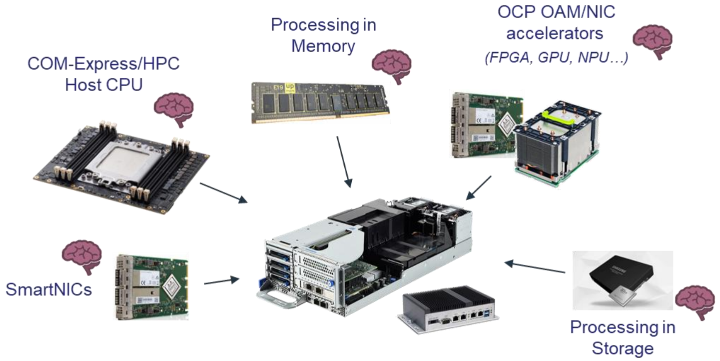
- Use of existing open standards (OCP, interfaces, interoperability, firmware, power, security, etc.),
- Integration of heterogeneous and energy-efficient computing solutions (either low cost),
- High modularity and scalability capabilities (sustainability),
- Leverage IT/OT convergence,
- Chiplet architectures with UCIe interfaces, …

> Leverage the compute-everywhere architecture

- Compute where the data are stored (NearMC, InMC),
- Compute during data transfers (DPU).

> Use of embedded computers instead of IT ones

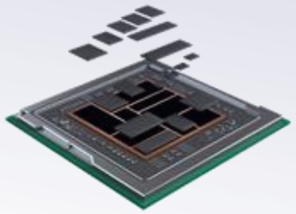
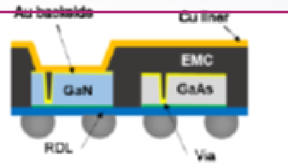
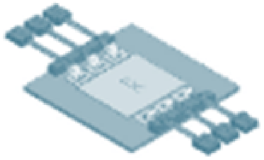
- eGPUs vs IT GPU accelerators,
- ARM vs x86 cores, RISC-V tomorrow.



Compute-everywhere Edge architecture

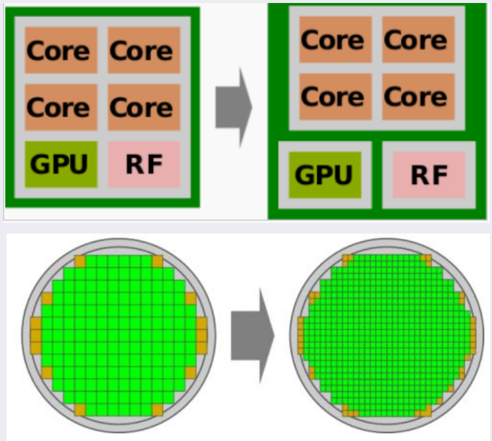
→ **Opening up to European Suppliers (SMEs, start-ups, etc.) and then creating an European Edge Ecosystem**

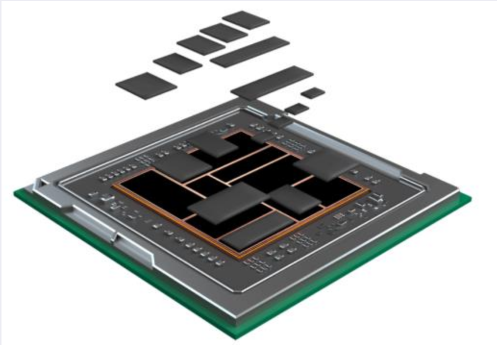
Motivation: evolutions expected to 2030

	Expected	Why
	MCM > SiP	More integration
	SoC > Chiplets	Exponential increasing costs of design and production for the latest Si nodes
	More RDL	Frequency increasing
	More optical interfaces	Sensors, Free space communications and data transmission

Heterogeneous integration > Chiplets

https://en.wikichip.org/wiki/chiplet



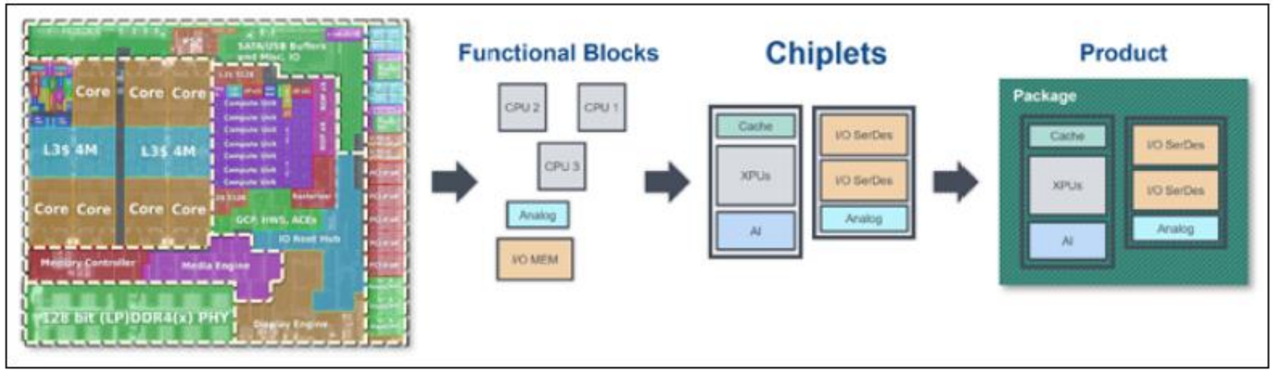


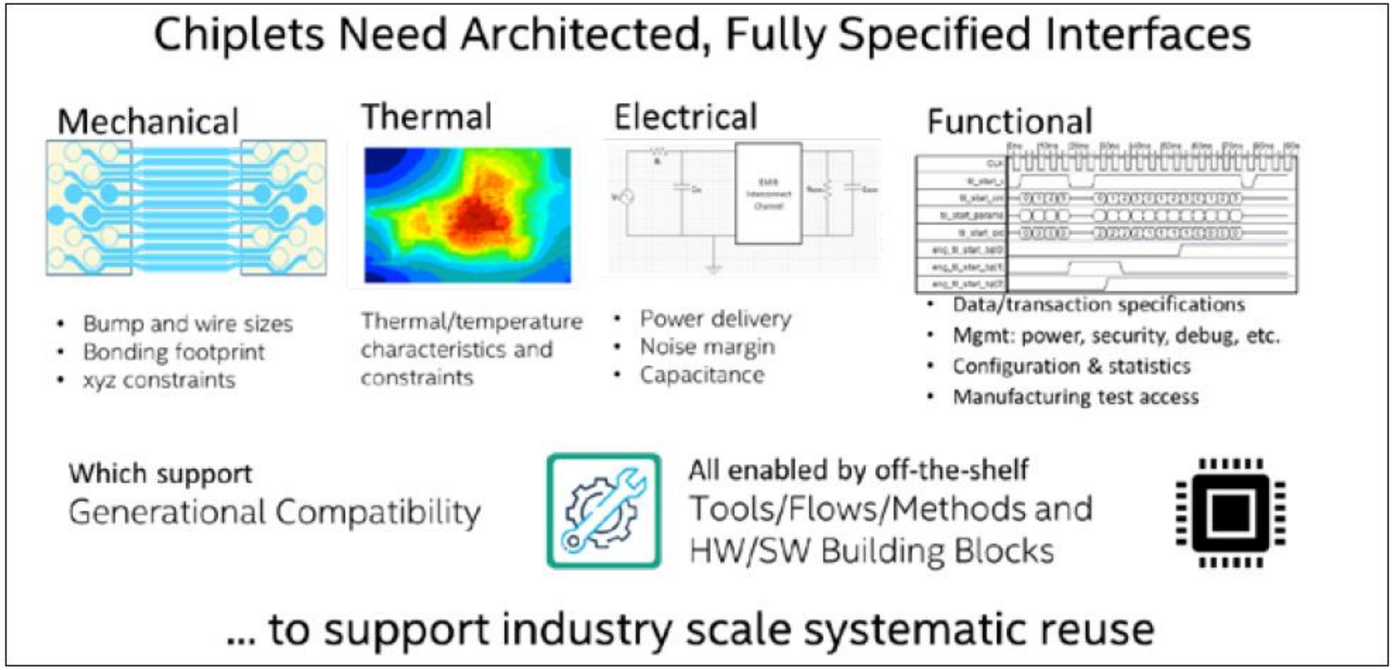
https://www.chipscalereview.com/blog/An-introduction-to-chiplet-based-architectures

https://www.3dincites.com/2020/06/iftle-451-advanced-packaging-is-leading-electronics-into-the-2020s/

HI mandatory to use the latest Si nodes technologies

Heterogeneous integration > Modularization





New HPC architectures >
Modular Approach
Commercial Chiplets?

Heterogeneous integration > Interconnects

Current Chiplet-based Interconnects				
Company	Intel	Intel	TSMC	OCP ODSA
Package	EMIB	EMIB/ODI	CoWoS	MCP
Interconnect	AIB Gen1	MDIO Gen1	LIPINCON	Bow Turbo (3 slices)
Data Rate	2 GT/s	5.4 GT/s	8 GT/s	16 GT/s
Shoreline BW Density	504 Gbps/mm	1600 Gbps/mm	536 Gbps/mm	1280 Gbps/mm
PHY Power	0.85 pJ/bit	0.5 pJ/bit	0.5 pJ/bit	0.7 pJ/bit (14nm measured) 0.5 pJ/bit (7nm estimate)
Areal BW Density	150 Gbps/mmÂ²	198 Gbps/mmÂ²	198 Gbps/mmÂ²	148 Gbps/mmÂ²

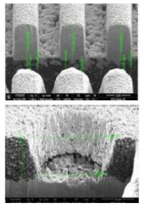
Other solutions Chiplet integration solutions

> OCP / ODSA

https://www.opencompute.org/projects/open-domain-specific-architecture

FINE LINE STRUCTURING
Starting with 5µm Line/Space

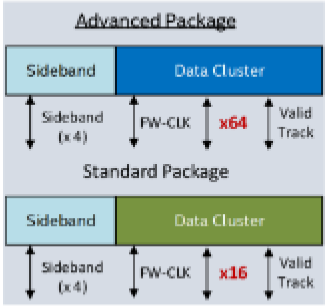
SMALL VIA FORMATION
CO2 and UV Laser Systems



Finer design structures with 2µm Line/Space on the Roadmap

µVia diameter 10µm and smaller for z-interconnection

Standardized interfaces (ODAS / UCIe)



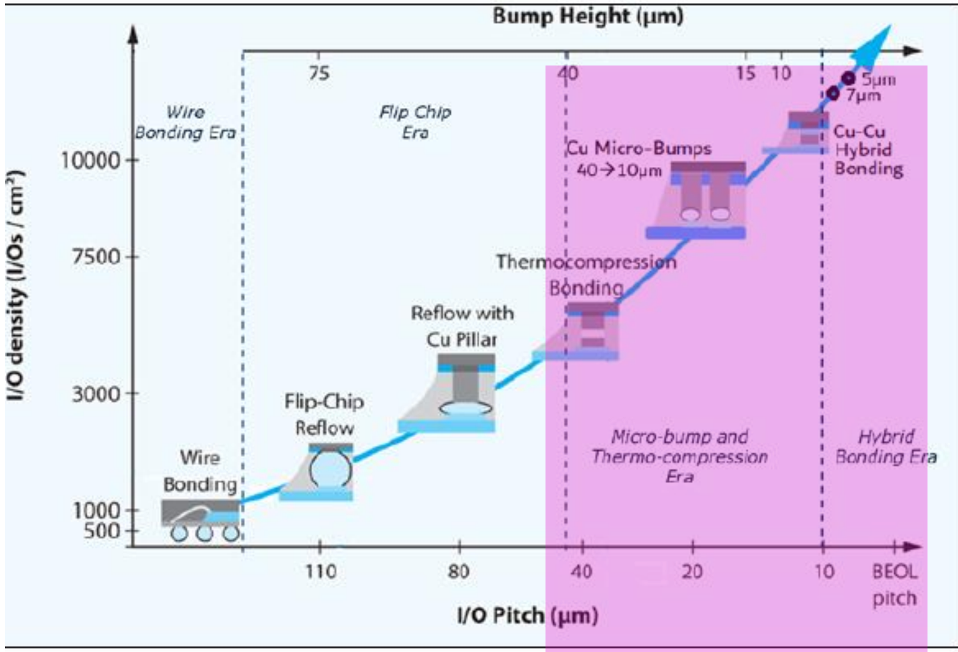
https://www.uciexpress.org/_files/ugd/0c1418_c5970a68ab214ffc97fab16d11581449.pdf

> UCIe

- The physical layer supports up to 32 GT/s
  - with 16 to 64 lanes
  - uses a 256 byte Flow Control Unit (FLIT) for data, similar to PCIe 6.0

Shorter signal paths allow the links to have 20× better I/O performance and power consumption (~0.5 pJ per bit) comparing to typical PCIe SerDes

- with bandwidth density up to 1.35 TByte/s per mm2 for a common bump pitch of 45 µm
- 3.24× higher density with a bump pitch of 25 µm



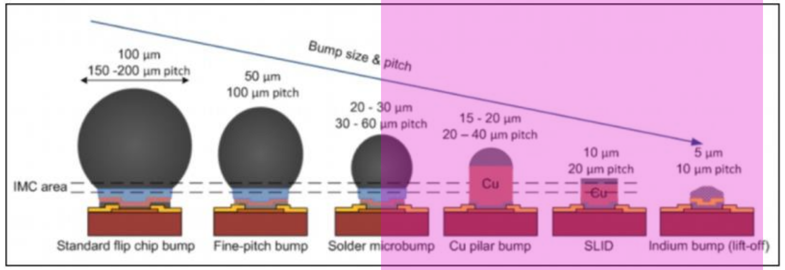


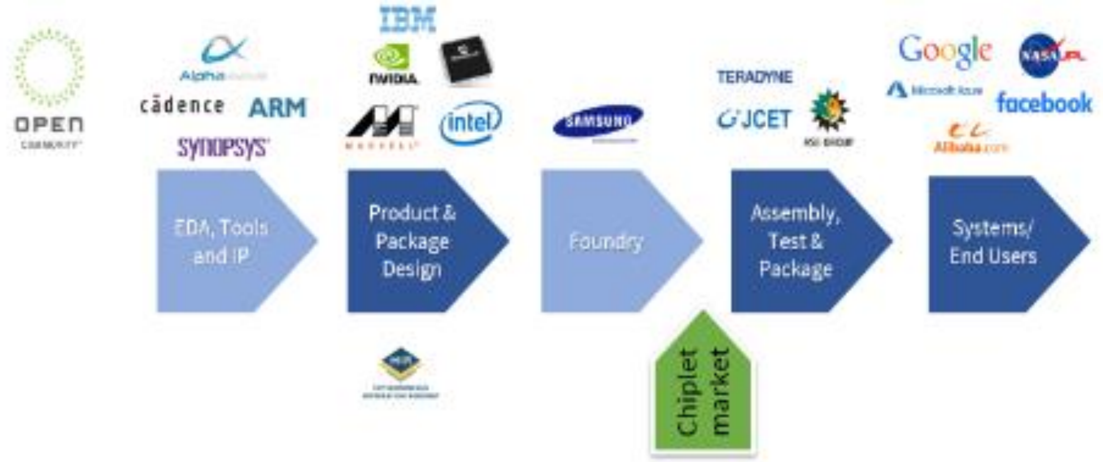
Figure 1: Evolution of bump size and pitch. Image courtesy of T. Tick and S. Vahanen [1]

Advanced integration (pitch below 50 µm)

Heterogeneous Integration fo ADHP

> Datacenter, High-Computing will probably benefit from Chiplet architecture

- It allows modular and scalable designs
- It is well suited for digital computing applications (CPU, GPU, APU, HBM) > Competitive solution for latest nodes



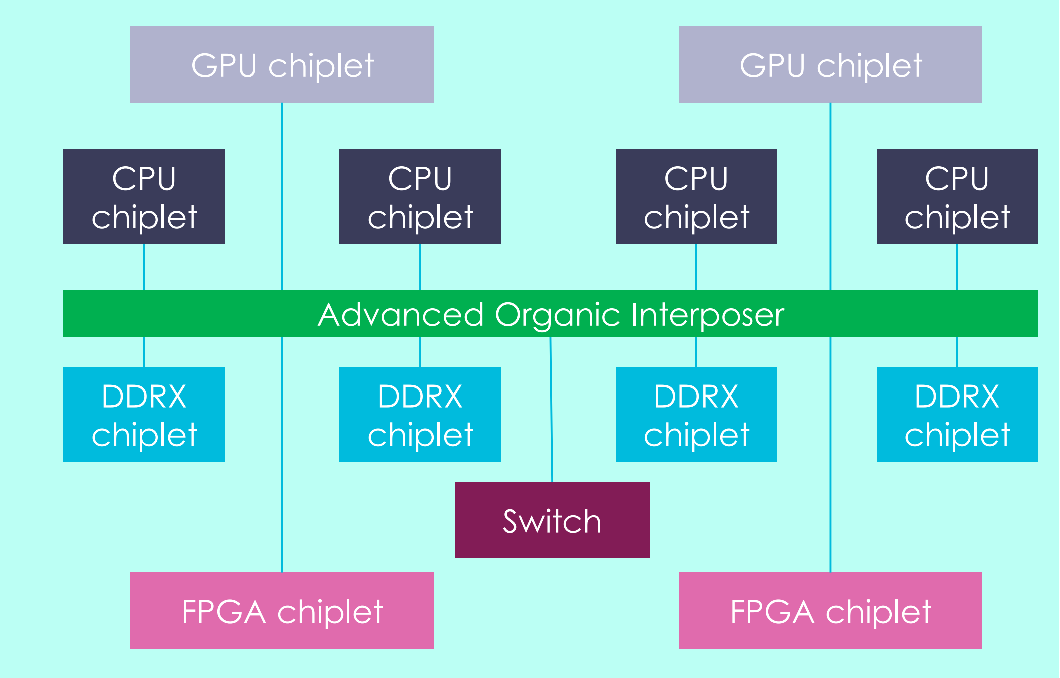
> Aerospace (including constellations), Defense and High Performance (including ADAS) applications have specificities

- High-reliability
- Harsh environment
- Long mission profile
- + … medium to low volume

Will be there a Heterogeneous Integration Supply Chain?
Is Chiplet Integration possible in medium to low volume?

Heterogeneous integration > Industrial, Safety, Security and Reliability

Next generation of Avionics computing including chiplets



Intent-Based Architecture

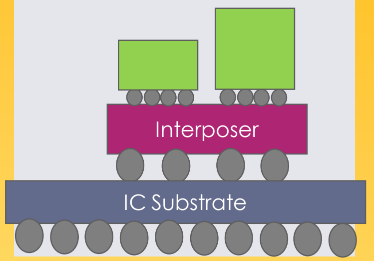
> Challenges

- Standardization of interfaces (ODSA, UCIE)
- Low volume interposers (organic L/S 2 µm)
- Chiplet assembly and test
- Computing architecture (determinism)
- Reliability for Long Mission Profile

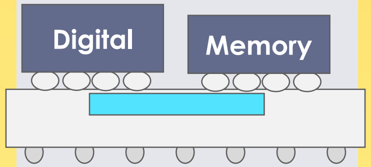
THALES involves in this complex subjects

2023	2024	2025	2026	2027	2028	2029

2.5D SiP

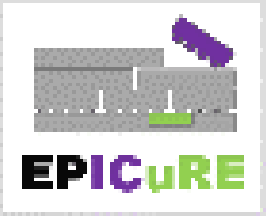


HI > Commercial Chiplets



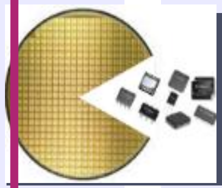
ML for DOE

IG



FED | EPICURE
Synergie CAD, IZM, UM
SiP 2.5 D RDL, GaAs, Glass

Big WP LEADER



CHIPS JU | E2PACKMAN
AT&S, Swissbit, Extoll
Chiplet

Big WP LEADER

PACK4EU

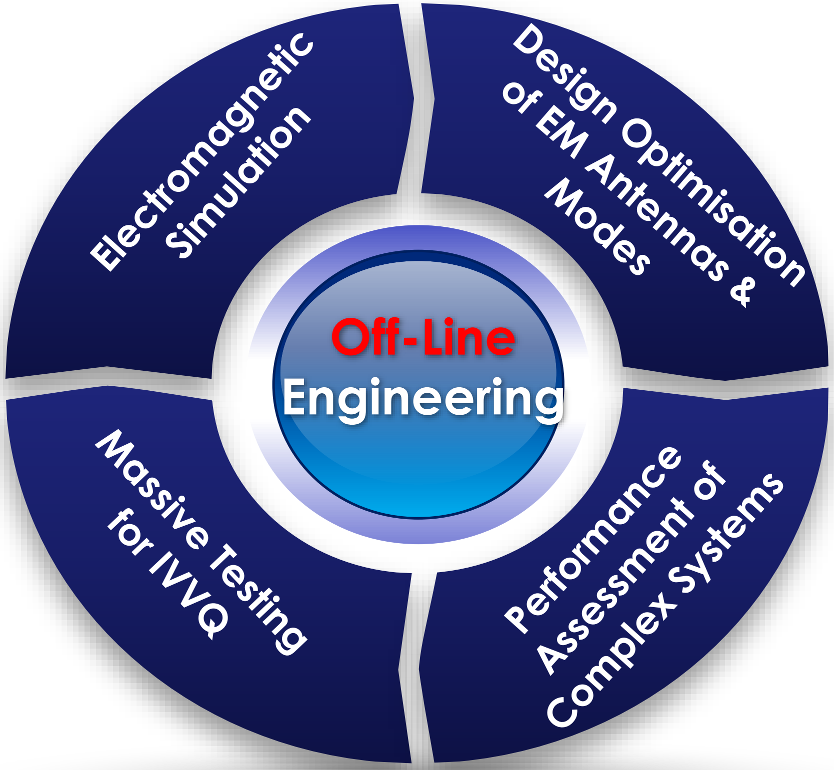
KDT-JU CSA | PACK4EU

EIC Pathfinder | COOLBRAIN
Chiplets for Harsh
Bristol, Aveiro, IT-PT, DiamFab, III-V Lab

COORDINATOR

DGAC-OHPERA
AVS + Safran + Airbus

Quantum algorithms use-cases: Engineering, Mission preparation & Operations

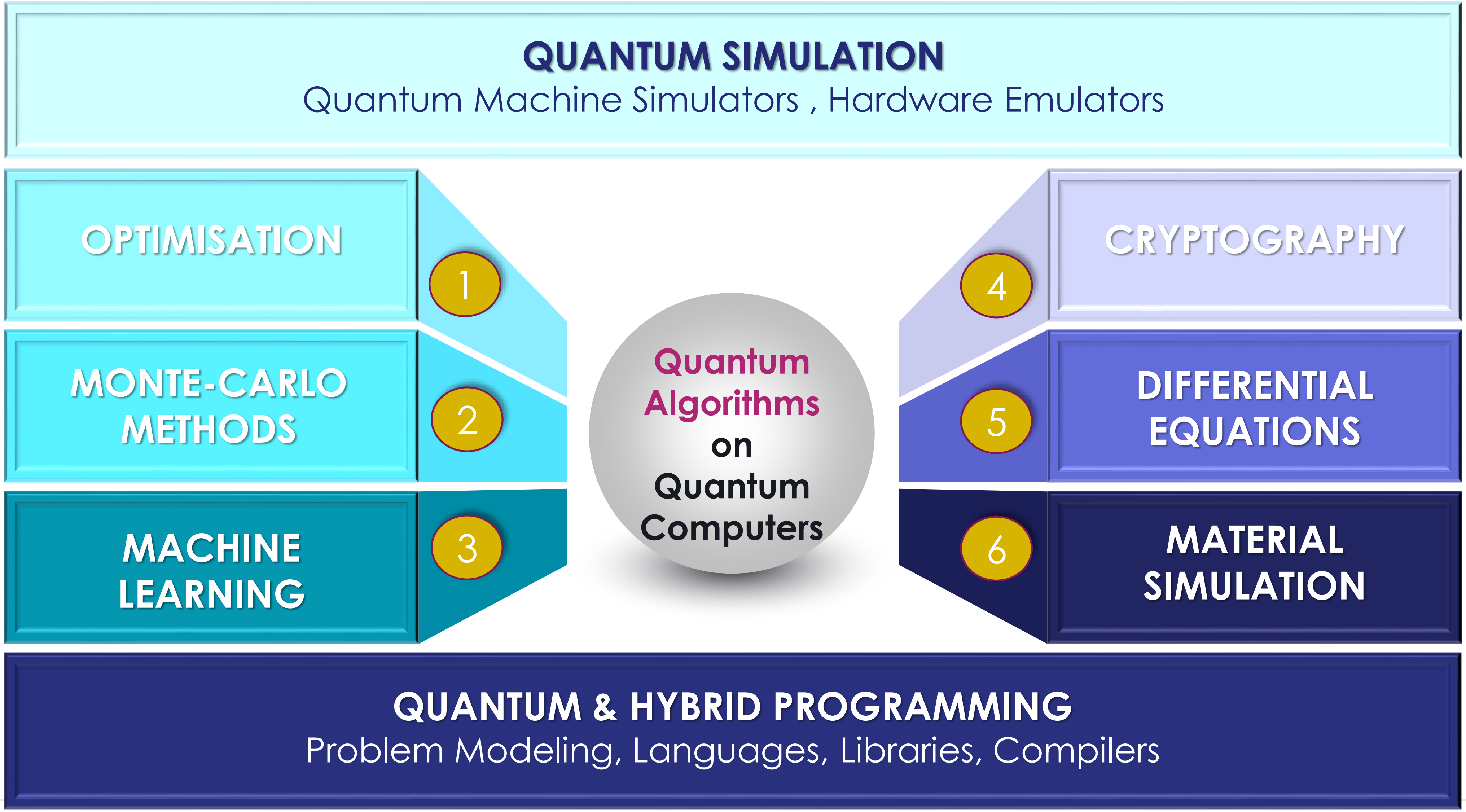


Quantum Code Analysis and Verification for Industrial and Military Critical Systems

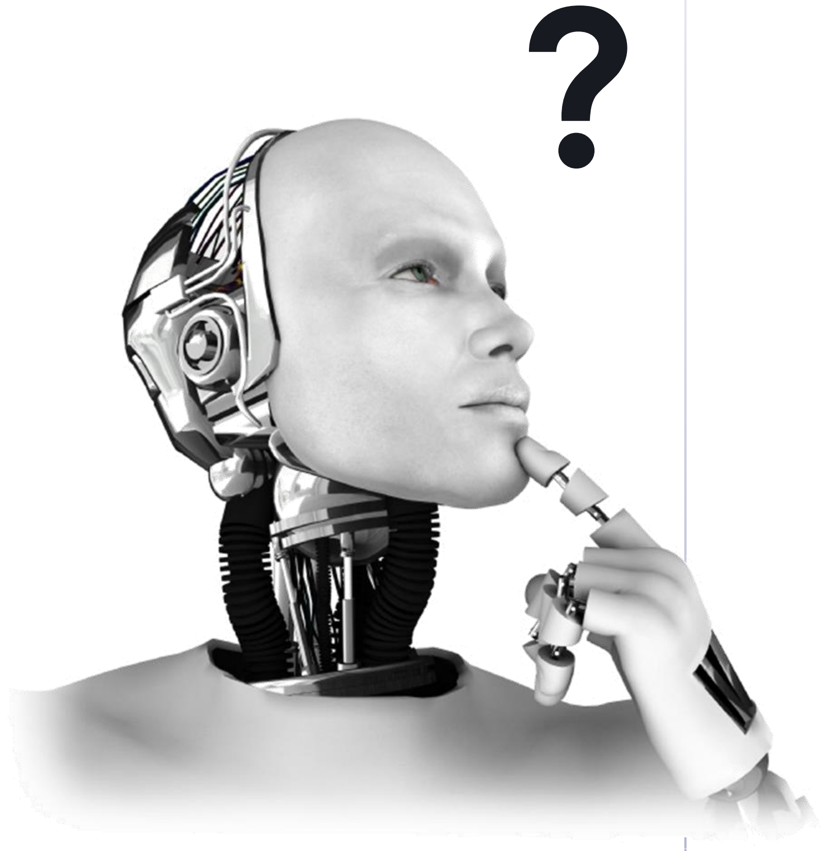
Constraints on Performance (integrity, accuracy,…)

Constraints on Low Latency (OODA loop acceleration)

Computational problems solved by Quantum Algorithms



THALES
Building a future we can all trust



Thank you

www.thalesgroup.com