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EMBEDDING INNOVATIONS

Security by Design: Introduction to MILS

MILS Workshop

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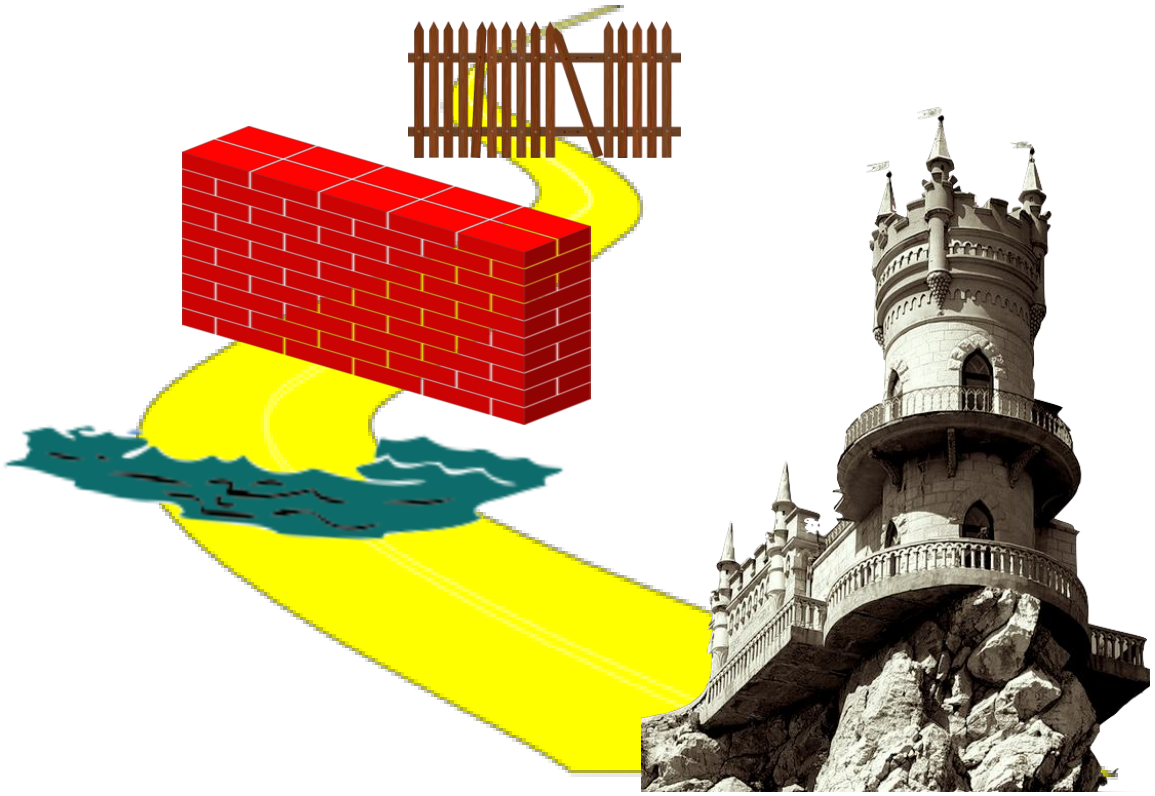
SECURING ASSETS:
EARLY DAYS AND NOWADAYS

Protecting Assets

- **People started protecting their assets (e.g. life) from the very beginning of their existence**
- **People started building**
  - Fences
  - Walls
  - Trenches + water
  - Air-gapping
  - …



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Fences + Walls + Air-gap + Underground + …

YOUR NEXT LIVING-WORKING PLACE?

or embrace information flow?

What is going to be hacked?

Short Answer: the weakest link

Long Answer: Attack Surface

- **Typically attacks aim at**
  - components with the exposed interfaces
  - information flow within system, i.e. components interaction
- **Thus, the attack surface is the full system architecture**
- **Security is the integral system property!**
- **Without a clean design, it is extremly difficult to identify/define the attack surface**

Example: Hacking Cryptography

- **Hacking cryptography often imagined as using BIG supercomputers, hacking crypto algorithms, hacking crypto protocols ….**
- **In reality, hacking crypto is a hard task**
  - unless some secret services have placed backddors ☺
- **In reality, it is easier to attack how the crytpo subsystem/engine is integrated in the system**
  - Integrated means: information exchange between security domains, calling APIs, storing (critical) auxilary data
- **Example: Talk ”Crypto wont save you either” by Peter Gutmann**
  - List a lot of prominent hacks, for all of them crakcing crypto was **not** necessary
  - All of them targeted **integration**

SAFETY AND SECURITY

Safety and Security

- **Safety – system shall not harm the environment**
  - Example in aircrafts/cars: passengers shall stay alive and unharmed while transportation from start to destination
    - System: aircraft/car
    - Environment: passengers
    - Harm: crash leading to deaths

- **Security – environment shall not be capable to harm system**
  - Example in information gateways: information shall only be read/written by authorized subjects
    - System: information processing device
    - Environment: unauthorized subjects (hackers)
    - Harm: modification or leak

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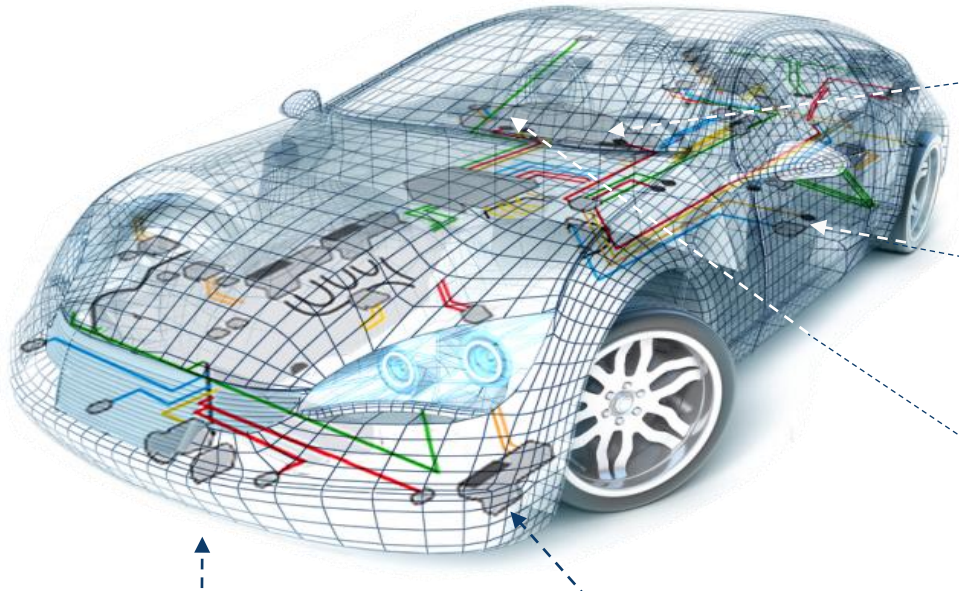
Aircraft Today

- **Aircraft is network based (AFDX & IP)**
- **Increasing usage of common computing resources**
  - IMA, Open World
- **Open World domain with COTS software**
  - Wi-fi products, Linux
- **New IT services**
  - Pilots (tablets), passengers, crew, maintenance
- **Increasing integration and information flows between systems**
- **Aircraft is heavily connected to other IT services**
  - Airlines, ATC
- **Aircraft is connected to INTERNET**

Highly integrated ECUs with COTS SW

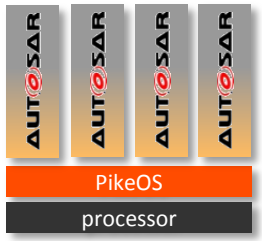


Instrument Cluster

Connectivity Box

Infotainment Head Unit

Domain Controllers



Driver Assistance Systems

Tachograph

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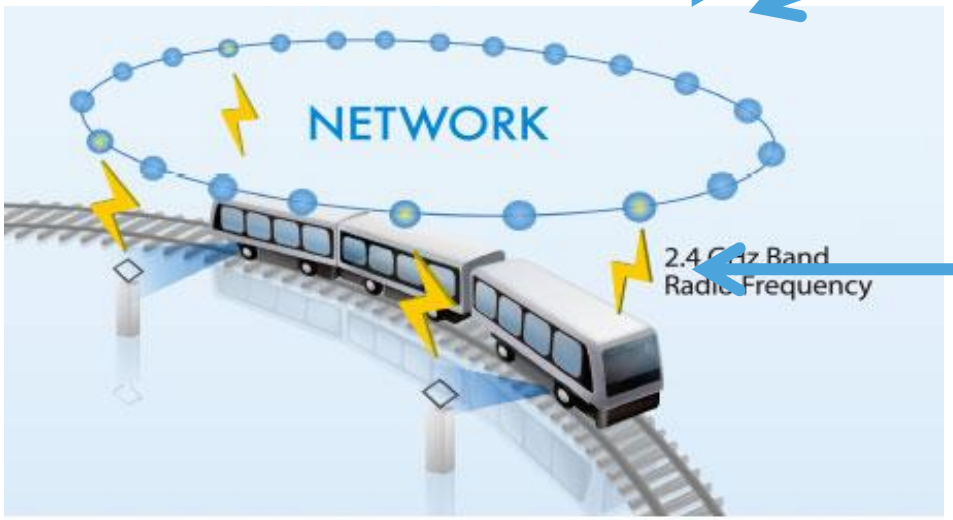
Railway going online

Field elements

Wired,
public wireless

Interlocking



CBTC (Communications-Based Train Control)

Operation Management and Supervision Systems

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Common Challenges in Cyber-Physical-Systems

- **Functionality density is increasing**
  - Integrate functions on small numbers of ECU
  - Reduce the number of ECUs or keep (at least) the same
  - Benefit on powerful COTS HW and SW
  - **Need proper se**

Affordable assurance

- **Heterogeneous information flows**
  - Systems are interconnected and e ed to exter l world
  - Usage of common network infr
  - **Need proper separation a ontrol of information flows**

- **High-assurance for mixed-critica CUs**
  - Functionalities have different assurance requirements, e.g. safety vs. security
  - The overall assurance design shall be enough to run the most demanding one
  - **Need proper compositional certification approach**

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Secure Design Methodology for integrated CPS
Sharing Challenges

Challenge: Resources sharing

- **Resources**
  - CPUs
  - Memory, IO memory
  - Flies, drivers, devices, buses
- **Safety**
  - Integrity, availability
  - Isolation, application errors, fail safe
- **Security**
  - Integrity, availability, confidentiality
  - Possible side channels via shared resources
  - Resources and API are attack surface

MILS methodology addresses

Resource Partitioning

Challenge: Time sharing

- **Time**
  - CPU cycles
  - Time effects of accessing shared resources, e.g. buses
- **Safety**
  - Availability, deterministic behavior, meeting deadlines
  - Right balance between time- and event-triggered tasks
- **Security**
  - Availability, confidentiality
  - Possible timing side channels via shared resources, e.g. caches, busses
  - Time is the attack surface

MILS methodology addresses

Time Partitioning

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Common: Assurance via Certification

	Aerospace	Automotive	Railway	Smart Grid
Safety	Long history of standardisation	Recently introduced standard	Long history of standardisation	Based on industrial automation
Security	On-going work on security standard	Staring work on security standard	Staring work on security standard	Many national initiatives; defining path

Standards are focused on
development processes, risk modelling, V&V, and domain specifics

MILS – is architectural principle addressing these requirements

MILS – LET'S SECURE!

Brief MILS History

1975
- Saltzer and Schroeder “The Protection of Information in Computer Systems”

1981
- Rushby “Sesign and Verification of Secure Systems”

1992-2005
- IMA concepts, safety focus

2005
- Hardware virtualisation Intel VT-x, AMD-V

2007
- US Separation Kernel Protection Profile

2007-…
- US-based studies
- The OpenGroup standardisation
- Hardware was not in the focus

2012
- SKPP sun-setted by US government: HW complexity, monolithic eval, politics

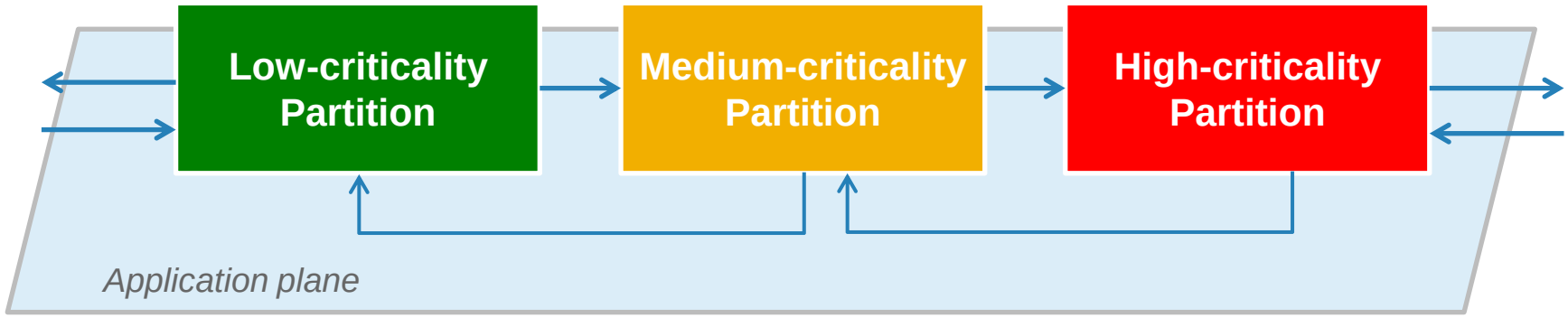
2012
- EURO-MILS
  - MILS Architecture
  - Protection Profile for Separation Kernel
  - High Assurance methods
  - Compositional cert
- D-MILS
  - Research on configuration and analysis of distributed MILS

2014
- Founding of the MILS Community

2016
- CITADEL: adaptive MILS

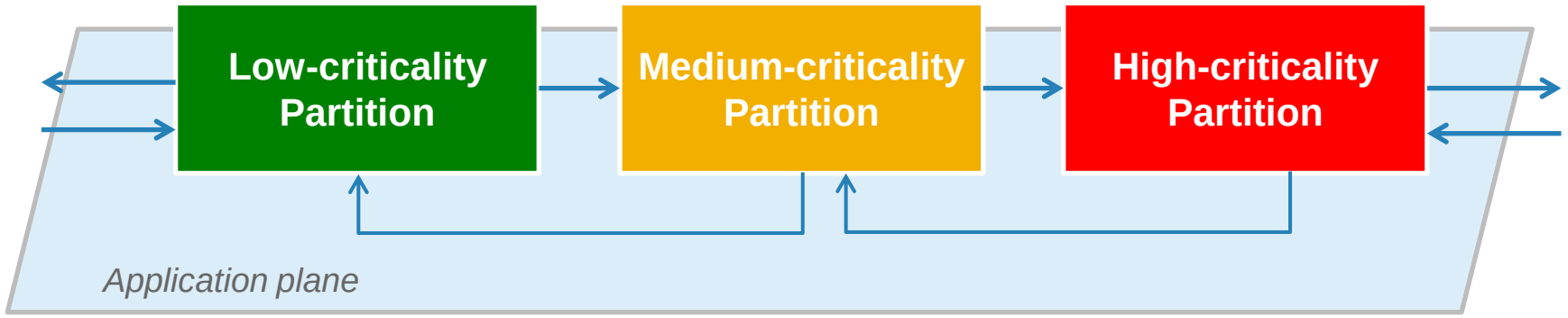
2017
- certMILS: compositional certification of system based on MILS

Developing System Architecture



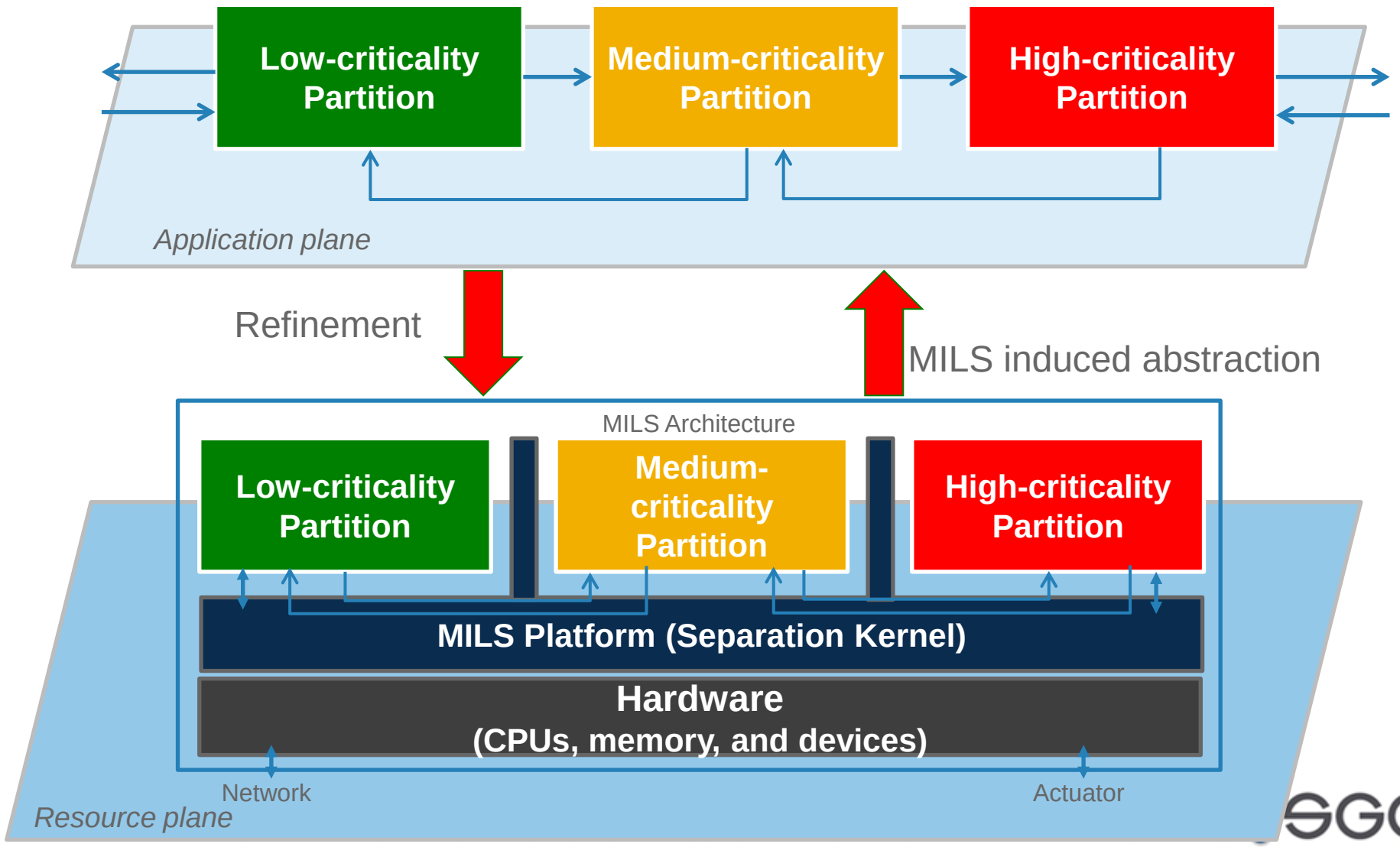
- Generic problems:
  - Composition preserving safety, security, assurance arguments
  - Refinement is a composition, i.e. adding execution environment OS, HW, services
  - Mitigate effects of “have to refine”
    - where we need something to execute systems

MILS



MILS is a **high-assurance security architecture** that supports the **coexistence** of untrusted and trusted components, based on **verifiable separation mechanisms** and controlled information flow

MILS Architectural Approach

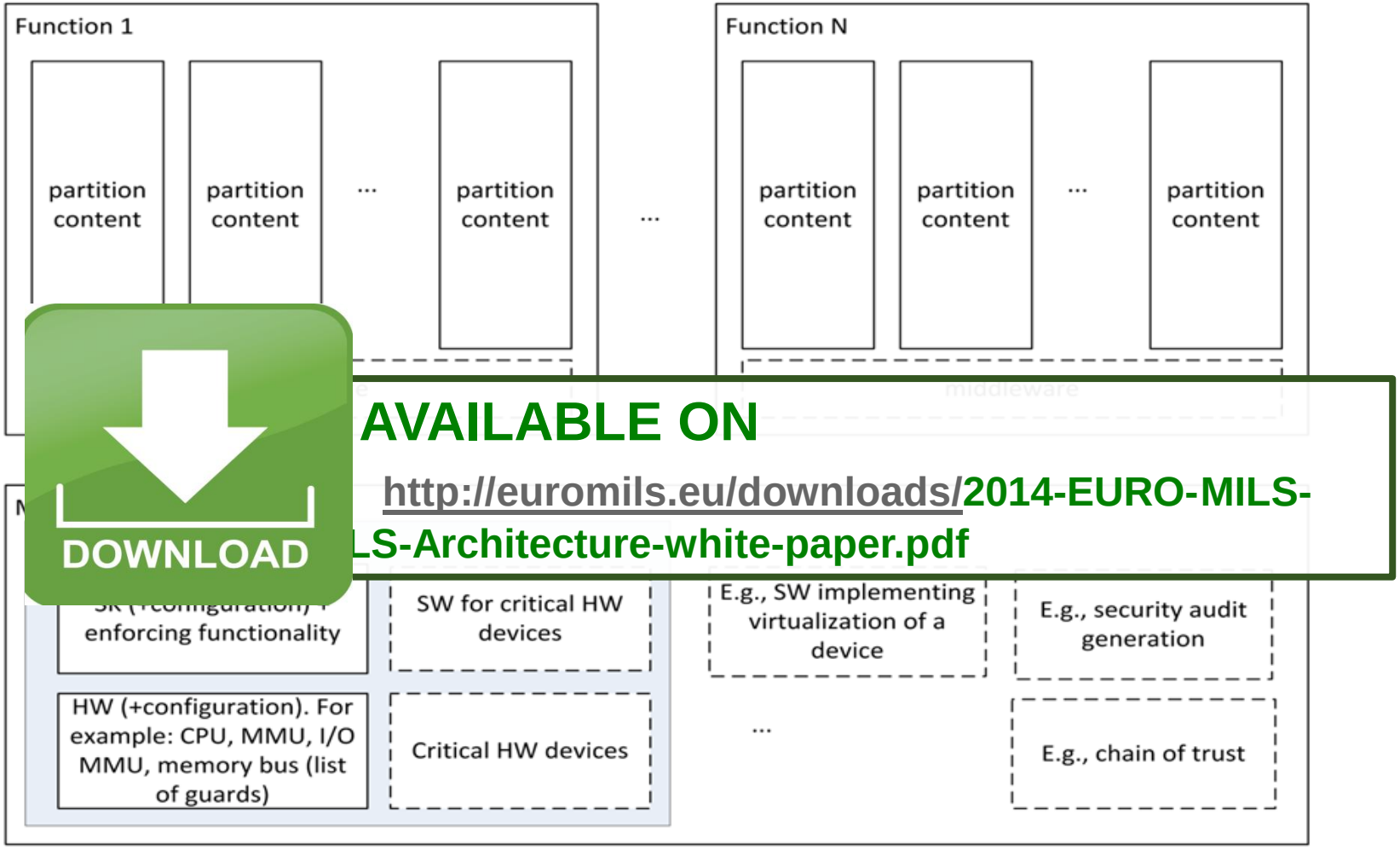


How to build a MILS system

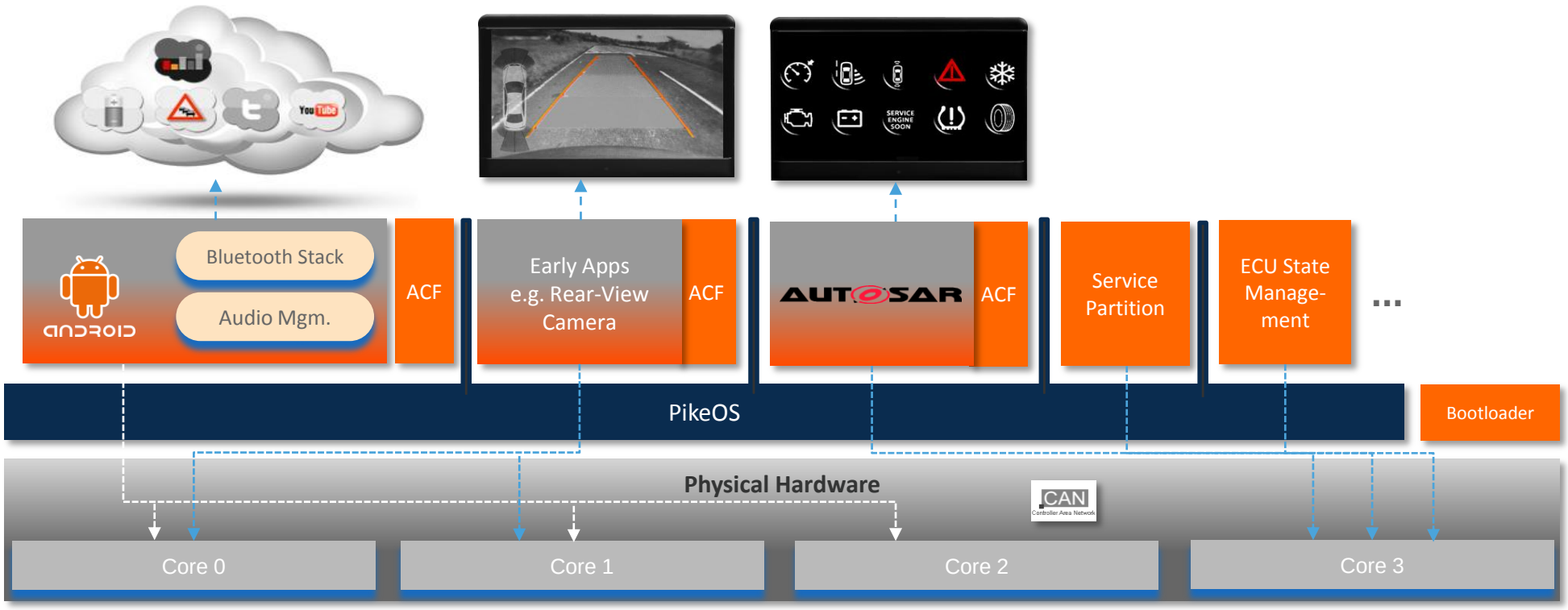
How to use a MILS platform

- **Develop a system architecture consisting of different safety and security domains, i.e. partition system in domains**
- **Assign platform resources to partitions**
  - Assign CPUs, CPU time, memory, I/O devices, file access, available services to partitions
- **Define communication channels between partitions**
  - Default: everything is forbidden what is not explicitly allowed
- **Optionally, add libraries/run-time environments to partitions**
  - e.g. POSIX, ARINC, AUTOSAR, Linux, ANDROID, Ada

MILS Architecture



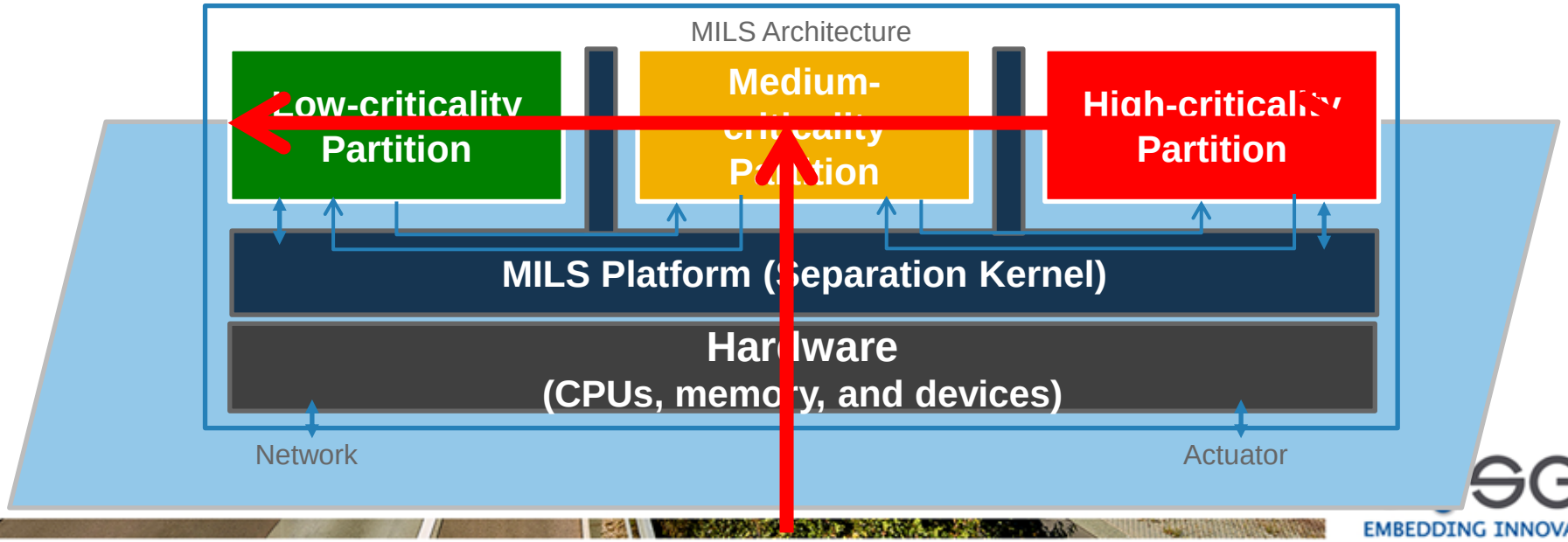
Example MILS in Automotive:
Secure Android-based Head-Unit + Payment Services



Compositional Certification: Scenario-T

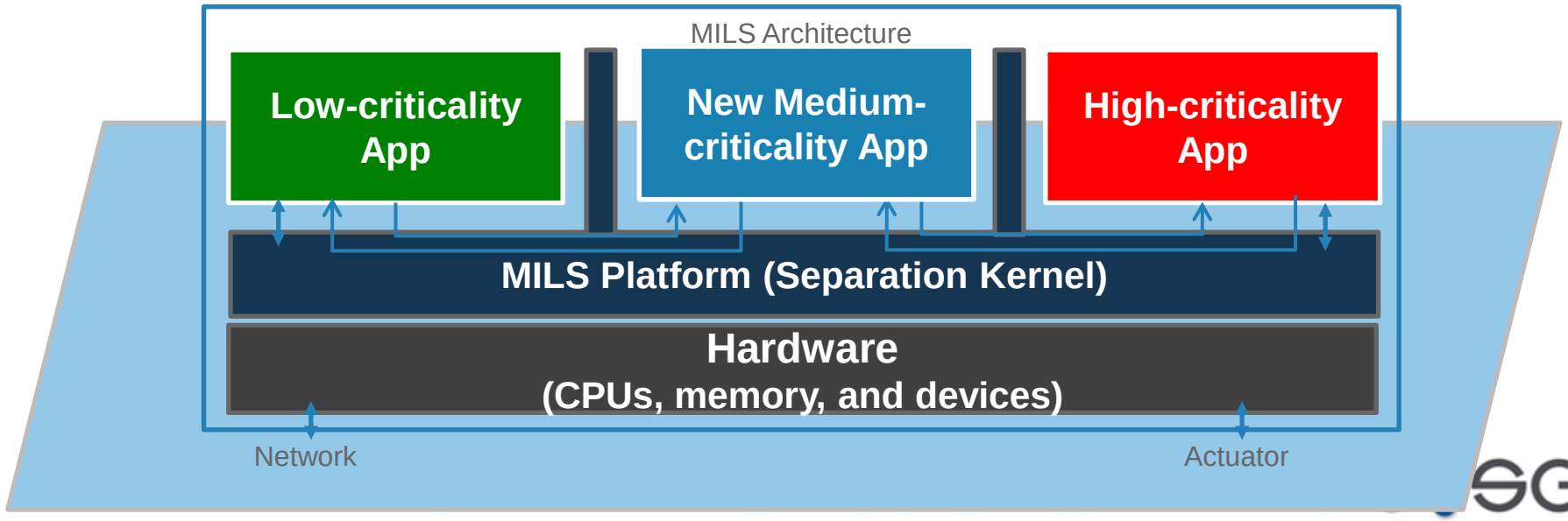
- The core is Separation Kernel
- Components under certified composition
  - Hardware, Separation kernel, Applications

T - composition



Compositional Certification: Scenario-P

- **Puzzle Composition**
  - Exchange system component with interface/function-compatible one
  - Use-cases
    - Product from Vendor-A is replaced by product from Vendor-B
    - Flexible in-the-field update

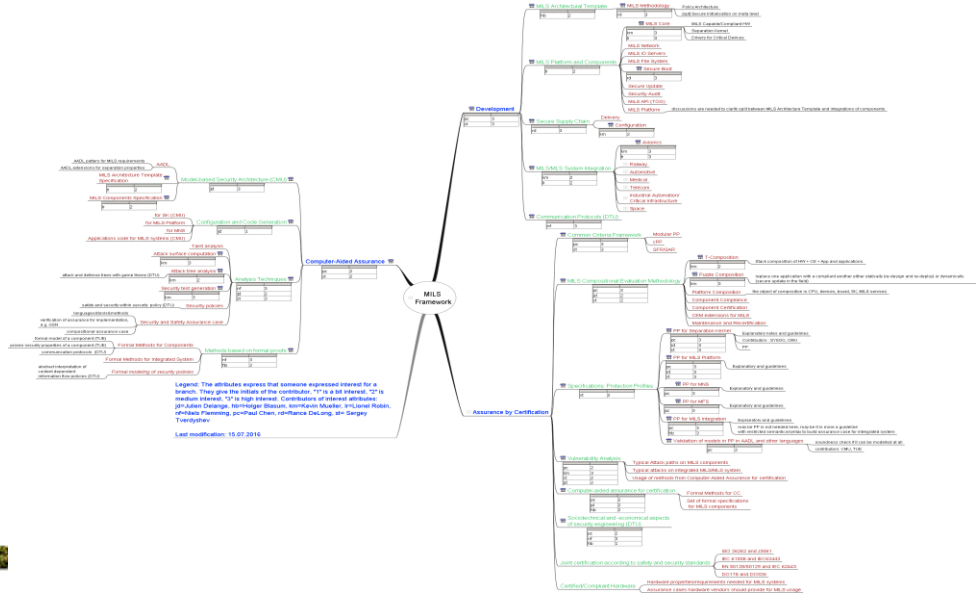


Further Topics/Advances

- **MILS Framework**
- **Certification**
  - Protection Profile for Separation Kernel
  - Compositional Security Evaluation Methodology
    - Baseline for T and P compositions
- **Components**
  - MILS components, e.g. network,
- **Tool based assurance**
  - Formal methods
  - Introspection tools
  - Compositional assurance cases
- **On-going research**
  - Adaptive and Distributed MILS
  - Compositional evaluation

MILS Community: Roadmap

mils-community.euromils.eu



SUMMARY

Summary: Assurance via Certification

	Aerospace	Automotive	Railway
Safety	Long history of standardisation	Recently introduced standard	Long history of standardisation
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Security Assurance in Cyber-Physical Systems is **HOT** topic

Takeaways

- Consider adverse actors at the very beginning of the system design stage
- Your system will not be isolated:
  neither physically not information-flow-wise
- System integration concept, i.e. architecture, is
  the most important SECURITY MEASURE
- MILS architectural approach is enabler for
  High-assurance safety and security architecture and
  Compositional certification

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Thank you for your attention!

More information on www.sysgo.com