EURO-MILS: Building and certifying modular secure systems

Sergey Tverdyshev, SYSGO
The Euro-MILS consortium

MILS Workshop 2015
20.01.2015 Amsterdam

www.euromils.eu

EURO-MILS Consortium

14 Partners from 6 Countries

TECHNIKON

SYSGO
EMBEDDING INNOVATIONS
France Germany

AIRBUS
GROUP Innovations, Germany
Innovations, France

DEK

UNIVERSITEIT
GENT

AIRBUS
AN EADS COMPANY

OPENSYNERGY

UNIVERSITÉ
PARIS
SUD

THALES

Open Universiteit
www.ou.nl

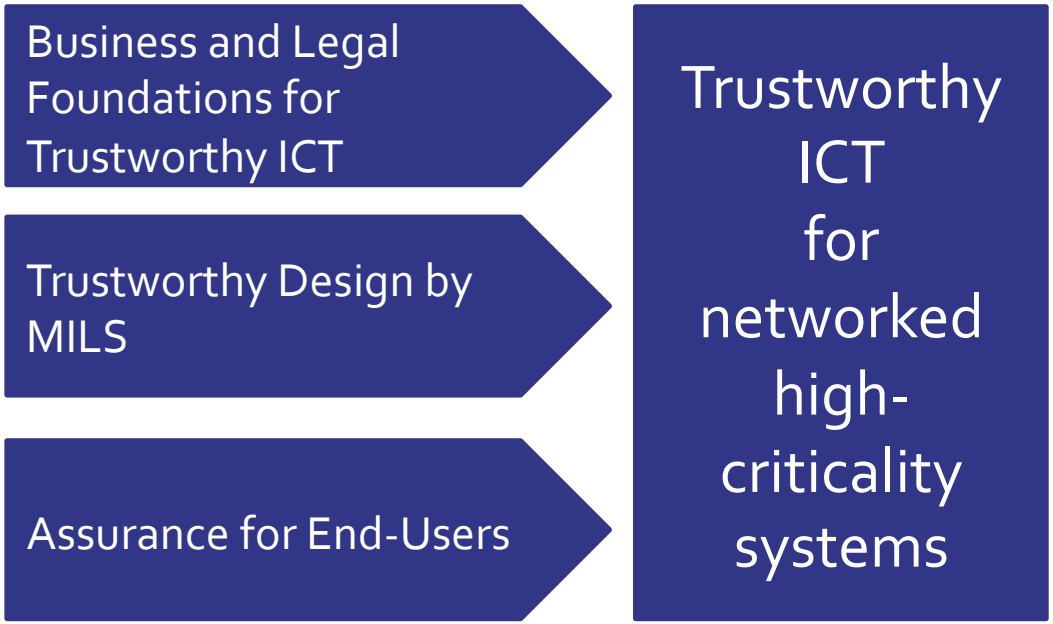
T-Systems

JEMM
research

EURO-MILS: Strategy and Objectives

- High-criticality networked cyber-physical systems
  - Drivers are avionics and automotive
  - EURO-MILS delivers cross-domain solutions

- Integration and networking requires trustworthy ICT
- MILS Architecture
  - High-assurance security architecture
  - Scalable and affordable security
  - Compositional design, assurance, security

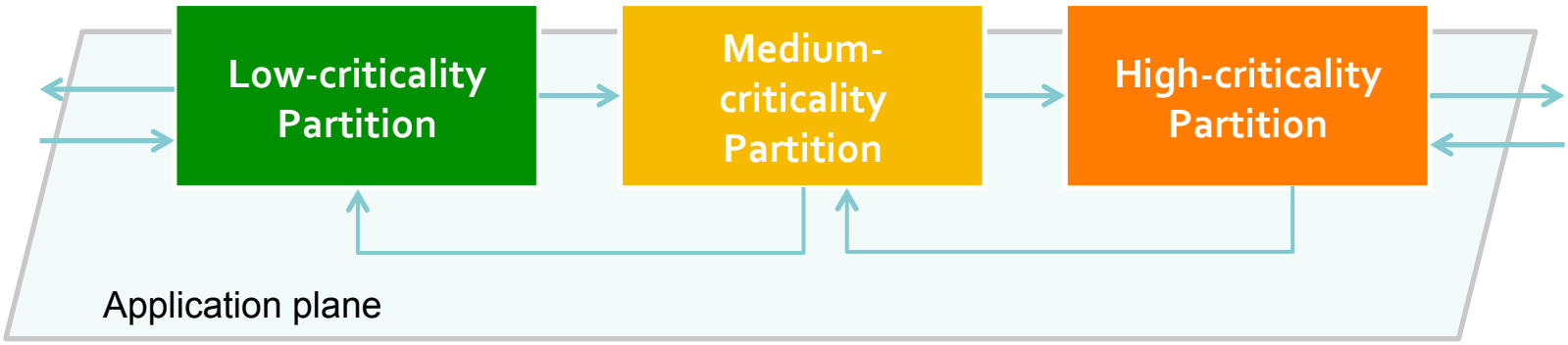


- EURO-MILS: European MILS architecture and certifiable platform

ICT: Information and Communication Technologies
MILS: Multiple Independent Levels of Security

COMPOSITIONAL SYSTEM DESIGN
FOR SECURITY AND SAFETY

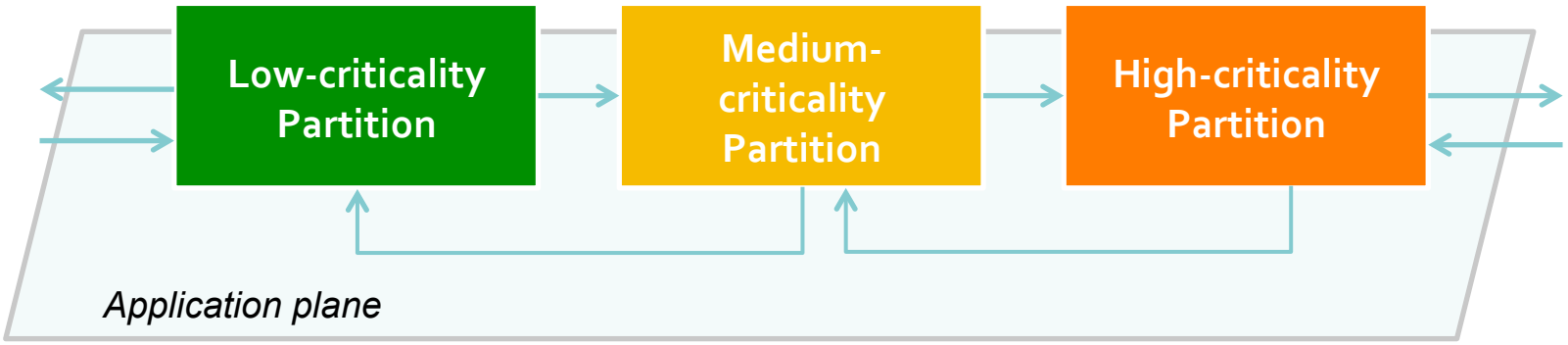
Developing System Architecture



- System is
  - a group of related components that work together
  - possessing a set of properties

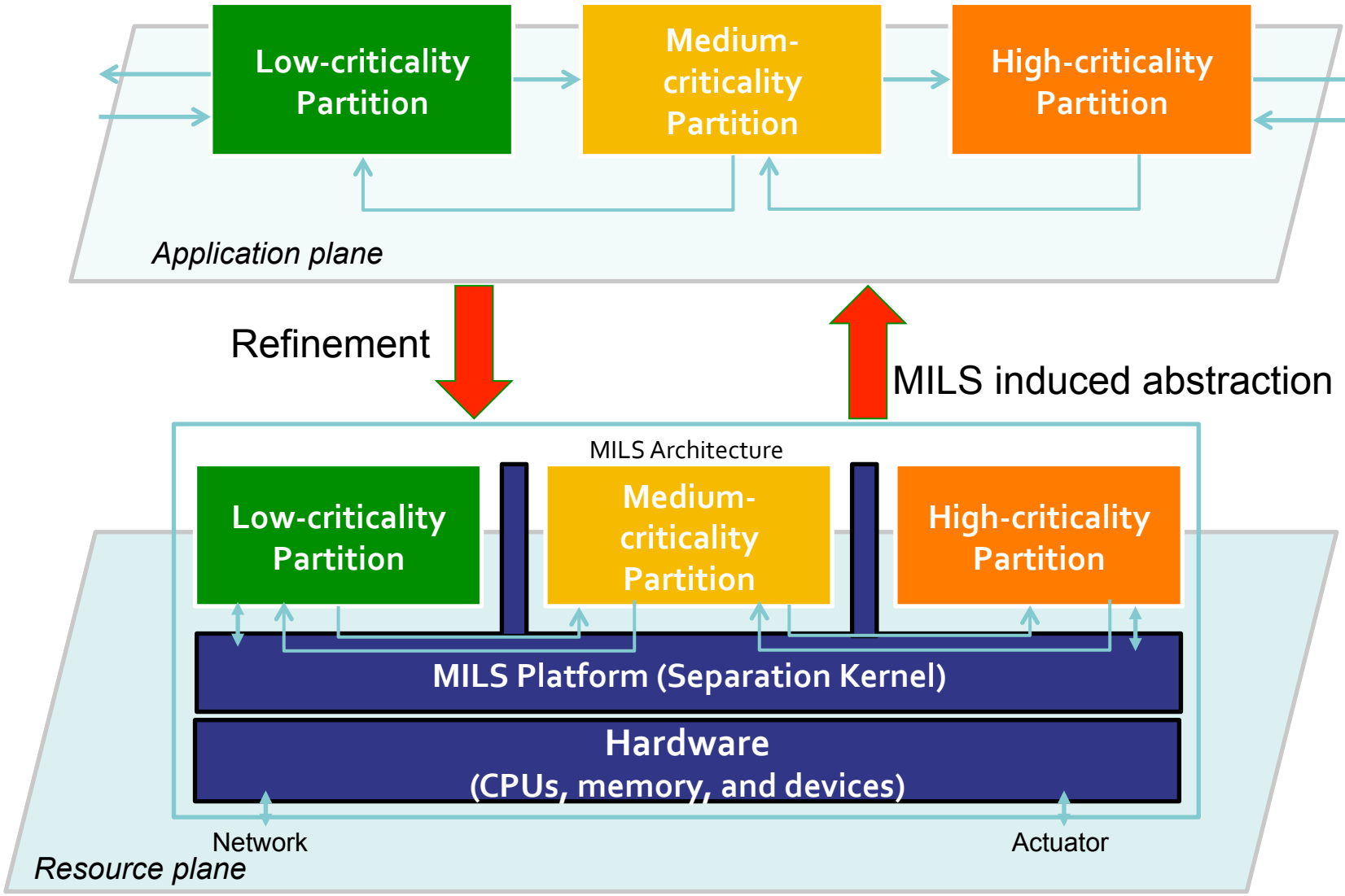
- To bring that components to life you need an execution platform
  - Execution platform introduces new components and interfaces
  - Execution platform has (physical) resources
  - Execution platform possesses a set of new properties
  - i.e. refine system design

Developing System Architecture



- Generic problems:
  - Composition preserving safety, security, assurance arguments
  - Refinement is a composition
  - Mitigate effects of “have to refine”
    - where we need something to execute systems

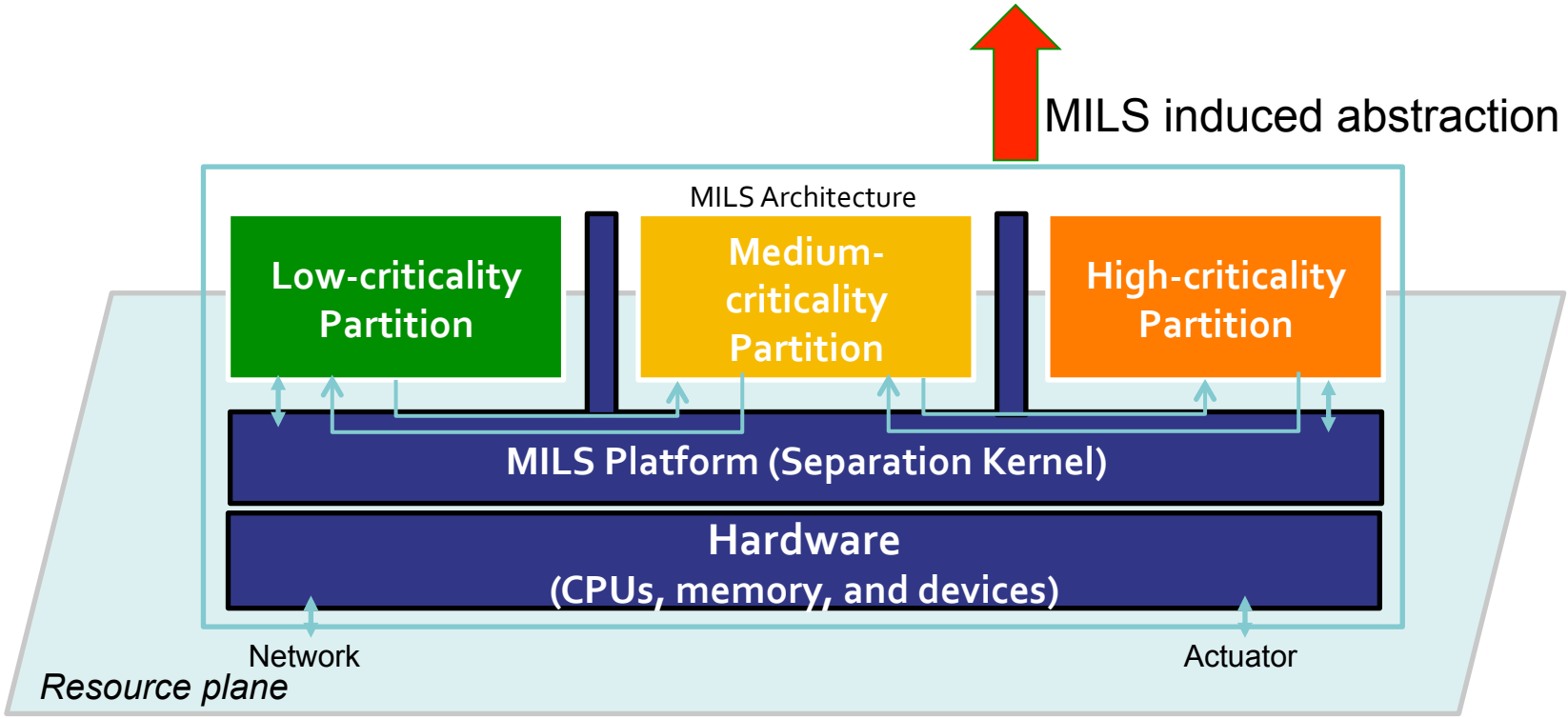
MILS Architectural Approach



MILS Architectural Approach

MILS induced abstraction enables truly **compositional**

- Safety and Security
- Assurance
- Evaluation



MILS DESIGN AND ASSURANCE FRAMEWORK

MILS Design and Assurance Framework

- EURO-MILS focus is to create a framework with focus on
  - Compositional Design/System integration
  - Compositional Assurance
  - Certified MILS separation kernel
- Framework shall cover major life-cycles of system design, integration, validation, evaluation
- EURO-MILS validates framework on industrial applications in avionics and automotive
- **Goal:** create validated MILS Framework as set of
  - specifications, examples, guidelines,
  - evaluation methodology
  - to ease system designing and creating assurance artefacts

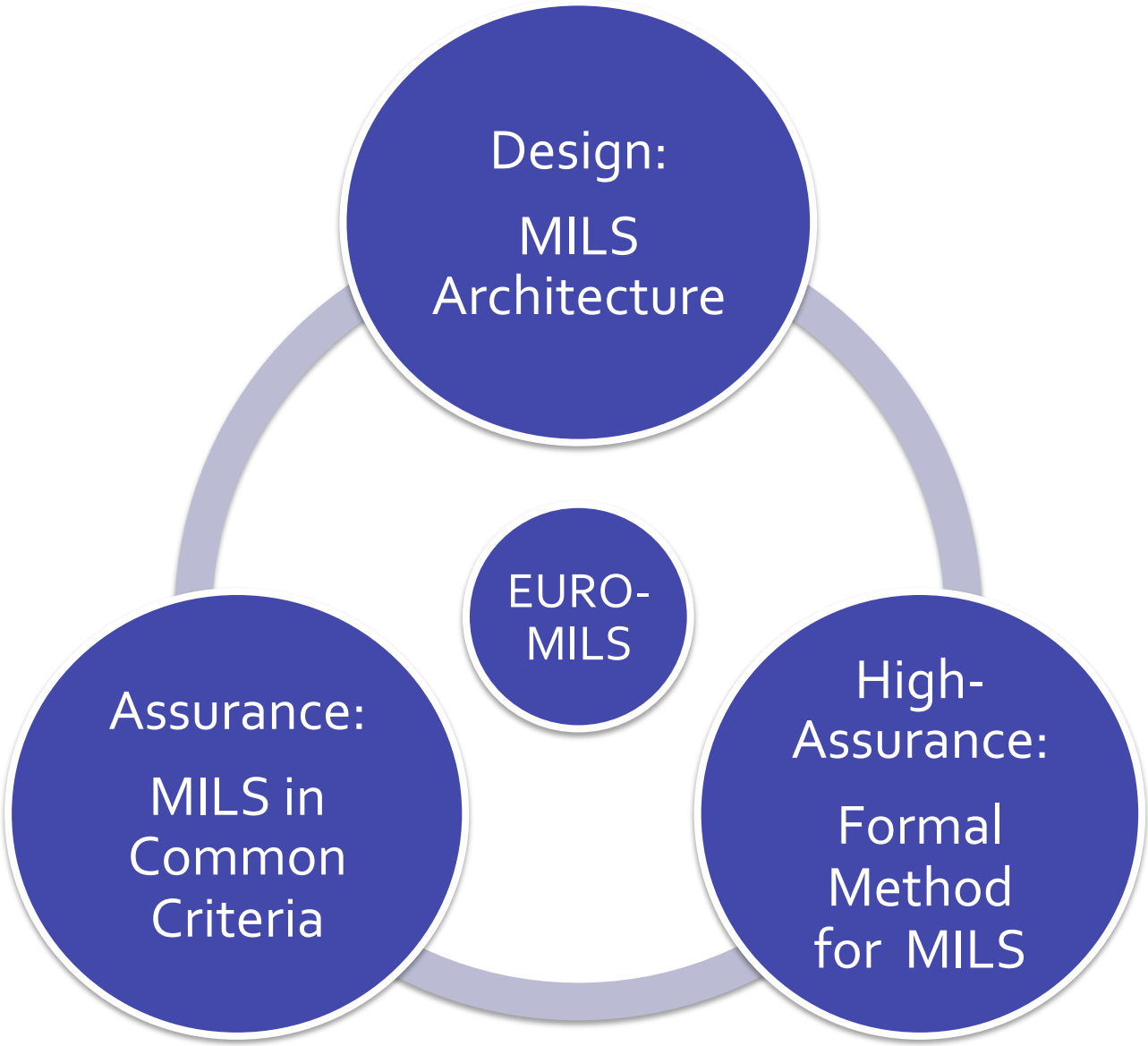
Scope: MILS Disambiguation

- MILS is not equal to separation kernel (SK)
  - MILS SK cannot be a stand-alone component neither in application nor in certification (PP)

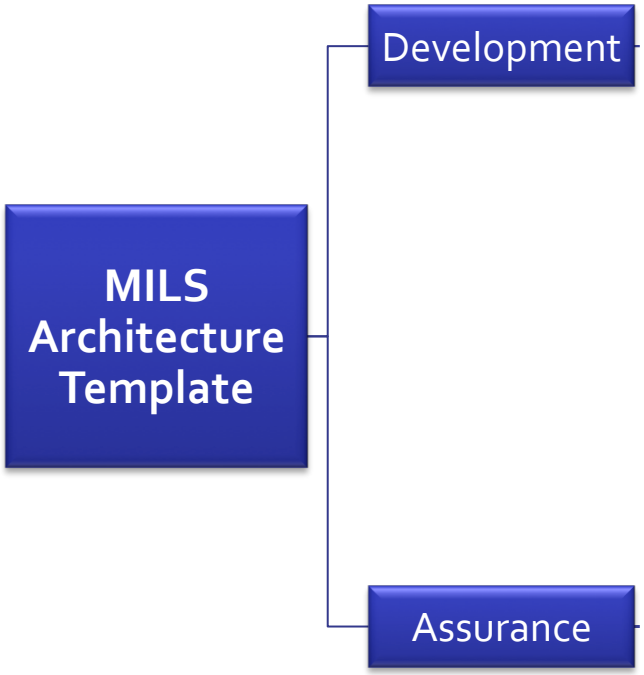
- MILS is
  - Design approach and Architecture
  - System integration approach
  - Mils API
    - see also The Open Group MILS WG
  - High-assurance components (separation kernel, minimal file system, network etc.)
  - …

- However, one of the cornerstone is a separation kernel

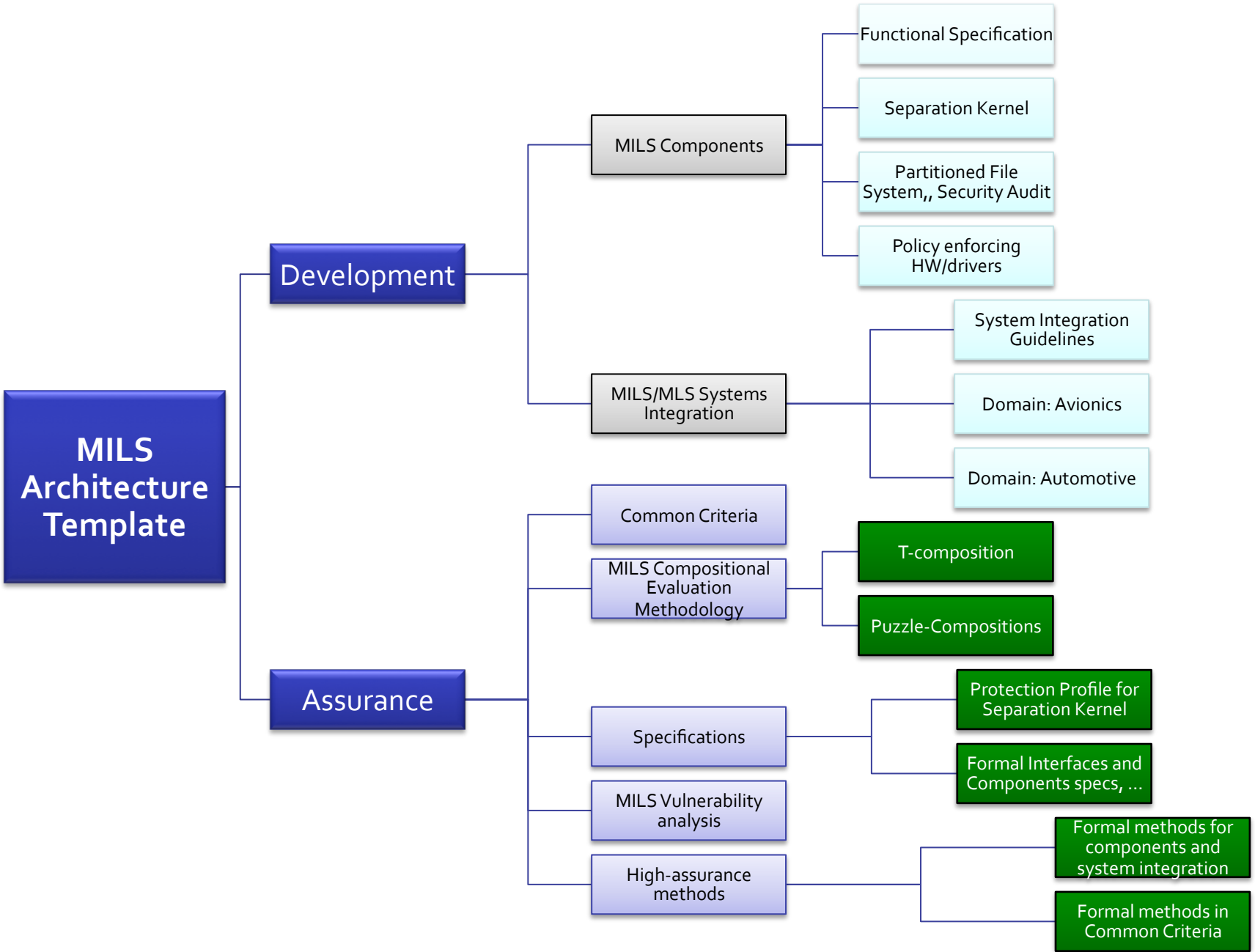
Achieving EURO-MILS Goal



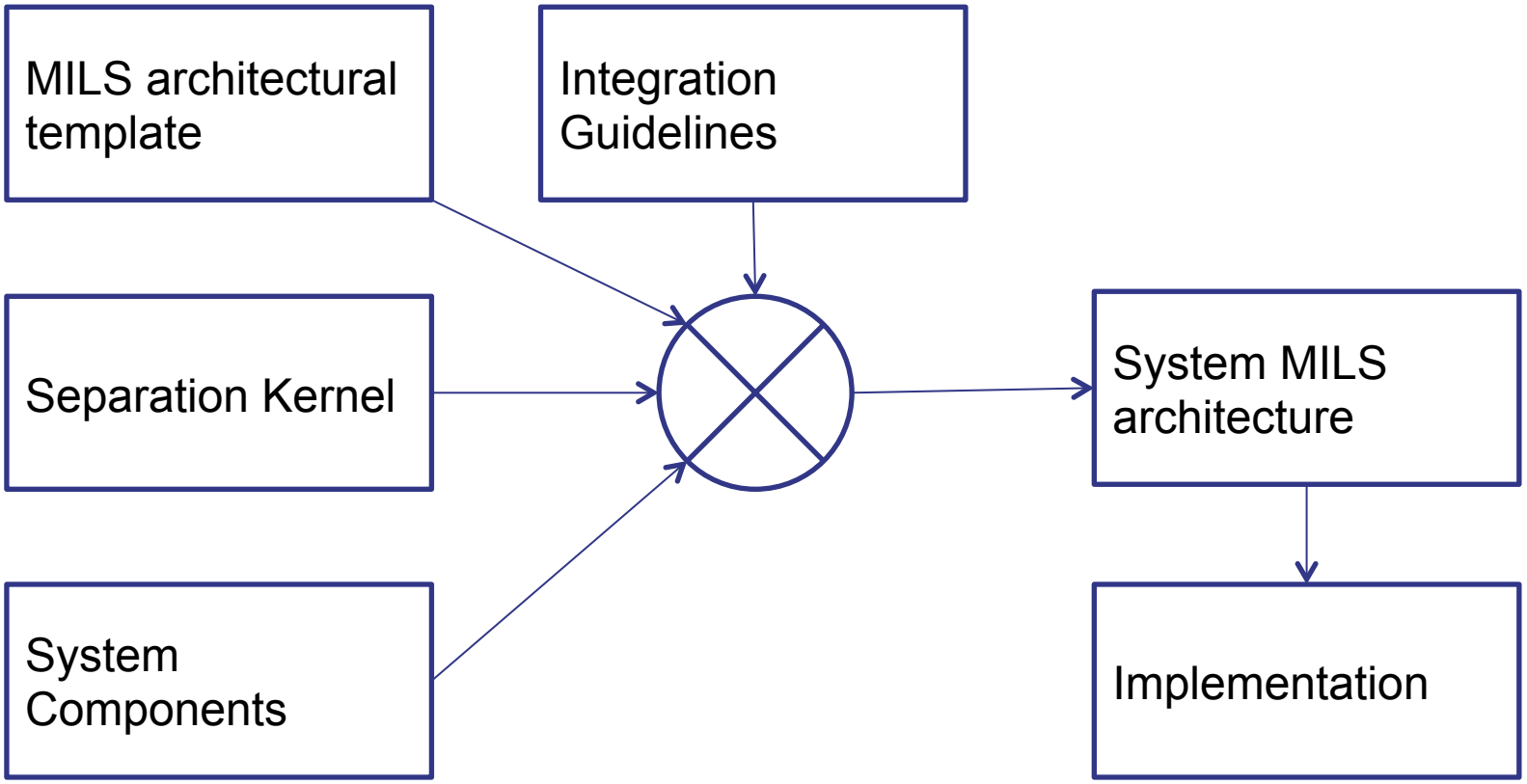
MILS Framework



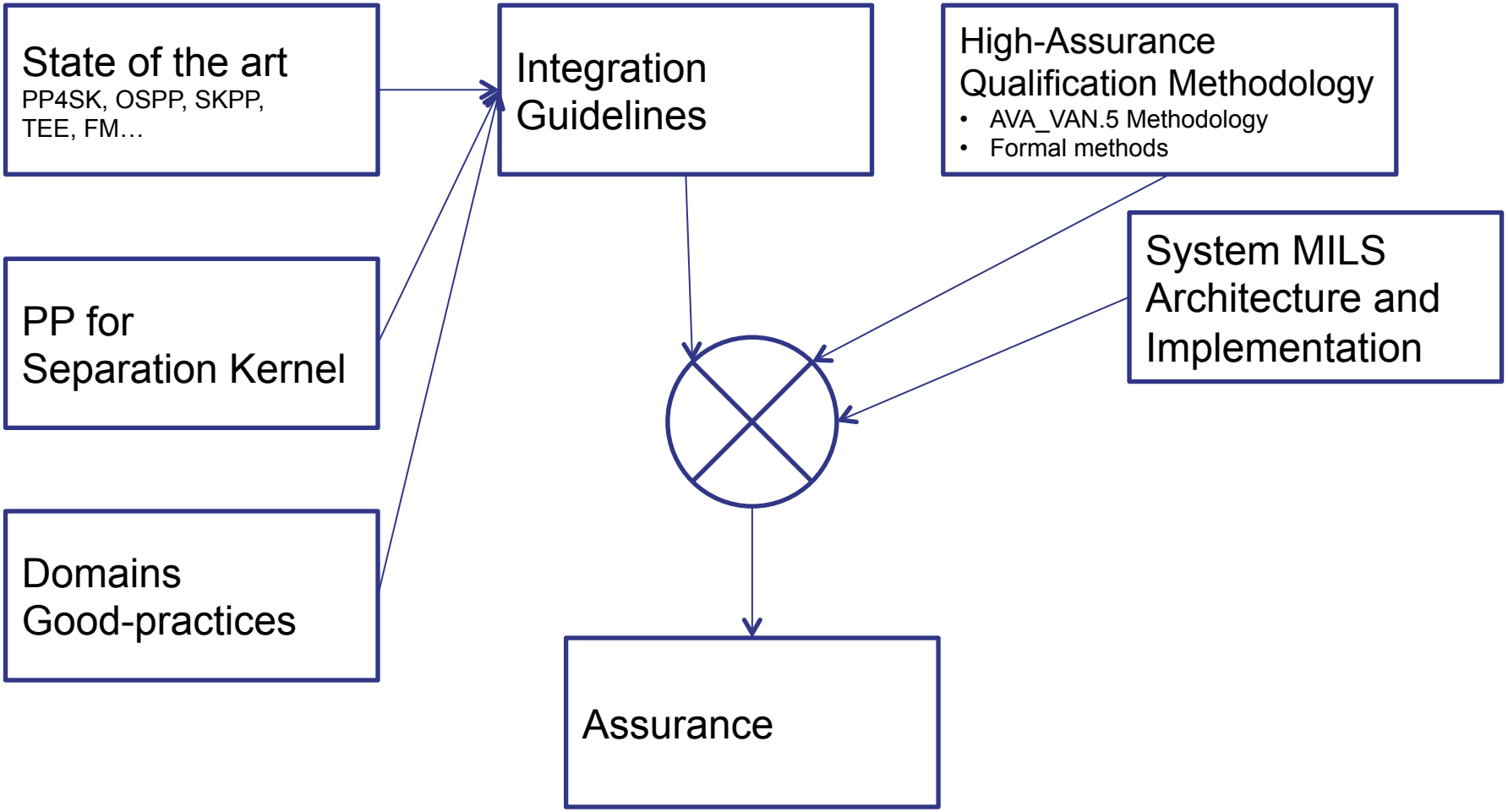
MILS Framework



MILS Framework: Developer track

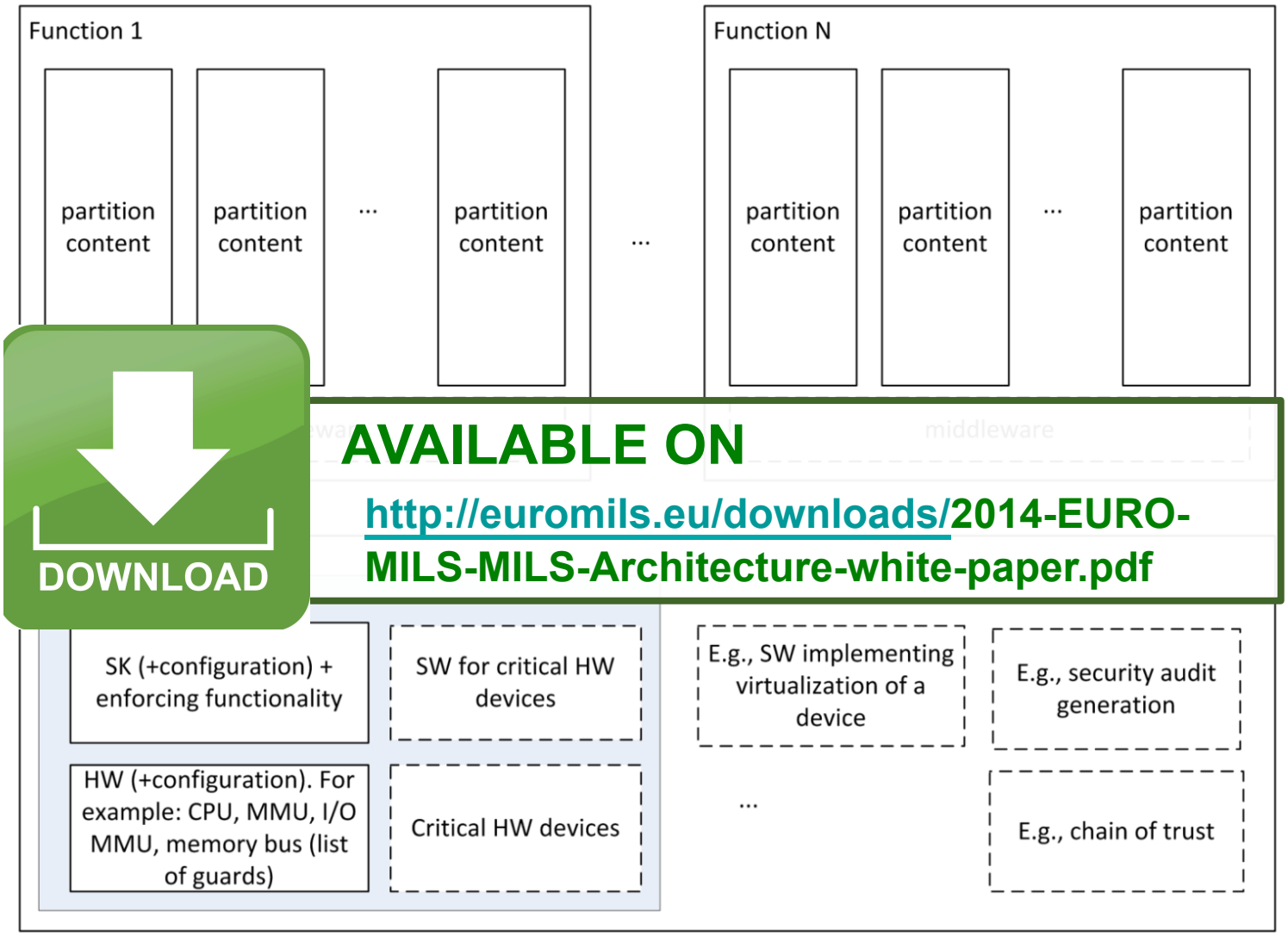


MILS Framework: Assurance track



The Developer Track

MILS Architectural Template



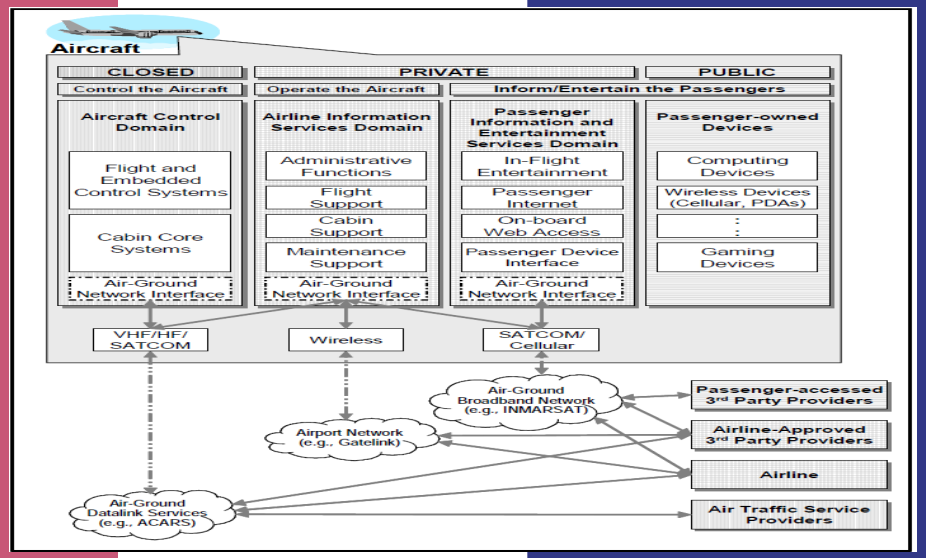
Security Services Provided by the Separation Kernel

MILS architectural template defines main components.

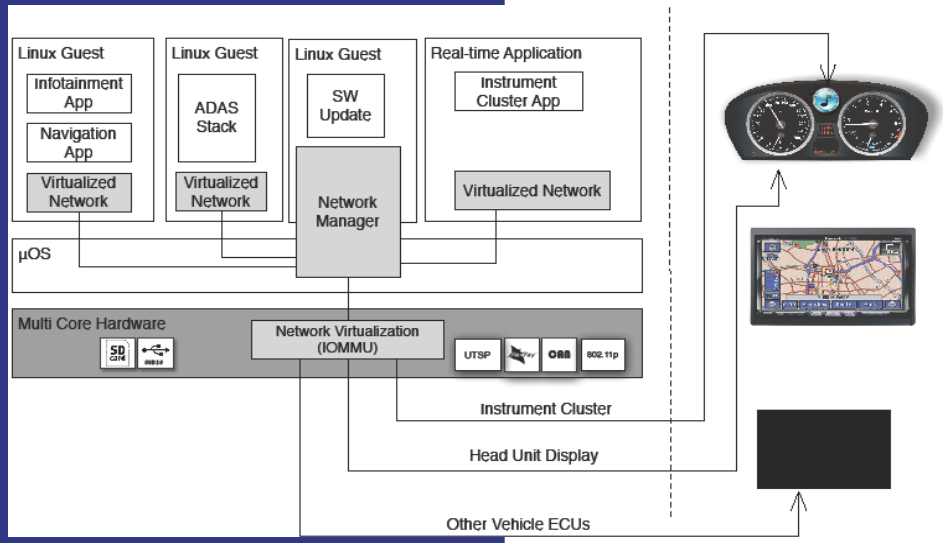
Example: Separation Kernel (SK).

- *Separation in space* of applications hosted in different partitions from each other and from the separation kernel
- *Separation in time* of applications hosted in different partitions from each other and from the separation kernel
- *Provision and management of communication objects*
- *Management* of and access to the SK and SK data
- Separation kernel *self-protection and accuracy of security functionality*
- *Generation and treatment of audit data according to the configuration*

Avionics

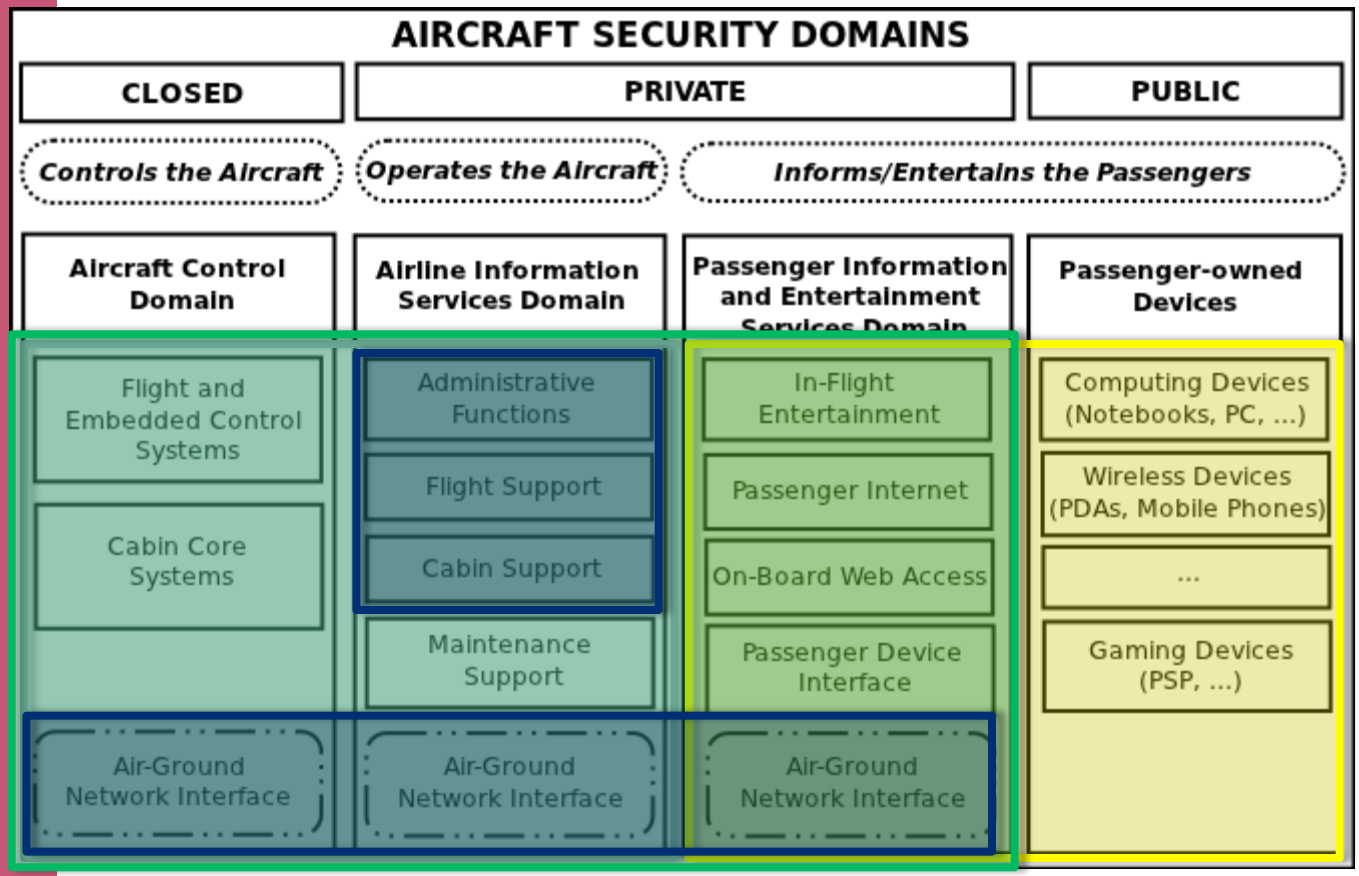


Automotive



Trustworthy ICT
for networked
high-criticality systems

Example: Aircraft Security Domains

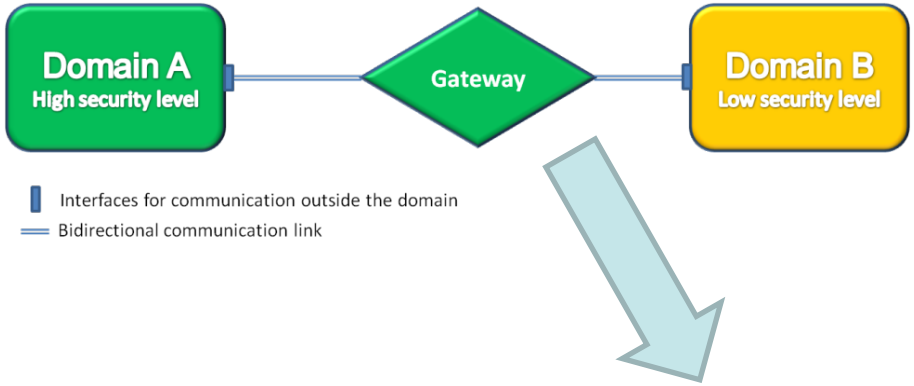


Perspective "User"
(not 100% accurate)

- Crew
- Passenger
- Maintenance (all types)
- Others (Air Traffic Control, Airline Services, Ground)

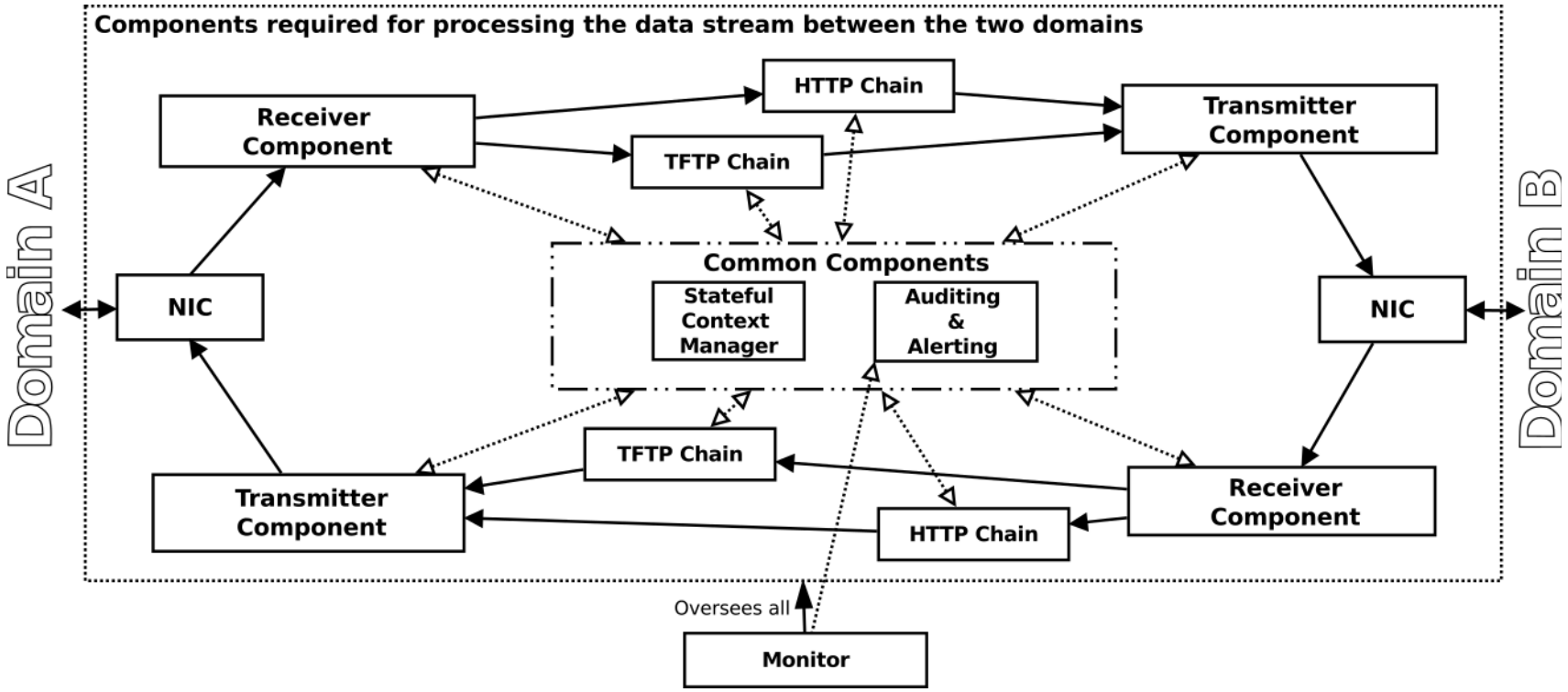
- Picture adapted from ARINC 811.
- Domains are defined In ARINC 664 Part 5.

The Avionics MILS Gateway

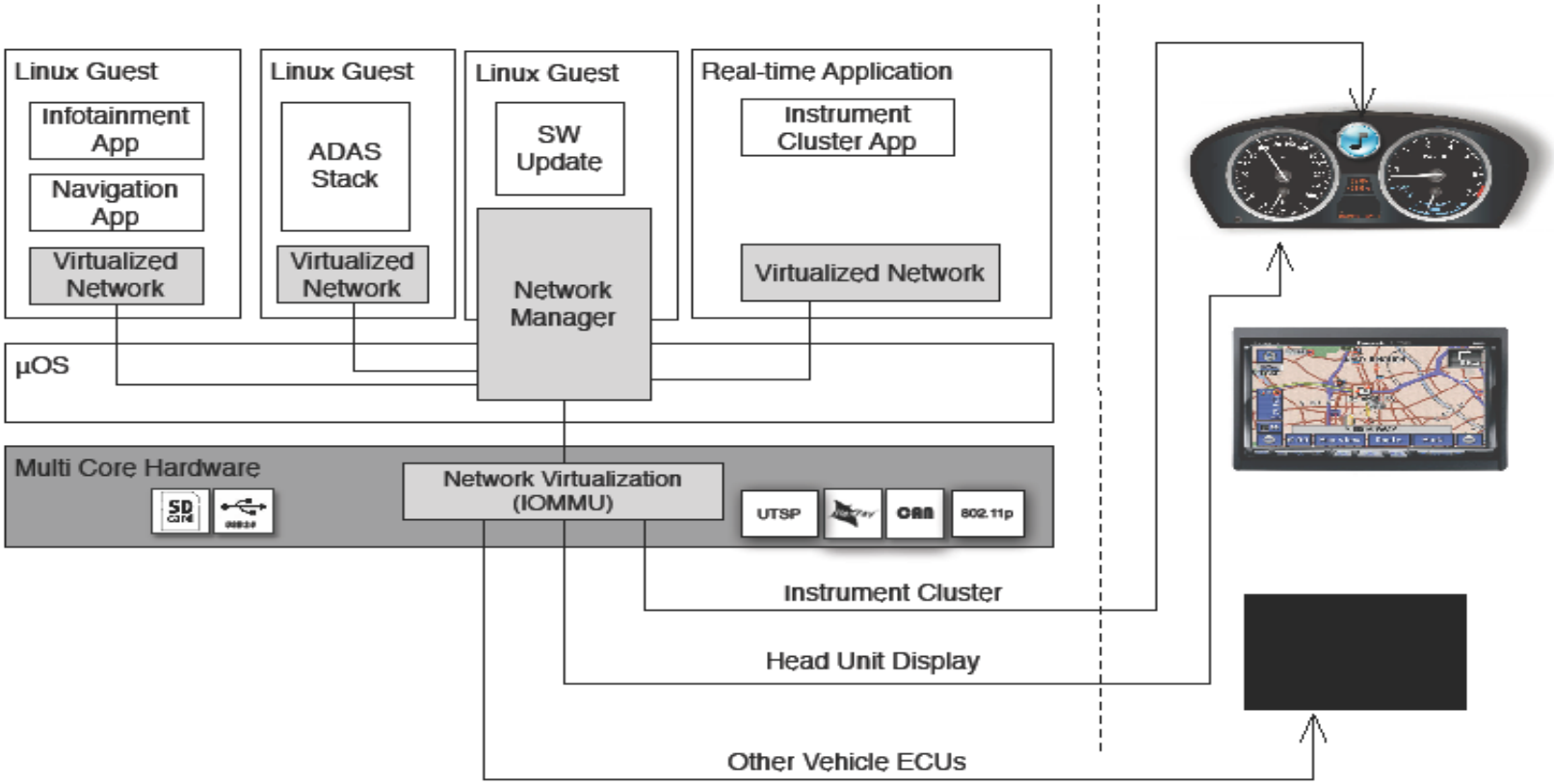


Key aspect of architecture:

Rely on MILS platform security services for the implementation of gateway layers (e.g. coarse information flow control of separation kernel and using unidirectional flow)

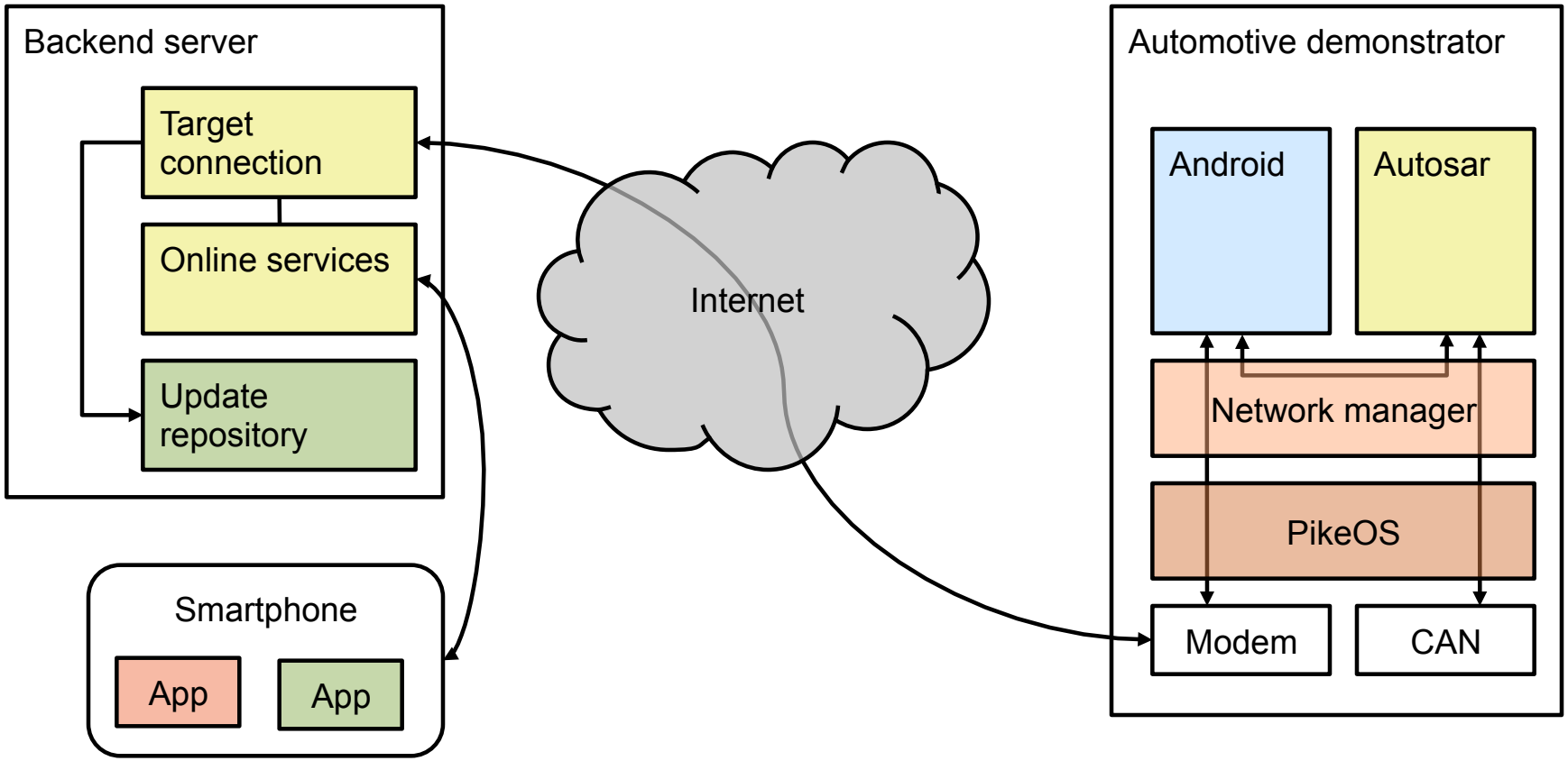


Example: Automotive Security Domains



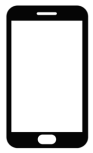
- Target of automotive security measures is the protection of instrument cluster and head unit display control, as well as the underlying virtualisation platform. Under no circumstances, these units may be compromised or disturbed in their normal operation.

Automotive Telematics Environment



More Use-cases

MILS is applicable and gathering interest across all domains



Avionics/UAV

Automotive

Industrial automation

Railway

Railway automation

Mobile devices

Telecom and communication

Multiple-payload satellites

Sea/Subsea

Banking

…

The Assurance Track

EURO-MILS Platform: Common Criteria Certification

An international standard (ISO/IEC 15408)
for computer security certification

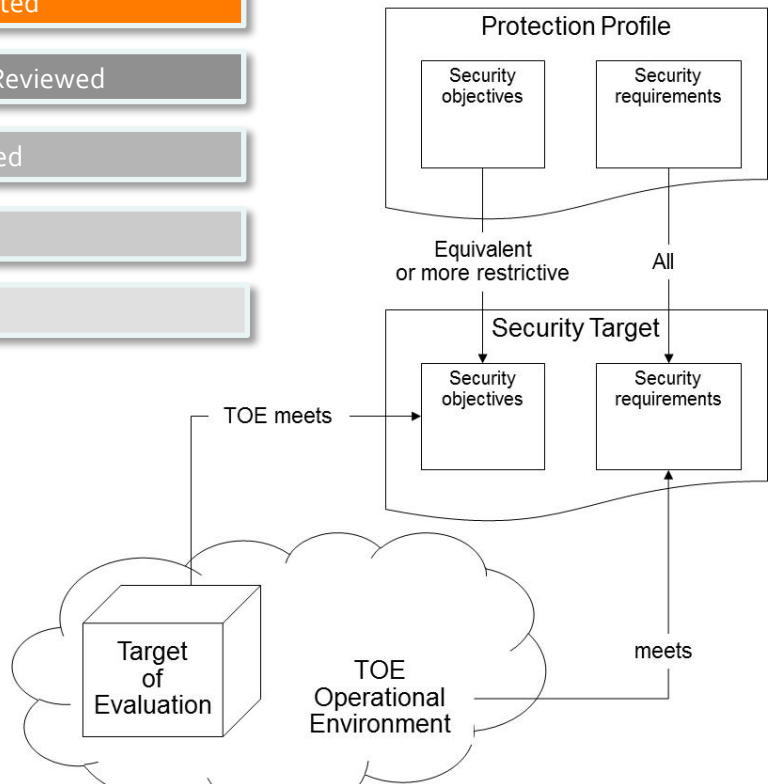
EURO-MILS Project Goals EAL 5+ (7)

Certification Schemes

- **ANSSI (FR) and BSI (GE)**

Confidence / Assurance

EAL 7	Formally Verified Design and Tested
EAL 6	Semiformally Verified Design and Tested
EAL 5	Semiformally Designed and Tested
EAL 4	Method.Designed, Tested and Reviewed
EAL 3	Methodically Tested and Checked
EAL 2	Structurally Tested
EAL 1	Functionally Tested

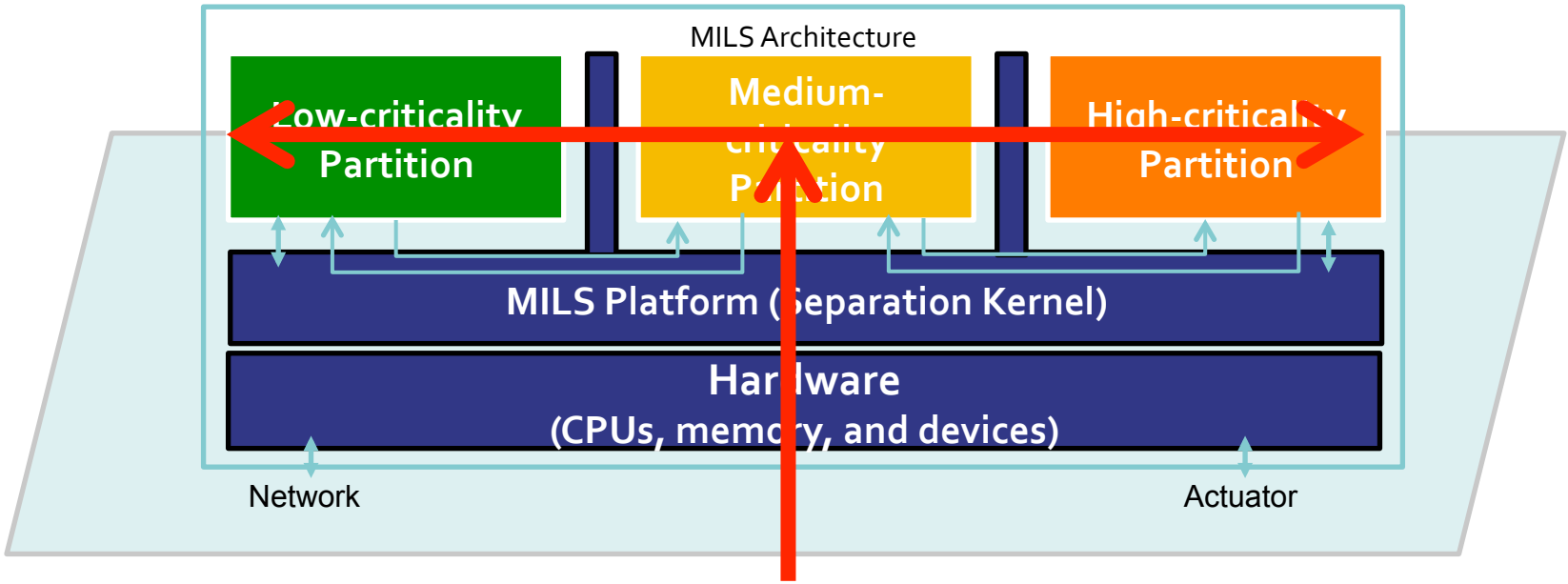


EAL: Evaluation Assurance Level

Compositional Certification: Scenario-T

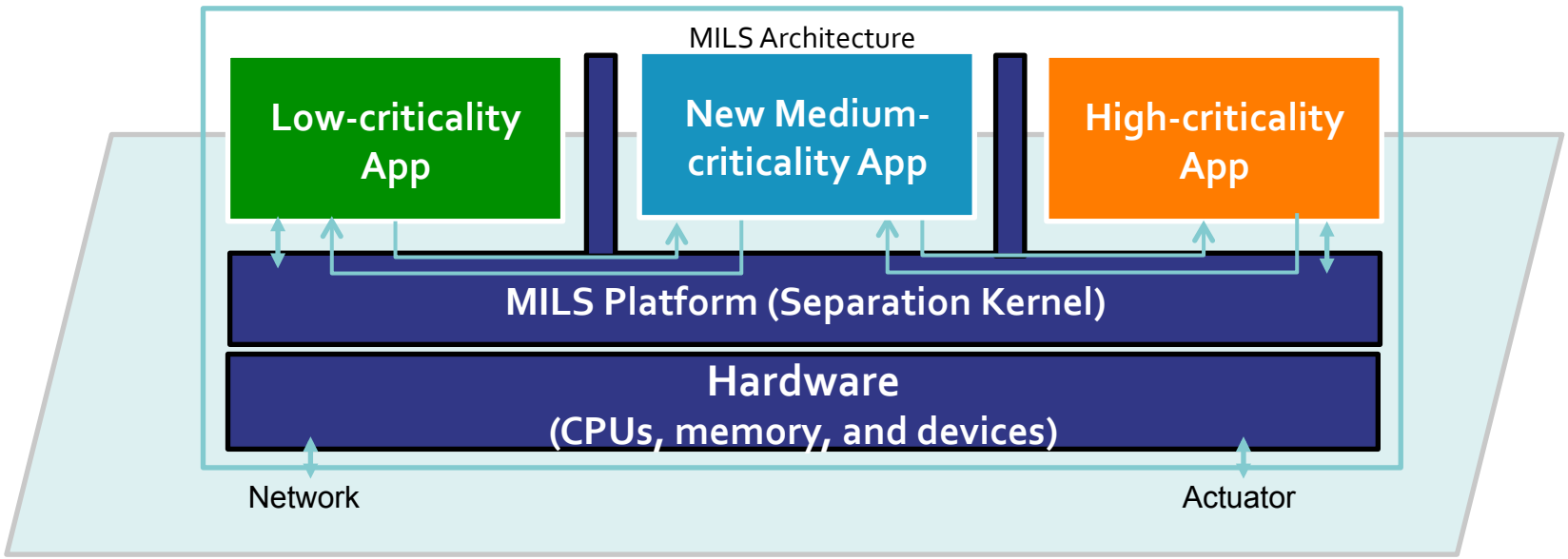
- MILS architecture is the enabler for high-assurance compositional certification
- The core is Separation Kernel
- Components under certified composition
  - Hardware, Separation kernel, Applications

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

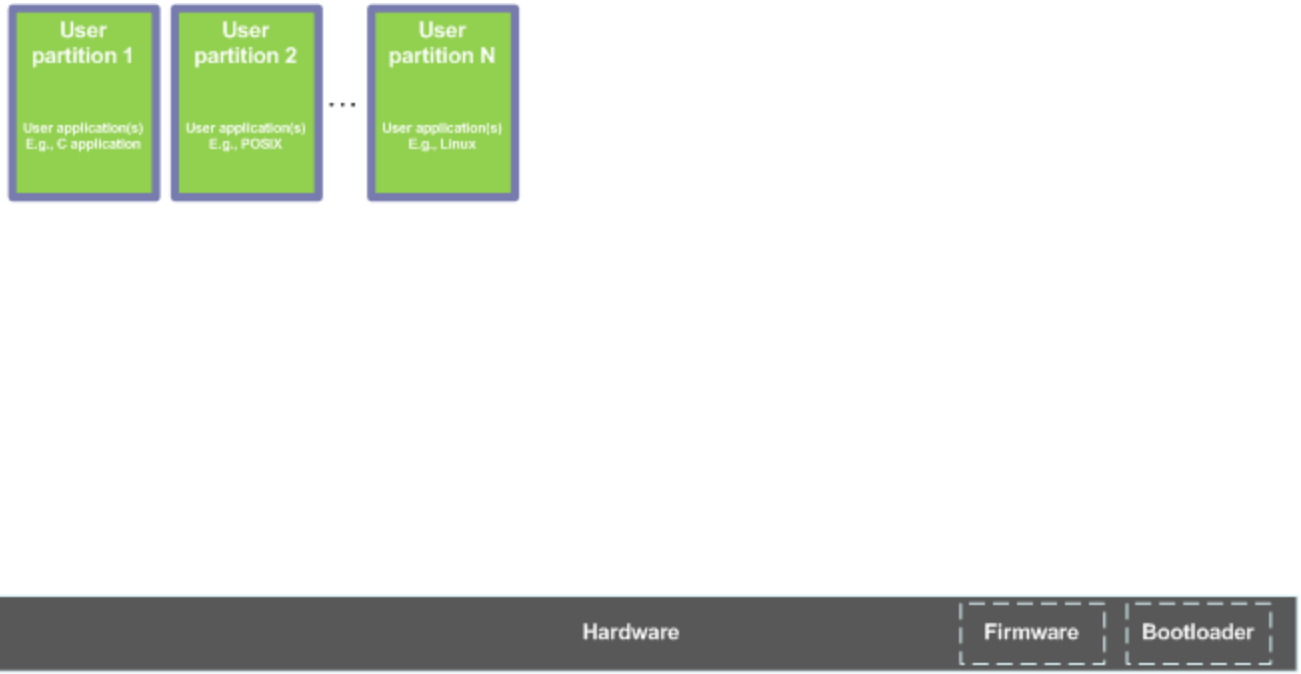


Protection Profile for Separation Kernel

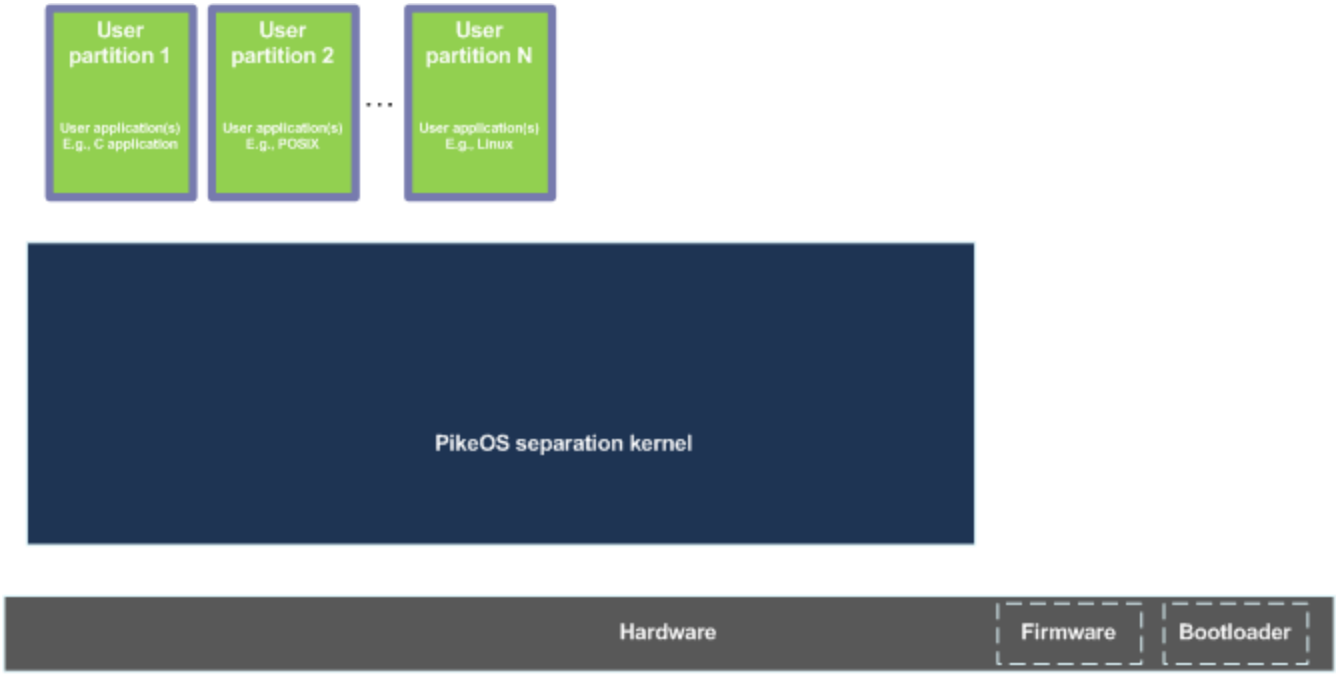
- **Protection Profile** defines a MILS separation kernel
- **Protection Profile** defines
  - a special kind of operating systems for embedded systems
  - with support for real-time
- **MILS separation kernel** allows separation of applications running on the same platform from each other
  - User applications can be malicious and be developed by arbitrary developers

TOE Physical Boundaries

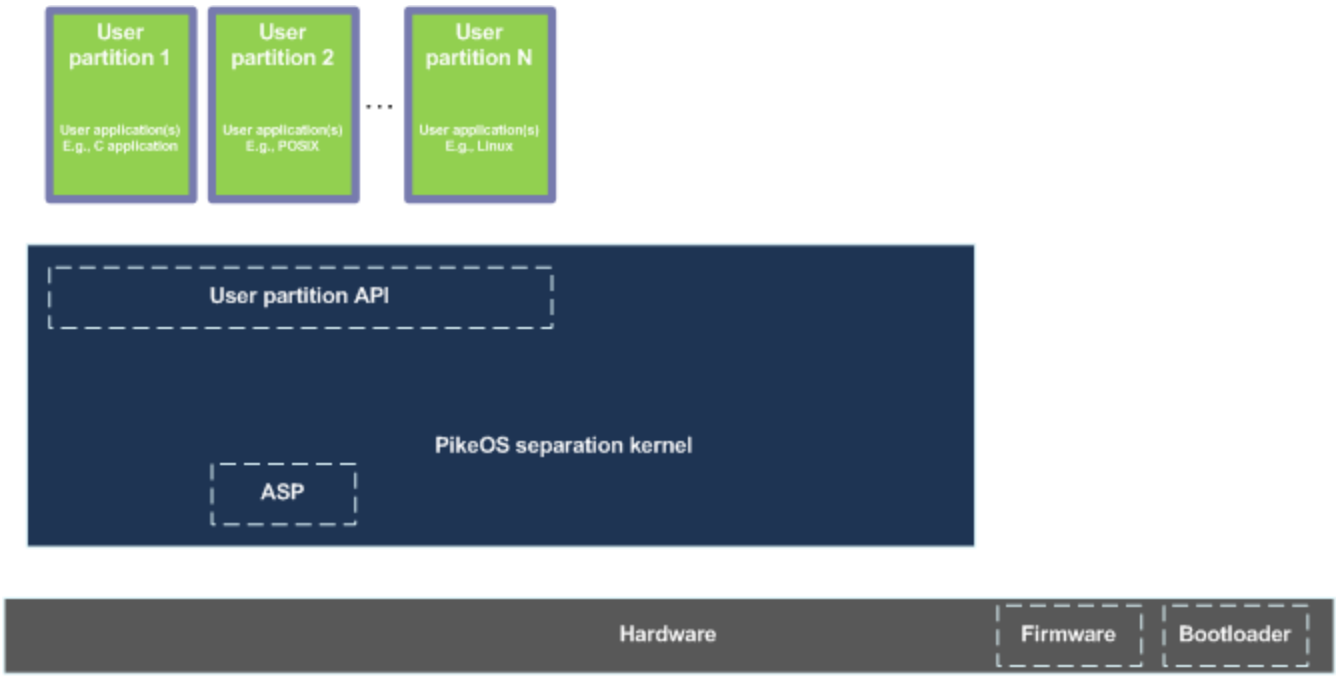
TOE Physical Boundaries



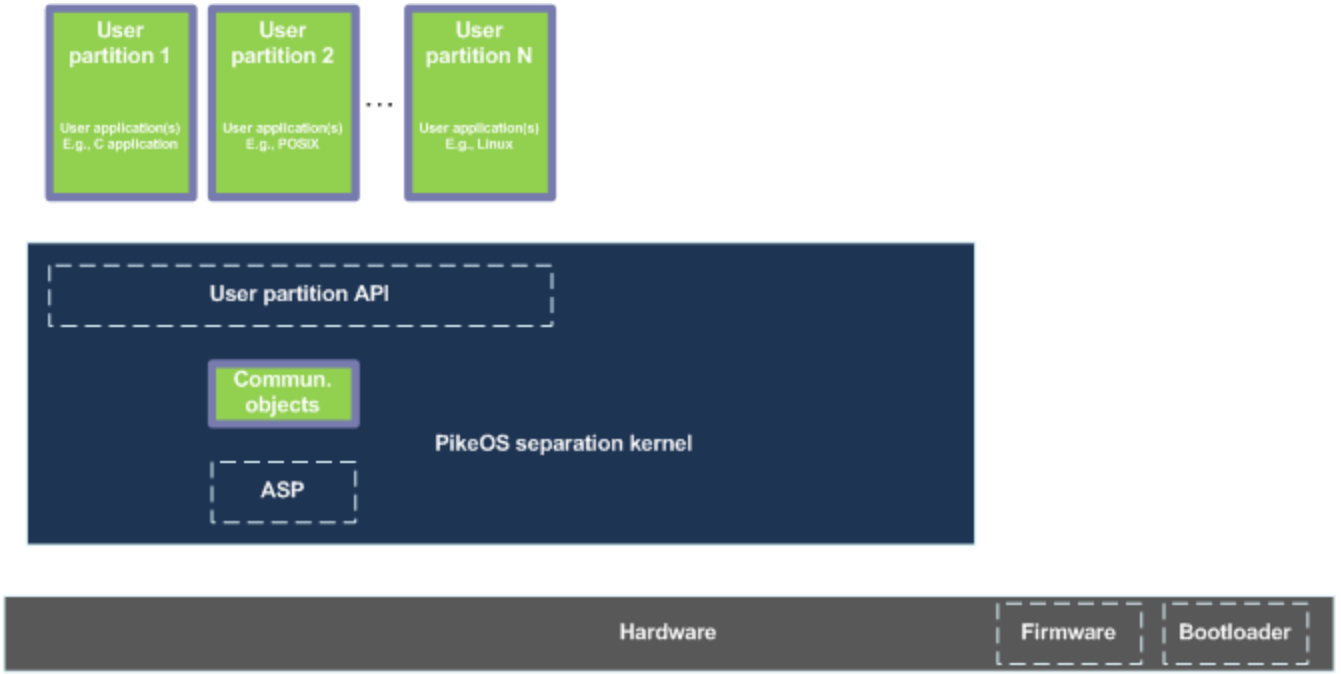
TOE Physical Boundaries



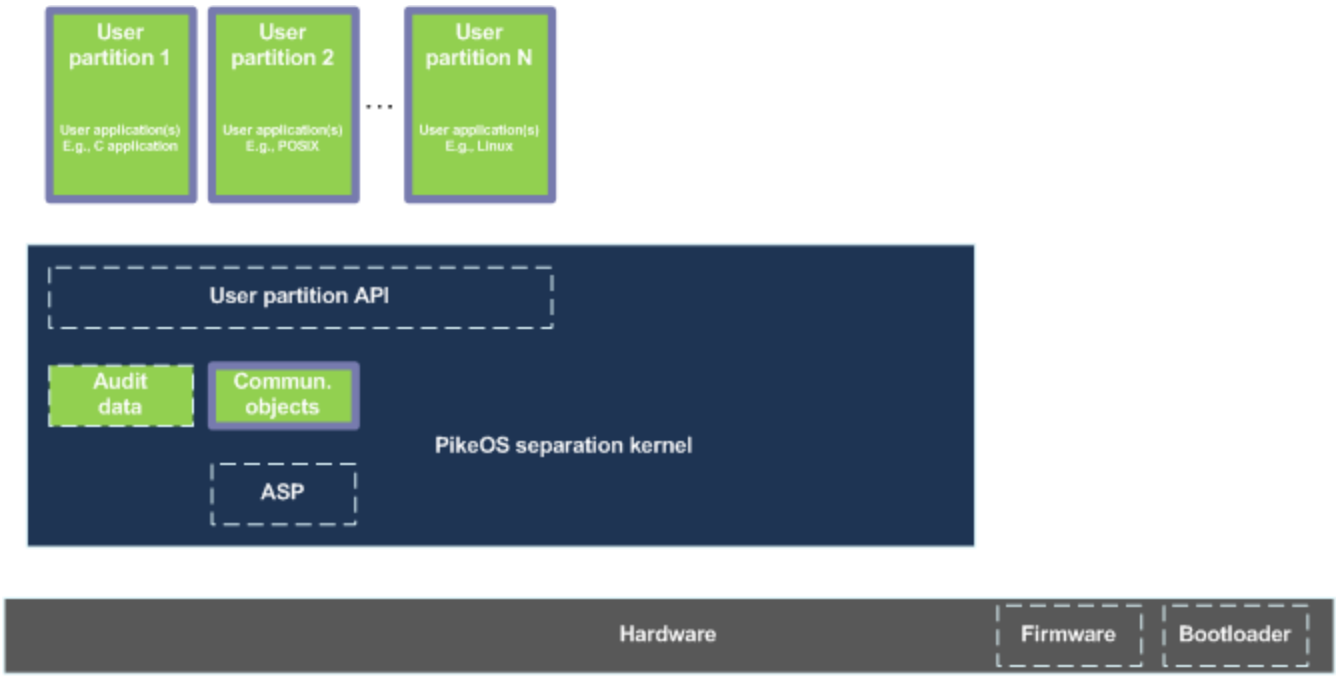
TOE Physical Boundaries



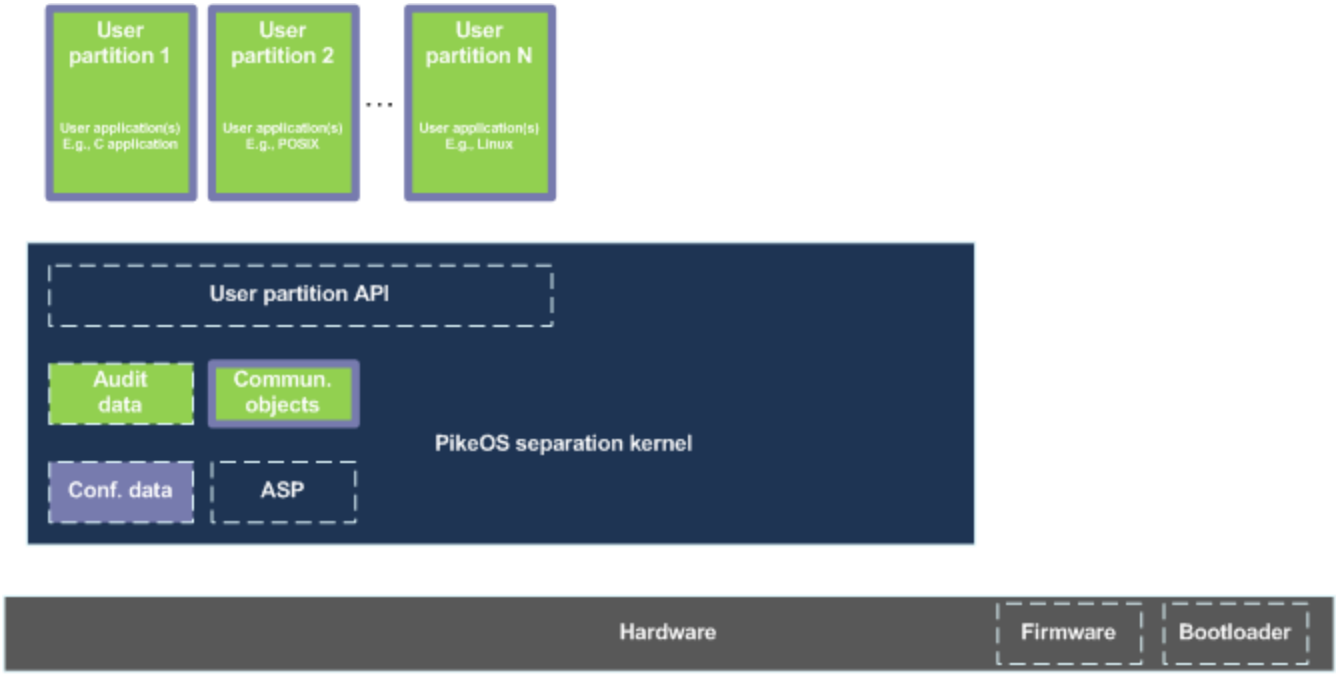
TOE Physical Boundaries



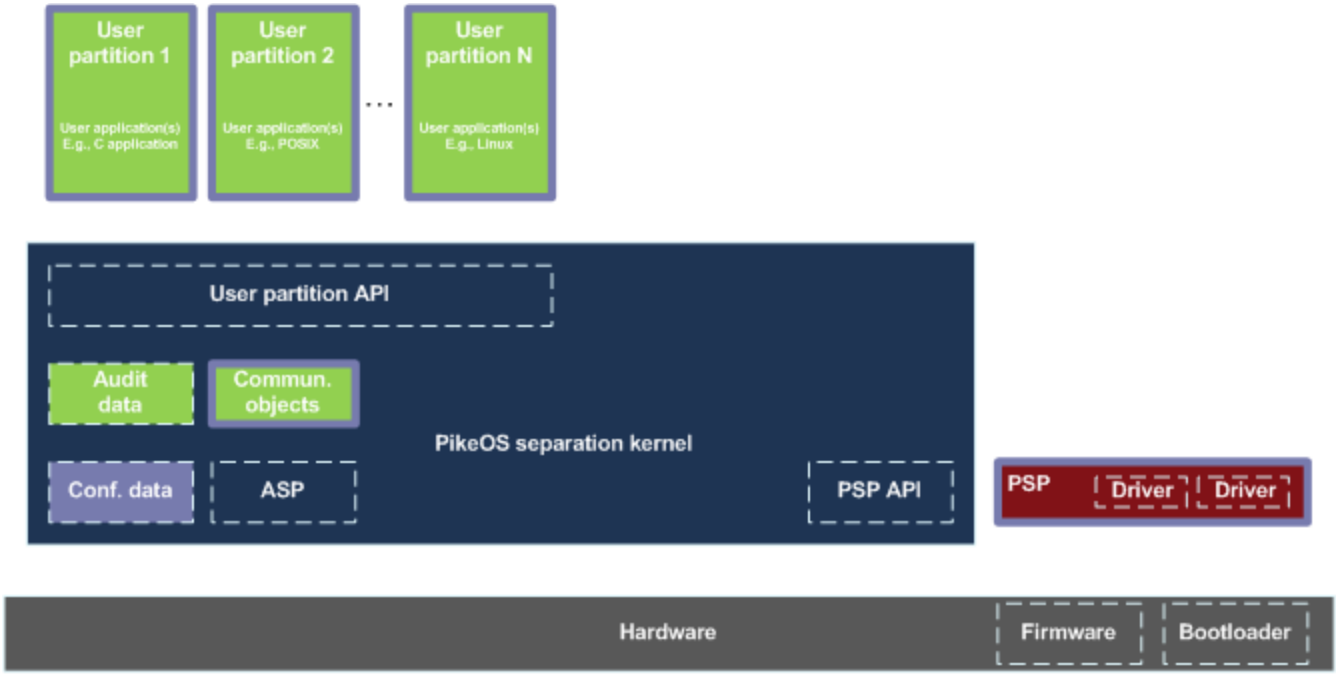
TOE Physical Boundaries



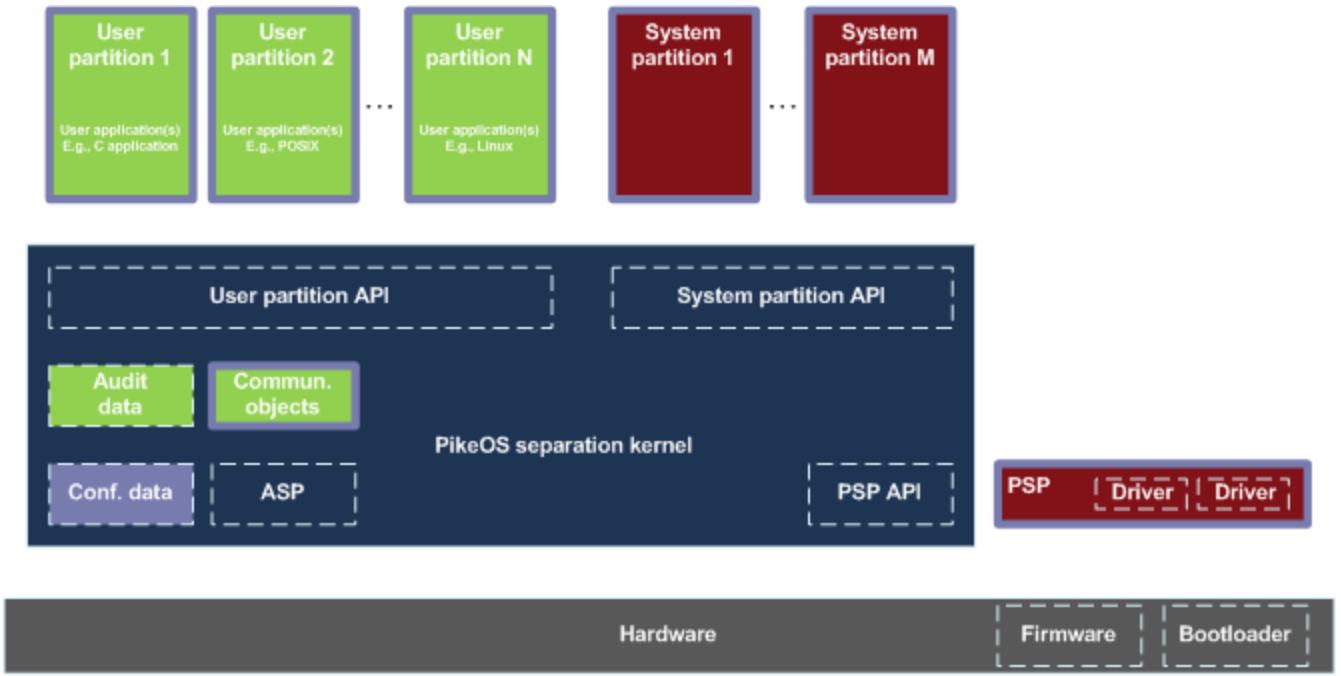
TOE Physical Boundaries



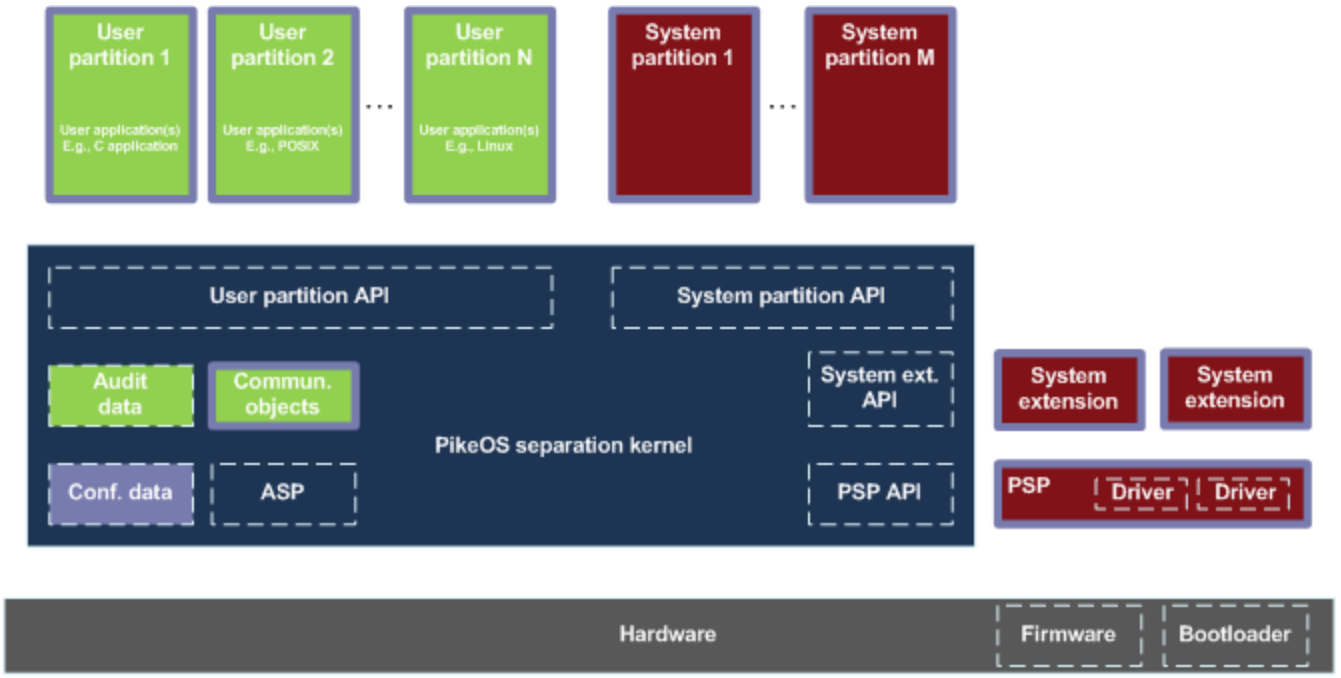
TOE Physical Boundaries



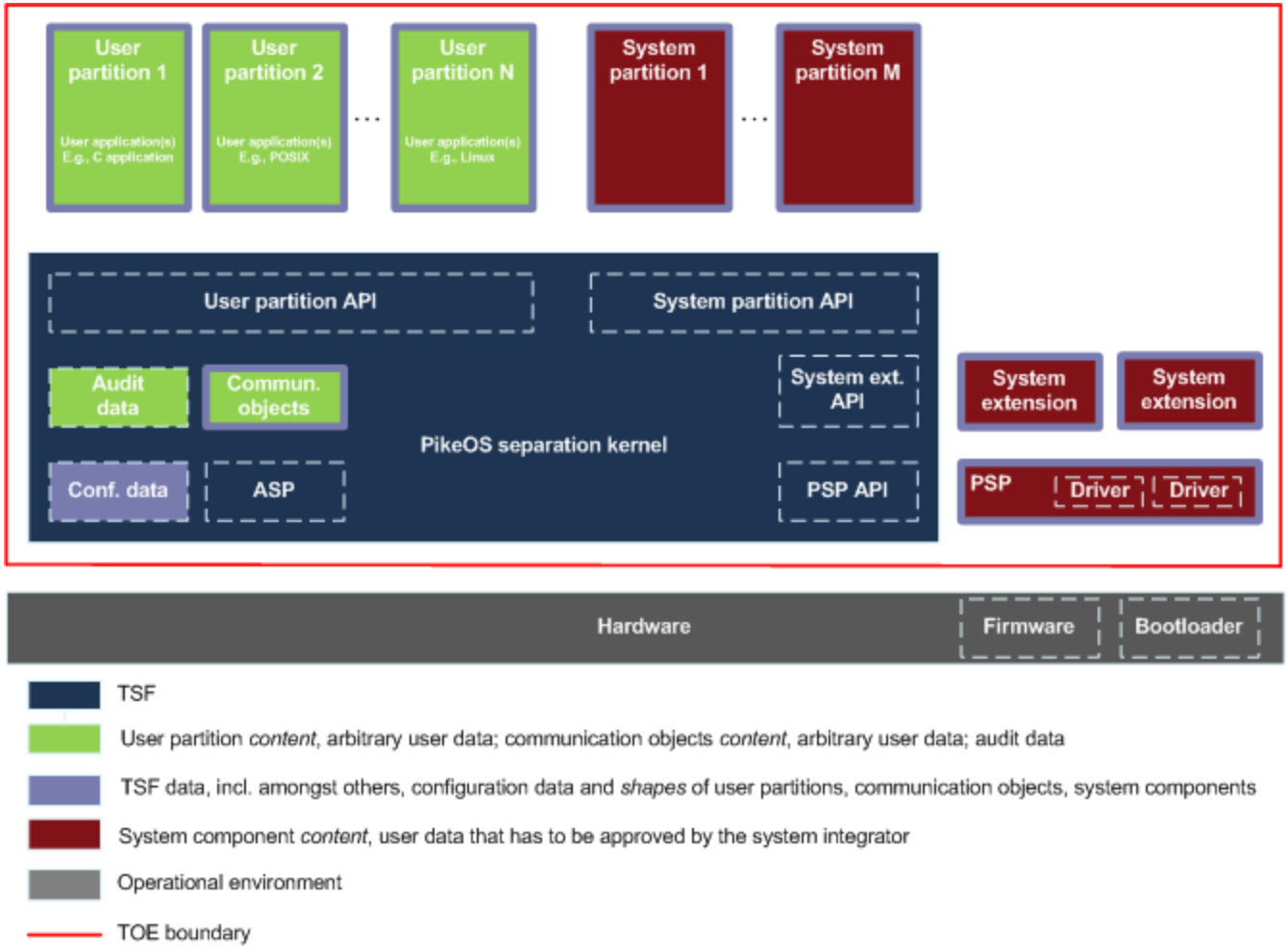
TOE Physical Boundaries



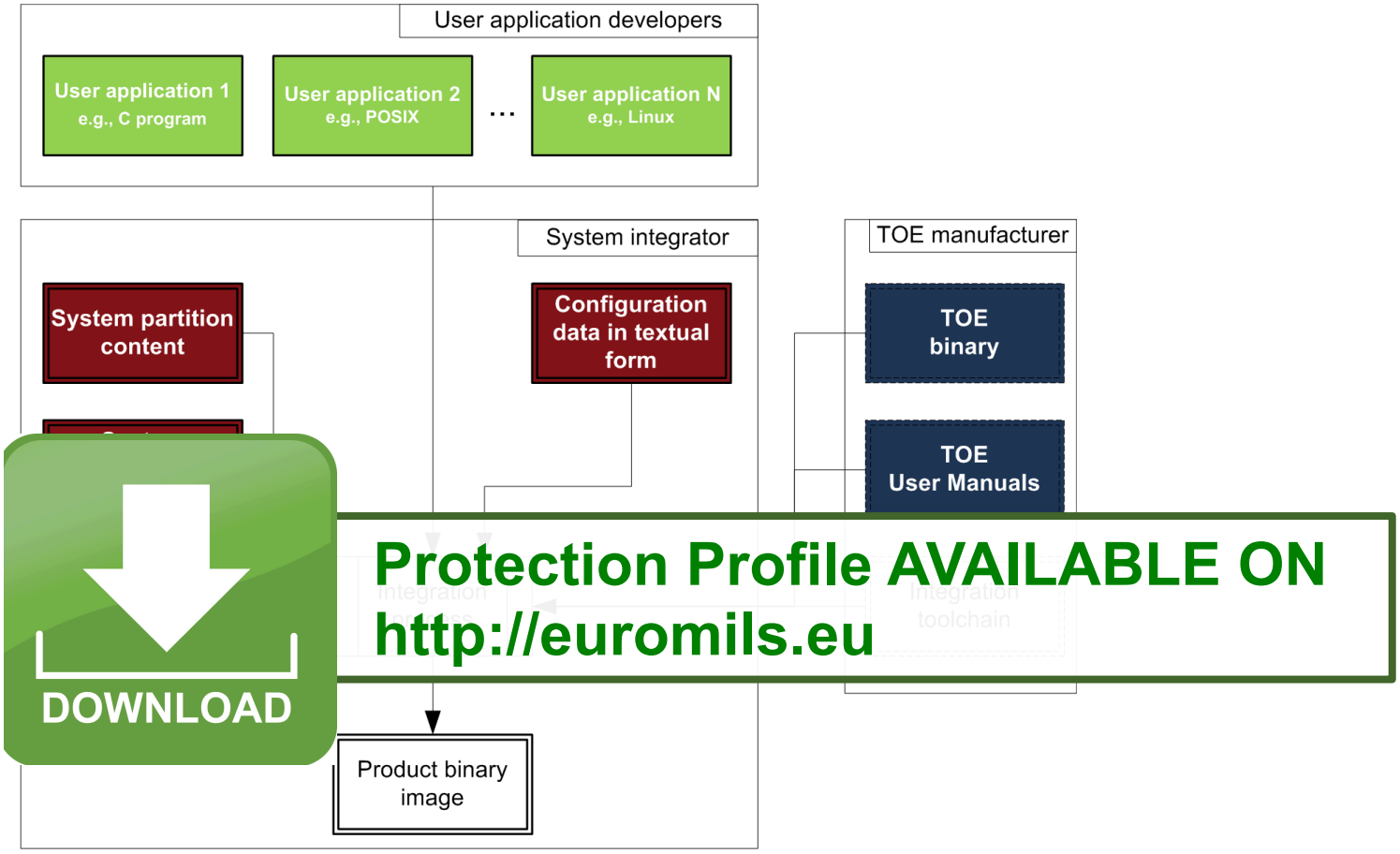
TOE Physical Boundaries



TOE Physical Boundaries



System Integration and Roles



On-going work

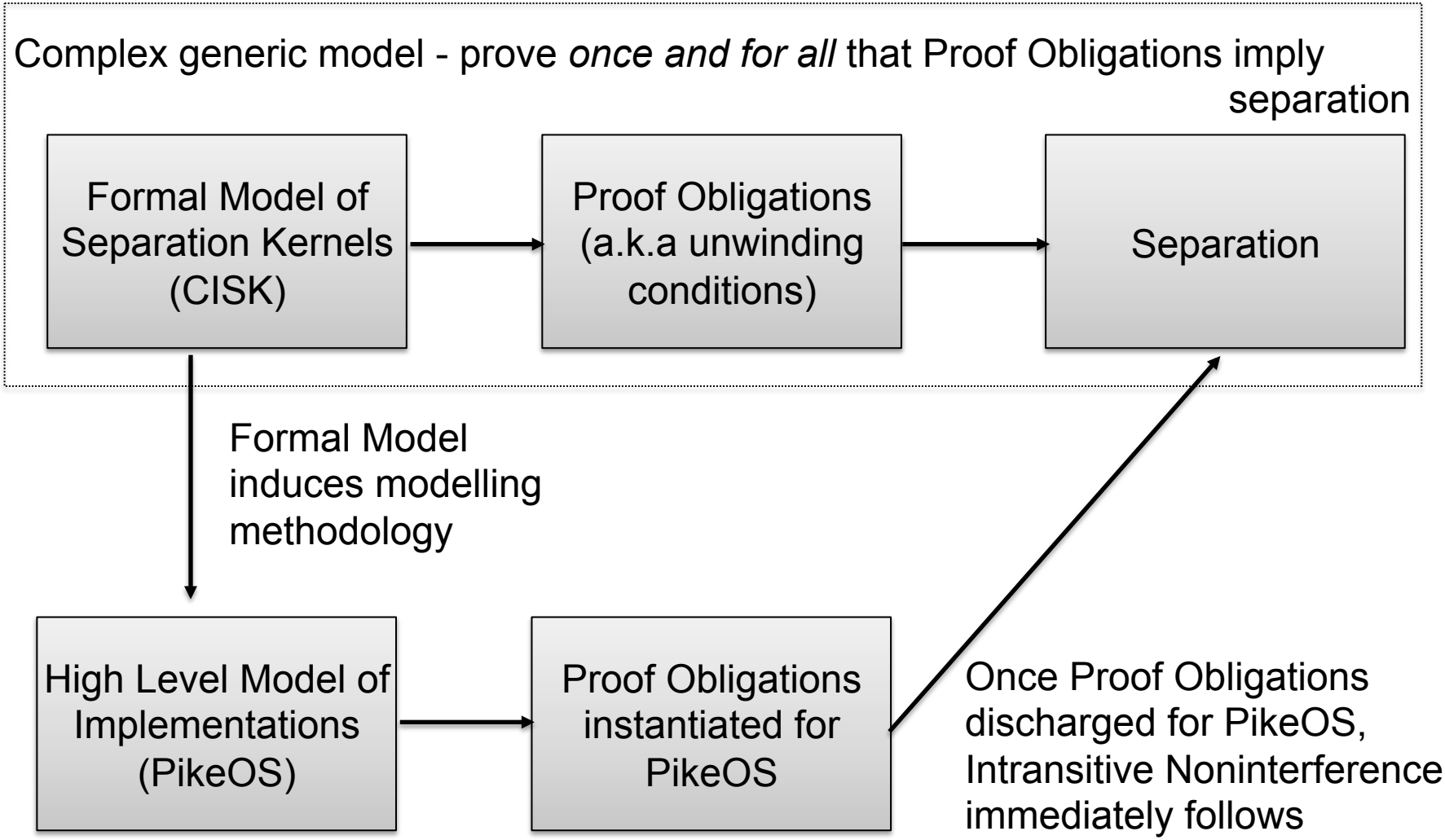
- MILS Vulnerability Analysis
  - Define attack paths
    - Inspired by the SOGIS JIL SmartCard
  - Define evaluation methodology
  - Focus on system integration and composition
  - Goal:
    - Define work items for evaluators
    - Define what, **at least**, system integrator should consider

- MILS System Integration Guidelines
  - Good-practices on system integration
  - Examples of MILS Architecture Template applications
  - Focus on system integration and composition
  - Goal: ease the work of the system integrator

High-Assurance

FORMAL METHODS

Formal Modelling: Separation Kernel



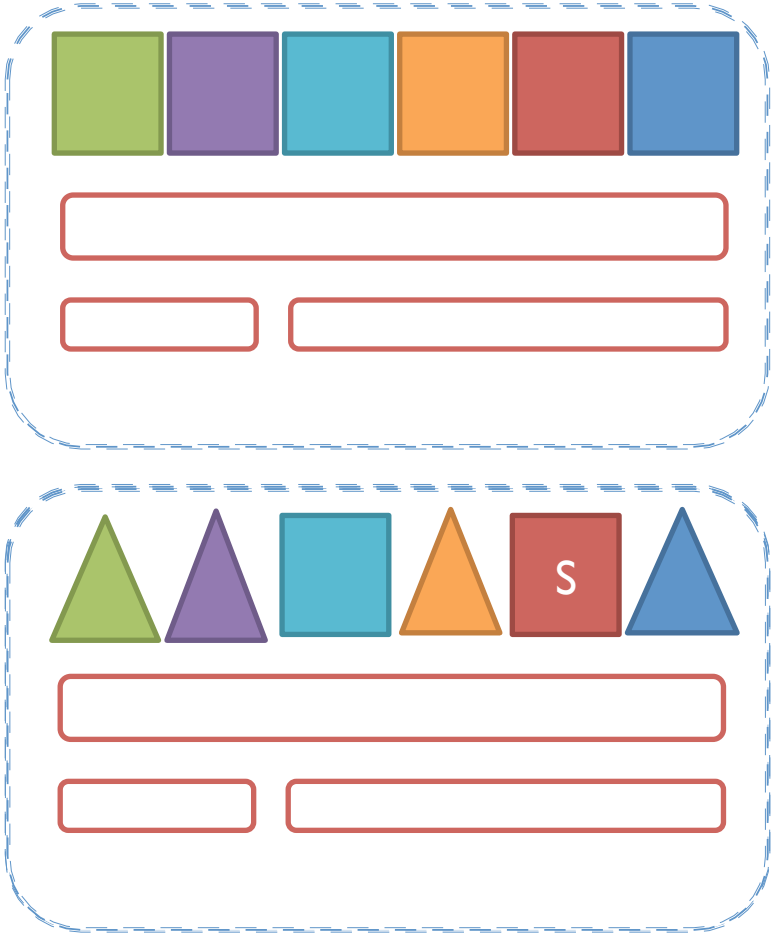
Specification

- Separation property is expressed as non-interference
- Based on more than 35-years of research
  - a refinement of „industry-standard“ Rushby non-interference, extended by stateful actions
- Small, comprehensible, evaluatable, trustworthy
  - This is our “**gold**” model, you have to have a warm feeling by looking at it ☺

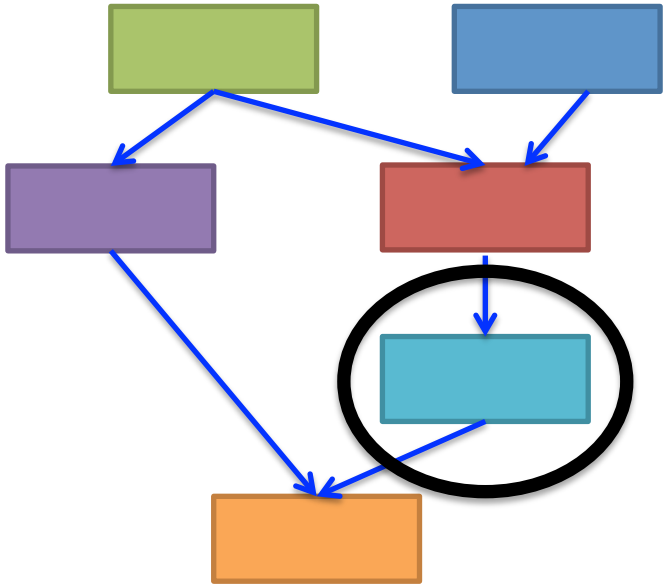
- Single core model (CISK) has been published
  - AFP - Archive of formal proofs
  - AFP contains only approved theories
  - http://afp.sourceforge.net/entries/CISC-Kernel.shtml
  - Multi-Core model is being finilized

Specification: Non-Interference

System Components

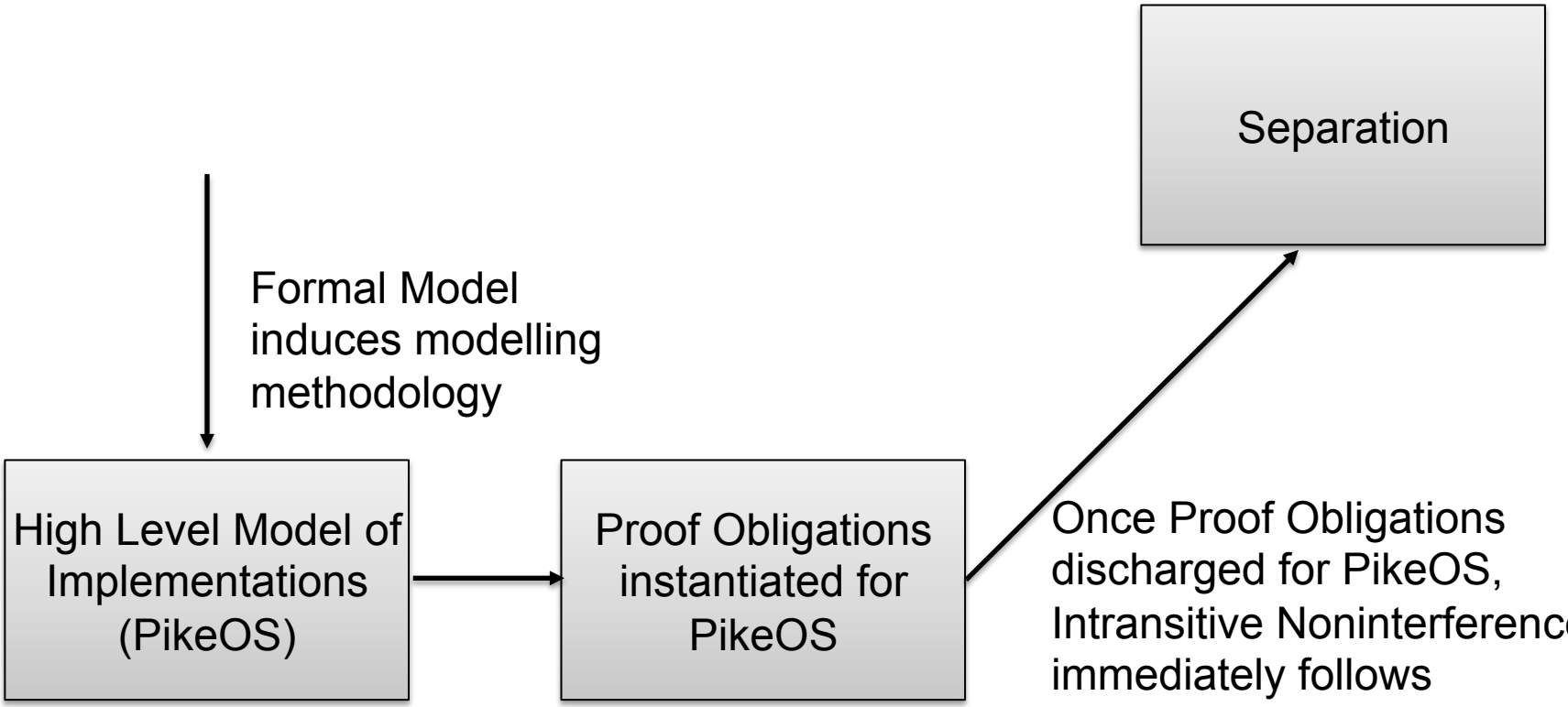


Security Policy



Formal Implementation

- **Implementation Model**
  - Model of PikeOS separation kernel actions
  - The formal implementation contains proves for the proof obligations of the specification



Formal models as Isabelle/HOL Source Code

Specification

```
definition separation :: bool
where "separation ≡ ∀ u x . well_formed_executions x ⟶
                    {x} ≙u { x' . well_formed_executions x' ∧ littered u x x'}"
```

Implementation

```
lemma PikeOS_instantiates_CISK:
  shows "Controllable_Interruptible_Separation_Kernel
       step
       output_f
       initial_state
       current
       cswitch
       precondition
       state_invariant
       duration
       action_sequences
       aborting
       waiting
       involved
       ifp
       vpeq
       dom_act_equivalent"
proof -
  write state_invariant ("⟨_⟩" 100)
    and current ("^")
```

Proof

```
corollary instantiation_is_secure:
shows PikeOS.separation
  using PikeOS.unwinding_implies_separation_CISK
  by blast
```

Formal Model for MILS System

On-going work on a base formal model for MILS system

- Formalisation of the “MILS Architectural Template”
- Separation kernel is a component
- Express information flows on top of separation kernel
- Integrate security policies of other critical components, e.g. file system, network stack
- Target user-level security policies, e.g. re-graders with labelled information flows

High-Assurance

FORMAL METHODS AS CERTIFICATION ARTEFACT

Formal Methods in Common Criteria

- Goal: Develop framework how to create formal models for Common Criteria evaluation

- What we are doing
  - Developing guidelines for developers (how to do) and evaluator (how to check) formal models in Isabelle/HOL
  - Isabelle/HOL description for certification scheme
  - Template to instantiate developed
    - Formal specification
    - Formal implementation
    - Formal proof

    to form Common Criteria artefact (for ADV_SPM)
  - Artefact compliance with AIS34 (BSI) and Note12 (France)

SECURITY VALUE?
EURO-MILS SURVEY

EURO-MILS Value ?

Industries

Medical Defense Control Avionics Transport Smart cities Energy

Ecosystems

Finance Smartcards Smart home Personal Automotive Entertainment Telecoms Security

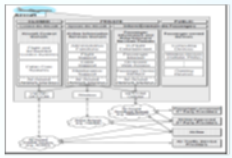
Consumers

- Security and Safety –

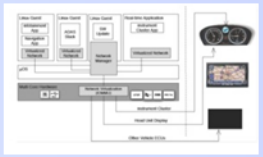
- Certification and User acceptance –

- Virtualization and Partitioning –

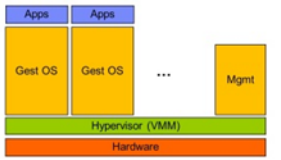
Avionic Prototype



Automotive Prototype

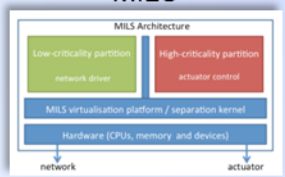


Virtualisation



Realtime OS

MILS



Certification

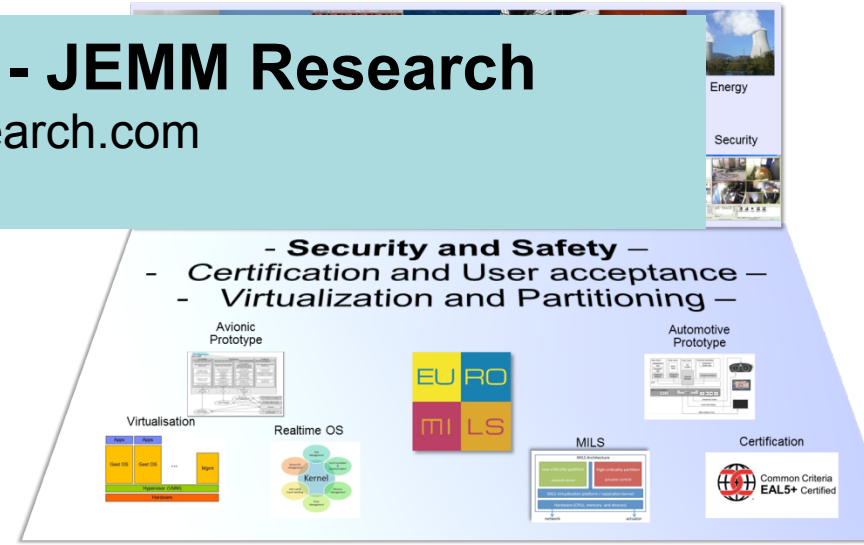
Common Criteria EAL5+ Certified

EURO-MILS Social Survey

- EURO-MILS Context : Common definitions
  - Security, Safety, Trustworthiness,
  - Embedded systems, virtualization, partitioning, MILS
  - Certification, User acceptance, standards

Christophe Toulemonde - JEMM Research
christophe.toulemonde@jemmresearch.com
+33 6 30 67 95 57

- EU
  - professionals interviewed on
    - Security and Safety
    - Platform Virtualization and Partitioning
    - User Acceptance and Certification



- EURO-MILS Consumer Point of View
  - Via a Online survey of 537 respondents from 6 geographies (DE, UK, FR, IT, SP, BX)
    - Information security value, practices
    - Security and data privacy expectations and assurance
    - Acceptance of technologies and Trust

SUMMARY

EURO-MILS Main Outcomes

- Trustworthy foundations by the MILS approach, architecture, and applications

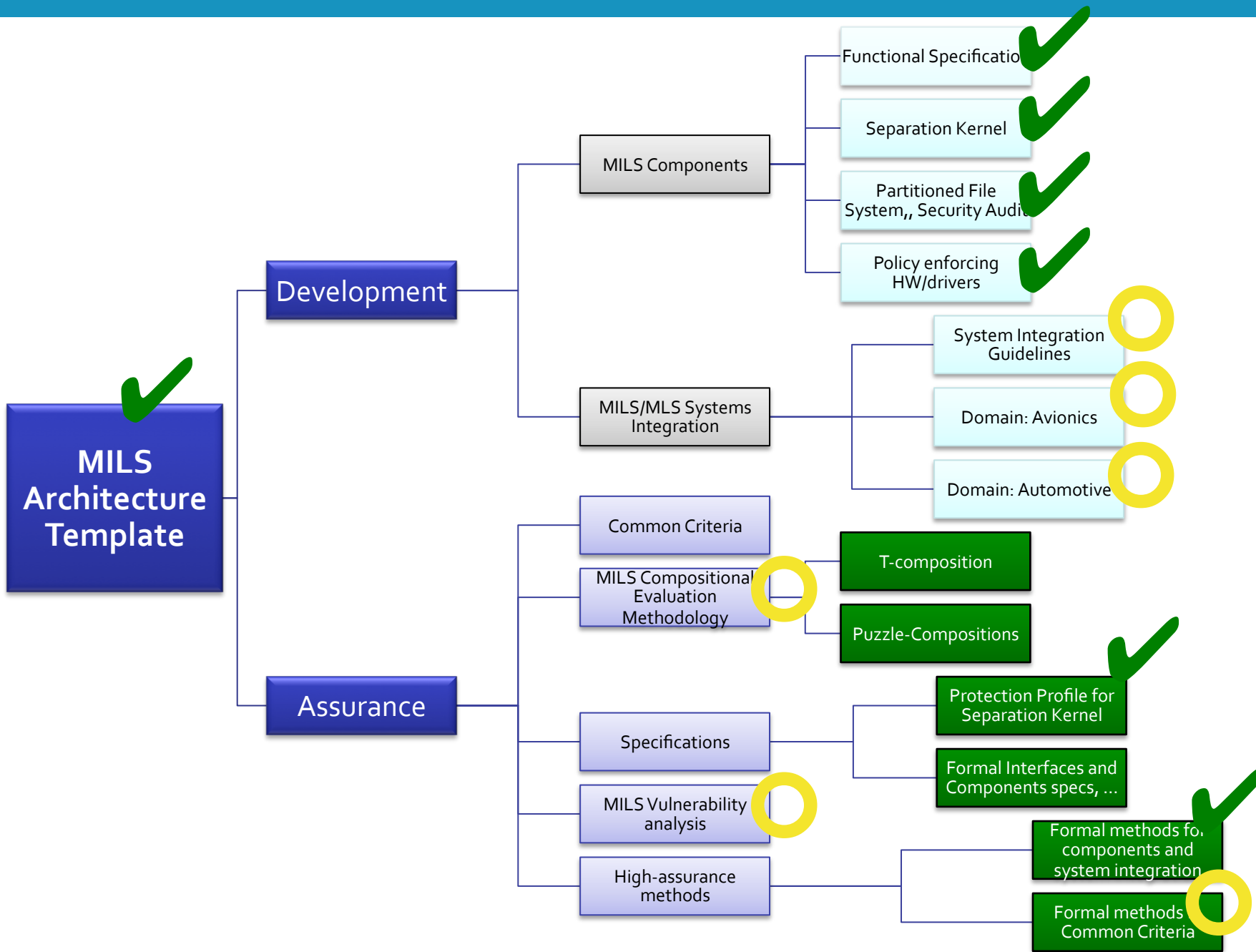
- MILS platform and its usage
  - Design, development and usage of a MILS platform based on virtualization technique
  - Framework to develop secure and safe products
  - Integrating domain-specific functionalities and components

- High Assurance
  - Certification along highest levels of “Common Criteria”
  - Pragmatic approach to use formal methods for certification
  - Innovative approach for compositional security assurance and vulnerability analysis
    - New CEM units, guidelines

- True cross European certification
  - Cross-European usage of the Common Criteria for high EALs
  - European approach for a generic certification process acceptable by national certification authorities (ANSSI, BSI)

- Validation of concepts by two prototypes

MILS Framework: Status



EURO-MILS CONTRACT N0: 318353

"The EURO-MILS project has received funding from the European Union's Seventh Framework Programme ([FP7/2007-2013]) under grant agreement number ICT-318353."

If you need further information, please contact the coordinator:

Technikon Forschungs- und Planungsgesellschaft mbH

Burgplatz 3a, 9500 Villach, AUSTRIA

Tel: +43 4242 233 55 Fax: +43 4242 233 55 77

E-Mail: coordination@euromils.eu

59