DREAMS

Mixed-Criticality Cluster Workshop
Barcelona, Nov. 2016

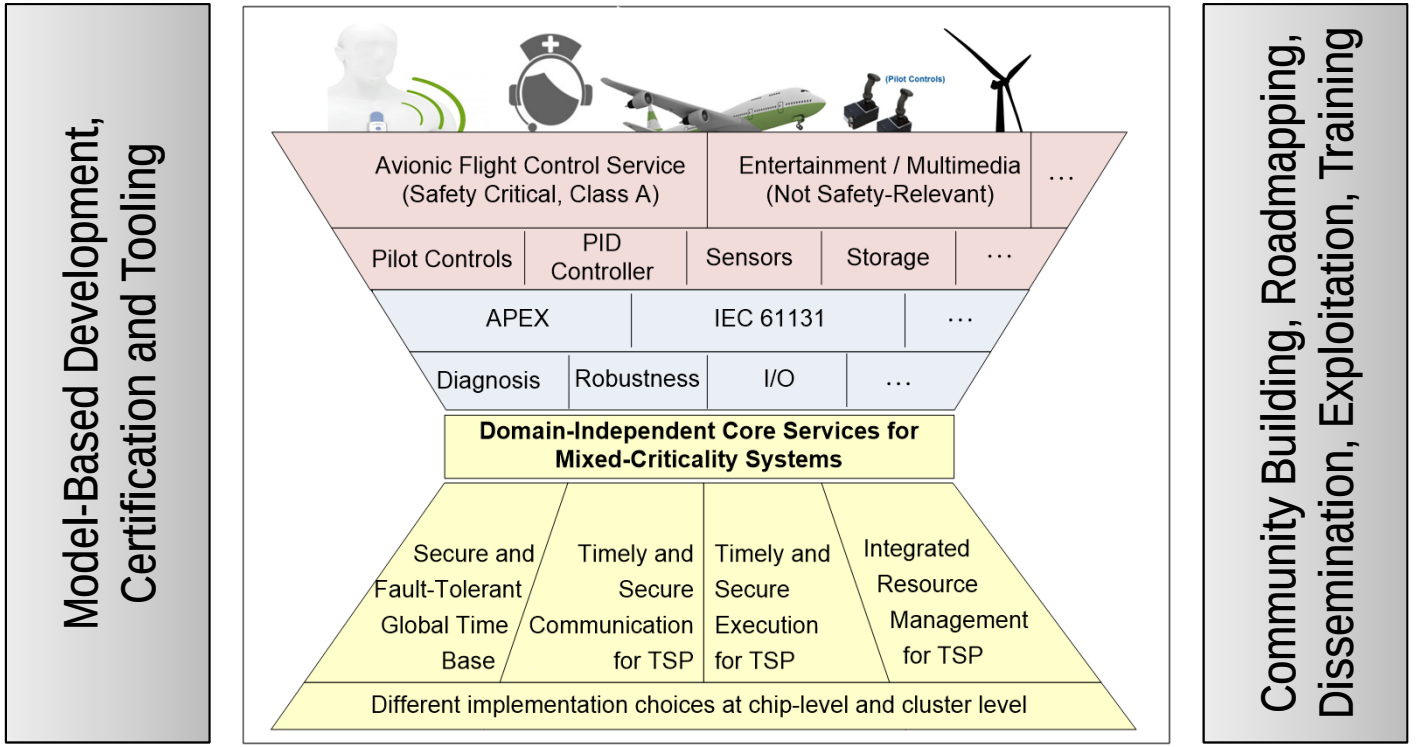
UNIVERSITÄT SIEGEN

SEVENTH FRAMEWORK PROGRAMME

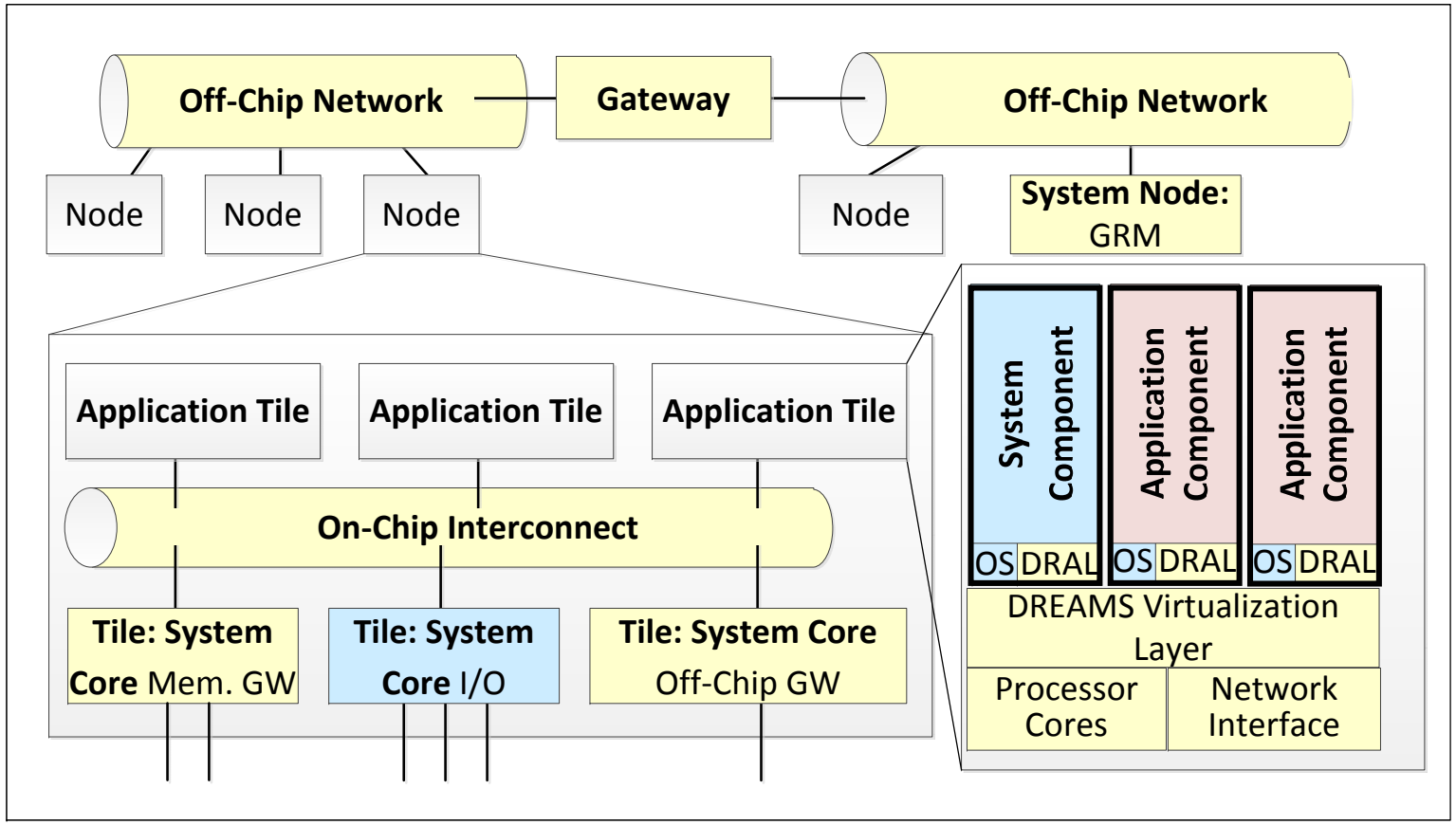
Mixed-Criticality Architecture for Networked Multi-Core Chips

DREAMS

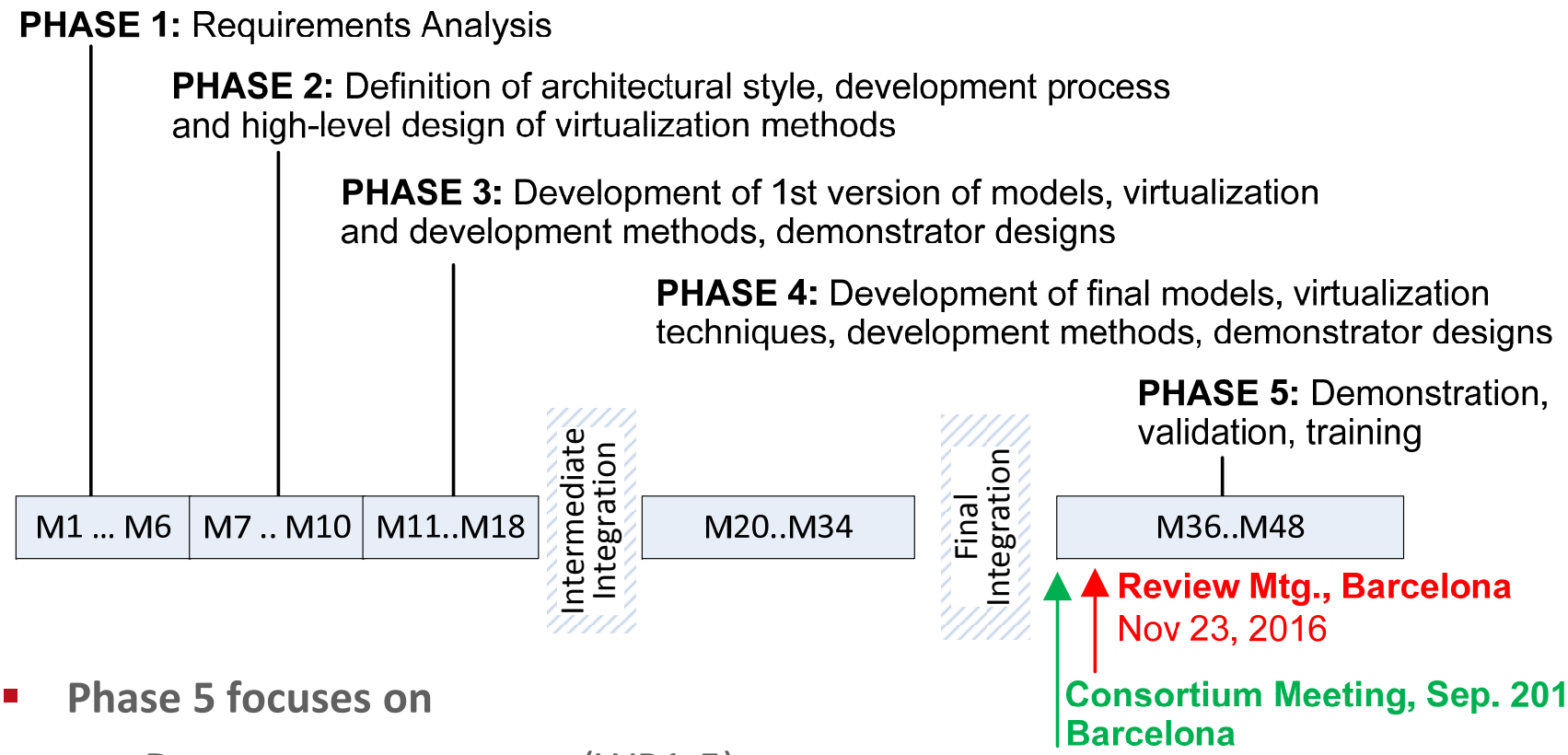
- Cross-domain architectural style and models for MCS
- Modular certification and mixed-criticality product lines
- Platform with virtualization at chip and network level
- Adaptation strategies for mixed-criticality systems
- Development methodology, variability management and tools



- Mapping to different technology targets (e.g., Xilinx ZYNQ, PPC, Intel)
- Demonstration in avionic, healthcare and wind power use cases

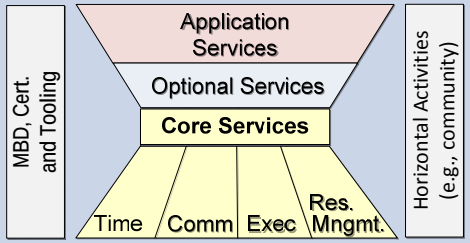
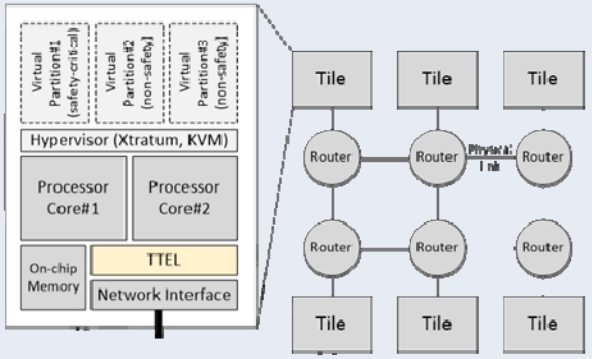
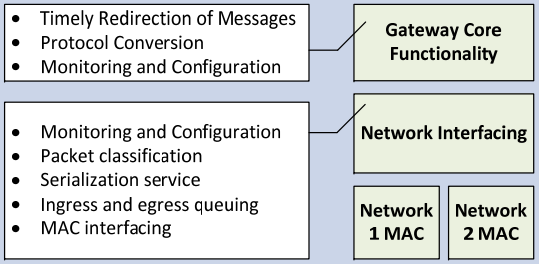
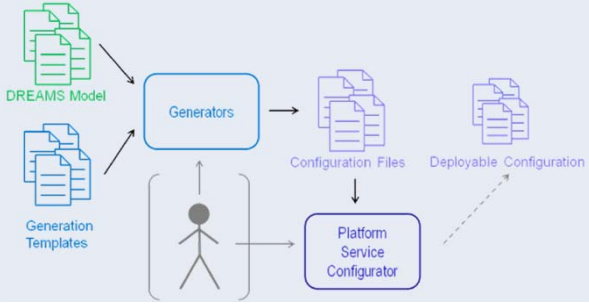


Project Timing

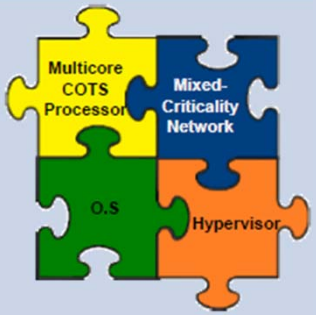


- **Phase 5 focuses on**
  - Demonstrator support (WP1-5)
  - Demonstration (WP6-8)
  - Community building and standardization (WP9)
  - Dissemination (e.g., book manuscript), exploitation and training (WP10)

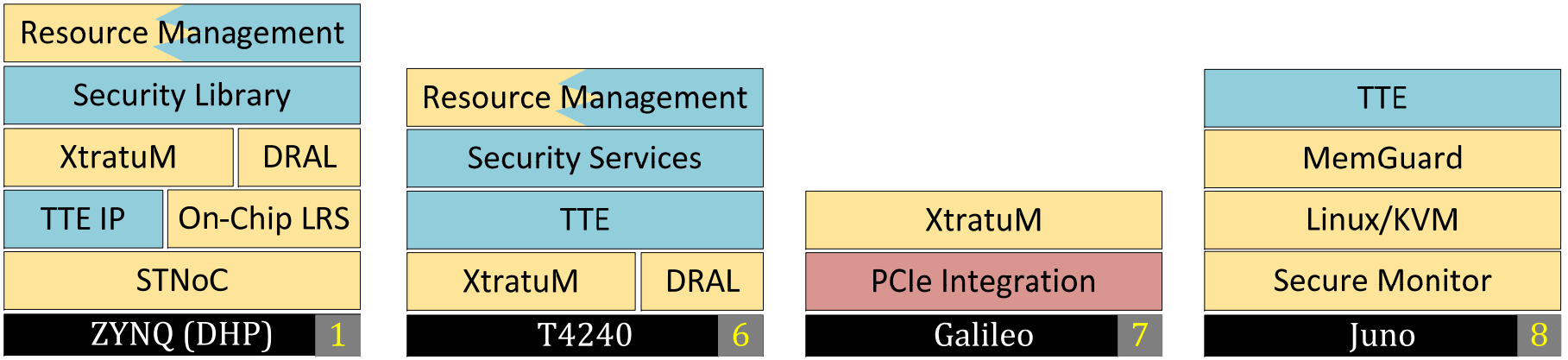
Project Results (1)

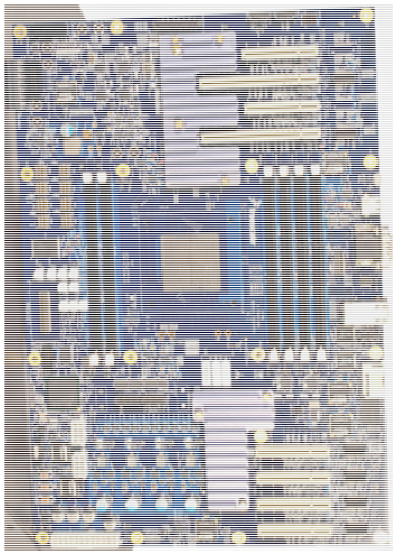
		Major Results				
WP1 Architecture		Architectural style	Application and platform Models			
WP2 Multicore Virtualization Technology		Firmware monitoring for virtualization of processor	Memory virtualization and interleaving	Execution environment based on XtratuM and KVM	On-chip network virtuali-zation	Local resource manage ment
WP3 Mixed-Criticality Network		Communi-cation services	Security services	Resource management services		
WP4 Tooling, Scheduling and Analysis		Offline adaptation strategies for MCS	Generation of platform configuration files	Tool integration	Explicit variability configu-ration	

Project Results (2)

	Major Results				
WP5 Mixed-Criticality Certification 	Modular safety case	Simulation Framework	Cross Domain Mixed Criticality Patterns	Guidelines for Process / Tool Integration	Certification of Product Families
WP6-8 Demonstrators 	Avionic (FMS)	Windpower (e.g., safety system)	Healthcare (e.g., patient monitoring, entertainment)		
WP9 Community Building 	Community Building	Road-mapping			
WP10 Dissemination, Exploitation and Training 	Dissemina-tion	Exploitation	Training		

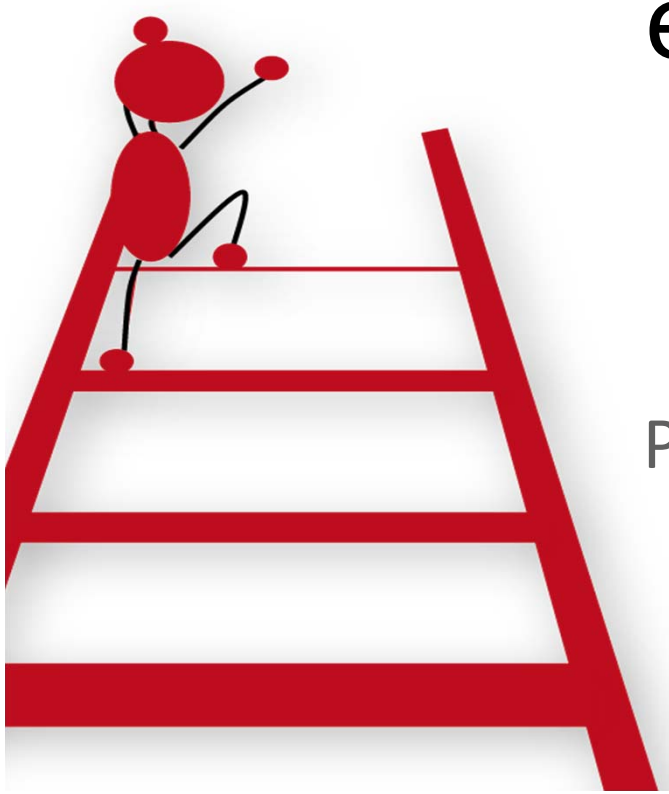
Physical DREAMS Platforms





DREAMS

Technology Pitch: Execution environments



Presenter: Javier Coronel

fentISS

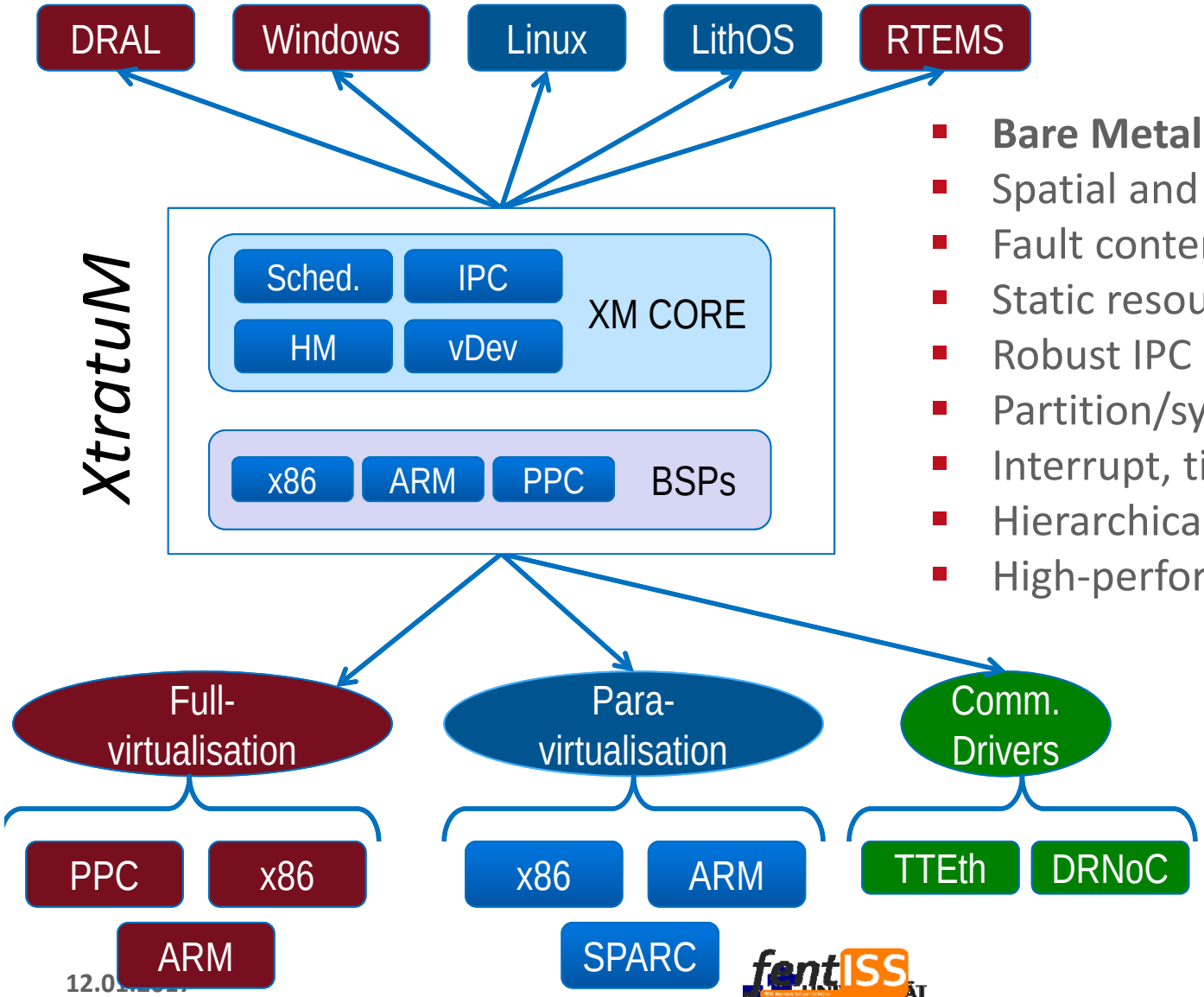
Virtual Open Systems

UNIVERSITÄT SIEGEN

SEVENTH FRAMEWORK PROGRAMME

Execution environments - XtratuM

Execution environments based on



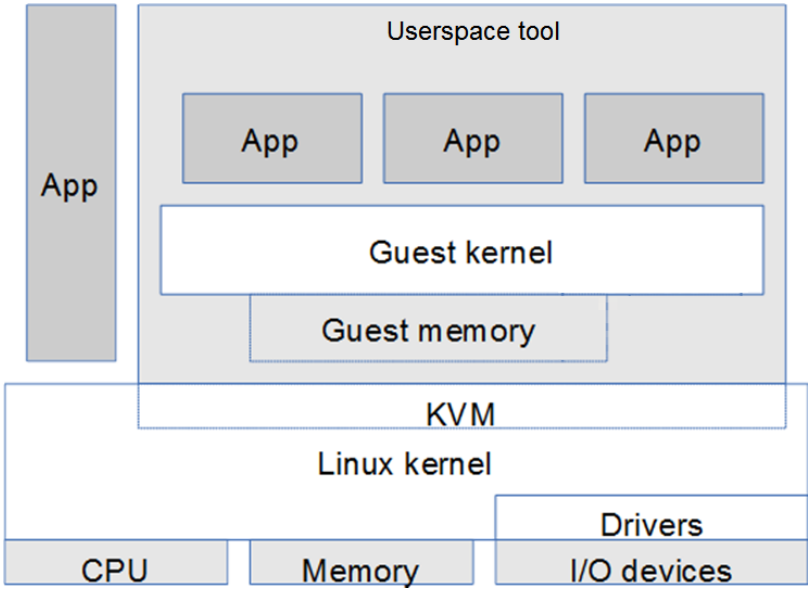
- **Bare Metal hypervisor for MCS**
- Spatial and temporal isolation
- Fault contention and management
- Static resources allocation
- Robust IPC
- Partition/system management
- Interrupt, time, memory and CPU
- Hierarchical scheduling
- High-performance/scalability

Execution environments - KVM

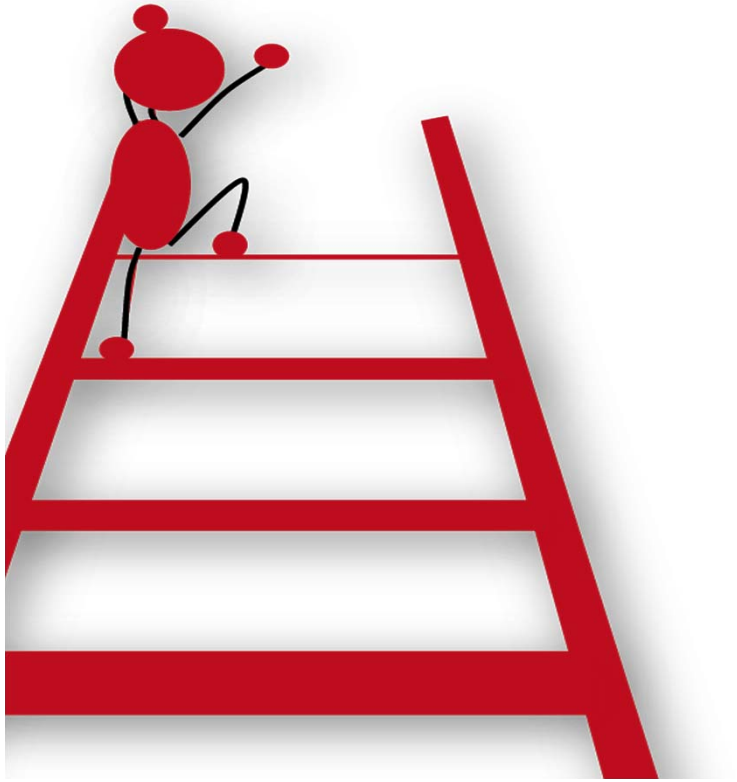
- Turns the Linux kernel into a full-blown hypervisor
- Leverages infrastructure of Linux for scheduling and memory management
- Multiple architectures supported, including ARMv7/v8
- KVM features:
  - Support for hardware virtualization
  - High performance and scalability
  - Open Source community
  - Used in conjunction with various userspace tools
- Provides virtualization support for CPU, memory, interrupts, timers

KVM architecture overview

- Machine model or device emulation is not provided by KVM but by userspace application
- KVM exposes a /dev/kvm interface for userspace tools
- Popular tools to use with KVM: QEMU, kvmtool



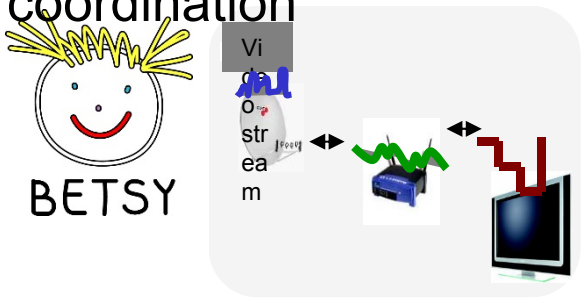
Resource Management

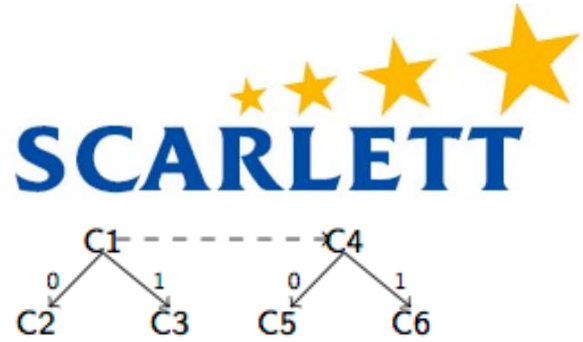


Gerhard Fohler (TUKL)
(input from ONERA, TRT, USIEGEN)

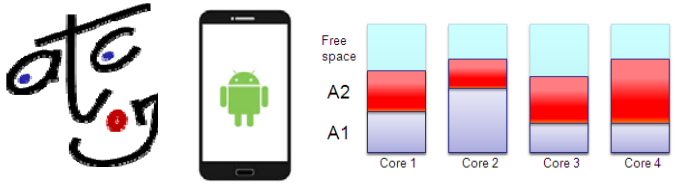
before DREAMS: from EU projects

global – local coordination





fault handling, reconfiguration



resource mgt - multicore

XtratuM

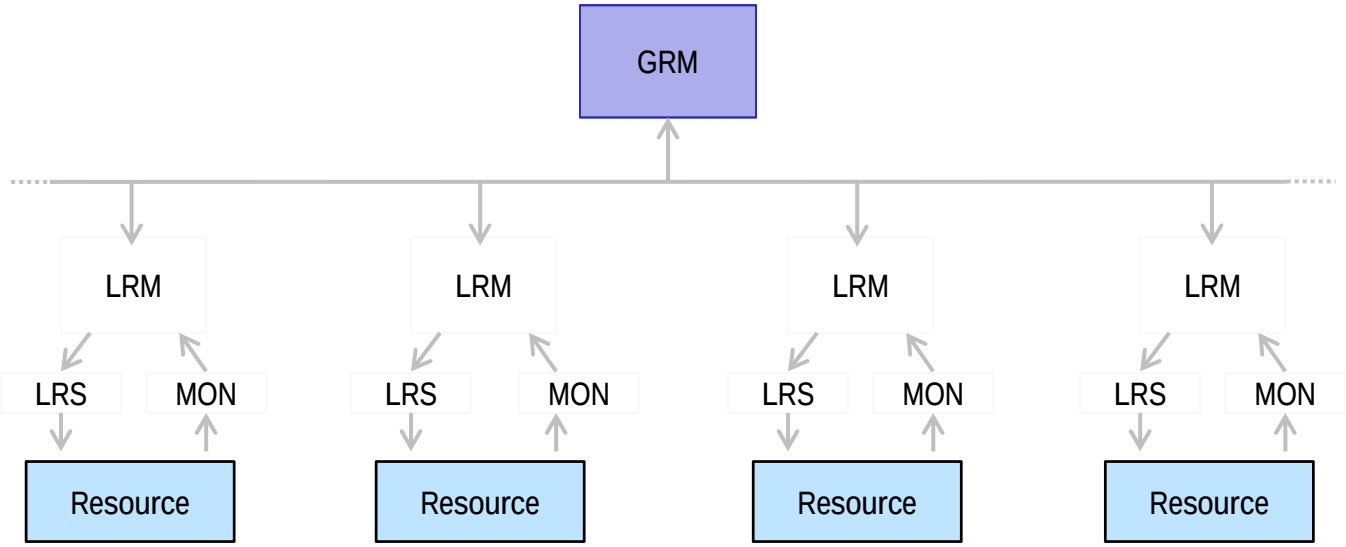
UNIVERSITÄT SIEGEN

Goals of resource management

- reconfiguration of a mixed-criticality system
  - upon foreseen and unforeseen changes
    in its operational and environmental conditions
- adaptability mechanisms for securely reconfiguring the system
  - without interrupting or interfering with execution

- secure, adaptive fault tolerance

Resource Management

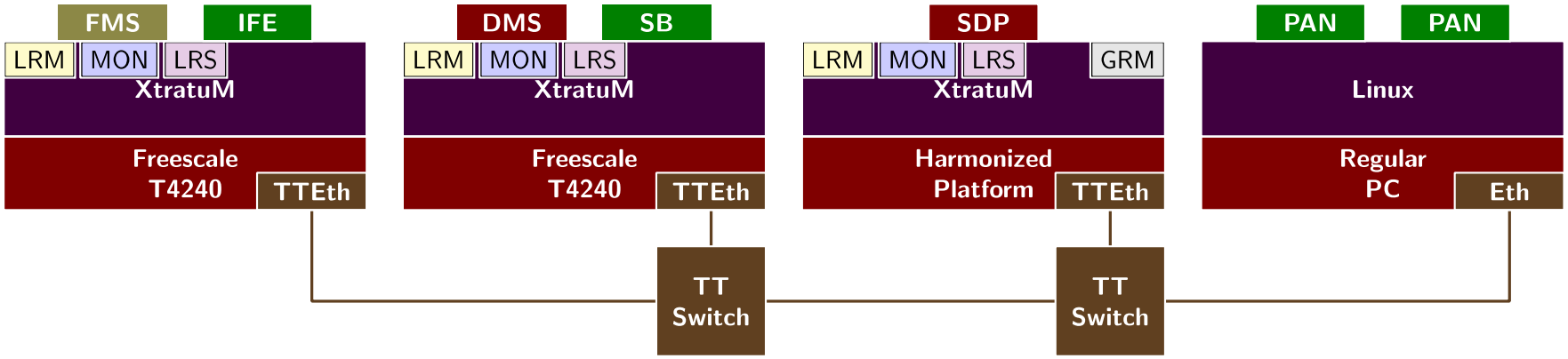


coordination via separation of decisions

- local
- global (system wide)

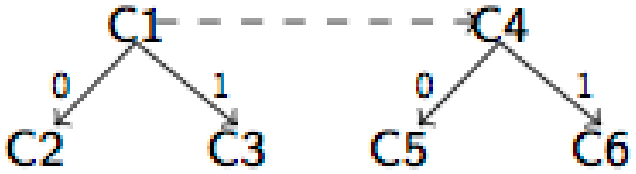
offline computed configurations

DREAMS: Virtualization and RM



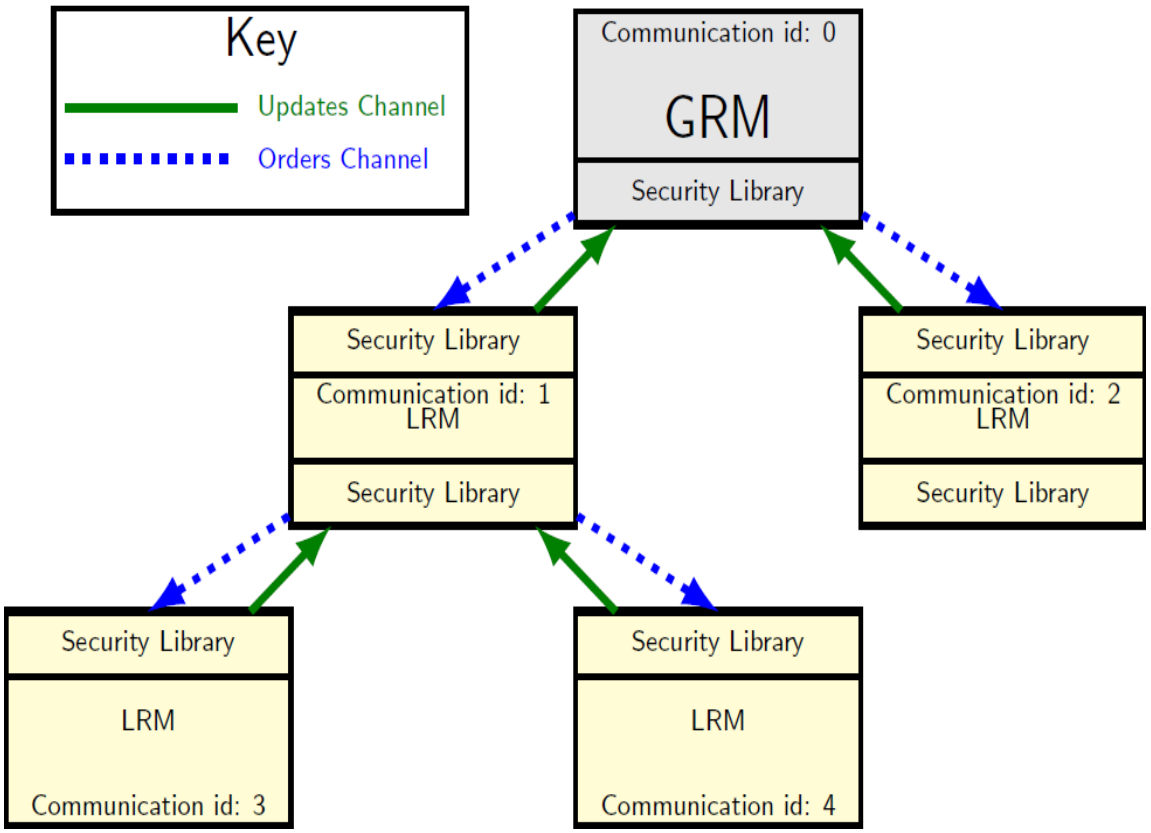
- Hypervisor XtratuM
- DREAMS services on top of XtratuM
- Applications:
  - critical applications: Flight Management System (FMS), Display Management System (DMS), and Sensors Data Provider (SDP)
  - Best-effort applications are: In-Flight Entertainment (IFE) and panels (PAN)

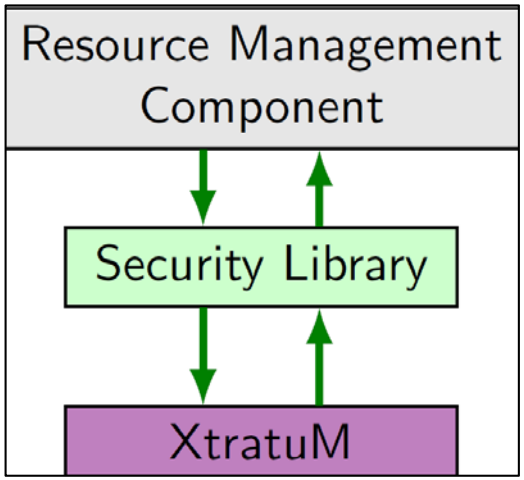
DREAMS: adaptive, faults, reconfiguration



- GRM stores the global reconfiguration graph (LRMs must have complete symmetric local reconfiguration graph).

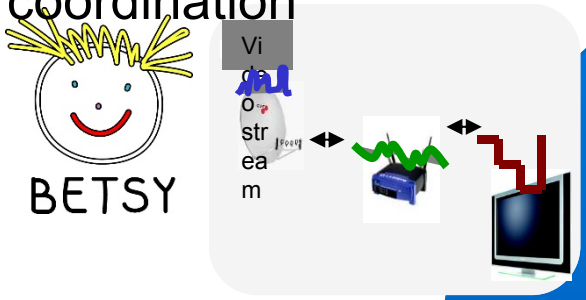
DREAMS: secure RM

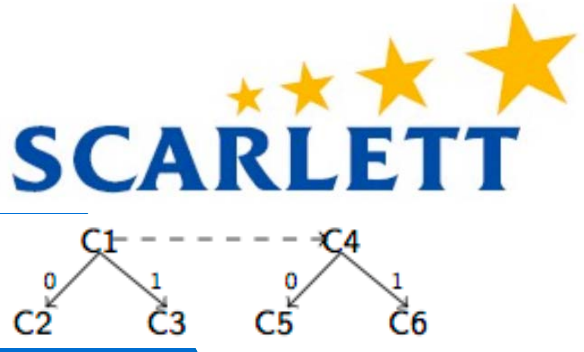




with DREAMS: from EU projects

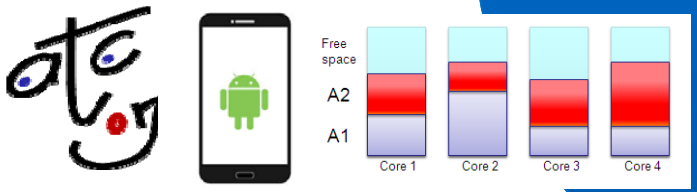
global – local coordination





fault handling
secure res mgt
virtualization
offline configurations
on/off chip networks

fault handling, reconfiguration



resource mgt - multicore

XtratuM

Technology Pitch:
Modular Safety Cases (MSCs)

November 23rd, 2016

Imanol Martinez

IK4-IKERLAN

Certification & Modularity

Certification: “Procedure in which an accredited or authorized person or body assesses and verifies the requirements of a system in accordance with established requirements or standards”

Safety Certification: “assess the compliance of a system to the requirements of a safety-related standard (E.g., IEC 61508)”

Traditional approach to certification relies on the certification of the whole system, where if a safety aspect of the system changes, the re-certification of the entire system is required.

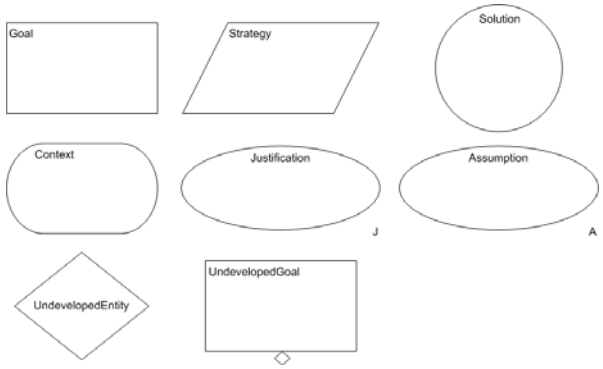
Modularity - “is a complexity management technique that subdivides the system into smaller parts (modules) that are independently generated and re-used to compose a system”. [Kopetz08]

Safety Cases, Modularity and Notation Languages

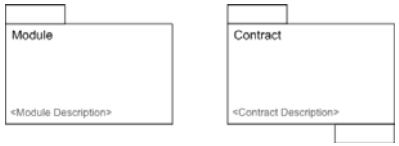
Safety Case – "A documented body of evidence that provides a convincing and valid argument that a system is adequately safe for a given application in a specific environment (such as automotive, railway, lift and etc.)." [Bishop98]

Modular Safety Cases (MSCs) – "Safety cases that enable the reusability of predefined modules, reducing the overall complexity (simplification strategy) and limiting the impacts of changes to specific modules or areas."

GSN safety-case notation language

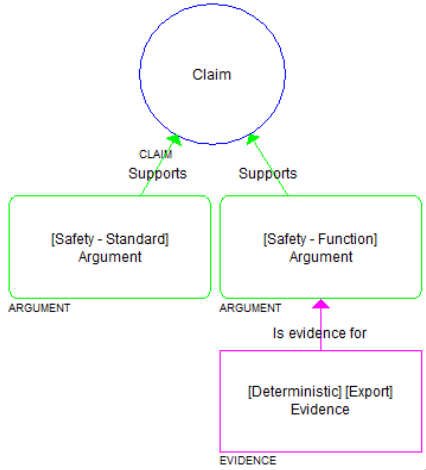


Safety Case – GSN elements.



Safety Case – GSN elements for modularity

CAE safety-case notation language



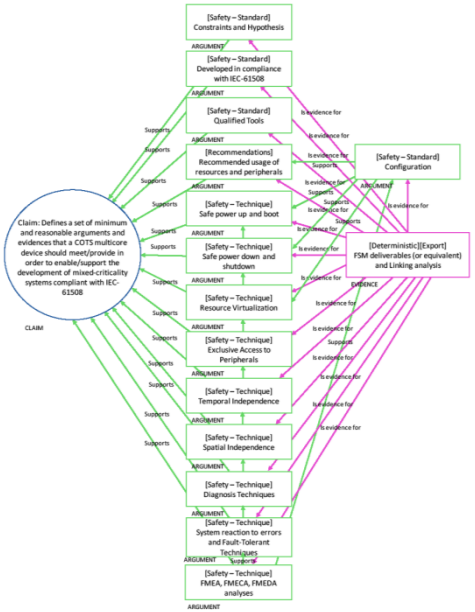
Modular Safety Cases for Mixed-Criticality Systems

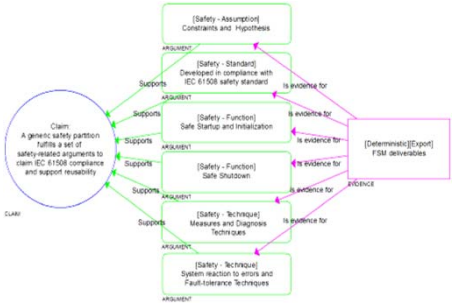
D5.1.1
A Modular Safety Case for an IEC 61508 compliant Generic Hypervisor

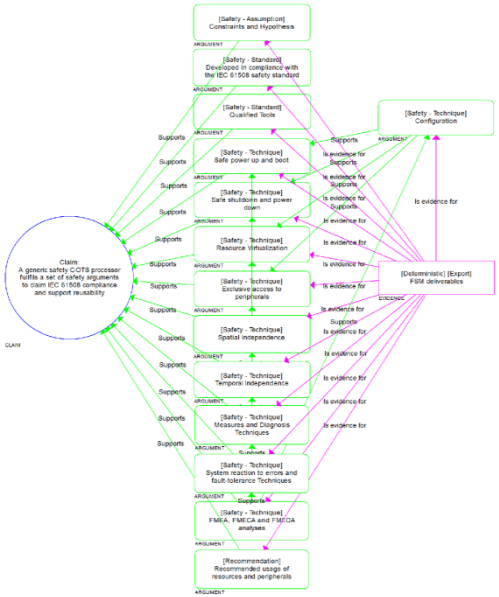
D5.1.1
A Modular Safety Case for an IEC 61508 compliant Generic Partition

D5.1.2
A Modular Safety Case for an IEC 61508 compliant Generic COTS Multi-Core Device

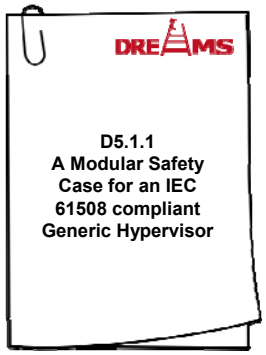
D5.1.3
A Modular Safety Case for an IEC 61508 compliant Generic Mixed-Criticality Network

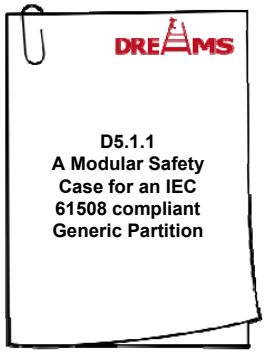


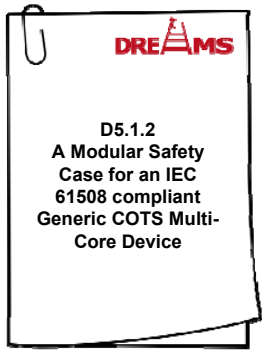


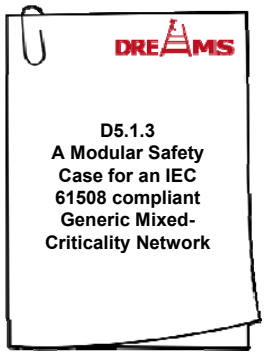


Modular Safety Cases and Linking Analysis

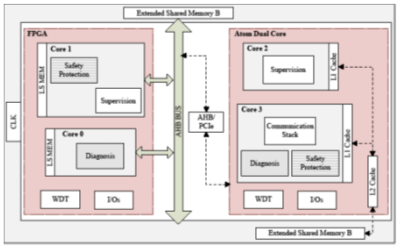








XtratuM



Safety over EtherCAT®

UNIVERSITÄT SIEGEN

Technology Pitch

Model-Based Development and Toolchain

November 22nd, 2016

Simon Barner

fortiss GmbH

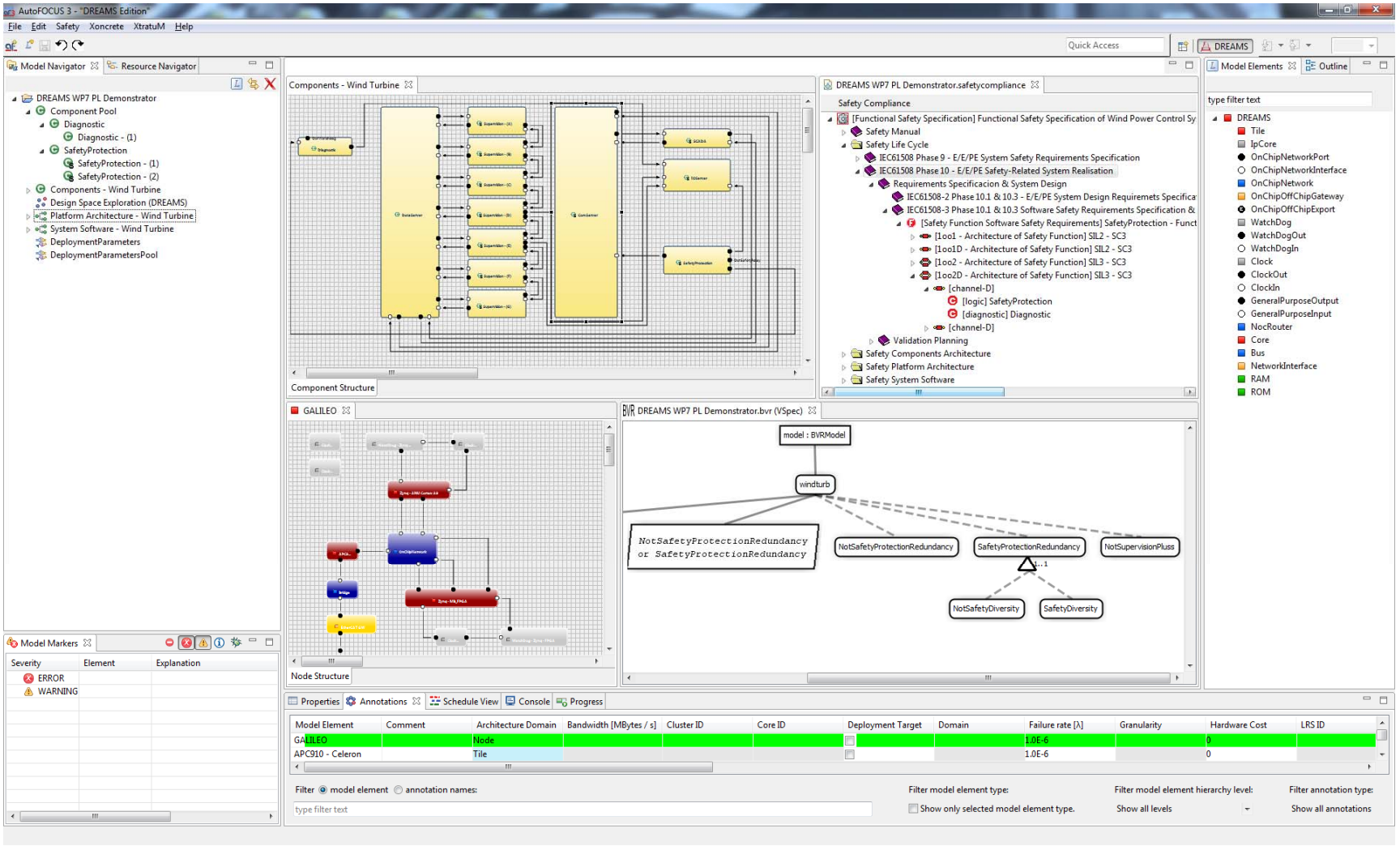
fortiss

SEVENTH FRAMEWORK PROGRAMME

- Development Methodology and Integrated Toolchain
  - Variability Exploration
  - Design-Space Exploration
  - Resource Allocation and Scheduling
  - Reconfiguration
  - Safety Checker and Argumentation Synthesis
  - Platform Configuration Generation

- Modeling Mixed-criticality Systems
  - Applications (Architecture, Timing Requirements)
  - Safety Requirements and Properties
  - Hierarchical Platforms
    (DREAMS: Cluster, Node, Tile, Processor & Hypervisor Level)
  - Deployments and Resource Allocations

DREAMS Model-Based Development and Toolchain



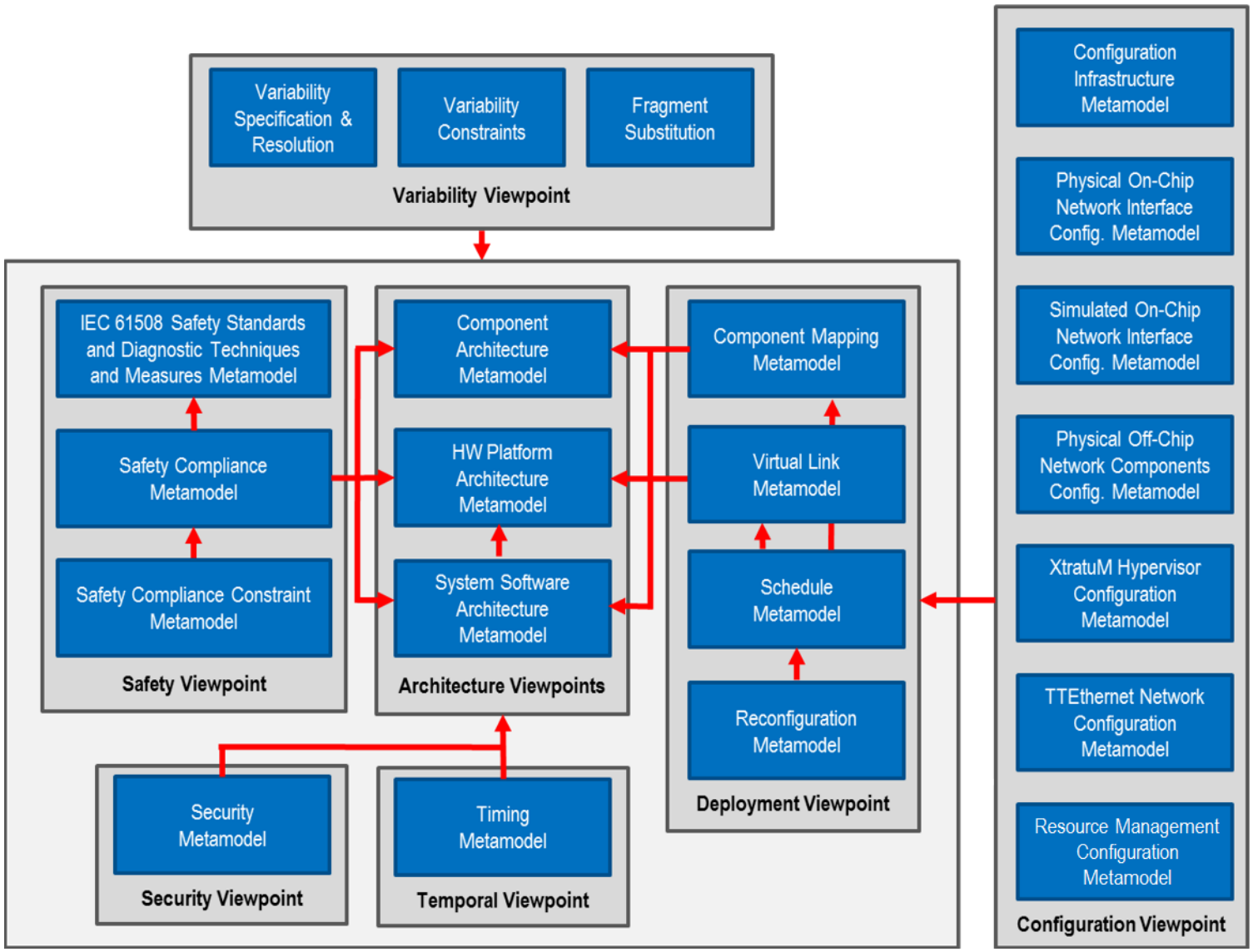
DREAMS Model-Based Development Process & Toolchain

1. Basic Scheduling Configuration
   - Mapping of Application to Computation and Communication Resources
   - Offline Scheduling
   - Configuration Generation

2. Scheduling Configuration with Resource Management
   - Extends Use Case 1
   - Global and Local Reconfiguration Strategies
   - Compensates Core Failures and Deadline Overruns

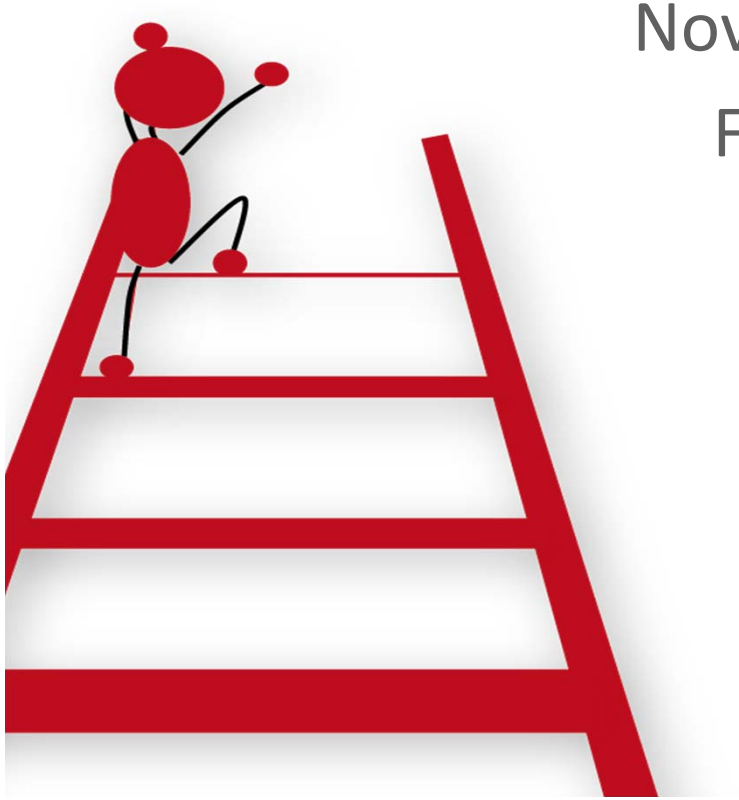
3. Variability and Design-Space Exploration
   - Extends Use Case 1 to MCS Product-Lines
   - Business variability: Which Features and Requirements?
   - Technical variability: How are Features implemented?

Modeling Mixed Criticality Systems



DREAMS

Variability & Product-lines



November 23rd, 2016

Franck CHAUVEL

SINTEF ICT

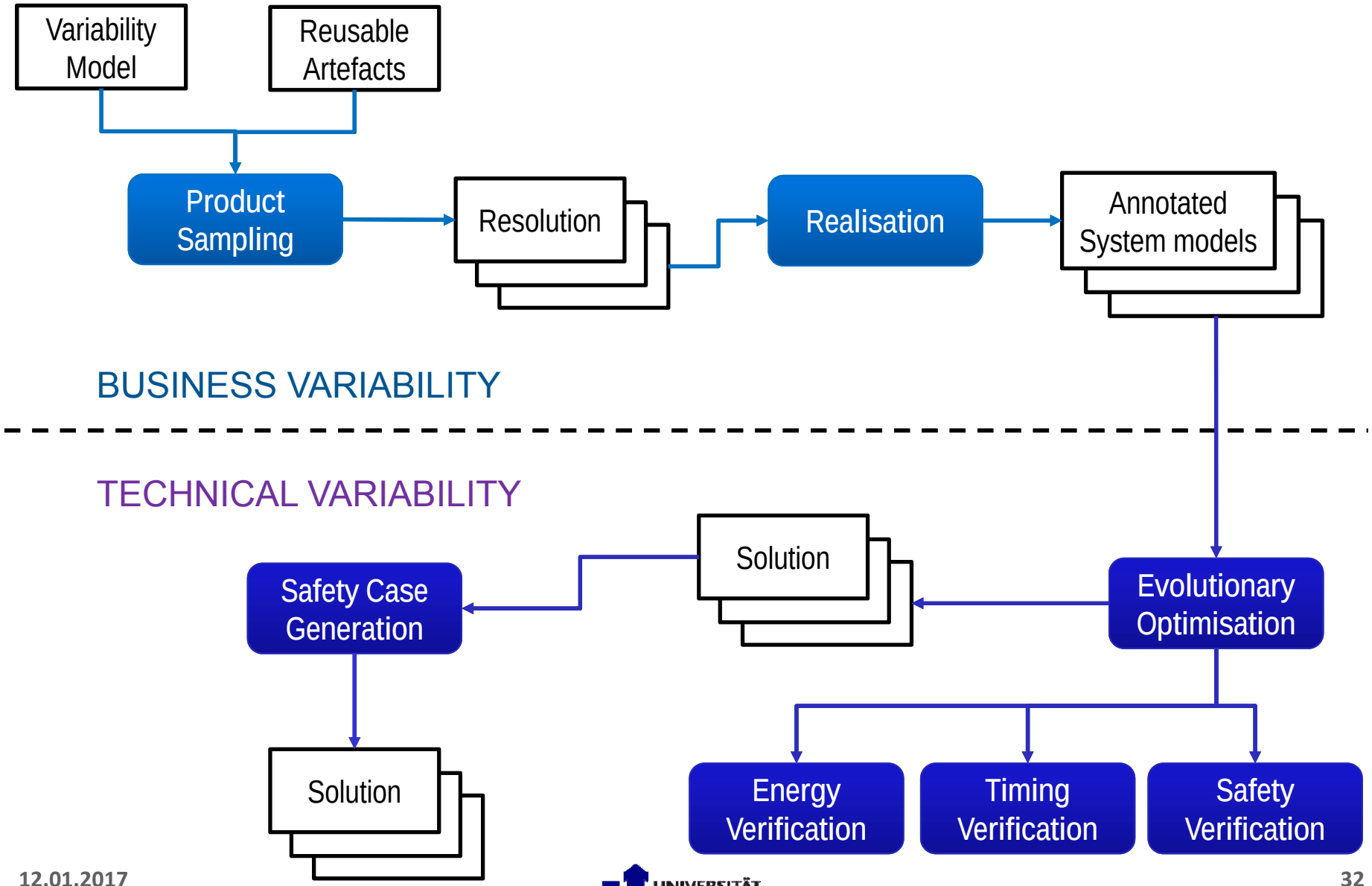
UNIVERSITÄT SIEGEN

SEVENTH FRAMEWORK PROGRAMME

Reuse Beyond one System

- Each customer is different
- Why Product-lines?
  - Lower Costs
  - Higher quality
  - by Reusing across products
- Certification?

Variability Management in DREAMS



DREAMS

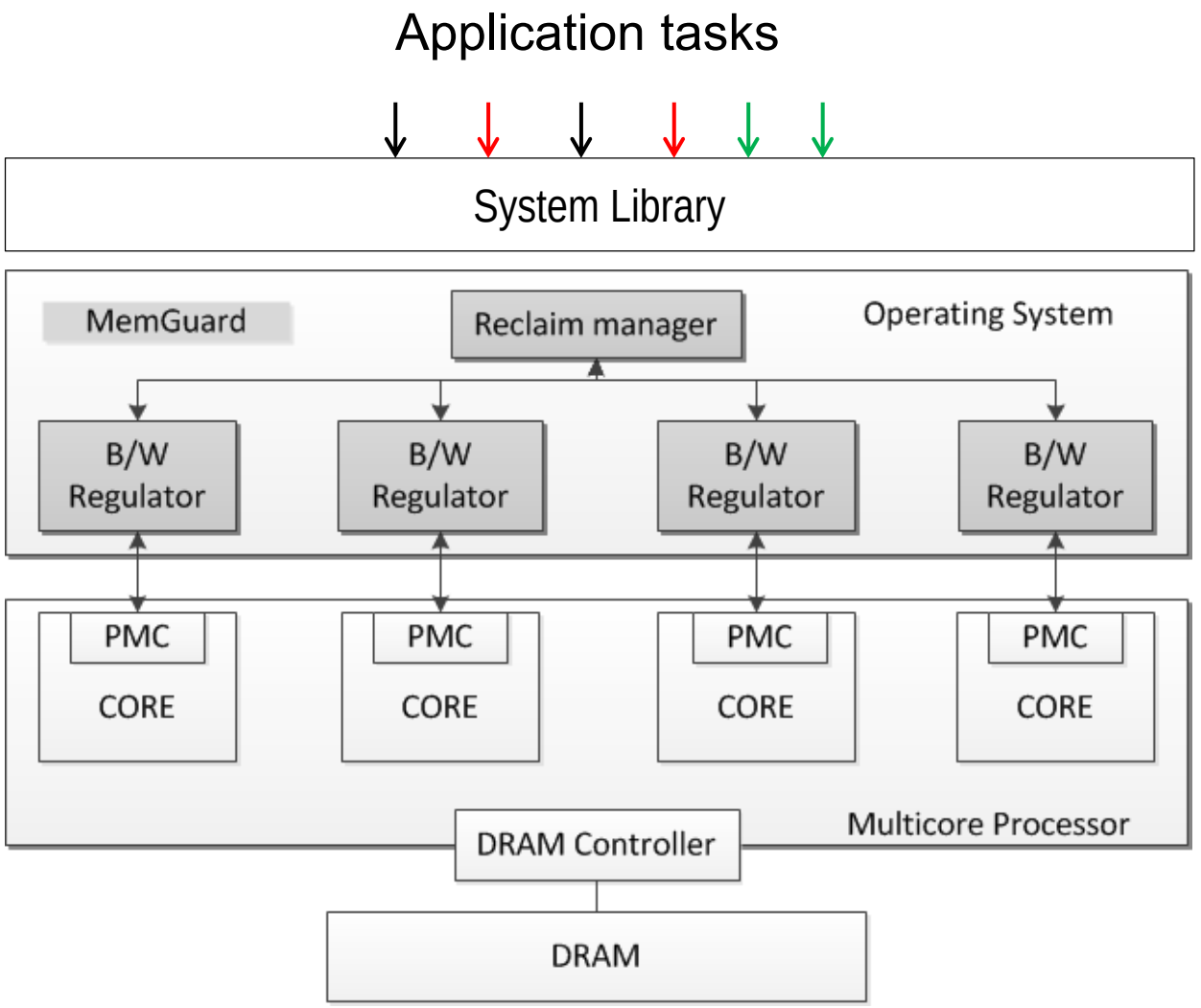
Memory/Network Bandwidth Regulation & Virtualization

ST Microelectronics, TEI & VOSYS

UNIVERSITÄT SIEGEN

SEVENTH FRAMEWORK PROGRAMME

Genuine MemGuard



Porting Genuine MemGuard/Linux

- MemGuard regulates memory bw per core
  - working implementation as kernel module on ARM v7 (Zedboard) & v8 (Juno)
  - ARM v8 (Dragonboard 410c) issues, e.g. kernel readjusts perf-event update rates
- Genuine MemGuard already used with KVM hypervisor
  - control memory bw of VMs mapped to different cores

Extended MemGuard

- Extended MemGuard supports Violation-Free mode, improved BW reservation and reclaiming, EWMA
  - HW prototype (Zedboard FPGA)
    - backpressure to avoid deadlock
    - improvements vs Genuine MemGuard HW
  - Linux implementation on Intel CPU & ARM v7
    - optimization & exploration

Netguard

- Linux NetGuard Extension on Intel CPU & ARM v7
  - network bw regulation for video streams (WP8)
  - ARM v8 implementation & further extensions
- Linux scheduler policy for regulation per process group
- Examine interactions with STNoC QoS policies

Video Streaming Demo

```
root@linaro-ubuntu-desktop:~/netguard_driver# echo "1500 50 300 1200" > /sys/kernel/debug/netguard/netguard_config
root@linaro-ubuntu-desktop:~/netguard_driver# echo "1500 50 1200 300" > /sys/kernel/debug/netguard/netguard_config
root@linaro-ubuntu-desktop:~/netguard_driver#
```

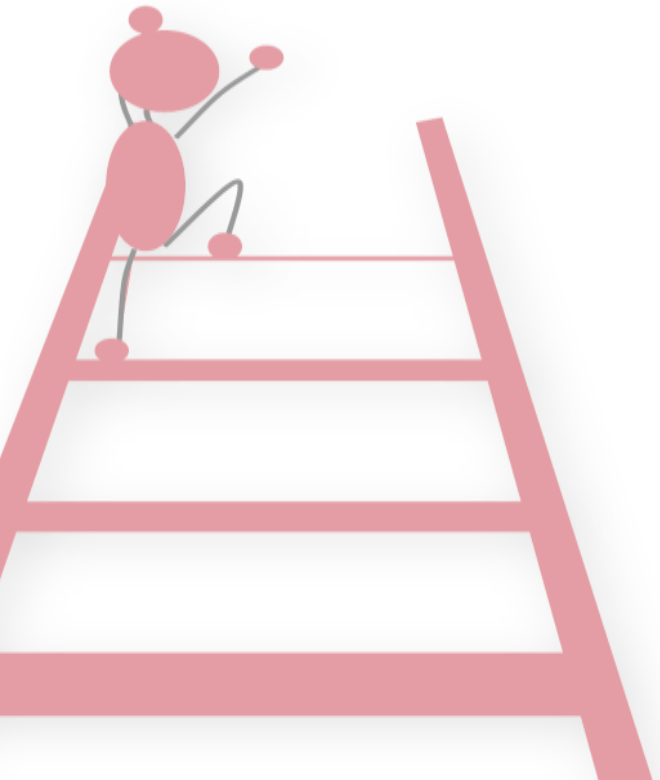
DREAMS Architectural Style

TTEthernet Technology Maturation

Scheduling in the Real-Time IoT

Mixed Criticality in Healthcare

Marcello Coppola



Background

- *Thirty years ago, health care technologists realized a simple truth: monitoring patients improves outcomes.*
- *However, hospital error is still a leading cause of death;*
  - *the Institute of Medicine named it the third leading cause of death after heart disease and cancer.*
  - *Thousands and thousands of errors occur in hospitals every day.*
  - *Many of these errors are caused by **false alarms**, **slow responses**, and inaccurate treatment delivery*

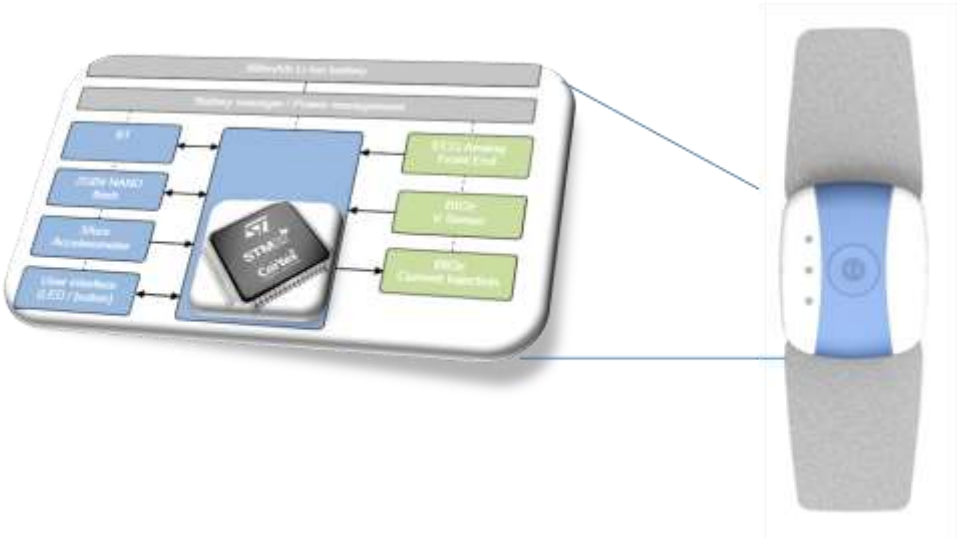
HealthCare Challenges

- Main Objective: new technology spreading through patient care

  - By networking devices, alarms can become smart,
    - Only sounding when multiple devices indicate errant physiological parameters.
  - By connecting measurements to treatment, smart drug delivery systems can react to patient conditions much faster and more reliably than busy hospital staff.
  - By tracking patients around the hospital and connecting them to the hospital server, efficiency of care can be dramatically improved.

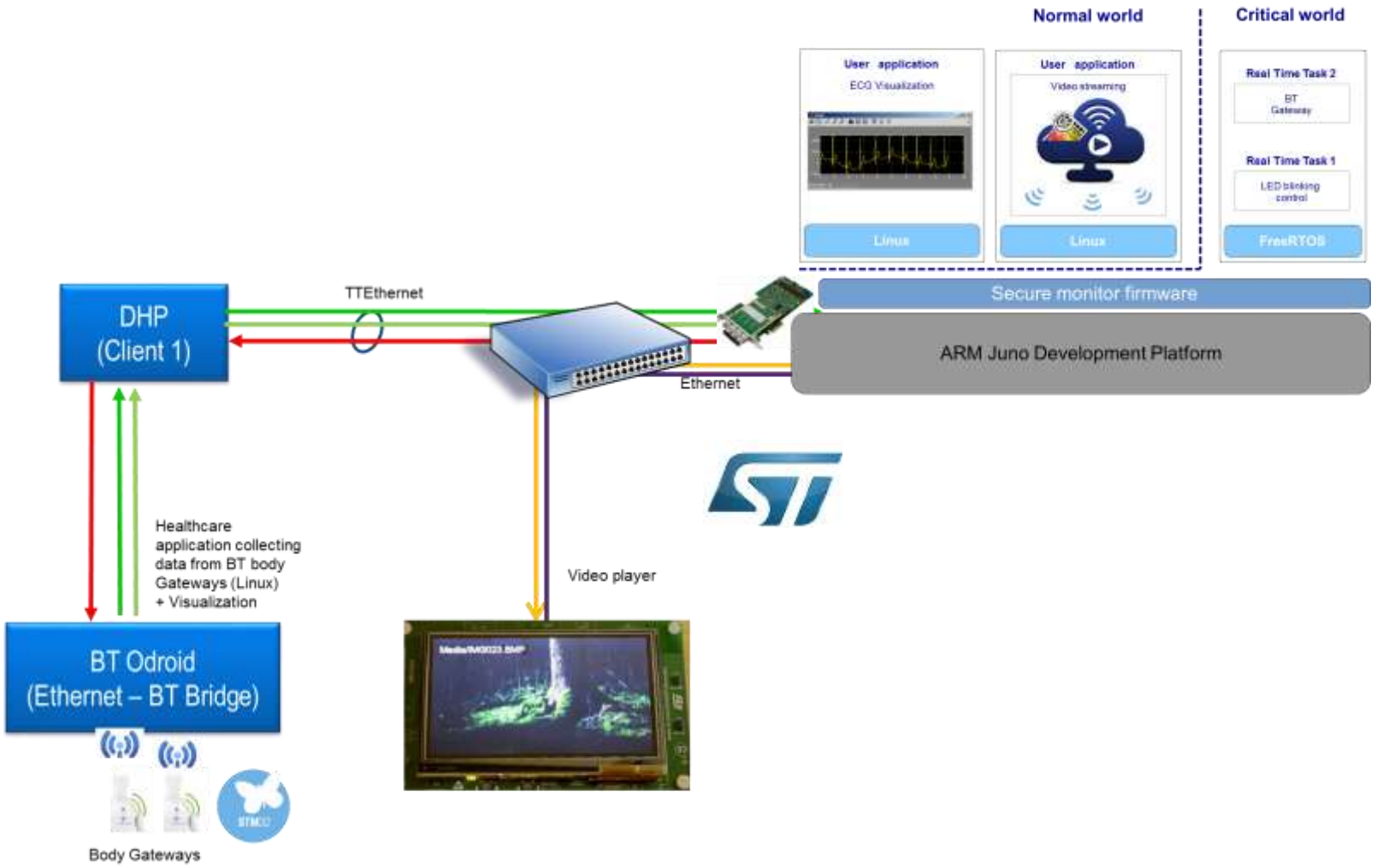
BODY GATEWAY

- **The BG is a wearable, battery-operated device intended for use as a part of a multi-parameter analysis system: it acquires, digitalizes, stores and periodically transmits via a Bluetooth.**
- **It is based on our bestselling STM32 product**
- **Key features**
  - Heart-rate detection
  - Physical-activity estimation
  - Breathing-rate measurement
  - Body position
- **Applications**
  - Chronic cardiac-disease monitoring
  - Home monitoring for the elderly
  - Event monitoring



System Architecture Overview

DREAMS: Proof of the concept Platform (PoC)



From PoC to ST Products

- Body Gateway Product
  - Started to be used in Hospitals, and Medical Services companies
- NoC supporting mixed criticalities used in real products
  - Space, Multimedia Applications, Automotive
- Applications (eg Video Streaming) on STM32

Conclusions

DREAMS enables ST to add extra value to our products increasing our sales and growing our customer base in different market segments

EC DREAMS Success Story: VOSYSmonitor, a low latency monitor firmware for mixed-criticality systems

Kevin Chappuis

2016-11-22

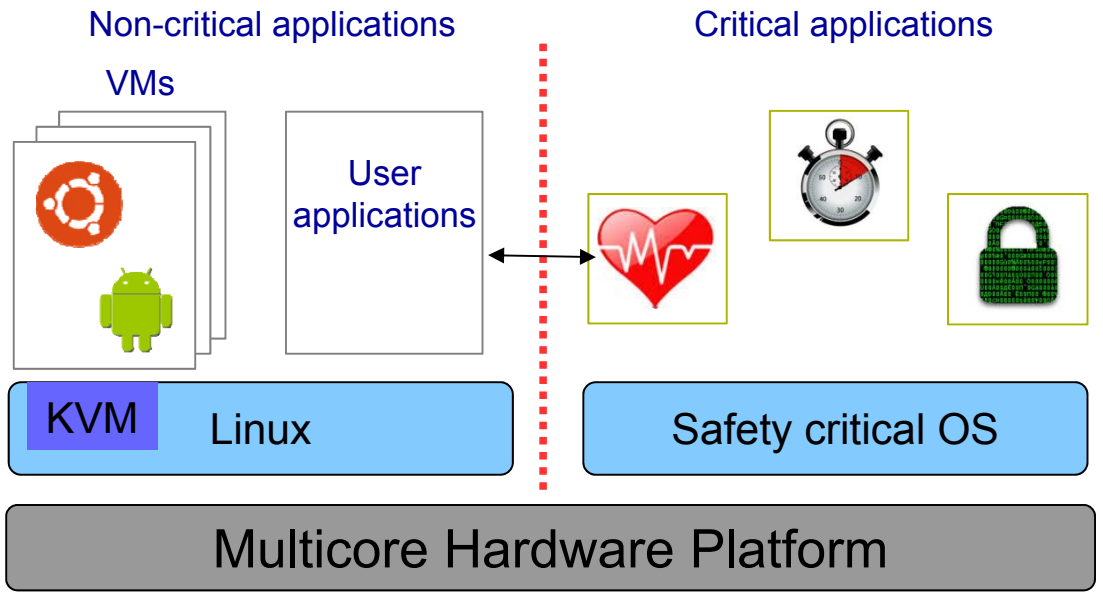
UNIVERSITÄT SIEGEN

SEVENTH FRAMEWORK PROGRAMME

Introduction

- An important trend in the design of embedded systems is the integration of applications with different levels of criticality.

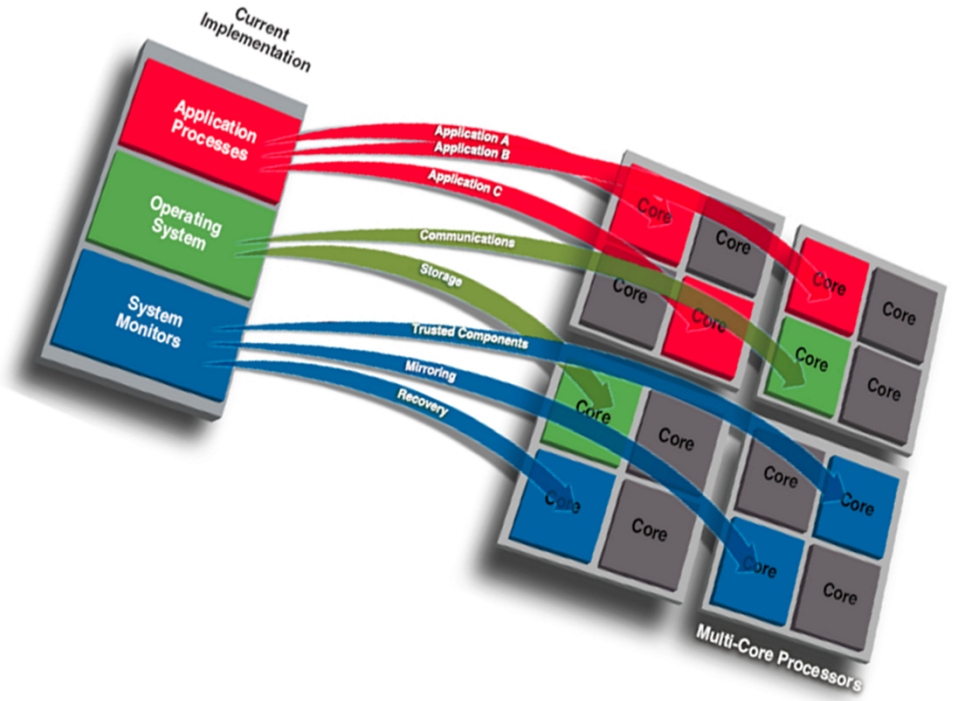
- Such concept brings new challenges to the industry :
  - Multi-OS support and integration
  - Efficient shared use of SoC ressources (e.g., peripheral, memory, etc)
  - Separation of functions and ensure the isolation of safety critical systems



Software systems consolidation

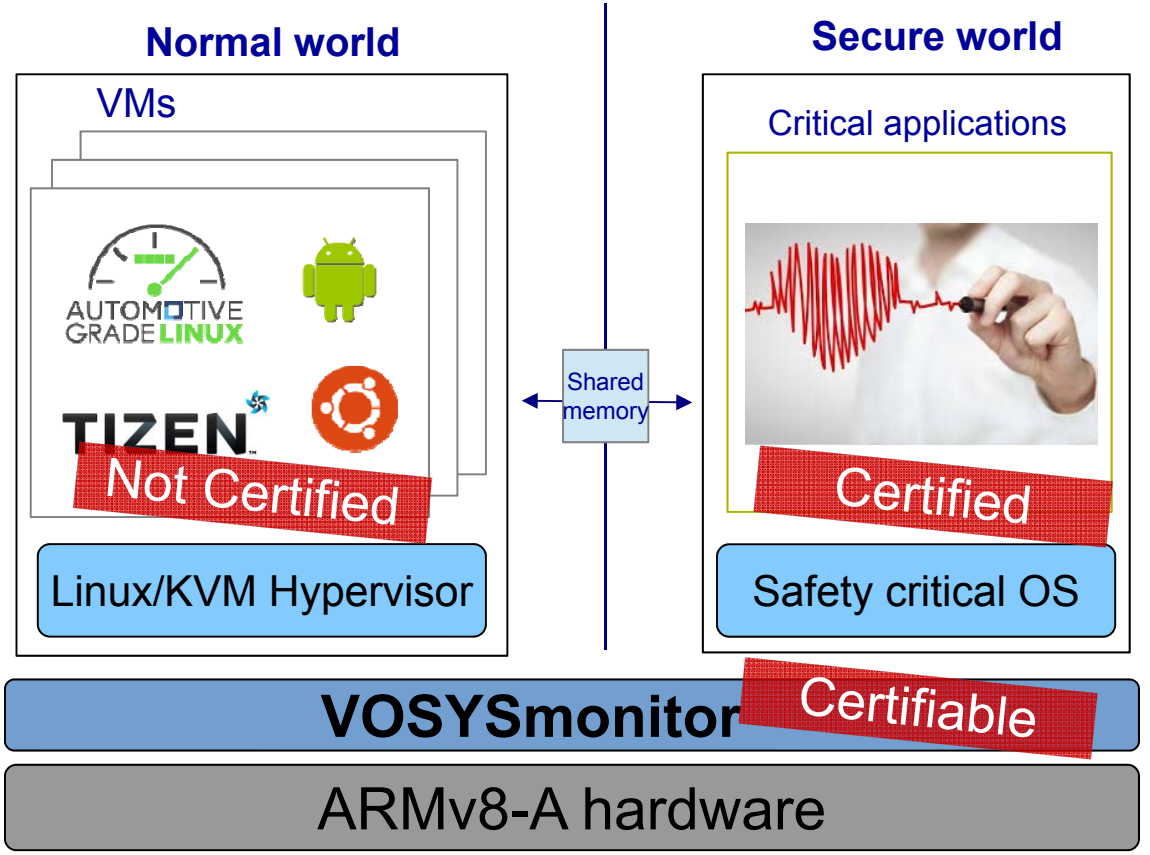
- Last multi-cores architectures (e.g., ARMv8-A) are bringing new features to hardware platforms.
  - Computing performance is increasing
  - Power comsuption is decreasing
  - New hardware extensions (e.g., security, virtualization, etc)

- The goal is to use the computing performance and hardware capacities to embed more functionalities with different levels of criticality in the same platform in to decrease the number of hardware ressources needed.



VOSYSmonitor description

- VOSYSmonitor, developed by Virtual Open Systems, enables the co-execution of virtualized systems along with a safety critical application on the same ARMv8-A platform.
- Safety critical OS isolation using ARM TrustZone
- GPOS virtualization extensions (KVM) enabled
- Ability to safely exchange data between RTOS/GPOS
- Certifiable firmware
- High priority to the critical applications to meet timing constraints.
- Power management coordination



VOSYSmonitor specification

- VOSYSmonitor design is based on the following requirements in order to integrate mixed-criticality systems without compromising safety applications.
  - VOSYSmonitor setup impact less than 1% on the total Safety critical OS boot process.
  - Minimize the interrupt latency impact – GPOS / Safety critical OS context switching time must be lower than 1us.
  - Support complete safety critical OS resources (e.g., Memory, Peripherals, etc) isolation from GPOS illegal access.
  - Standard compliances (e.g., PSCI, SMCCC).

- VOSYSmonitor supports several ARMv8 platforms:
  - ARM Fast Models AEMv8A (virtual platform)
  - ARM Juno Development Board
  - Renesas R-Car H3 (ISO 26262 – ASIL B compliant)
  - Nvidia Jetson TX1

Application fields

- **Drones:** Run a safety software (e.g., landing, overflight, etc) in case of the main control OS fails.

VOSYSmonitor

- **Automotive:** Consolidation of the Infotainment and cluster dashboard systems on a common hardware.

- **Mobiles:** Execute Android OS and secure applications (e.g., online payment, DRM, fingerprint, etc)

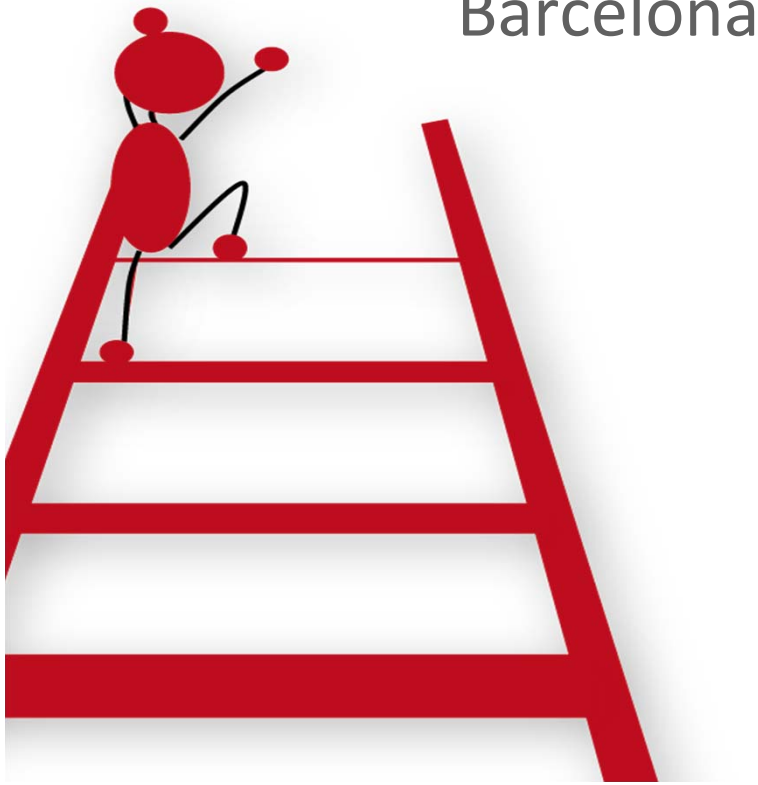
- **Healthcare:** Monitor critical signals (e.g. ECG) and infotainment video streaming

All possible use-cases with mixed-criticality systems.

Alstom Wind Exploitation story

Barcelona, November 22nd, 2016

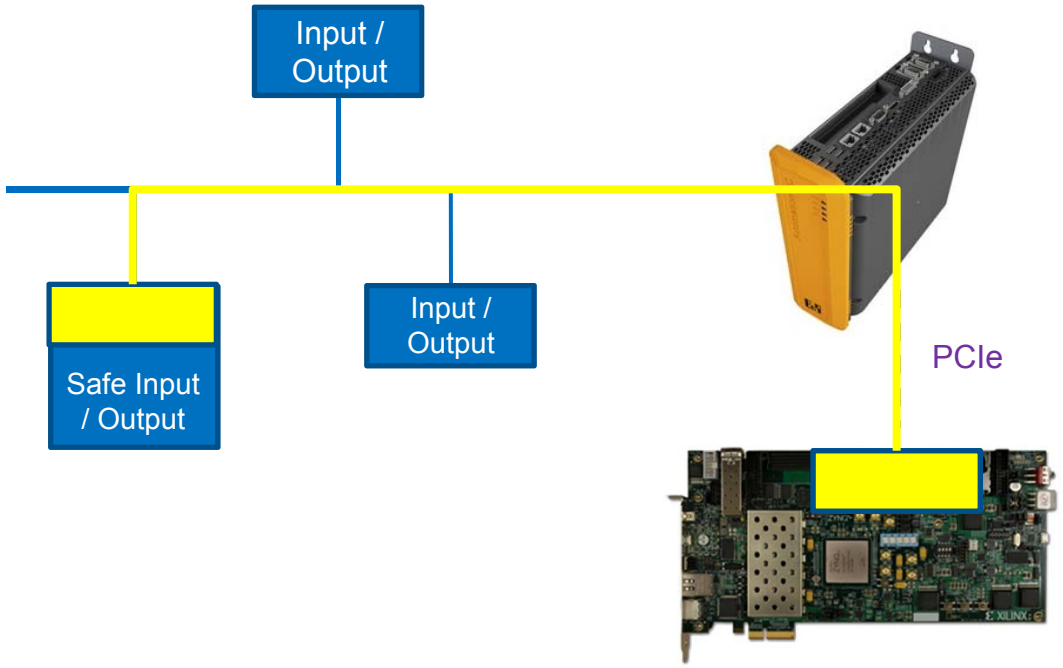
Ton Trapman



UNIVERSITÄT SIEGEN

SEVENTH FRAMEWORK PROGRAMME

Planned Product Overview



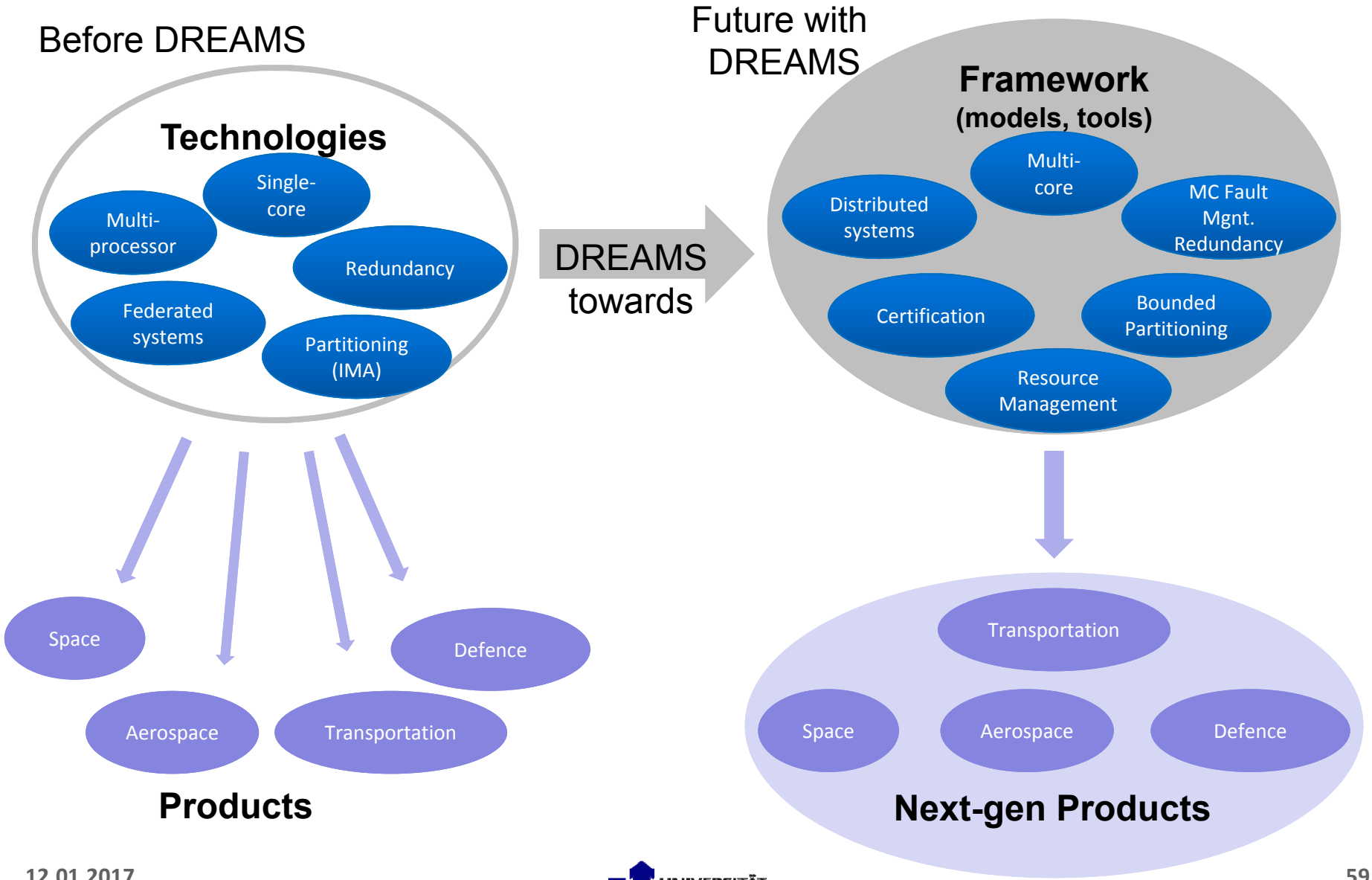
Control Unit (Galileo Platform)

Protection Unit (Dreams Harmonized Platform)

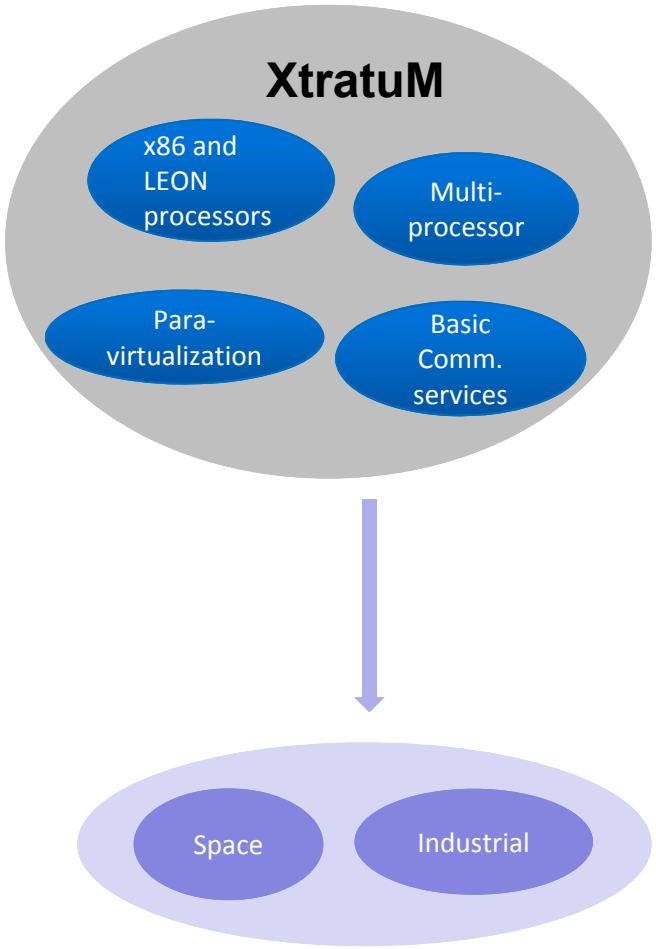
Value proposition

- Compliance with customer demands for:
  - Increase in product safety for Health, Safety and Environment (HSE)
  - Higher flexibility towards customisations
  - Compliant with product certification requests demonstrating product reliability and resilience
- Marketing:
  - Competitive value proposition for offering SIL 3 safety in wind turbines
- Product evolution in:
  - Following the tendency of using more standard hardware and industrial controllers
  - Compliance with stricter industry related standards (IEC 61400)
  - Product updates for lifetime extension
  - Cost reduction by using hypervisor technologies

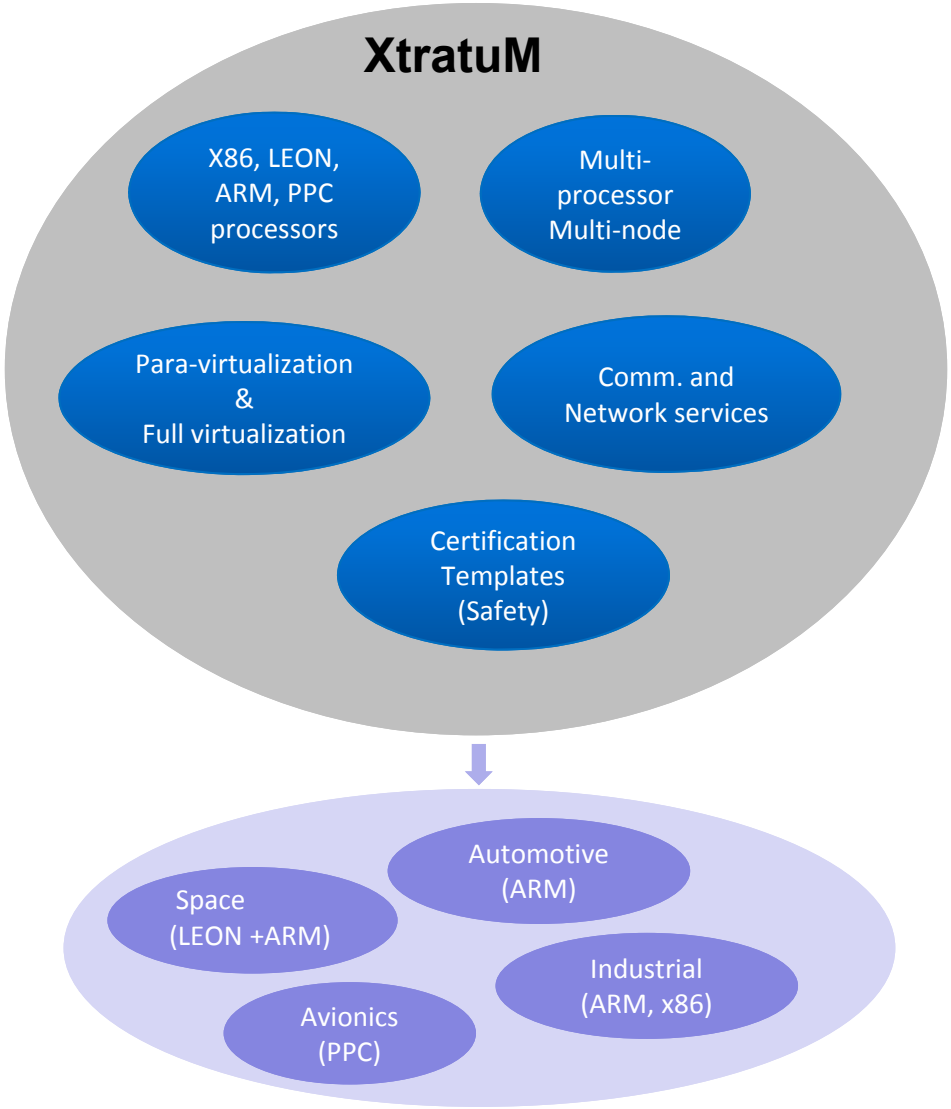
THALES Exploitation Story



Before DREAMS



After DREAMS



TÜV Rheinland Exploitation Story

TÜV Rheinland is a service provider for:

- Testing
  - Inspection
    - Certification

DREAMS project helps:

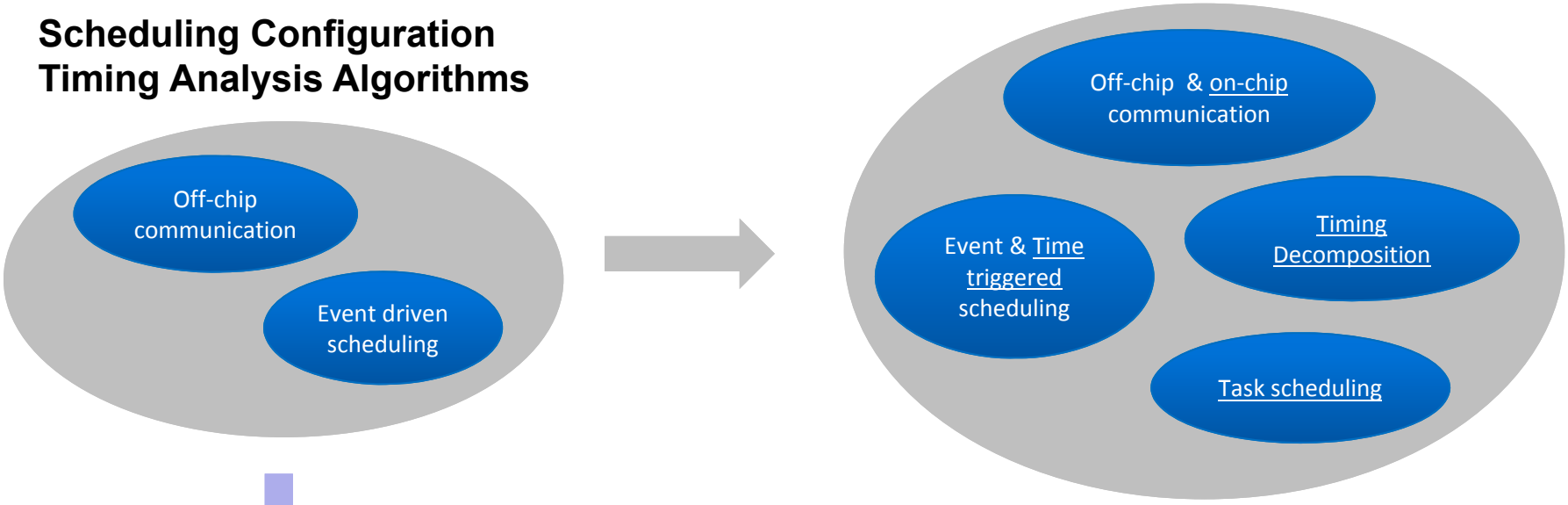
- to increase the competencies regarding the use of multi-core processor systems in mixed criticality applications
- to stay in business and beyond to be able to assess the increasingly complex safety applications using increasingly powerful and complex processing engines
- to evaluate components and systems, which are not sufficiently taken into account in today's safety standards

Exploitation Story: RTaW

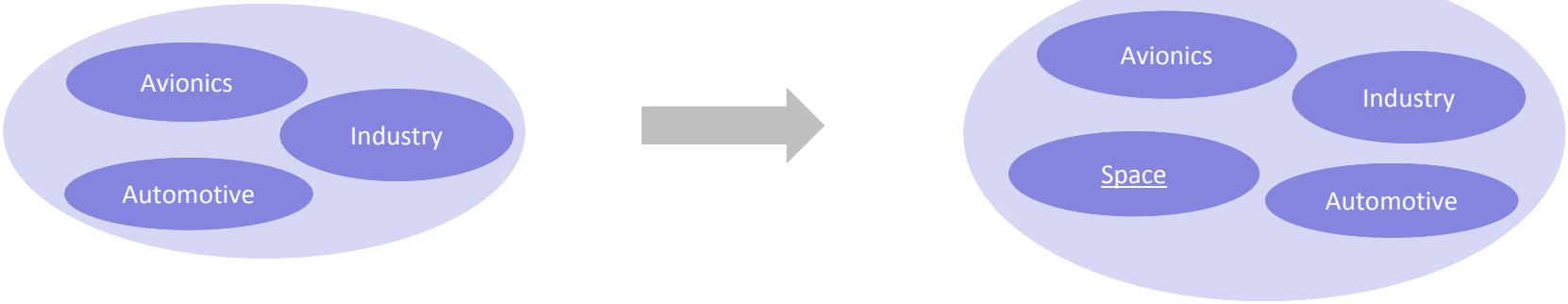
Before DREAMS

After DREAMS

Scheduling Configuration
Timing Analysis Algorithms



Design & Verification Tool
Engineering, R&D



Exploitation Story: RTaW

- RTaW offering, **before DREAMS**:
  - Software Tools
    - Worst-Case Timing Analysis and Simulation of event-driven networks: Switched Ethernet, CAN, DITS
    - Corresponding optimization of scheduling parameters
  - Competences (consultancy, R&D)
    - Event-driven communication protocols:
      - Optimal configuration
      - Verification through analysis and simulation
  - Application domains
    - Automotive, Aerospace

Exploitation Story: RTaW

- RTaW offering, **after DREAMS**:
  - Gained competences (consultancy, R&D, tooling) :
    - Mixed criticality systems
    - Layered time triggered and event triggered scheduling
    - Hierarchical task/partition scheduling with mode changes
    - NoC technologies and scheduling
    - Model driven configuration file generation
  - Extensions of tools:
    - Timing decomposition
    - Scheduling Configuration: NoC
    - Timing analysis: STNoC, TTEthernet, cyclic partition/task scheduling

Exploitation Story: RTaW

- New opportunities
  - Satellites launch vehicles
  - Multi/many-core in automotive
  - High performance embedded computing: many core with NoC
  - All industries using time-triggered control systems

Dissemination

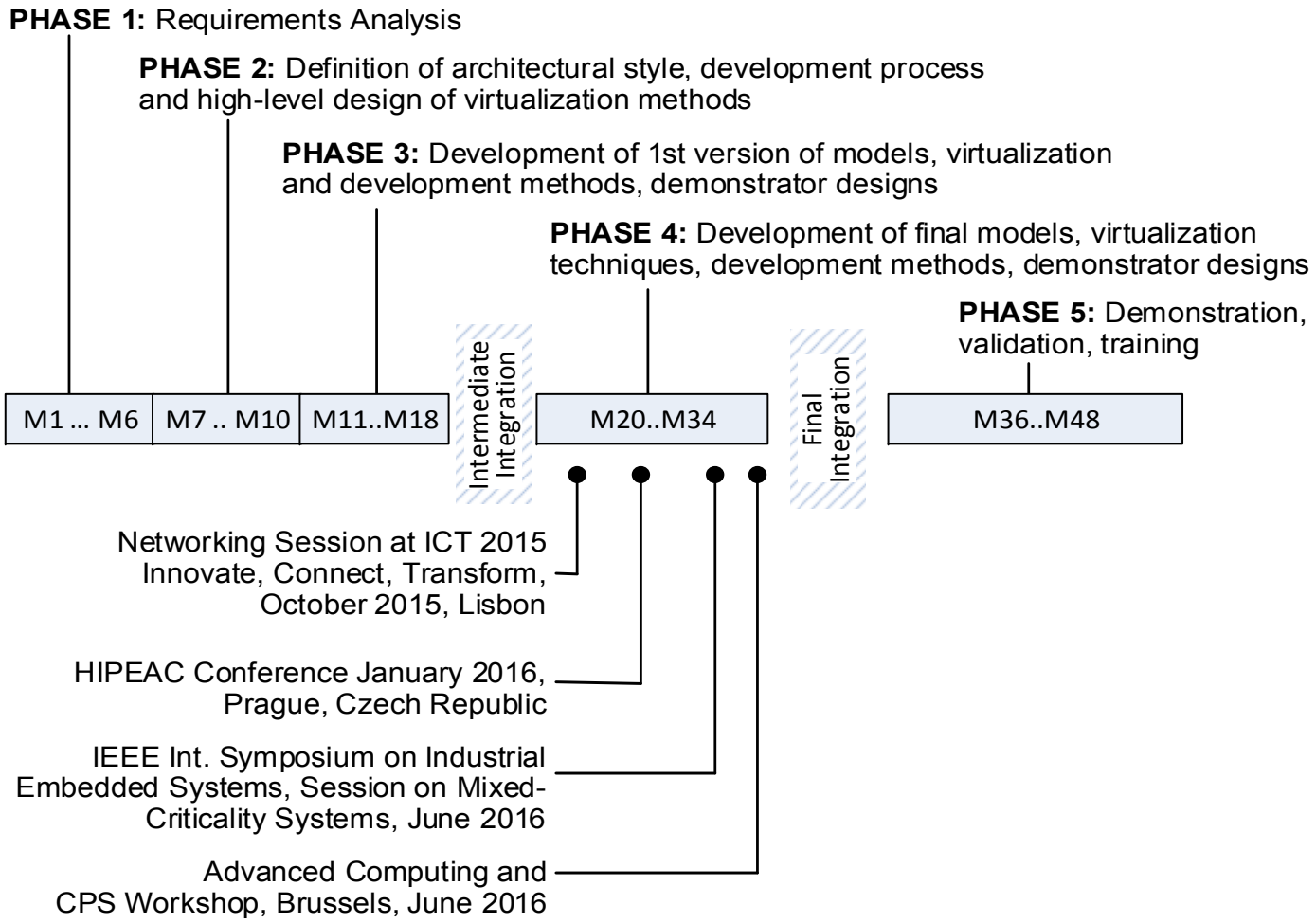
Roman Obermaisser, Univ. of Siegen
Barcelona, Nov. 2016

DREAMS Dissemination Policy and Goals

Achieve the widest possible awareness for scientific & technical concepts and integrated technologies in DREAMS

1. Broadcast research results to stakeholder community
2. National and international exhibitions and fairs
3. Focused training
4. Academic and industrial clusters and networks
5. Public Awareness

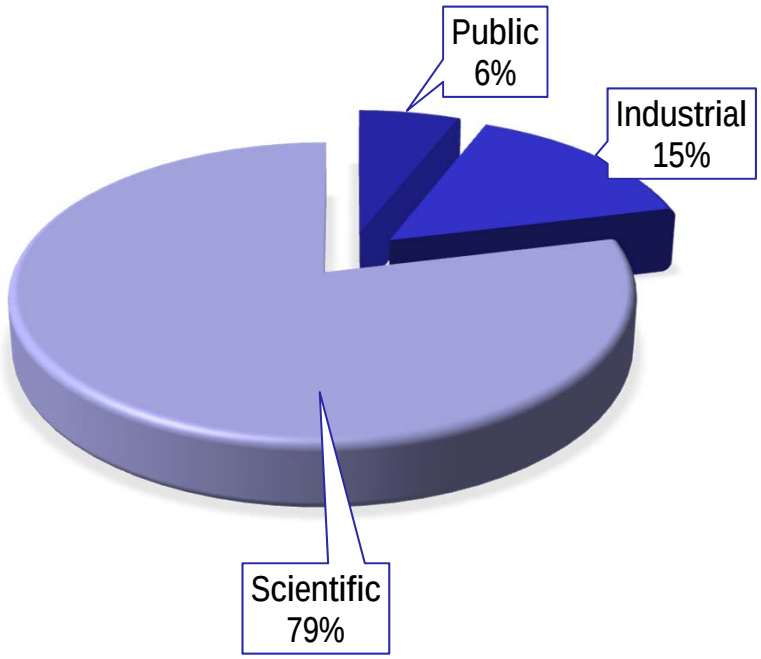
DREAMS Timeline and Dissemination in Year 3

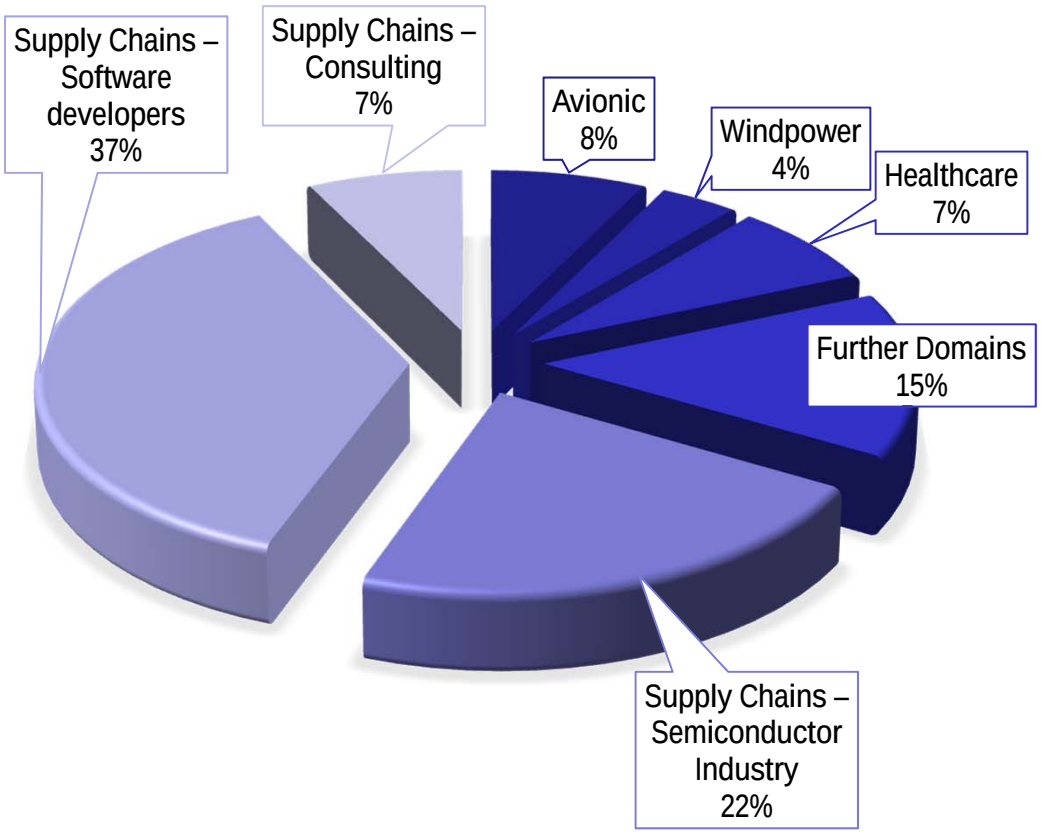


Target Groups

- Application Domains
  - Avionics
  - Industrial stakeholders
  - Healthcare
  - Further domains (e.g., railway, automotive)
- Stakeholders along Supply Chains
  - System integrators
  - Tool developers
  - Hardware platform developers
  - Software developers
  - Consulting
- Public

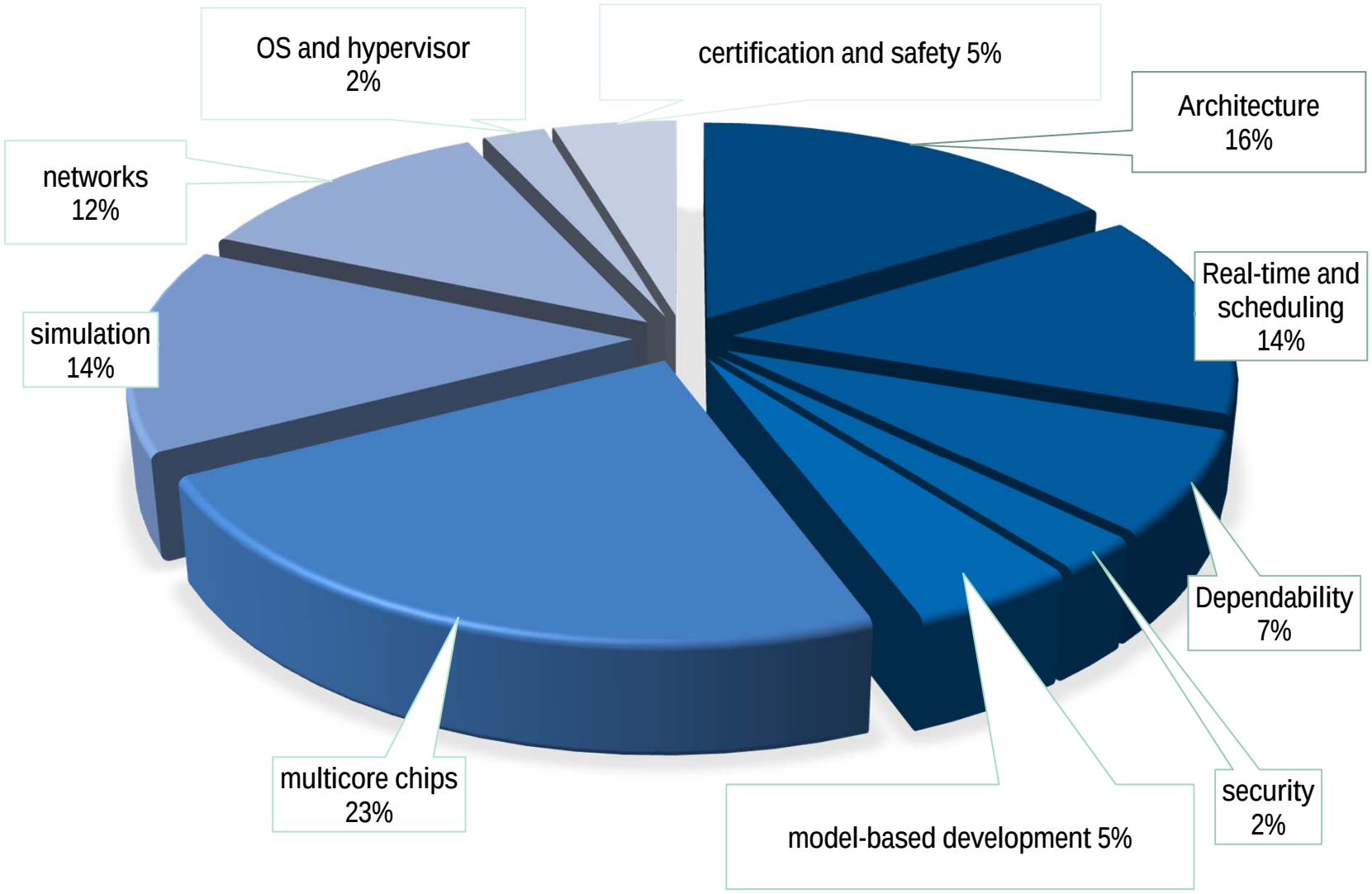
Overview of Dissemination: DREAMS Year 3





Total Number of Publications in Year 3: 44

Overview of Dissemination: DREAMS Year 3



DREAMS Webpage and Information for the Public

Social Media (Linkedin, Twitter)