State of the Art on Software Radio Frameworks

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Thales Land & Joint Systems

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- **Software Radio – Main Features**

- **Reference Model for SDR Framework**

- **SCA and HAL Implementation Choices**

- **PEA AL Return of Experience**

- **SDR Framework Evolutions**

- **Conclusions & Perspectives**

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Multi-Bands

- HF, VHF, UHF…

Multi-Channels

- Simultaneous & Independent Tx/Rx Communication Channels

Multi-Modes

- New Wide Band Networking Waveforms
- Legacy Narrow Band Waveforms
- Advanced Protocols
- Programmable Cryptos

Network Oriented (Tactical Internet)

- Embedded Routing Features

Multi Domains Compatible

- Ground, Maritime, Aeronautical
- Vehicular, Manpack, Handheld

Modular & Programmable

- Software and Hardware Independent
- Standard Architectural Framework
- Waveform Library
- Certification Center
- Radio System Integrator

Multi-Missions / Network Oriented Joint Operations - National / Coalition

Smooth transition from Legacy systems to full potential SDR system
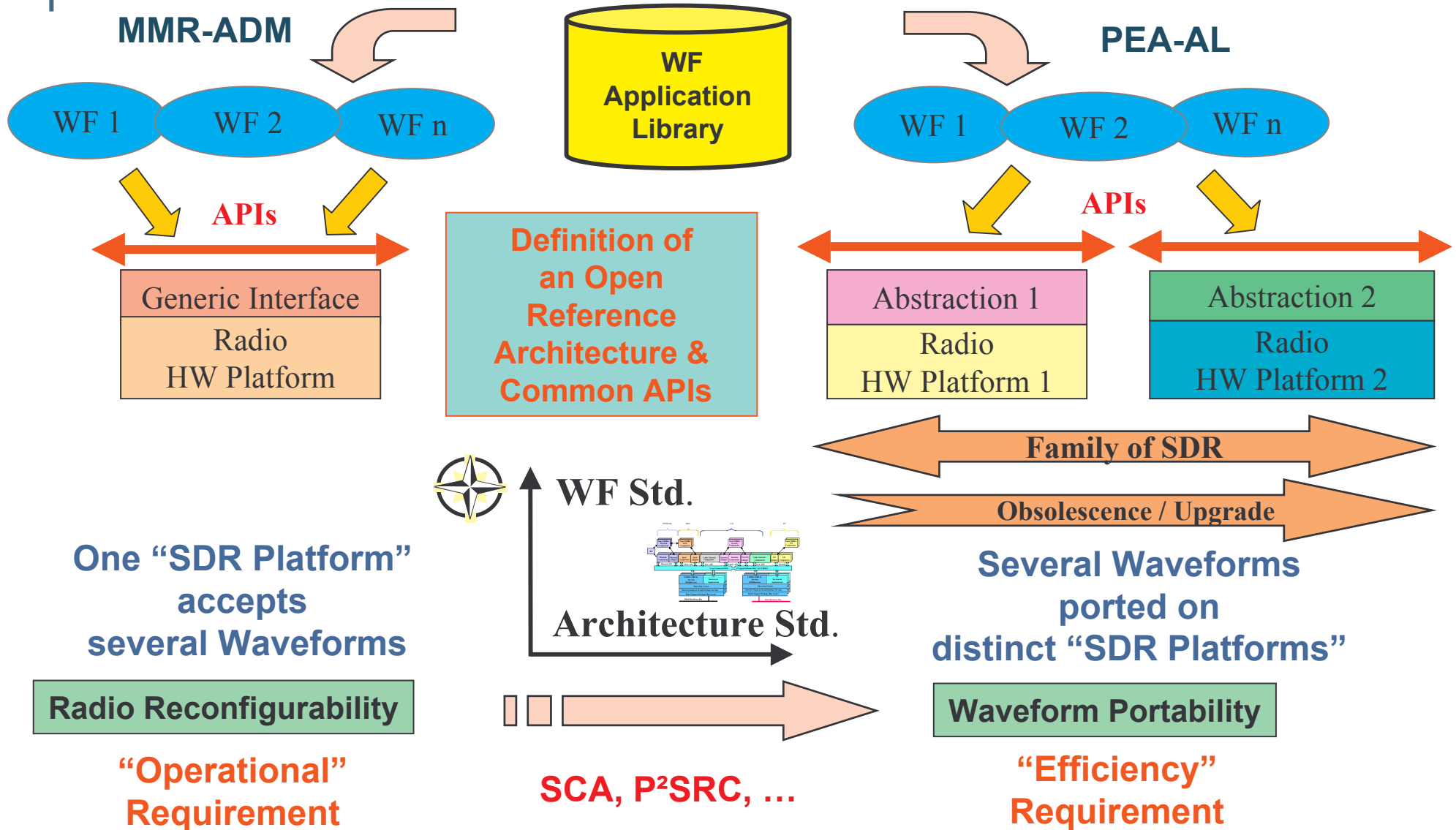
User

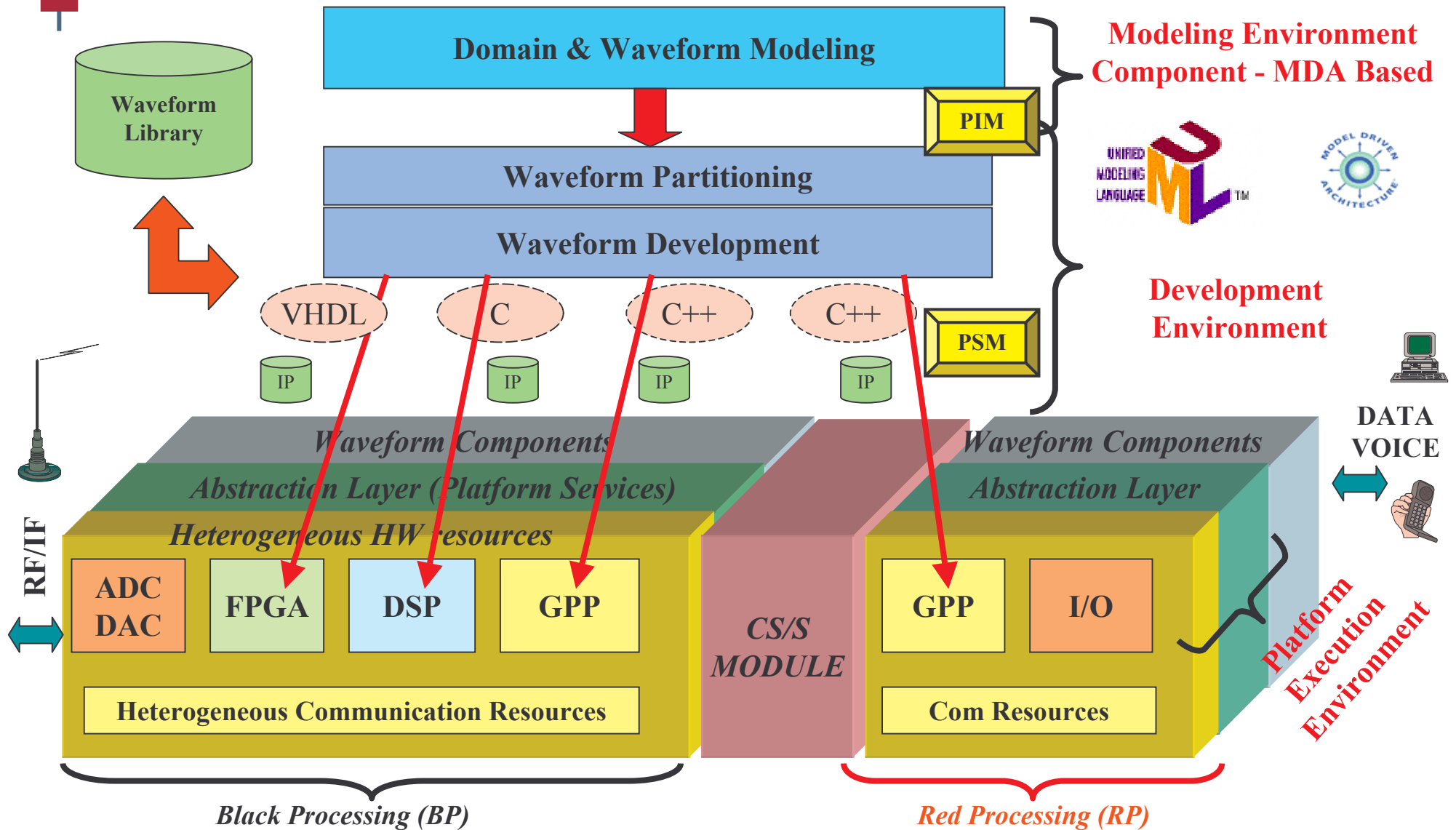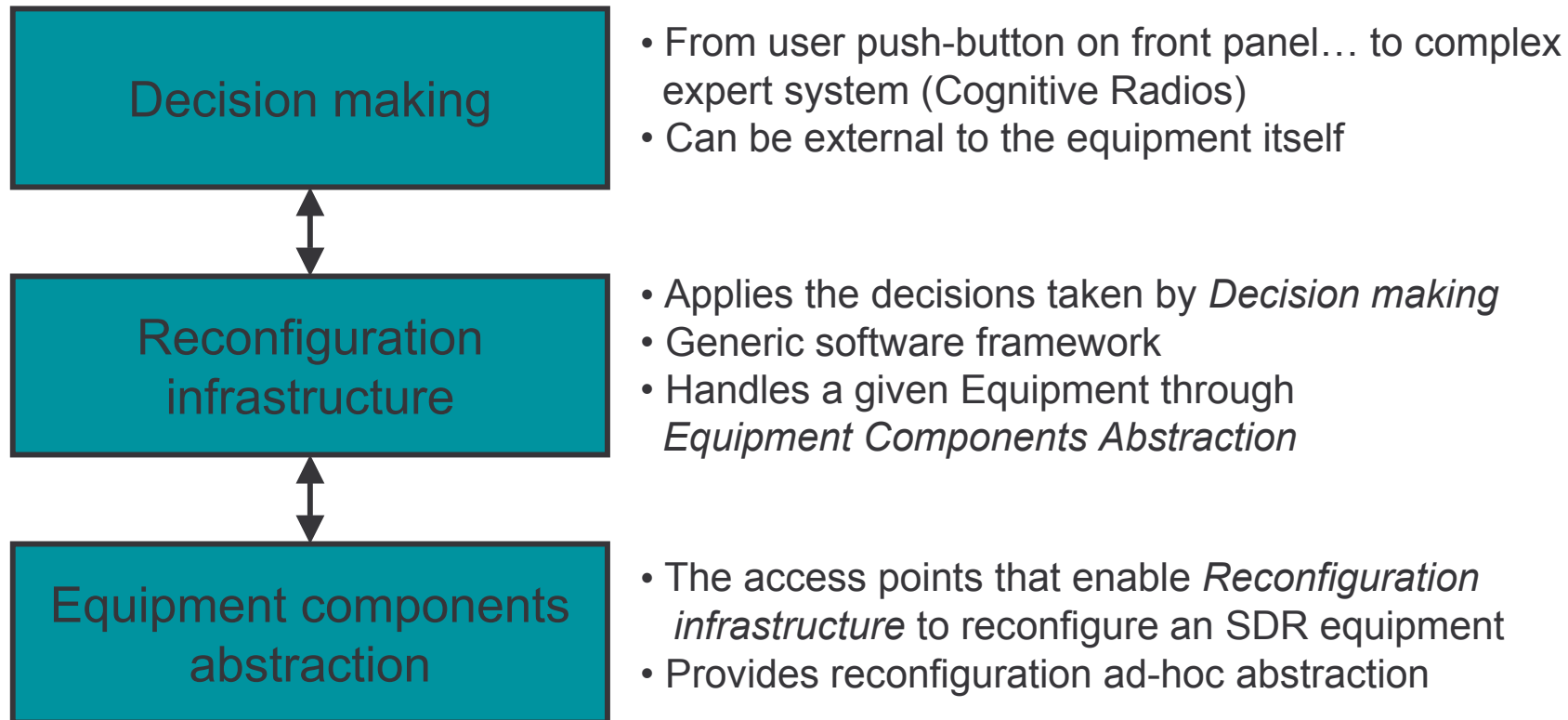WAVEFORM 1

WAVEFORM 2

Personality

Software Radio

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MMR-ADM

WF 1   WF 2   WF n

APIs

Generic Interface

Radio
HW Platform

WF Application Library

Definition of an Open Reference Architecture & Common APIs

PEA-AL

WF 1   WF 2   WF n

APIs

Abstraction 1

Radio
HW Platform 1

Abstraction 2

Radio
HW Platform 2

Family of SDR

Obsolescence / Upgrade

One "SDR Platform" accepts several Waveforms

WF Std.

Architecture Std.

Several Waveforms ported on distinct "SDR Platforms"

Radio Reconfigurability

SCA, P²SRC, …

Waveform Portability

"Operational" Requirement

"Efficiency" Requirement

SCA: Software Communications Architecture – P²SRC: PIM & PSM for Software Radio Components

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Software Radio - System Design - Separation of Concerns

Domain & Waveform Modeling

PIM

Modeling Environment Component - MDA Based

UNIFIED MODELING LANGUAGE — UML™

MODEL DRIVEN ARCHITECTURE

Waveform Partitioning

Waveform Development

Development Environment

Waveform Library

VHDL   C   C++   C++

IP   IP   IP   IP

PSM

DATA VOICE

Waveform Components

Abstraction Layer (Platform Services)   **Waveform Components**

Heterogeneous HW resources   **Abstraction Layer**

| ADC DAC | FPGA | DSP | GPP | CS/S MODULE | GPP | I/O |

Heterogeneous Communication Resources   **Com Resources**

RF/IF

Platform Execution Environment

Black Processing (BP)   **Red Processing (RP)**

Heterogeneous Processing Resources & Transfer Mechanisms

* MDA: Model Driven Architecture

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Decision making	• From user push-button on front panel… to complex expert system (Cognitive Radios) • Can be external to the equipment itself
Reconfiguration infrastructure	• Applies the decisions taken by *Decision making* • Generic software framework • Handles a given Equipment through *Equipment Components Abstraction*
Equipment components abstraction	• The access points that enable *Reconfiguration infrastructure* to reconfigure an SDR equipment • Provides reconfiguration ad-hoc abstraction

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Software Radio - Layered Reference Architecture

Component Based Design

Certified WAVEFORMS Library

XML

Services Common to Several WFs

Abstraction of Radio Hardware Behavior

Black Control Cpt

Red Control Cpt

Common Services

Modem Cpt

I/O Cpt

WAVEFORM APPLICATION COMPONENTS
National / STANAG

Radio System Integrator

Communication between Components

WF Configuration & Deployment

SCA STANDARD API

Certification Center

SCA Compliant
Operating Environment (OE)

Logical Devices Facilities

Transport ORB, OCP (COTS)

Core Framework (COTS)

Low Level Access to Hardware Resources

OS (COTS) & BSP

SOFTWARE RADIO PLATFORM
Featured for Waveform Performances

Multi-Bands HARDWARE Resources

Power Amplifier & Antenna

Universal Transceiver

RF/IF   Modem

Black Control Routing

CS/S

Red Control Bridging

I / O

BSP: Board Support Package - ORB: Object Request Broker - OS: Operating System

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SCA API = Service Definition + Transfer Mechanism

"Waveform" is an Application running on the OE infrastructure, connected with the Hardware Platform through the "Radio Devices"

- Service Definition Messages (APIs) guarantee Waveform Components can communicate between each others regardless of OE or Language (IDL)

- Transfer Mechanism encapsulates "Service Definition Messages" in a transmission format compatible with the selected OE (ORB, OCP, HAL-C,..)

- Standardized Radio Devices / Facilities APIs (*Service Definition Messages*), give access to HW features - Essential for Waveform Portability

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Demonstrators Development Phase

3rd Party WF Platform Test Software

Thales WF FM3TR HF 4285 HF 4444

DGA Customer

Thales Radio Integrator

CELAR Certification Center

Platforms Common & Open API's

Abstraction Layer

SCA Based

Abstraction Layer

SDR Platform 1 **Thales**

SDR Platform 2 **3rd Party**
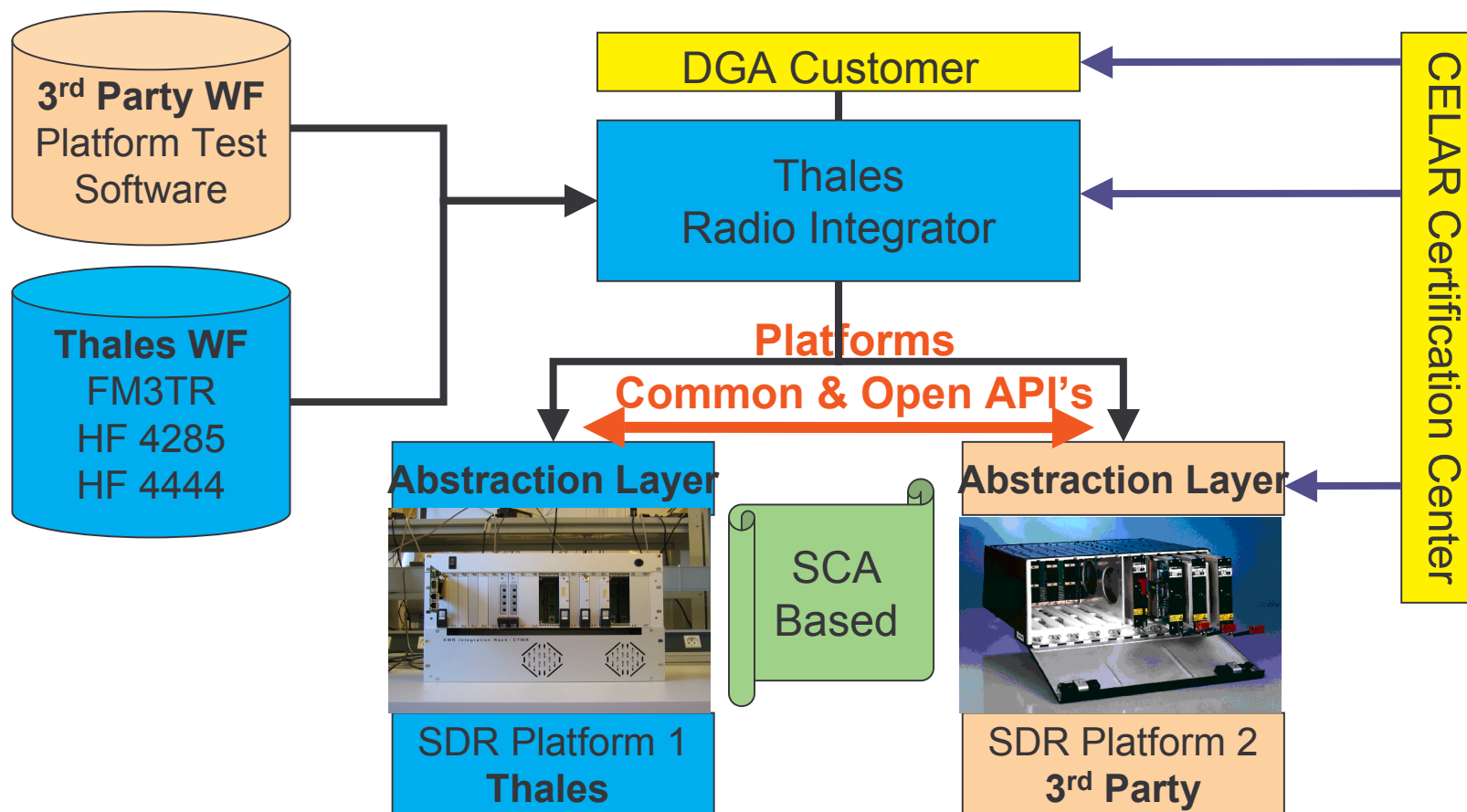
To experiment Waveform Portability between two different SDR Platforms

* PEA: Plan Etude Amont – Advanced Study Program
* DGA: Délégation Générale de l'Armement – French MoD Procurement Agency

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SCA Based Reference Architecture

Waveform Application Components

Security APIs
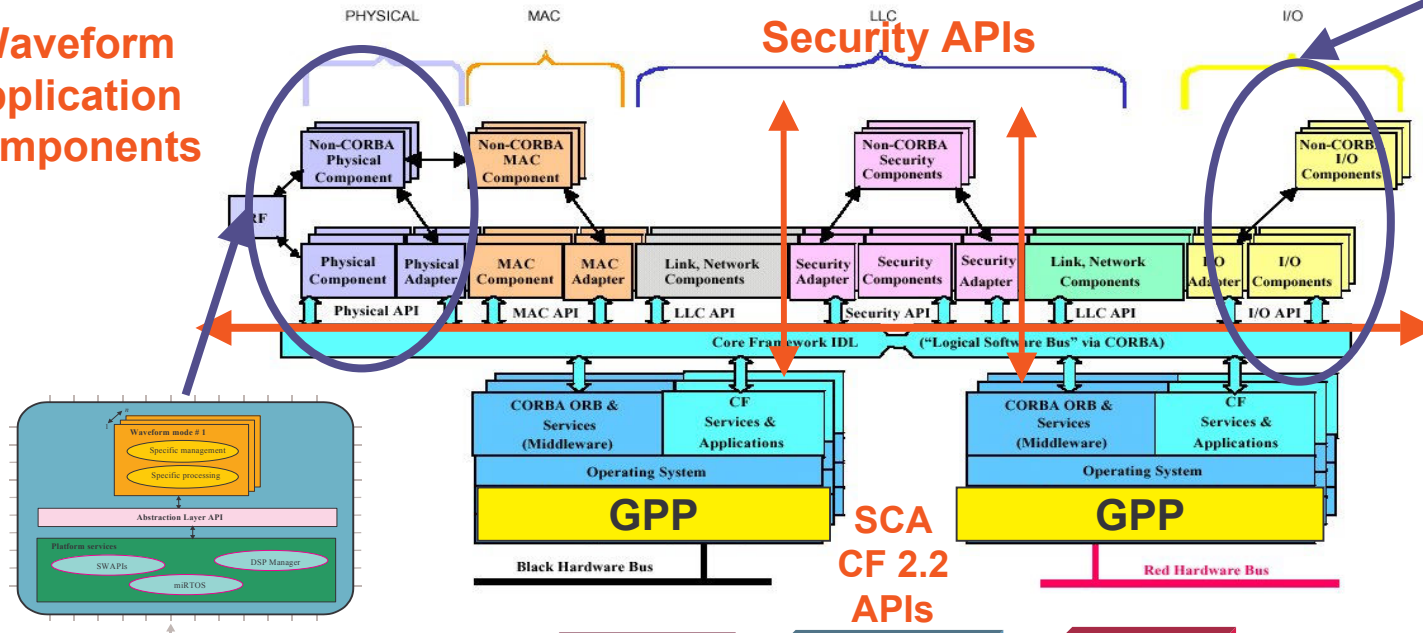
DSP OE Definition

OMG / SDRF Radio Devices API's
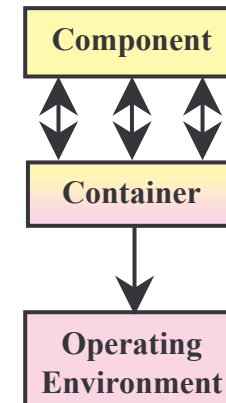
DSP OE Definition

Contribution to SCA 3.x

SCA CF 2.2 APIs

BP **CS/S** **RP**

SCA Architecture framework

SW development methodologies

SW deployment and configuration

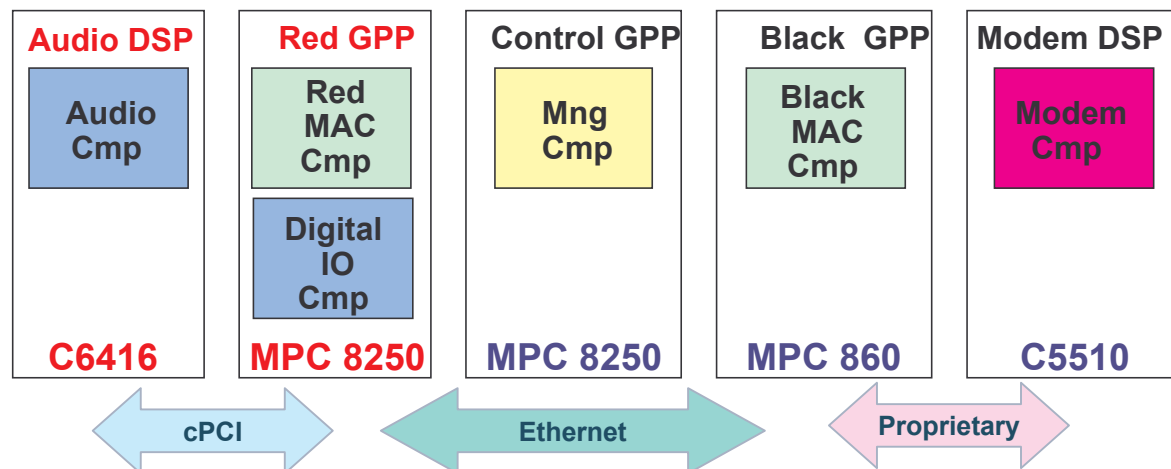*To validate SCA in front of French MoD Requirements*

Core Framework V2.2

COTS integration

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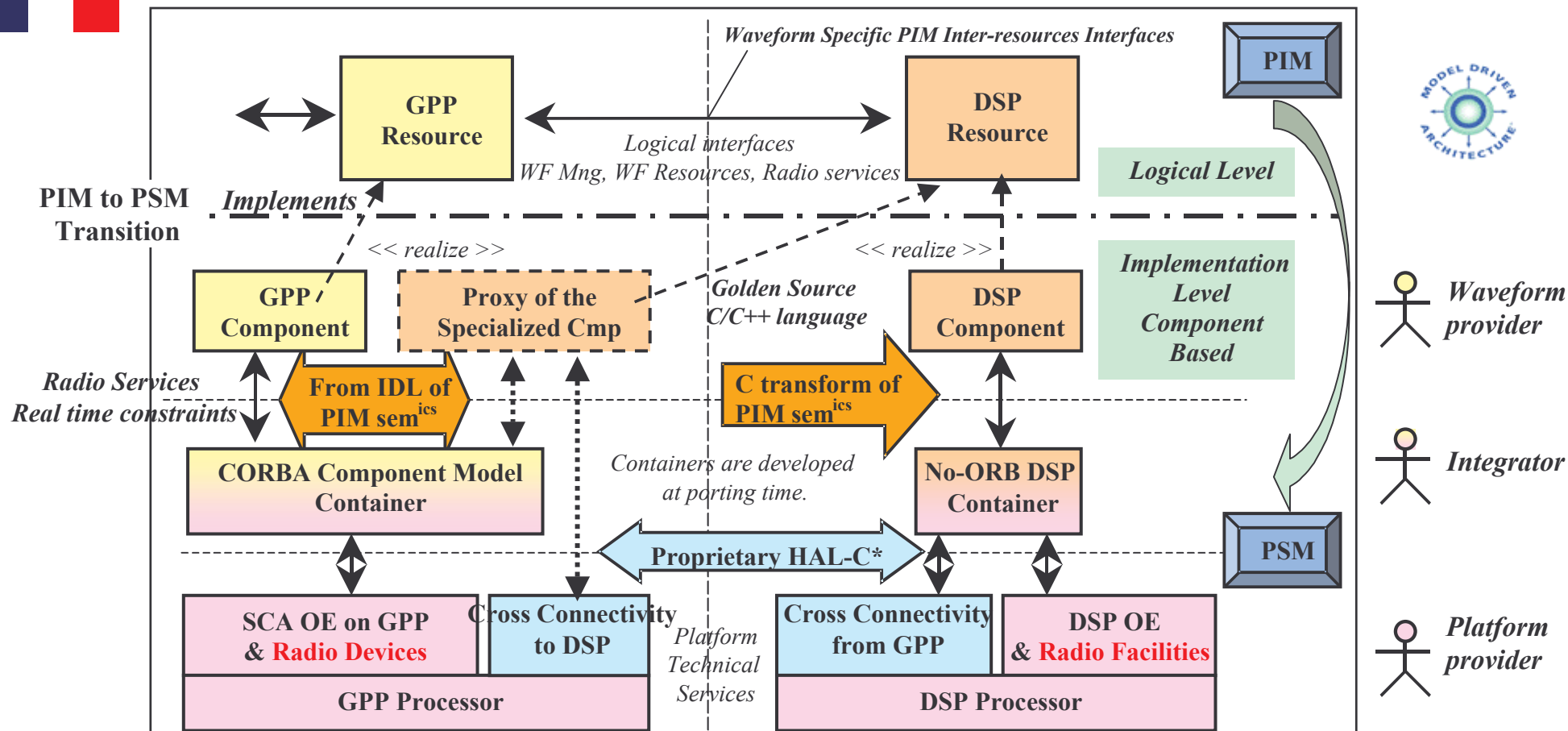
- **DSP Component : in C/C++, with PIM interfaces mapped into C++**
- **DSP OE: Based on DSP proven techniques – Small footprint – No ORB**
  - Co-localized Connectivity : Ultra-light POSIX profile - Cross-connectivity : HPI low level drivers
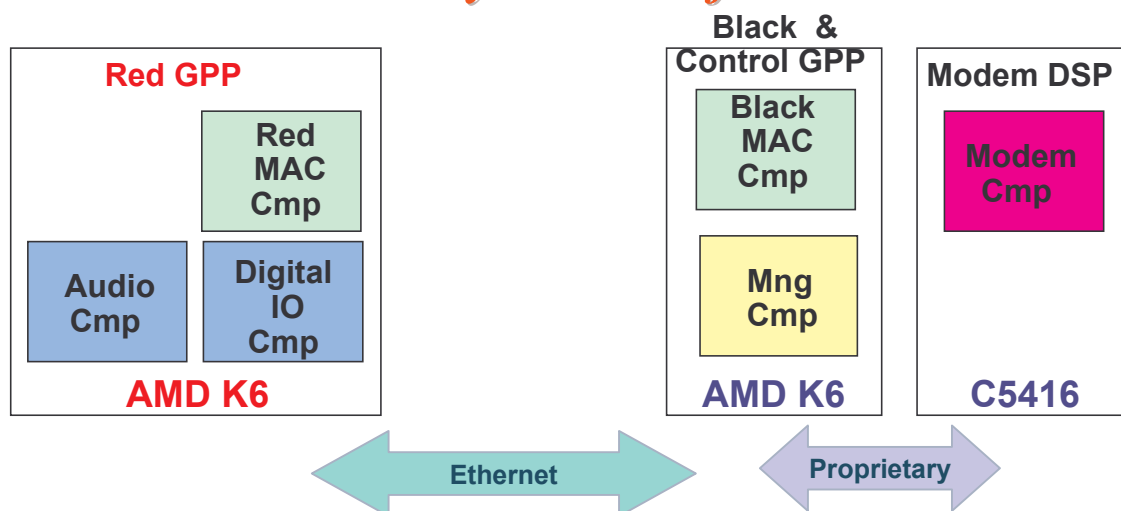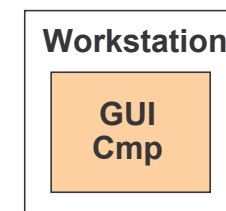- **DSP Non CORBA Container is hand-written at application porting time**
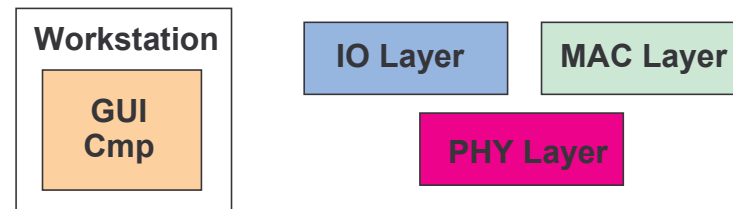
* HAL-C: Hardware Abstraction Layer - Connectivity

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Thales SDR Platform 1

Workstation
GUI Cmp

IO Layer   **MAC Layer**

PHY Layer

Audio DSP
Audio Cmp
C6416

Red GPP
Red MAC Cmp
Digital IO Cmp
MPC 8250

Control GPP
Mng Cmp
MPC 8250

Black GPP
Black MAC Cmp
MPC 860

Modem DSP
Modem Cmp
C5510

cPCI ⟷   Ethernet ⟷   Proprietary ⟷

SCA OSI Layer	Component	Processor
Physical layer	Modem	Modem DSP
MAC Layer	Black MAC	Black GPP
	Red MAC	Red GPP
I/O Layer	Audio	Audio DSP
	Digital I/O	Red GPP
Management	Management	Control GPP
	GUI	IHM (PC)

Heterogeneous Architectures / Buses Processing / Mapping

3rd Party SDR Platform 2

Red GPP
Red MAC Cmp
Audio Cmp
Digital IO Cmp
AMD K6

Black & Control GPP
Black MAC Cmp
Mng Cmp
AMD K6

Modem DSP
Modem Cmp
C5416

Ethernet ⟷   Proprietary ⟷

SCA OSI Layer	Component	Processor
Physical layer	Modem	Modem DSP
MAC Layer	Black MAC	Black Control GPP
	Red MAC	Red GPP
I/O Layer	Audio	Red GPP
	Digital I/O	Red GPP
Management	Management	Black Control GPP
	GUI	IHM (PC)

Workstation
GUI Cmp

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Thales SDR Platform 1 – Software Architecture

Logical Devices

Facilities

HAL Connectivity

Security

OE

Waveform

Control GPP

GPP Device

Domain Manager

File Manager

ORB

Application Factory

File System

WF Mng Components

File

Application

Naming Service

Event Service

OS

Device Manager

Log Service

GUI

Modem DSP

Transceiver Facility

WF Modem Components

HAL Modem Connectivity

Audio DSP

AudioACR Facility

WF Audio Components

HAL Audio Connectivity

Black GPP

FPGA Device

ORB

Device Manager

GPP Device

WF Black Components

Black Crypto Device

Modem Device

Transceiver Device

OS

File System

File

CS/S

Red GPP

Device Manager

ORB

Serial IO Device

Red Crypto Device

WF Red Components

GPP Device

File System

Audio Device

File

OS

AudioACR Device

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SCA – Software Communications Architecture

- Initial Specification (SCA 2.2) addresses GPP based OE - **Implemented Worldwide**
  - Interleaved PIM & CORBA-based PSM
- Evolution to DSP & FPGA (SCA 3.x): Specialized Hardware Supplement (SHS)
  - Maturation in process - **Currently Demonstrated** - SDR Forum '05 Technical Conference
- **Industry is structuring to improve the offer – 3rd Parties : OE & WF Providers**

P²SRC - "PIM & PSM for Software Radio Components" (OMG - SBC DTF)

- Extension of SCA concepts – MDA based
  - "Platform Independent Model" (PIM) of SDR – **Abstract Model**
  - "Platform Specific Model" – Currently CORBA-based PSM – Other Possible
- **Initial Implementations claimed to be in process**

EC 6th FP – End to End Reconfigurability (E2R) Program

- **E2R Phase 1 ('04-'05) - Architecture Phase - Extension of above concepts**
  - Configuration Management Module (CMM)
  - Configuration Control Module (CCM)
  - Execution Environments (EE)
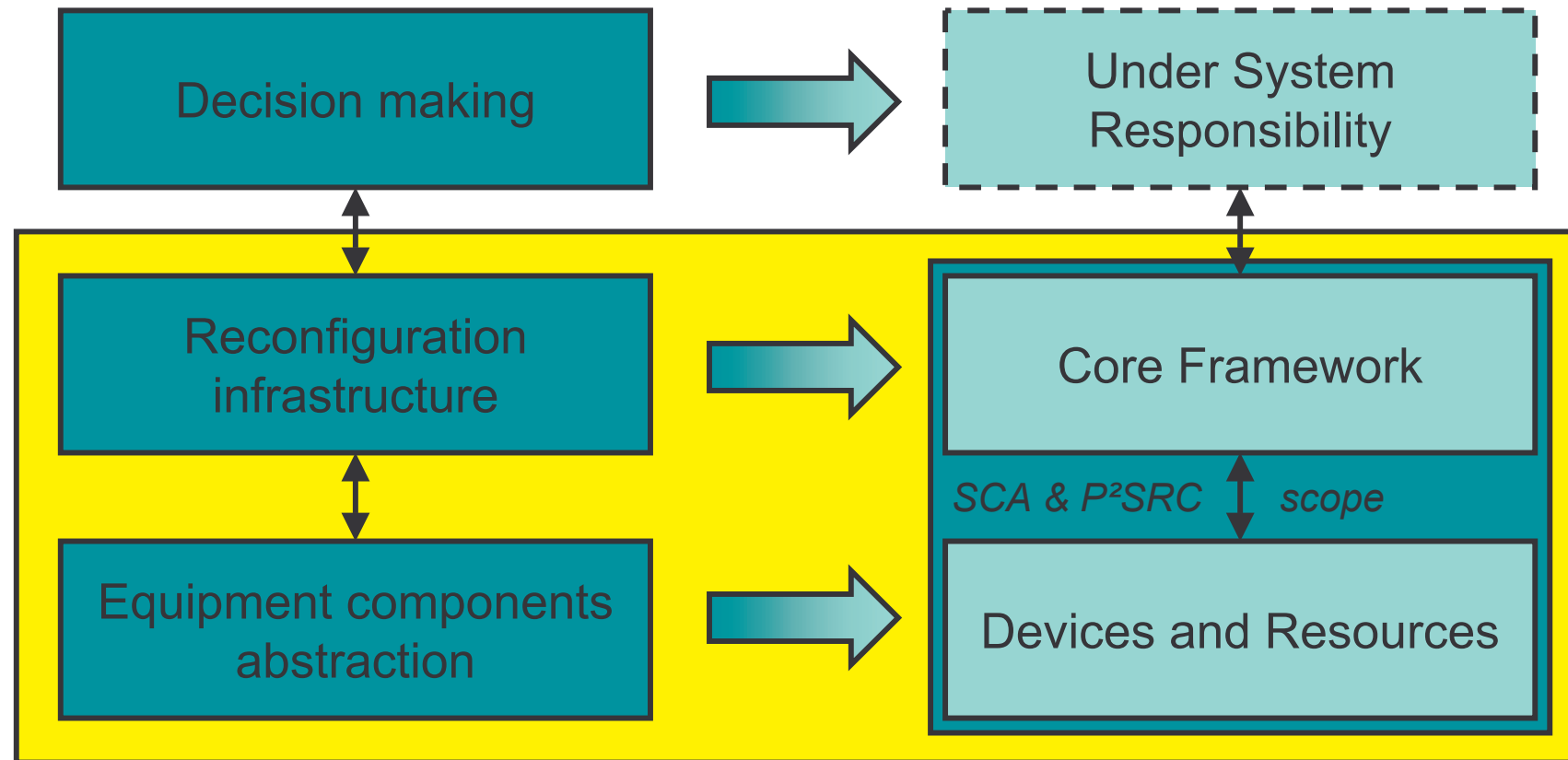- **E2R Phase 2 ('06-'07) - Maturation & Initial Implementations planned**

  * SBC: Software Based Communications   **THALES**
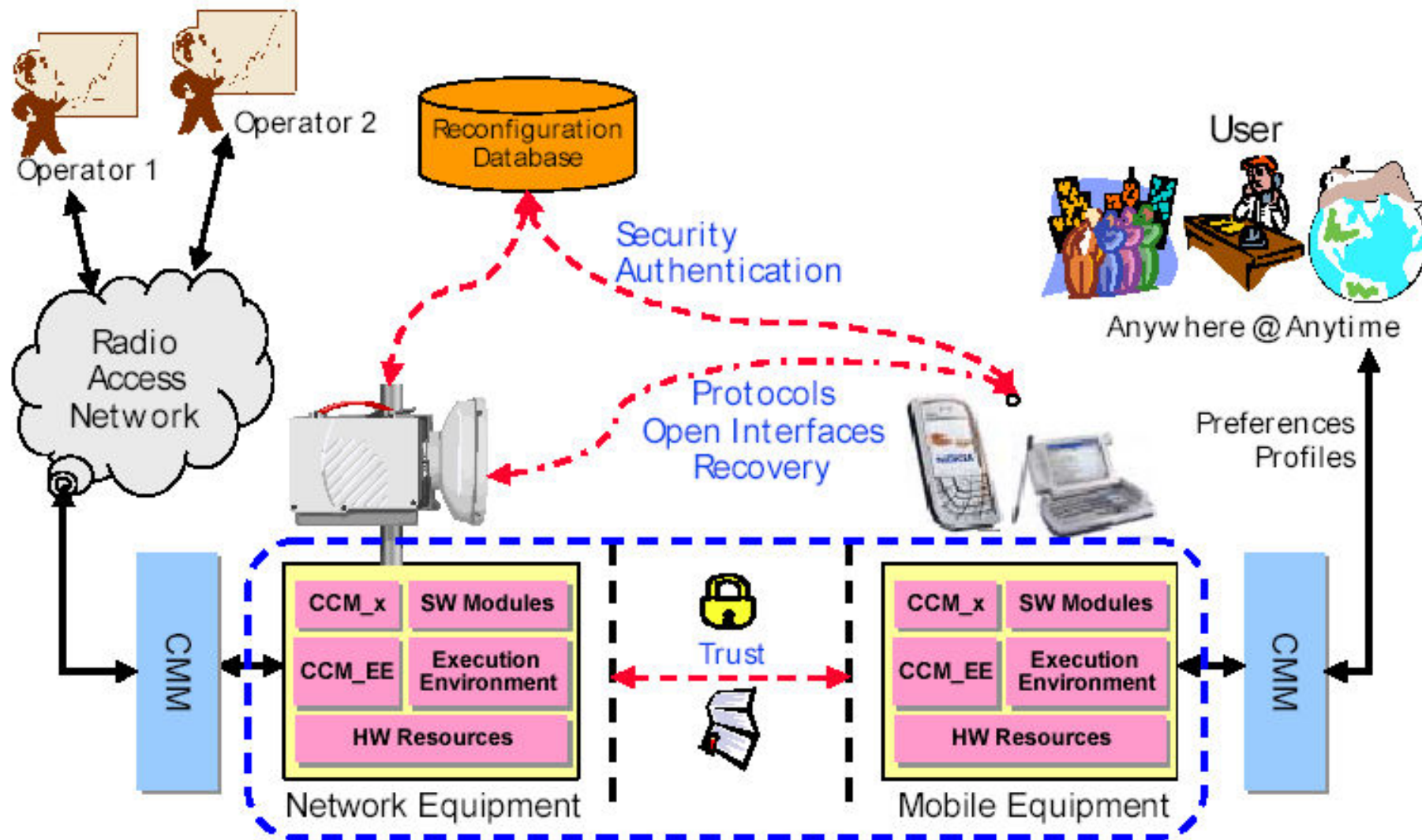
* Source: E2R & P²SRC: Some fruitful research opportunities ? – OMG SBC Workshop – August '05
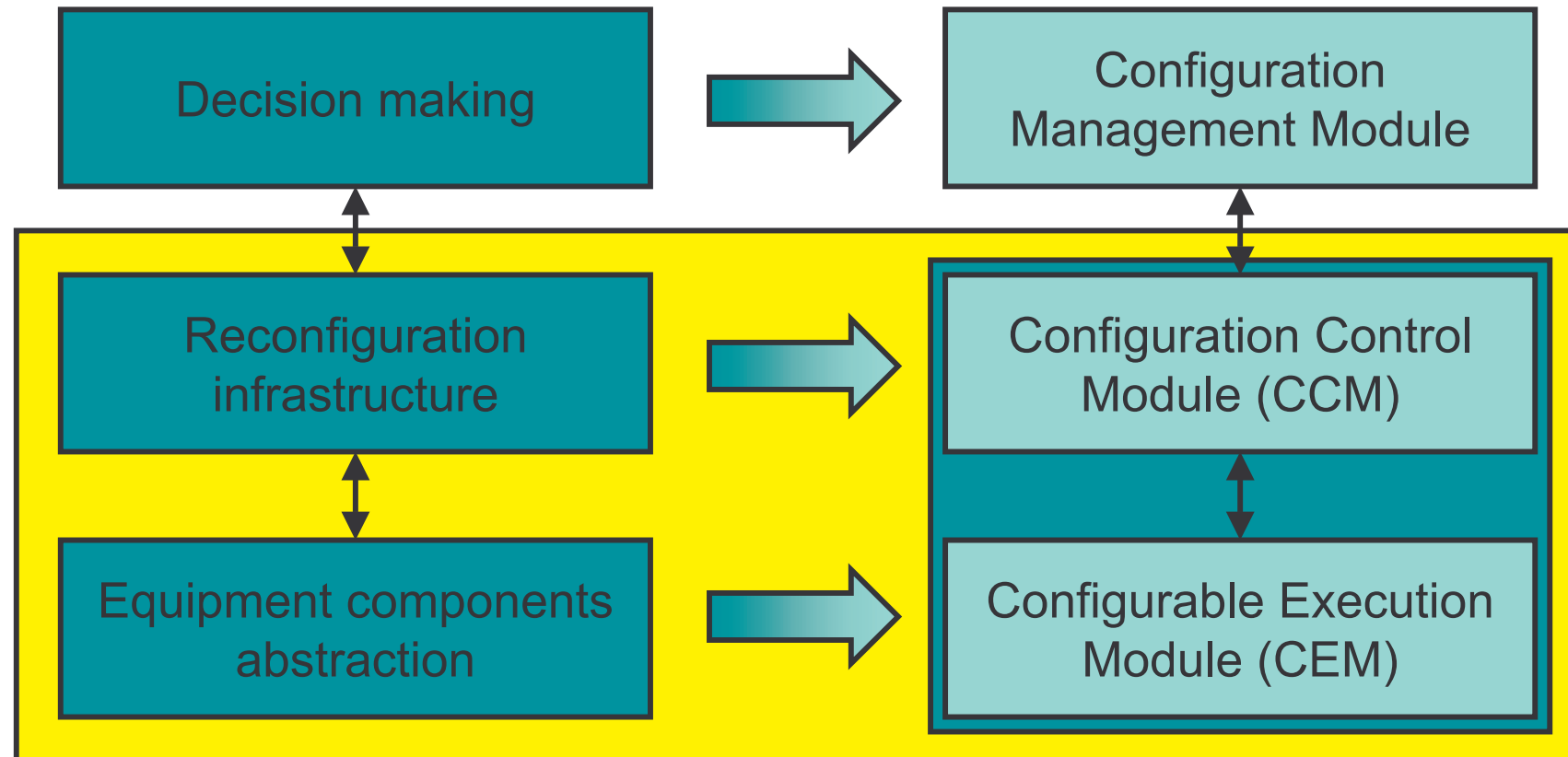
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SCA & P²SRC Frameworks

« The CF interacts with Devices and Resources to enable deployment and configuration of Waveform Applications »

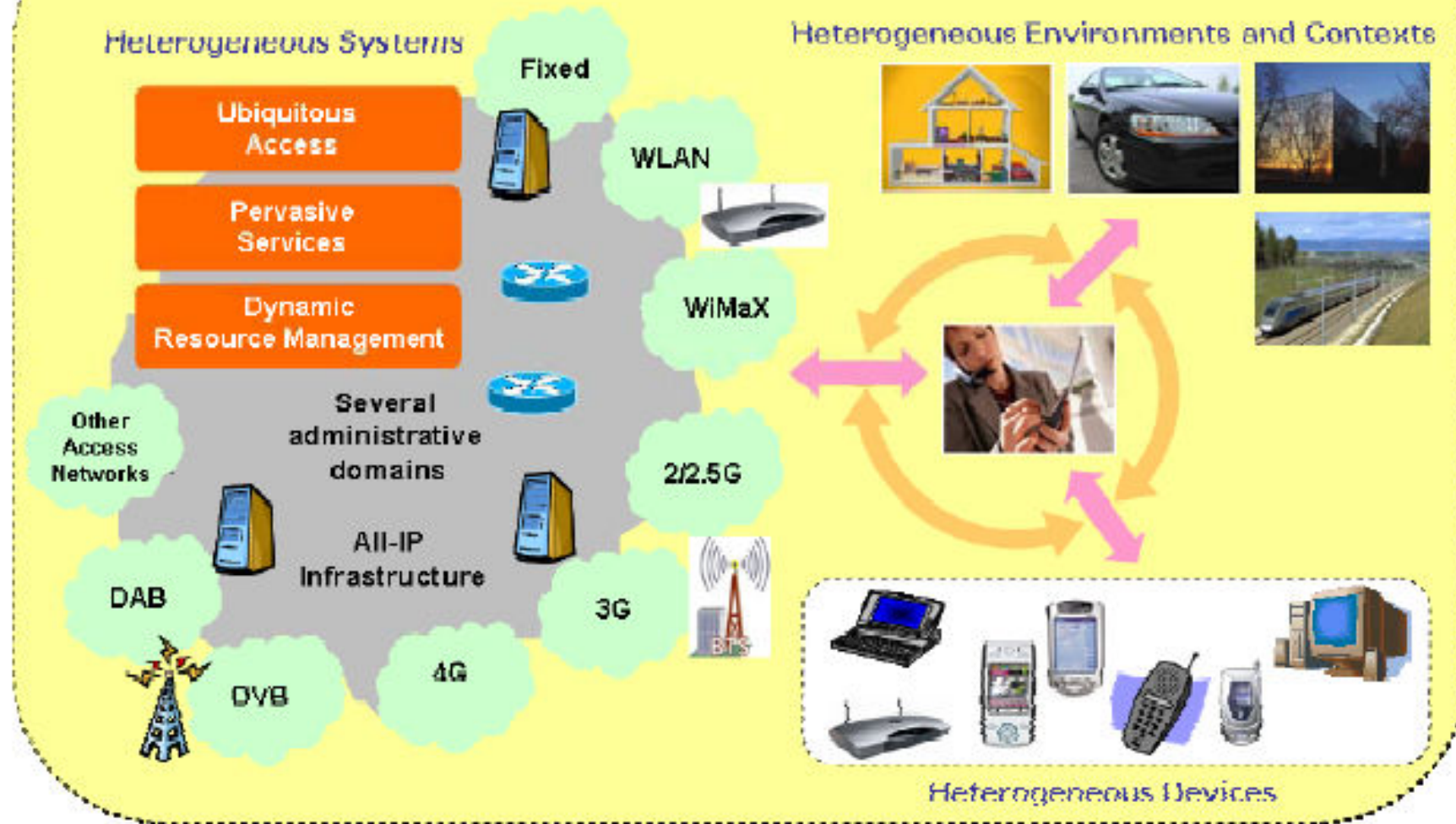**SCA : Currently Implemented - OMG P²SRC: In Development**

End-to-End Reconfigurability: Enabler of the Seamless Experience

From Low (2G) / Medium (2,5 G) to High Data Rates (3G, WiMax,…) & IP Services

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Supports Interoperability

Multifunctional Platform

Standard Architecture (SCA) & certification

Waveform Portability

WF Library

Radio
B

Radio
A

Radio
C

Waveform „STANAG"

Exchange of WF

Procurement Policy

Security Evaluation

Military Operational Requirements (MOR)
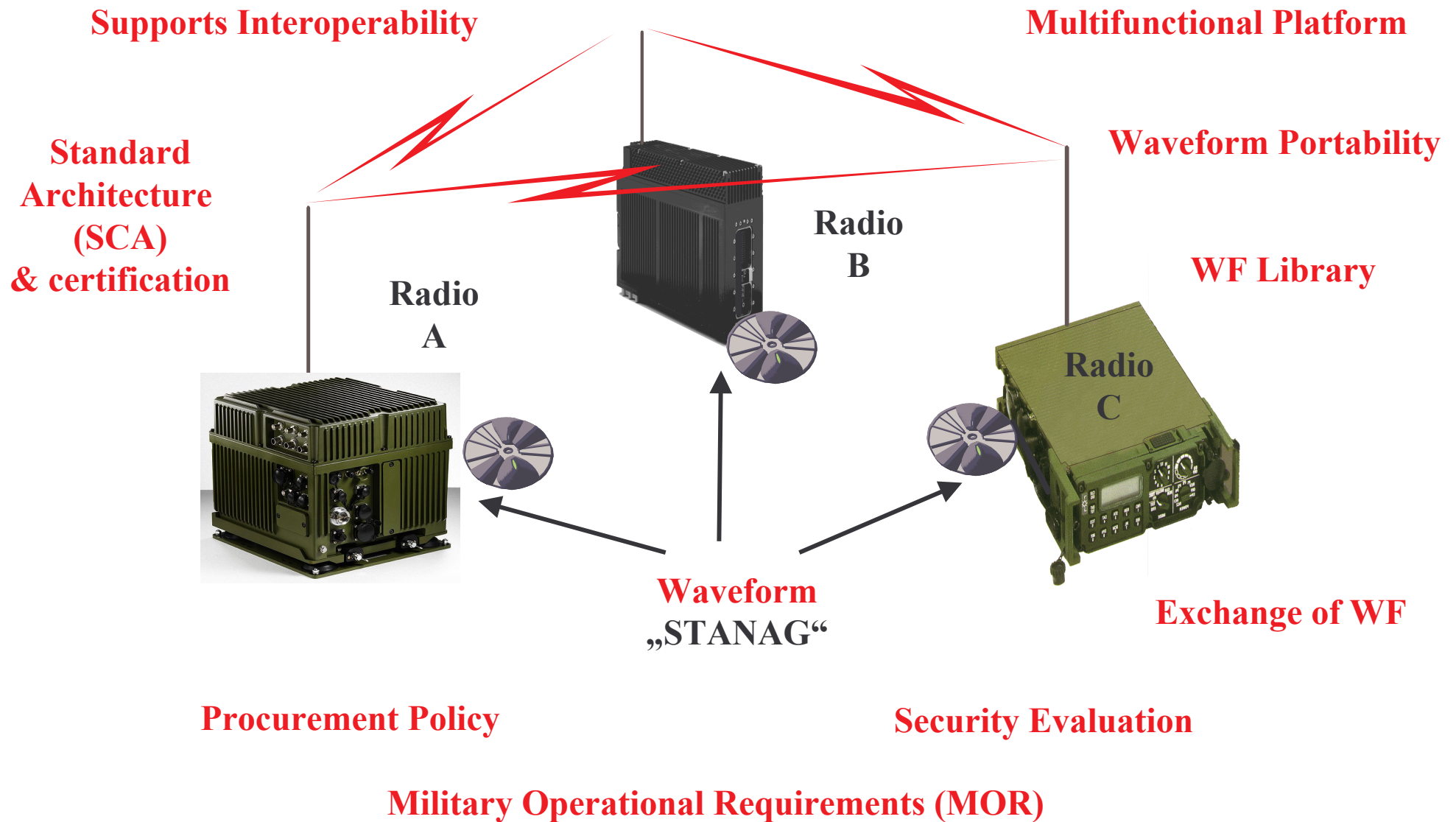
SDR Architectural Frameworks are currently Implemented, Matured & Improved and are raising a Worldwide Interest

- SCA 2.2 => SCA 3.1 (SHS) => P²SRC => E2R Frameworks
- **3rd Parties COTS Vendors are structuring to improve the offer: OE, Tools & Waveforms**

Certification & Radio System Integrator are key roles in the SDR process

Thales is currently demonstrating the ability to port different waveforms on different SCA compliant SDR Platforms (DGA "Software Radio Architecture" PEA)

Thales is largely involved in the SDR Frameworks Maturation & Standardization Processes: SDR Forum, OMG, E2R, … A3S

- Development of an Hardware Abstraction Layer (HAL) for DSP which exhibits Small Footprint and Open Interfaces - Submitted to standardization – SCA CP 278
- Refinement & validation of some critical SCA *Radio Devices* & HAL *Facilities* APIs -Transceiver APIs submitted to standardization – OMG Digital IF RFP & SCA CP 277

To achieve Waveform Portability, it is recommended

- **To implement a Design Methodology based on the OMG's MDA approach**
- **To use a complete suite of tools providing SDR Platform & Waveform validation**

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Questions ?

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