Make CIP Safety Your Safety Protocol

Lechler, Schlechtendahl, Leurs, Verl
Institute for Control Engineering of Machine Tools and Manufacturing Units (ISW)
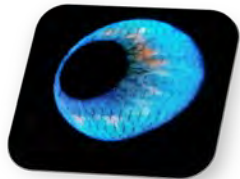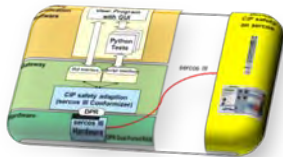University Stuttgart
and
Bosch Rexroth

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▶ Using CIP Safety as Safety Protocol for a fieldbus

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Content

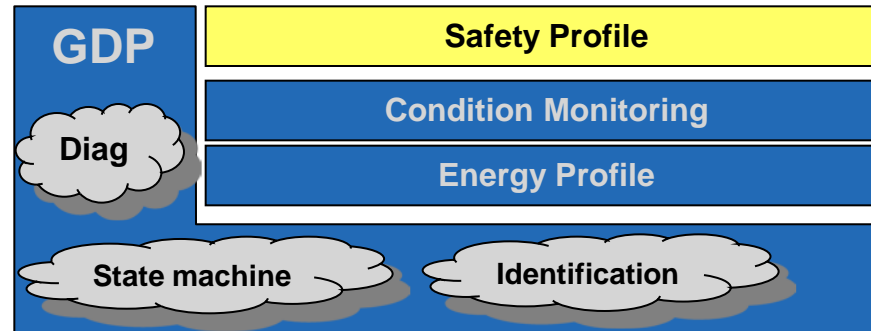- **Introduction into sercos III**

- **Specification enhancement**

- **Concept validation**
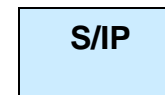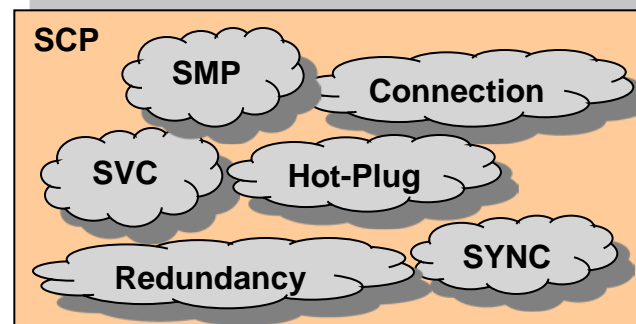
- **Conformance testing**

- **Summary + Conclusion**

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basics – sercos III

Function Specific Profiles

FSP Drive	FSP IO	FSP Encoder	FSP …

Generic Device Profile

GDP

Diag

Safety Profile

Condition Monitoring

Energy Profile

State machine

Identification

Standard IP Applications

sercos communication profile

SCP

SMP

Connection

SVC

Hot-Plug

Redundancy

SYNC

S/IP

UDP/TCP

IP

Ethernet

Hardware 100 Mbit/s

SERCON100 Master or SERCON100 Slave Ethernet Dual PHY

or

netX with core of sercos Master or sercos Slave

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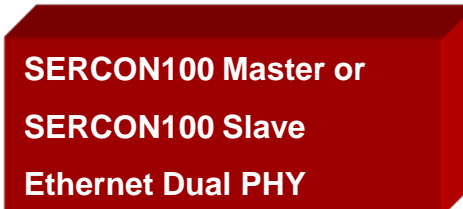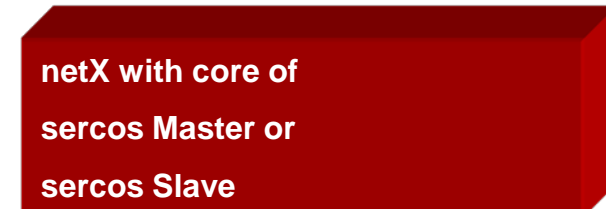
sercos III – important facts

sercos III:

▶ Master – Slave design

▶ Connection orientated

▶ Unified Communication Channel

▶ Ring or Line Topology

▶ Support of different Profiles (e.g. I/O, Drive, Energy, Safety)

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sercos communication

Master

Application Application

P C P C

Connection in AT

Connection in MDT

Communication

Connection in AT

C P P

Application App

Slave

C C P

App Application

Slave

P = Producer
C = Consumer
red = Connection
green = transmitted data

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sercos – general problems

sercos is designed to...

▶ really hard real-time,

▶ high precision synchronization with minimal jitter

▶ and high band width.

lack of following features

▶ Fully application-controlled transmission in a time pattern uncoupled from the transmission layer

▶ Flexible multiplexing and fragmenting of data for optimum utilization of the specified band width

▶ Transmission of non-cyclical messages of variable length.

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sercos messaging protocol (SMP)

Applications layer

(CIP Safety, …)

SERCOS session layer

- Point-to-point connections
- Management of logical connections between two endpoints

SERCOS transport layer

- Definition of transport containers
- Decoupling from SERCOS timing
- Fragmentation

SERCOS Messaging Protocol (SMP)

SERCOS data link layer

- Service channel services
- Hotplug services
- Real time services

SERCOS II physical layer

SERCOS III physical layer

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SMP Tasks

▶ Manage Session (ID + Priority), New Data Toggle (NDT), Last and First of Sequence Bit, Session Counter

▶ Split and rebuild message

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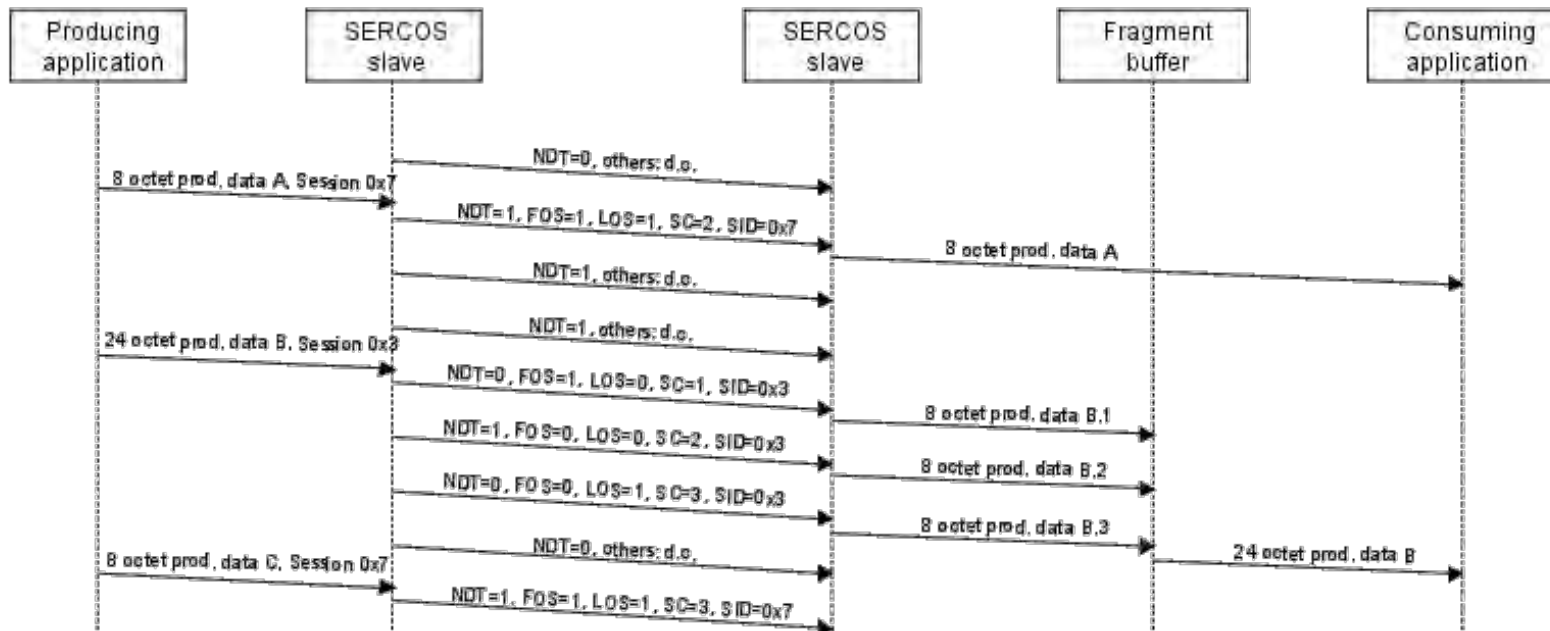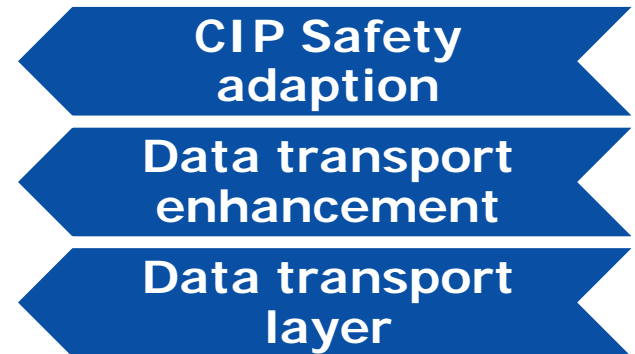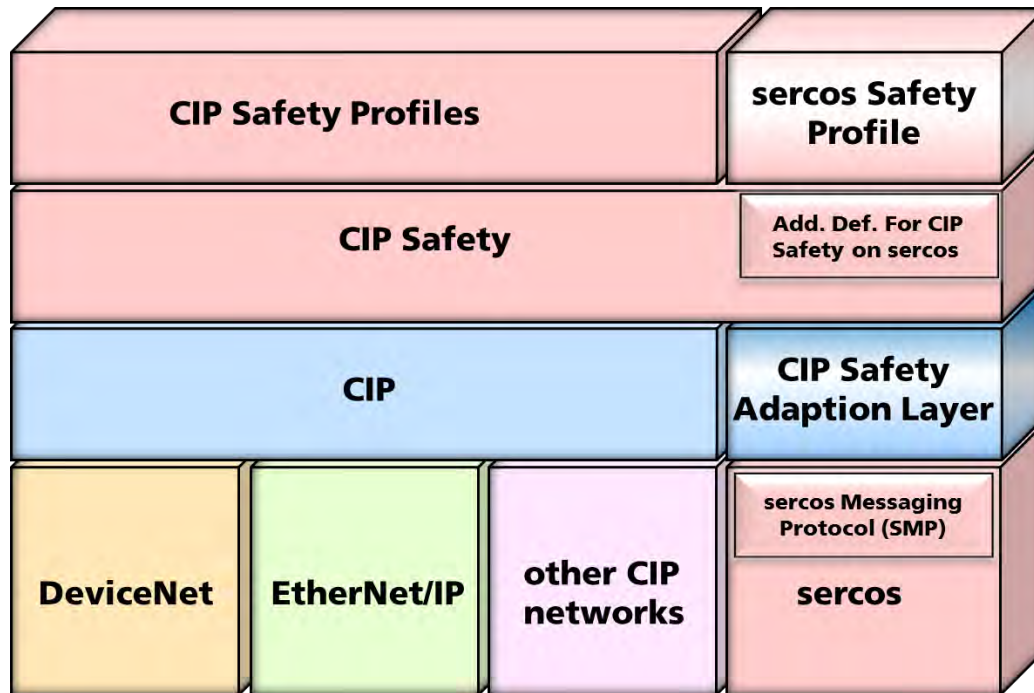
Motivation

▶ sercos does not support the Common Industrial Protocol (CIP)

▶ adoption of CIP Safety as a safety layer for sercos devices raises the need for an adaptation layer that implements a basic set of CIP services and objects
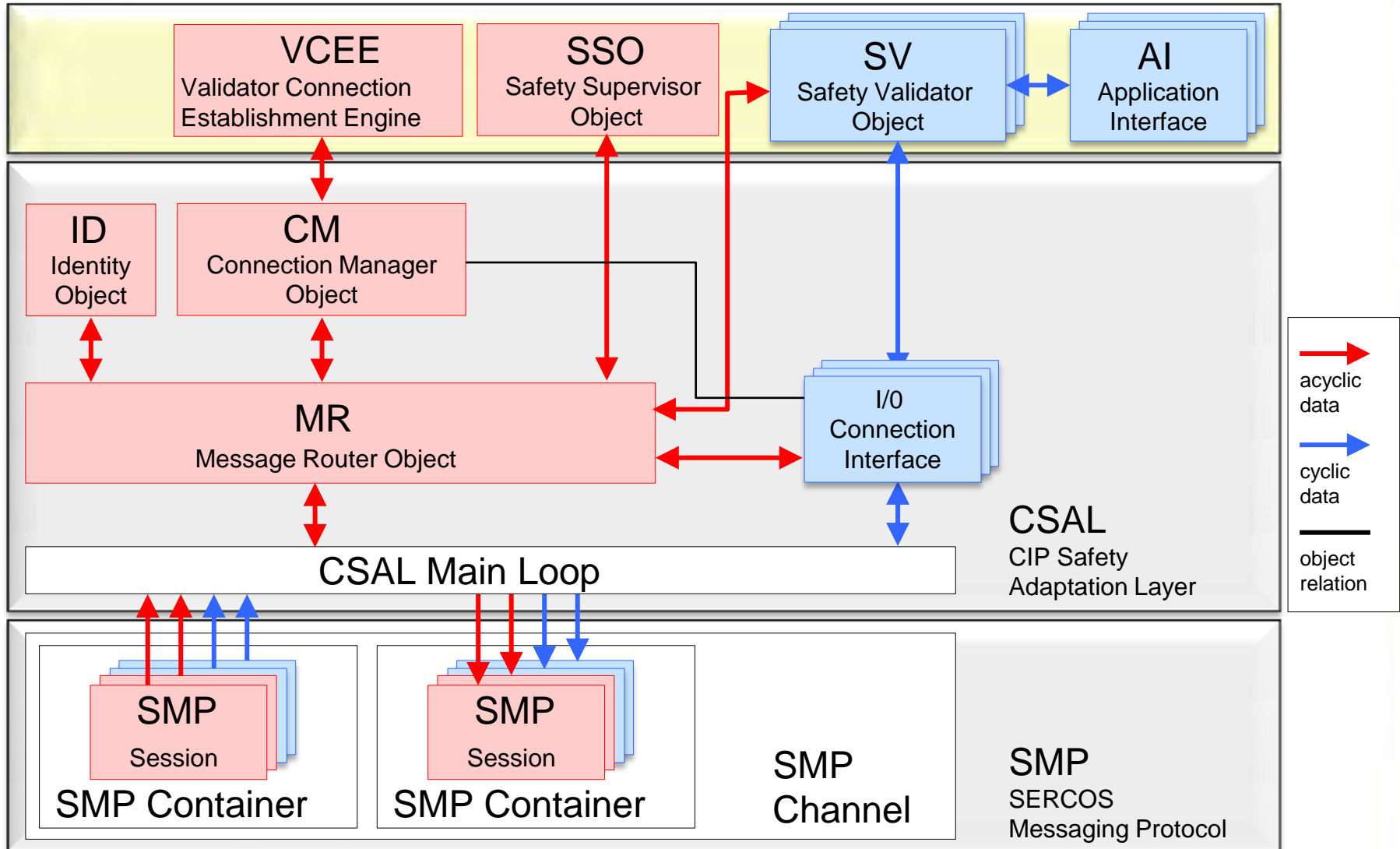
Note:

CIP Safety Adaption layer is not part of the safety protocol itself ➜ black channel

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CIP Safety Adaption Layer

Services and Objects

▶ Identity Object (Get Attribute Single)

▶ Connection Manage Object (Forward Open and Close)

▶ Connection Configuration Object (Get/Set Attributes All, Create & Delete, Get/Set Attribute Single, Open/Close Connection, Stop Connection, Get Status)

▶ Message Route Object (no service, task to distribute incoming explicit messages)

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CIP Safety Adaption Layer

VCEE — Validator Connection Establishment Engine

SSO — Safety Supervisor Object

SV — Safety Validator Object

AI — Application Interface

ID — Identity Object

CM — Connection Manager Object

MR — Message Router Object

I/0 Connection Interface

CSAL Main Loop

CSAL — CIP Safety Adaptation Layer

SMP Session — SMP Container

SMP Session — SMP Container

SMP Channel

SMP — SERCOS Messaging Protocol

Legend:
- acyclic data (red arrow)
- cyclic data (blue arrow)
- object relation (black line)

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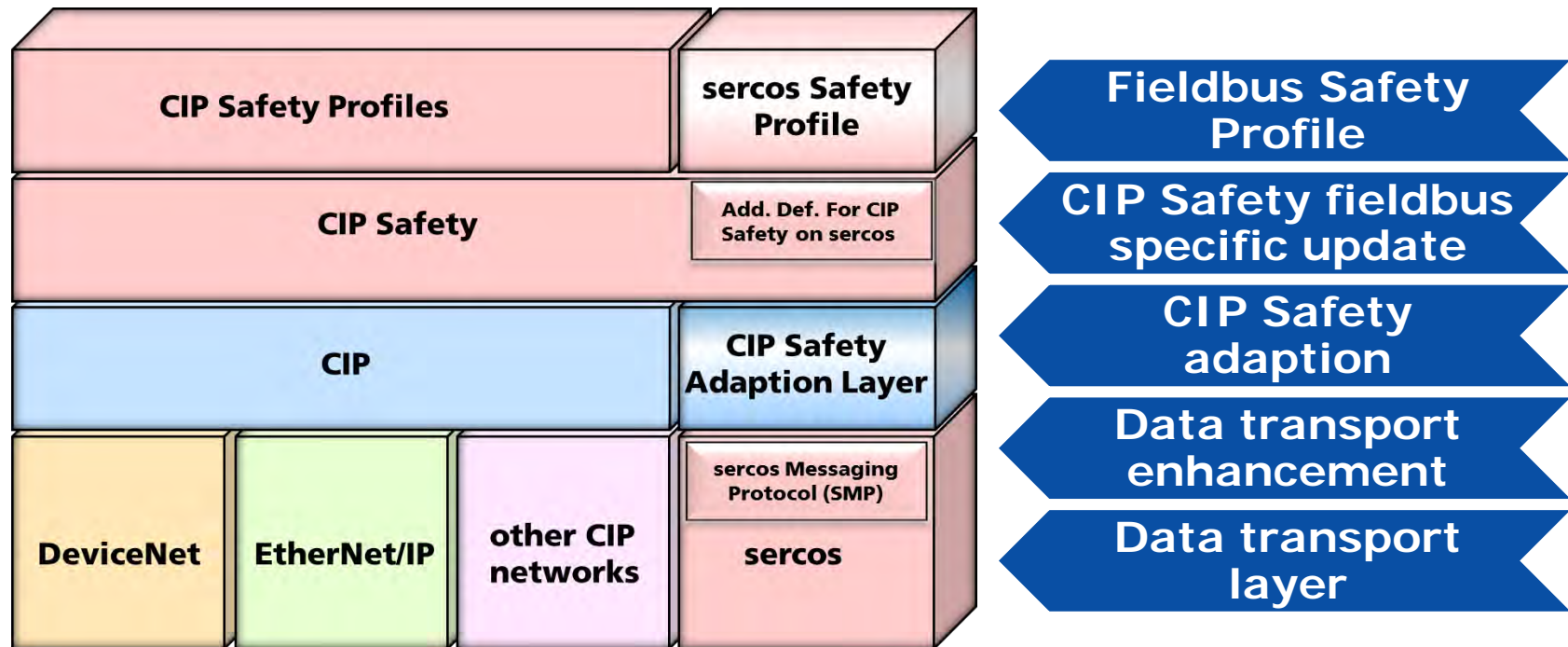All rights reserved.

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Adaption of CIP Safety

Add Requirements to Volume 5:

▶ Transport layer information (➜ Sercos Messaging Protocol)

▶ Adaption layer description (➜ CIP Safety on sercos Adaption Layer)

▶ CIP Safety and sercos device model

▶ Mechanism for Unique Node ID (UNID) assignment

➜ In total 12 pages

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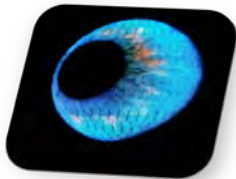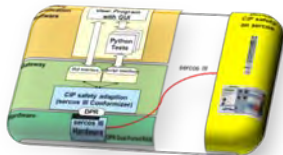All rights reserved.

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Fieldbus Safety Profile

Additional Safety Profiles

▶ Possibility to add additional Safety Profiles to fieldbus specification

▶ Profiles are located on top of CIP Safety

Preferred way:

▶ Specify a common profile with ODVA (e.g. safe motion profile)

▶ Advantage is the common usability of profile over fieldbus boundaries

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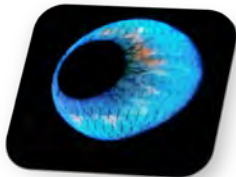All rights reserved.

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Validation by TÜV

▶ No need to recertify Safety Protocol

▶ Only sercos specific extension have to be approved ➜ done through cyclic review of new Volume 5 by TÜV & BGIA

▶ TÜV does not care about black channel (CIP Safety Adaption Layer, sercos Messaging Protocol, sercos Communication)

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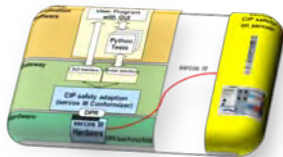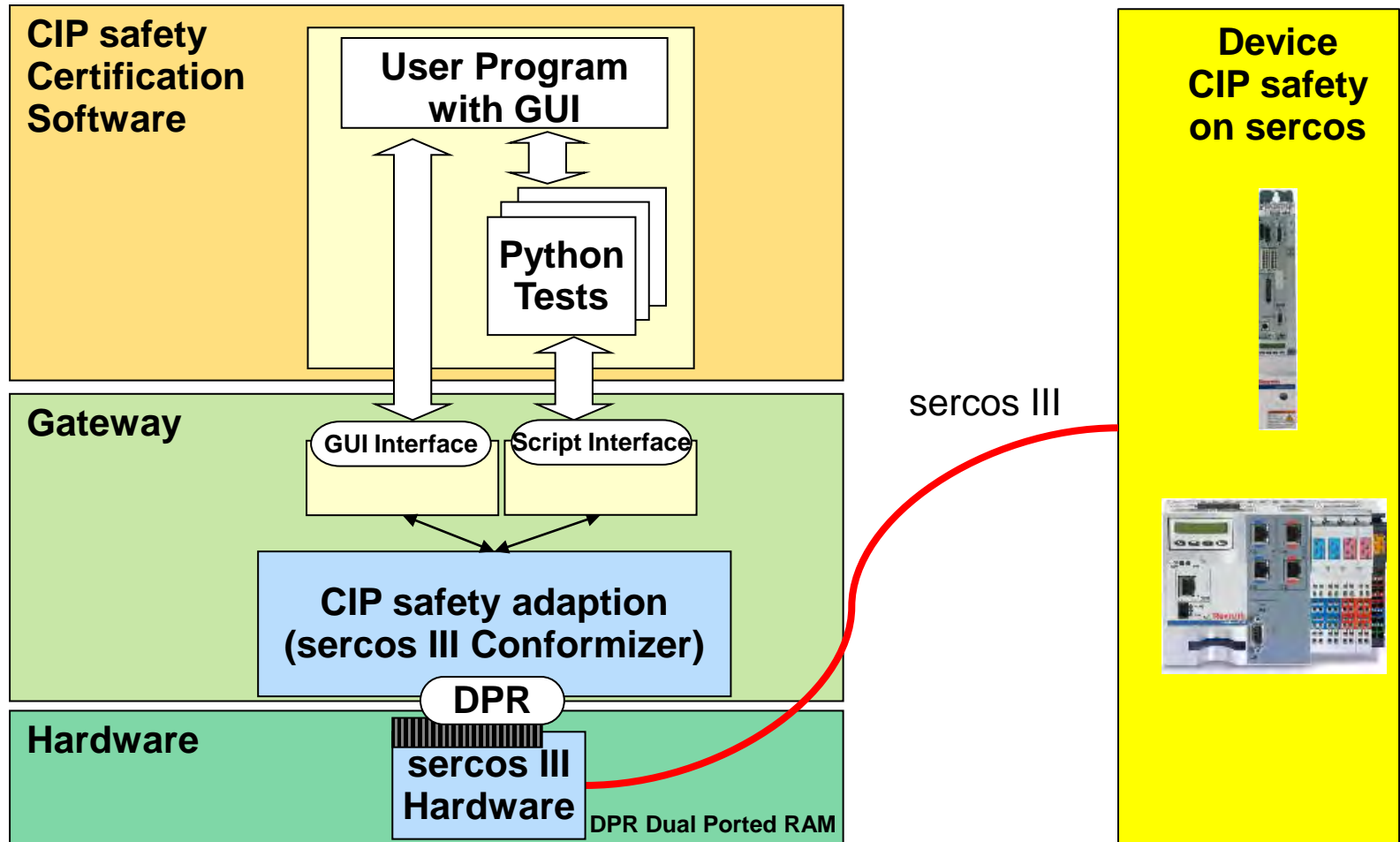All rights reserved.

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Topology Considerations

Topology sercos:

▶ Master

▶ Slave

Topology CIP Safety

▶ Originator

▶ Target

➔ **In total 4 combinations**

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Hardware Architecture

sercos slave solution:

▶ Using active sercos master PCI card

▶ Certification of Originator and Target located on sercos Slave

Windows XP mit PCI Port

CIP safety Certification Software

DPR

sercos Master

Sercos III

sercos Slave & CIP Safety Target / CIP Safety Originator

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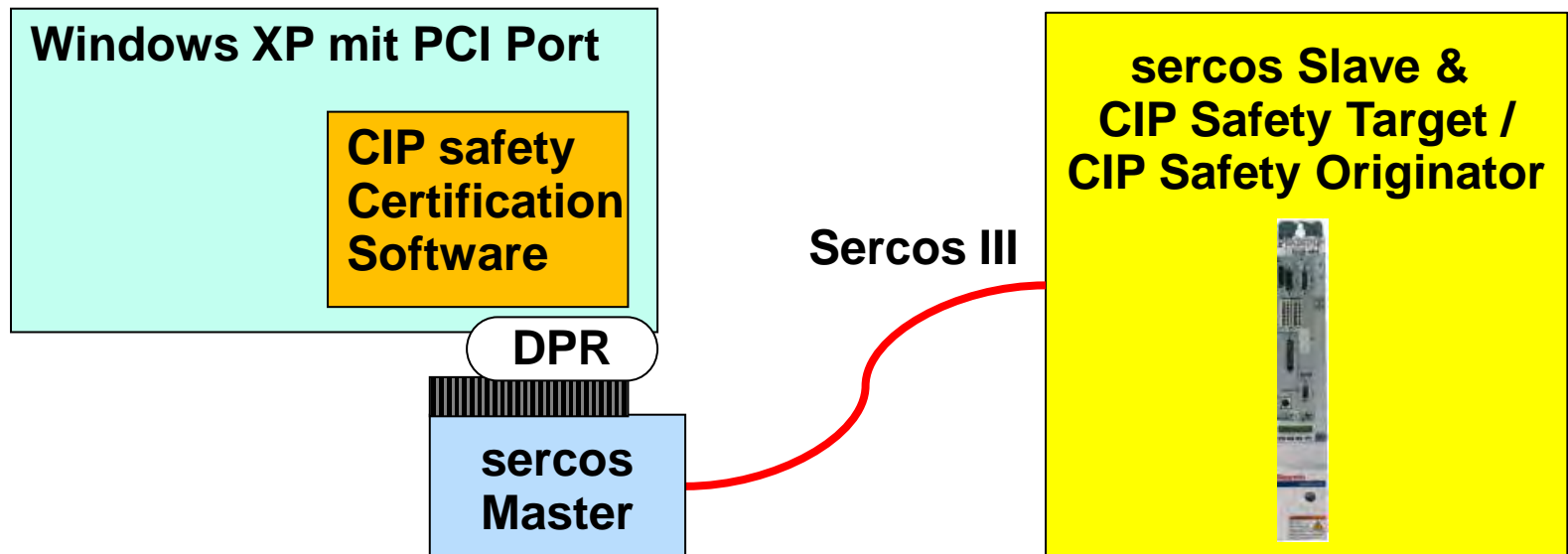
Hardware Architecture

sercos master solution:
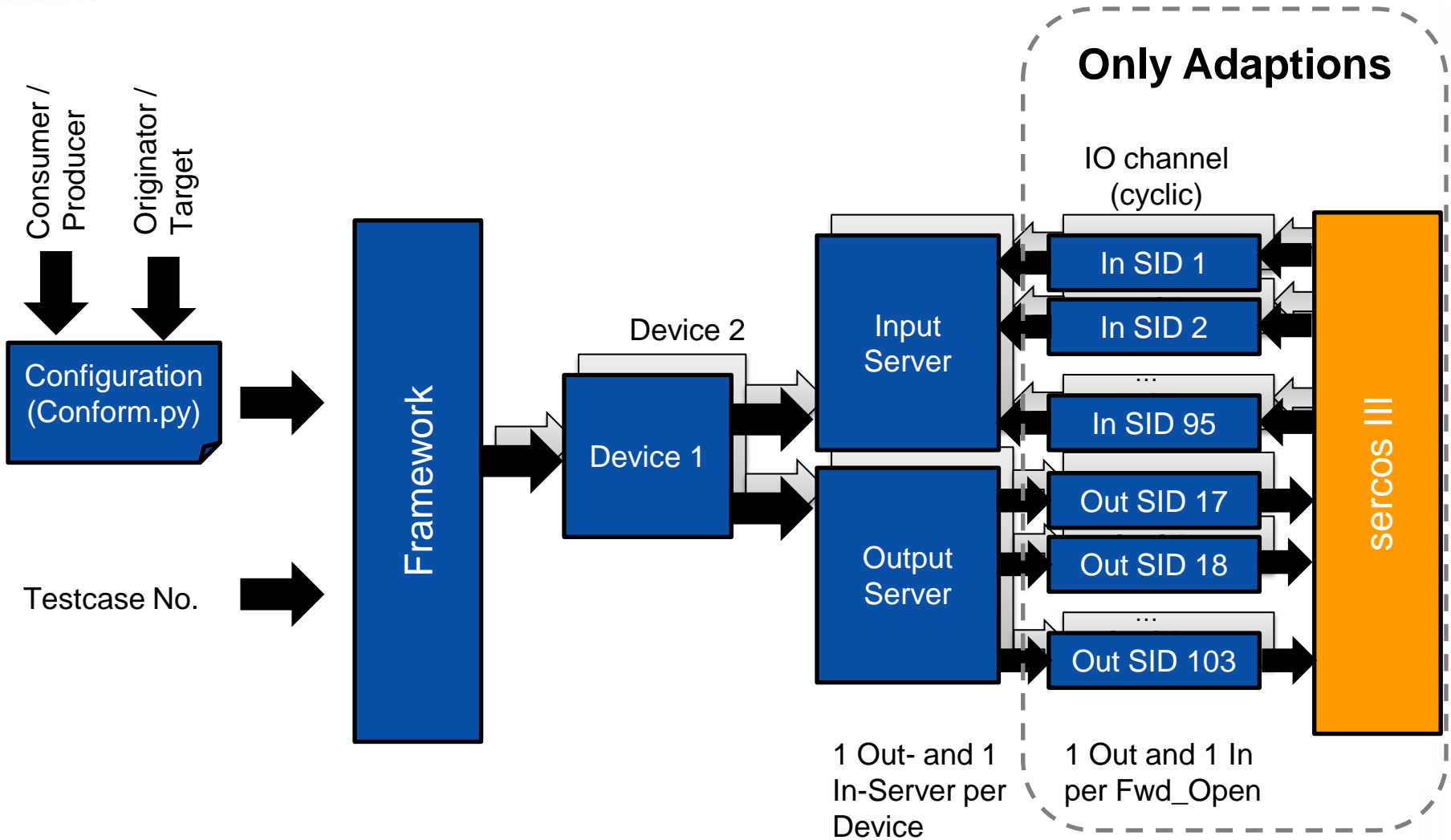
▶ Using passive sercos slave PCI card

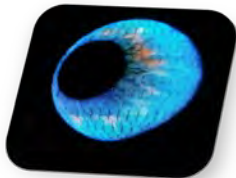▶ Certification of Originator and Target located on sercos Master

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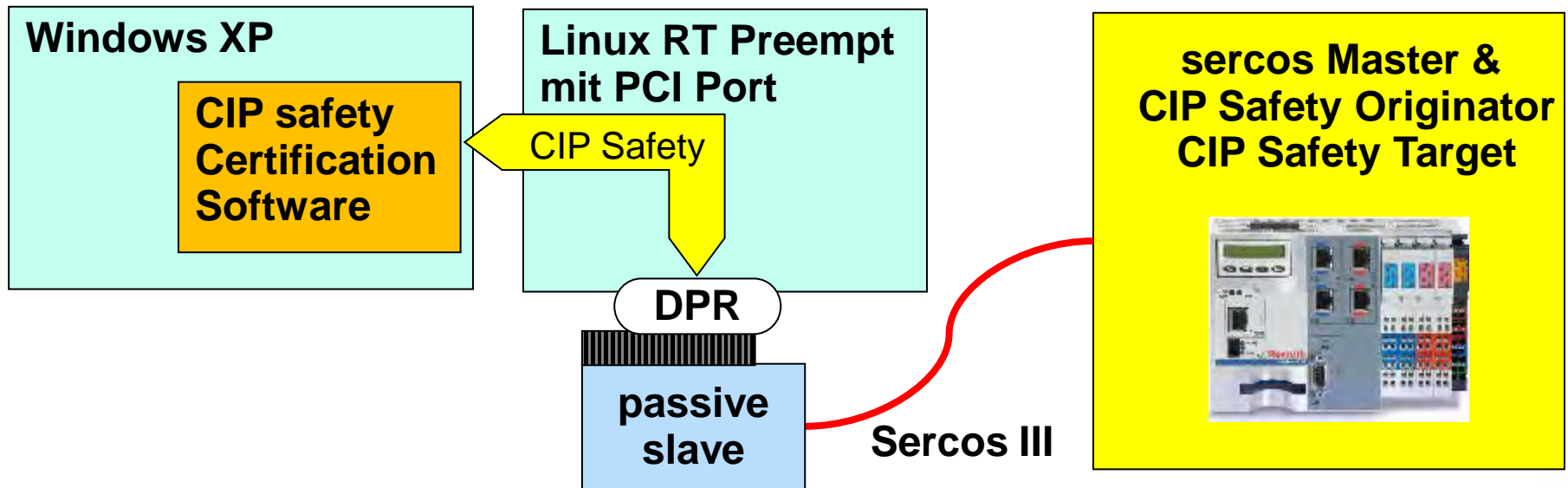
Software Architecture Python

Only Adaptions

Consumer / Producer

Originator / Target

Configuration (Conform.py)

Testcase No.

Framework

Device 2

Device 1

Input Server

Output Server

IO channel (cyclic)

In SID 1

In SID 2

...

In SID 95

Out SID 17

Out SID 18

...

Out SID 103

sercos III

1 Out- and 1 In-Server per Device

1 Out and 1 In per Fwd_Open

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Conformance Software Interface:

▶ Use of 4 simple functions encapsulated in DLL:
   - Explicit: sendExplicitMessage & receiveExplicitMessage
   - I/O: sendIOMessage & receiveIOMessage

▶ Attributes for send functions: Instance (sercos connection number), SMP Session ID, length and message pointer

▶ Attributes for receive functions: Instance (sercos connection number), SMP Session ID, length and message pointer

▶ For diagnostic purpose: readSercosPhase
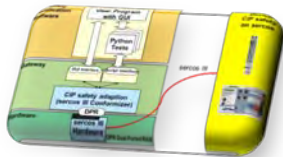
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Points to do:

▶ Develop a concept to connect CIP Safety to your fieldbus

▶ Show concept to the TÜV and let it be approved through review of Volume 5

▶ Connect the certification solution to your network

➔ communicate SAFE

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Thank you very much
Any questions?

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