知从木牛操作系统 OS ARM CORTEX R52+产品手册

ZC.MUNIU OS PRODUCT MANUAL

BASED ON ARM CORTEX R52+

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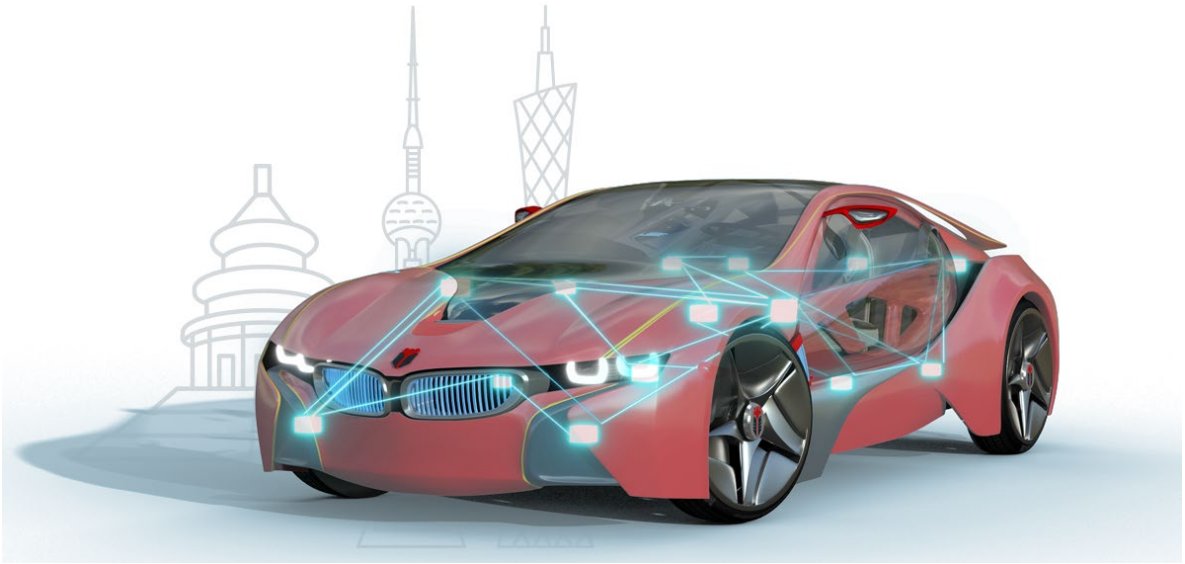
ZC.MuNiu OS ARM CORTEX R52+



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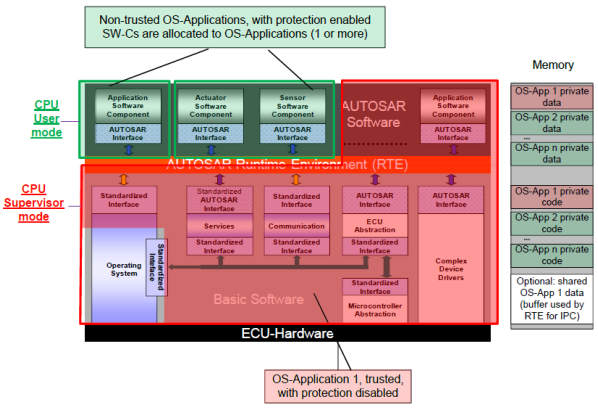
1 功能概述 FUNCTIONAL OVERVIEW

知从.木牛（ZC.MuNiu）为汽车电子控制器产品开发，提供完整的基础软件平台解决方案。该产品参考 AUTOSAR、OSEK 等国际规范，有基于 AUTOSAR ARTOP 架构的上位机配置工具。木牛操作系统 OS ARM CORTEX R52+产品是适用于汽车芯片的高安全嵌入式实时操作系统（RTOS）。符合 AUTOSAR 规范中定义的可伸缩性类（Scalability Classes，SC）所要求的全部功能集，可支持不同 ASIL 等级应用共存，最高支持 ASIL-D 等级应用。

ZC.MuNiu provides a comprehensive basic software platform solution for the development of automotive electronic control units. This product refers to international standards such as AUTOSAR and OSEK, and has configuration tool based on the AUTOSAR ARTOParchitecture. ZC.MuNiu Operating System (OS) product is a embedded real-time operating system (RTOS) suitable for automotive electronic control units. It conforms to the full set of functionalities required by the Scalability Classes (SC) defined in the AUTOSAR specifications, and includes functional safety features such as memory protection, timing protection, service protection, and stack protection as defined in the SC4 functionality set. ZC.MuNiu Operating System (OS) can also support the coexistence of applications with different ASIL levels, with the highest support for ASIL-D level applications.



(From 《AUTOSAR_EXP_FunctionalSafetyMeasures.pdf》)

2 应用领域 APPLICATION FIELD

木牛操作系统 OS ARM CORTEX R52+产品可应用于汽车电子控制器产品开发。例如：

MuNiu Operating System OS ARM CORTEX R52+ product can be applied to the development of automotive electronic control units. For example：

- 新能源整车控制器(VCU)
  Vehicle Control Unit for new energy vehicles (VCU)
- 电机控制器(MCU)
  Motor Control Unit (MCU)
- 电池管理系统控制器(BMS)
  Battery Management System (BMS)
- 电子助力转向控制器(EPS)
  Electric Power Steering (EPS) Controller
- 车身控制器(BCM)
  Body Control Module (BCM)
- 智能驾驶控制器安全岛(ADAS Safety Island)
  Advanced Driver Assistance Systems (ADAS) Safety Island
- 智能网关控制器(Gateway)
  Gateway Controller
- 智能刹车助力控制器
  Intelligent Braking System Controller
- 电子驻车系统(EPB)
  Electronic Parking Brake (EPB) System
- 发动机管理系统(EMS)
  Engine Management System (EMS)

3 配置环境 CONFIGURATION ENVIRONMENT

i. 木牛操作系统 OS 产品的 ARM CORTEX R52+系列芯片软件配置：
The software configuration for the ARM CORTEX R52+ series chips in ZC.MuNiu Operating System product is as follows:

配置环境 Configuration Environment	
Hardware (Chip)	ARM Cortex-R52+
Compilers Supported	Arm C Compiler 6
Evaluation Hardware	Based on ARM Cortex-R52+ EVB
Debugger	Arm DS IDE 2023.1
Configuration Tools	Muniu_v5.1.0
Configuration Environment	Win7/Win10 64bit

4 开发背景 DEVELOPMENT BACKGROUND

木牛操作系统 OS ARM CORTEX R52+产品符合 AUTOSAR 和 OSEK（ISO17356-3）标准，支持主流汽车电子控制器，支持多 Cluster 多核体系结构，实现了任务抢占式调度和高效的中断处理框架，为系统实时性提供了良好保障。产品包含上位机配置工具，可实现灵活的配置和裁剪，自动化生成配置源代码和应用参考框架，大大降低汽车电子控制器开发成本。

ZC.MuNiu Operating System ARM CORTEX R52+ product complies with AUTOSAR and OSEK (ISO17356-3) standards, supporting multi-cluster and multi-core architectures. ZC.MuNiu Operating System ARM CORTEX R52+ product implements task preemptive scheduling, and efficient interrupt processing framework, providing good assurance for system real-time performance. ZC.MuNiu Operating System ARM CORTEX R52+ product includes configuration tool that can achieve flexible configuration and tailoring, can automatically generate configuration source code and application reference frameworks. It can significantly reduce the development costs of automotive electronic control units.

ARM CORTEX R52+体系结构支持配置多个 Cluster，每个 Cluster 可包含多个物理核心。木牛操作系统 OS ARM CORTEX R52+产品支持多 Cluster 多核体系结构，具备优异的硬件适应性。木牛操作系统 OS ARM CORTEX R52+产品支持 ARM GIC V3.0 中断体系结构，实现了非虚拟机模式下的中断参数静态配置、中断安装和中断路由机制，有效保障了系统实时性。结合 ARM CORTEX R52+体系结构的特点，对任务调度、核间通信等关键算法进行优化，进一步提高系统性能。

The ARM CORTEX R52+ architecture supports the configuration of multiple clusters, with each cluster containing multiple physical cores. ZC.MuNiu Operating System ARM CORTEX R52+ product supports multi-cluster and multi-core architectures and has excellent hardware adaptability. ZC.MuNiu Operating System ARM CORTEX R52+ product supports the ARM GIC V3.0 interrupt architecture, implementing static configuration of interrupt parameters, interrupt installation, and interrupt routing mechanisms in non-virtual machine modes, effectively ensuring system real-time performance. By the characteristics of the ARM CORTEX R52+ architecture, key algorithms such as task scheduling and inter-core communication are optimized to improve system performance.

木牛操作系统 OS ARM CORTEX R52+产品具备自主研发的轻量化内存保护和时间保护框架，可有效防止低安全等级应用访问非法内存区域，阻止低安全等级应用出现非预期时间行为，从而实现故障隔离，使系统具备多种功能安全等级应用共存的能力。通过服务保护机制判定应用对服务接口的调用是否符合标准中定义的规则，防止应用由于实现不符合标准而带来的非预期行为。通过堆栈保护机制，对任务和中断的堆栈使用量进行实时检测，防止任务或者中断出现堆栈溢出，进一步提高系统安全性。

ZC.MuNiu Operating System ARM CORTEX R52+ product has an lightweight memory protection and timing protection framework, which can effectively prevent low-safety-level applications from accessing illegal memory areas and prevent unexpected timing behavior in low-safety-level applications. Thereby achieving fault isolation and enabling the coexistence of multiple functional safety level applications in the system. The service protection mechanism determines whether the application's call complies with the rules defined in the standard, preventing unexpected behavior caused by non-standard implementation. The stack protection mechanism provides real-time monitoring of the stack usage of tasks and interrupts, preventing stack overflow in tasks or interrupts, and further improving system safety.

木牛操作系统 OS ARM CORTEX R52+产品可针对汽车领域微控制器（MCU）以及智能座舱、智能驾驶控制器中所集成的安全岛（Safety Island）进行深度定制和优化，具有执行效率高和应用代码部署灵活的特点。

ZC.MuNiu Operating System ARM CORTEX R52+ product can be deeply customized and optimized for microcontrollers (MCU) in the automotive field, as well as for the safety islands integrated in controllers. ZC.MuNiu Operating System (OS) product has characteristics of execution efficiency and flexible code deployment.

知从科技积极投入对国产芯片的适配工作，率先基于旗芯微、杰发科技等国产芯片厂商的核心产品进行适配，不断完善木牛基础软件对国产芯片的兼容和支持。

ZC actively invests in the adaptation of domestic chips, taking the lead in adapting to the products of domestic chip manufacturers such as Flagchip and AutoChips Inc. ZC will continuously improving the compatibility and support of ZC.MuNiu basic software for domestic chips.

知从科技掌握 AUTOSAR 平台软件的开发和应用核心技术，提供本地现场支持，质量好，速度快，成本低。

ZC has the core technology of the AUTOSAR basic software. Can provide on-site support with high quality, fast speed, and low cost.

5 功能描述 FUNCTIONAL DESCRIPTION

5.1 产品特点 Product Feature

- ARTOP 架构上位机配置工具，符合 AUTOSAR 4.2.2/4.3.1/4.4.0 版本

  ARTOP architecture upper computer configuration tool, compliant with AUTOSAR 4.2.2/4.3.1/4.4.0

- 支持 AUTOSAR SC1、SC2、SC3 和 SC4

  Supports AUTOSAR scalability classes SC1, SC2, SC3, and SC4

- 高效的中断处理框架，支持 ARM GIC V3.0 版本

  Efficient interrupt processing framework, supporting ARM GIC V3.0 version

- 支持多 Cluster 多核体系结构

  Supports multi-cluster and multi-core architecture

- 轻量化内存保护和时间保护框架

  Lightweight memory protection and timing protection framework

- 针对不可信 Os-Application 的全方位保护能力

  Comprehensive protection capabilities for untrusted Os-Applications

- 针对可信 Os-Application 的可选保护能力

  Optional protection capabilities for trusted Os-Applications

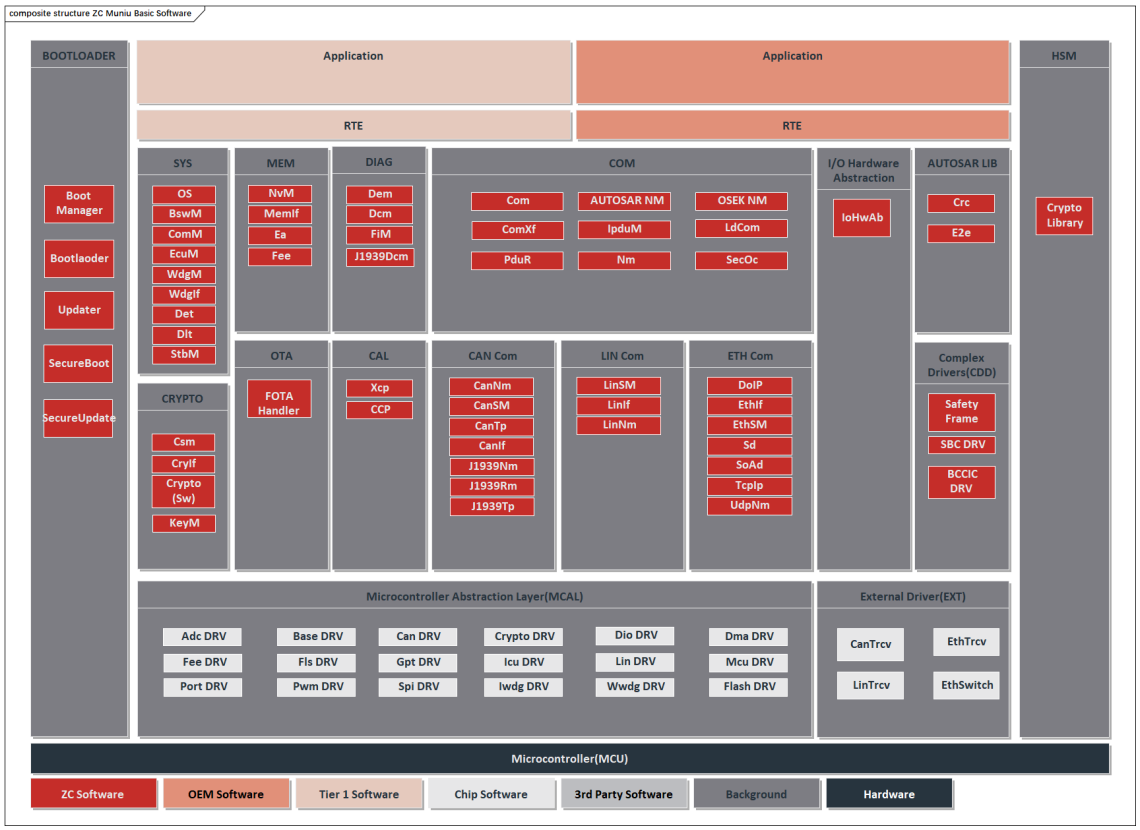
- 定制化服务

  Customized services

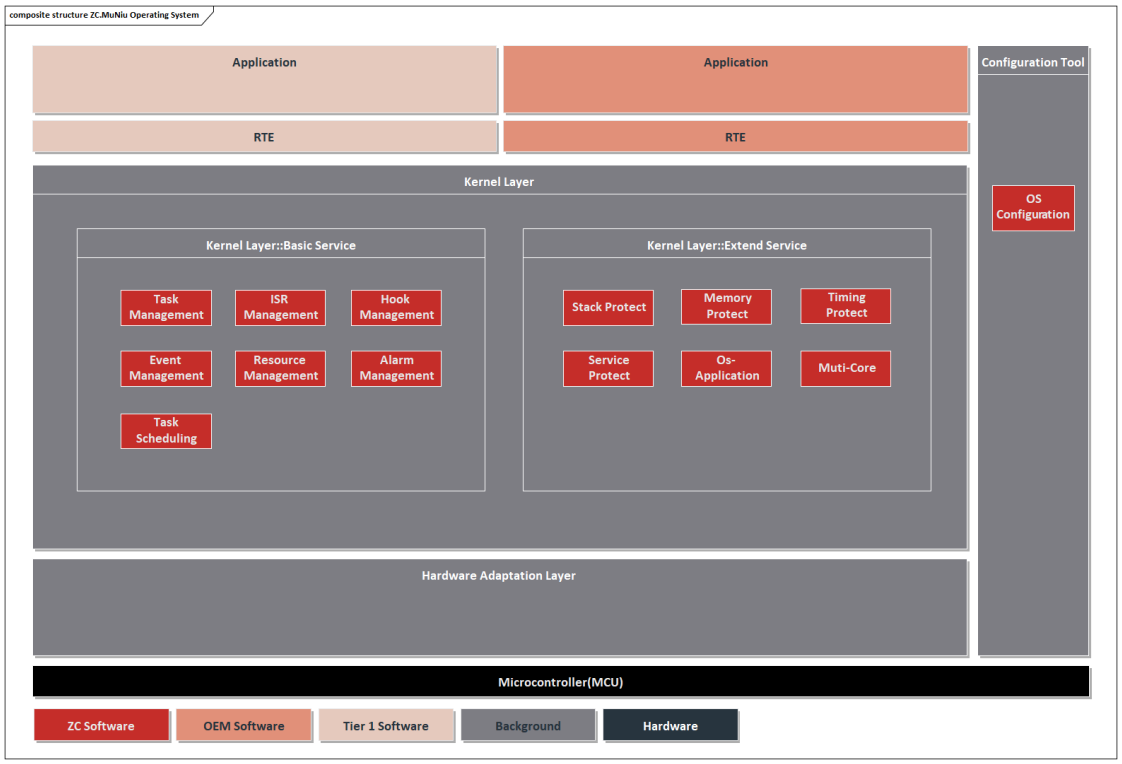
Feature	Described in Section	Scalability Class 1	Scalability Class 2	Scalability Class 3	Scalability Class 4	Hardware requirements
OSEK OS (all conformance classes)	7.1	✓	✓	✓	✓	
Counter Interface	8.4.17	✓	✓	✓	✓	
SWFRT Interface	8.4.18, 8.4.19	✓	✓	✓	✓	
Schedule Tables	7.3	✓	✓	✓	✓	
Stack Monitoring	7.5	✓	✓	✓	✓	
ProtectionHook	7.8		✓	✓	✓	
Timing Protection	7.7.2		✓		✓	Timer(s) with high priority interrupt
Global Time /Synchronization Support	7.4		✓		✓	Global time source
Memory Protection	7.7.1, 7.7.4			✓	✓	MPU
OS-Applications	7.6, 7.12			✓	✓	
Service Protection	7.7.3			✓	✓	
CallTrustedFunction	7.7.5			✓	✓	(Non-)privileged Modes

AUTOSAR 符合性类
AUTOSAR SCALABILITY CLASSES

5.2 软件架构 Software Architecture



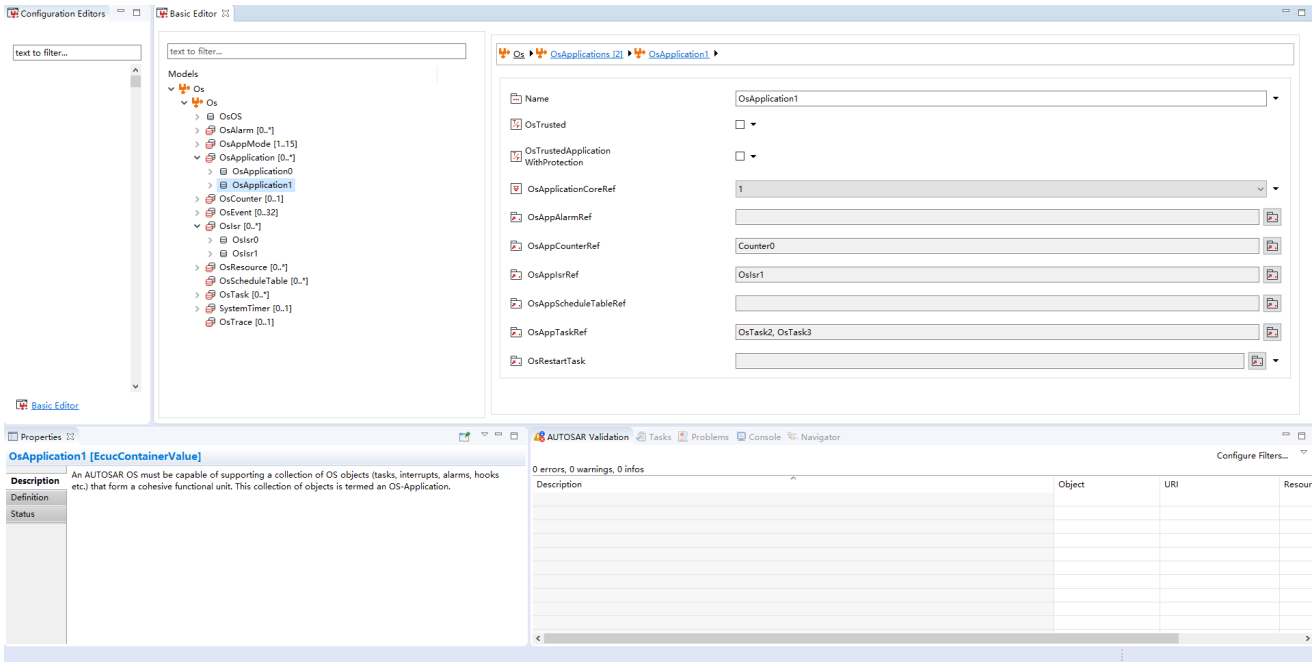
知从木牛基础软件架构
ZC.MUNIU BASIC SOFTWARE ARCHITECTURE



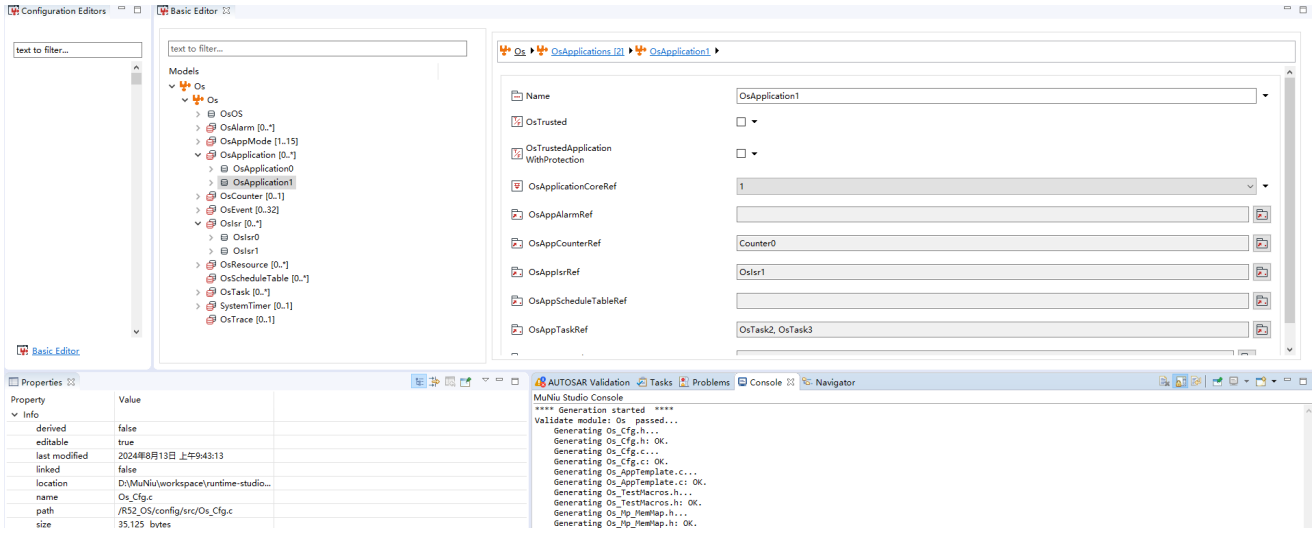
知从木牛操作系统 OS 产品软件架构
ZC.MUNIU OPERATING SYSTEM SOFTWARE ARCHITECTURE

模块 Module	子模块 Submodule	描述 Description
硬件适配层 Hardware Adaptation Layer (HWAP)	硬件适配层 Hardware Adaptation Layer	硬件处理器适配 Processor adaptation
OS配置 OS Configuration	OS 配置 OS Configuration	OS 配置代码 OS configuration code
内核层 Kernel Layer (KERNEL)	任务管理 Task Management	实现系统服务，包括OSEK和AUTOSAR中定义的接口和机制，是OS的核心组件 Implementing system services, including the interfaces and mechanisms defined in OSEK and AUTOSAR
	中断管理 ISR Management（GIC V3.0）	
	Hook管理 Hook Management	
	Event管理 Event Management	
	Resource管理 Resource Management	
	Alarm管理 Alarm Management	
	Counter管理 Counter Management	
	任务调度管理 Task Scheduling Management	
	堆栈保护 Stack Protect	
	空间保护 Memory Protect	
	时间保护 Timing Protect	
	服务保护 Service Protect	
	Application管理 Os-Application Management	
	多核管理 Muti-Core Management	

5.3 配置工具 Configuration Tool



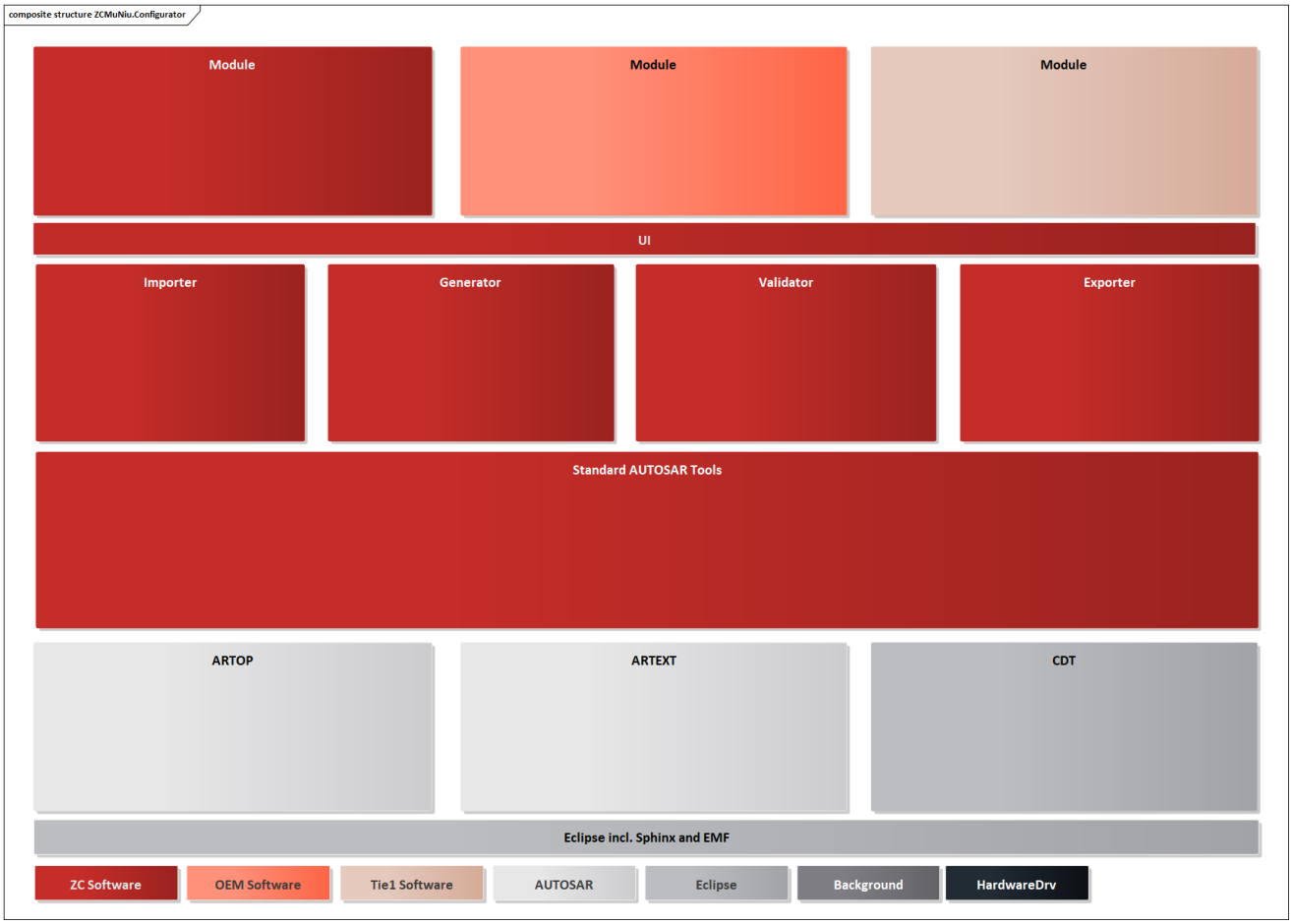
木牛配置工具 OS 主界面
MUNIU CONFIGURATION TOOL OS MAIN INTERFACE



木牛配置工具生成 OS 配置代码
MUNIU CONFIGURATION TOOL GENERATES OS CONFIGURATION CODE

为了满足客户的不同项目需求，提高基础软件平台的扩展性，木牛基础软件平台实现了各个模块可配置性，并且实现了配置工具。客户可根据不同需求，在配置工具上完成各个模块的配置工作，可生成配置代码文件，将生成的配置文件集成到工程中即可。

To meet the requirements of customer and enhance the extensibility of the basic software platform, ZC.MuNiu has implemented configurable modules and configuration tool. Customers can use the configuration tool to configthe modules according to their specific needs, generate configuration code files, and integrate these files into projects.



木牛配置工具架构
ZC.MUNIU CONFIGURATION TOOL ARCHITECTURE

木牛基础软件平台的配置工具是基于 Eclipse 平台，并基于 ARTOP 架构，实现 AUTOSAR 模型和 ARXML 的解析。除了 AUTOSAR 标准定义的模块之外，还支持 OEM 和 Tie1 厂商二次开发自己的模块。配置完成后，可生成各个模块的配置代码。

ZC.MuNiu basic software platform configuration tool is based on the Eclipse platform and is built on the ARTOP architecture, which implements the parsing of the AUTOSAR model and ARXML. In addition to the modules defined by the AUTOSAR standard, it also supports OEM and Tie1 manufacturers to develop their own modules for secondary development. After the configuration is completed, the configuration code for each module can be generated.

6 过程文档 PROCESS DOCUMENTATION

开发流程 Development Process	文档描述 Document Description
需求收集 Requirement Collection	需求文档 Requirement Document
软件需求分析 Software Requirement Analysis	软件需求追踪表 Software Requirement Traceability Matrix
	问题沟通表 Issue Communication Form
软件架构设计 Software Architecture Design	软件架构说明书 Software Architecture Specification
	软件架构的追踪表 Software Architecture Traceability Matrix
软件详细设计和单元设计 Software Detailed Design and Unit Design	软件详细设计说明书 Software Detailed Design Specification
	配置工具设计文档 Configuration Tool Design Document
	软件详细设计追踪表 Software Detailed Design Traceability Matrix
	软件详细设计评审表 Software Detailed Design Review Form
软件单元测试 Software Unit Testing	QAC 分析报告 QAC Analysis Report
	Tessy 测试报告 Tessy Test Report
	软件单元验证策略 Software Unit Verification Strategy
软件集成和集成测试 Software Integration and Integration Testing	集成策略 Integration Strategy
	集成手册 Integration Manual
	集成测试策略 Integration Test Strategy

开发流程 Development Process	文档描述 Document Description
	集成测试报告 Integration Test Report
	资源分析报告 Resource Analysis Report
软件系统测试 Software System Testing	符合性测试报告 Compliance Test Report
	系统测试报告 System Test Report
	性能测试报告 Performance Test Report
	系统测试报告评审 System Test Report Review
发布 Release	发布文档 Release Documentation

7 证书 CERTIFICATE

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计算机软件著作权登记证书

证书号：软著登字第6824926号

软件名称：知从木牛基础软件平台
[简称：知从木牛]
V4.4

著作权人：上海知从科技有限公司

开发完成日期：2020年06月18日

首次发表日期：2020年09月30日

权利取得方式：原始取得

权利范围：全部权利

登记号：2021SR0100609

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2021年01月19日

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