

**EC**  *Master*

**EC**  *Engineer*

**EC**  *EngineerWeb*

**EC**  *Simulator*

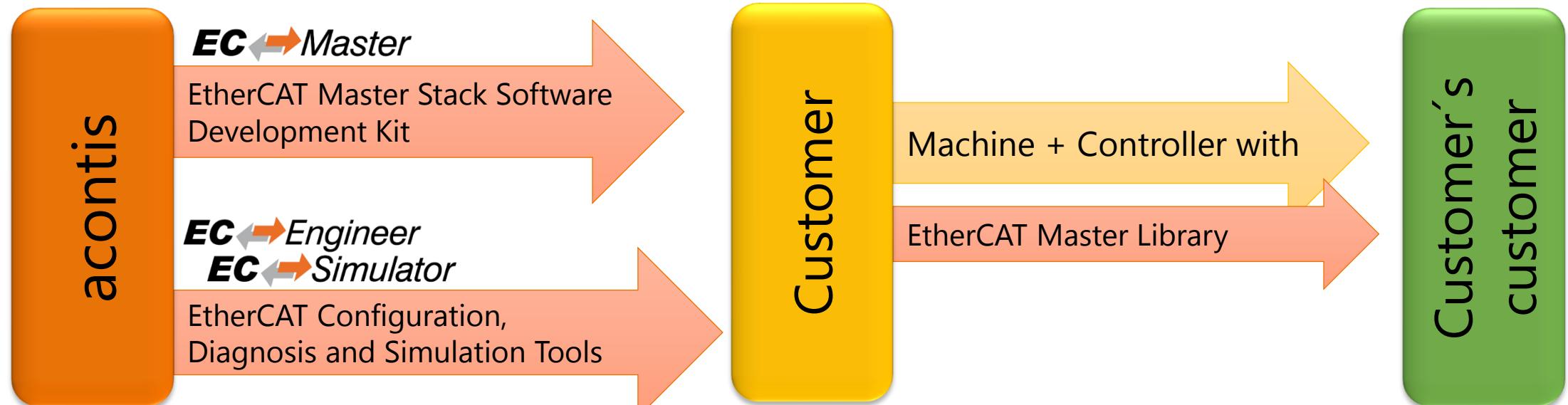
**Software and Tools for  
EtherCAT® Master Controller Development**

# EtherCAT Software Solutions for Machine Builder Controller

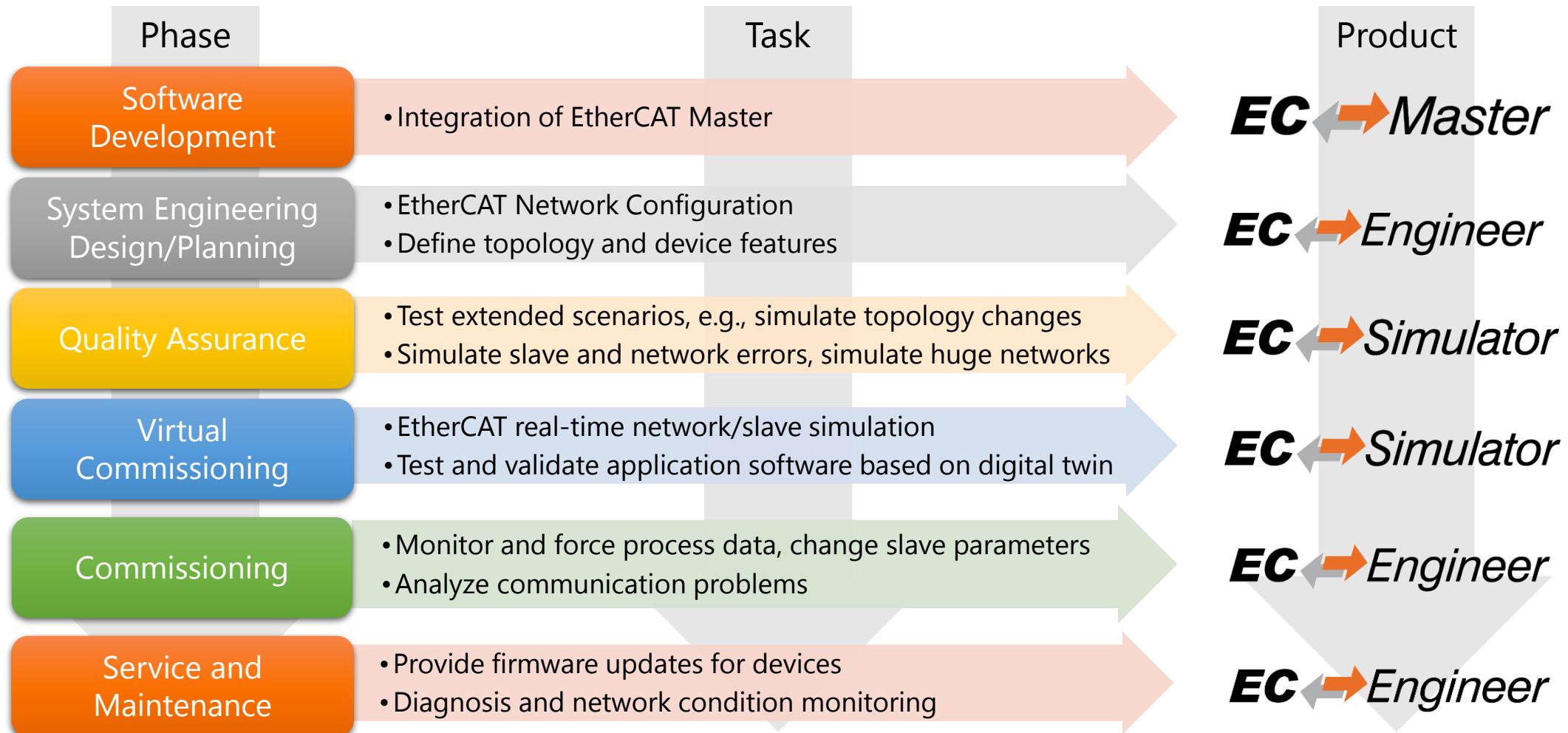


## Machine Builders

- Motion Control, CNC, Material Handling
- Surgical Robotics, Simulators
- Test benches, Semiconductor tooling



# Machine Builder Controller Development Life Cycle



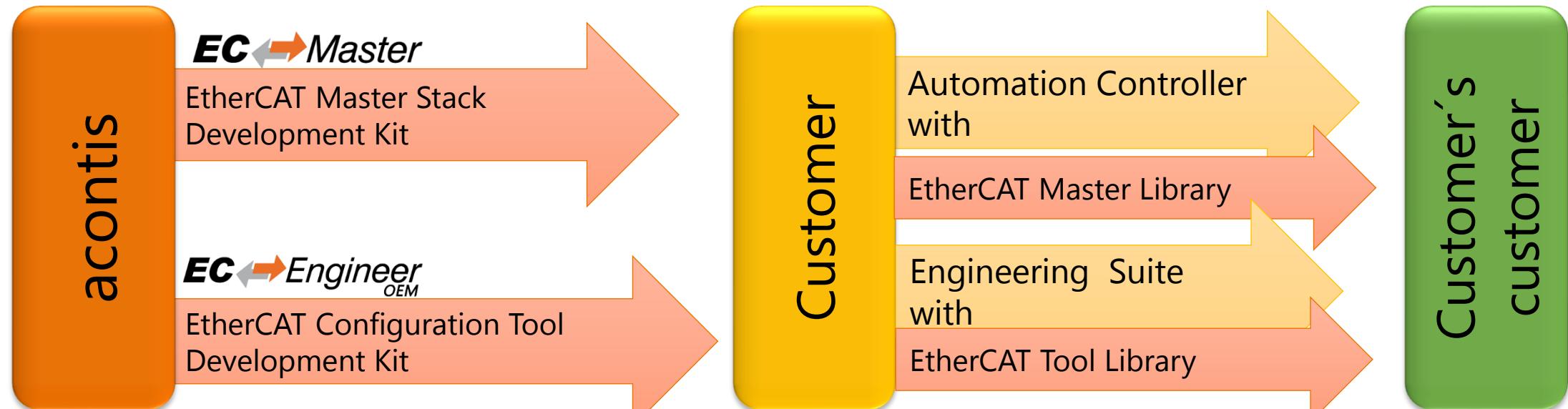
# EtherCAT Software Solutions for Automation Controller Manufacturers

**EC**  **Master**

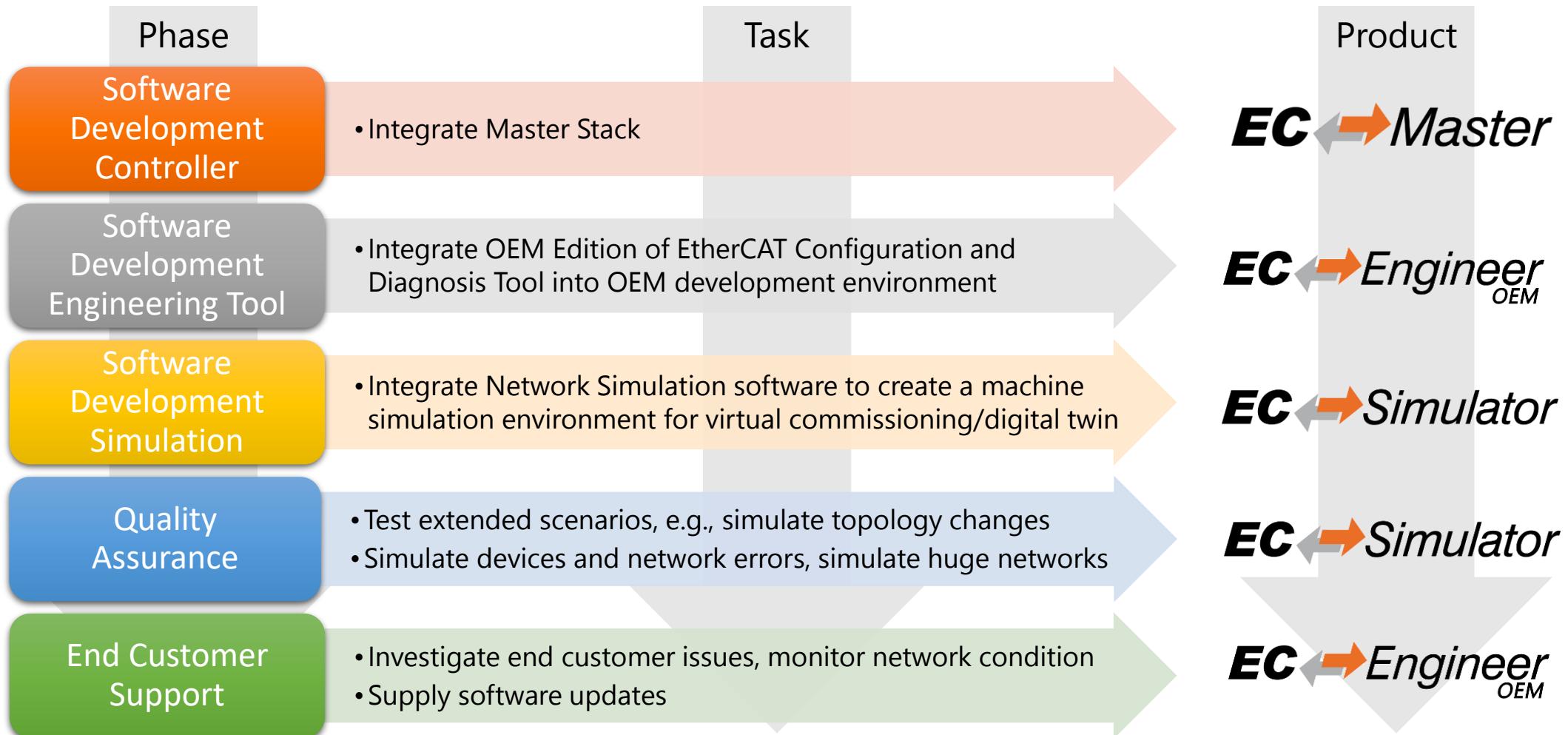


## Automation Controller Manufacturers

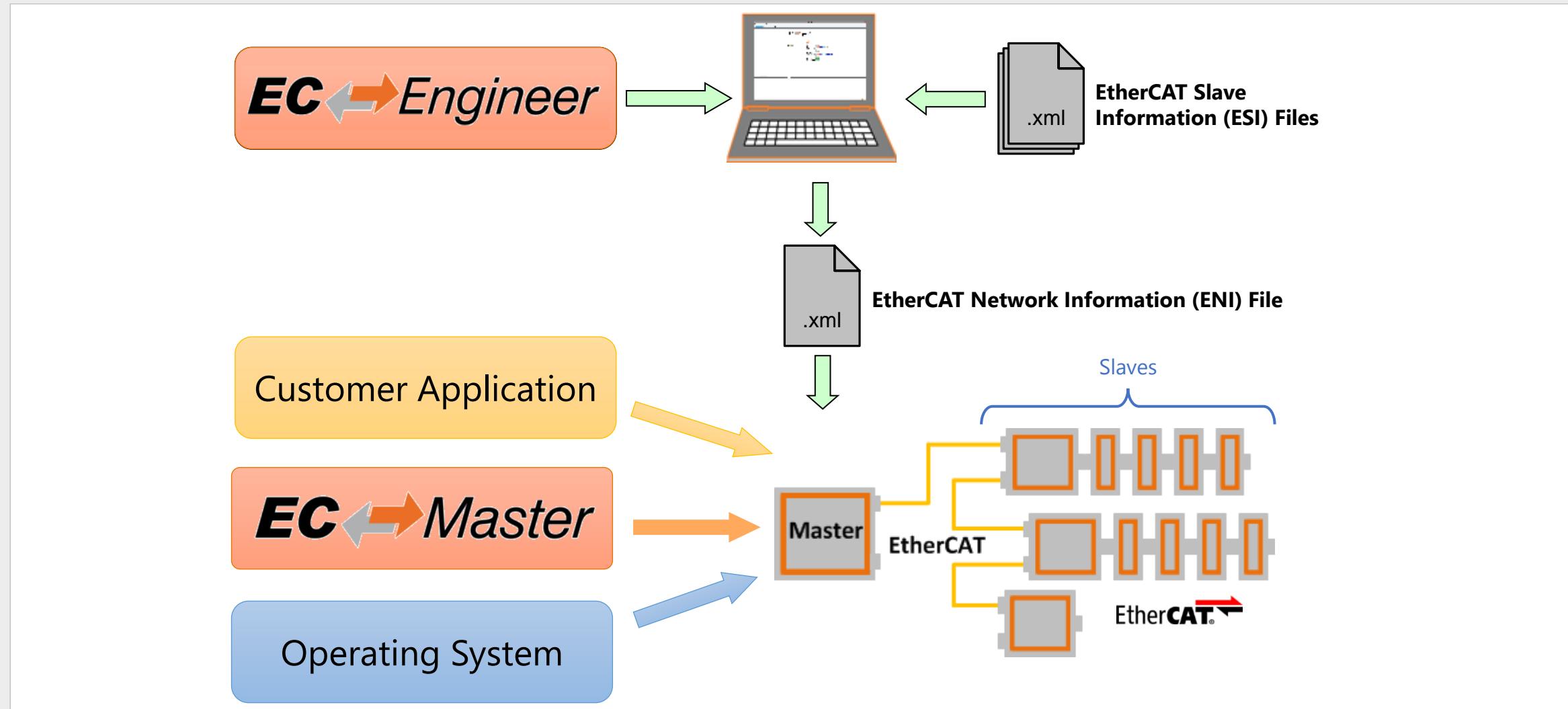
- Programmable Logic/Automation Controller (PLC/PAC)
- Motion Controllers (MC), Measurement Controllers
- HMI with controller



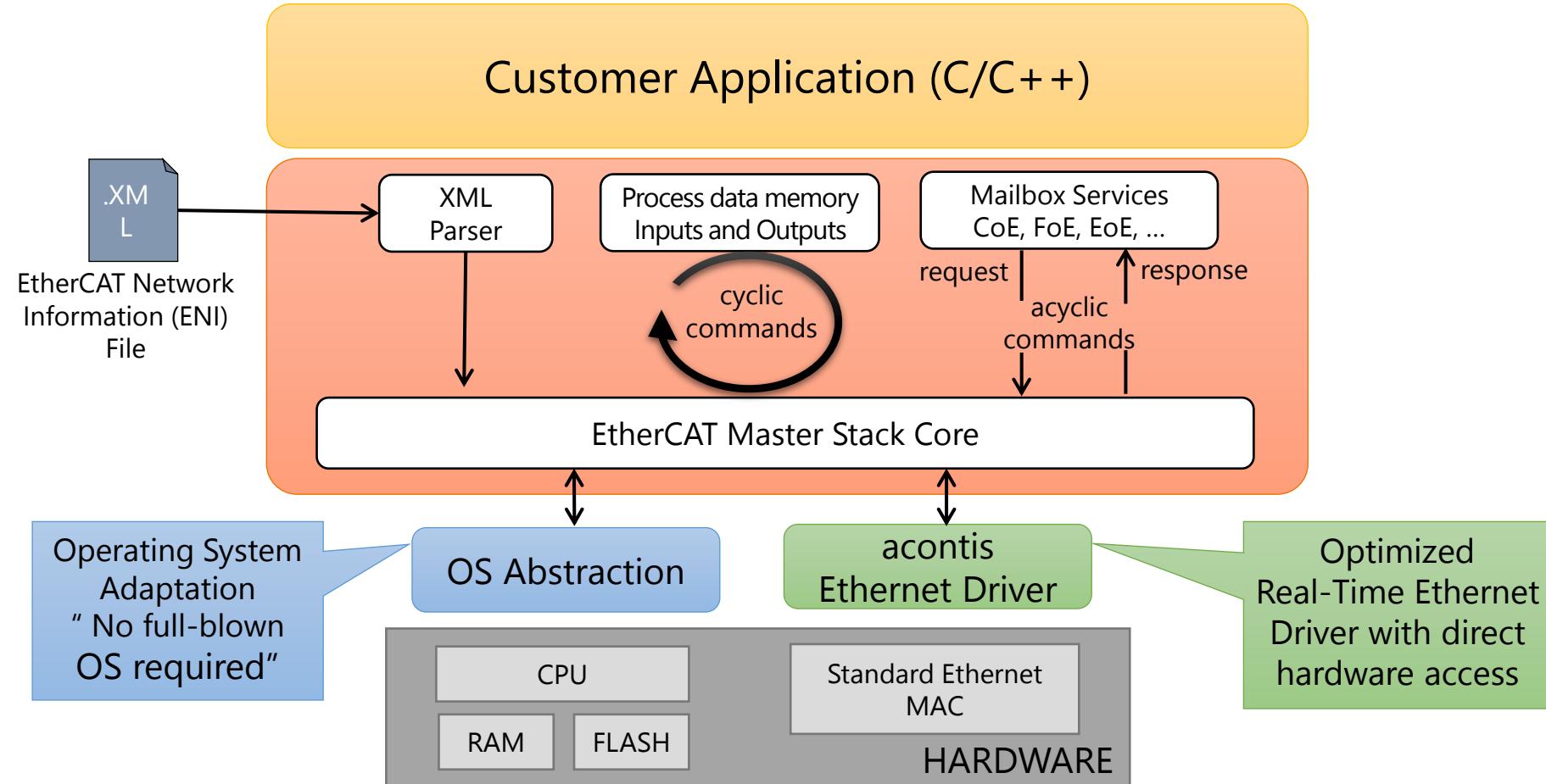
# Automation Controller Manufacturers Development Life Cycle



# EtherCAT System Architecture



# EC-Master Software Architecture



### OS Abstraction



VxWorks

TI-RTOS



INTEGRITY



QNX



Windows

SylinxOS



and more

### Ethernet Controllers

Intel Pro/1000

Xilinx GEM

Realtek Gigabit

NXP  
FEC, eTSEC

Renesas RZ Family

TI Sitara  
CPSW, ICSS-PRU

Intel Elkhart Lake

SMSC 9218

Beckhoff CCAT

and more

X86  
32-Bit

X64  
64-Bit

ARM  
32-Bit

Aarch64  
64-Bit

PowerPC

# EC-Master Available for Many Platforms



**25 Operating Systems**

**22 Ethernet controller families**

**5 CPU Architectures**

**> 90**

Combinations

## Class B Core

- Compare network configuration
- Cyclic process data exchange
- Slave to slave communication
- Mailbox protocols CoE, SoE
- Mailbox protocols EoE, FoE
- Mailbox protocols AoE, VoE

## Class A Core

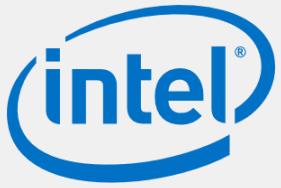
- All Class B Features
- **Distributed Clocks with master synchronization**

## Feature Packs = Options

Cable Redundancy, Hot Connect, Superset ENI,  
External Synchronization, EoE Gateway, Master Redundancy, ...

# EC-Master broad CPU support



 <b>BROADCOM</b> <sup>®</sup>	BCM2711 - Raspberry Pi 4 (Cortex-A72)
 <b>infineon</b>	XMC4800 (Cortex M4)
 <b>intel</b> <sup>®</sup>	Core-i Atom Atom <sup>®</sup> x6000E (Elkhart Lake) Altera Cyclone V Celeron, Xeon
 <b>NVIDIA</b>	Jetson TX2 (Quad Cortex-A57)
 <b>NXP</b>	i.MX6 (Cortex-A9) i.MX7 (Cortex-A7), i.MX RT1064 (Cortex M7) i.MX8 (Cortex-A53) Layerscape 1021A QorIQ P-Series MPC8548 PowerQUICC
 <b>Qualcomm</b>	QRB5165 with Kryo 585 CPU (Octo Cortex-A77)
 <b>RENESAS</b>	RIN32, RZ-T, RZ-N, RZ-G (Cortex-A55) RZ-A (Cortex-A9)
 <b>Rockchip</b> 瑞芯微电子	RK3328 (Quad Cortex A53) RK3399 (Dual Cortex-A72) RK3588s (Quad Cortex-A76) RK3568 (Quad Cortex-A55)
 <b>ST</b> life.augmented	STM32MP1 (Dual Cortex-A7) STM32H7 (Cortex M7) STM32F769 (Cortex M7)
 <b>TEXAS INSTRUMENTS</b>	Sitara AM335x (Cortex-A8) Sitara AM437x (Cortex-A9) Sitara AM57xx (Dual Cortex-A15) Sitara AM64x (Dual Cortex-A53) Jacinto TDA4VM (Dual Cortex A72 / Quad Cortex R5F)
 <b>XILINX</b> <sup>®</sup>	Zync-7000 (Dual Cortex-A9) Zynq UltraScale+ (Quad Cortex-A53)

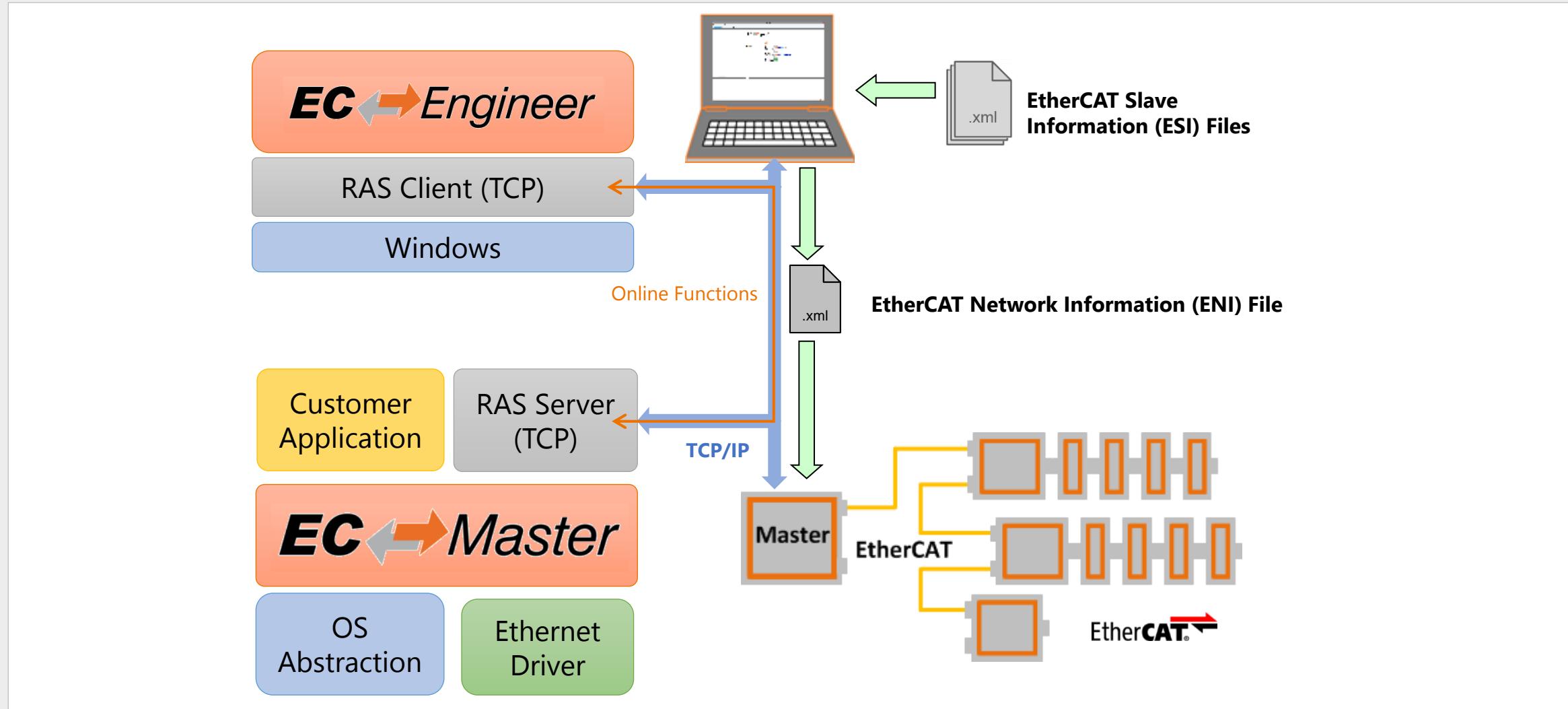
- **Out-of-the-box** for the most popular operating systems
  - ⇒ Get it running on your system in one day!
- **Reliable** and **robust** implementation
  - ⇒ Field proven in several 100000 systems per year!
- Sophisticated **diagnosis** functions
  - ⇒ Detect state change problems and frame loss errors easily
  - ⇒ More than 300 different error codes
- High **performance** and **hard real-time**
  - ⇒ Low CPU load due to acontis real-time Ethernet drivers
- **Easy** to integrate
  - ⇒ Various example applications and comprehensive user manuals

- EC-Master Operating Systems and Real-time Ethernet Drivers  
<https://www.acontis.com/en/os.html>
- EC-Master user manual and quick start guide  
<https://developer.acontis.com/ec-master>
- Request for EC-Master feature pack slides
- Request for EC-Master technical details slides
- Request for evaluation software  
<https://www.acontis.com/en/ethercat-support-eval-request.html>

**EC**  *Engineer*

**EtherCAT Configuration and Diagnosis Tool**

# EtherCAT System Architecture



# Operating Modes

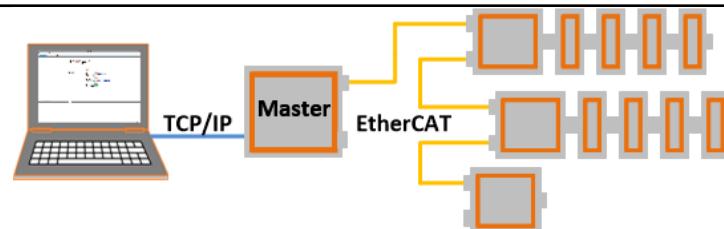
Offline **Configuration**:  
(In the Office)



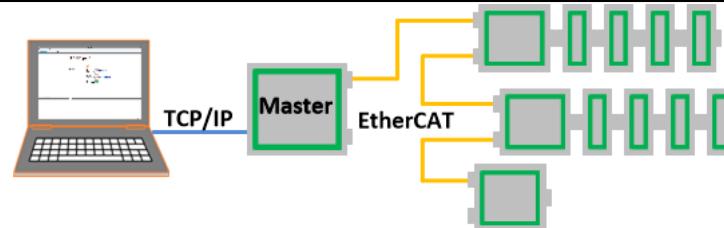
Online **Configuration**:  
Slaves connected to  
Engineering System



Remote **Configuration**:  
Slaves connected to  
Target System



Remote **Diagnosis**:  
Slaves connected to  
Target System



# Build a configuration in less steps

**EC-Engineer [-]**

File View Network Settings Help

Configuration Mode Export ENI Export EXI Diagnosis Mode

**Project Explorer**

- Class-A Master
  - Slave\_1001 [EK1100] (1001)
    - Slave\_1002 [EL2008] (1002)
    - Slave\_1003 [EL2008] (1003)
    - Slave\_1004 [EL1014] (1004)
    - Slave\_1005 [EL2004] (1005)
    - Slave\_1006 [EL1034] (1006)
    - Slave\_1007 [EL1018] (1007)
    - Slave\_1008 [EL2008] (1008)
  - Slave\_1009 [EK1122-0080] (1009)
    - Slave\_1010 [EK1101-0080] (1010)
      - Slave\_1011 [EL2252] (1011)
      - Slave\_1012 [EL2612] (1012)
      - Slave\_1013 [EL4132] (1013)
      - Slave\_1014 [EL3162] (1014)
      - Slave\_1015 [EL1008] (1015)
      - Slave\_1016 [EL1094] (1016)
      - Slave\_1017 [EK1110] (1017)
        - Slave\_1018 [BK1120] (1018)
    - Slave\_1019 [VIPA 053-1EC00] (1019)
    - Slave\_1020 [EK1122] (1020)

Classic View Flat View Topology View

**Short Info**

Information

Name	Slave_1019 [VIPA 053-1EC00]
Description	VIPA 053-1EC00 EtherCAT Fieldbus coupler (MDP)
Vendor	VIPA GmbH (0x0000AFFE)
Physical Address	1019
Autoln. Address	0xcccc / -10
Networks: 1   Slaves: 26	

**Messages**

Severity	Time	Message
INF	06:57:03	Master state change from 'Init' to 'Pre-Op'
INF	06:56:59	Master state change from 'Unknown' to 'Init'
INF	06:56:58	Master state change from 'Unknown' to 'Init'
INF	06:56:55	Network scan successful - 26 slaves found

**EC-Engineer [-]**

File View Network Settings Help

Configuration Mode Export ENI Export EXI Diagnosis Mode

**Project Explorer**

- Class-A Master
  - Slave\_1001 [EK1100] (1001)
  - Slave\_1002 [EL2008] (1002)
  - Slave\_1003 [EL2008] (1003)
  - Slave\_1004 [EL1014] (1004)
  - Slave\_1005 [EL2004] (1005)
  - Slave\_1006 [EL1034] (1006)
  - Slave\_1007 [EL1018] (1007)
  - Slave\_1008 [EL2008] (1008)
  - Slave\_1009 [EK1122-0080] (1009)
    - Slave\_1010 [EK1101-0080] (1010)
      - Slave\_1011 [EL2252] (1011)
      - Slave\_1012 [EL2612] (1012)
      - Slave\_1013 [EL4132] (1013)
      - Slave\_1014 [EL3162] (1014)
      - Slave\_1015 [EL1008] (1015)
      - Slave\_1016 [EL1094] (1016)
      - Slave\_1017 [EK1110] (1017)
        - Slave\_1018 [BK1120] (1018)
    - Slave\_1019 [VIPA 053-1EC00] (1019)
    - Slave\_1020 [EK1122] (1020)

**Device Editor**

General Modules PDO Mapping Variables Advanced Options Init Commands CoE Object-Dictionary Sync Units Motion

**Assign the modules**

001 : Terminals [022-1BD00] (VIPA 022-1BD00, DI 2xDC)

002 : Terminals [021-1BD00] (VIPA 021-1BD00, DI 2xDC)

003 : Terminals [022-1BD00] (VIPA 022-1BD00, DI 2xDC)

004 : Terminals [032-1BB30] (VIPA 032-1BB30, AC 1xDC)

005 : Terminals [021-1BD00] (VIPA 021-1BD00, DI 2xDC)

006 : Terminals [022-1BB70] (VIPA 022-1BB70, DC)

007 : Terminals [022-1BD00] (VIPA 022-1BD00, DI 2xDC)

008 : Terminals [021-1BD00] (VIPA 021-1BD00, DI 2xDC)

009 : Terminals [021-1BB70] (VIPA 021-1BB70, DI 2xDC)

010 : Terminals [-]

011 : Terminals [-]

012 : Terminals [-]

013 : Terminals [-]

014 : Terminals [-]

015 : Terminals [-]

016 : Terminals [-]

**Additional settings**

Download Slot Configuration

**Messages**

Severity	Time	Message

Load Modules

SM 021 - Digital Input Modules

  - 021-1BB00 (VIPA 021-1BB00, DI 2xDC)
  - 021-1BB10 (VIPA 021-1BB10, DI 2xDC)
  - 021-1BB50 (VIPA 021-1BB50, DI 2xDC)
  - 021-1BB70 (VIPA 021-1BB70, DI 2xDC)
  - 021-1BD00 (VIPA 021-1BD00, DI 4xDC)
  - 021-1BD10 (VIPA 021-1BD10, DI 4xDC)
  - 021-1BD40 (VIPA 021-1BD40, DI 4xDC)
  - 021-1BD50 (VIPA 021-1BD50, DI 4xDC)
  - 021-1BD70 (VIPA 021-1BD70, DI 4xDC)
  - 021-1BF00 (VIPA 021-1BF00, DI 8xDC)
  - 021-1BF01 (VIPA 021-1BF01, DI 8xDC)
  - 021-1BF50 (VIPA 021-1BF50, DI 8xDC)
  - 021-1DF00 (VIPA 021-1DF00, DI 8xDC)

SM 022 - Digital Output Modules

  - 022-1BB00 (VIPA 022-1BB00, DO 2xDC)

State: Mode: CONFIG EXPERT

# Comprehensive diagnostic: Monitor and force process data

EC-Engineer [--]

File View Network Settings Help

Configuration Mode Export ENI Export EXI Diagnosis Mode Take Snapshot Run Break

Project Explorer

- Class-A Master <connected>
  - Slave\_1001 [EK1100] (1001)
  - Slave\_1002 [EL2008] (1002)
  - Slave\_1003 [EL2008] (1003)
  - Slave\_1004 [EL1014] (1004)
  - Slave\_1005 [EL2004] (1005)
  - Slave\_1006 [EL1034] (1006)
  - Slave\_1007 [EL1018] (1007)
  - Slave\_1008 [EL2008] (1008)
- Slave\_1009 [EK1122-0080] (1009)
  - Slave\_1010 [EK1101-0080] (1010)
    - Slave\_1011 [EL2252] (1011)
    - Slave\_1012 [EL2612] (1012)
    - Slave\_1013 [EL4132] (1013)
    - Slave\_1014 [EL3162] (1014) **Selected**
    - Slave\_1015 [EL1008] (1015)
    - Slave\_1016 [EL1094] (1016)
  - Slave\_1017 [EK1110] (1017)
- Slave\_1020 [EK1122] (1020)

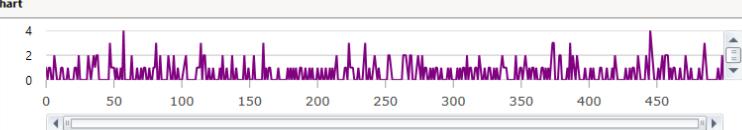
Device Editor

General Variables ESC Register EEPROM Extended Diagnosis CoE Object-Dictionary FoE

Variables

Name	Datatype	Offset	Size	Value	Forced
Slave_1014 [EL3162].Channel 1.Status	BYTE	IN:	157.0	1.0	0
Slave_1014 [EL3162].Channel 1.Value	INT	IN:	158.0	2.0	0
Slave_1014 [EL3162].Channel 2.Status	BYTE	IN:	160.0	1.0	0
Slave_1014 [EL3162].Channel 2.Value	INT	IN:	161.0	2.0	0

Chart



Edit Variable

Value: 0 Force Release

Messages

Severity Time Message

Device Editor

General Variables ESC Register EEPROM Extended Diagnosis CoE Object-Dictionary FoE

Values

Index	Name	Value	Type	Flags
0x1011	Restore default parameter	1 (0x01)	USINT	---- (RW RW RW)
0x1018	Identity object	4 (0x04)	USINT	---- (RO RO RO)
0x1800	TxPDO 001 parameter	6 (0x06)	USINT	---- (RO RO RO)
0x1801	TxPDO 002 parameter	6 (0x06)	USINT	---- (RO RO RO)
0x1810	TxPDO 017 parameter	6 (0x06)	USINT	---- (RO RO RO)
0x1A00	TxPDO 001 mapping	2 (0x02)	USINT	---- (RW RO RO)
0x1A01	TxPDO 002 mapping	2 (0x02)	USINT	---- (RW RO RO)
0x1A10	TxPDO 017 mapping	2 (0x02)	USINT	---- (RW RO RO)
0x1C00	SM type	4 (0x04)	USINT	---- (RO RO RO)
0x1C13	SM 3 PDO assign (inputs)	2 (0x02)	USINT	---- (RW RO RO)
0x3101	Inputs	2 (0x02)	USINT	-- TX- (RO RO RO)

Edit Value

Value: 0 Dec Hex Write

Short Info

Information

Name Slave\_1014 [EL3162]  
Description EL3162 2Ch. Ana. Input 0-10V  
Vendor Beckhoff Automation GmbH & Co. KG  
Physical Address 1014  
Autoln. Address 0cccc2 / 12  
Networks: 1 Slaves: 26

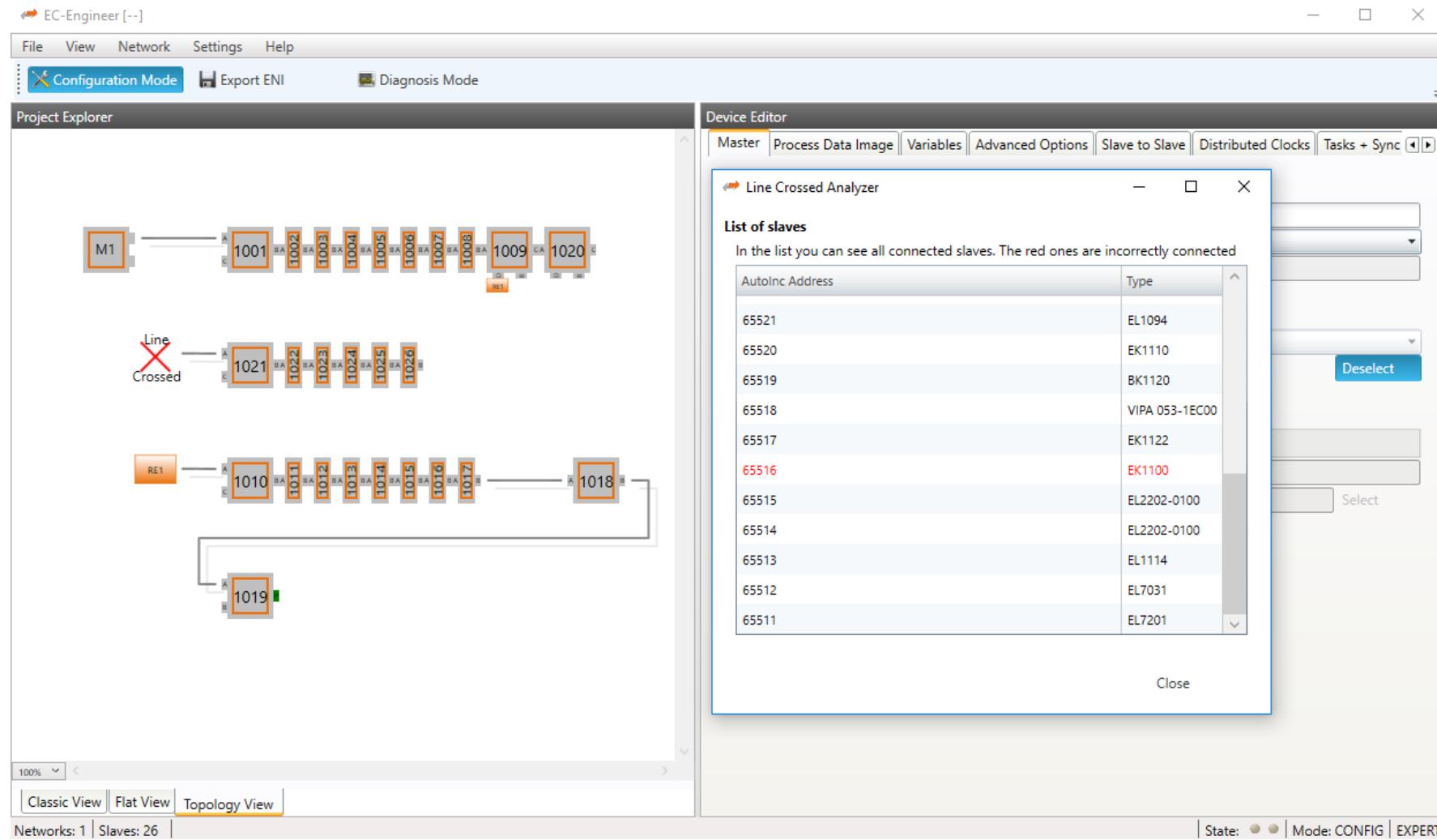
State:  Mode: DIAGNOSIS EXPERT

Classic View Flat View Topology View

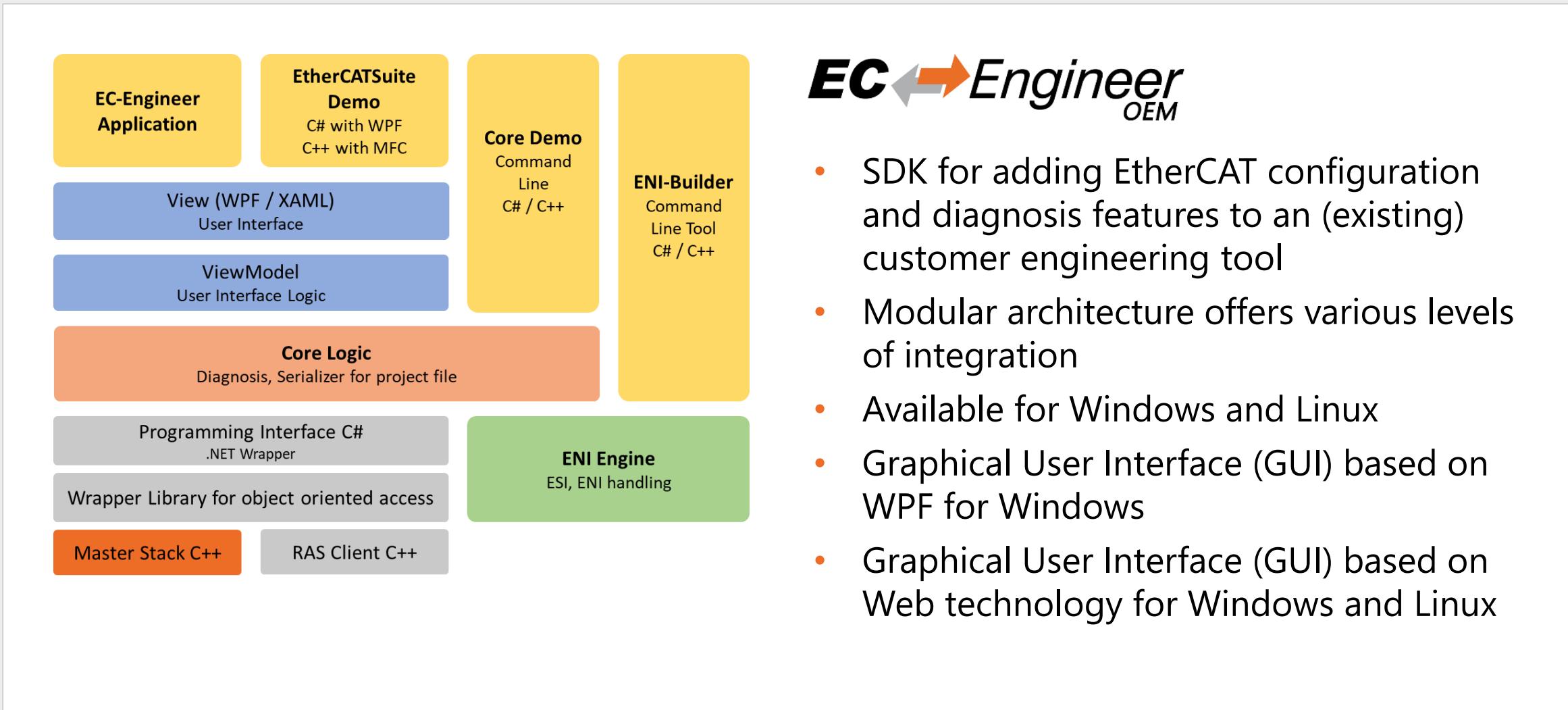
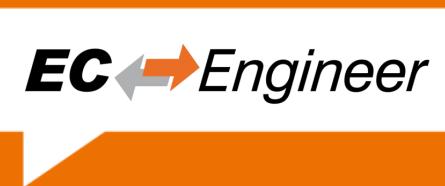
Messages

Severity Time Message

# Comprehensive diagnostic: Powerful “Line crossed” detection



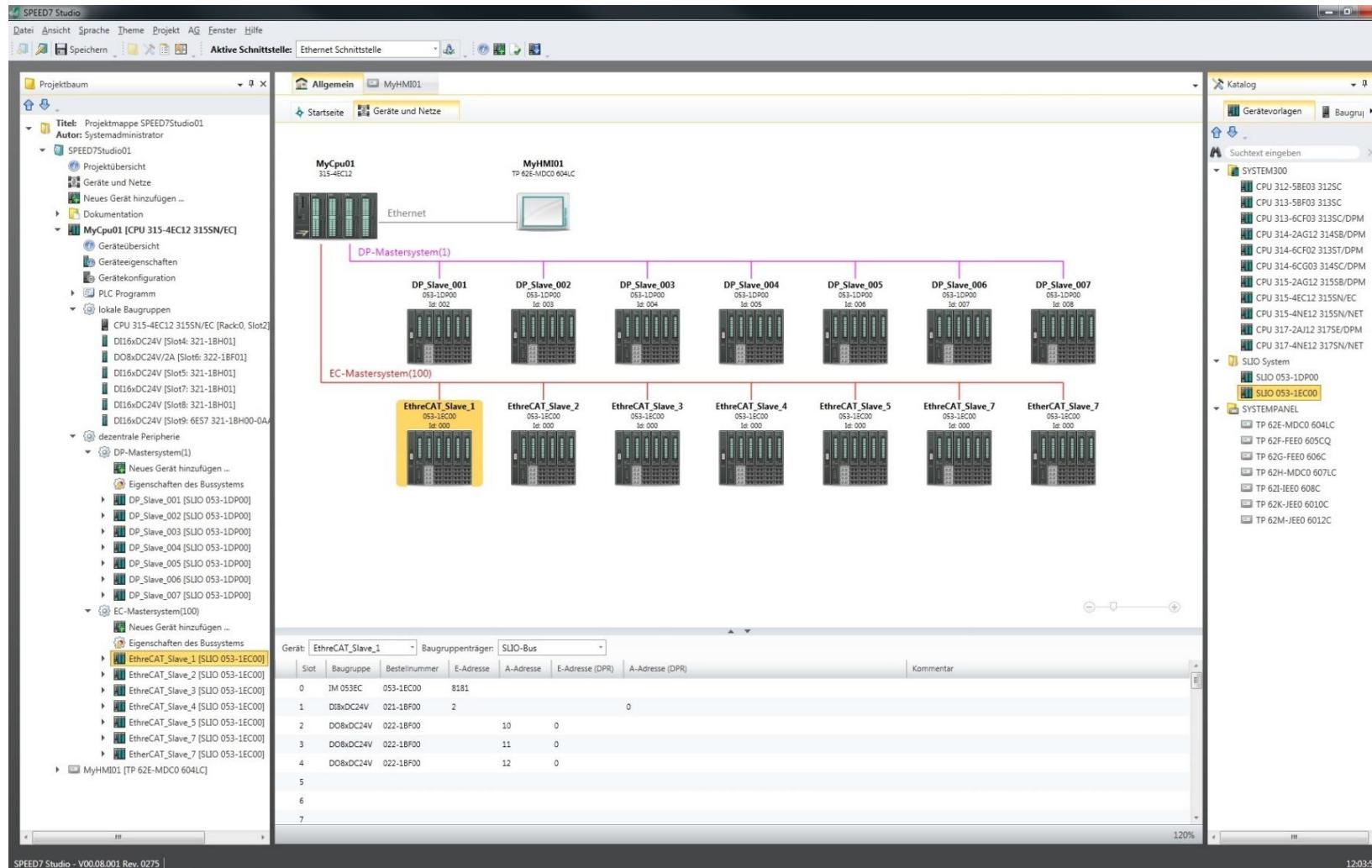
# EtherCAT Configuration Tool Software Development Kit (SDK)



**EC** **Engineer**  
*OEM*

- SDK for adding EtherCAT configuration and diagnosis features to an (existing) customer engineering tool
- Modular architecture offers various levels of integration
- Available for Windows and Linux
- Graphical User Interface (GUI) based on WPF for Windows
- Graphical User Interface (GUI) based on Web technology for Windows and Linux

# Example: Integration into PLC programming tool YASKAWA SPEED7 Studio

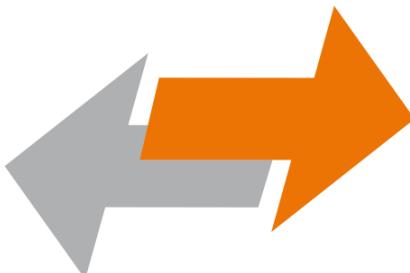


- **Easy to use - modern** design
  - ⇒ Build a configuration in less steps
  - ⇒ Only reasonable settings and options are visible, expert settings visible only if required
- **Powerful online functions** together with EC-Master
  - ⇒ Network scan local & remote, compare configured and found slaves (network mismatch view)
  - ⇒ Access to states, variables, object dictionary, ESC register, EEPROM, etc.
  - ⇒ Figure out the location of communication errors (bad cables and connectors, vibrations, etc.)
- **EtherCAT Master Information (EMI)** file for specifying master device features
  - ⇒ The configuration tool offers only supported features of the selected EtherCAT controller
  - ⇒ E.g. maximum number of EtherCAT SubDevices or process data size or cycle time limitations
- **Software Development Kit** available
  - ⇒ Adjust to customer needs or integrate into customer engineering environment

# Additional information



- EC-Engineer tutorials and user manual  
<https://developer.acontis.com/ec-engineer>
- Request for EC-Engineer technical details slides
- Request for evaluation software  
<https://www.acontis.com/en/ethercat-support-eval-request.html>

**EC**  *EngineerWeb*

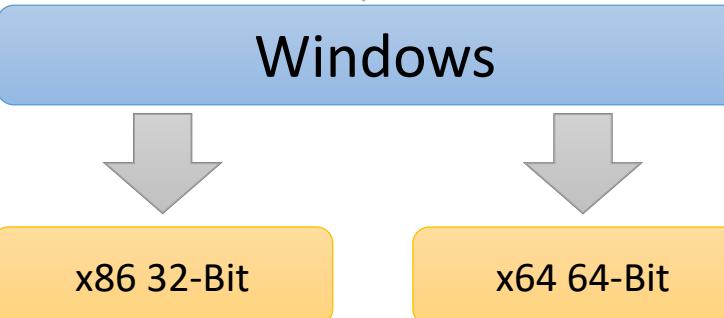
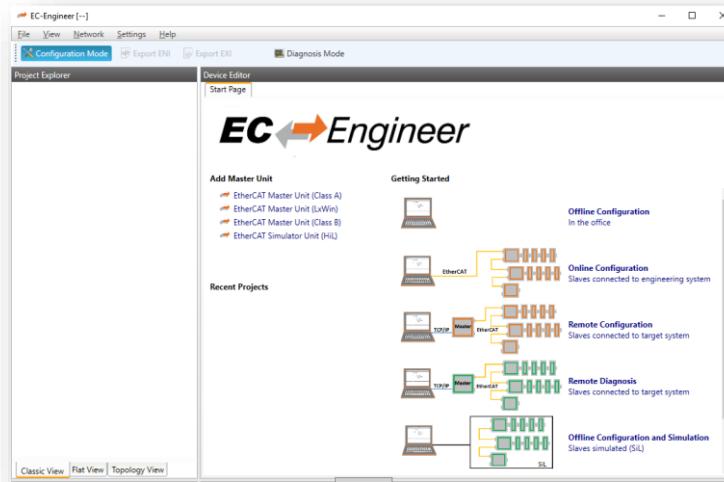
**Web Edition**

**EtherCAT Configuration and Diagnosis using a Browser**

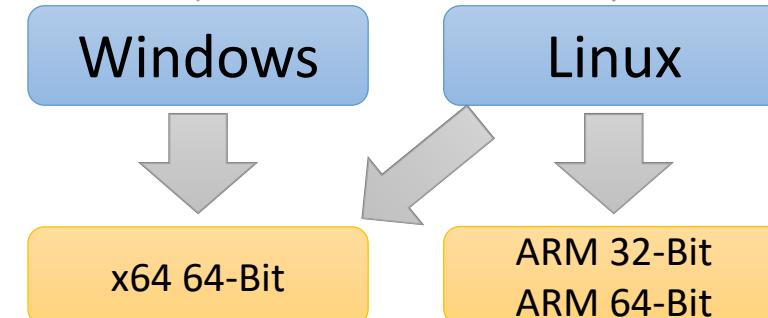
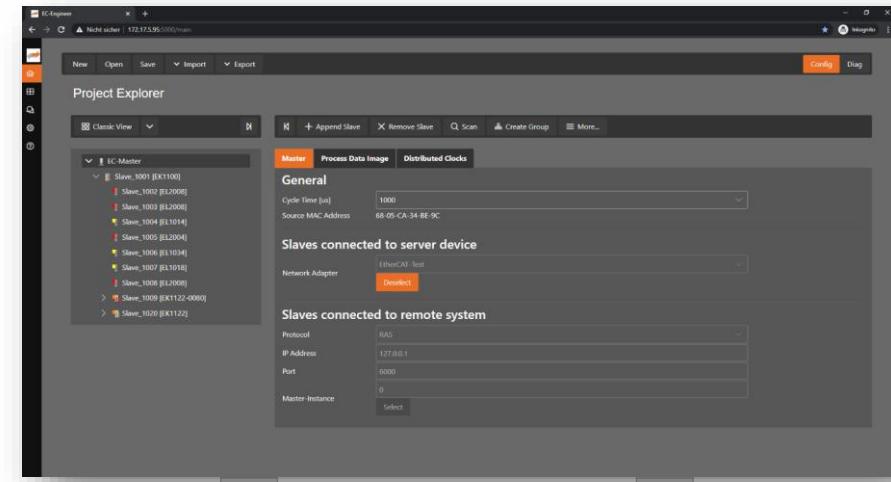
# EC-Engineer vs EC-EngineerWeb



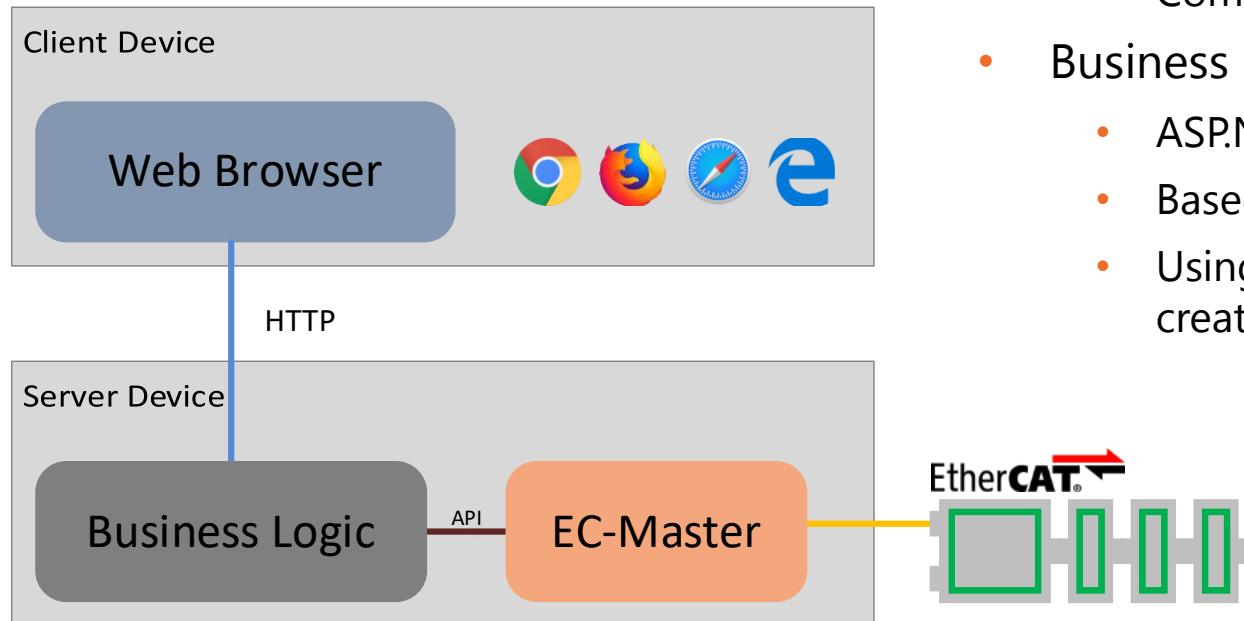
**EC**↔Engineer



**EC**↔EngineerWeb



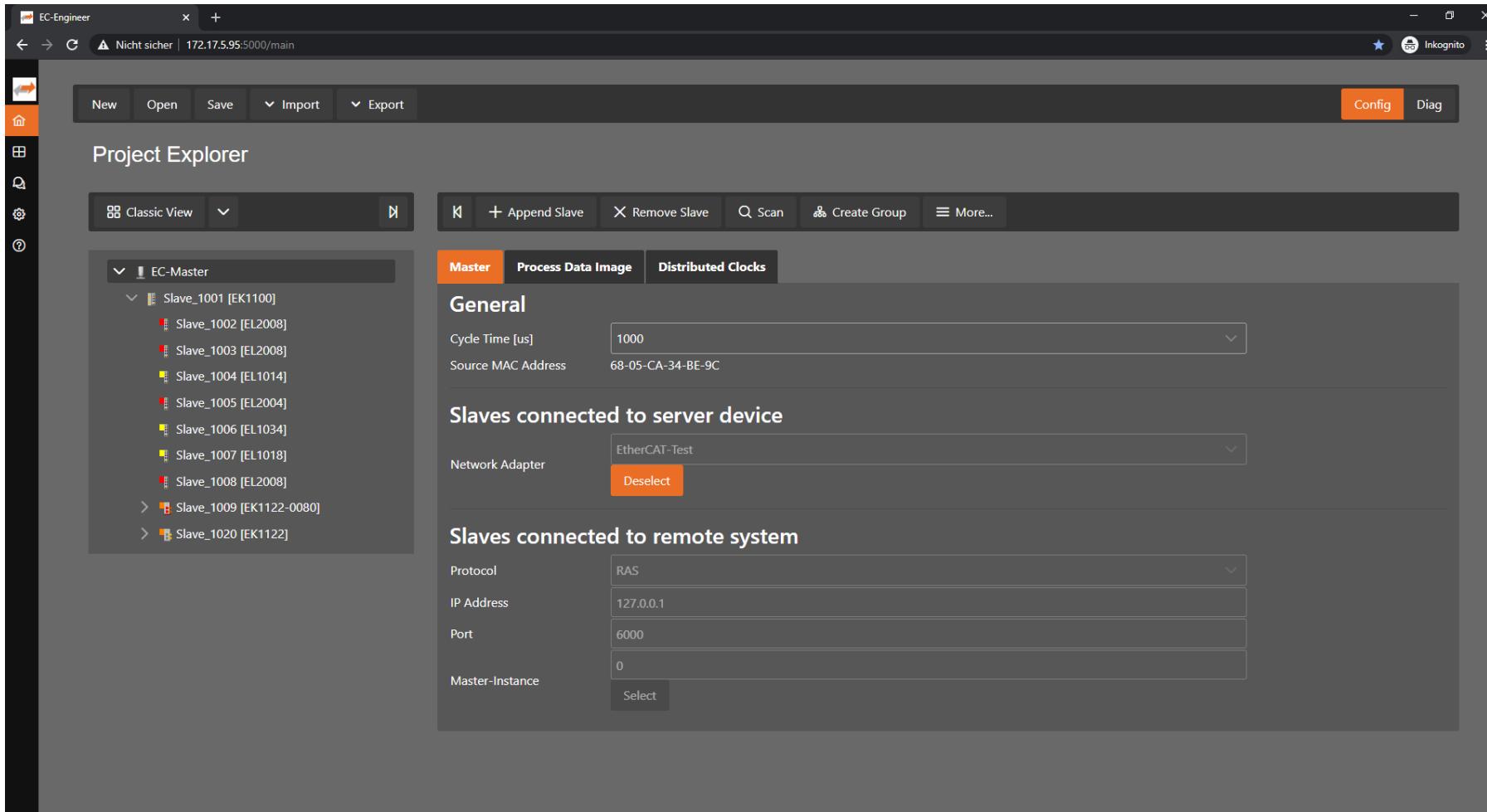
EtherCAT configuration and diagnosis tool using a standard browser as user interface:



- Web Browser with HTML5 and JavaScript support
  - Desktop computer
  - Mobile devices (tablet, smartphone)
  - Communication to backend via HTTP
- Business logic (RACE)
  - ASP.NET Core Web Application
  - Based on Microsoft .NET Core 3.1
  - Using the same, well proven core logic and ENI creation algorithm as EC-Engineer

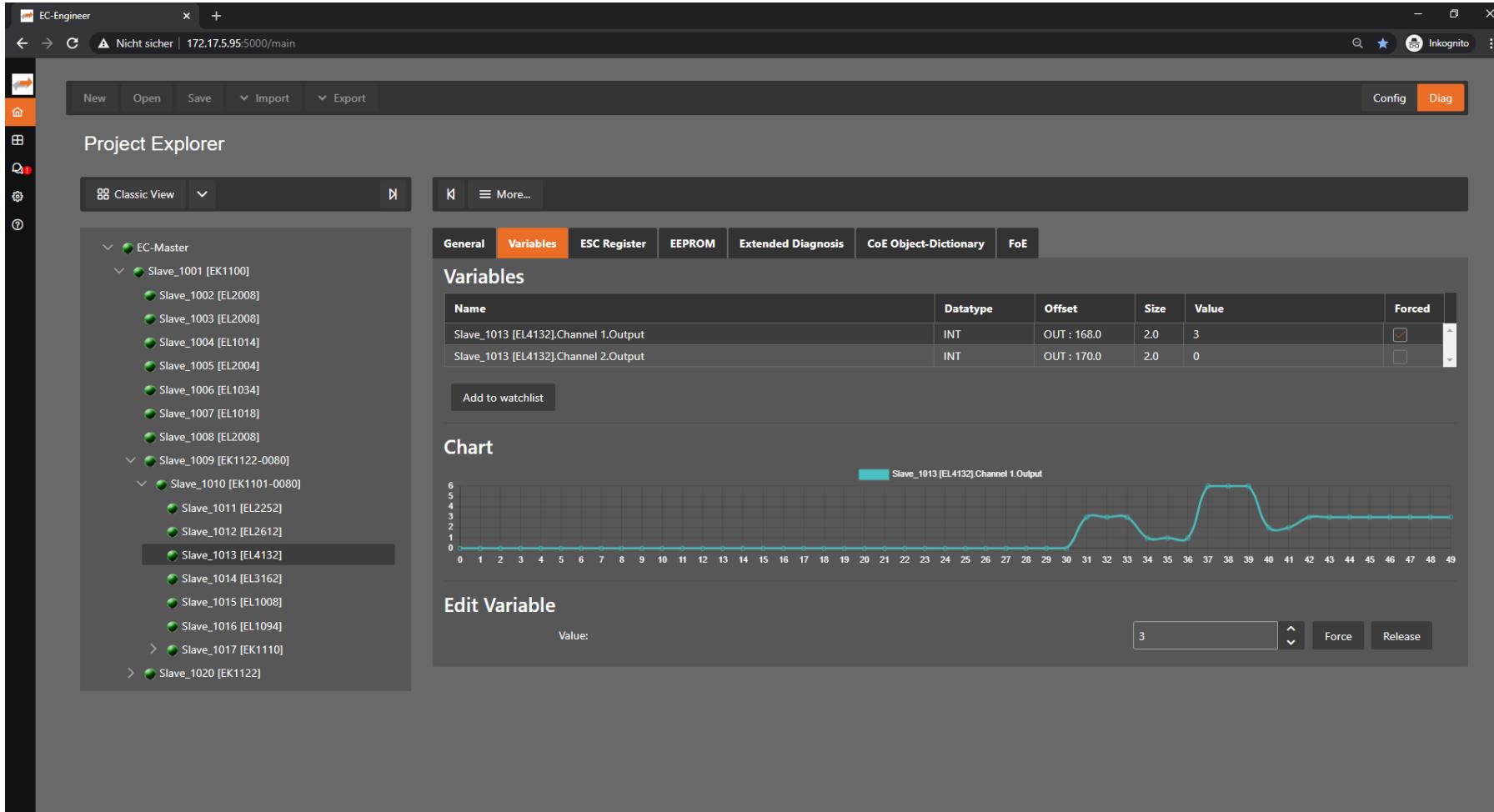
# Configuration Mode

## Full features including MDP etc.



# Sophisticated Diagnosis Features

## Monitoring and forcing of Variables etc.



The screenshot shows the EC-Engineer software interface. The top navigation bar includes 'New', 'Open', 'Save', 'Import', 'Export', 'Config', and 'Diag' buttons. The 'Diag' button is highlighted in orange. The left sidebar features a 'Project Explorer' with a tree view of project components, including 'EC-Master' and various 'Slave' nodes. The main content area is titled 'Variables' and displays a table with the following data:

Name	Datatype	Offset	Size	Value	Forced
Slave_1013 [EL4132].Channel 1.Output	INT	OUT : 168.0	2.0	3	<input checked="" type="checkbox"/>
Slave_1013 [EL4132].Channel 2.Output	INT	OUT : 170.0	2.0	0	<input type="checkbox"/>

Below the table is a 'Chart' section showing a line graph of 'Slave\_1013 [EL4132].Channel 1 Output'. The x-axis represents a sequence of numbers from 0 to 49, and the y-axis represents values from 0 to 6. The graph shows a step function that remains at 0 until index 30, then rises to 3, stays at 3 until index 38, drops to 0, and then stays at 0 until index 49. A legend indicates the blue line represents 'Slave\_1013 [EL4132].Channel 1 Output'. At the bottom, there is an 'Edit Variable' section with a 'Value:' input field containing '3' and 'Force' and 'Release' buttons.

# Additional information



- EC-Engineer Web user manual  
<https://developer.acontis.com/ec-engineer>
- Request for EC-Engineer Web technical details slides
- Request for evaluation software  
<https://www.acontis.com/en/ethercat-support-eval-request.html>



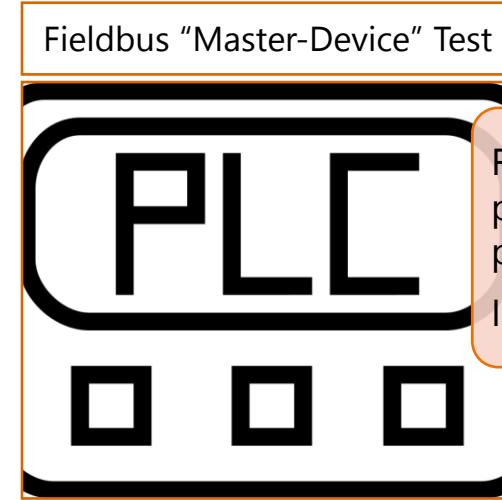
## EtherCAT® Network Simulation

Run an EtherCAT controller with a simulated network

# Use Cases



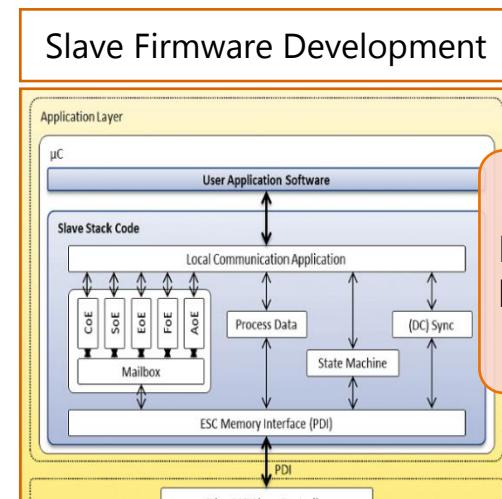
Run the Master application without real slaves  
Comfortable Debugging of complex topology/slave type scenarios



Replace manual test procedures by automatic procedures.  
Implement enhanced tests

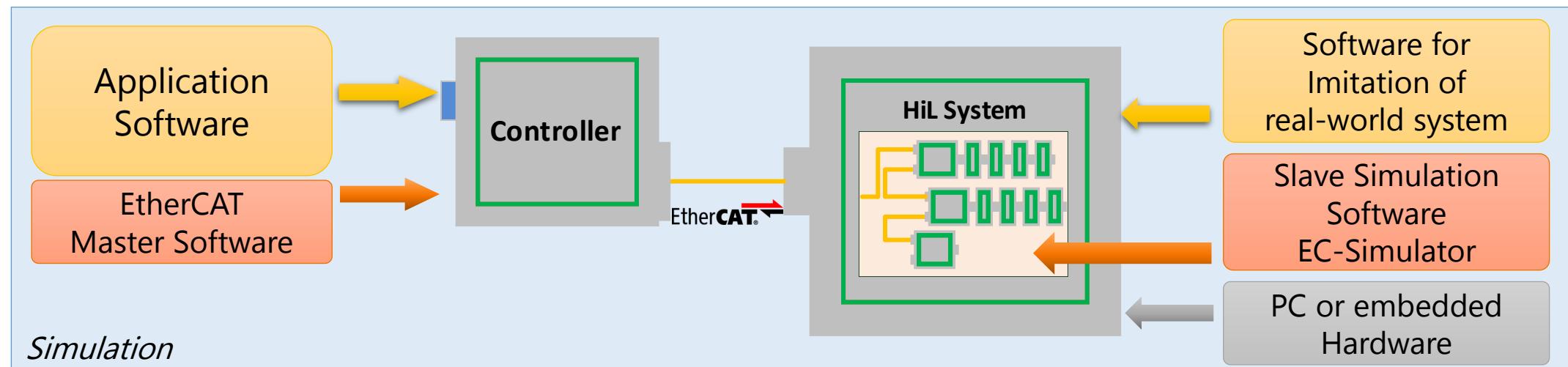
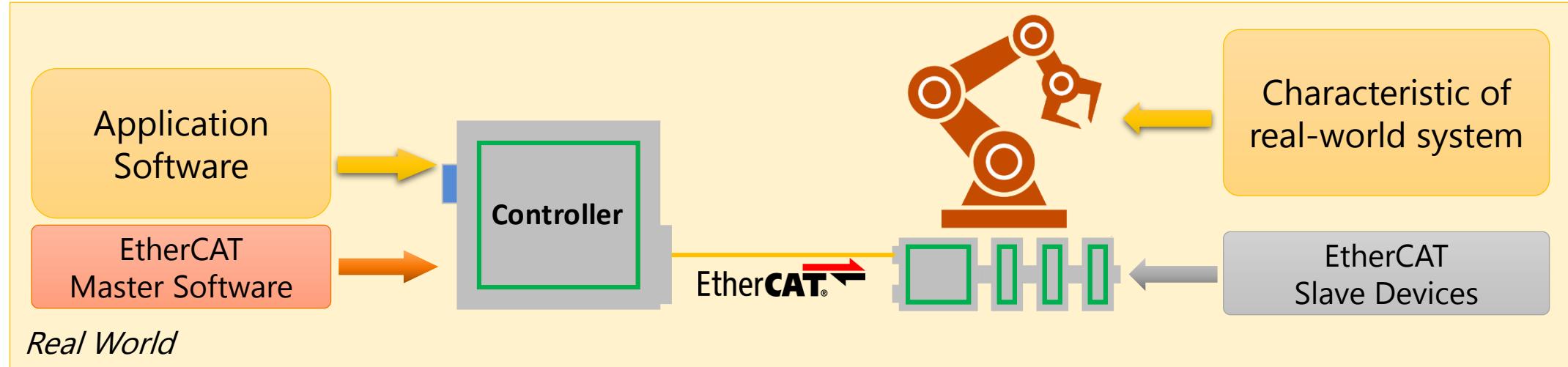


Develop and test applications based on a software emulation of the machine logic



Develop slave firmware before hardware is available

# General System Architecture

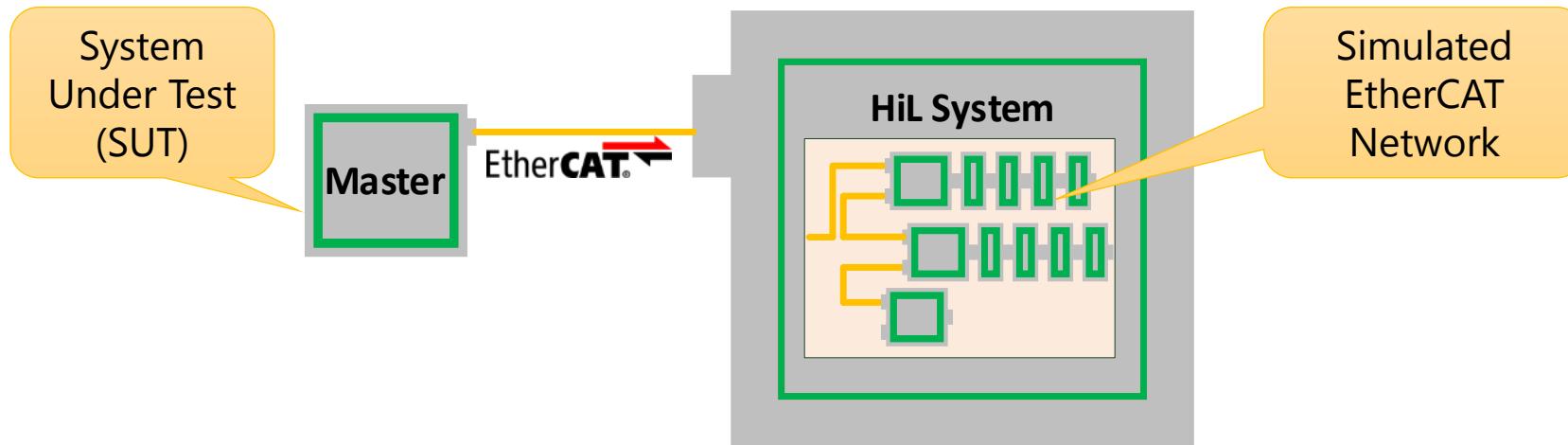


# Hardware-in-Loop (HiL) Simulation

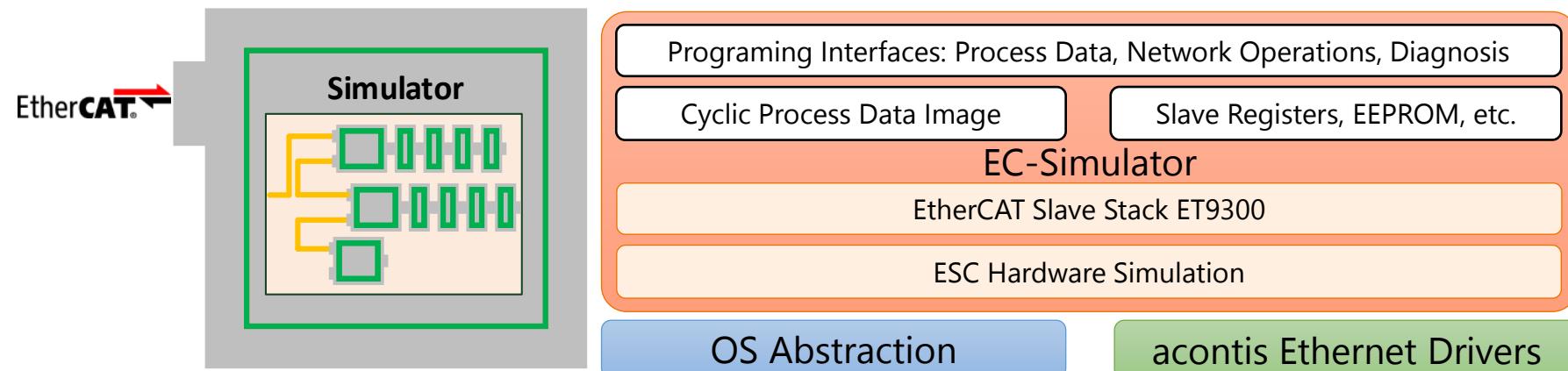
## All slaves are simulated

EC  Simulator

- The System-Under-Test (SUT) is communicating via an EtherCAT cable with the EC-Simulator software running on an external hardware, the HiL System.
- HiL System doesn't require special hardware, a standard Ethernet interface can be used
- In this setup the original application together with the EtherCAT Master can be tested



# HiL Simulation: Software architecture

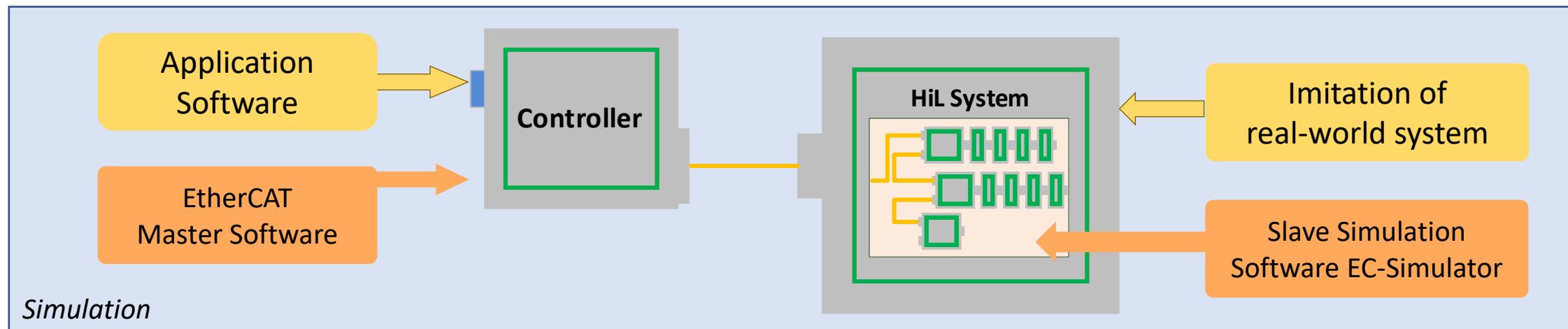


- Support for various operating systems, e. g. Linux and Windows
- High performance due to the acontis Real-time Ethernet drivers
- Simulation of EtherCAT Slave Controller (ESC) hardware in software
- Implementation of Beckhoff EtherCAT Slave Stack ET9300
- EC-Simulator offers a "C" language application programming interface (API)

# Use Case: Virtual Commissioning

EC  Simulator

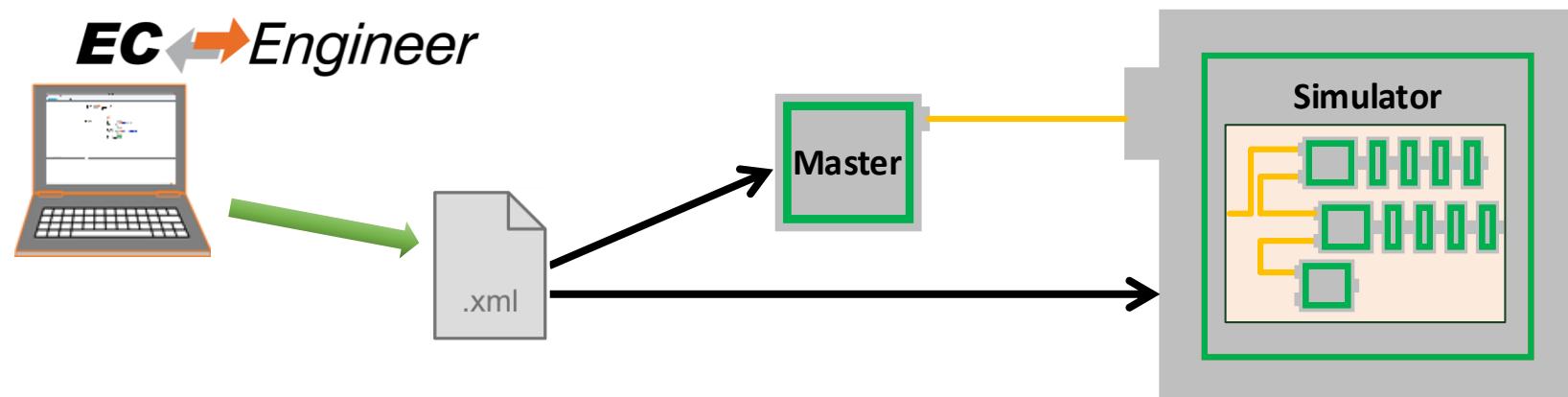
- EC-Simulator together with Digital-Twin Software
- Test and optimize the application during early engineering-stages, without real existing target hardware.
- Test error scenarios which are dangerous and/or lead to damages



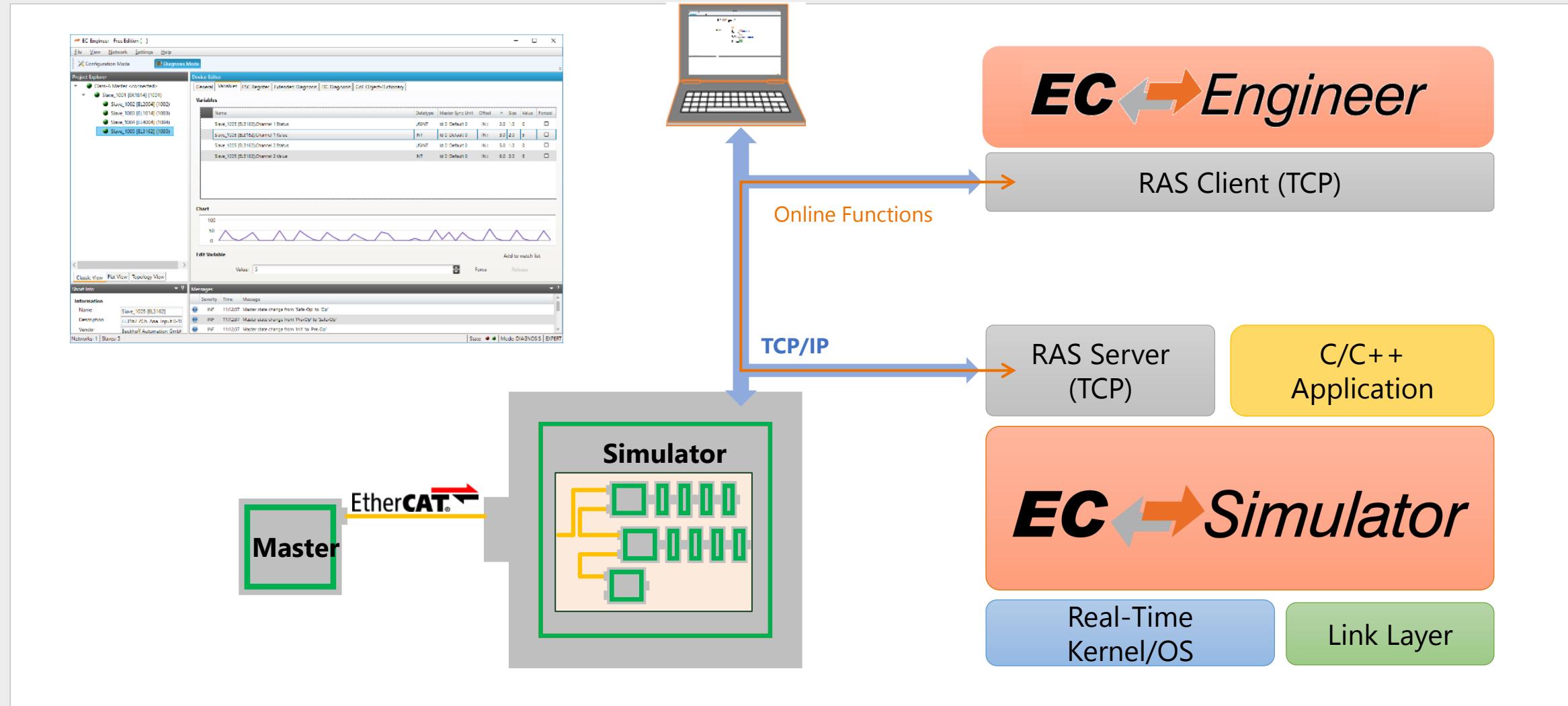
# Configuration based on ENI file



- Standard EtherCAT Network Information (ENI) file is used to configure the EC-Simulator software
- ENI can be exported by EC-Engineer or any other configuration software, e. g. Beckhoff TwinCAT, supporting it.



# Diagnosis with EC-Engineer



# Simulate Power Loss, Link Loss and Frame Errors with EC-Engineer



**Device Editor**

General Variables ESC Register EEPROM Extended Diagnosis DC Diagnosis CoE Object-Dictionary FoE Simulator

**State Machine**

Current State: Op

**Slave Power**

Change the power condition of the slave. After a power cycle the slave is in INIT.

Power off Power on

**Slave Connection**

Change slave connection. Unplug or change connection to previous slave. Does not power off the slave.

Connect to Slave Address: 1001 Port: B

Disconnect Connect

**CRC Error**

Generate a CRC error at a specific port (once or probability).

Port: A Probability (%): 0,0500

Set once Set random Reset random

**Link Loss**

Generate a Link Loss at a specific port for a specific time (once or probability).

Port: A Down time (s): 5,0 Probability (%): 0,01

Set once Set random Reset all ports

- Power down/up a specific slave
- Create CRC errors on a specific port (by random)
- Simulate test cases like "Unplugging a cable"

# Software-in-Loop (SiL) Simulation



## Setup with real devices only

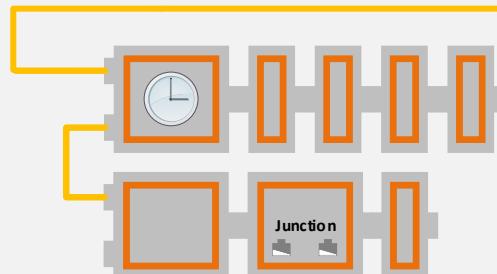
Customer Application C/C++

**EC** Master

OS  
Abstraction

Ethernet Driver

Standard  
Ethernet MAC



## Simulated Slaves

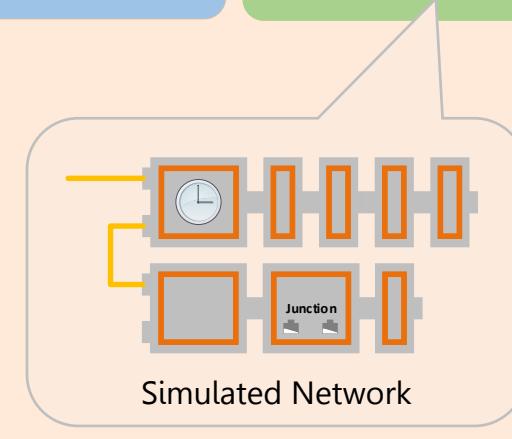
## Flexible setup with simulated devices

Customer Application C/C++

**EC** Master

OS  
Abstraction

**EC** Simulator



- **Hardware-in-the-Loop:**
  - ⇒ Simulate a complete EtherCAT network on a PC or embedded system running Windows, Linux, QNX, etc.
- **Software-in-the-Loop:**
  - ⇒ Simulate a complete EtherCAT network on the EC-Master controller
- Comprehensive functions to **simulate errors**
  - ⇒ Including broken cable, wrong cabling, slave failures
- EC-Simulator **API** is mainly **equal** to EC-Master API
- Integration of **own slave firmware** possible

# Additional information



- EC-Simulator product intro video  
[https://youtu.be/5ToJh7gJ\\_Go](https://youtu.be/5ToJh7gJ_Go)
- EC-Simulator tutorials and user manual  
<https://developer.acontis.com/ec-simulator>
- Request for EC-Simulator technical details slides
- Request for evaluation software  
<https://www.acontis.com/en/ethercat-support-eval-request.html>