Challenges for Cluster Simulation for FlexRay Systems

Dietmar Millinger, May 2008

EB Today

- Cutting-edge embedded technology solutions for **automotive** and **wireless** markets
  - superior technology skills
  - unique development culture
  - ability to lead the most challenging projects
  - anticipating changing and growing market and end-user needs
- Over 1700 employees
- Present in 7 countries on 3 continents.
- Net Sales of MEUR 144 or MUSD 211 in 2007, listed on OMX Helsinki

Facts and Figures EB Automotive

- Executive Vice President, Automotive: Otto Fößel
- Employees: approx. 500 (June 30th, 2007)
- Germany:
  - Erlangen
  - Munich
  - Böblingen
  - Gaimersheim
  - Braunschweig
- Austria: Vienna
- Japan: Tokyo
- USA:
  - Novi, MI
  - Bothell, WA

Automotive Software

Infotainment

Cockpit, Multimedia, Navigation, HMI, MOST

- Functional software, HMI development, tools
- References: HMI development of the MOST based infotainment system in the current A6 (direct order from AUDI)

Driver Assistance

Driver Environment Information, Predictive Systems

- Functional software, basic software, sensor fusion, pattern recognition, embedded 2D & 3D image processing, lane detection
- Software infrastructures for research, development and benchmarking

Automotive Software

Navigation

White label for mobile devices, fixed installation

- Navigation kernel, user interface, localization for Europe, North America, Asia, flexible feature extension
- References: Medion, Ford, Blaupunkt, Delphi, Falk, Freescale, Analog Devices, NXP

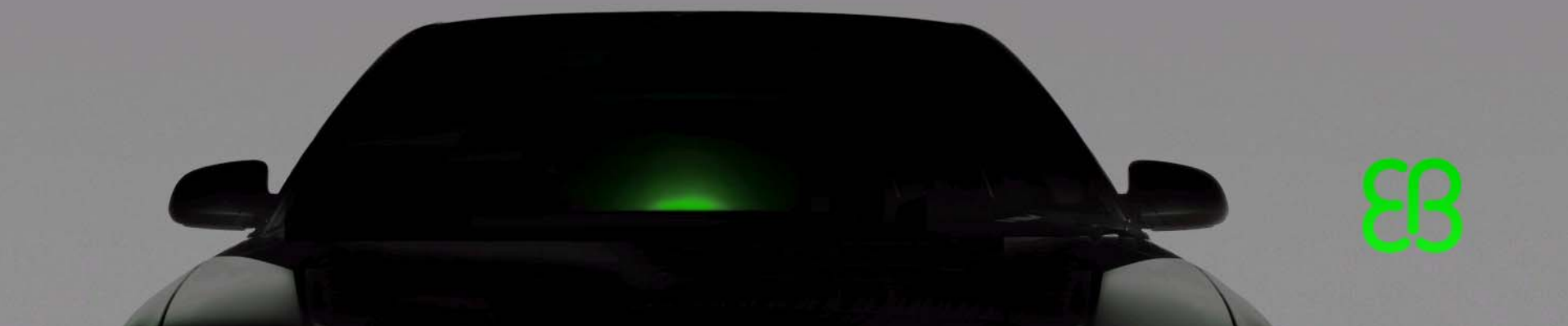
Body / Chassis / Comfort / Powertrain

Comfort electronic, x-by-wire, etc.

- AUTOSAR-compliant basic software
- FlexRay products and technologies
- References: BMW standard core, EB tresos® Automotive Standard Core

FlexRay Cluster Simulation

- Overview
- FlexRay properties
- Cluster simulation system
- Findings in first projects



Why Cluster Simulation?

- Use areas are
  - development of distributed functions
  - development and integration of ECU basic software
  - testing and validation of ECUs
  - production testing of ECUs

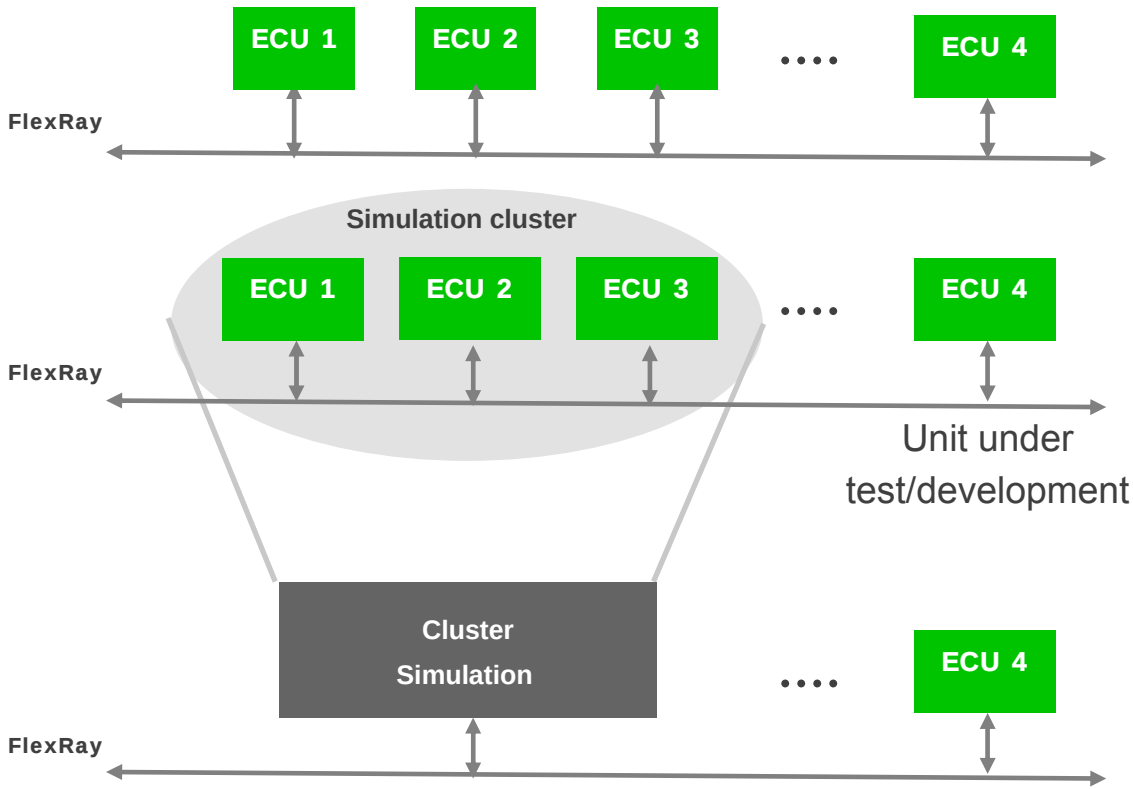
- Objectives are
  - simulation of function parts that are still under development
  - simulation of ECUs which are still under development or not available
  - control over network based system services
  - generation of stimuli for function testing
  - judgment of generated output of ECUs under development

Cluster Simulation Principle

Planned FlexRay network

Definition of simulation cluster

Development/Test cluster



Current Status of Cluster Simulation

- Widely used
  - multiple suppliers
  - broad customer basis
- Huge number of legacy systems for testing in operation
- Suitable for CAN network technology
- Soft real-time behavior
  - network and simulation system can align to each other
- Easy to configure
  - vendor specific databases

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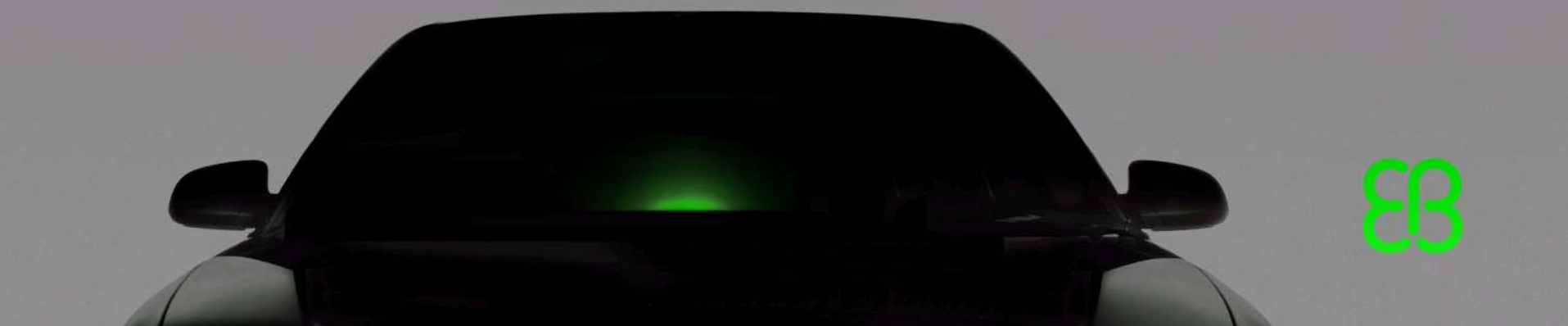
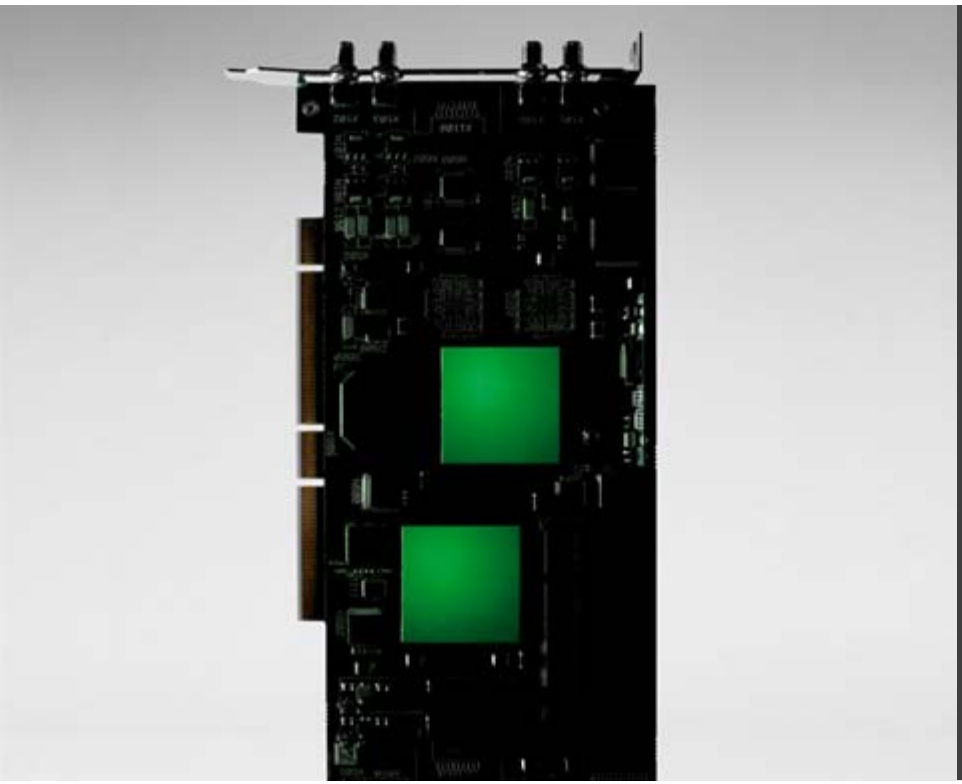


Selected Properties of FlexRay



- Configuration
- Real-Time Protocol
- High bandwidth
- Startup

Configuration

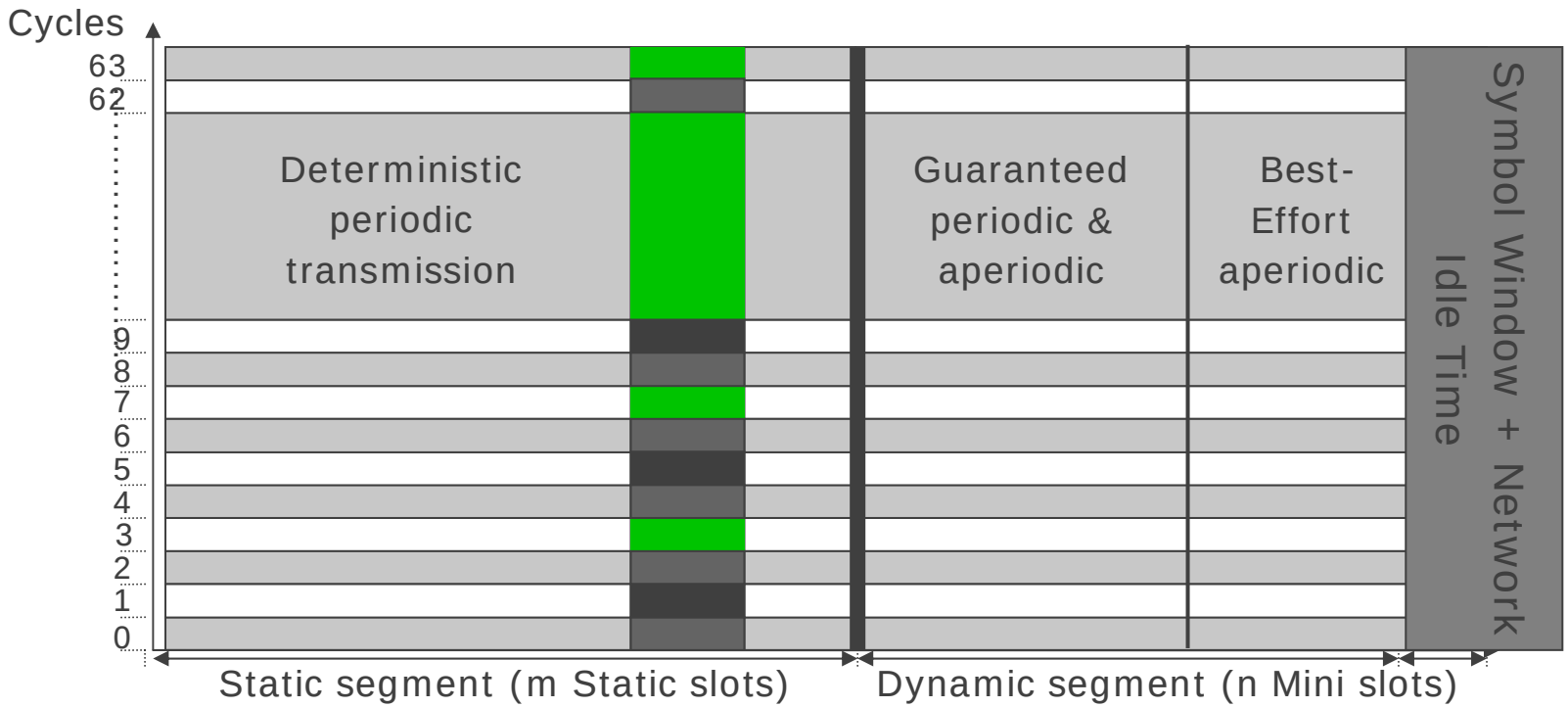
- FlexRay requires an extensive configuration
  - TDMA pattern (global)
  - buffer layout (local)
  - register settings (local)

- Global part of configuration needs to be provided by network integrator
- Local part has to be calculated

- Configuration exchange format for FlexRay is FIBEX
  - FlexRay configuration parameters
  - System architecture information (ECUs, signals, functions,…)

FlexRay Configuration Space

64 Cycles by up to 2047 slots on two channels ➔ up to 130.000 cells on two channels
many constraints



Missing Configuration in FIBEX

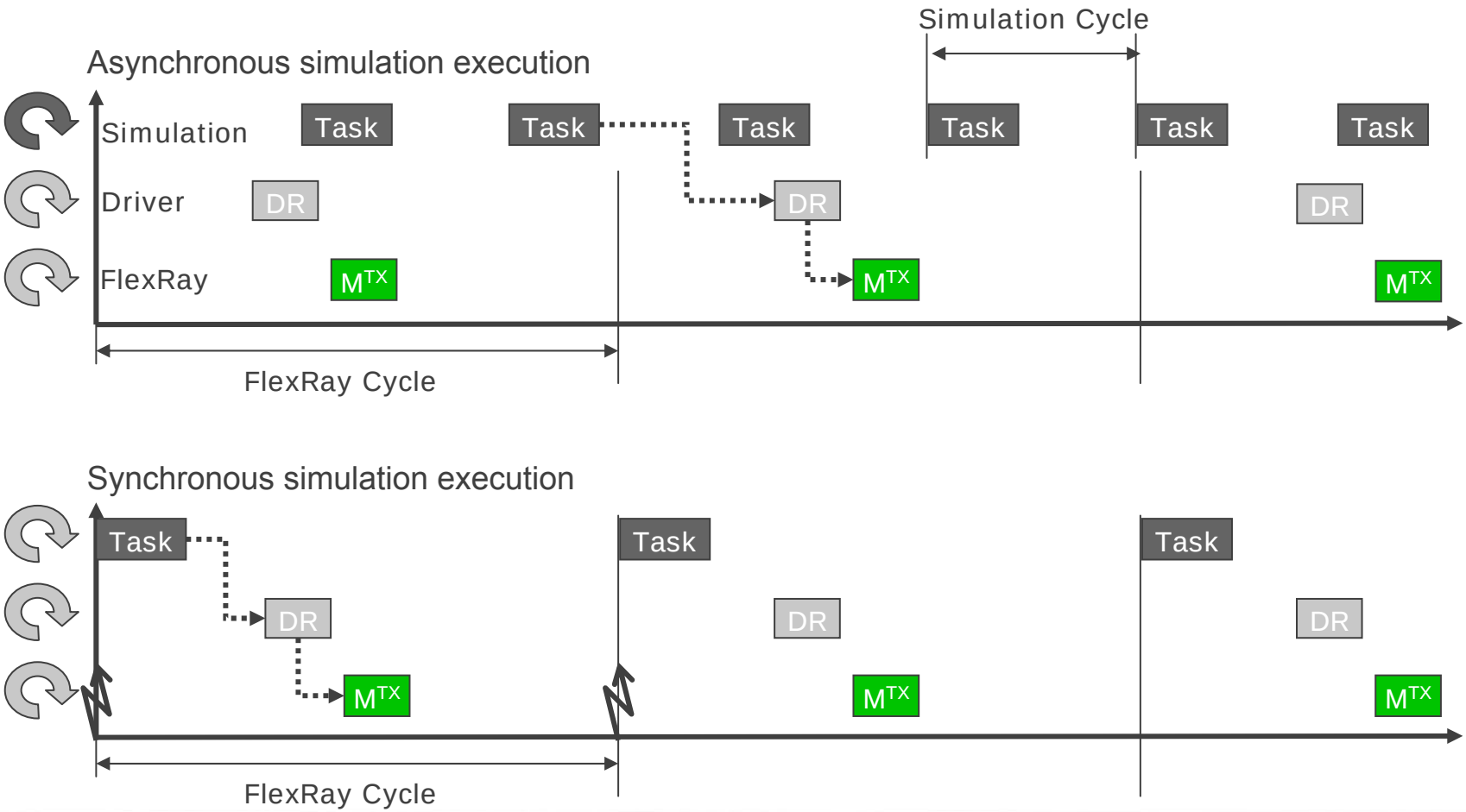
- FIBEX is the exchange file format for FlexRay network design
- Some parameters for cluster simulation configuration are missing in the FIBEX file
  - FlexRay parameters at register level
  - Allocation of receive and transmission buffers
  - Scheduling of communication driver tasks
  - Selection of ECUs in simulation cluster

Configuration tool needs to hide configuration complexity from test engineer and has to complete missing configuration information automatically

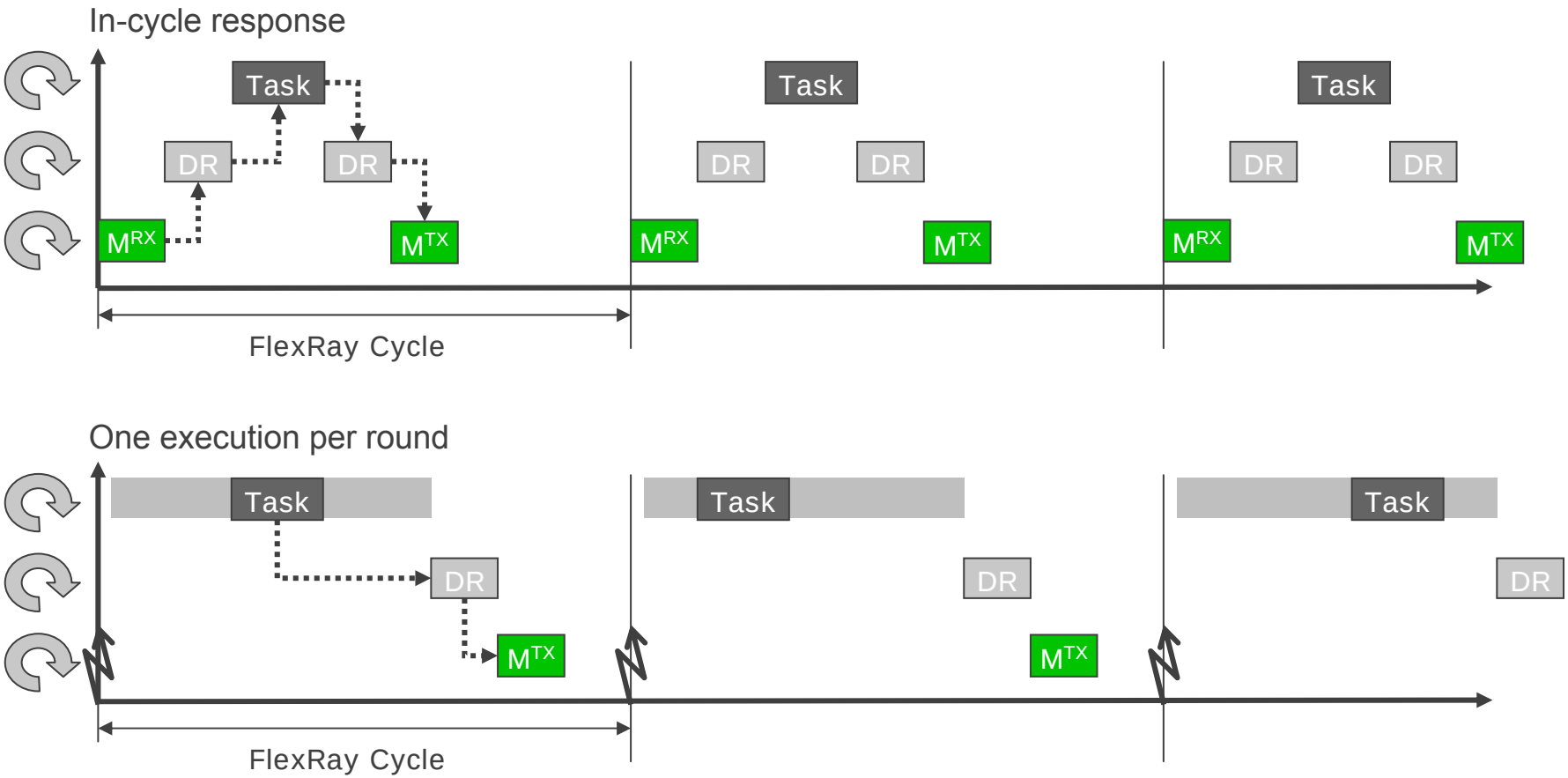
Real-Time Protocol

- FlexRay protocol executes a strictly periodic time regime
- Communication stack has to be executed synchronous to FlexRay
  - Ensure data consistency
  - Avoid loss of data
- In certain cases simulation tasks need to be executed synchronous to FlexRay
  - in-cycle response required (receive, process, transmit inside one cycle)
  - system services (e.g. round based algorithms, exactly one calculation per round)
  - manipulation of frames after complete assembly of frame (e.g., CRCs)

Real-time Execution



Synchronous Models



Real-Time Task Execution

- Simulation tasks run asynchronous to FlexRay cluster
  - usual case, since HIL is hard to synchronize with FlexRay
- Simulation task runs synchronous to FlexRay

- In case of asynchronous model execution, some simulation tasks must be encapsulated and executed synchronously (real-time modules)
- In both execution models consistent data exchange must be ensured

Cluster simulation needs to support both types of real-time execution in one system

FlexRay Bandwidth

- 10 MBit/s bandwidth on one channel
- 7,6 MBit/s bandwidth on one channel available for application payload
- e.g. 254 bytes each 266 µs

- →FlexRay bus can produce a very high CPU load for data handling

A cluster simulation solution for FlexRay should keep CPU load for FlexRay handling encapsulated

FlexRay Startup

- An isolated FlexRay controller does not perform startup
- An isolated FlexRay controller does not establish a continuous communication
- Due to the distributed clock synchronization mechanism in FlexRay at least one partner node is required
- For a stable development environment of one ECU at least two additional communication partners are required

A cluster simulation solution should provide a stable network for the ECU under development

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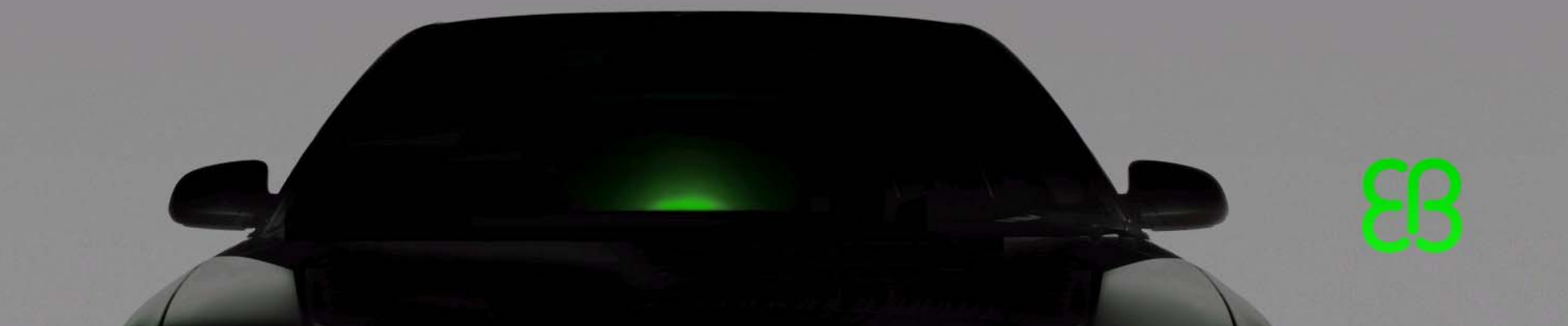
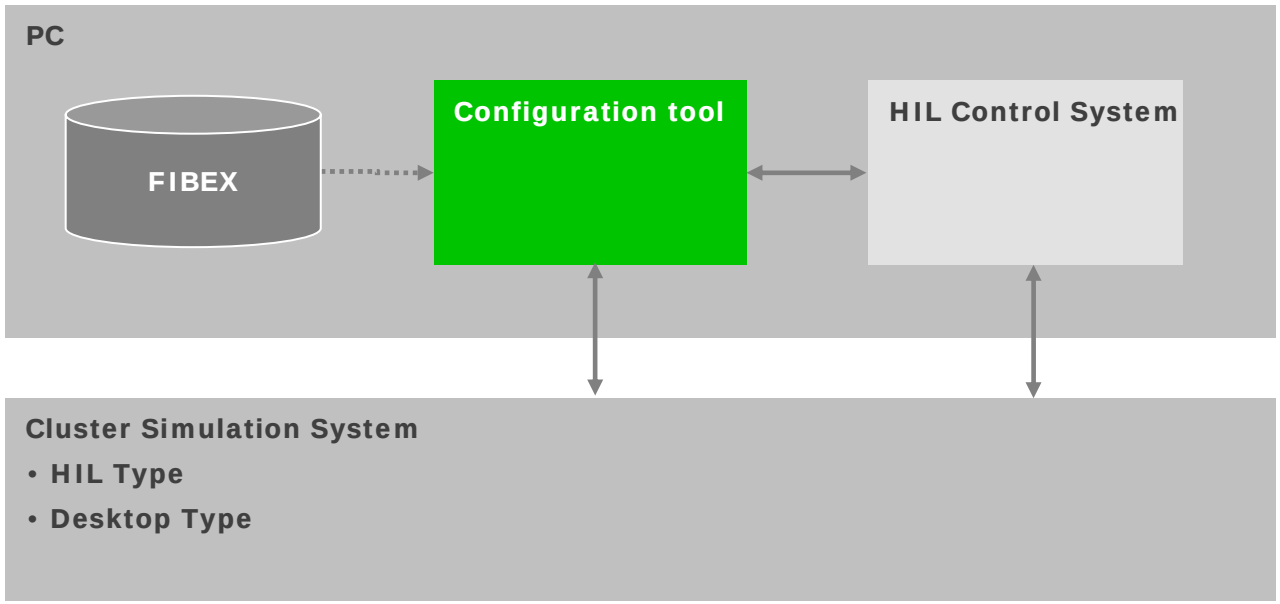
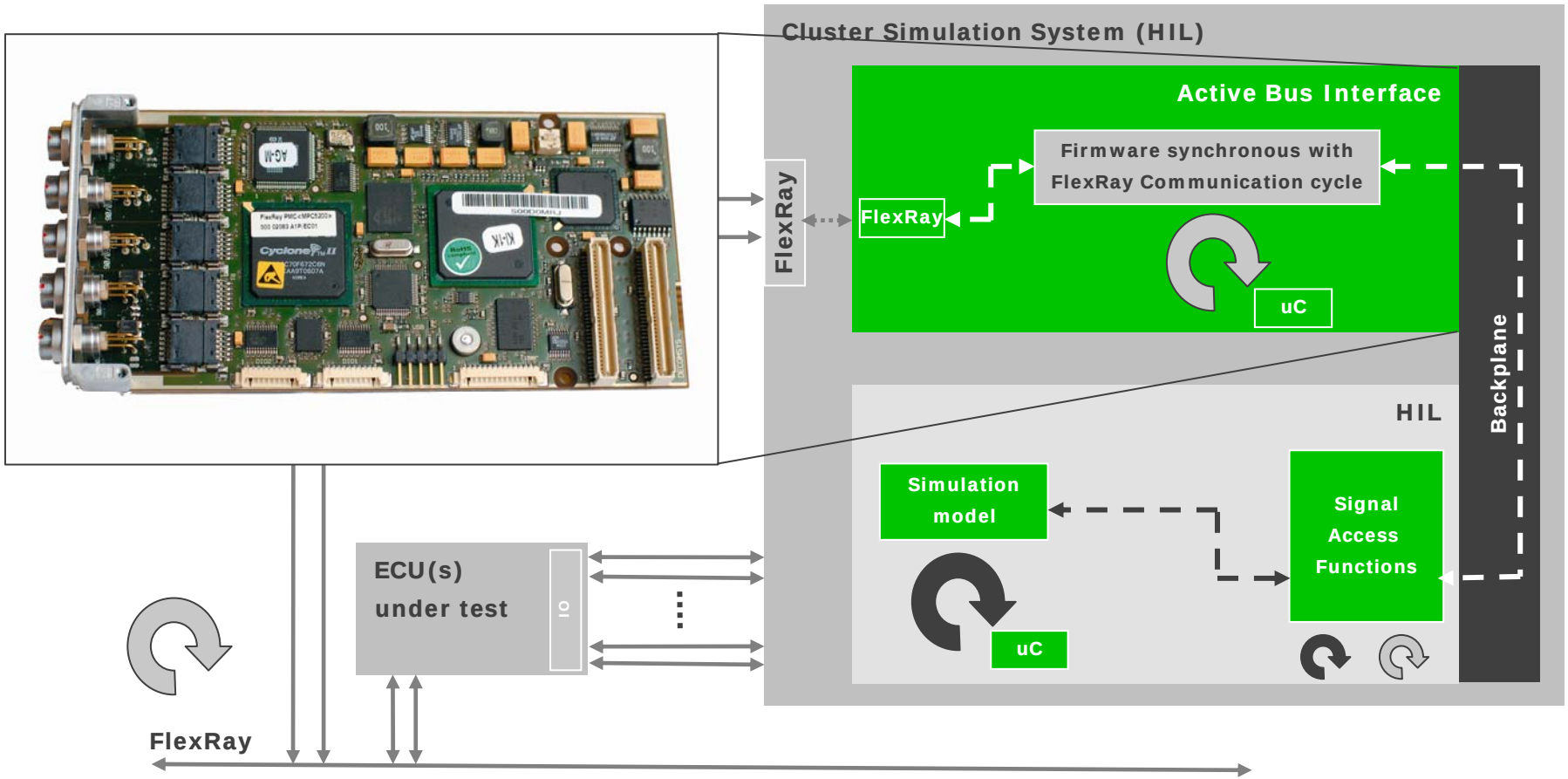


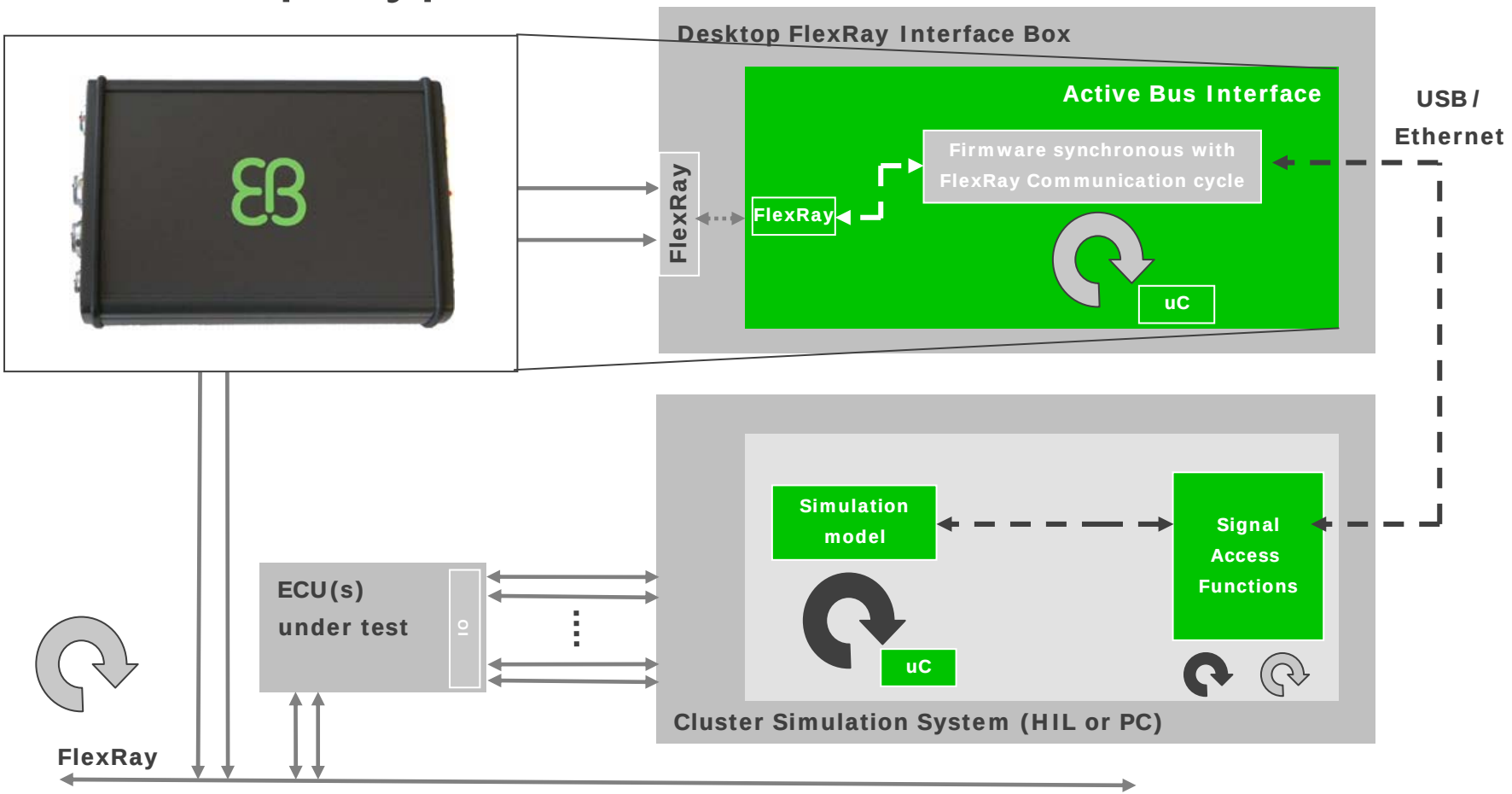
Cluster Simulation System
Control system



Cluster Simulation System
HIL Type

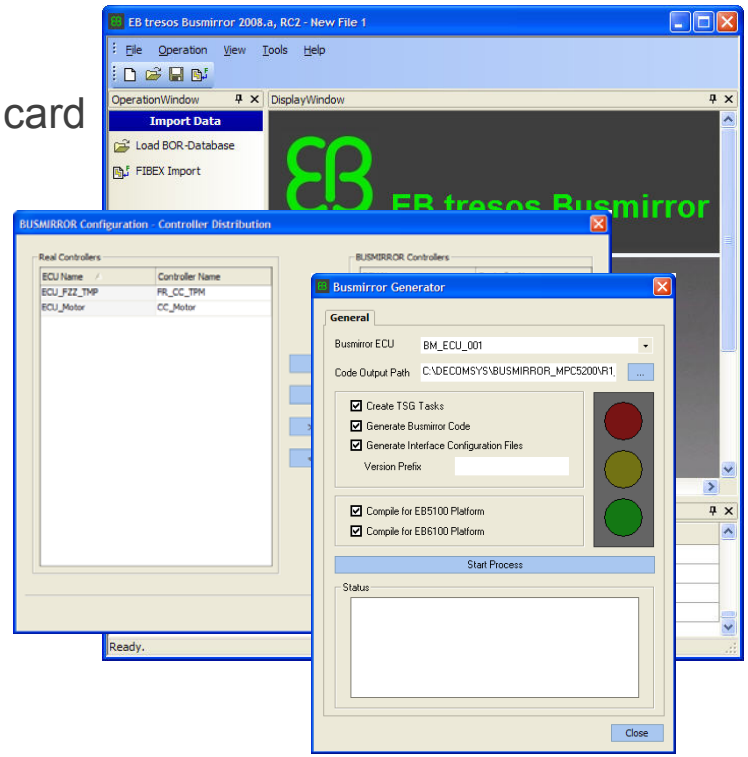


Cluster Simulation System Desktop Type



Configuration tool

- Import of FIBEX database
- Selection of ECU or controllers to simulate
- Generation of configuration for active interface card
- Download of configuration
- Definition of real-time modules
- Dynamic load/unload of real-time modules



Active Bus Interface

- Sufficient CPU resources for driver task handling
- Real-time modules
  - Execute application functions synchronous with FlexRay
- Mechanism to synchronize HIL with FlexRay
- Standard interface to download configuration
  - USB, Ethernet, PCI, …
- High performance interface to HIL simulator
  - PCI, PCIexpress, PXI, VME, compactPCI,…
  - Ethernet, USB
- Flexible support of different physical layer silicon

Signal Access Functions

- Signal level data access
- Signal conversion
  - conversion between coded format and physical format of signal
- Consistent PDU access
  - in asynchronous task execution model mandatory
  - in synchronous task execution advantageous
- Adaptation to HIL environment
  - Operating system
  - Simulation system
  - Easy to port
  - Library to be integrated in simulation system

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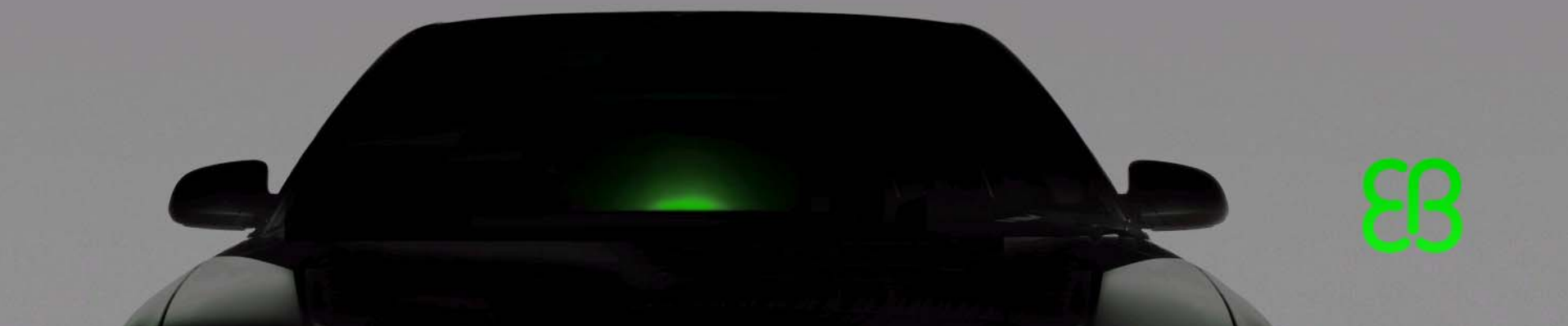

Findings in first projects

- Several projects for OEM and Tier 1 companies evaluated

- Encapsulation of hard real-time execution very important
- Strong request to encapsulate FlexRay configuration complexity
- OEM specific services
  - real-time modules with OEM specific service simulation are valuable assets
- Communication channel between simulation and real-time modules
  - Control behavior of real-time modules (e.g. fault-injection,…)
- Dynamic Change of FlexRay Configuration to support different schedules
  - different schedules for flashing, ECU sensor/actuator tests, application tests
  - fast change of configuration to support fast test turn-around time

Findings from first projects

- Editing of FlexRay configuration in FIBEX
  - complete FIBEX information
  - adapt FIBEX information to reflect new development states
  - FIBEX is not FIBEX is not FIBEX (different OEM flavors)
- Installed hardware base varies widely
  - Flexible solution required

Conclusion

- Cluster simulation and testing for FlexRay is possible even in existing systems
- A range of challenges has to be taken
- Hard real-time regime of FlexRay drives these challenges
- A strong FlexRay development partner and suitable products help you to focus on your test jobs

Discover the Experience