Real-Time Simulation and Testing of Dynamic Systems using xPC Target Turnkey

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Agenda

Why do Real-Time Testing?

How to do Real-Time Testing using xPC Target?

- Preparing models for real-time execution
- Building and deploying models on target machine
- Real-time signal logging, monitoring and parameter tuning
- Test Automation

Understanding Hardware Architecture

Frequent Real-Time Testing Applications

(Aero, Defense, Auto, Energy, Medical Industries)

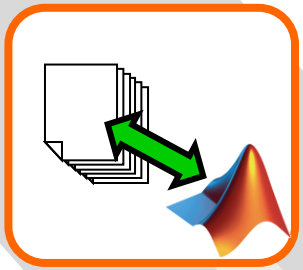
Summary | Q&A

Why do Real-Time Testing?

- ✓ Test, verify, validate, and prove in real-time while maintaining a complete Model-Based Design approach
- ✓ Achieve determinism through system modeling, automatic code generation and a flexible real-time environment
- ✓ Evaluate new ideas using a production independent development platform
- ✓ Reduce costs, shorten time-to-market, and minimize risks

Real-Time Testing: Model-Based Design Tasks

(Continuous Verification and Validation)

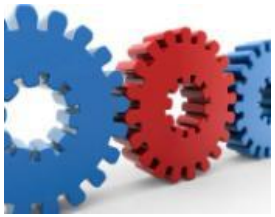


Define Requirements

Modeling and Simulation

System-Level Specification

Rapid Controller Prototyping



Subsystem Design

Code

On Target RCP, Production

Subsystem Implementation

Software-in-the-Loop Simulation

Subsystem Integration & Test

Hardware-in-the-Loop Simulation

System-Level Integration & Test

Complete Integration & Test

System Design

System Testing

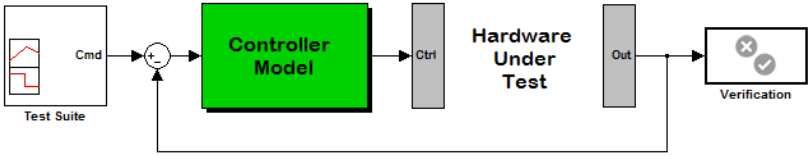
Rapid Controller Prototyping

Hardware-in-the-Loop Simulation

Targeting

Real-time Testing

About Rapid Controller Prototyping

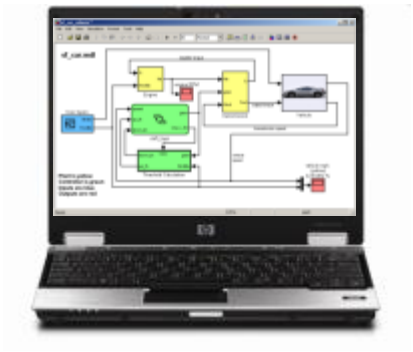


Model, simulate, and test your controller designs while connecting to your physical plant/system

(hardware = physical plant/system)

(software under test = controller model/design)

Code generation



Host including your Simulink control design strategy

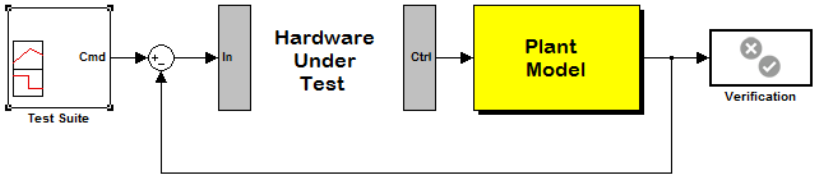
Real-time target machine running your control strategy

Hardware under test

Ethernet (Host-Target link)

Wide range of I/O connectivity options

About Hardware-in-the-Loop Simulation



Model and simulate your physical plant/system while connecting to and testing your actual controller
(software = physical plant/system)
(hardware under test = controller)

Code generation

Host including your Simulink plant model

Real-time target machine running your plant model

Controller, ECU, sensor/actuator hardware, fully control system

Ethernet (Host-Target link)

Wide range of I/O connectivity options

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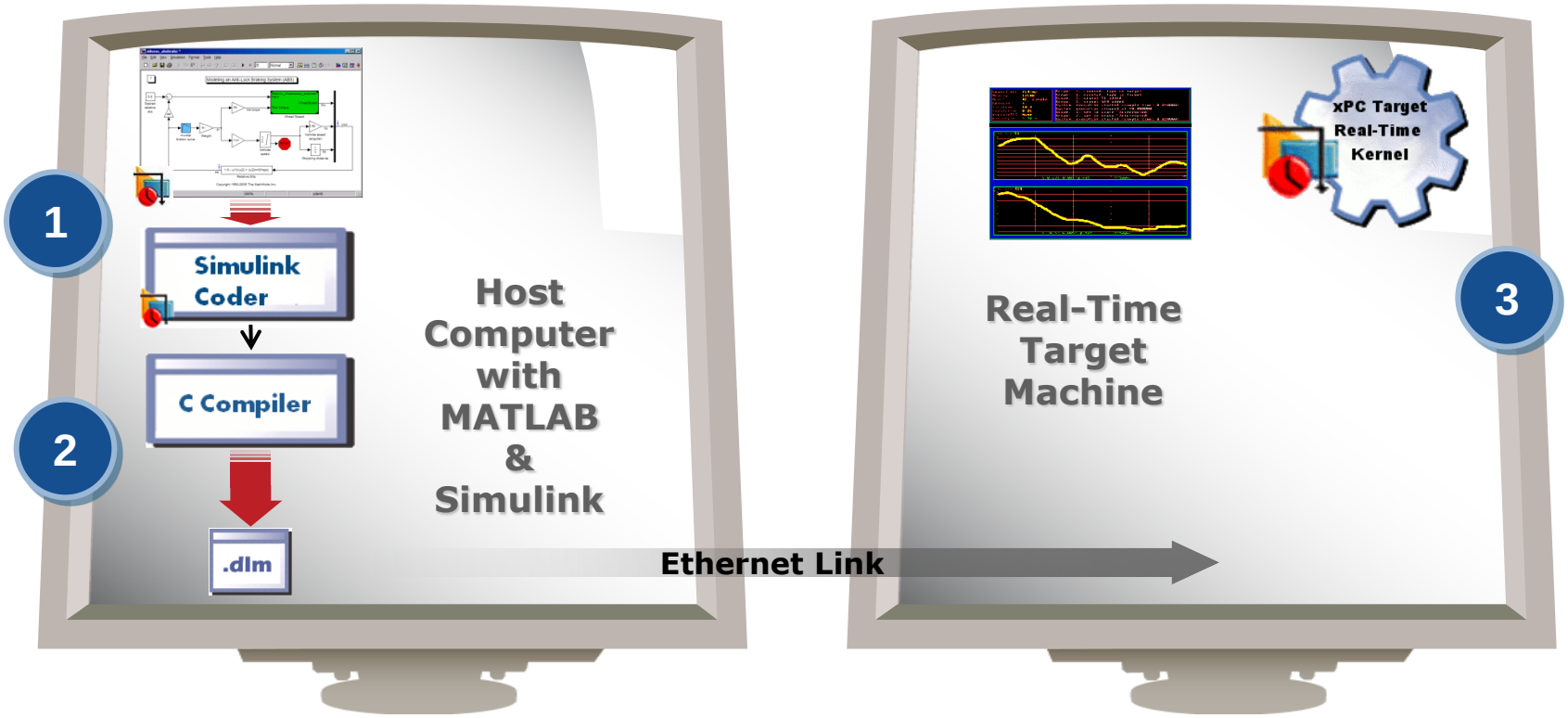
Summary | Q&A

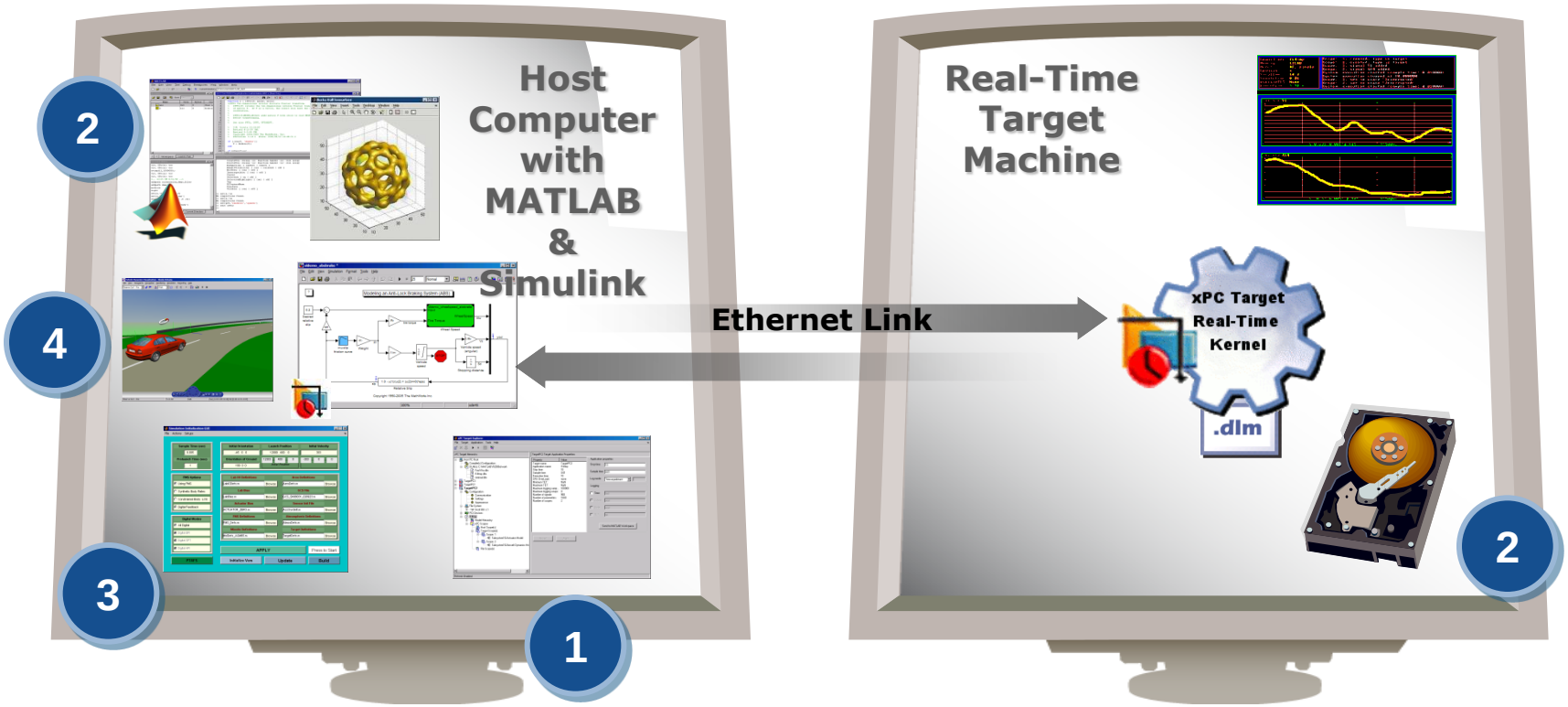
What is xPC Target?
Workflow



- A software environment that allows for real-time execution of Simulink models on a separate x86, PCI-based target machine. Automatically:
  1 Generate code, 2 Compile & Link, 3 Run executable .dlm

What is xPC Target?

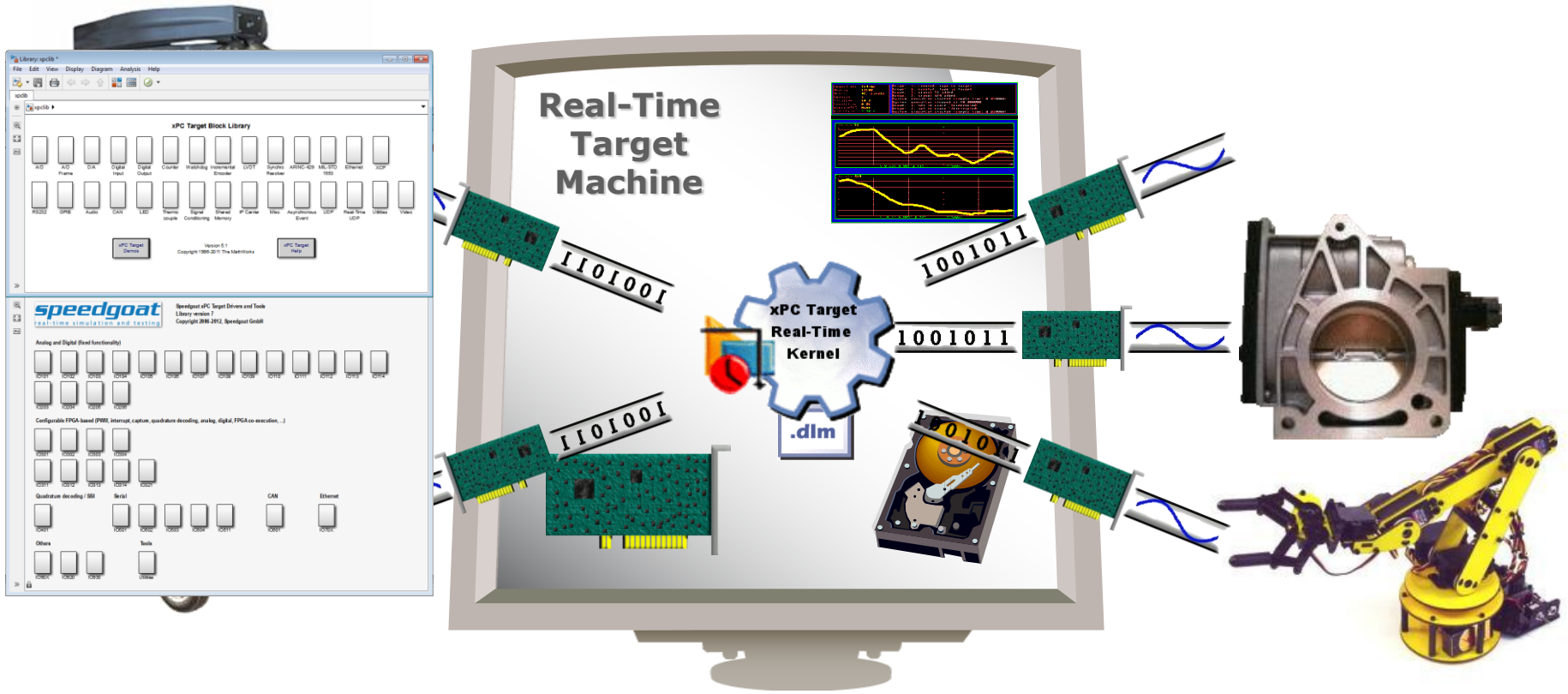
Interactive control and access to the real-time application while it runs



- 1 live parameter tuning, signal monitoring, and control from the Simulink model, 2 real-time data logging for offline or post-test analysis in MATLAB, 3 GUI/HMI support, 4 3-D visualization.

What is xPC Target?

I/O support to communicate with your hardware under test



- Includes Simulink blocks and software drivers supporting a broad suite of I/O devices and device types.
- Blocks are easily configurable within the Simulink model and communicate with the I/O hardware in real-time.

xPC Target Turnkey

A complete software/hardware solution for real-time testing

MathWorks | **Speedgoat** | **Your Hardware/Systems**

HOST COMPUTER

Design and model in Simulink.

TARGET COMPUTER

Run your Simulink model in real-time with xPC Target.

HARDWARE UNDER TEST

Interactively control plant, ECU, sensors, and actuators.

Host-Target link

REAL-TIME TARGET MACHINES

- High performance
- For office, lab or field use
- Multiple form factors
- Supported bus types: PMC, PCI, PCIe, cPCI, PC104
- For industry and academia

I/O Interfaces

I/O MODULES

- Analog and digital I/O
- Pulse generation/capture
- Communication buses
- Serial protocols
- Shared/reflective memory
- Configurable FPGA

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Understanding Hardware Architecture

Frequent Real-Time Testing Applications

(Aero, Defense, Auto, Energy, Medical Industries)

Summary | Q&A

Speedgoat Real-Time Target Machines

6 standard platforms

Performance real-time target machine

Mobile real-time target machine

Openframe real-time target machine

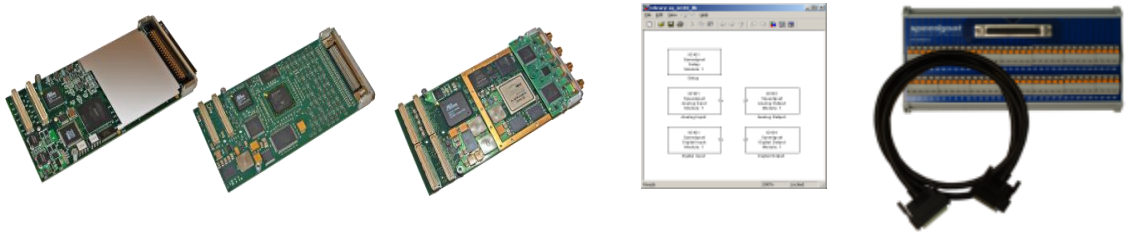
Education real-time target machine

Automation real-time target machine

Modular real-time target machine

- Optimized for highest real-time performance
- Various form factors for office, lab, and mobile use
- Open architecture and wide range of supported I/O connectivity

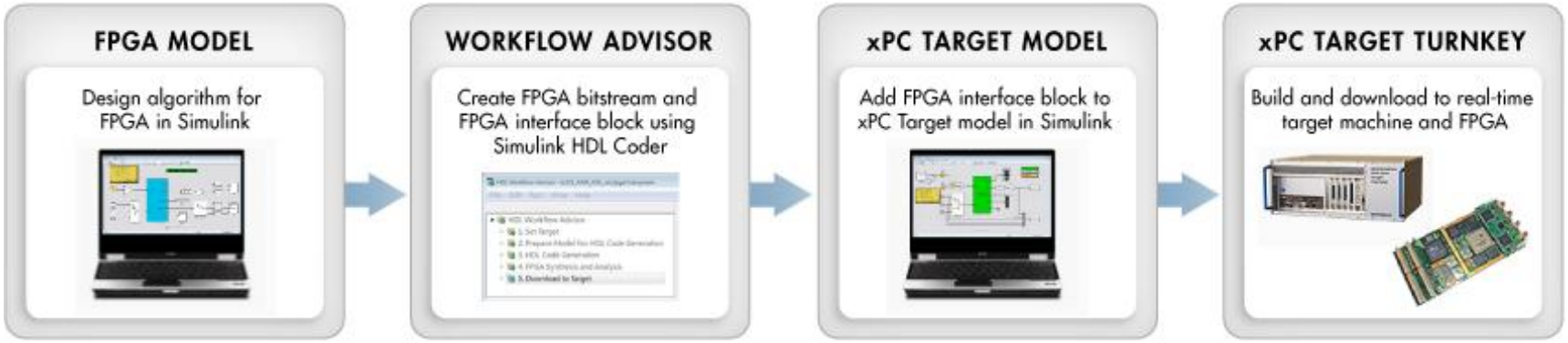
I/O Modules



Wide range of PCI-based (PMC, PCI, PCIe) I/O modules are available. Delivered with xPC Target drivers, test models, cables, terminal blocks.

IO Type	Functionality
Analog	High-resolution, high-speed, simultaneous sampling, BNC and XLR panels
Digital	TTL, 12V, 24V, high-drive, opto-coupled
Serial	RS232, RS422, RS485, SDLC, HDLC
Protocols	CAN, SAE J939, real-time UDP, raw Ethernet, SPI, I2C, SSI, EtherCAT, USB WebCam, CameraLink, ARINC 429, MIL-STD-1553, FlexRay, ...
Audio/Speech	Audio/Speech optimized analog IO modules
Shared Memory	Reflective Memory for high speed data transfer in multi-processor systems
Various	LVDT/RVDT, Synchro/Resolver, reed relays, programmable resistors, thermocouple I/O module from Measurement Computing, external signal conditioning modules (current to voltage, voltage to current, temperature, …)
Configurable FPGA	• Pulse train (PWM, capture, quadrature decoding, hall effect) • Event based interrupts • Analog I/O with lowest latency and/or special synchronization schemes

FPGA Programming for xPC Target



Program FPGA boards for xPC Target Turnkey real-time target machines using HDL Coder Workflow Advisor.

- Execute high-speed algorithms on an FPGA connected to a model running in real time with xPC Target.
- Automatically program the FPGA without needing to know HDL code - ideal for functional testing and verification.
- Quick reconfiguration of FPGA I/O promotes a flexible real-time testing environment.
- Compatible with both new and existing xPC Target Turnkey systems.

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Summary | Q&A

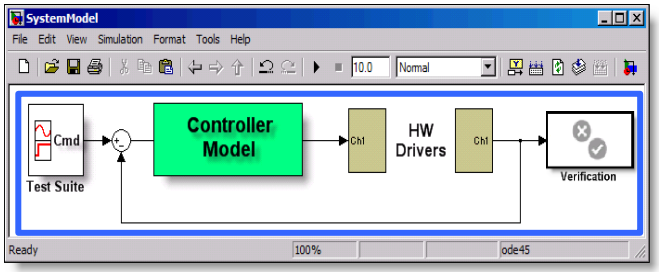
Frequent Real-Time Testing Applications

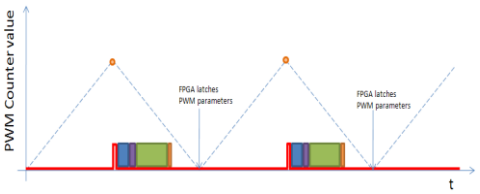
Example: Motor Control Prototyping

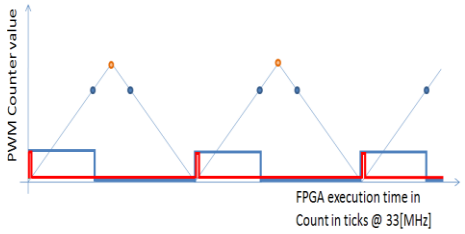
AC (electrical grid, inverter, combustion) or DC (battery) powered electric motors converting electrical or heat energy into mechanical motion

Typical requirements:

- Support for various sample rates, e.g.:
  - 1 – 20 kHz for outer speed and/or position control loops
  - 10 – 200 kHz for inner current control loops
  - 1-100 MHz for PWM generation
- Heavy use of reconfigurable FPGA-based I/O modules
  - PWM generation, capture, synchronization, quadrature decoding, digital I/O
- Encoders used to provide position/speed feedback (servo)
- High-speed A/D used to provide torque feedback
- Additional I/O often required (e.g., CAN for hybrid projects)





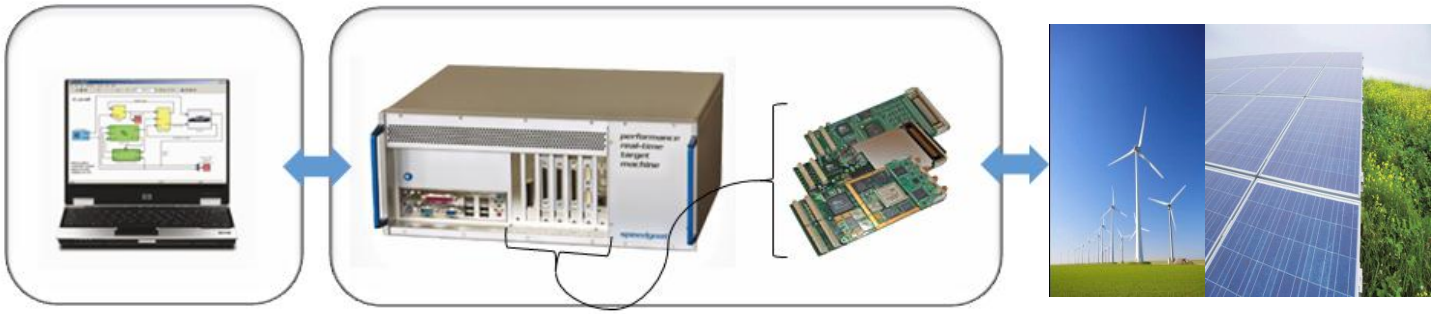


Frequent Real-Time Testing Applications

Example: Green Energy (Solar, Wind, Wave) Technologies

Solar inverter and wind or wave power generation control designs

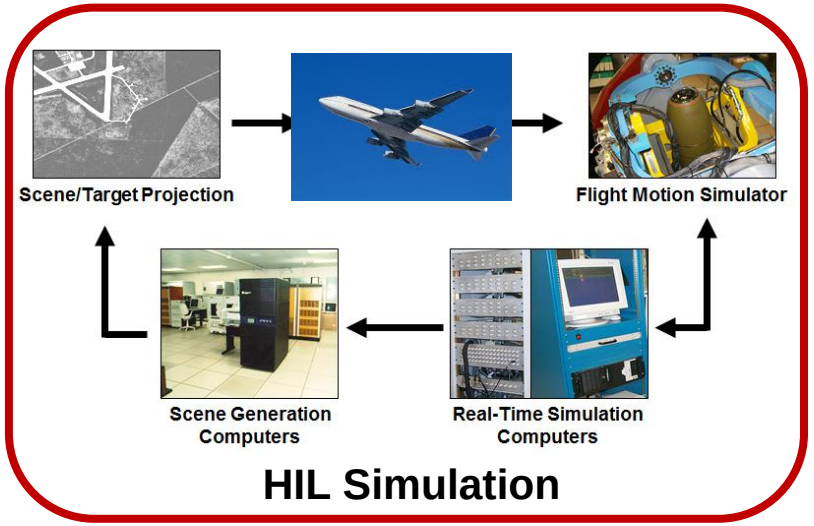
- Interface to fast switching power electronics
- High base sample rates:
  - Up to 20KHz for algorithms
  - Up to 200KHz for power electronics control
- High-speed analog I/O
- Heavy use of reconfigurable FPGA I/O modules
  - PWM generation and capture for simulating and controlling H-bridge topologies (multi-phase, dead-times, inter-phase synchronization)



Frequent Real-Time Testing Applications

Example: Aerospace/Defense Systems

Hardware-in-the-loop Simulation/Testing



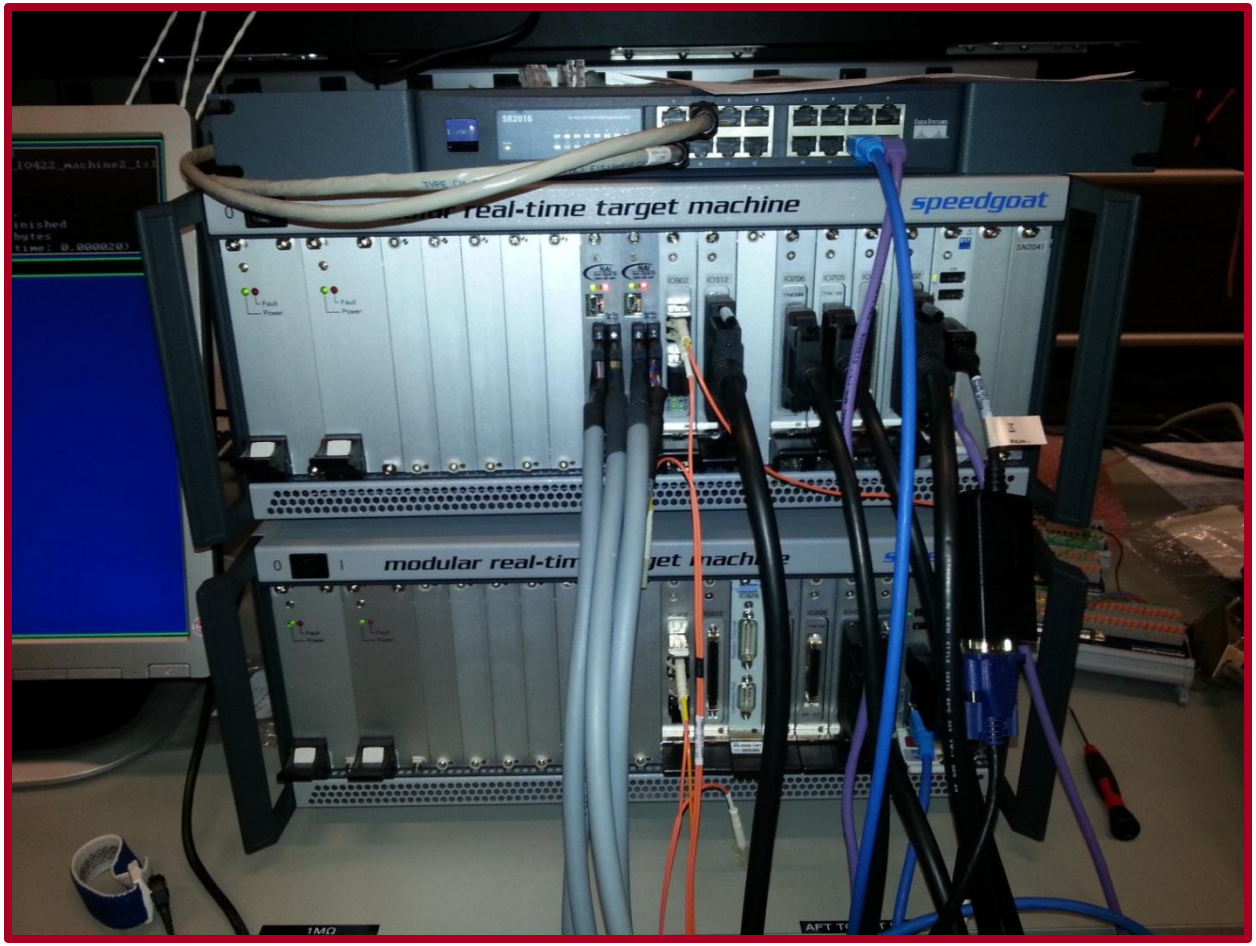
- Hardware Under Test
  - Onboard Sensors
  - Navigation/Guidance/Control Units
- Simulation
  - Environmental conditions
  - Airframe dynamics
  - Control surfaces, other sensors/actuators
- 5 KHz base sample rate
- Complex model/simulation (1000's of blocks)
- Multiple test computers connected through high-speed interfaces
- 100's of channels of I/O
- Allows for proving out test scenarios before incuring high cost of field or live-fire testing

Frequent Real-Time Testing Applications

Example: Aerospace/Defense Systems

Hardware-in-the-loop Simulation/Testing

- Hardware Under Test
  - FADEC
- Simulation
  - A/C Engines

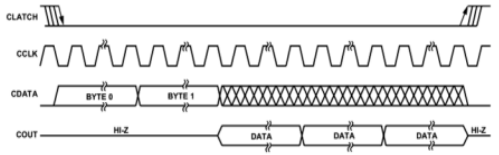


Frequent Real-Time Testing Applications

Example: Medical, Industrial Machines & Devices

Testing of Ventilators, Pumps, Infusion Devices, etc.

- Control system designs
- Functional verification and validation
- Specialized (SPI, EtherCAT, etc.) interfaces
- Multi-channel communications
- Reconfigurable FPGA-based I/O



speedgoat

Advanced Signal Processing

- Prototyping of hearing aids
- Complex model/algorithm: 14,000+ blocks
- Base sample rate: 20.48 kHz
- Low-latency analog I/O: 24bit, up to 96kHz
- Highest-speed and lowest-noise setup
- Reflective/Shared memory
- Rack mounts and XLR Panels

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xPC Target Turnkey

Each Speedgoat target machine and/or complete host/target solution is built to work out-of-the-box

- ✓ assembled based on your specific requirements
- ✓ designed and optimized for use with Simulink and xPC Target
- ✓ test models, external terminal boards and cables provided
- ✓ open architecture – reconfigurable, flexible, expandable
- ✓ includes 3 years of warranty, tech. support, and software updates

Customer Quote

"Up and running in less than a day!"

Darren Hartman, Excavator Design, HUSCO International, USA

Customer Quote

"We received Speedgoat's real-time target machine in the morning, and in the evening our system under test was already up and running.

That's how rapid prototyping should be, shouldn't it?"

M. Feriencik, RUAG Space AG, Switzerland

Benefits of xPC Target Turnkey

Complete solution

- ✓ Focus on your next generation software and hardware designs instead of developing the tools & hardware infrastructure

Shorten time-to-market

- ✓ Benefit from a flexible and production independent platform which can be easily adapted to changing requirements
- ✓ Prove and improve your Simulink design with your hardware at the earliest possible stage and continuously try new ideas

Reduce costs

- ✓ Avoid otherwise costly design flaws by detecting errors at a stage where they are still cost effective to correct
- ✓ Simulate and automate test scenarios and hardware interactions which are otherwise complex, expensive, or dangerous to perform

REAL-TIME TARGET MACHINES

- High performance
- For office, lab or field use
- Multiple form factors
- Supported bus types: PMC, PCI, PCIe, cPCI, PC104
- For industry and academia

I/O MODULES

- Analog and digital I/O
- Pulse generation/capture
- Communication buses
- Serial protocols
- Shared/reflective memory
- Configurable FPGA

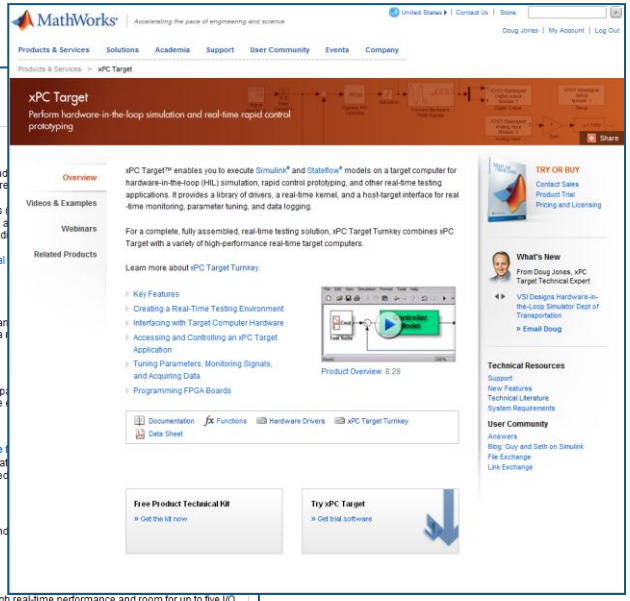
Resources & Contact Information

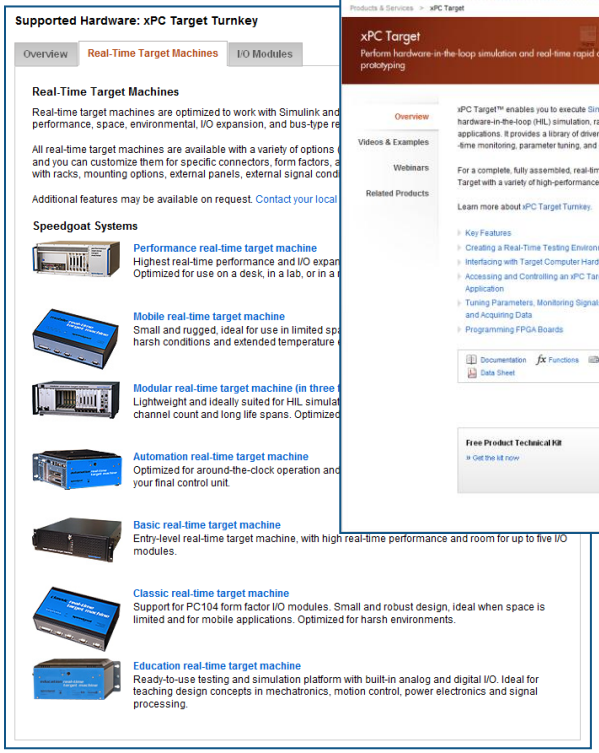
Have questions? Want to know more about xPC Target or xPC Target Turnkey?

Contact your MathWorks Account Manager or Speedgoat.

xPC Target

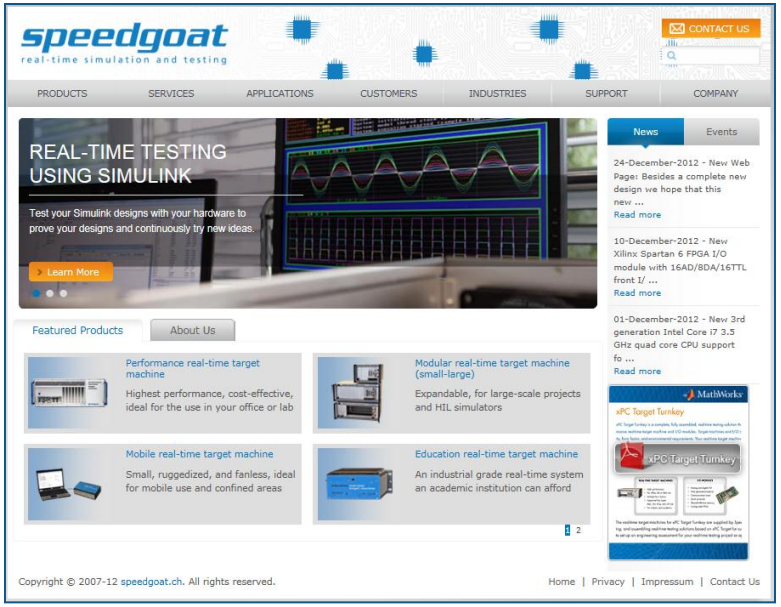
www.mathworks.com/products/xpctarget





Speedgoat

www.speedgoat.ch



xPC Target Turnkey

www.mathworks.com/products/xpctarget/supported-hardware/index.html