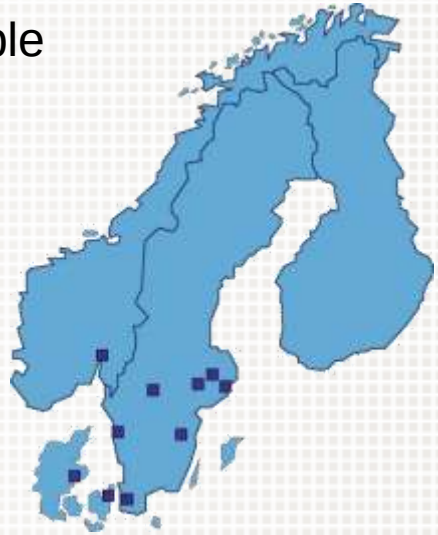
New approach in Developing Scalable Dynamic Test Systems with HIL Simulation

Hans Nystrom, Prevas &
Arnoud de Kuijper, T&M Solutions

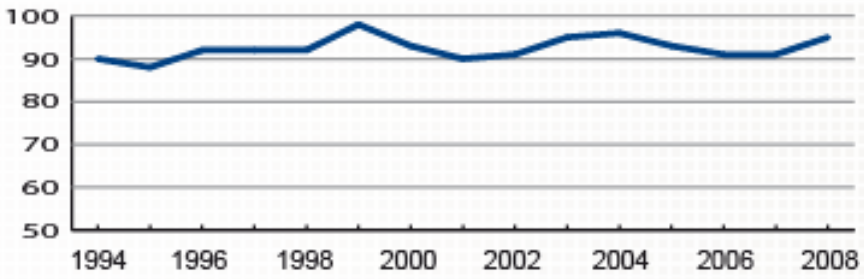
Prevas delivers what's promised

- Founded in 1985, >20 years experience of delivering profitable solutions to clients.
- Approximately 550 employees
- Listed on the Stockholm Stock Exchange since 1998.

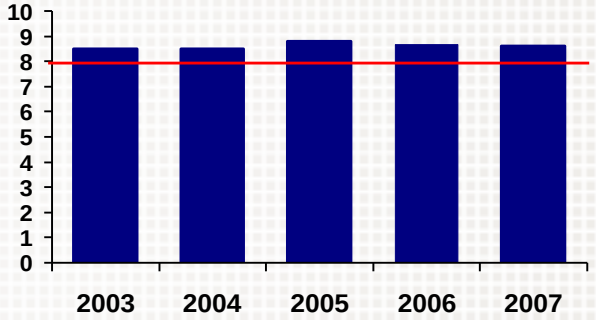
- Certified according to ISO 9001:2000. Using well documented and tested project and development models.



Reliability of delivery



Customer satisfaction



T&M Solutions

- Founded in 2001, >7 years experience in delivering Test & Measurement Solutions.
- More than 300 projects succeeded in different industries.
- Offices in Arnhem and Eindhoven,
- Total of 11 technical skilled employees.
- Experienced in small and large LabVIEW projects.

Mission:

"T&M Solutions BV goal is to increase customer satisfaction in Test & Measurement automation by being a reliable engineering partner. We can achieve this goal with the help of graphical system design tools."

Agenda

- HIL Explained
- Case Study by Prevas
- Scope of the test system
- Description of sensor simulation
- Description of fault insertion
- Overview of a system
- Key factors for scalable systems
- Other

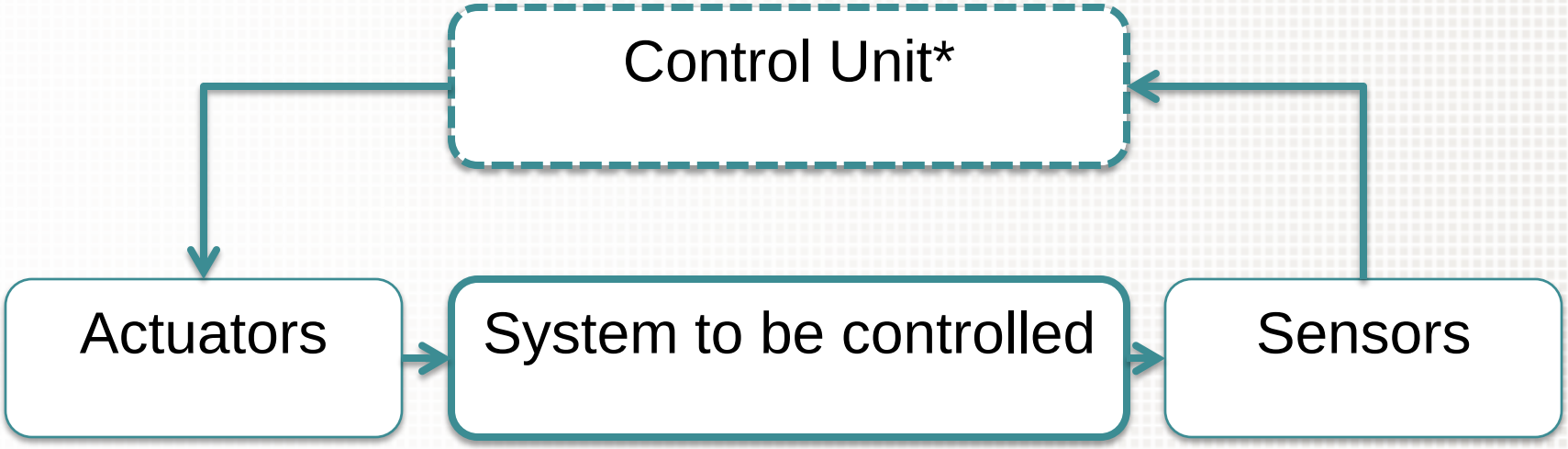
HIL Explained

(Arnoud de Kuijper)

HIL Simulation

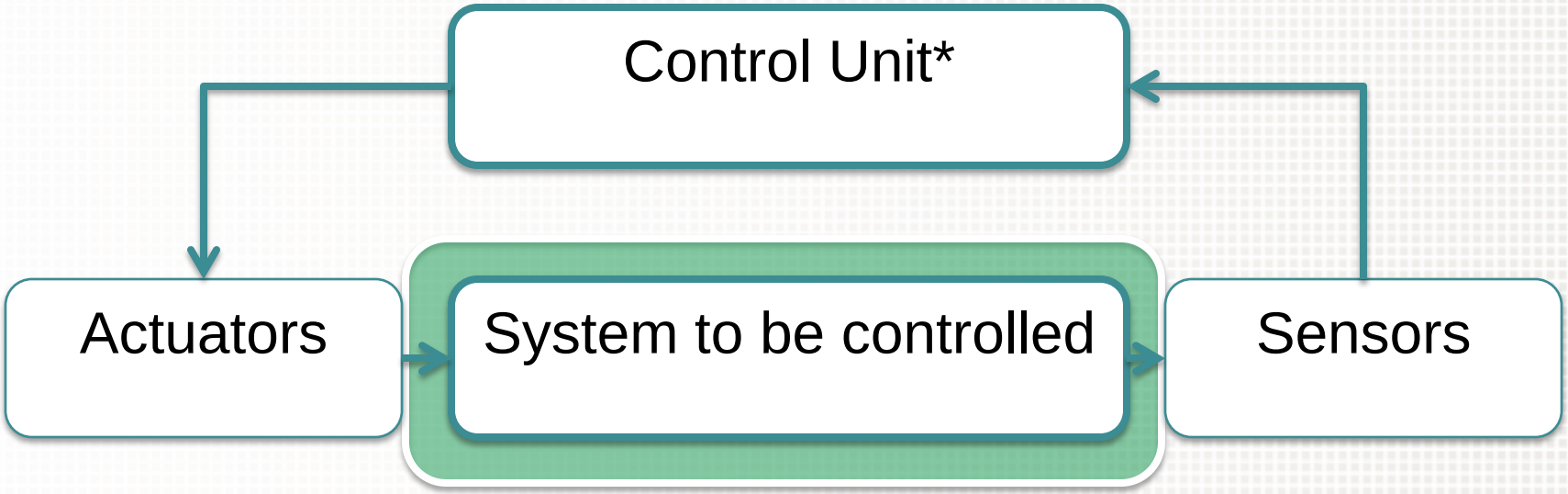
- **Hardware-in-the-loop** (HIL) simulation is a technique that can be used in the **development and test of (real-time) control units**.
- HIL simulation provides an effective platform by adding the **behavior of the system that is controller** to the test platform.
- The behavior of the **system** is included in test and development by adding a mathematical representation of all related dynamic systems.

HIL Simulation



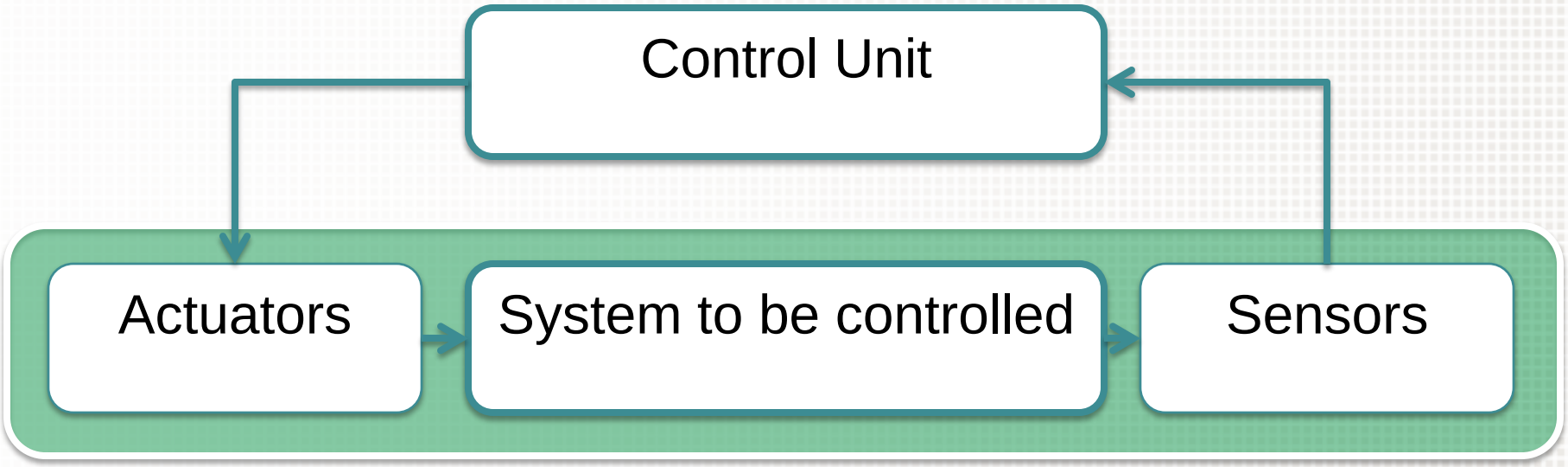
*Control Unit is under development or under testing

HIL Simulation



HIL can also be the system to be controlled with the actuators and sensor belonging to the control unit.

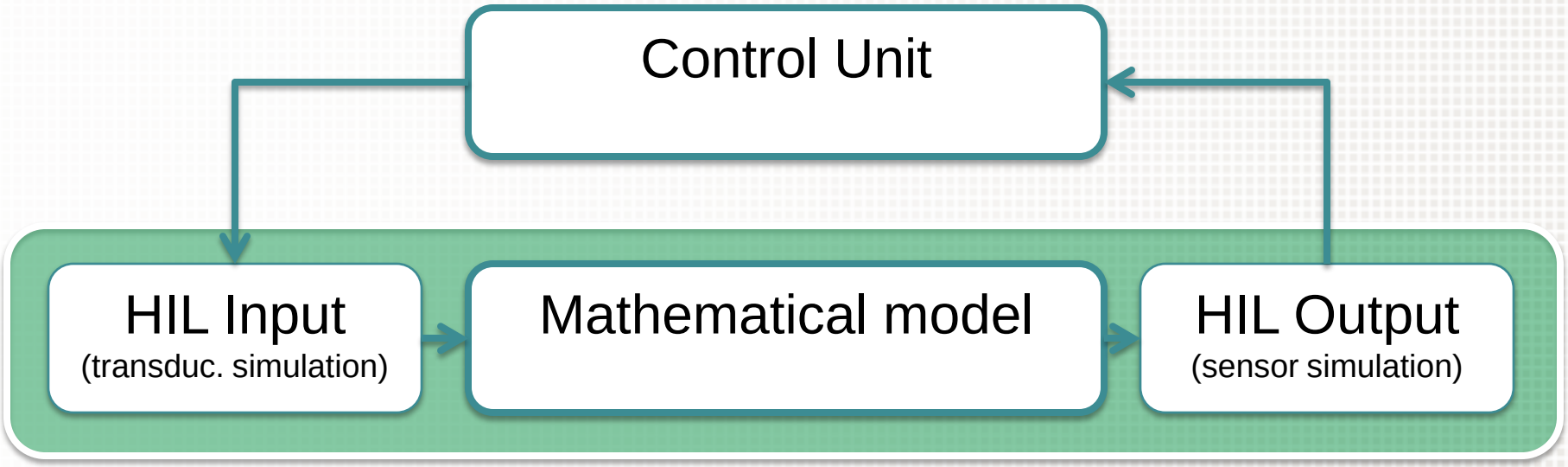
HIL Simulation



HIL can be the system to be controlled including sensors and actuators.

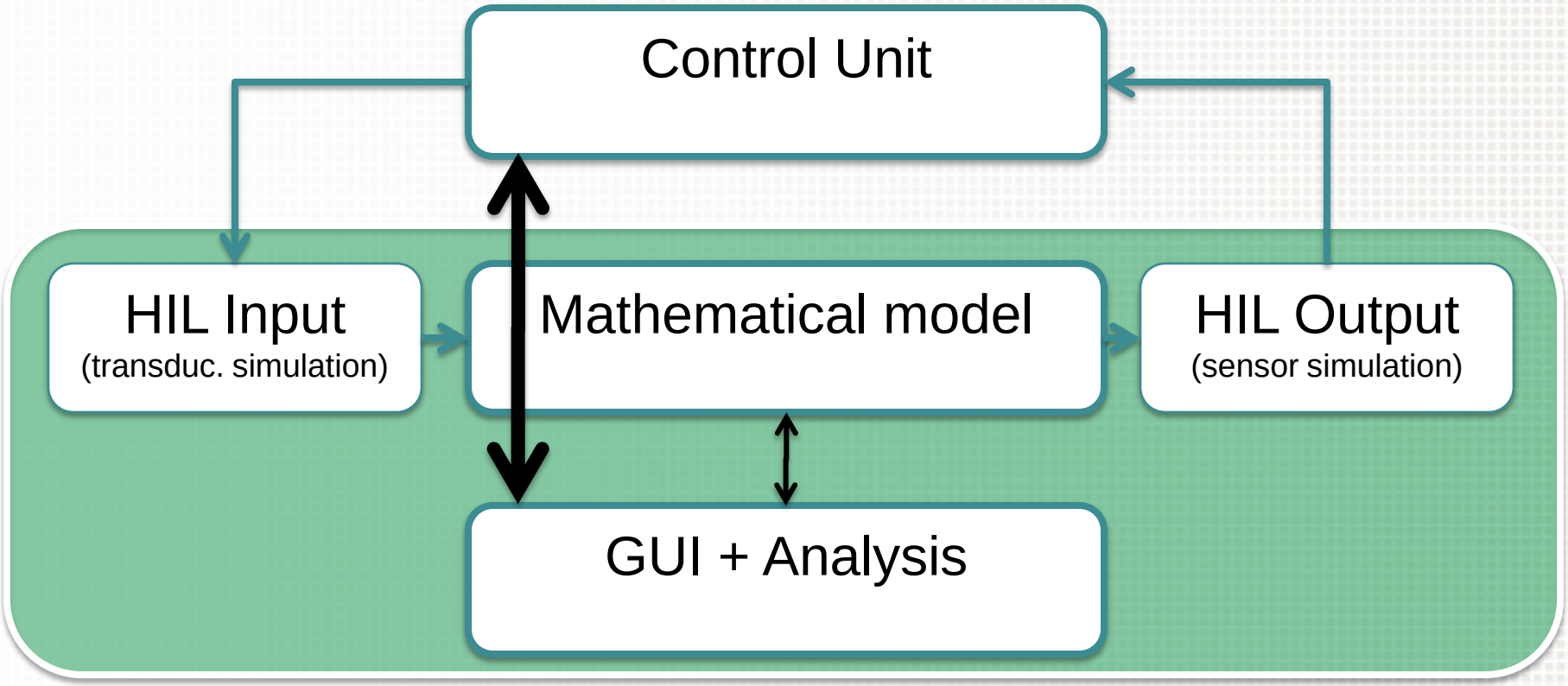
This is actually a new definition of “system”

HIL Simulation



HIL replacement of components

HIL Simulation



Added Interface to control and monitor model.

HIL Simulation

- When the mathematical representation of the system-to-be-controlled is more accurate, the better the control-unit can be developed and tested.
- An HIL simulation could include electrical emulation of sensors and actuators. Depends on target: HW, SW.
- Using physical loads and a fault insertion modules, the HIL test system can accurately simulate real-world conditions and test response to fault situations.

When to use HIL?

- In many cases, the most effective way to develop an embedded system is to connect the embedded system to the real plant. In other cases, HIL simulation is more efficient.

- The metric of development and test efficiency is typically a formula that includes the following factors:

Case Study by Prevas

(Hans Nystrom)

CaseStudy, Automated Guided Vehicles

Main challenge:

- The main challenge was to test the control system of the automated guided vehicles without using real vehicles.
- The control system is a combination of up to three electronic units with different software depending on installation.
- The solution needs to be able to test the different installation and also simulate electronic units under development.

Solution in brief:

- Hardware-In-the-Loop System
- Hardware built on standard PC with NI-CAN and RS-485 boards.
- The I/O is based on distributed CAN
- Connects to Test Sequencer and Test Cases developed in Python
- All software and dynamic models developed in LabVIEW

Main benefits:

Each installation can be tested early and safe with minimum use of real vehicles. This reduces the cost for each installation.

Faults reported from different installations can be found and corrected faster with less cost..

New Technology

(Hans Nystrom)

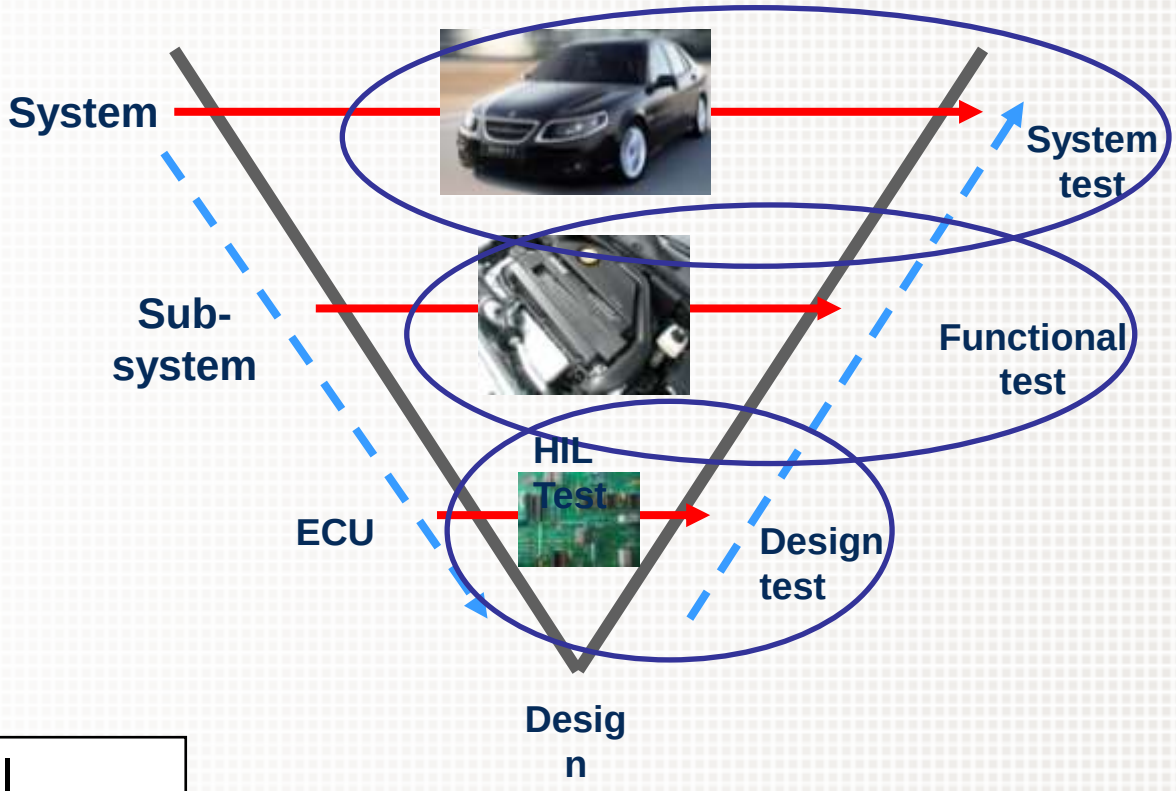
New technologies

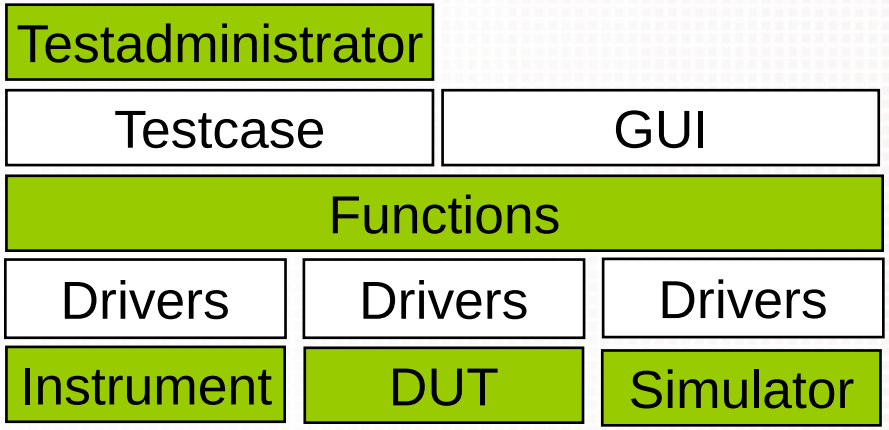
- COTS (Commercial Off The Shelf) hardware
  - PXI platform
  - FPGA technology

- PC technology
  - Multicore
  - PCI Express

New Approaches, modularity

System can be scaled up or down





Easy adopts to new products, instruments or tools

New approaches, Open architecture

- An open, adaptable platform is essential to the long-term success of your hardware-in-the-loop (HIL) test investment.
- With support for multivendor I/O
- Flexible software architecture.
- Good documentation of modeling and setup

Scope of the test system

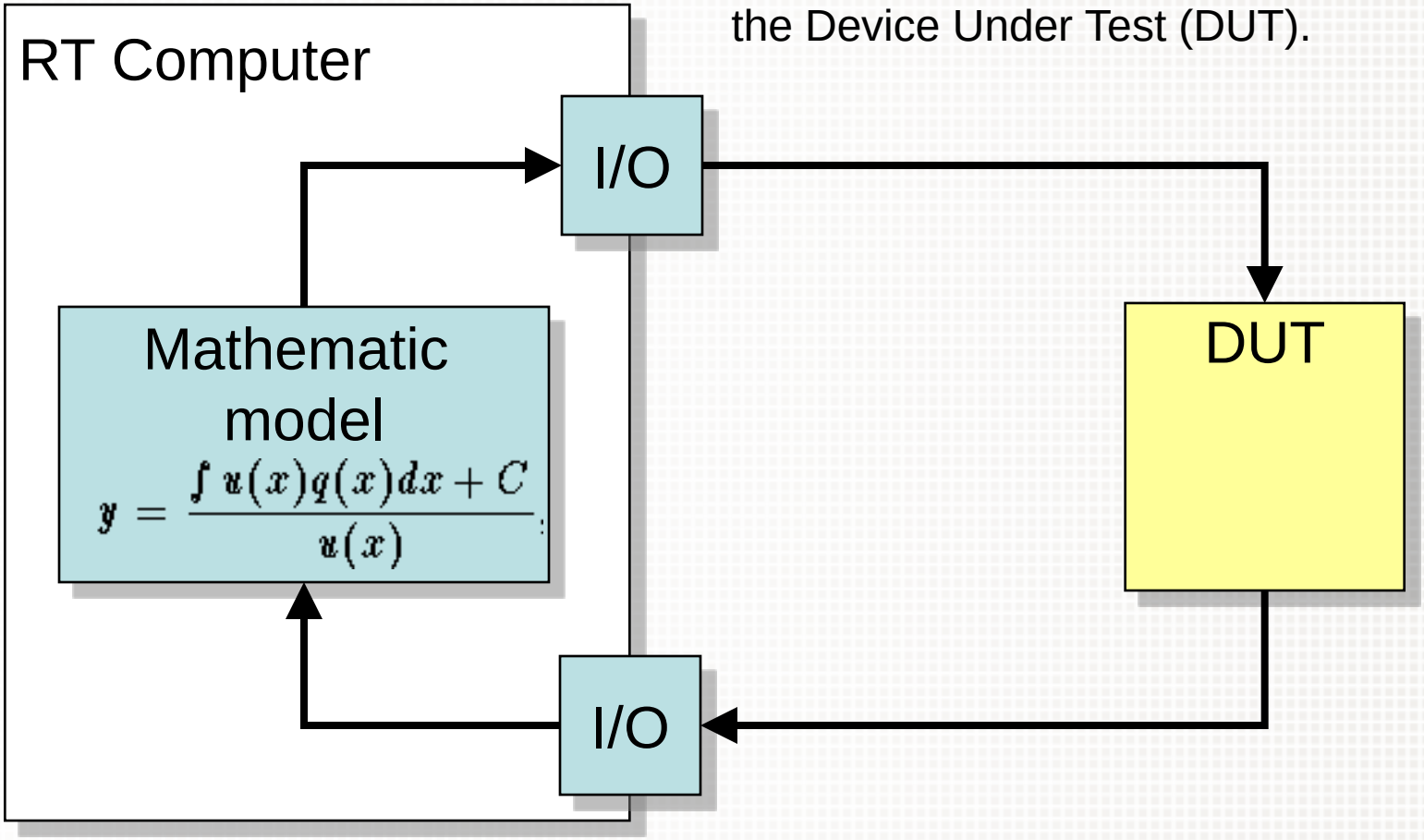
(Arnoud de Kuijper)

Define the scope of the test system:

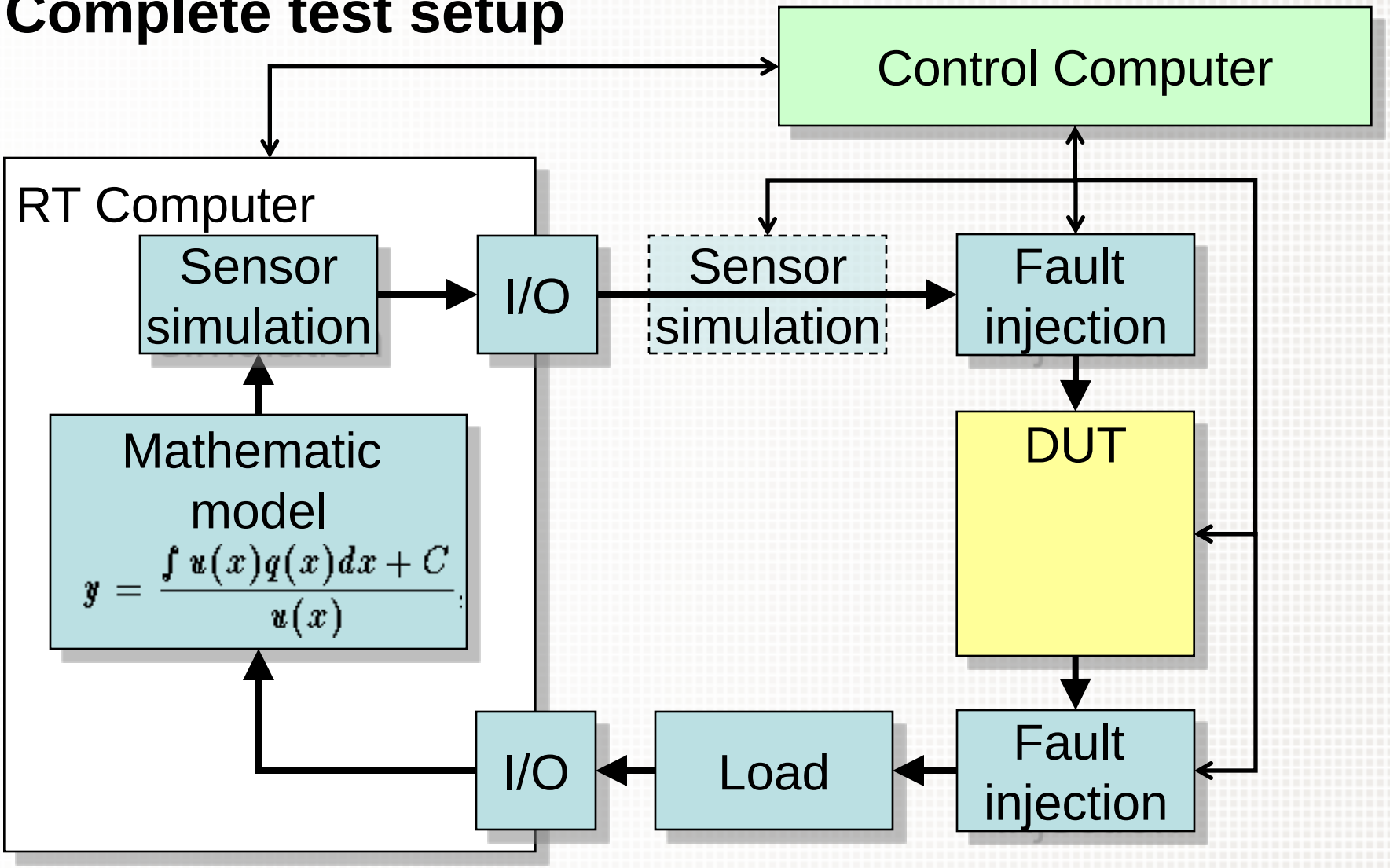
- Prioritize what is most important
  - Where do you save most time (=money) !
  - What can you **not** do **without** a test system?
- Organization, Company
  - Human resources and knowledge available?
  - What equipment and tools are preferred?
  - Processes (requirement handling, configuration and code management)
- Project needs
  - Product
  - Time

Basic Dynamic test setup (HIL)

The use of real-time I/O to simulate the dynamic behavior of a device/system that interfaces to the Device Under Test (DUT).



Complete test setup



Dynamic testing + and -

+

- HIL makes a reproducible, dynamic test possible
- HIL makes critical tests possible, without destructive testing.
- In safety critical areas necessary due to product liability

-

- Simulation might not be sufficiently accurate
- Complexity increases the requirements to the service personnel

FPGA used for Sensor simulation and tricky measurements

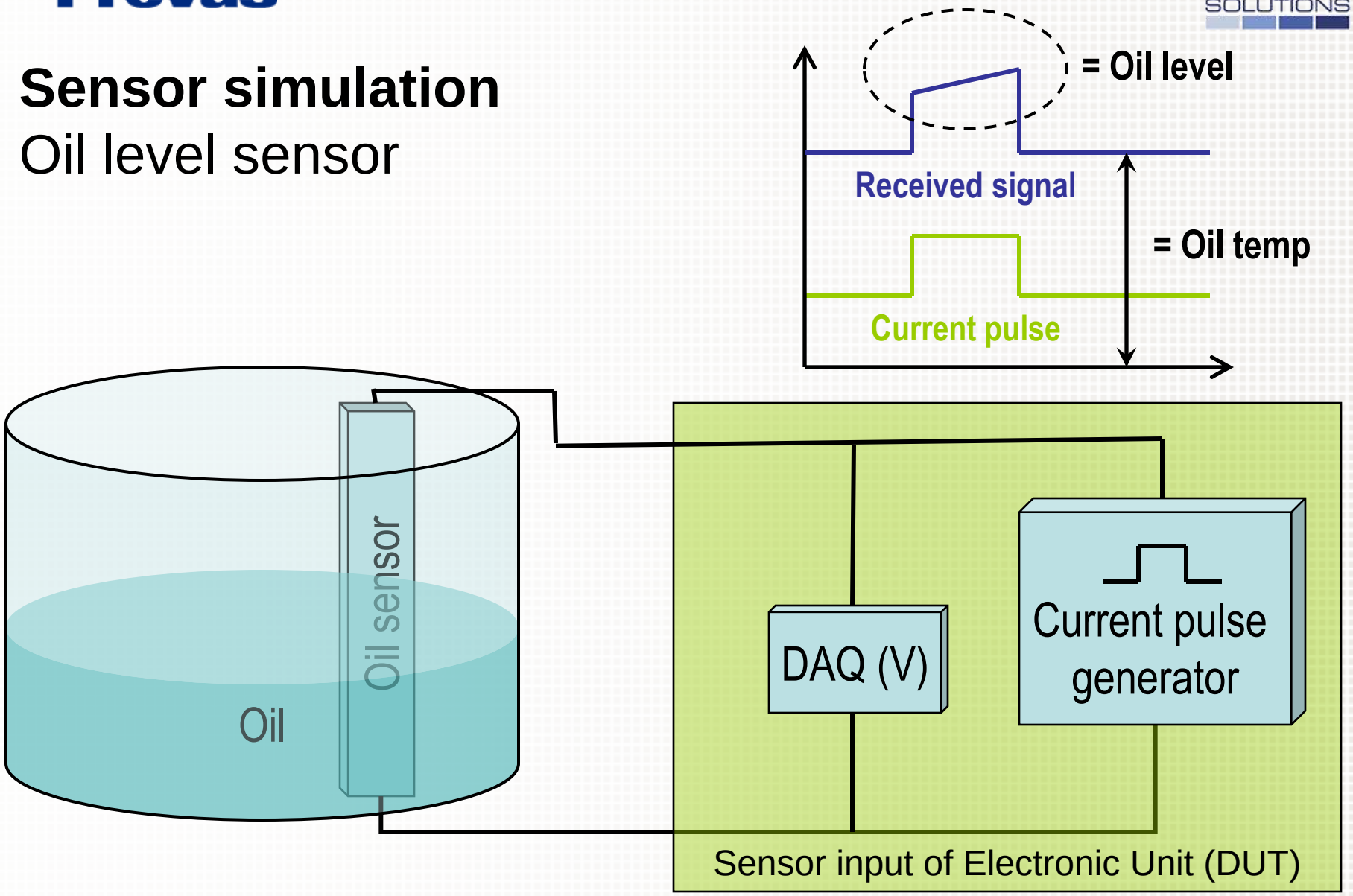
- Duty cycle measurement with glitch filter (diagnostic)
- Oil level sensor
- Inductive position sensor
- Knock sensor
- Custom serial protocols (Imobilizer etc)
- Fast command response (RFID etc)
- LVDT / RVDT
- Cam/Crank position sensor

Description of sensor simulation

(Hans Nystrom)

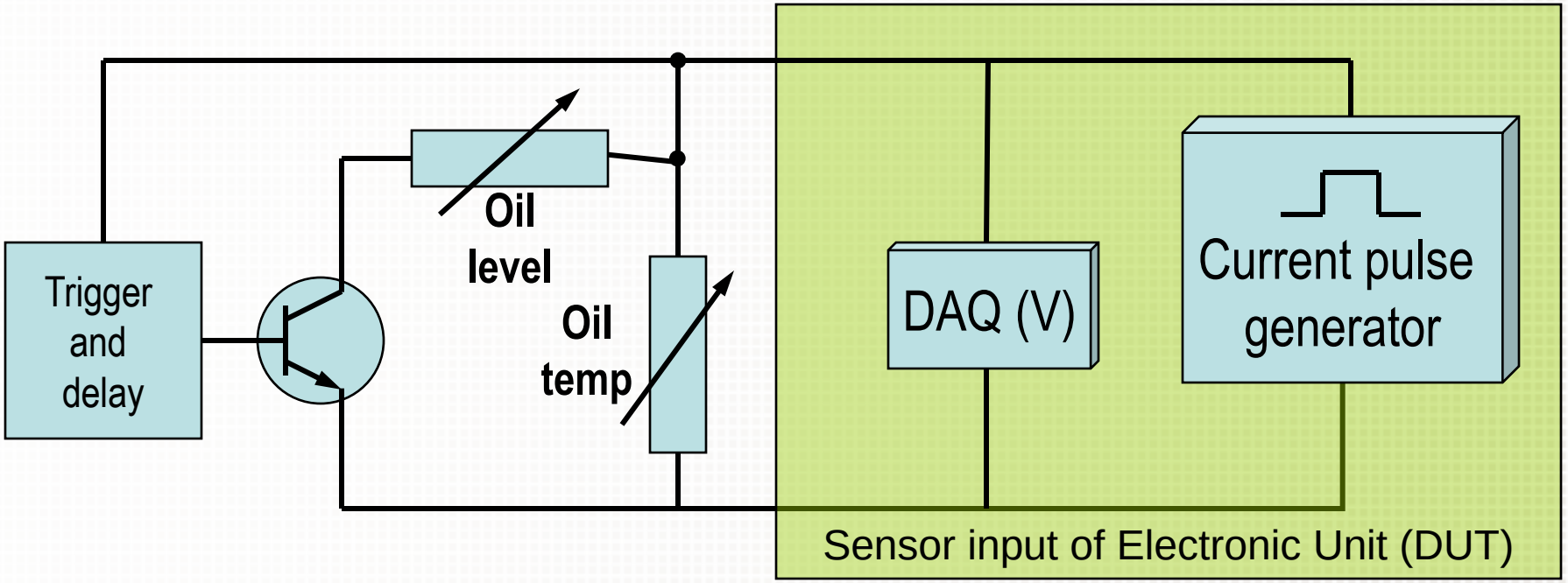
Sensor simulation

Oil level sensor



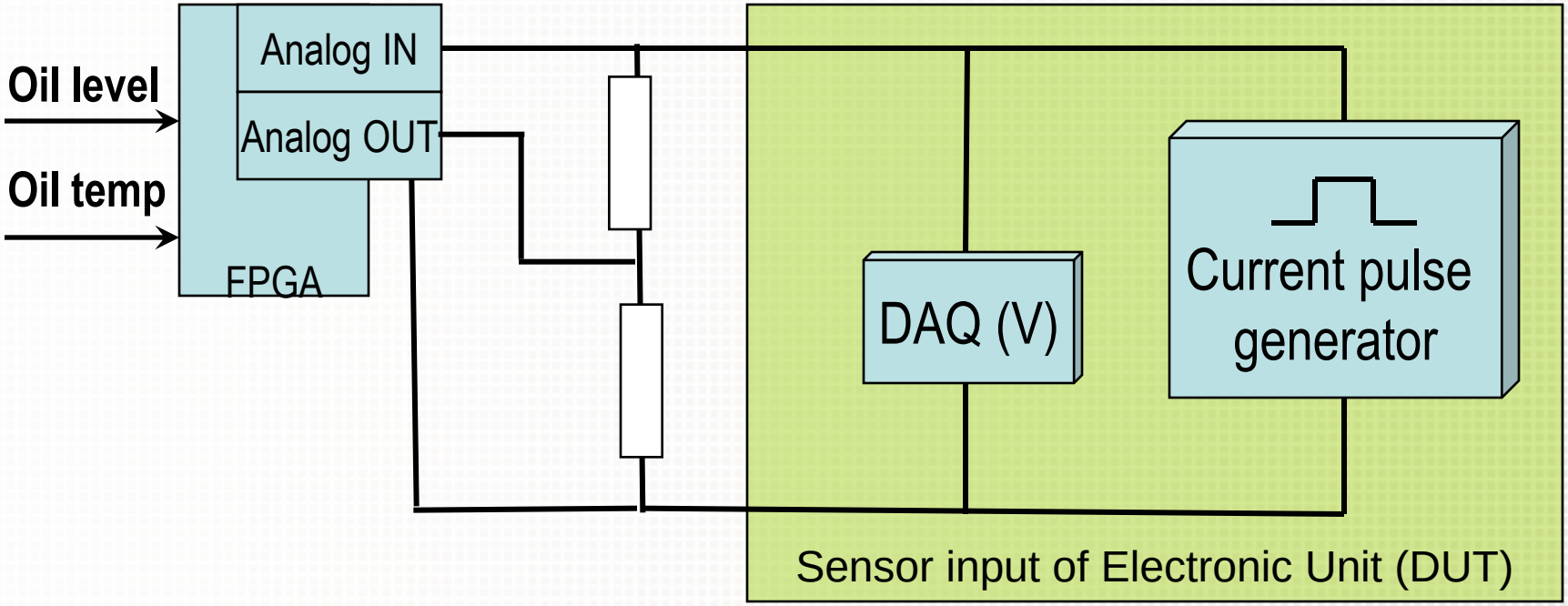
Sensor simulation

HW Oil level sensor simulation



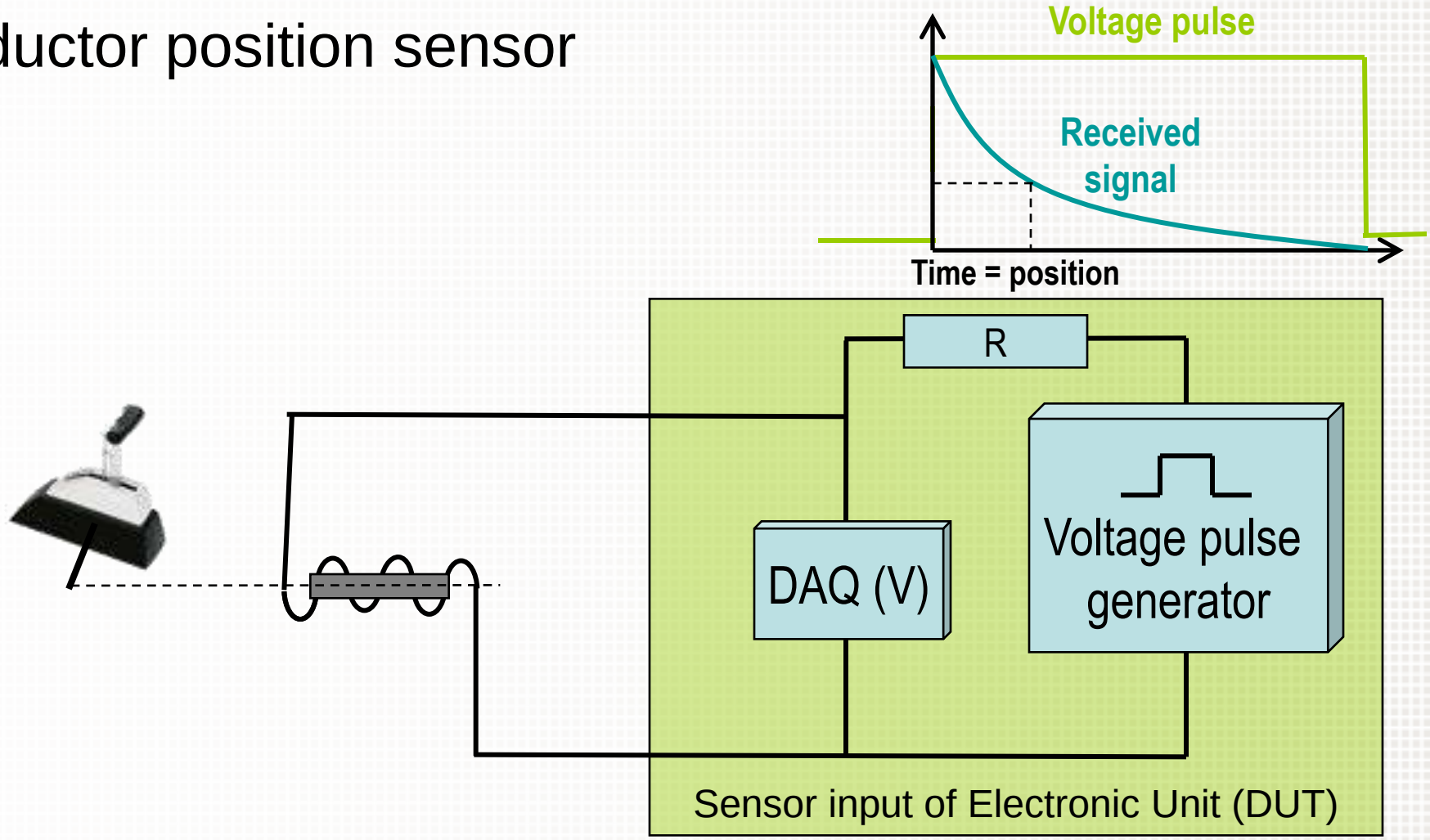
Sensor simulation

FPGA simulated oil sensor



Sensor simulation

Inductor position sensor

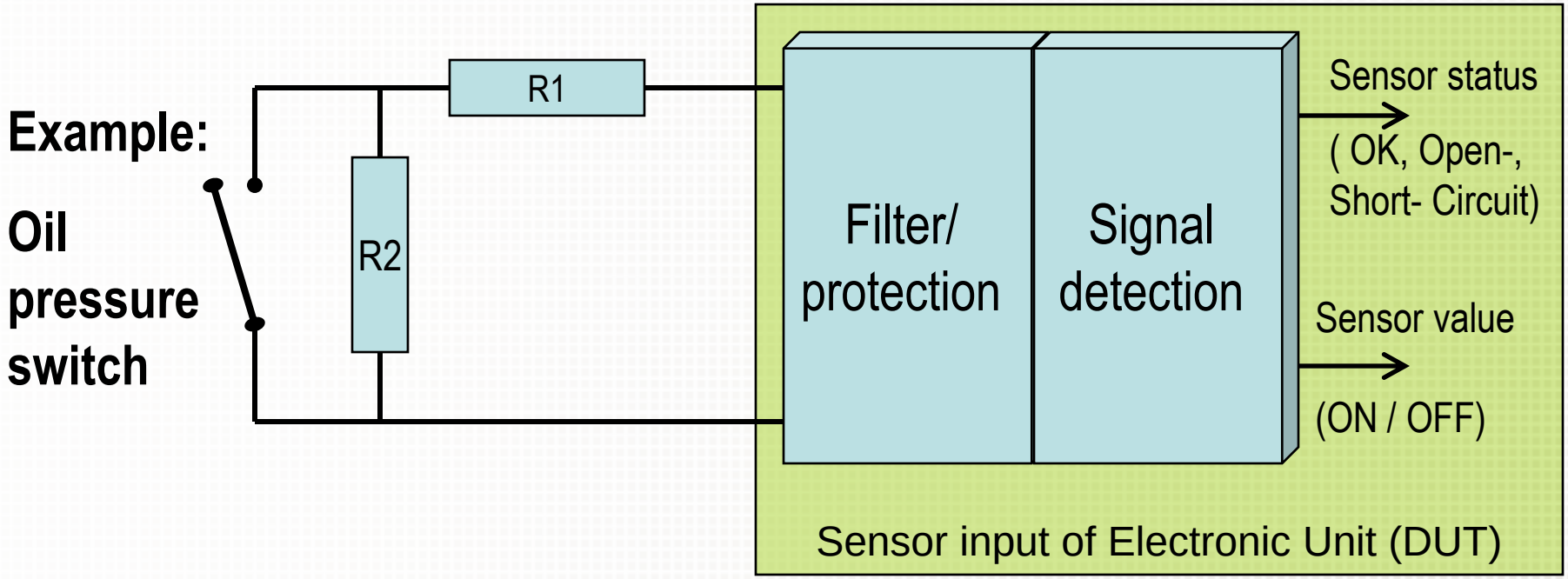


Description of fault insertion

(Hans Nystrom)

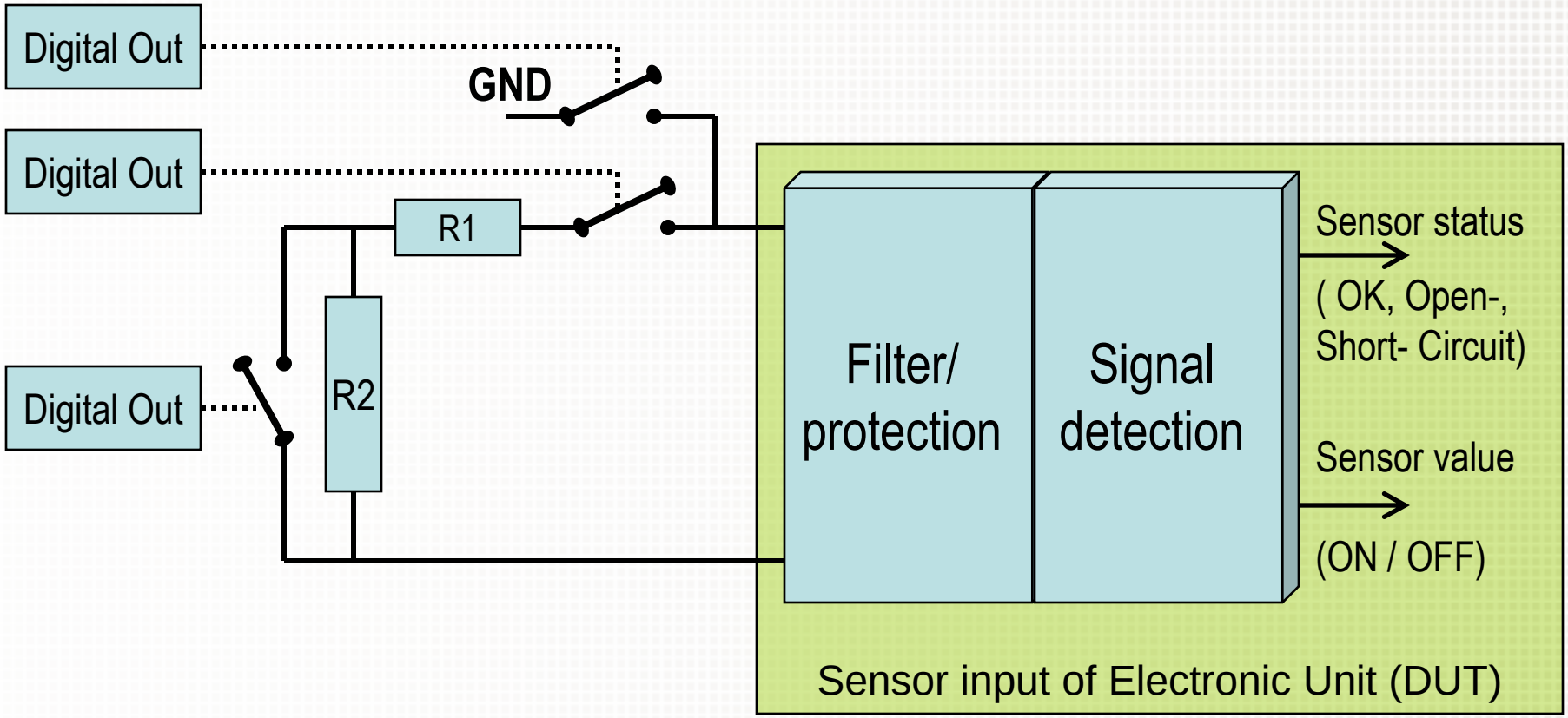
Fault insertion

Oil pressure switch circuit



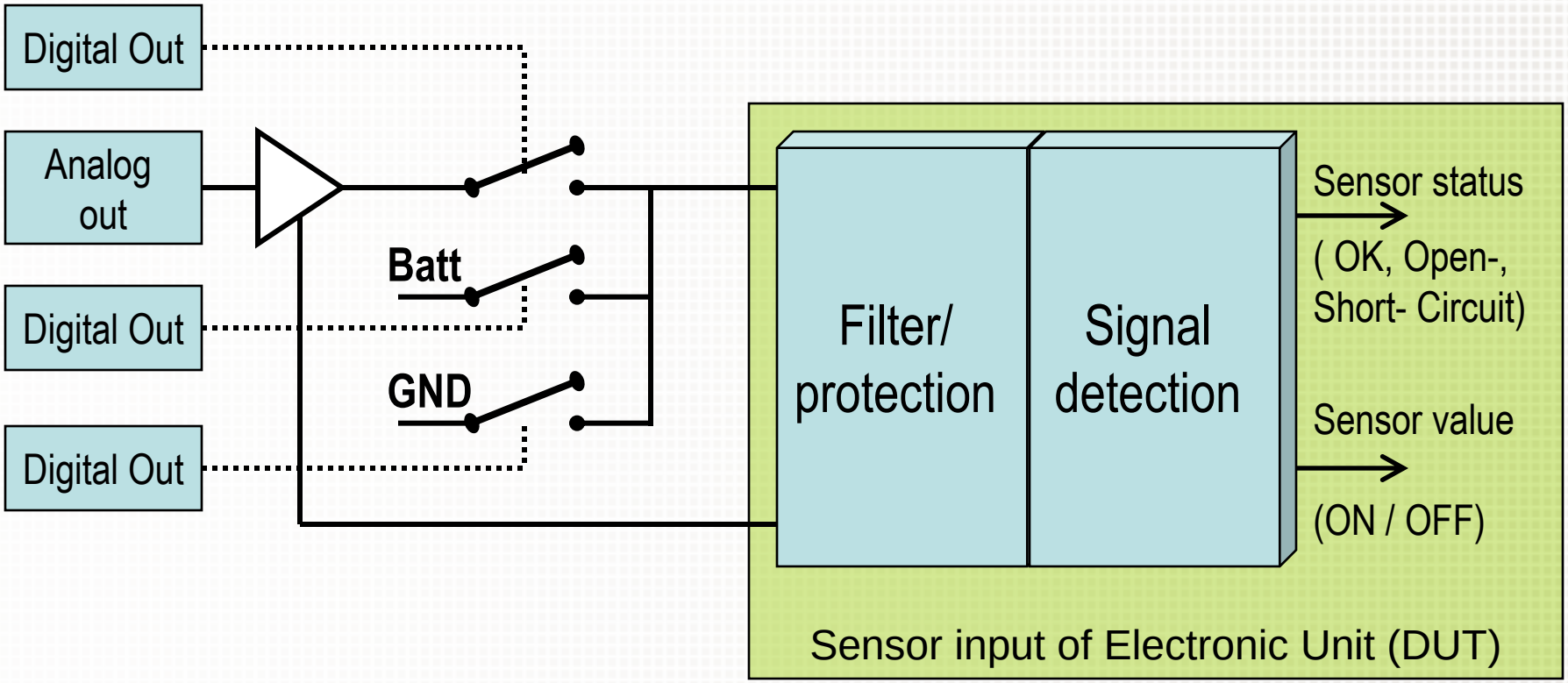
Fault insertion

Basic fault insertion, Oil pressure switch



Fault insertion

Advanced fault insertion, Oil pressure switch



Overview of a system

(Hans Nystrom)

HIL system example:

Rig power and PS
(Battery simulator)

ECU1 Interface box

ECU1 adaptation box

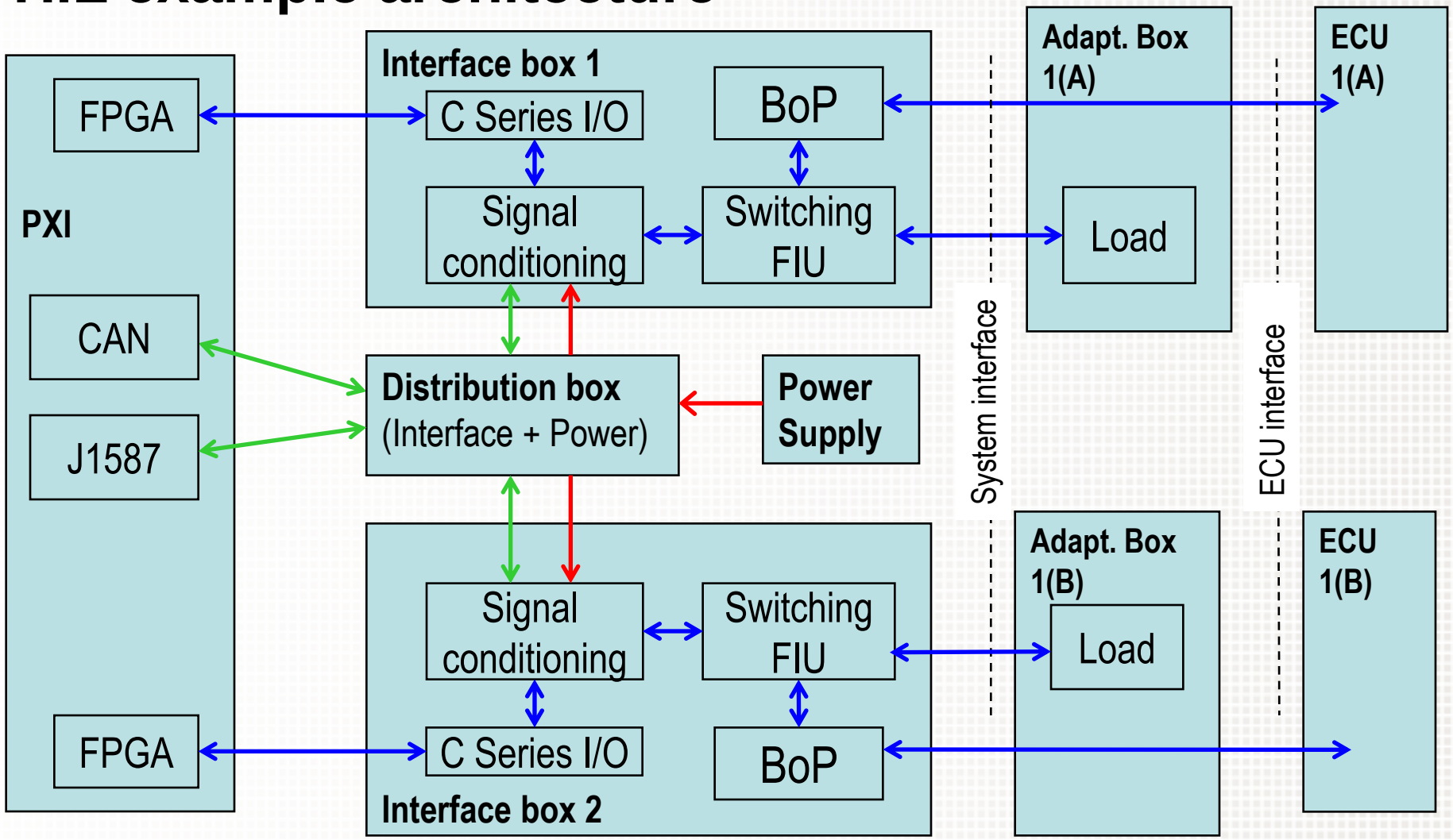
Shelf for ECU's

Distribution Unit
(data bus and Power)

ECU2 adaptation box

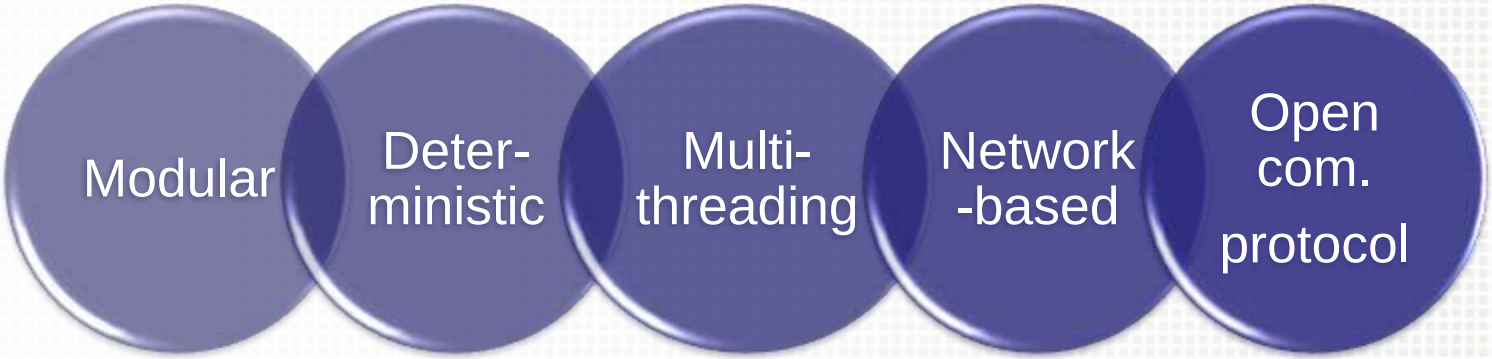
ECU2 Interface box

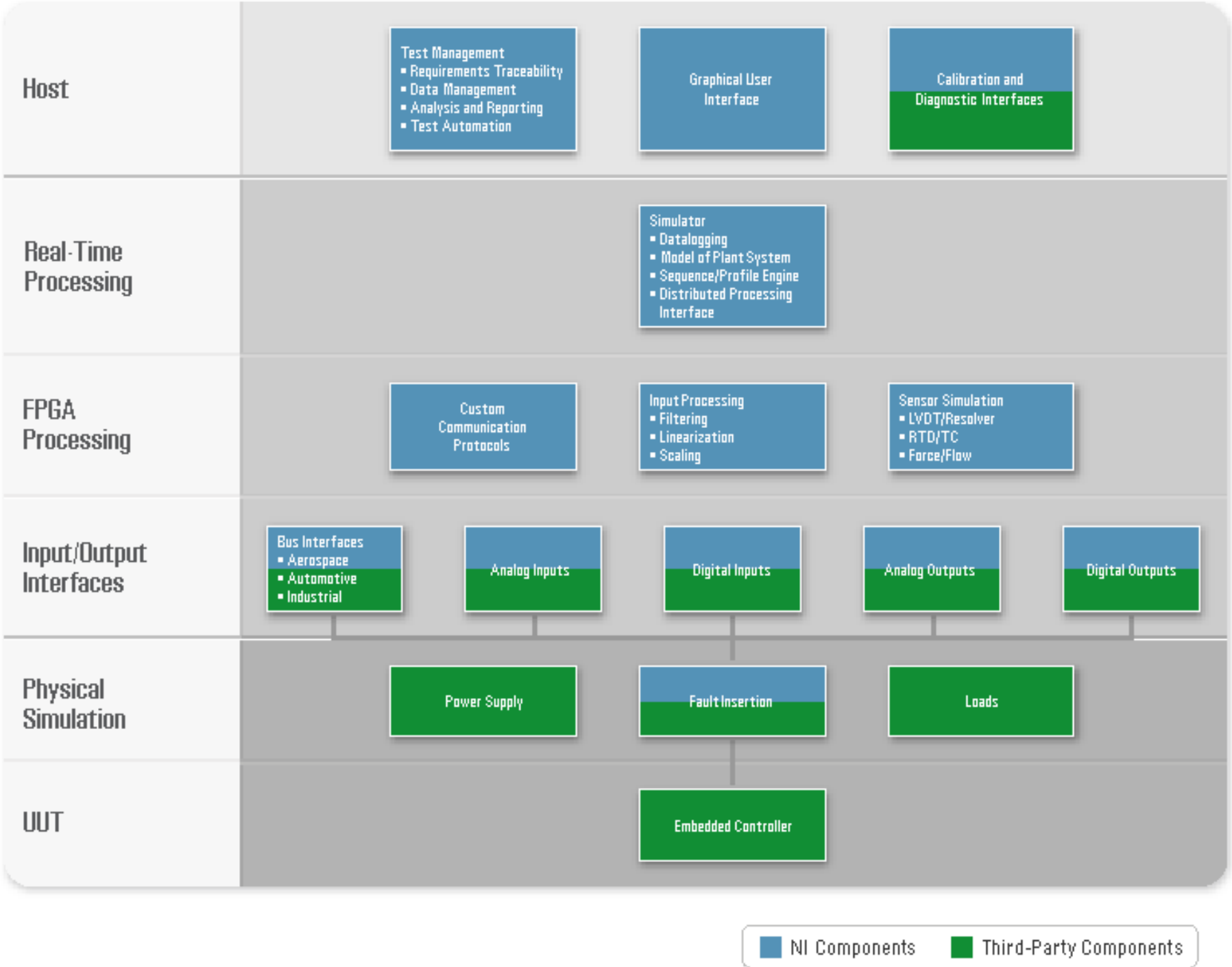
HIL example architecture



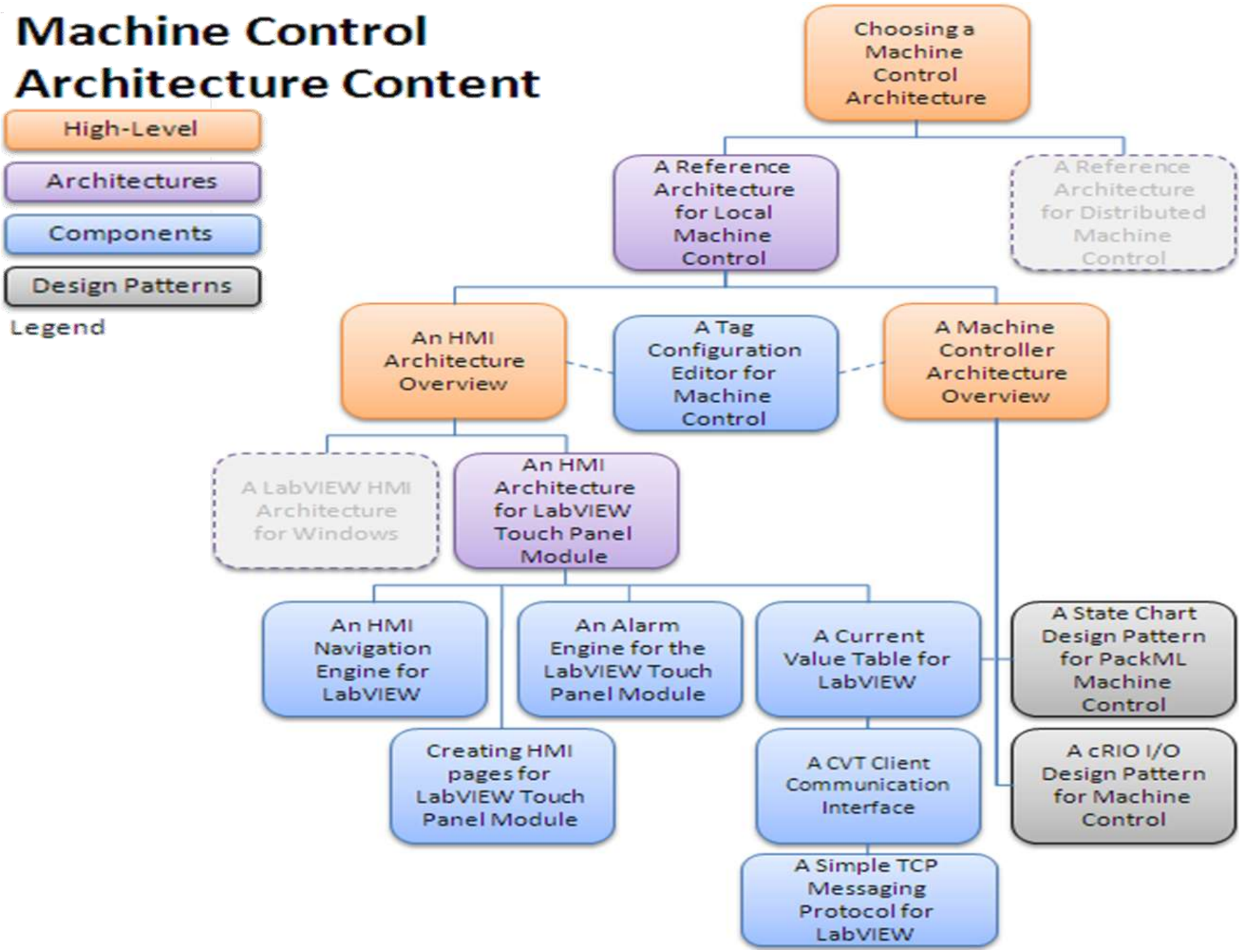
Software Requirement

A lot of advantages in software can be found in the following behavior.




Host
Test Management
• Requirements Traceability
• Data Management
• Analysis and Reporting
• Test Automation
Graphical User Interface
Calibration and Diagnostic Interfaces
Real-Time Processing
Simulator
• Datalogging
• Model of Plant System
• Sequence/Profile Engine
• Distributed Processing Interface
FPGA Processing
Custom Communication Protocols
Input Processing
• Filtering
• Linearization
• Scaling
Sensor Simulation
• LVDT/Resolver
• RTD/TC
• Force/Flow
Input/Output Interfaces
Bus Interfaces
• Aerospace
• Automotive
• Industrial
Analog Inputs
Digital Inputs
Analog Outputs
Digital Outputs
Physical Simulation
Power Supply
Fault Insertion
Loads
UUT
Embedded Controller
NI Components
Third-Party Components

Machine Control Architecture Content



How to proceed?

Recommendations for how to proceed:

- Get started but be prepared for changes !
  - Build with a well defined structure and you will be able to modify it according to your needs.
- Involve all potential users and let them participate
  - System architect, Designer, Integration and Verification, Production test, After market
- Prioritize the requirements in order to get a first system up and running
  - Add functionality and scale up the system later
  - Incremental system development
- Build upon standard components (SW and HW)
- If you are not familiar with advanced test systemization and the new technologies. Get a partner that can help you.

Added value of a Partner

- Knowledge of common issues & challenges
- Knowledge of Software Tools
  - LabVIEW Platform
  - Control Design & Simulation Module
  - MATLAB Simulink
- Expertise in OPEN Software Architecture
- Experienced in design & specification of HW & SW

NI Reference material

1. See the reference architecture for a typical Hardware In the Loop system,
2. to read a customer solution,
3. and view a webcast on how to develop Test Systems using LabVIEW.

Download the Hardware In the Loop Resources Kit.

http://digital.ni.com/express.nsf/bycode/ex4d5f
http://www.ni.com/pdf/misc/us/hil_simulation_checklist.pdf

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