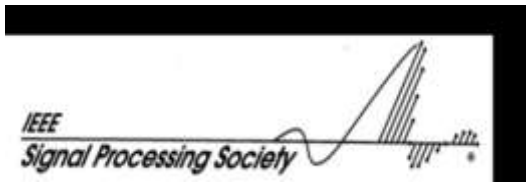


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# Sensor Signal Processing for Defence Conference



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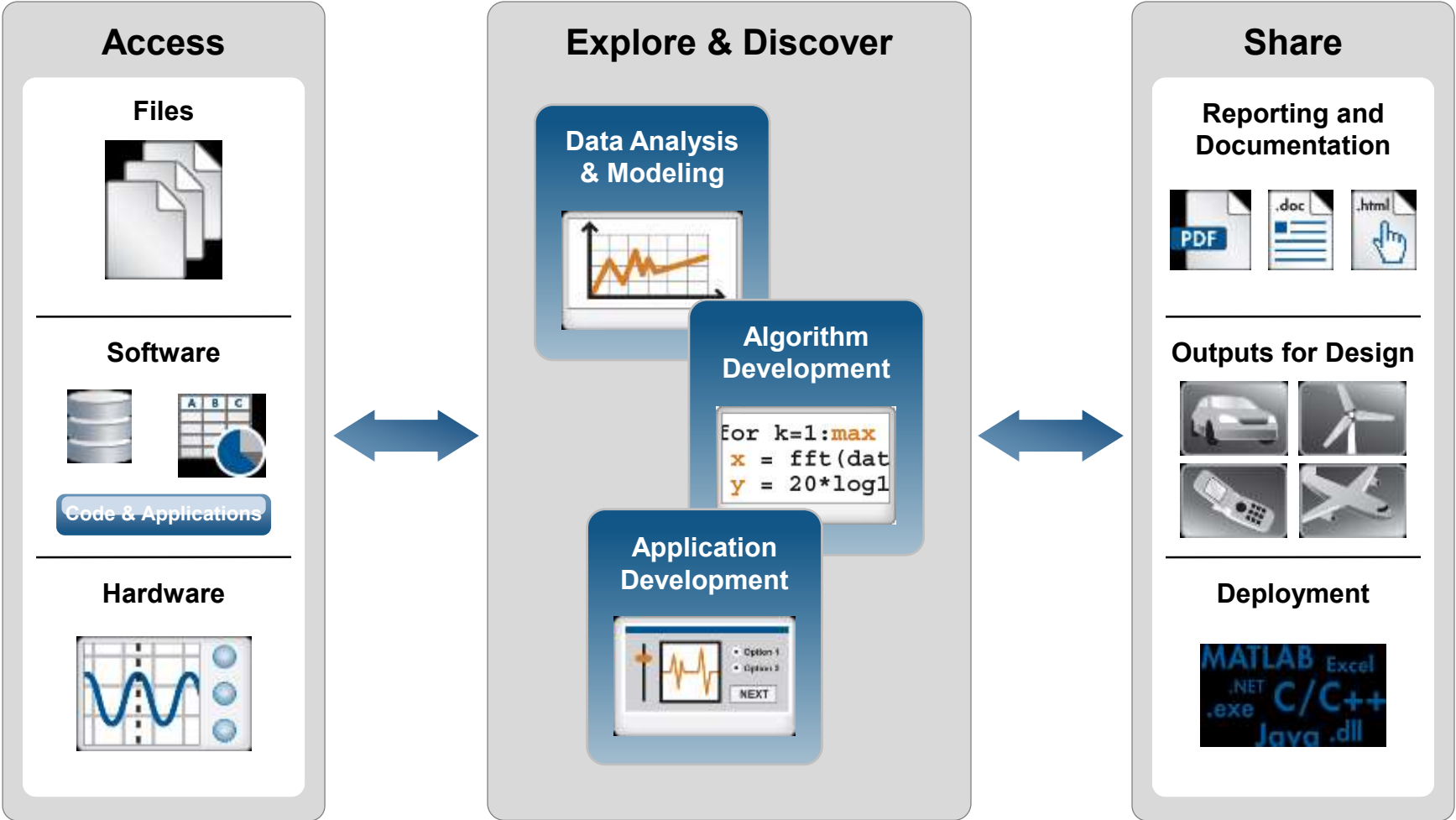
# Advanced Signal Processing with MATLAB & Simulink

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**Signal Processing and Communications**  
**MathWorks UK Glasgow**  
**10 September 2015**

# Introduction & Agenda

- A **complete workflow** for developing **advanced signal processing** systems
- **Toolboxes**: packaging proven algorithms
- **Sharing**: functions, classes, toolboxes and apps
- **Production**: HDL code generation case study

# MATLAB & Simulink: Tools for a Complete Workflow



# MathWorks and Advanced Signal Processing

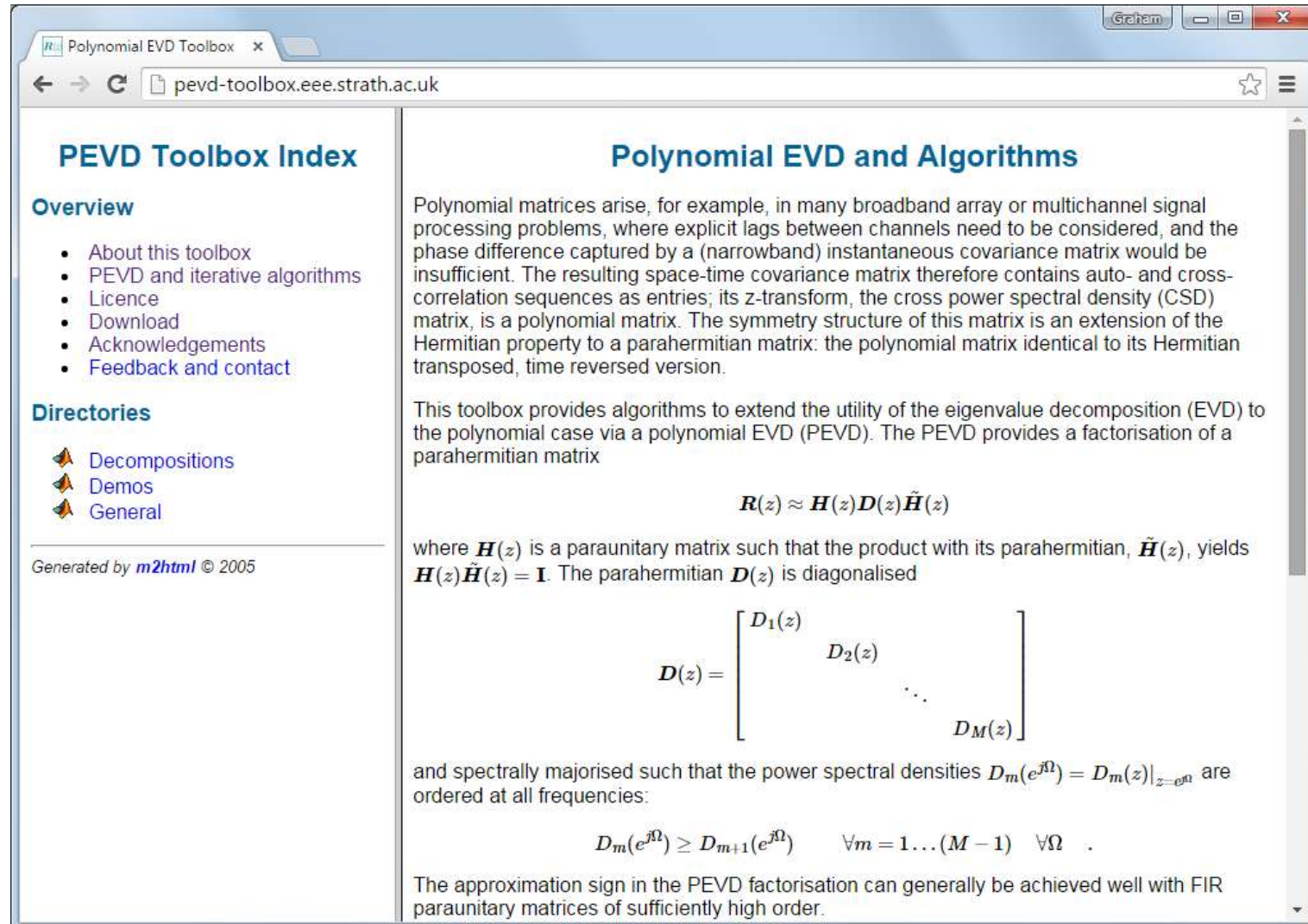
- **Toolboxes**
  - Packaging of proven algorithms as demanded by the field
  - Building blocks for advanced signal processing systems
- **Simulation Technology**
  - High performance execution of algorithms
  - Multi-threaded execution and GPU acceleration
- **Prototyping & Deployment**
  - C/C++ code generation
  - HDL code generation
  - Hardware support packages





# PEVD Toolbox (Polynomial Eigenvalue Decomposition)

- Available from University of Strathclyde
- Development work supported by EPSRC and the UDRC
- <http://pevd-toolbox.eee.strath.ac.uk>



The screenshot shows a web browser window titled "Polynomial EVD Toolbox" with the URL "pevd-toolbox.eee.strath.ac.uk". The page is divided into two main sections: a left sidebar and a main content area.

**PEVD Toolbox Index**

**Overview**

- About this toolbox
- PEVD and iterative algorithms
- Licence
- Download
- Acknowledgements
- Feedback and contact

**Directories**

- Decompositions
- Demos
- General

Generated by *m2html* © 2005

**Polynomial EVD and Algorithms**

Polynomial matrices arise, for example, in many broadband array or multichannel signal processing problems, where explicit lags between channels need to be considered, and the phase difference captured by a (narrowband) instantaneous covariance matrix would be insufficient. The resulting space-time covariance matrix therefore contains auto- and cross-correlation sequences as entries; its z-transform, the cross power spectral density (CSD) matrix, is a polynomial matrix. The symmetry structure of this matrix is an extension of the Hermitian property to a parahermitian matrix: the polynomial matrix identical to its Hermitian transposed, time reversed version.

This toolbox provides algorithms to extend the utility of the eigenvalue decomposition (EVD) to the polynomial case via a polynomial EVD (PEVD). The PEVD provides a factorisation of a parahermitian matrix

$$\mathbf{R}(z) \approx \mathbf{H}(z)\mathbf{D}(z)\tilde{\mathbf{H}}(z)$$

where  $\mathbf{H}(z)$  is a paraunitary matrix such that the product with its parahermitian,  $\tilde{\mathbf{H}}(z)$ , yields  $\mathbf{H}(z)\tilde{\mathbf{H}}(z) = \mathbf{I}$ . The parahermitian  $\mathbf{D}(z)$  is diagonalised

$$\mathbf{D}(z) = \begin{bmatrix} D_1(z) & & & \\ & D_2(z) & & \\ & & \ddots & \\ & & & D_M(z) \end{bmatrix}$$

and spectrally majorised such that the power spectral densities  $D_m(e^{j\Omega}) = D_m(z)|_{z=e^{j\Omega}}$  are ordered at all frequencies:

$$D_m(e^{j\Omega}) \geq D_{m+1}(e^{j\Omega}) \quad \forall m = 1 \dots (M-1) \quad \forall \Omega$$

The approximation sign in the PEVD factorisation can generally be achieved well with FIR paraunitary matrices of sufficiently high order.

# Hardware Support Packages

Simulink Library | Layout | Preferences | Set Path | Add-Ons | Help | Community | Request Support

ENVIRONMENT

- Get Add-Ons
- Manage Add-Ons
- Package Toolbox
- Package App
- Get Hardware Support Packages
- Check for Product Updates

**Support Package Installer**

Select support package to install

Show: All (72)

Support for:

- NI-845x I2C/SPI Interface
- NI-CAN
- NI-DAQmx
- NI-DCPower
- NI-DMM
- NI-FGEN
- NI-SCOPE
- NI-Switch
- NI-VISA and ICP
- NI-XNET
- OS Generic Video Interface
- Ocean Optics Spectrometers
- PEAK-System CAN Devices
- Point Grey Hardware
- QImaging Hardware
- RTL-SDR Radio
- Raspberry Pi
- STMicroelectronics Microcontrollers
- Teledyne DALSA IFC Hardware
- Teledyne DALSA Spera Hardware
- Texas Instruments C2000
- Texas Instruments C2000 Concerto
- Texas Instruments C6000
- Total Phase Aardvark I2C/SPI Interface
- USB Webcams
- USRP Radio
- Vector CAN Devices
- Wind River VxWorks
- Xilinx FPGA Boards
- Xilinx FPGA-Based Radio
- Xilinx Zynq-7000
- Xilinx Zynq-Based Radio

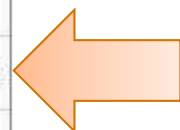
Support packages:

Action	Installed Version	Latest Version	Description	Required Base Product	Supported Host Platforms
1 <input checked="" type="checkbox"/> Install		15.2.0	<a href="#">Design and prototype SDR systems using Xilinx Zynq-based radio</a>	Communications ...	Win32,Win64,Linux64

Choose a support package to install, reinstall, or update.

Installation folder: C:\MATLAB\SupportPackages\R2015b

< Back | Next > | Cancel | Help





# Radio Design Framework

Zynq SDR  
System Dev Kit



MATLAB & Simulink

*Ethernet*

Radio  
Algorithm

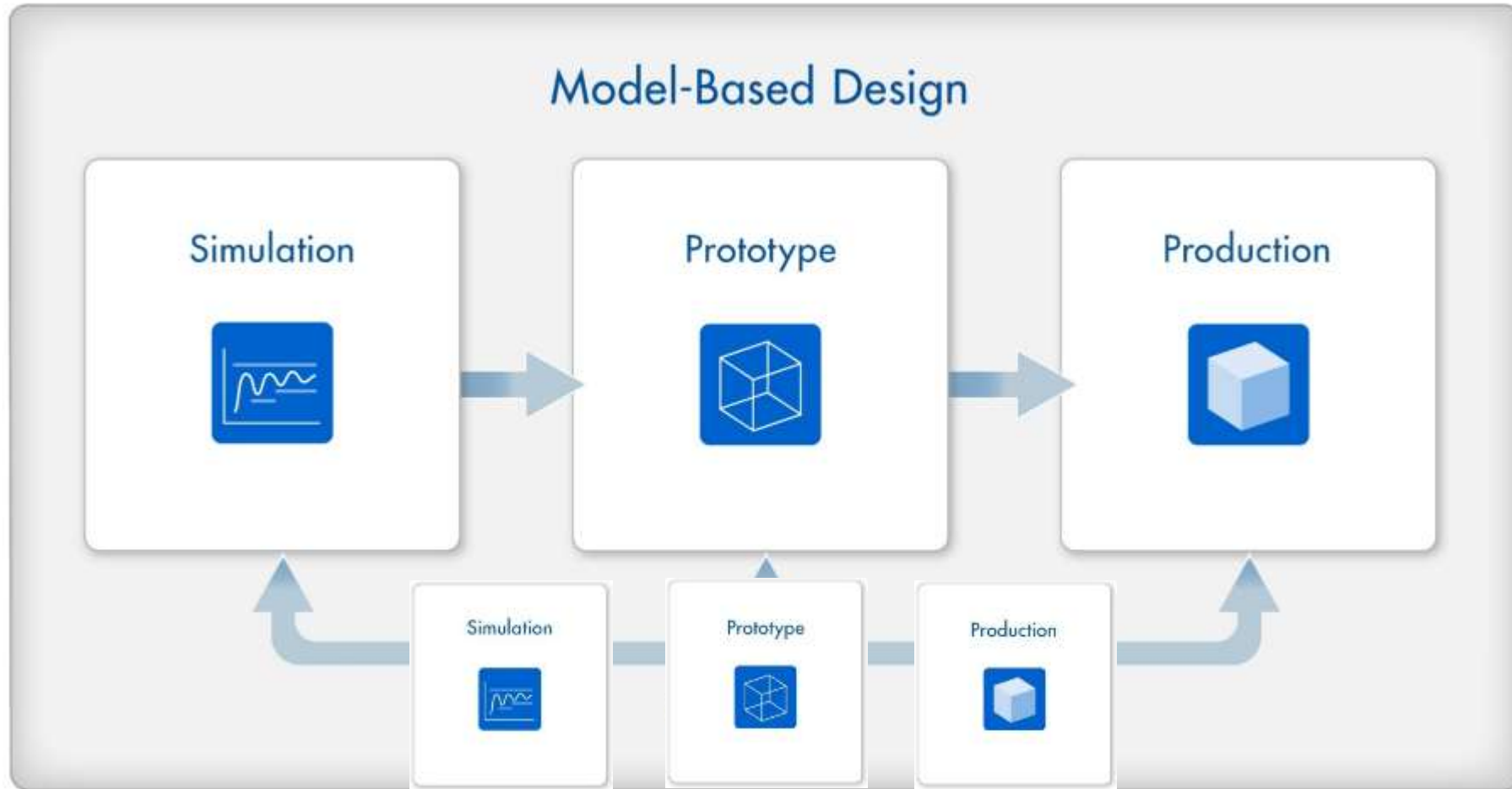
Signal Analysis

Develop and tune algorithms with off-the-air radio signals

Zynq SDR System Development Kit supports analog capture and export to Simulink

# Model-Based Design

A single shared development environment



# Model-Based Design

A single shared development environment

Simulation



**Verify algorithms and explore alternatives**

Prototype



**Validate performance with live data**

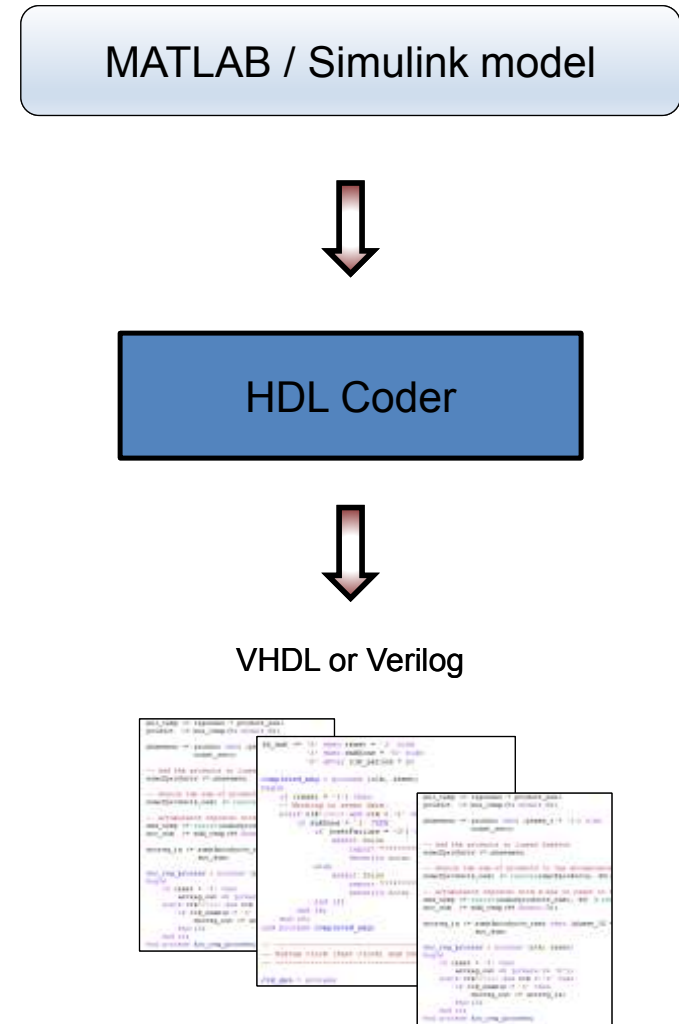
Production



**Deploy design on production system**

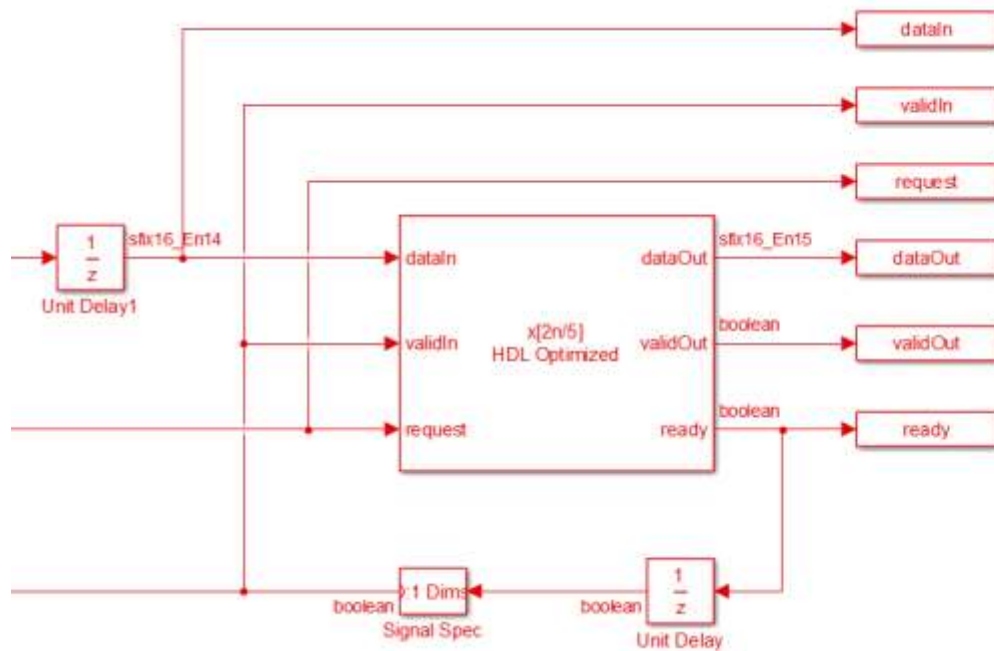
# Prototyping and Deployment on FPGAs and ASICs

- HDL Coder
  - Generate synthesizable VHDL & Verilog
  - Testbench generation
  - Integration with synthesis & implementation tools
- Algorithm support
  - DSP
  - Communications
  - Vision
- A few examples . . .



# HDL FIR Rate Conversion Simulink Block

- Rational factor ( $L/M$ ) sample rate conversion
- Polyphase implementation
- HDL code generation + hardware friendly interface





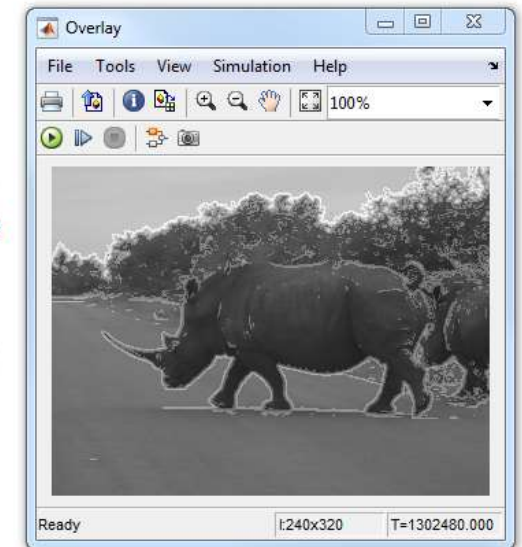
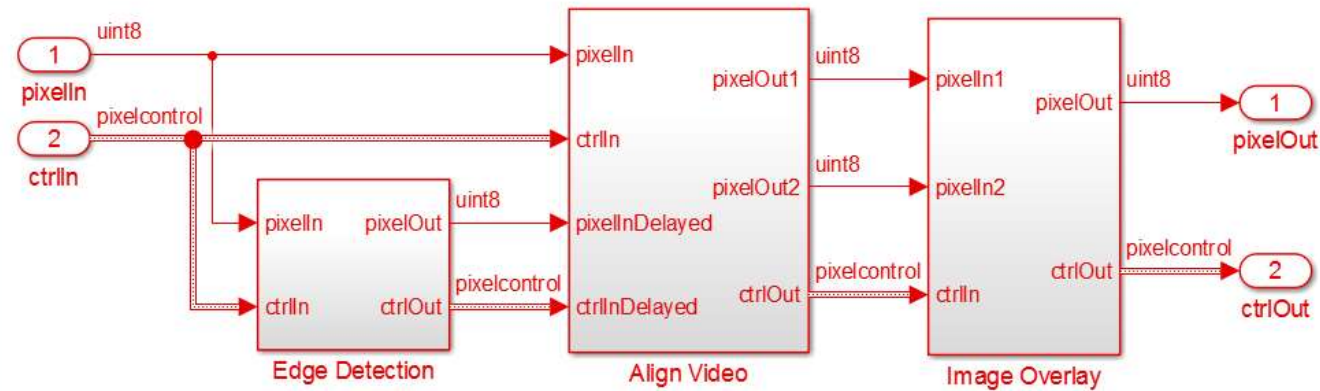
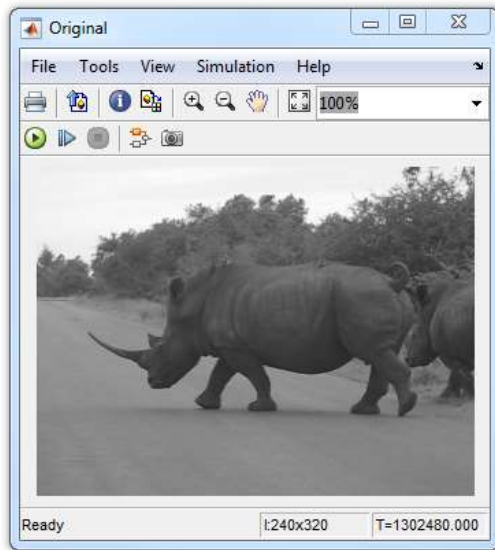
## Vision HDL Toolbox – Released in R2015a

***“Vision HDL Toolbox™ provides pixel-streaming algorithms for the design and implementation of vision systems on FPGAs and ASICs.***

- Analysis & Enhancement
  - Edge Detection
  - Median Filter
- Conversions
  - Chroma Resampling
  - Color-Space Converter
  - Demosaic Interpolator
  - Gamma Corrector
  - Look-up Table
- Filtering
  - Image Filter
  - Median Filter
- Morphological Operations
  - Dilation, Erosion,
  - Opening, Closing
- Statistics
  - Histogram
  - Image Statistics
- I/O Interfaces
  - Frame to Pixels
  - Pixels to Frame
  - FPGA In the Loop (FIL)
- Utilities
  - Pixel Control Bus Creator
  - Pixel Control Bus Selector

# Vision HDL Toolbox – Edge Detection Example

- Design framework for pixel-streaming systems
- Library of pixel-streaming algorithms
- Generate optimized HDL code



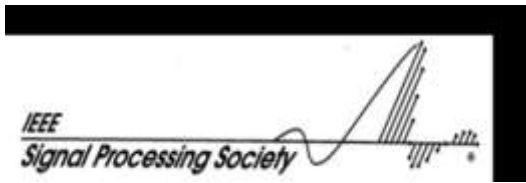
## Concluding Remarks

- **Tools for a complete workflow**
- Platform for algorithm development and exploration
- High performance simulation environment
- Toolboxes which package proven algorithms
- Sharing of functions, classes, toolboxes and apps
- Production & prototyping

Thank you!

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