



# Model-Based Design for Video/Image Processing Applications

*The MathWorks*

# Agenda

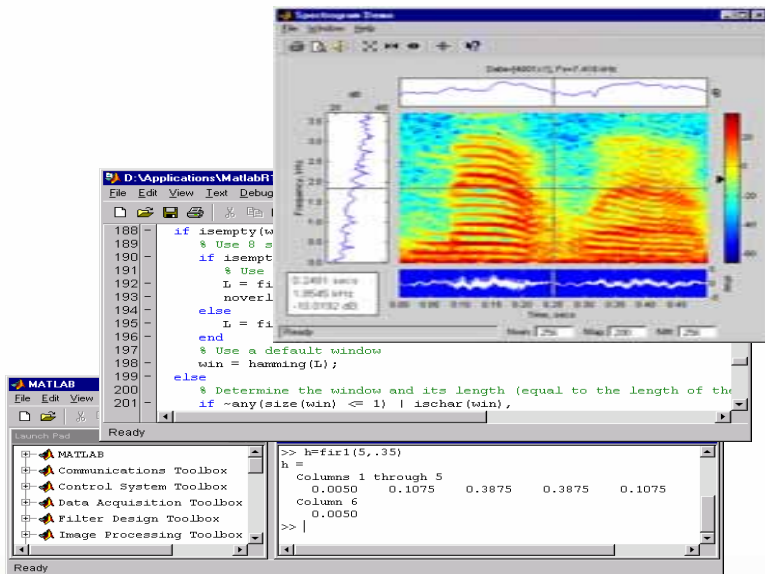
- Model-Based Design
- From MATLAB and Simulink to Altera FPGA
  - Step-by-step design and implementation of edge detection algorithm
  - NTSC-to-HD video converter design
- Roadmap for Model-Based Design and next steps

# The MathWorks Mission

Accelerating the Pace of Engineering and Science

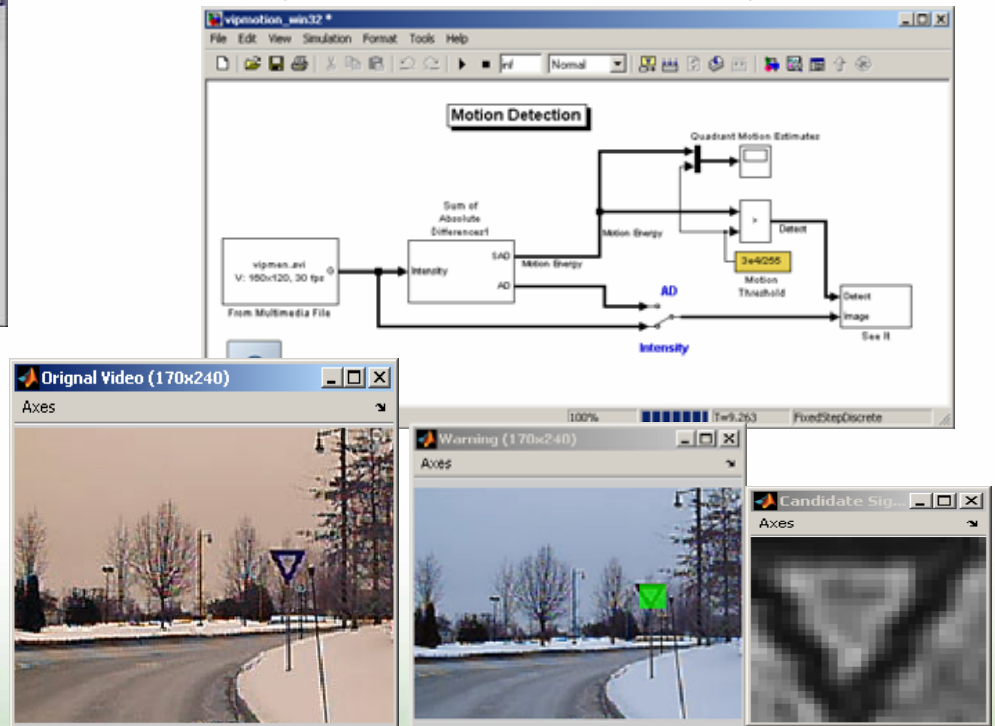
# MATLAB®

The leading environment for technical computing



# SIMULINK®

The leading environment for modeling, simulating, and implementing dynamic and embedded systems



# The MathWorks



**IDT-Newave Reduces Semiconductor Design Time by Months**

A CODEC CHIP THAT ACHIEVED 50% COMPRESSION IN DEVELOPMENT TIME.

THAT'S MODEL-BASED DESIGN.

to better understand with a comprehensive architecture, the IC design team at Realtek used the MathWorks' model-based design to reduce the time to market and a 50% model-based design. To demonstrate and compare the results, the team used the MathWorks' model-based design to reduce the time to market by 50%.

**The MathWorks**  
Accelerating the pace of engineering and science

**MATLAB**  
**SIMULINK**  
www.mathworks.com

**Realtek Cuts Development Time by 50%, Takes the Lead in New-Generation High Definition Audio (HDA) CODECs**



# Session Goal:

## *Solutions to Address Today's Design Challenges*

- Breaks in conventional design flows
- Verification of complex FPGA designs
  
- Solution - Model-Based Design
  - Integrated environment for simulation, implementation, testing, and verification of complex systems
  - Path to implementation on FPGA devices and digital signal processing (DSP) processors

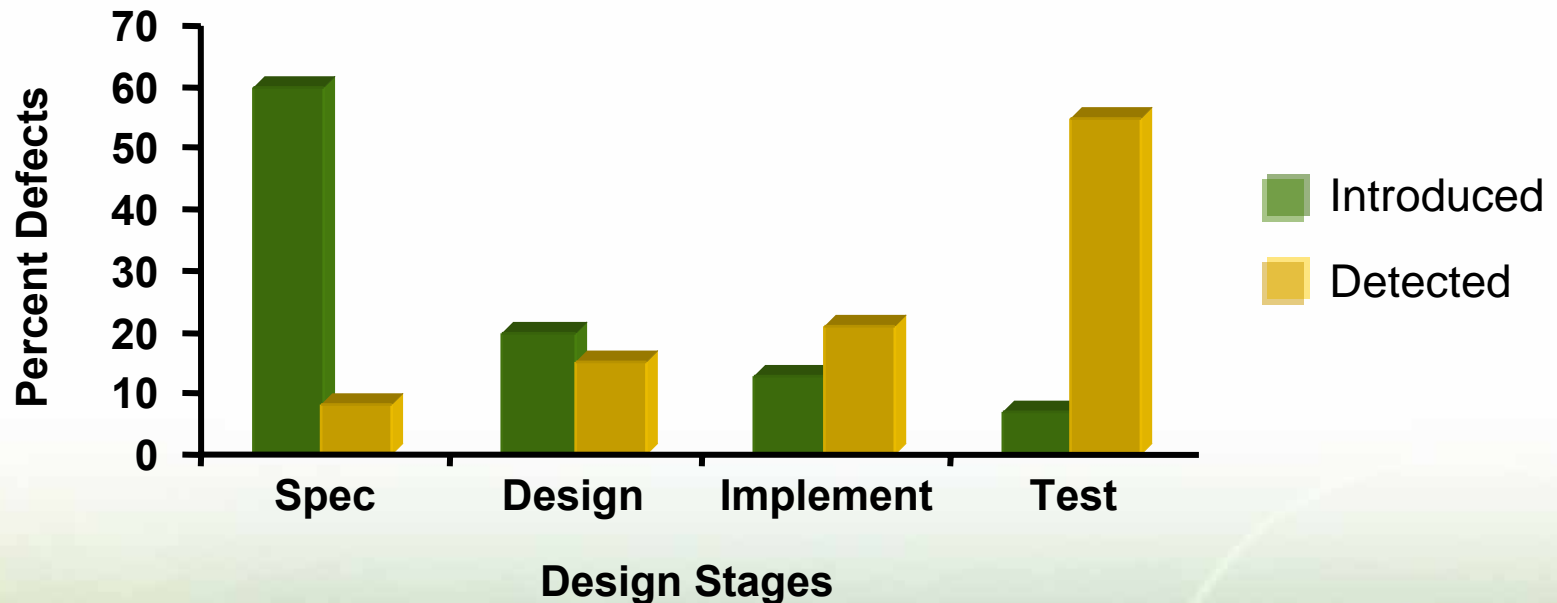
*Deliver better products  
in less time*

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# Design Failure and Time-to-Market in Embedded Systems

- Survey of ~1000 developers across multiple industries:
  - 54% of projects behind schedule
  - < 1/3 were within 10% of intended performance/feature requirements
  - >30% failed to meet 50% of performance/feature requirements



Source: Embedded Market Forecasters, July 2003

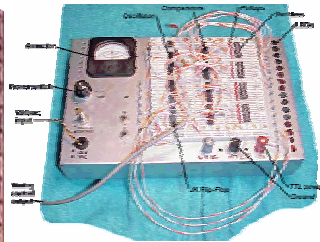
# Problems with Traditional Workflows

## Requirements / Specifications



**Text documents**  
prevents rapid iteration

## Design



**Physical prototypes**  
incomplete, expensive

## Implementation



**Manual implementation**  
separate tools & human error

## Test and Verification



**Traditional testing**  
errors found late in process

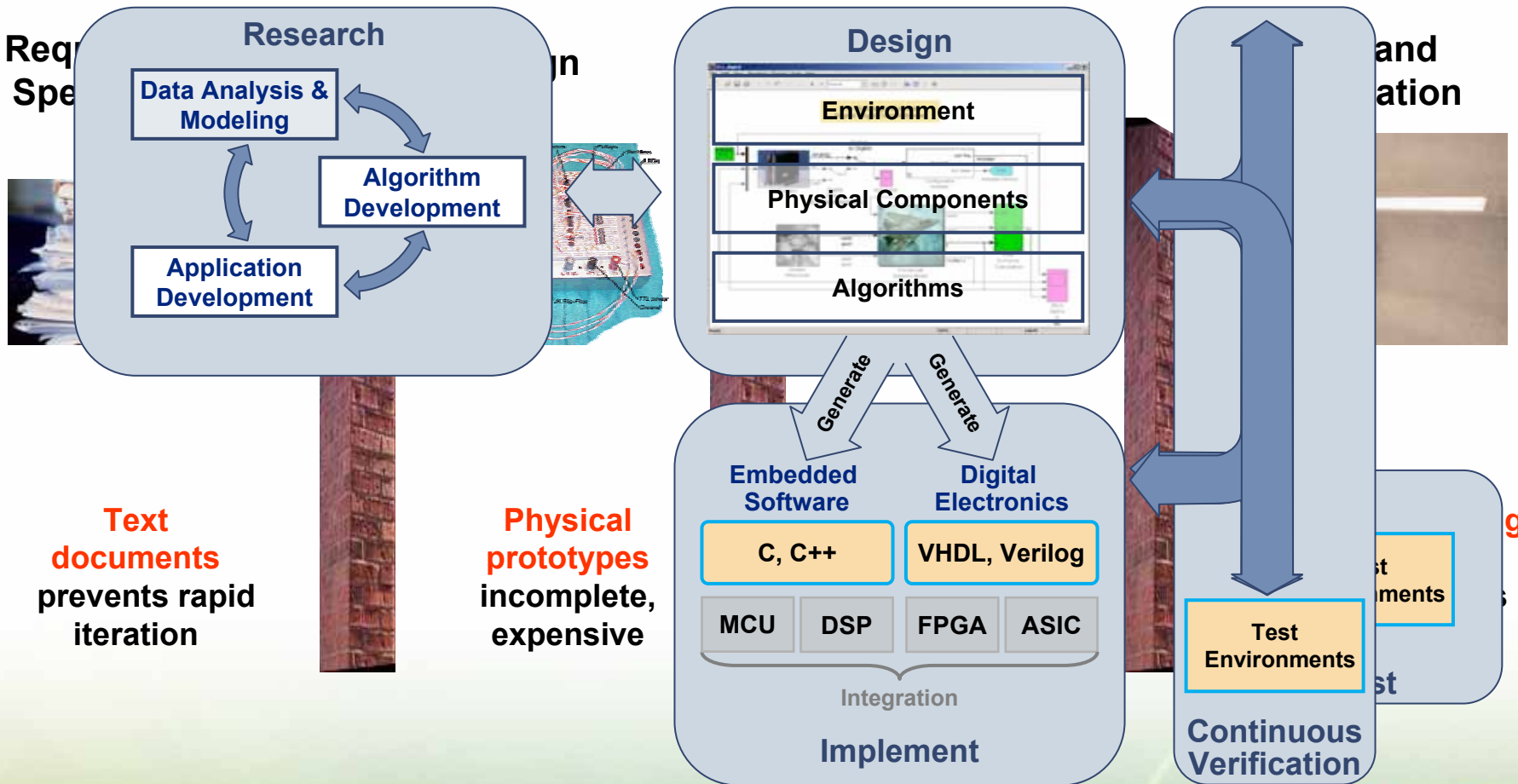


# Model-Based Design Workflow

## Research

## Design

## Requirements



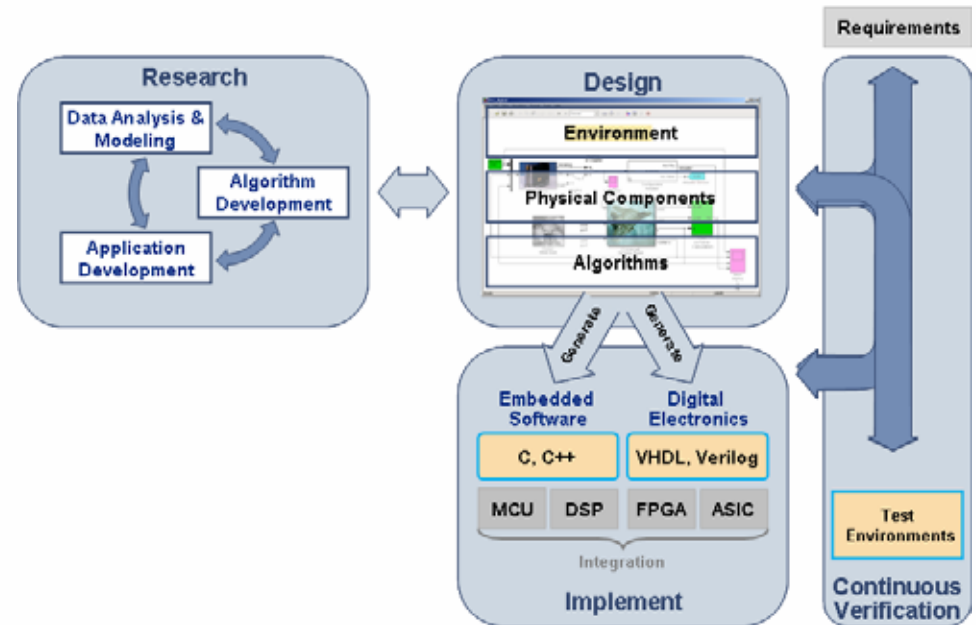
# The Benefits of Model-Based Design

## ■ Characteristics

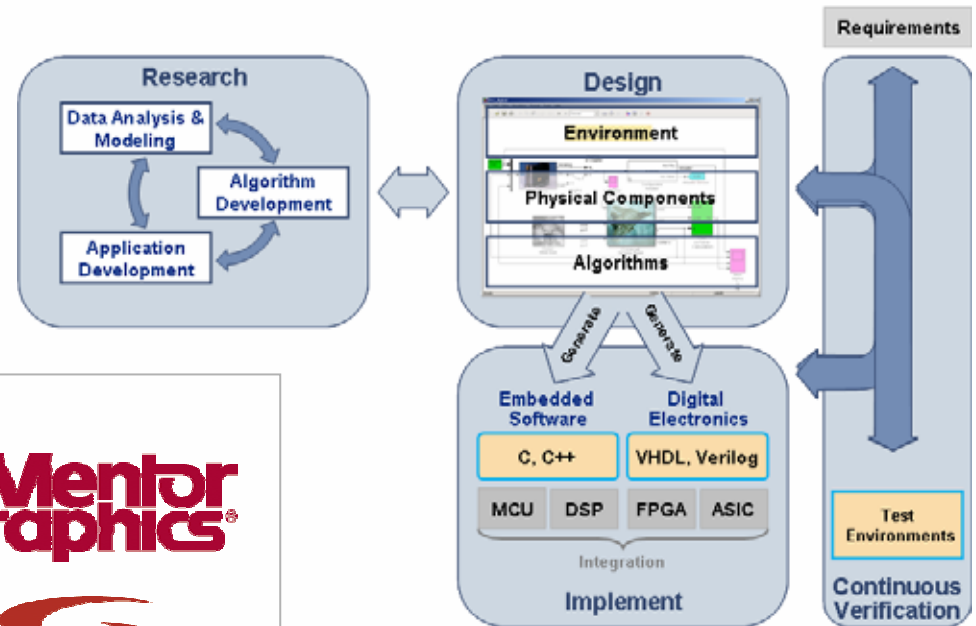
- Behavioral system modeling immediately
- Fixed-point modeling for hardware equivalency
- Automatic HDL code generation
- HDL and system model co-simulation

## ■ Benefits

- Validate design specification
- Rapid design iteration
- Accelerated time-to-first HDL
- Verify the implementation to a complete and valid specification.



# Industry Partners for Model-Based Design



Powered By

**ALTERA.**

**cadence**

 **The MathWorks**

**Mentor  
Graphics®**

  
**Synplicity®**

 **TEXAS INSTRUMENTS**

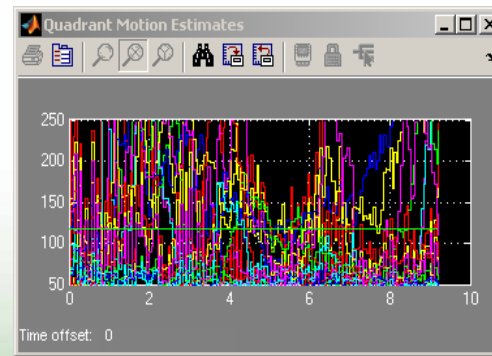
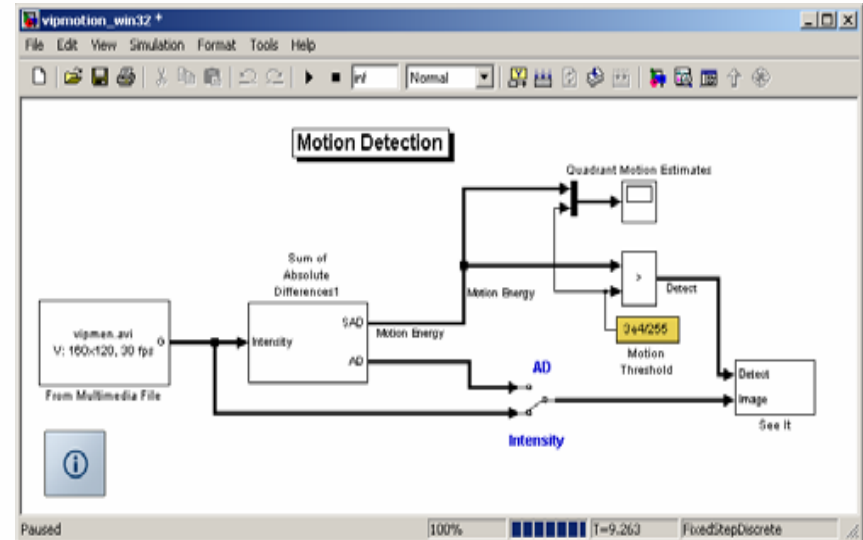
 **SOPC  
WORLD**

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# What is Simulink?

- Simulation, modeling, and design environment
- Key features
  - Hierarchical, component-based modeling
  - MATLAB® integration
  - Extensive library of predefined blocks
  - Application-specific libraries
  - Open Application Program Interface (API)

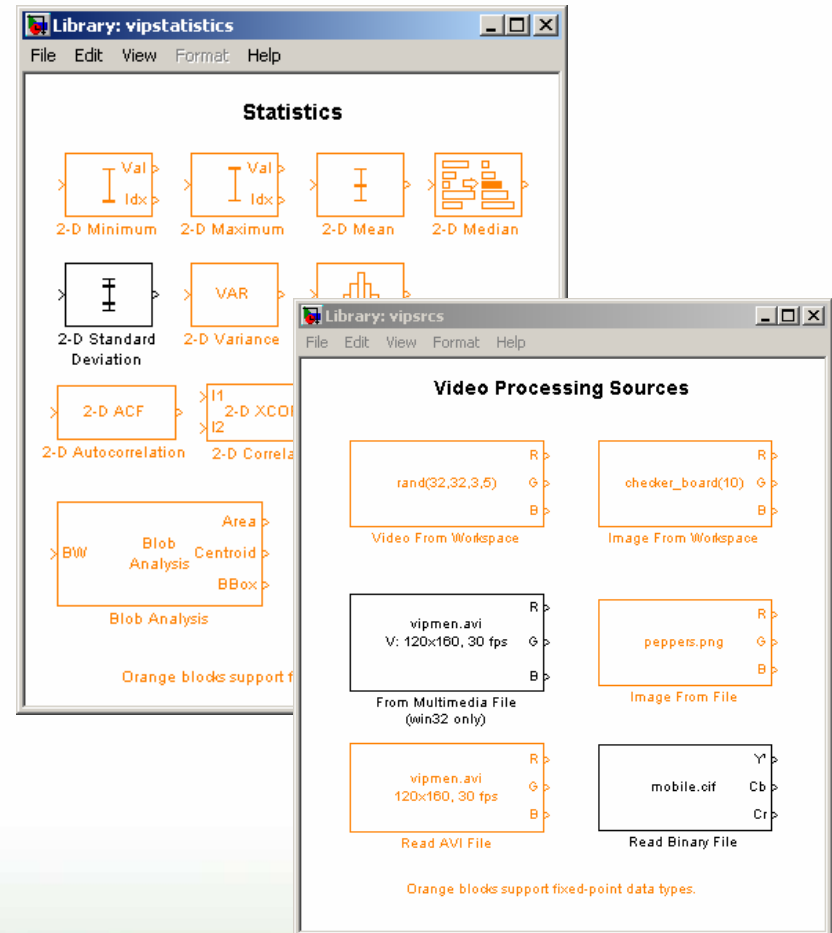




# Simulink Libraries and Blocksets

## Example: Video and Image Processing Blockset

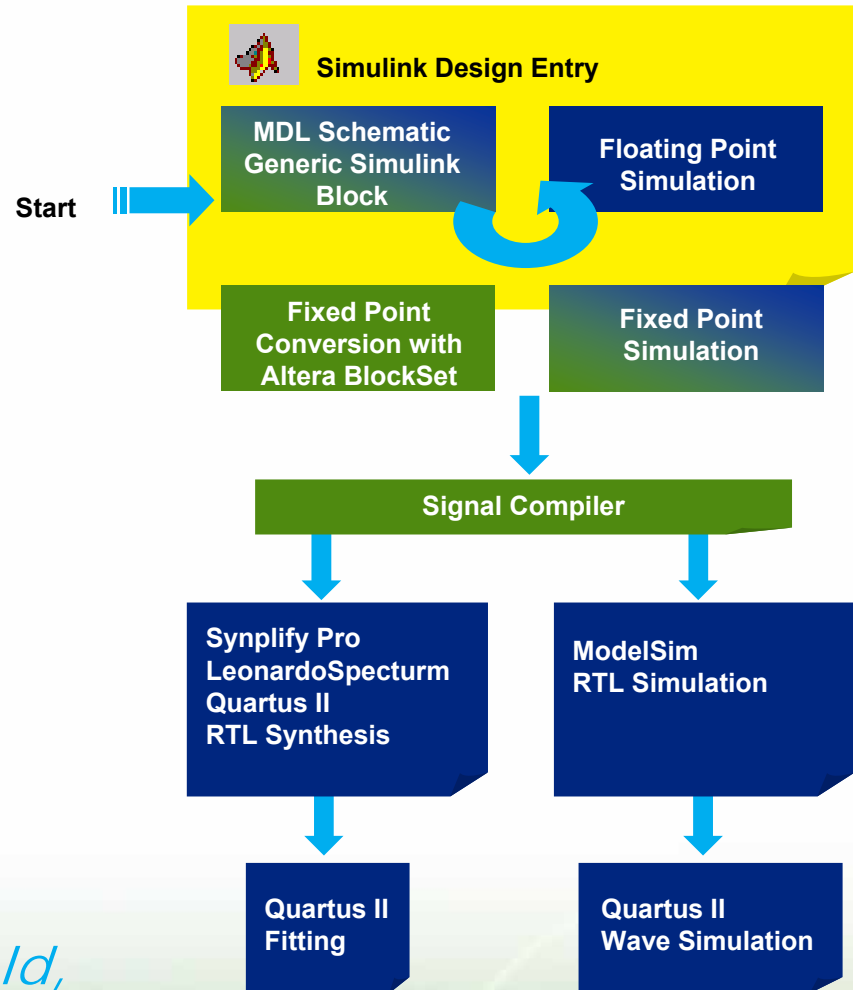
- Analysis and enhancement
- Conversions
- Filtering
- Geometric transforms
- Morphological operations
- Sinks
- Sources – video inputs
- Statistics
- Text and graphics
- Transforms
- Utilities



# What is Altera DSP Builder?



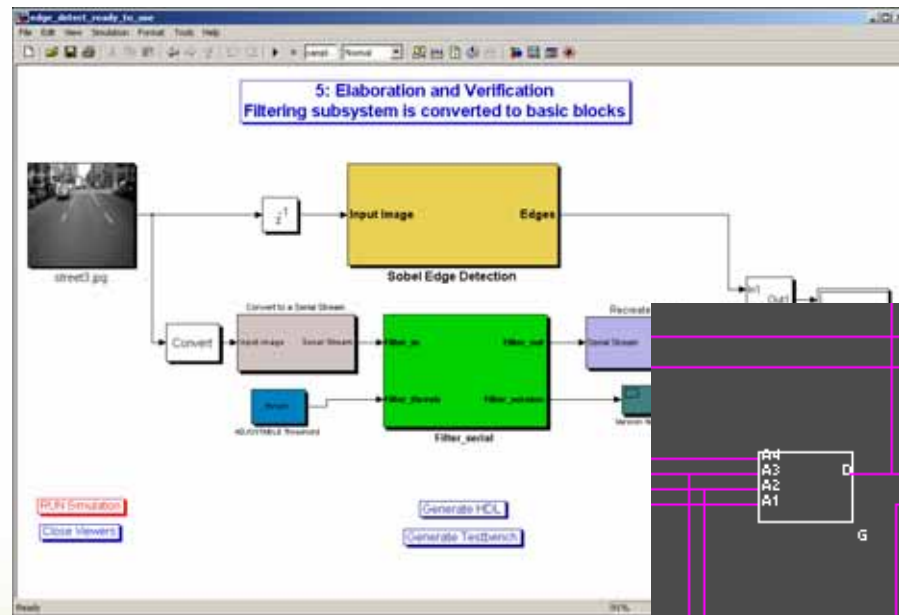
- Altera's interface between Quartus® II design software and MATLAB/Simulink
- Altera blockset
  - Library of optimized fixed-point Simulink functions
- Altera DSP IP
  - Open Core
- Signal compiler utility
  - Converts between Simulink and Altera domain
- Hardware Debug
  - Hardware-in-the-Loop/ SignalTap® II



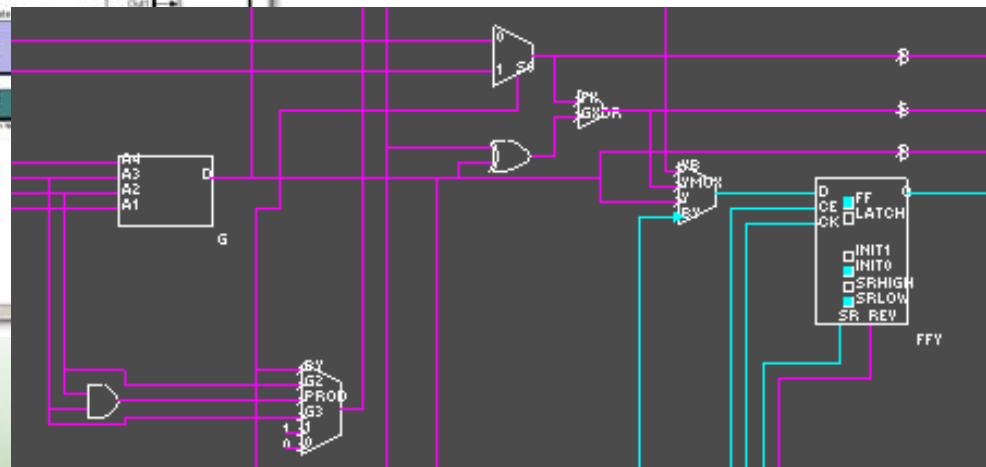
*DSP Builder is Developed, Sold,  
and Supported by Altera*

# Case Study

- Implementing Sobel Edge Detection Algorithm on an Altera FPGA



Live Demo

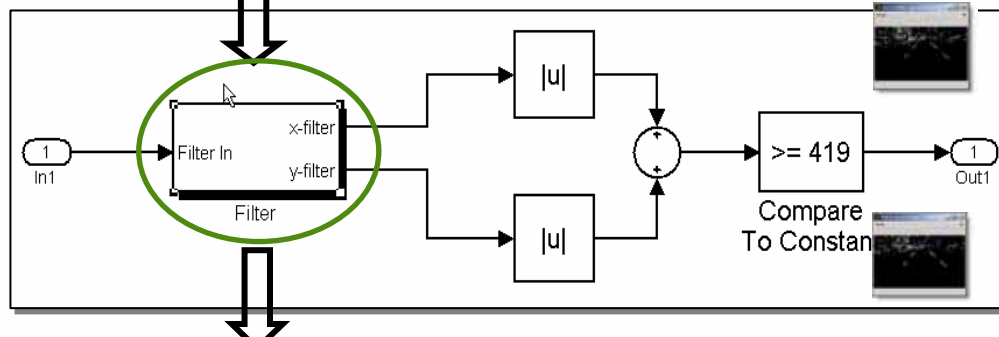


# Edge Detection Case Study

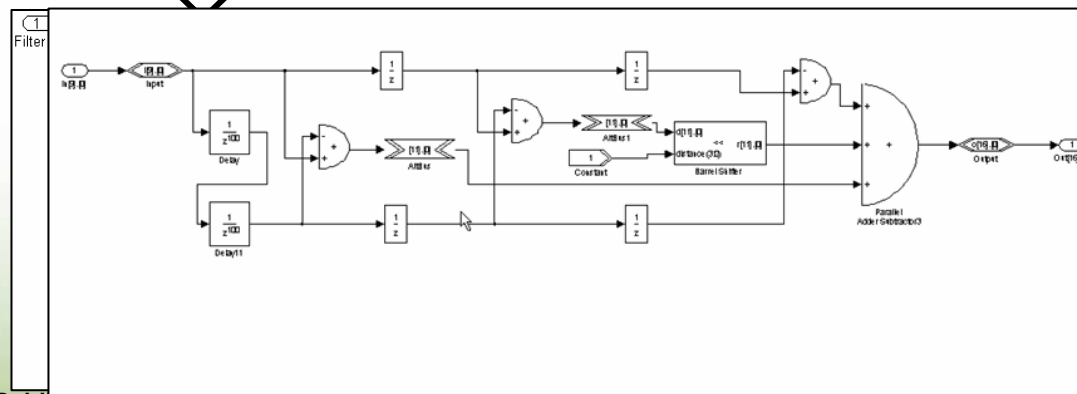
Floating-point model  $\equiv$  Fixed-point model = HDL



Floating-point model



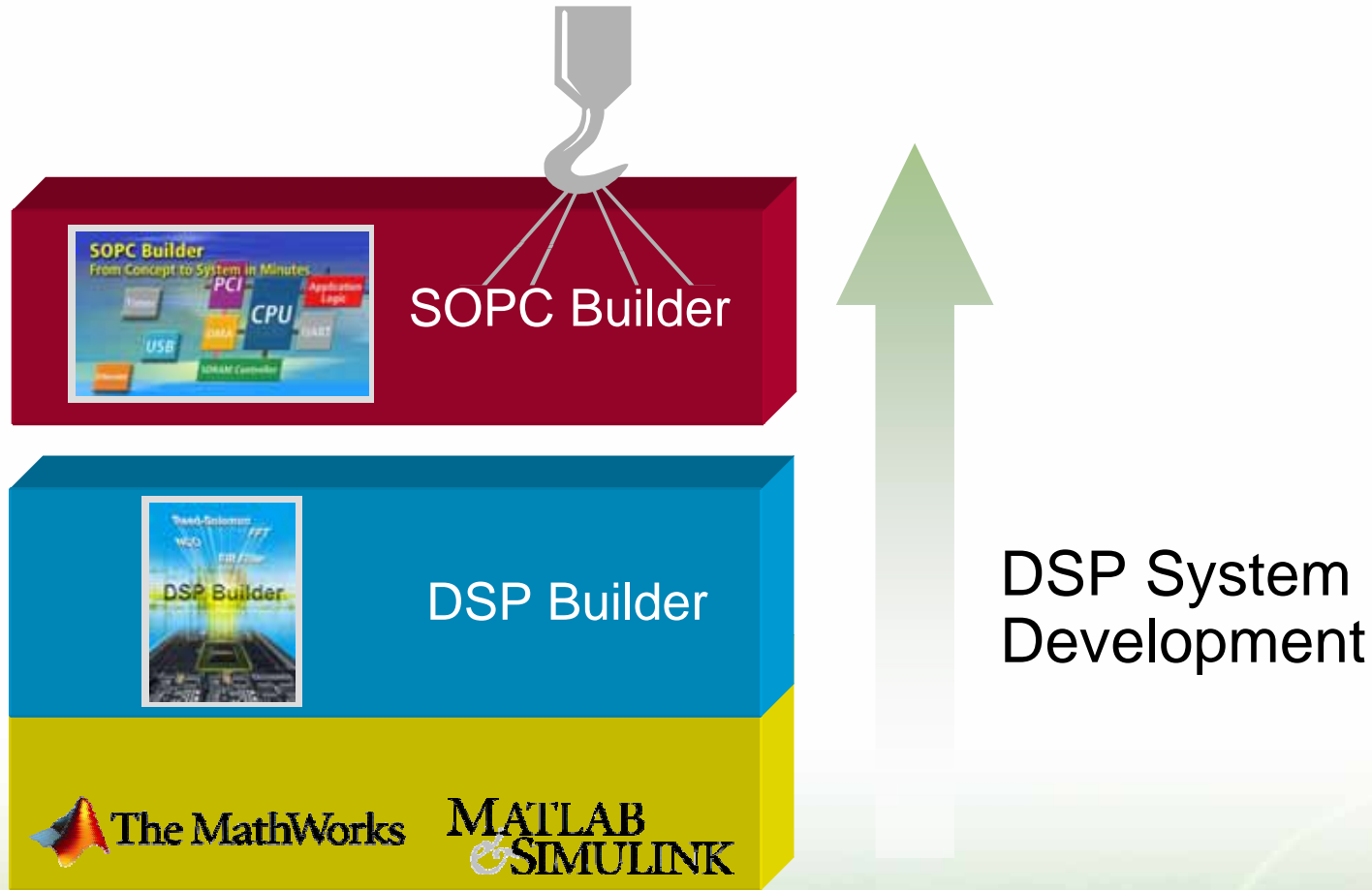
Fixed-point model



Fixed-point DSP Builder

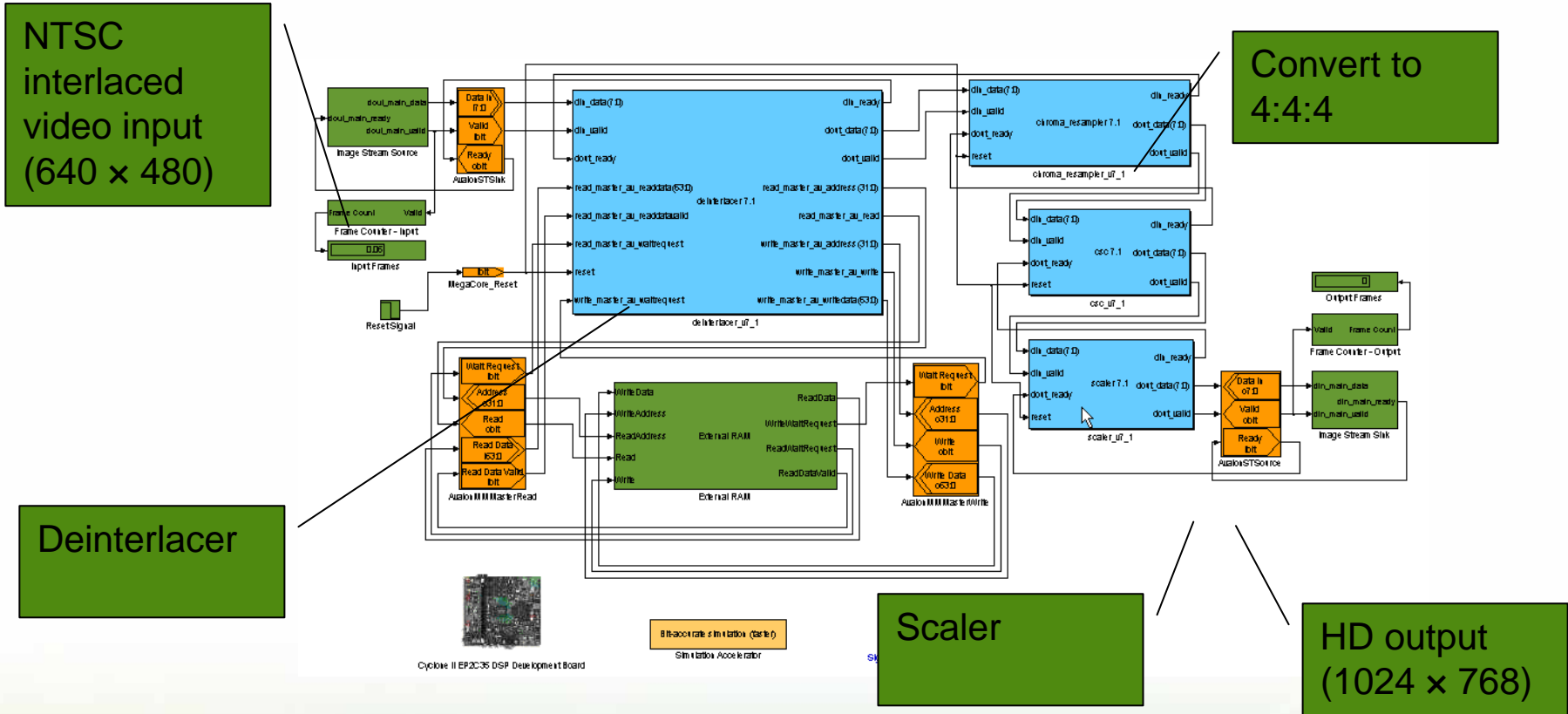


# Completing Design Flow from Simulink to Altera FPGAs





# Additional Demo at The MathWorks Exhibit: NTSC Video to HD Converter



NTSC  
interlaced  
video input  
(640 x 480)

Convert to  
4:4:4

Deinterlacer

Scaler

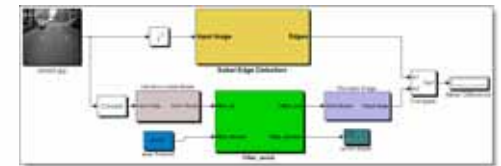
HD output  
(1024 x 768)

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# Simulink HDL Coder for Automatic HDL Code Generation

- Simulink HDL Coder generates 'correct-by-construction' HDL
  - Matches fixed-point system model
  - Reduces verification burden
    - Produces testbench in minutes
    - Stimulus Response auto-capture
  - Pre- & self-documenting
- The MathWorks and Altera working to support import of HDL from Simulink HDL Coder into DSP Builder



Automatic  
HDL



# In Summary

- Model-Based Design enables faster design times and increased quality
- Simulink for Model-Based Design
  - Single environment to simulate, implement, test, and verify complex video systems
- The Altera / MathWorks partnership
  - Providing Model-Based Design from design capture to hardware implementation
  - Altera DSP Builder provides rapid compilation of designs to Altera semiconductor devices
  - Tighter integration underway between DSP Builder and Simulink HDL Coder

# Next Steps

- Visit the MathWorks booth and talk to our engineers
  - Check out designs and demos
  - Ask for a trial, or schedule a meeting for your company

*Thank You!*





**Thank You!**