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MATLAB® & SIMULINK®

Communication System Design for Software Defined Radio

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Outline

Overview of Software Defined Radio (SDR)

- Working Definition of SDR
- MathWorks Activities in SDR
- Design Flows for SDR Development

MathWorks Tools for SDR Designs

- Demo: SDR Reference Waveform – FM3TR
  - Simulations
  - Fixed-Point System Design
  - Automatic Code Generation
- Example Design Flows for Target Platforms

Conclusion

A Working Definition of SDR

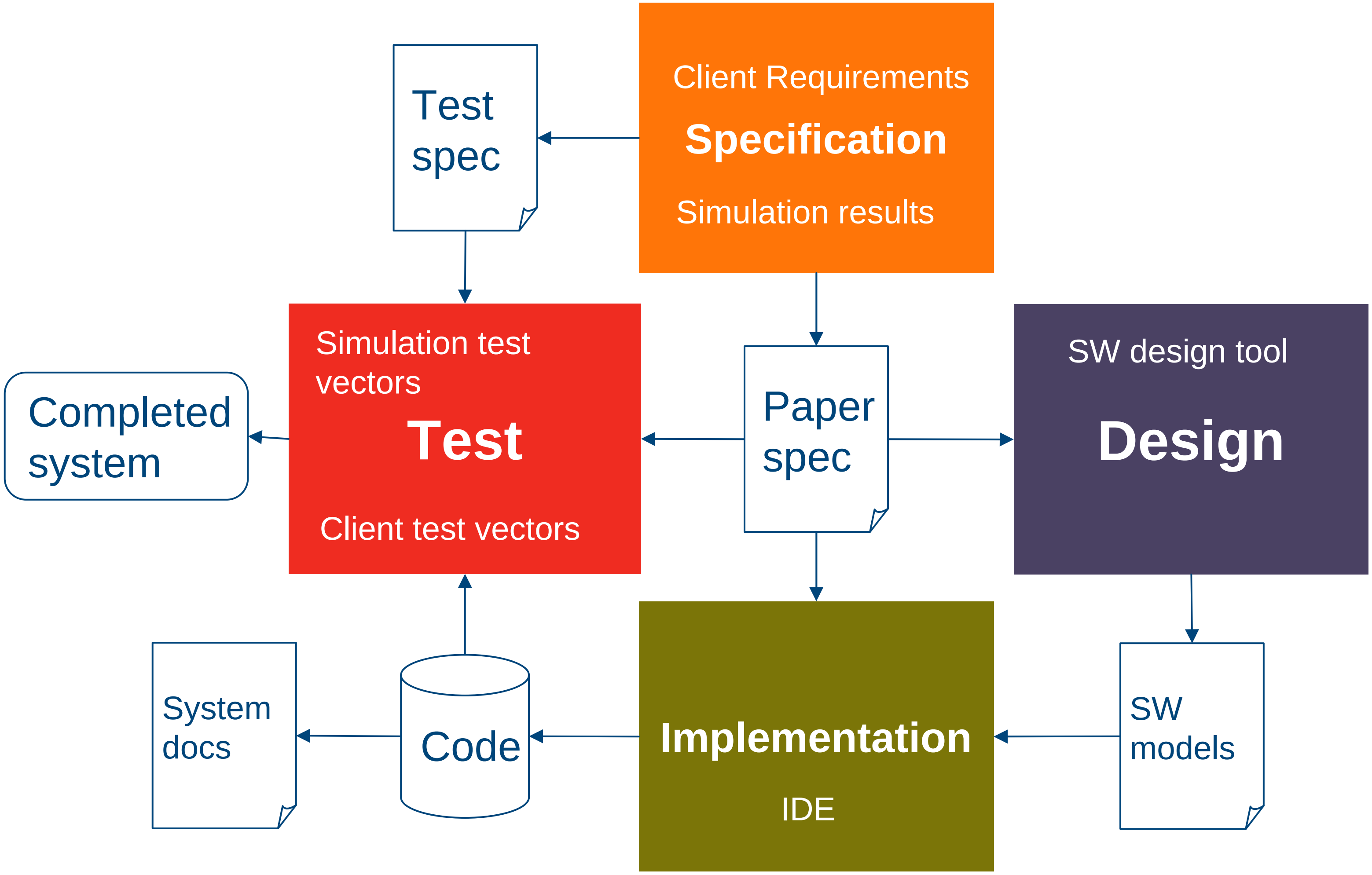
- SDR is a collection of hardware and software technologies that enable reconfigurable system architectures for wireless networks and user terminals.
- Embedded, portable, reusable software
  - Across diverse software and hardware platforms
  - Across teams, projects, and in time
  - For multistandard support
  - For reduction of development cost and time
- Defense industry driving the technology via JTRS

The MathWorks Activities in SDR

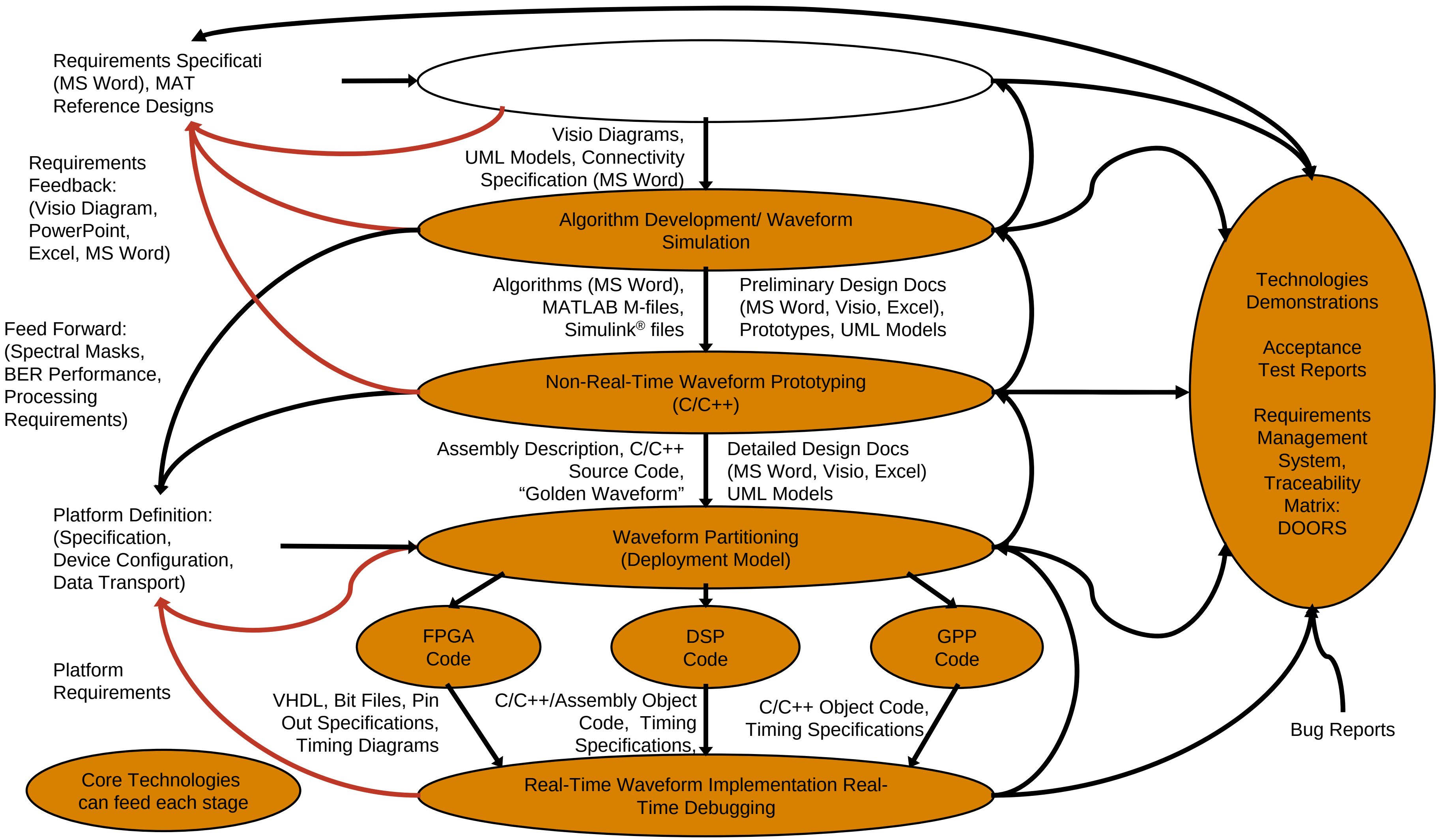
- Active member of the SDR Forum since 2002
- Participation in work groups:
  - Design Process and Tools
  - Hardware Abstraction Layer
  - Commercial Technology
- Delivered workshops on code portability and embeddable transceiver code generation

Design Flows for SDR Development

Traditional Design Flow



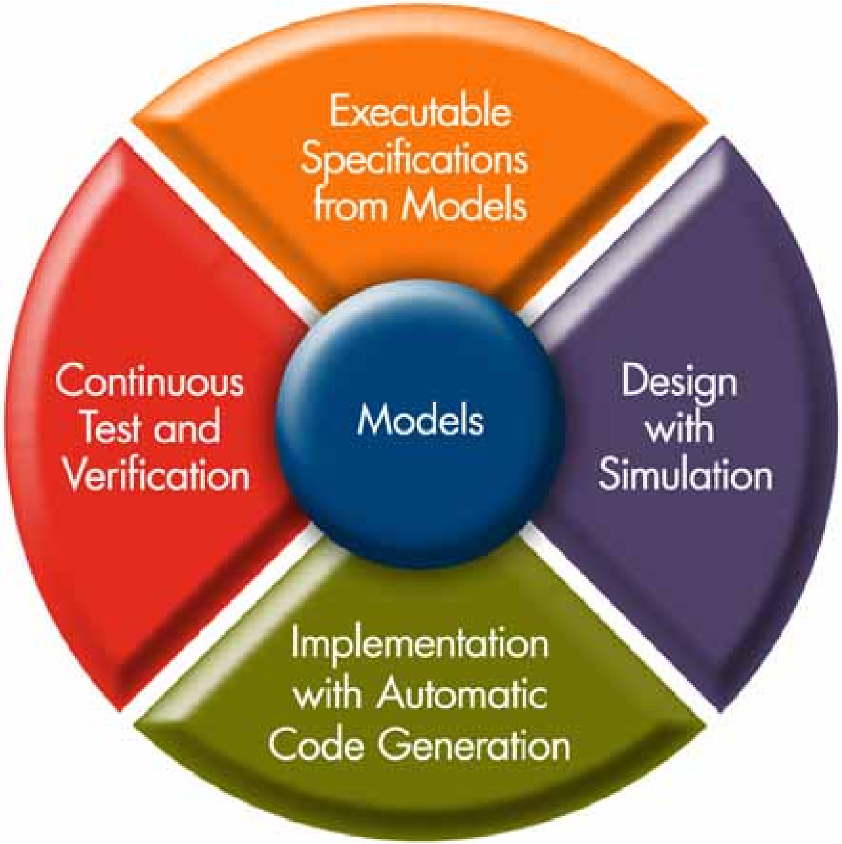
Waveform Design (by SDR Forum Tools Work Group)



Overview of Model-Based Design

Links to paper-based specs

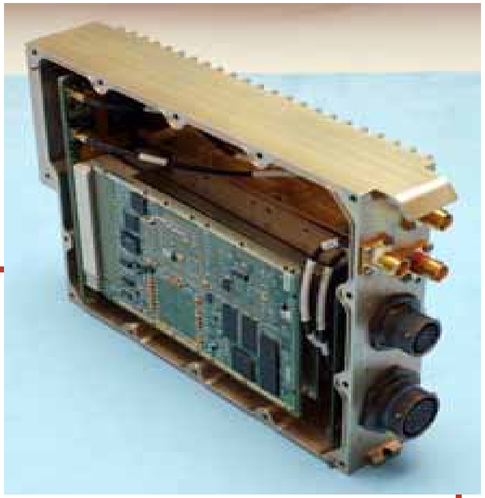
Iterate,
Iterate,
Iterate!



Floating point to Fixed point

Import your own custom code

BAE Systems Achieves 80% Reduction in Software-Defined Radio Development Time with Model-Based Design



The Challenge

To develop a military standard SDR waveform for satellite communications

The Solution

Use Simulink and Xilinx System Generator to rapidly design, debug, and automatically generate code for an SDR signal processing chain

The Results

- Project development time reduced by 80%
- Problems found and eliminated faster
- Clocking and interfacing simplified

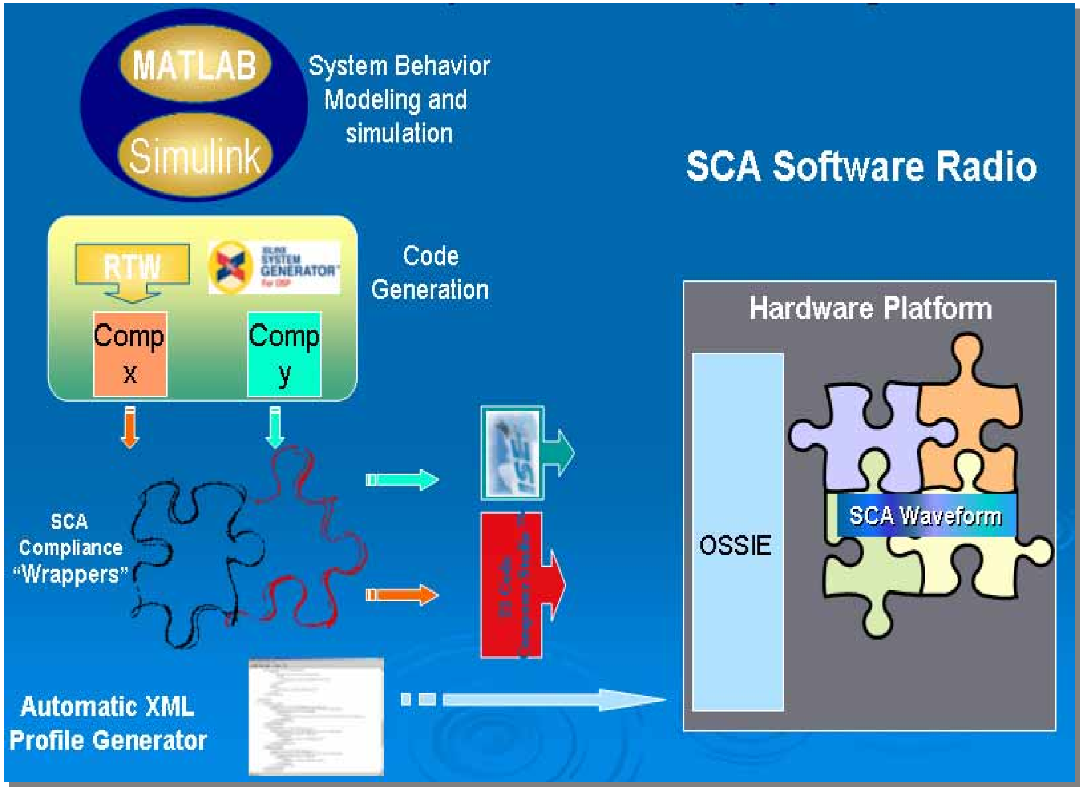
"Using Simulink and Xilinx System Generator we designed and developed the signal processing chain of the SDR and achieved a 10-to-1 reduction in development time."

Dr. David Haessig, BAE Systems

BAE SYSTEMS zeligsoft Virginia Tech The MathWorks XILINX

One SCA Rapid Development Project

- Develop glue code and wrappers that encapsulate signal processing code and interface it to SCA core framework
- Automatic code generation using MathWorks Real-Time Workshop® and Xilinx System Generator™
- TI Code Composer Studio™
- Zeligsoft CE for Automatic XML Profile Generation
- BAE expertise in SCA
- Virginia Tech Glue Code Development



Demo: SDR Reference Waveform – FM3TR

FM3TR Reference Waveform

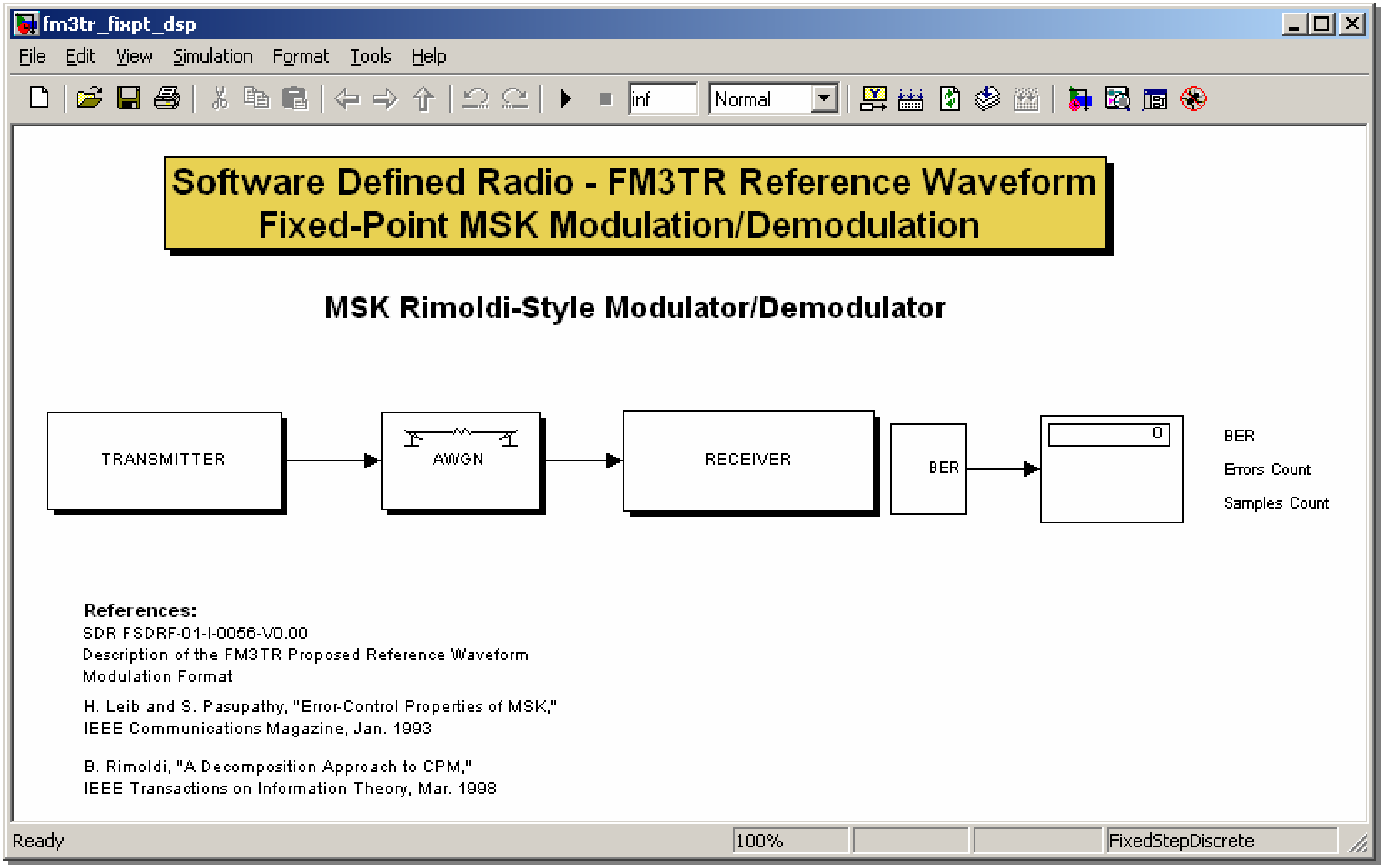
- Future Multiband, Multiwaveform, Modular, Tactical Radio Waveform (Reference waveform for SDR Forum)

Frequency range	**30-400 kHz**
Channel spacing	**25 kHz**
Modulation type	**CPFSK**
Modulation rate	**25 kbps**
Frequency hopping	**250-500 hops/second**
Framing, packetization	**Switched, packet**
CVSD voice coder	**16 kbps**
Coding	**Reed-Solomon**

The MathWorks FM3TR
Software Defined Radio Example

- Design, simulation, performance analysis
- Fixed-point analysis
- Automatic code generation
- Flexible system partitioning into components

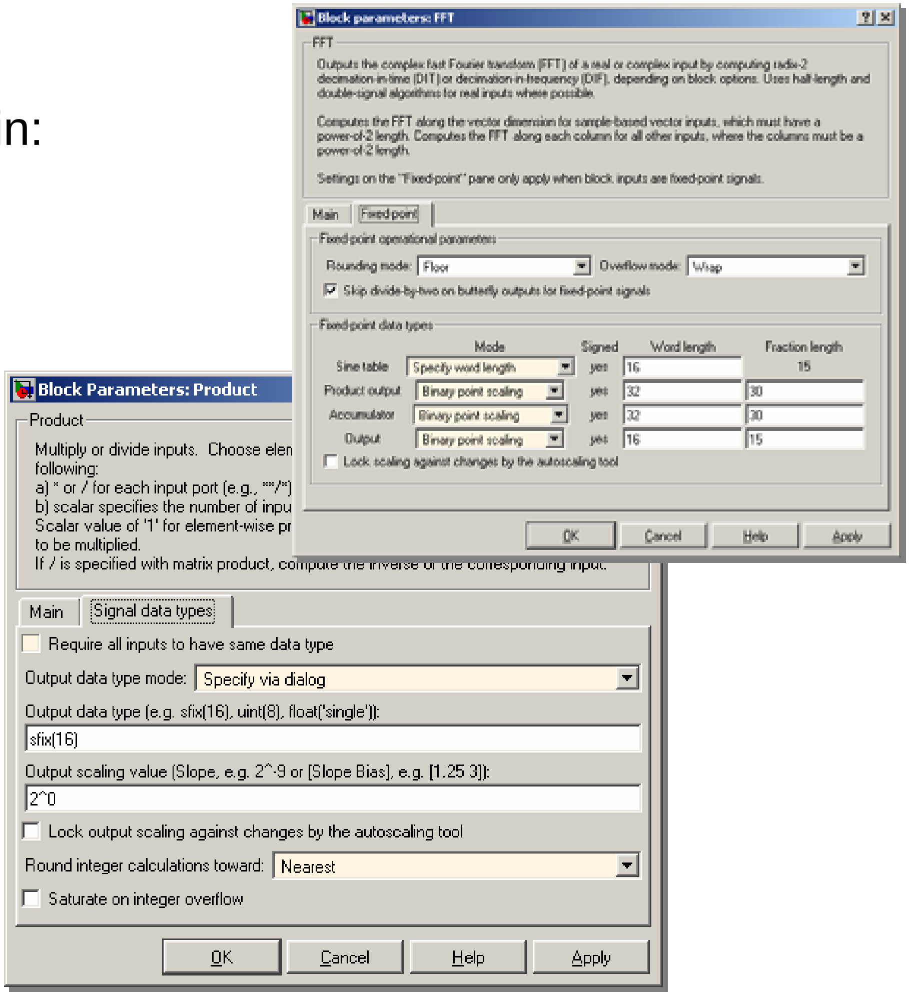
Software Defined Radio Example



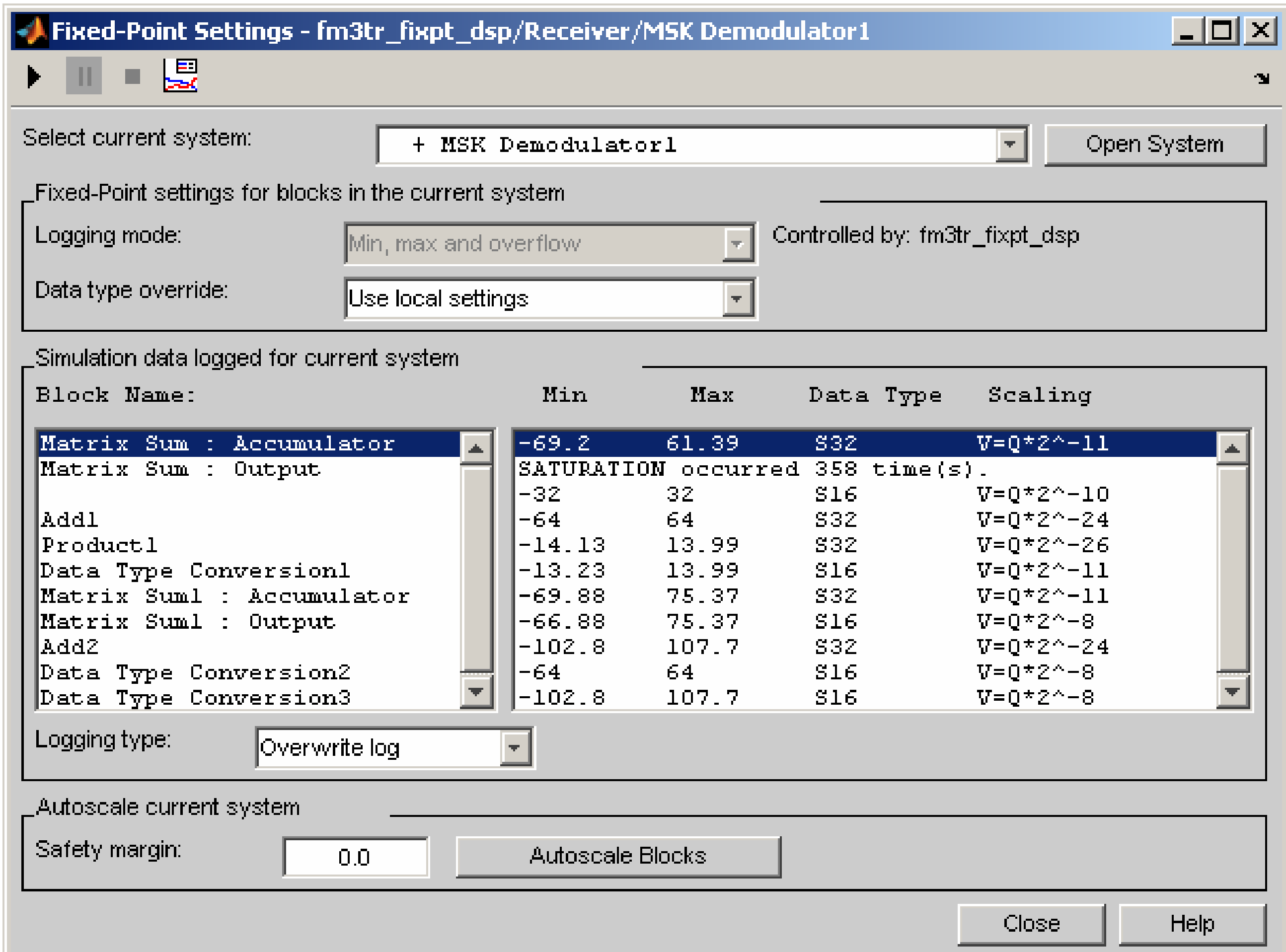
Fixed-Point System Design

Fixed-Point Design in Simulink®

- Simulink Fixed Point
  - Enables fixed-point support in:
    - Simulink
    - Signal Processing Blockset
    - Stateflow®
- Fixed-point settings at:
  - Block level
  - Subsystem level
  - Model level
- Control over
  - Inputs
  - Outputs
  - Internal values

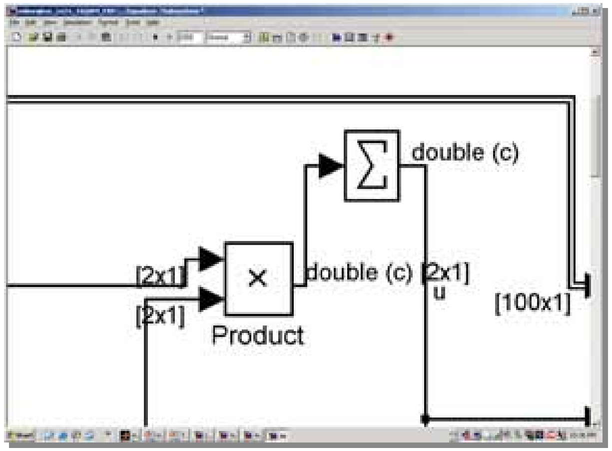


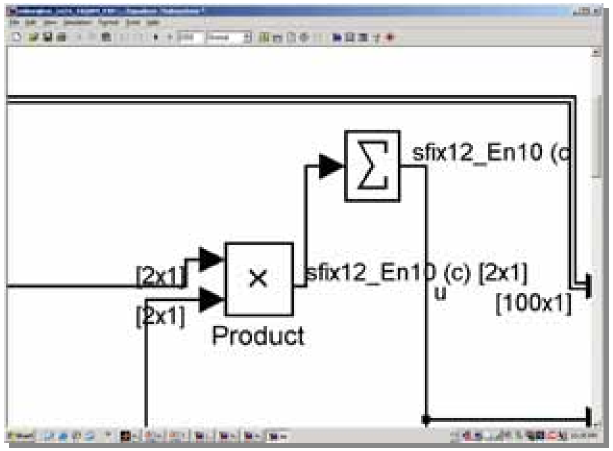
Tool: Fixed-Point Settings

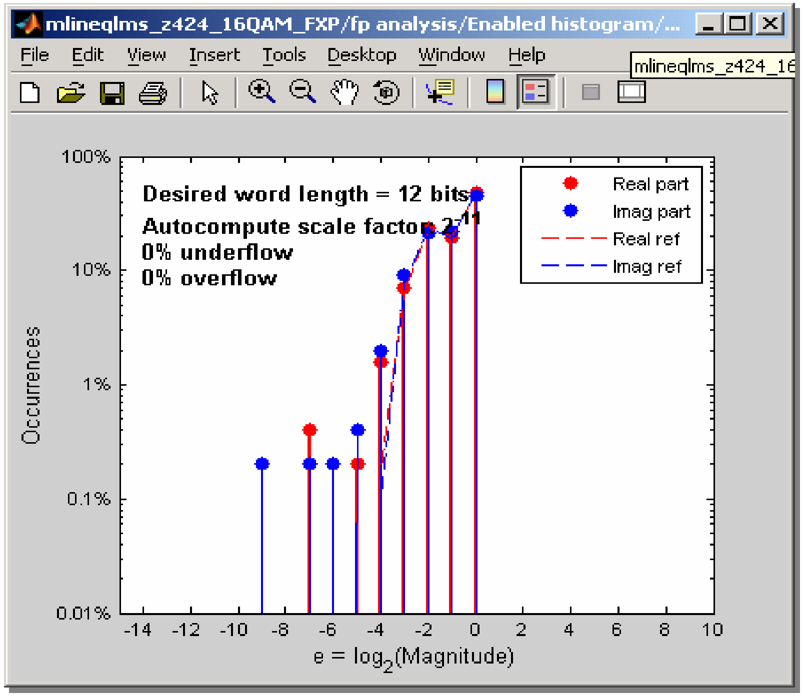


Fixed-Point Design Aids

- Model annotation
- Histogram techniques



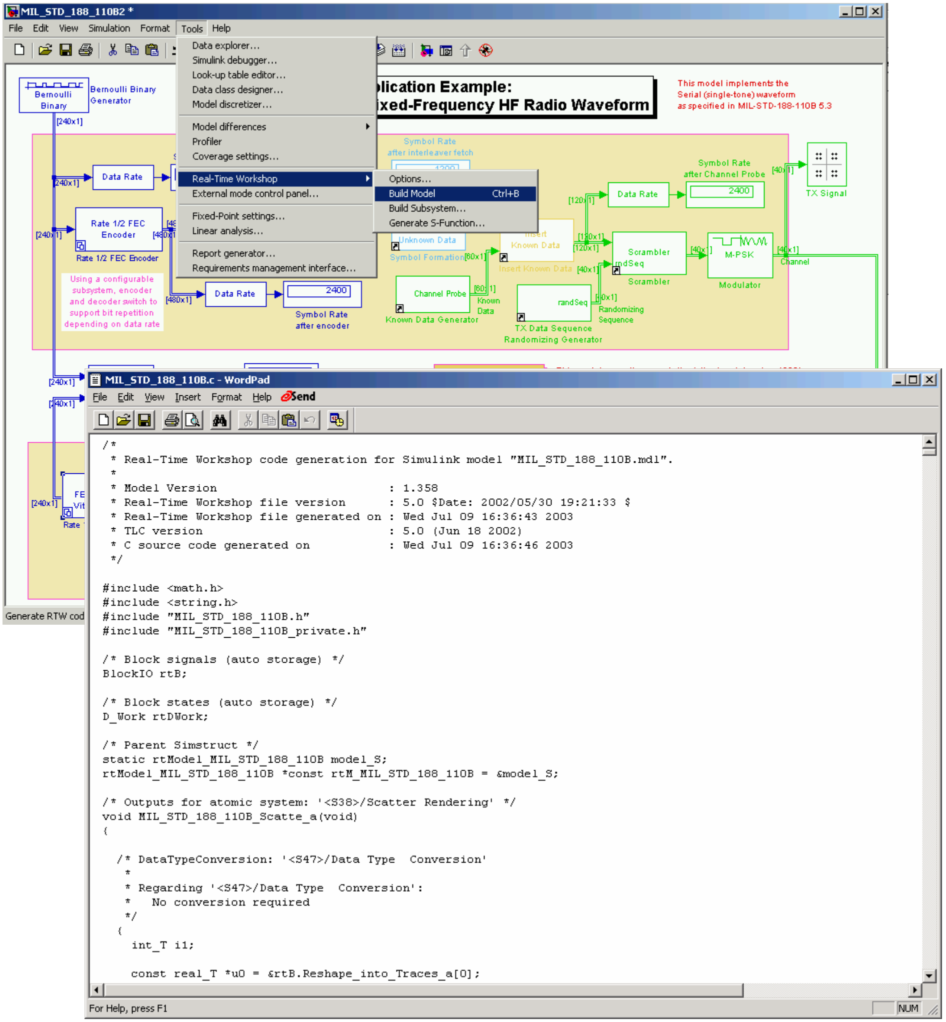




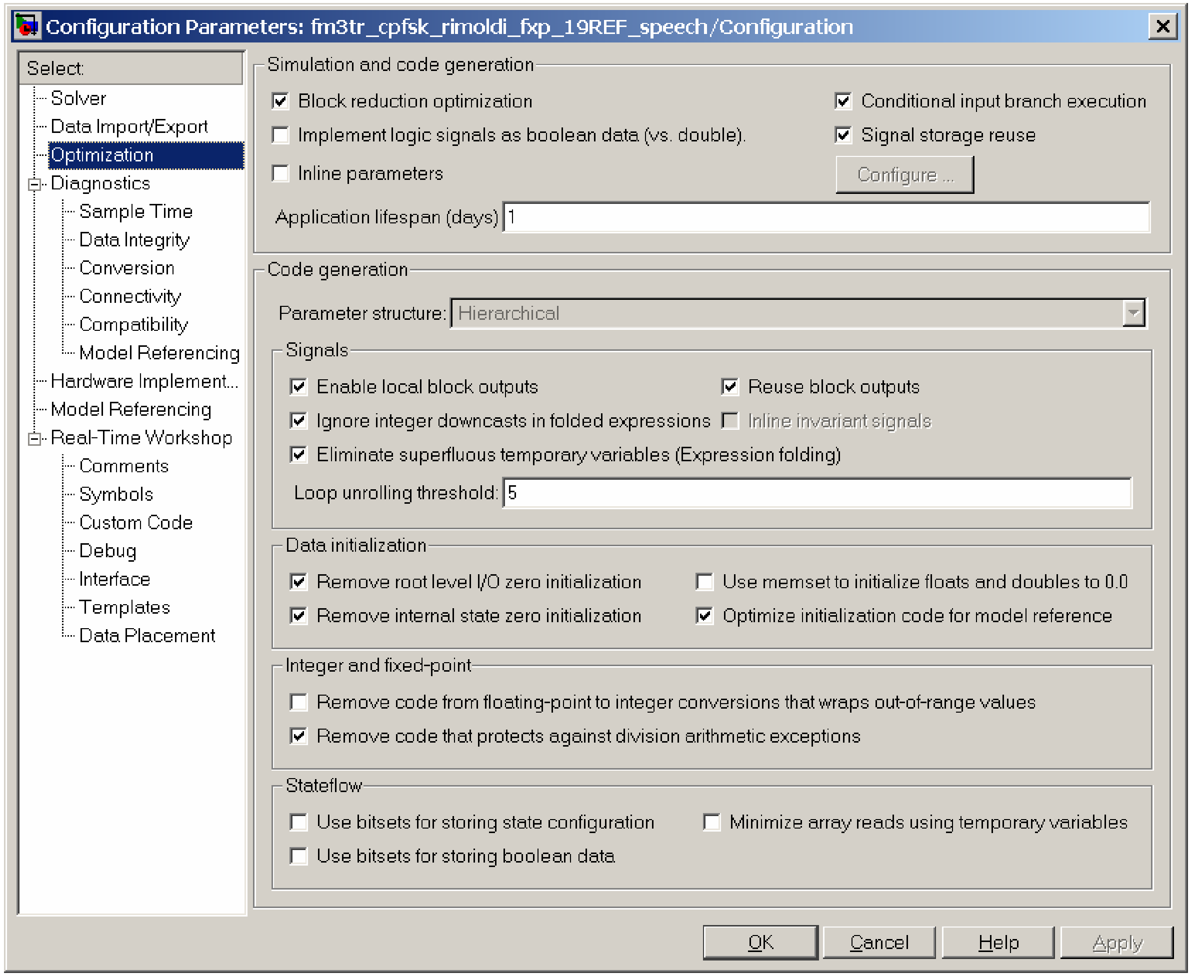
Automatic Code Generation

Code Generation from Models

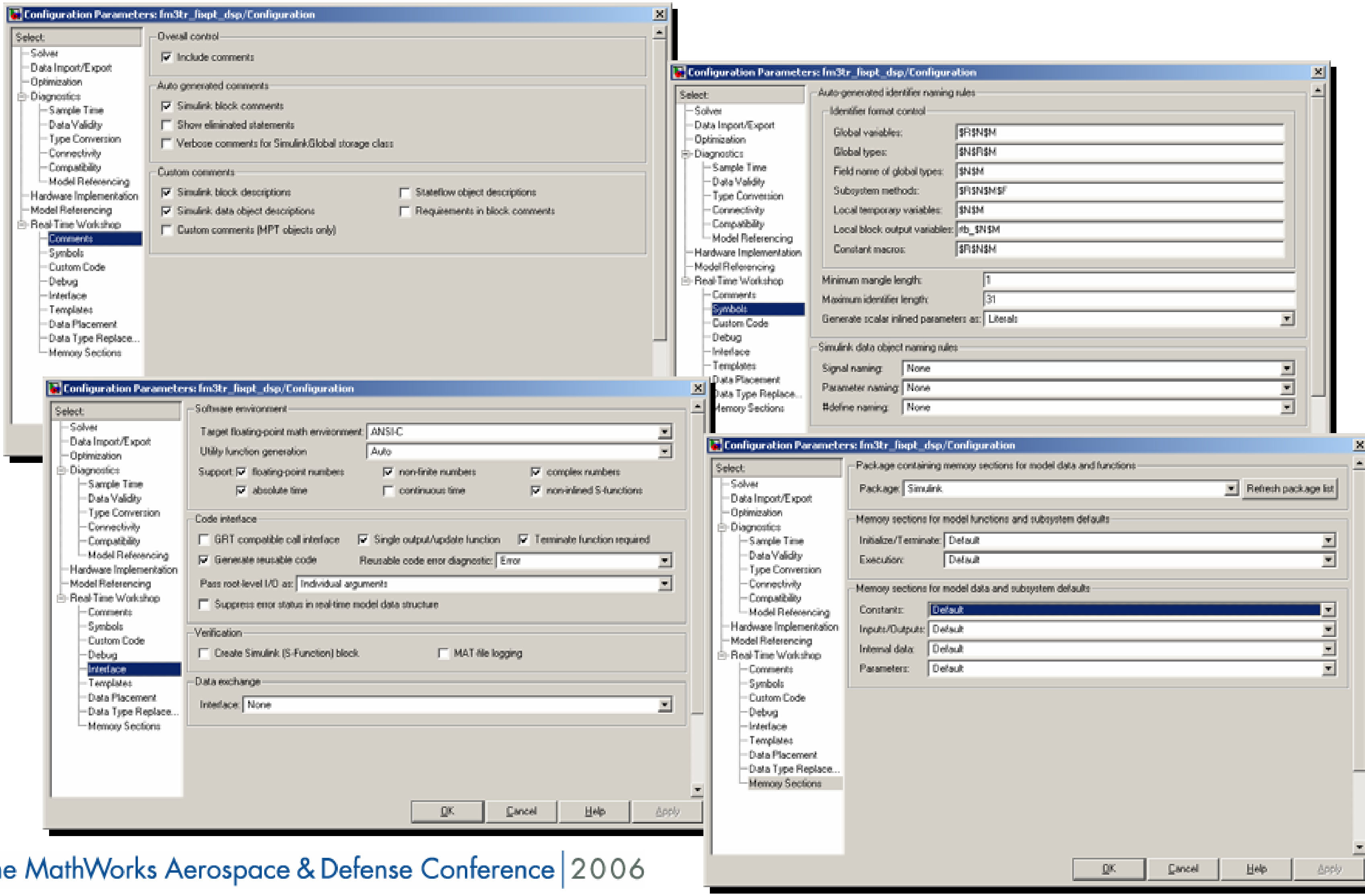
- Target generic C-programmable devices
- Production Code for embedded systems
  - *ROM size, RAM size, Execution Speed:* Comparable with optimized handwritten code
  - Compact ERT code format
    ANSI and ISO floating-point libraries
  - Customized main program:
    deploy on target with or without OS
  - Supports user-defined data objects and S-functions
  - Detailed HTML Reports



Code Optimization Options



Code Customization Options



Example Design Flows for Target Platforms

DSP Design Flow

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Link for Code Composer Studio™, Real-Time Workshop®, Embedded Target for TI C6000™ DSP

Target-Specific and Optimized Code

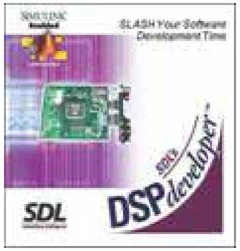
Specific Peripheral Software Drivers

TEXAS INSTRUMENTS

Code Composer Studio™ (Compiler, Linker, and Loader)

Customer-Specific Board

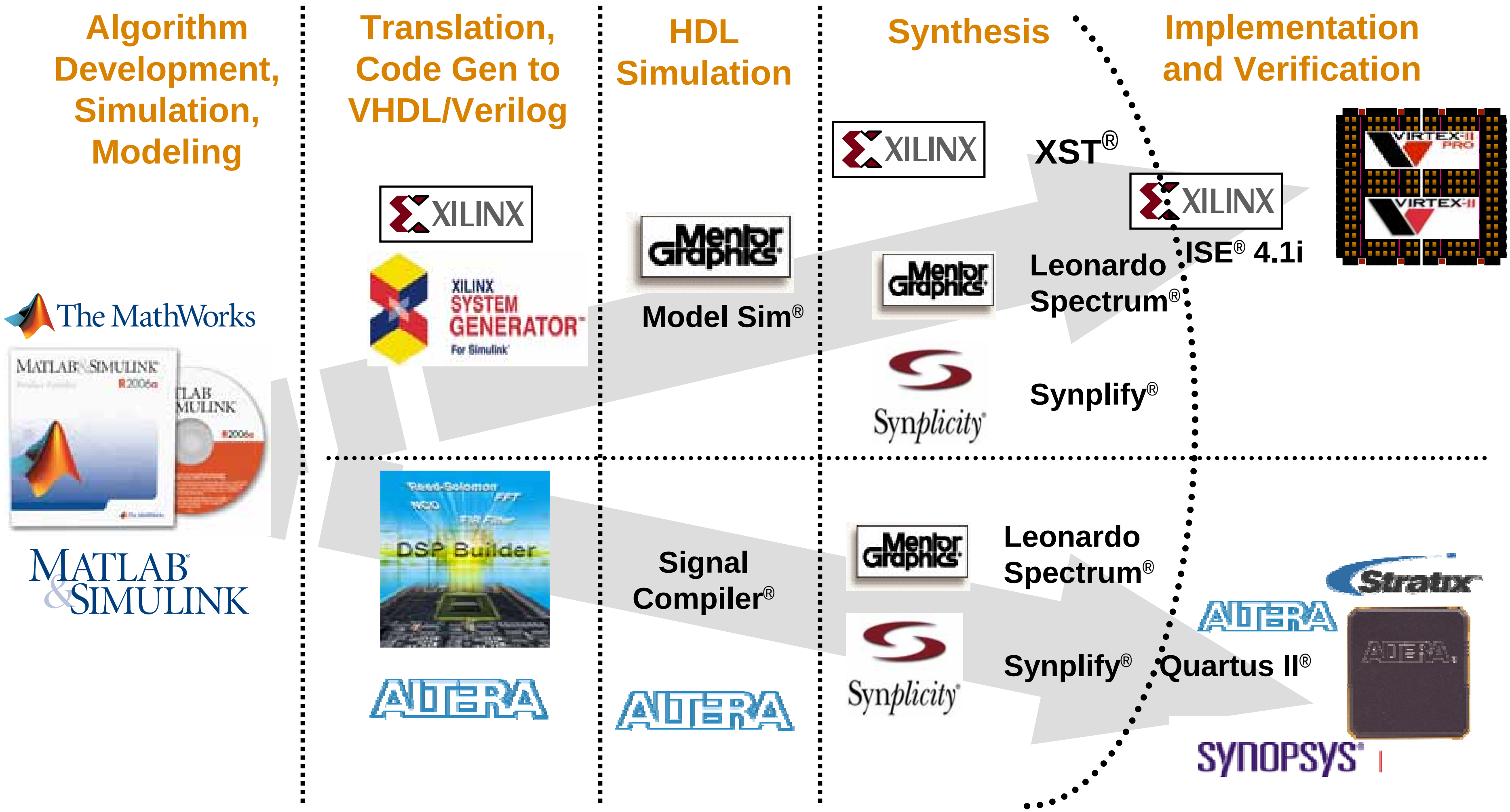
SDL Sheet Dynamics, Ltd.



THE DSP COLLABORATIVE

ANALOG DEVICES

FPGA Design Flows



Conclusion

Model-Based Design is a crucial methodology for successful design of Software Defined Radios

- Simulations
- Fixed-point design
- Code generation
- Deployment into diverse hardware and software platforms
- Integration with SCA tools