Prototype Platform for Imaging Applications

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Introduction

- QCT Multimedia R & D
  - Imaging domain

Our charter, what we do

- Systems
  - Technology exploration and development
  - Algorithm design, tuning and evaluation
  - IP development
- Hardware
  - Custom module designs (non main-stream)
- Software
  - Technology prototyping and enablement
  - Technology integration on host platforms
  - Productization and deployment support
- Cross Collaboration
  - Adjacent technology fusion
  - Downstream integration

Outline

Agenda

- ❑ Project introduction
- ❑ Problem statement
- ❑ Vision for the solution
- ❑ Proof-of-concept setup
- ❑ MathWorks tools used
- ❑ Results
- ❑ Benefits and Takeaways

The Project

Technology Prototyping

- Platform needs
- Desired features

- Platform needs
  - Rapid prototyping for system engineering
  - Efficient & accurate modeling of technology
  - Collaboration friendly
  - Early proof-of-concept demo & evaluation vehicle

- Desired features
  - Smooth development cycle, well defined workflow
  - Mature software toolchain
  - Extensive debug support
  - Broad user base

The Design

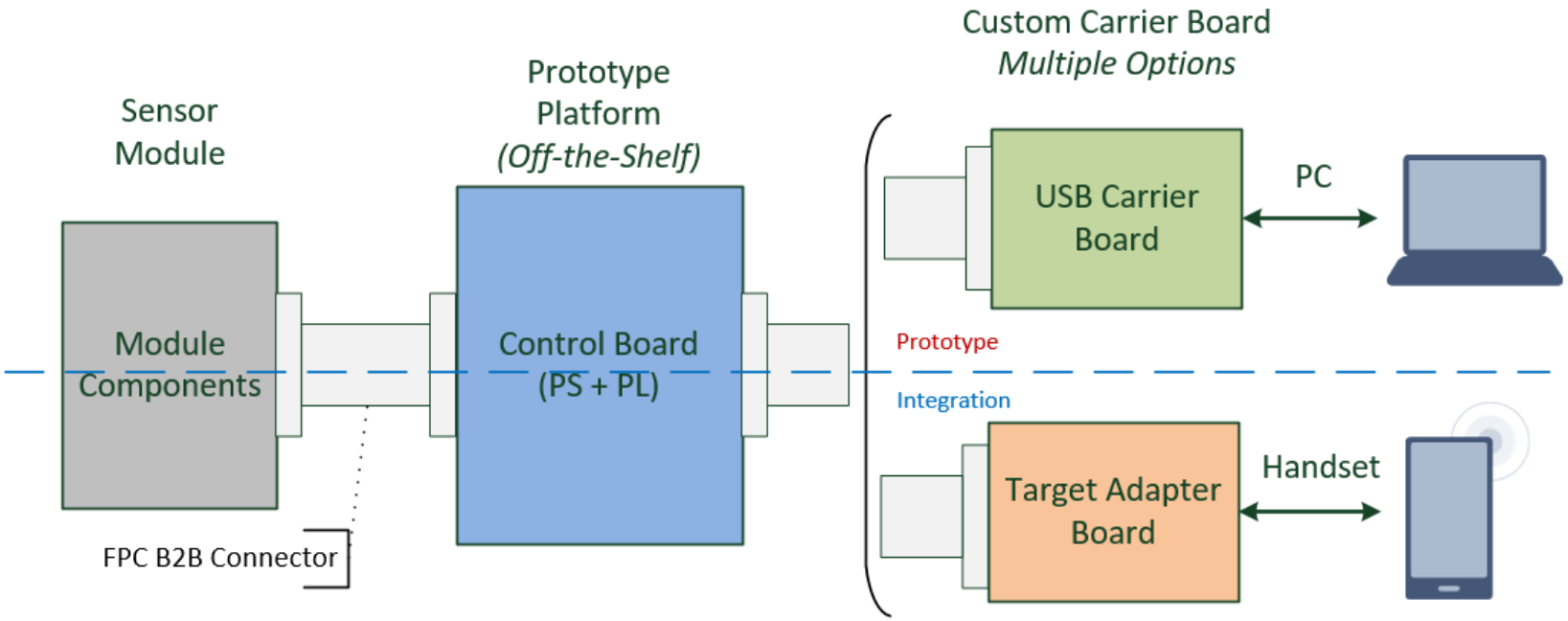
Prototype Platform

Desired features

- Rapid prototyping
- Multi-purpose
- Module independent
- Scalable
- Extensible
- Future proof

Target use cases

- Technology development
- Evaluation
- Demonstrations
- Collaboration



Current Workflow

Technology development mostly frame based

- Static image test vectors
- Disjoint simulated environments
- Manual/offline component tuning
- Offline analysis & optimization
- Limited static profiling
- Higher churn during integration

Desired Improvements

Technology development frame & stream based

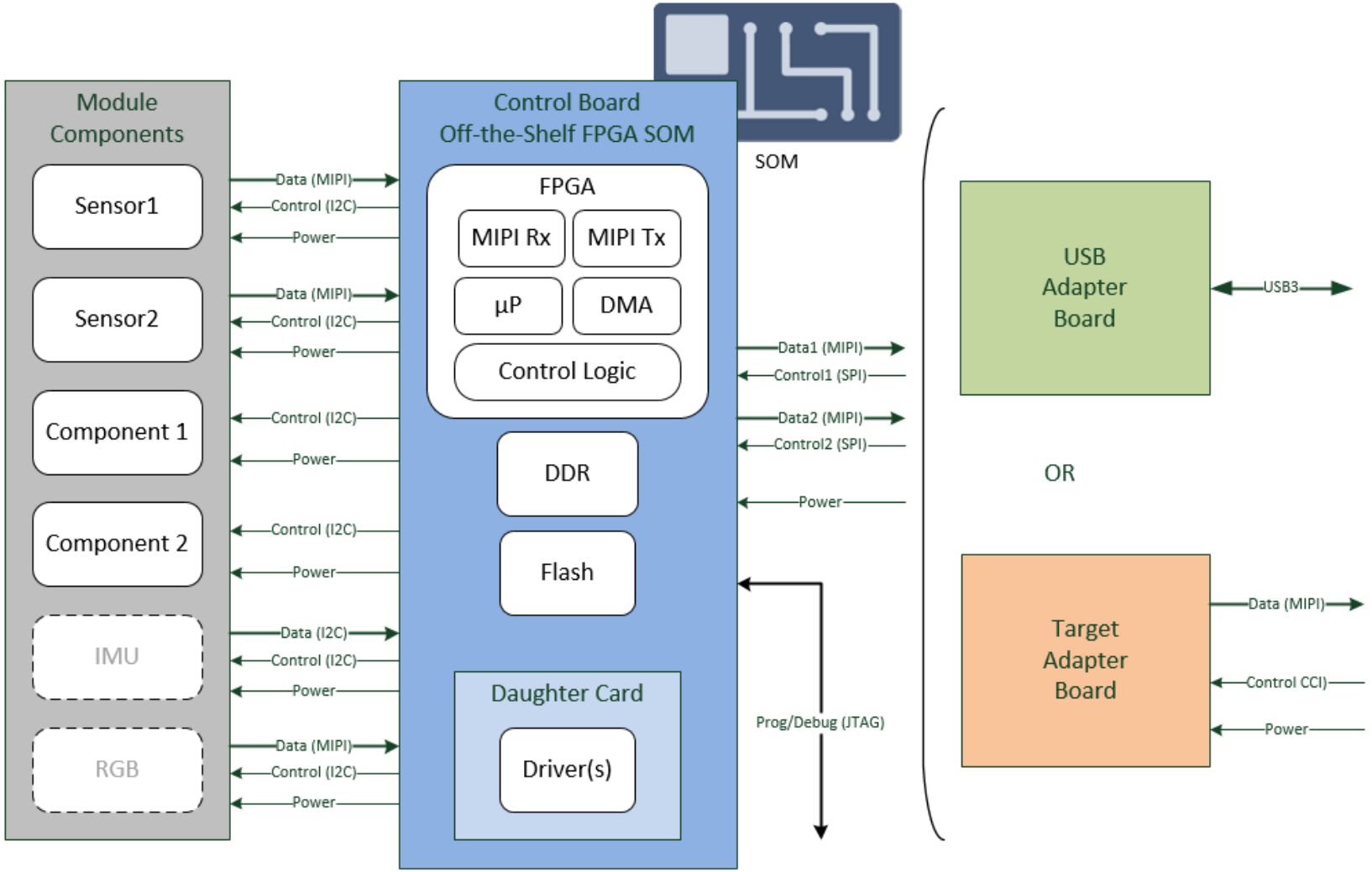
- Realtime stream inputs
- Live target environment
- Runtime component tuning
- Realtime closed loop control
- Realtime analysis & optimization
- Computation partitioning support (for example, ARM vs FPGA)
- Broader scope for profiling
- Efficient workflow, quick turnaround
- Reduced churn downstream

The Vision

Control board SOM (+FPGA)

Desired features

- Realtime stream inputs
- Live target environment
- Runtime component tuning
- Realtime closed loop control
- Realtime analysis & optimization
- Debug & profiling support
- Efficient workflow



The Proof of Concept

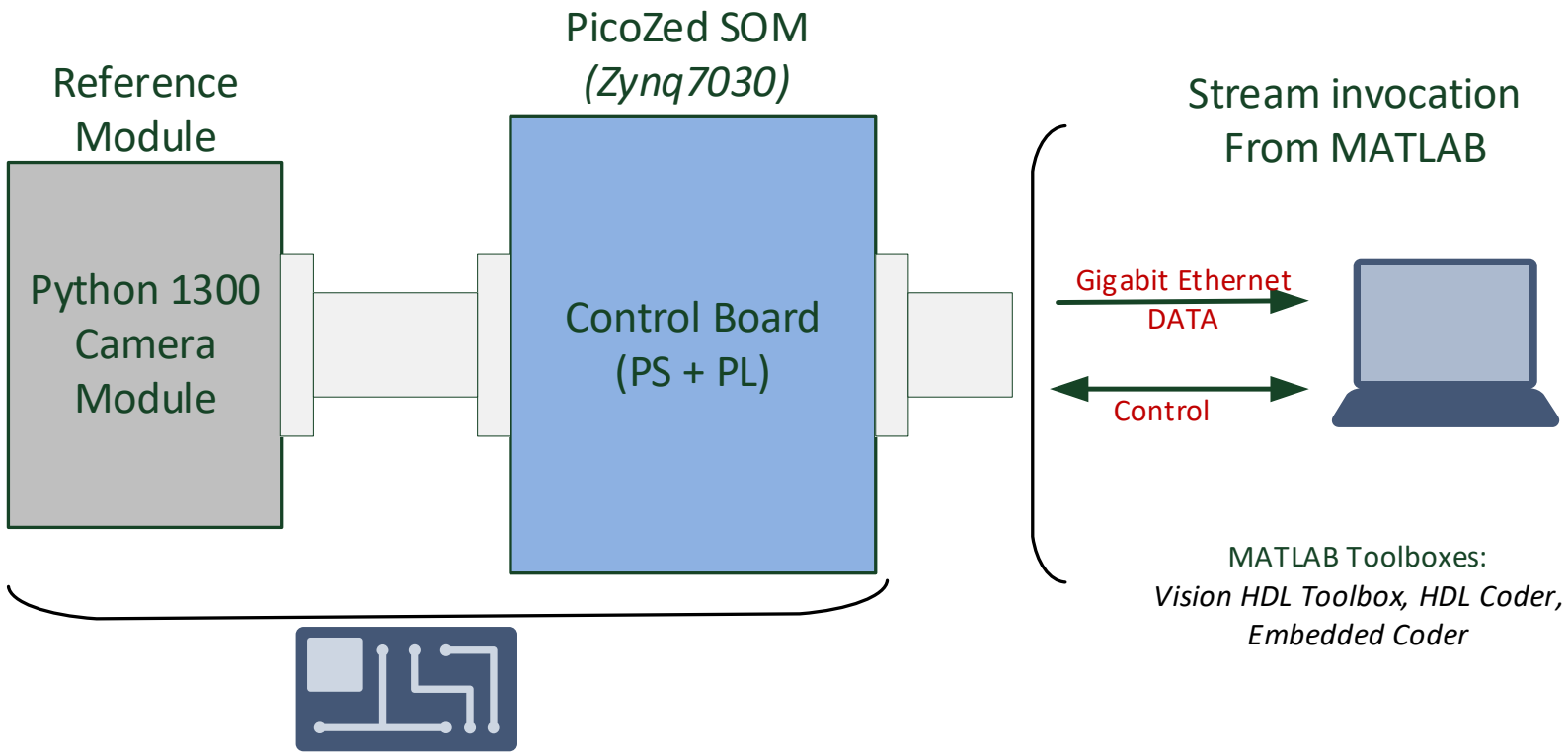
AVNET® PicoZed™ Embedded Vision Kit (Xilinx FPGA)

Highlights

- Python1300 Camera
- PicoZed SOM (7030)
- MATLAB Toolboxes

- **Target Use Cases**
  - Technology Prototyping
  - Evaluation
  - Demonstrations
  - Collaboration

- **MATLAB Toolboxes**
  - Simulation
  - Model based algorithm design
  - Hardware interfacing
  - Realtime validation



Simulation

Hardware Modeling

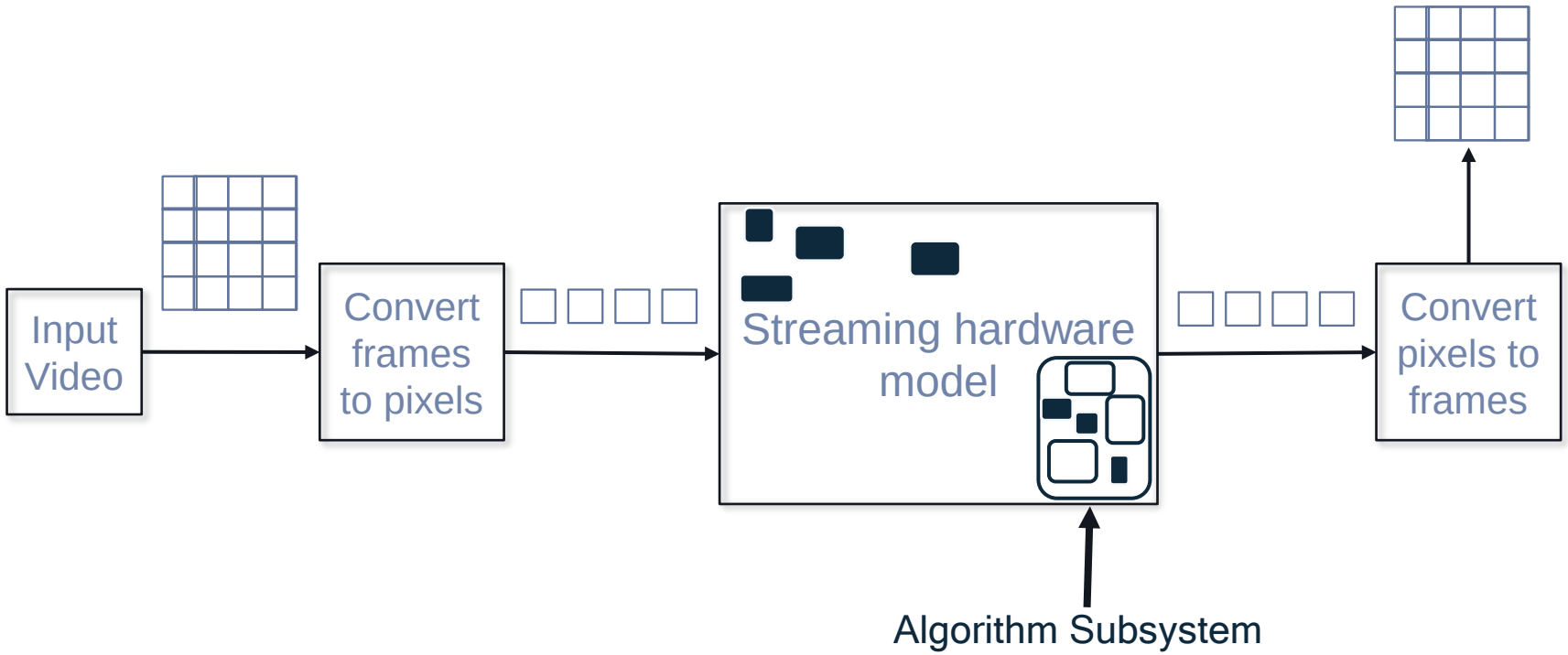
- Vision HDL Toolbox
- Simulink models
- Pixel streaming
- Float point to fixed-point conversions
- Cycle accurate

Hardware-ready building blocks

- Conversions
- Filters / edge detection
- Morphological transformations
- Image statistics
- Vision hardware design utilities

Reference applications:

- Camera pipeline
- Low-light enhancement
- Computer vision
- CLAHE (Contrast limited adaptive histogram equalization)



Model Based Design

Model re-use throughout MBD workflow

- Algorithm (Golden Reference)
- Hardware implementation
- Fixed-Point optimization
- FPGA/ASIC deployment

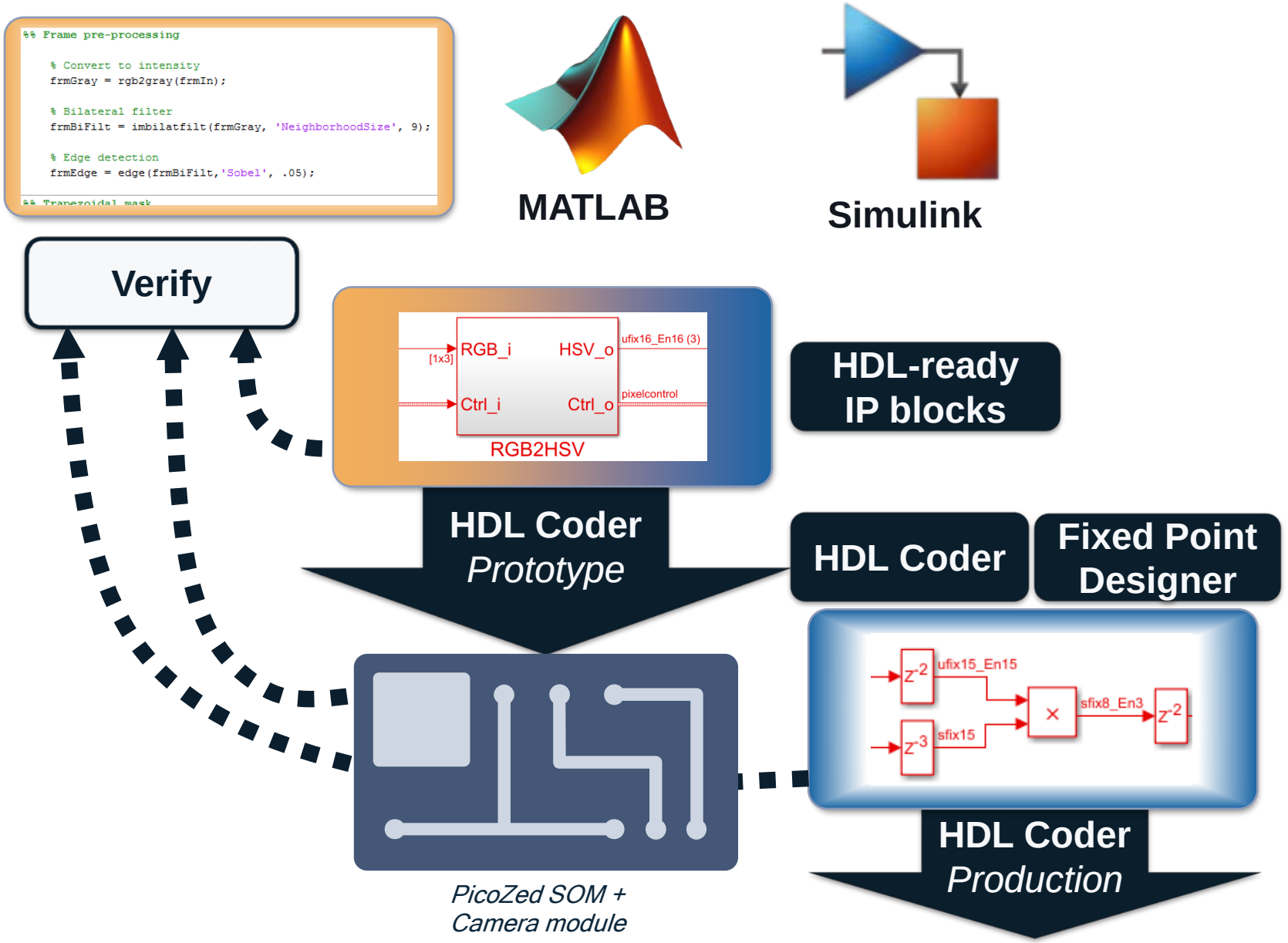
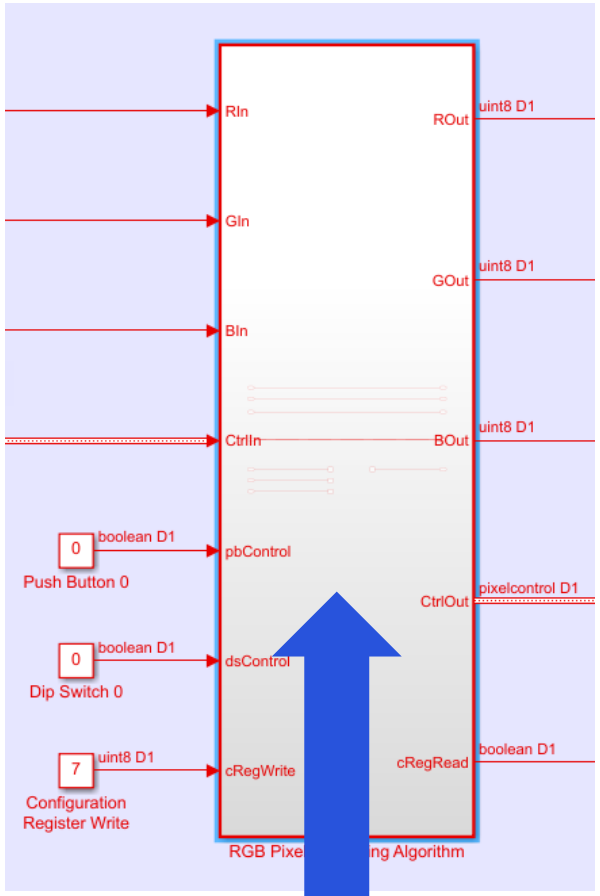


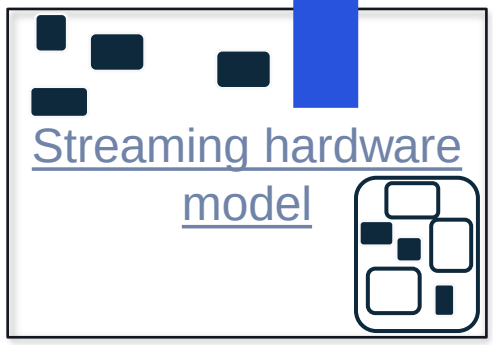
Image source: MATLAB/Simulink software

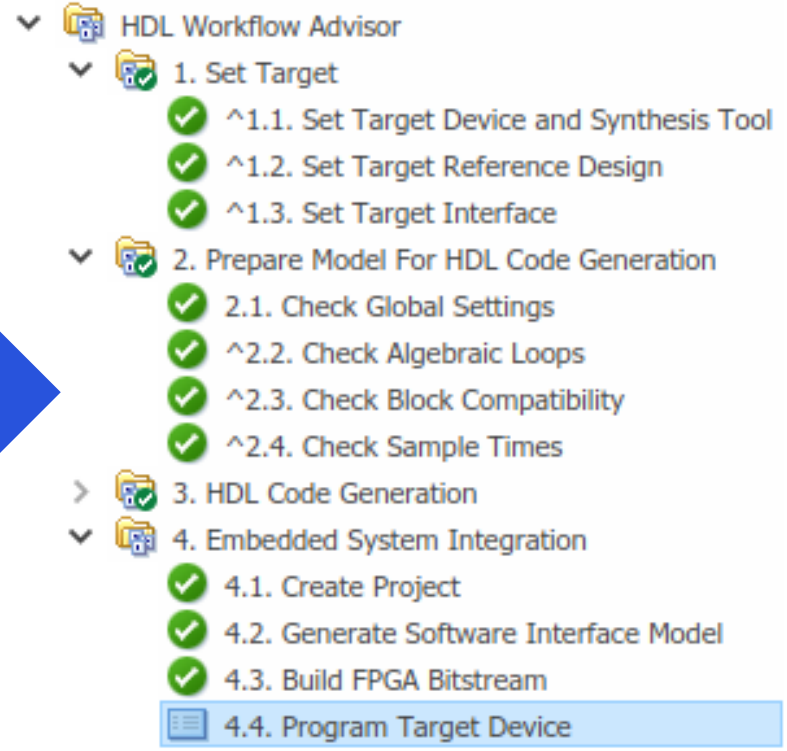
Rapid Prototyping Workflows

(FPGA/PL deployment)

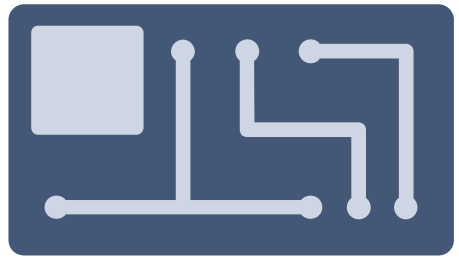
- HDL Workflow Advisor
- Custom reference design support
- Ability to define custom boards
- Author in EDA Tool (Vivado)







Raw Sensor Input (Python1300)



PicoZed SOM + Camera module

Monitor Output

Software Model

(ARM/PS deployment)

- Use ARM cores for ancillary data processing
- Perform other system level functions
- Uses Embedded Coder for customizations

Software Interface Model

- Auto generated from HDL Workflow Advisor
- Interfaces to generated IP Cores in PL
- Can further process data from hardware side
- Provides ability for run-time parameter tuning

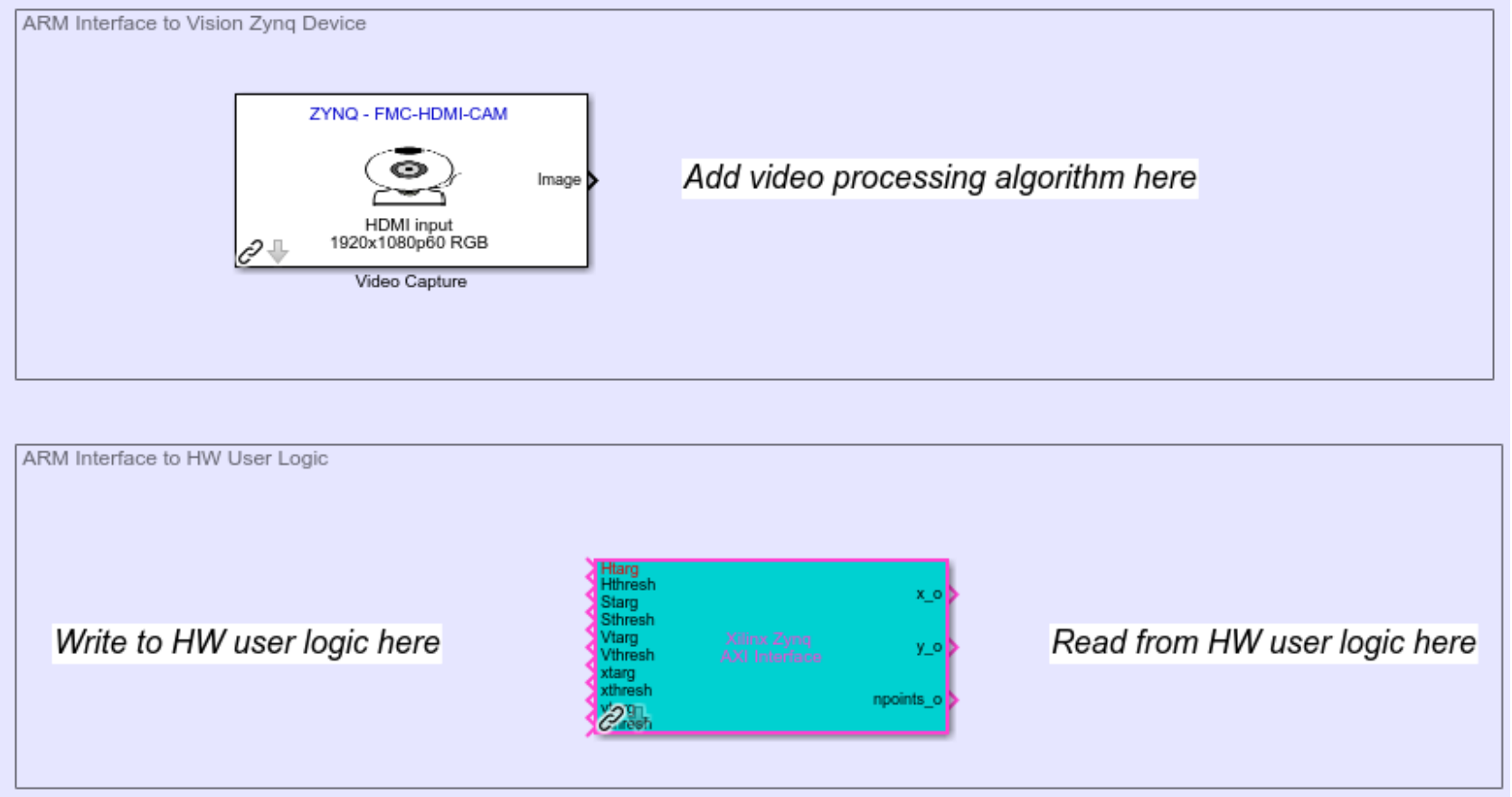


Image source: MATLAB/Simulink software

Results

PicoZed, MATLAB Model based design workflow

- MATLAB-PicoZed
- MBD workflow
- Example design
- HDL Workflow Advisor
- FPGA/ARM targeting
- Runtime validation
- Closed loop control

Hardware Setup

- PicoZed setup
- Setup Boot Process

Model Based Design

- Model design using Simulink
- Designed example processing pipeline
- System partitioning (ARM vs FPGA)
- Model validation
- Fixed & floating point
- Frame-based & pixel-based models

Unified Workflow

- Generated HDL using HDL Coder, Embedded Coder & HDL Workflow Advisor
- Validated closed loop control from Simulink
- Model fine tuning
- Validation using the Unified environment

- Live target environment
- Realtime stream inputs
- Runtime component tuning

- Computation partitioning support
- Broader scope for profiling
- Efficient workflow

- Closed loop control
- Realtime analysis & optimization
- Quick turnaround
- Reduced churn

Benefits

Long term vision

- Efficient workflow
- Flexibility
- Uniformity
- Reduced design spins
- Exploration options
- Streamlined process

Efficient Workflow

- Design > System model > Prototype > Product
- Fills the gap between FPGA vs ARM programming conundrum
- System partitioning offers greater flexibility to designers
- Uniformity across validation criteria between model and prototype

Unified Framework

- Ability to generate hardware agnostic HDL code for deployment to FPGAs
- Allows system engineers to stay within the MATLAB framework
- Offers direct runtime evaluation option on target hardware
- Reduced design churn in technology prototyping & algorithm design
- Easy traceable linkage between model and generated code

Long Term Vision

- Explore optimal system design models for rapid prototyping
- Compare and contrast tradeoffs among various design models
- Automation of calibration and regression test campaigns
- Utilize the streamlined fast and efficient integration options down stream

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