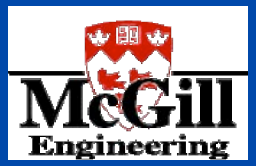
Using MATLAB and Simulink in a SystemC Verification Environment

Jean-François Boland[1]

Mathieu Hemon[2], Claude Thibeault[2], Zeljko Zilic[1]



[1]McGill University
Department of Electrical and Computer Engineering
Montréal, Québec, Canada

[2]École de Technologie Supérieure
Département de génie Électrique
Montréal, Québec, Canada

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RESMIQ
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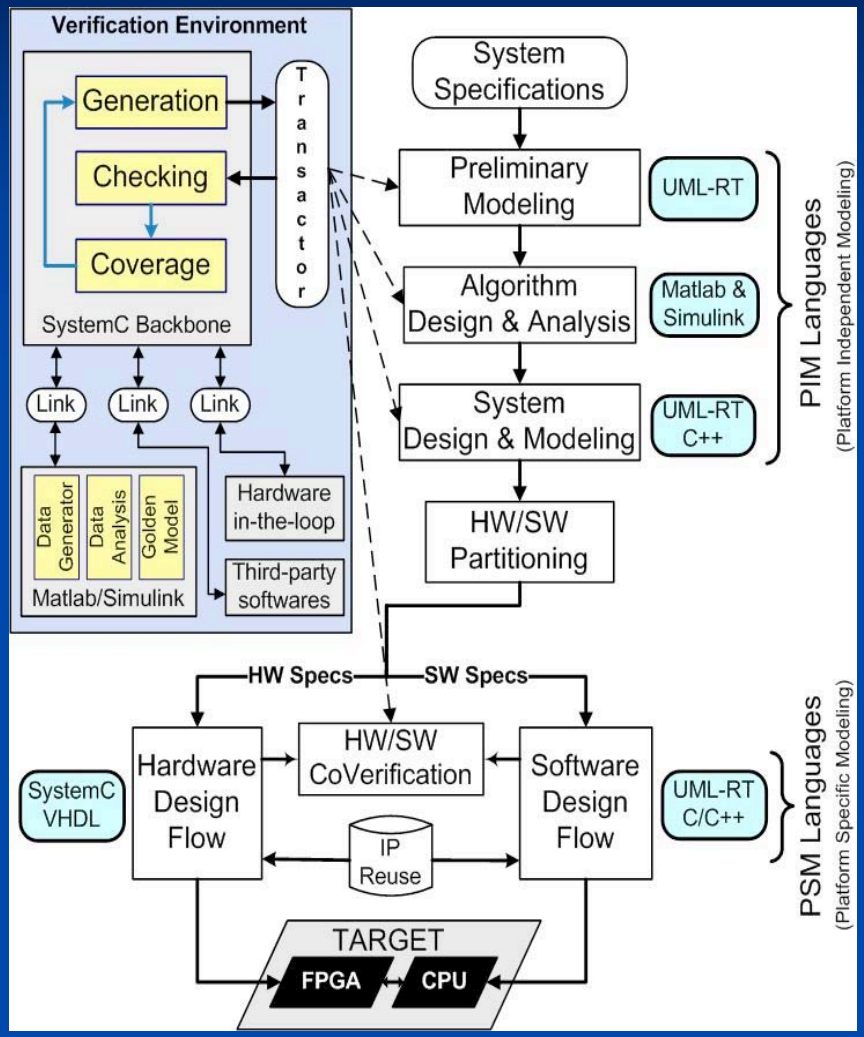
Outline

- Goals
- Context of work
- Using MATLAB and Simulink for verification
- Related work
- Interfacing SystemC and MATLAB
  - MATLAB Engine
  - Simulink S-Functions
  - Simulators synchronization
  - Data types
- Multi Equalizer examples

Goals

- Functional verification takes approximately 70% of the total effort on a project
  - Need new techniques to cut verification time
- Large number of DSP designs
  - MATLAB and Simulink for algorithmic modeling
- Need to efficiently model complex environment during the verification phase
- Add robustness to stimulus generator and response checking
- Early testbench development and reuse

Context of Work

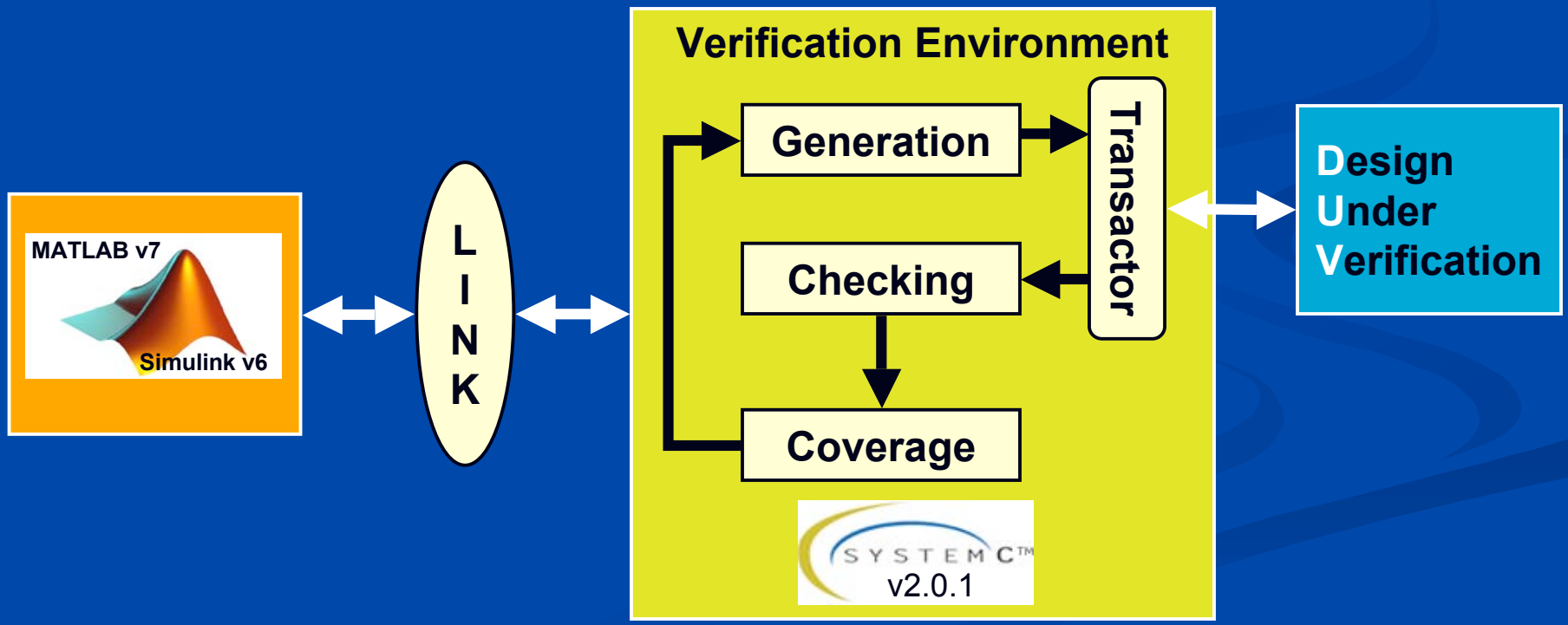


MAME's Design Flow

- Project MAME: Methodology and Architecture for Multi Equalization
- New design flow
  - Design and Verify
  - Software Defined Radio
  - Multi equalizer architecture
- SystemC Verification Environment (with SCV)

Functional Verification Environment

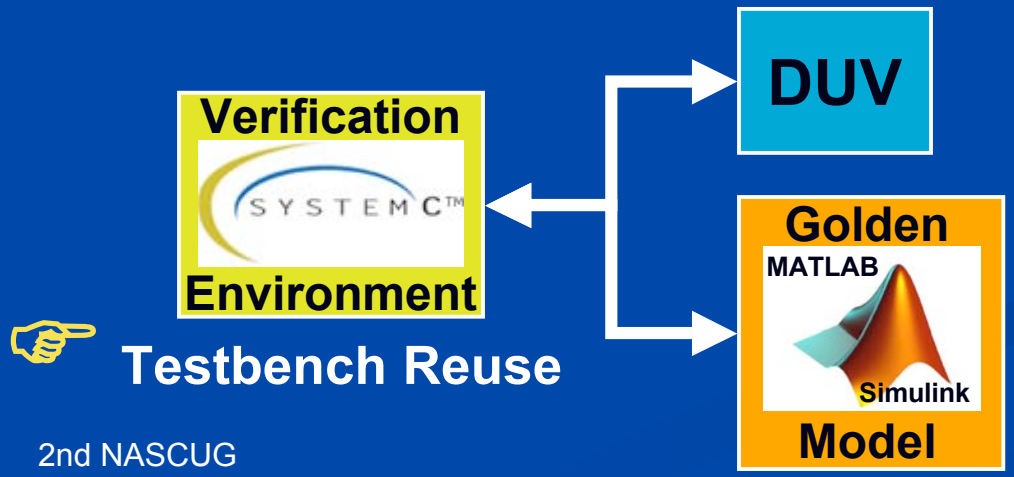
- Key contributions
  - Verification methodology
  - Interface between SystemC and Simulink



Why MATLAB and Simulink ?

For Data Generation

For Data Analysis



For "golden" Reference Model

☞ Testbench Reuse

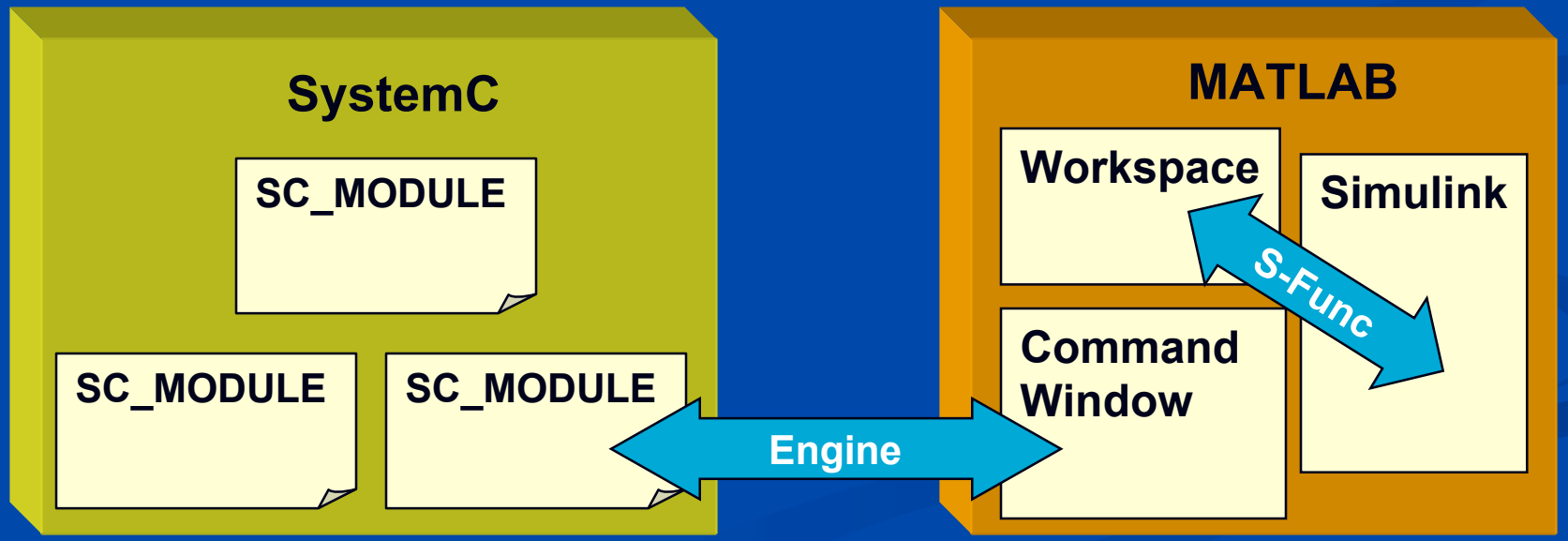
Related Work

- SystemC calls MATLAB demo
  - Source: MATLAB Central File Exchange, March 2003
  - Uses a SystemC module as a wrapper to call MATLAB via the Engine
  - No Simulink support

- Modeling Cycle-Accurate Hardware with MATLAB and Simulink using SystemC
  - Source: 6th European SystemC Users Group Meeting (ESCUG), October 2002
  - SystemC model included in Simulink as an S-Function
  - Simulink centric approach
  - Requires extensions to the SystemC kernel

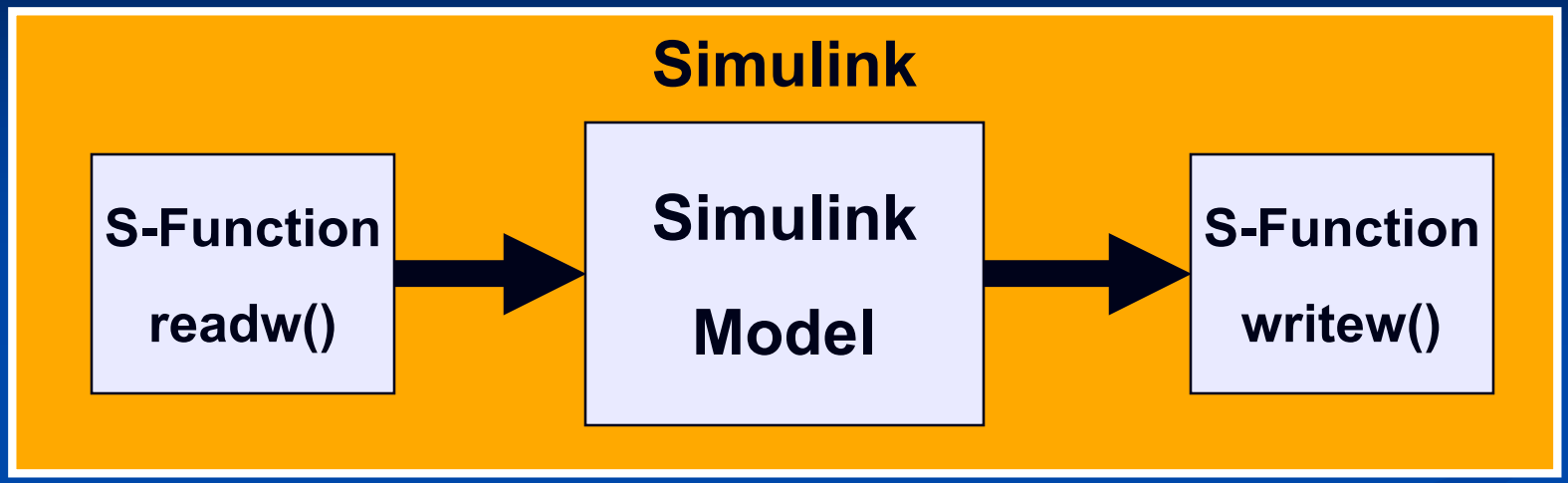
How to connect SystemC and MATLAB/Simulink ?

- SystemC communicates with MATLAB through MATLAB engine and the workspace
- Simulink communicates with MATLAB through S-Functions and the workspace



```
1 // MATLAB/Simulink Interface
2
3 #include "systemc.h"
4 #include <engine.h>   // Matlab engine header
5
6 // SystemC Module that create the interface to MATLA
7 SC_MODULE(matlab){
8   ...
9
10  Engine *ep;         // Pointer to MATLAB engine
11
12  // Module Constructor
13  SC_CTOR(matlab)
14  {
15    SC_THREAD(mat_sync);  // Thread function to sync
16    sensitive_pos << CLK; // Call at each rising clo
17
18    // Start MATLAB engine
19    if(!(ep = engOpen(""))){
20      cout << "\nCan't start MATLAB engine" << endl;
21      exit(-1); // Exit on error
22    }
23    engSetVisible(ep,1);  // Makes Matlab session wi
24
25    wd_path = get_wdpath();      // Get the working d
26    engEvalString(ep, wd_path); // Change MATLAB wor
```

Role of S-Functions



- Read SystemC data from the MATLAB base workspace
- Create I/O ports
- Create an input persistent class object in memory
- Synchronize the burst mode

- Data generator
- Data analysis
- Golden model

- Write Simulink data in the base workspace
- Pause the simulation
- Create an output persistent class object in memory
- Synchronize Simulink with SystemC

Simulator Synchronization

- SystemC is master of the simulation
- Simulink is controlled from SystemC through MATLAB command prompt with these commands:
  - **'set_param'**
    - start, stop, pause, continue, update
  - **'get_param'**
    - stopped, initializing, running, paused, updating, terminating, external

```
27  // Check if simulation is running
28  engEvalString(ep, "get_param('fir16b','SimulationStatus')");
29  mxB = engGetVariable(ep, "ans");
30  string = mxArrayToString(mxB);
31  cout << "\nMatlab: simulation is " << string << endl;
```

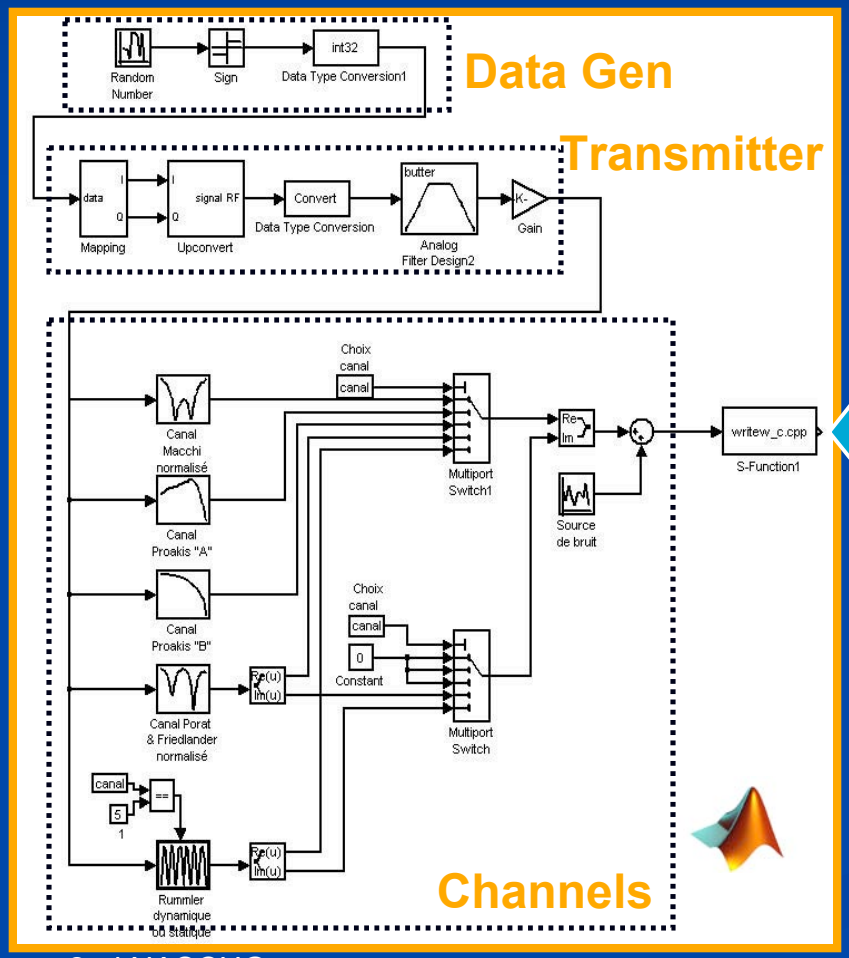
Data Type Conversion

- MATLAB single object type: MATLAB Array
- MATLAB Engine library uses the 'mx' prefixed API routines to manipulate MATLAB arrays in SystemC
  - In SystemC, MATLAB array is declared to be of type 'mxArray'
  - The API includes over 60 routines to create, access, manipulate, and destroy mxArrays

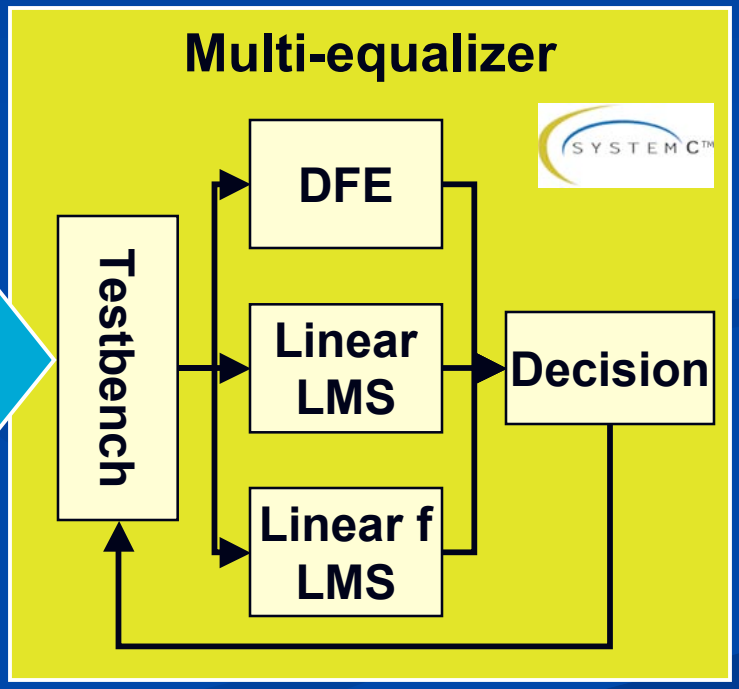
```
1 // Declare a C++ MATLAB array
2 mxArray *mxB = NULL;
3 // Read an Array from Matlab
4 mxB = engGetVariable(ep, "data");
```

Example 1

- Verification of a SystemC multi-equalizer with a MATLAB/Simulink data generator



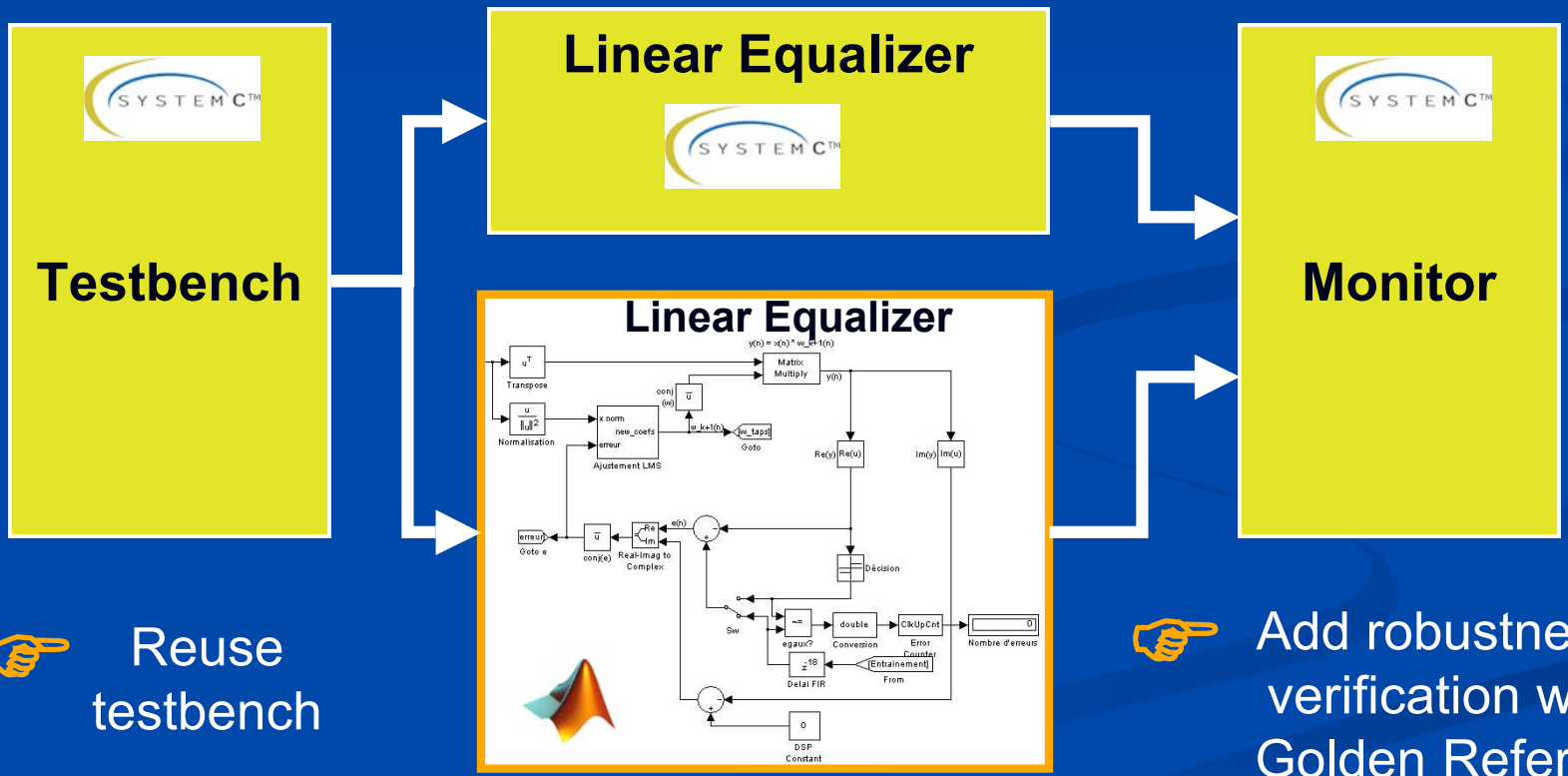
Engine



Reduce testbench development using a Simulink model

Example 2

- Verification of a SystemC linear equalizer with a Simulink 'golden' model reference



Reuse testbench

Add robustness to verification with a Golden Reference

Conclusion and Future Work

- Presented an interface from SystemC to MATLAB and Simulink for verification
- SystemC centric approach
- Reduce total verification time through faster testbench development
- Future Work
  - Use dynamic memory allocation for S-Function persistent objects
  - Add flexibility to S-Function block parametrically
  - Improve modularity within SystemC code
  - Other application areas
    - video processing, voice recognition, etc.

Questions

Thank you for your attention.

Contact:
jfboland@macs.ece.mcgill.ca