

## Vanderbilt/ISIS META Tool Description

GME: CyPhy META Domain Specific Language Editor – Graphical Modeling Language and Editor for capturing META designs. Parts of the language are:

- Component Modeling: Definition of components capturing the physical, behavioral, and interface properties of a component, including:
  - Multi-Physical Interfaces: Connections to/from the component for Rotational, Translational, Electrical, Hydraulic, Thermal, and Signals (Logical and Bus/Messages)
  - Multi-physics Dynamic Behavioral: Bond-Graph representations of the dynamic relationships of component inputs/outputs/internal state.
  - Physical Implementation and Interfaces: CAD Models and physical interfaces between CAD components.
  - Properties and Parameters: Properties of a component, and mathematical relationships between properties and parameters.
  - Cyber Components Behavior and Interface: Software Data/Comms interface, Communication Bus Messages, Processor Network Topology, Software Processor Allocation and Schedule, Traceable Link to Software Component implementation models
- Assembly Modeling: Definition of subsystems consisting of multiple components and associated topology.
- Design Space Modeling: Definition of a design space consisting of multiple architectural options component choices, and parameterization, along with constraints to represent the impact of requirements on design space choices.
- Test Bench Models: Definition of tests for systems or subsystems captured as assemblies or design spaces, with associated test drivers, wraparound system surrogates, and evaluators for computing system metrics.

The Models are supported by an integrated toolchain, including:

- DESERT: A design space exploration Tool using MTBDD's to rapidly apply constraints to META models to produce feasible logical design sets.
- Design Point Elaborator: Elaborates logical designs to fully composed design points.
- Dynamic System Simulation Composer and Execution Tool: Converts a TestBench to a single or series of dynamic simulations, executable under MATLAB/Simulink. Evaluators compute metrics which are logged at runtime, as data and graphical plots.
- CAD Composer Tool: Composes an assembly to a assembly metadata file. An associated driver interfaces with ProE to load and position/attach all components and scale all parametric components, to produce a full CAD model.
- Formula Evaluator: Evaluates properties and parameters to resolve all parametric dependencies.
- ESMOL: Elaborates continuous controller designs to Software/Hardware implementations. Converts Simulink-specified control algorithms to a discrete-time implementation, maps to physical processors and networks, and simulates test cases as defined in a test bench, including

assessment of platform timing effects on controller performance. Also produces embedded code for target microcontrollers.

- Visualization Dashboard: Excel-Based spreadsheet for visualizing the results of dynamic simulations, design choice parameters, and KPP weighting.