Lunch & Learn:

Modeling Aircraft Systems

Lockheed Martin Aeronautics ~ Palmdale, CA

June 17, 2015

From MathWorks

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- **Pascal Gahinet**
  - MathWorks Development: Controls

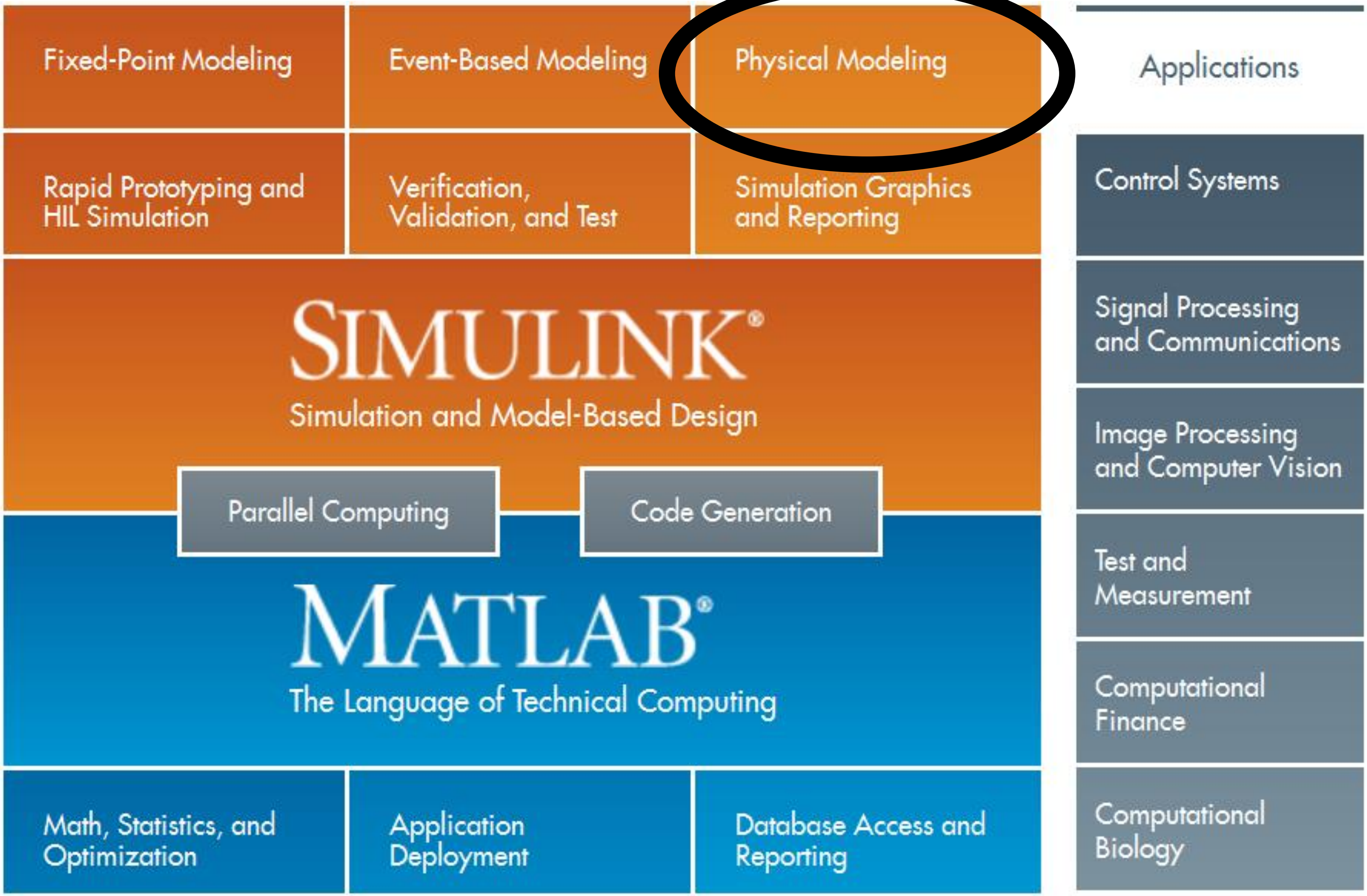
Please note…

- Today's slides & demos will be available (Follow-up Email)

- Feedback Forms…
  - **Need Anything???**
  - **How can we help you???**

- Giveaways…

MathWorks Product Overview



Corp License 339958 – MATLAB Based Products

352	**MATLAB**
12	Parallel Computing Toolbox
	Math, Statistics, and Optimization
14	Symbolic Math Toolbox
2	Partial Differential Equation Toolbox
28	Statistics Toolbox
16	Curve Fitting Toolbox
15	Optimization Toolbox
2	Global Optimization Toolbox
3	Neural Network Toolbox
	Control System Design & Analysis
29	Control System Toolbox
6	System Identification Toolbox
5	Fuzzy Logic Toolbox
5	Robust Control Toolbox
1	Model Predictive Control Toolbox
16	Aerospace Toolbox
	Signal Processing & Communications
44	Signal Processing Toolbox
19	DSP System Toolbox
13	Communications System Toolbox
4	Wavelet Toolbox
12	Fixed-Point Toolbox
4	RF Toolbox
2	Phased Array System Toolbox

	Image Processing and Computer Vision
31	Image Processing Toolbox
2	Computer Vision System Toolbox
1	Image Acquisition Toolbox
18	Mapping Toolbox
	Test & Measurement
4	Data Acquisition Toolbox
8	Instrument Control Toolbox
1	Image Acquisition Toolbox
	Code Generation
13	MATLAB Coder
1	HDL Coder
3	HDL Verifier
1	Filter Design HDL Coder
	Application Deployment
2	Spreadsheet Link EX
6	MATLAB Compiler
1	MATLAB Builder JA
1	MATLAB Builder NE
	Database Access and Reporting
4	MATLAB Report Generator
12	Database Toolbox

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76	**Simulink**
	Fixed-Point Modeling
3	Simulink Fixed Point
	Event-Based Modeling
23	Stateflow
6	SimEvents
	Physical Modeling
10	Simscape
3	SimHydraulics
6	SimMechanics
9	SimPowerSystems
4	SimRF
	Control System Design and Analysis
6	Simulink Control Design
3	Simulink Design Optimization
16	Aerospace Blockset
	Signal Processing and Communications
19	DSP System Toolbox
13	Communications System Toolbox
4	SimRF
2	Computer Vision System Toolbox

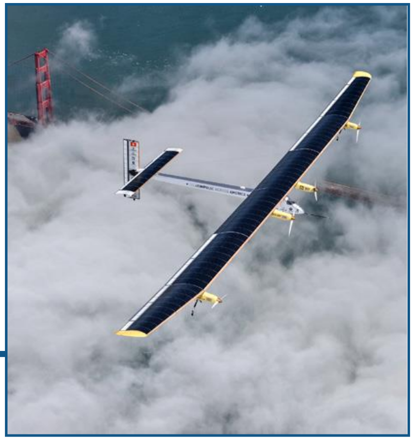
	Code Generation
7	Simulink Coder
7	Embedded Coder
1	HDL Coder
	Rapid Prototyping and HIL Simulation
2	xPC Target
2	Real-Time Windows Target
	Verification, Validation, and Test
6	Simulink Verification and Validation
0	Simulink Code Inspector
1	Simulink Design Verifier
2	SystemTest
3	HDL Verifier
	Simulation Graphics and Reporting
3	Gauges Blockset
4	Simulink 3D Animation
3	Simulink Report Generator

To see your license #, type "ver" in MATLAB

Key Messages

- Design and Analyze Electrical and Power Systems
- Develop and Implement Logic and Controls
- Perform Verification and Validation

Solar Impulse Develops Advanced Solar-Powered Airplane



The HB-SIA aircraft on a test flight over San Francisco Bay.
Photo © Solar Impulse | Revillard | Rezo.ch

Challenge

Develop a solar-powered aircraft capable of circumnavigating the globe

Solution

Use MATLAB and Simulink to create system models for trade studies and design tradeoff analysis, and aircraft dynamics models for high-fidelity simulations and pilot training

Results

- Key design decisions made early
- Vital pilot training enabled
- Models reused and shared throughout development

"Simulations with MATLAB and Simulink were essential to assessing feasibility and evaluating broad design tradeoffs as well as making detailed design decisions—like the size of control surfaces and the vertical tail—that directly affect aircraft dynamics and handling qualities."

Ralph Paul
Solar Impulse

Link to user story

GasTOPS Develops and Tests Propulsion Control Algorithms for the USS Makin Island

The USS Makin Island.

Challenge

Develop the propulsion control algorithms for the USS Makin Island

Solution

Use Model-Based Design with MATLAB and Simulink to model the ship's main systems, develop and verify control algorithms, and generate code for onboard training and HIL test setups

Results

- Time-to-simulation cut by two-thirds
- Key design issues identified early
- Models reused multiple times

"We mitigate risk by simulating complex marine and aircraft systems before they are built. To reduce costs, we automate simulations with MATLAB and reuse models throughout development. Understanding multidomain systems through simulations in Simulink and SimPowerSystems is invaluable to our business."

Shaun Horning
GasTOPS

[Link to user story]

NASA Interns Develop Guidance, Navigation, and Control Software for Quadcopter with Model-Based Design

NASA intern working with the quadcopter vehicle and ArduPilot Mega 2.5 hardware.

Challenge

Give engineering interns hands-on work experience in the aerospace field

Solution

Create a program in which interns use Model-Based Design to model, simulate, implement, and fly GNC algorithms for multirotor aircraft

Results

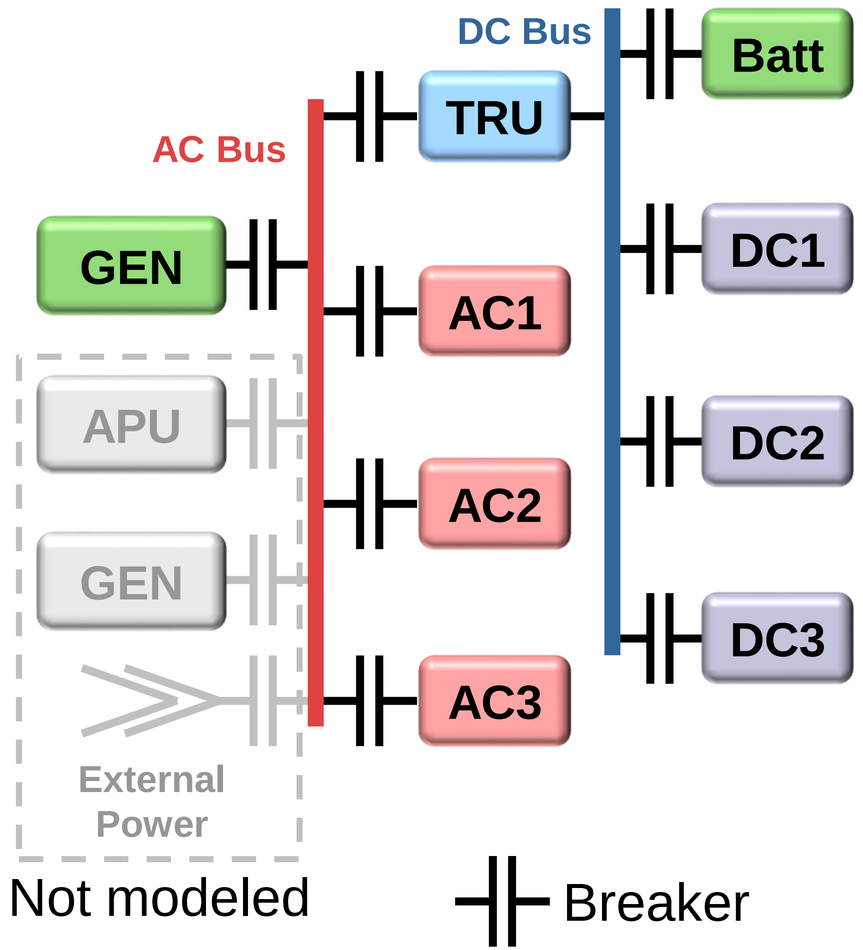
- GNC algorithms developed and implemented in 10 weeks
- Hardware integration streamlined
- Practical engineering experience acquired

Model-Based Design makes both working engineers and interns at NASA MSFC more productive. The students have more fun because they can run the GNC algorithms they create in Simulink on a real processor and quickly get things done.

Link to user story

Aircraft Power Network

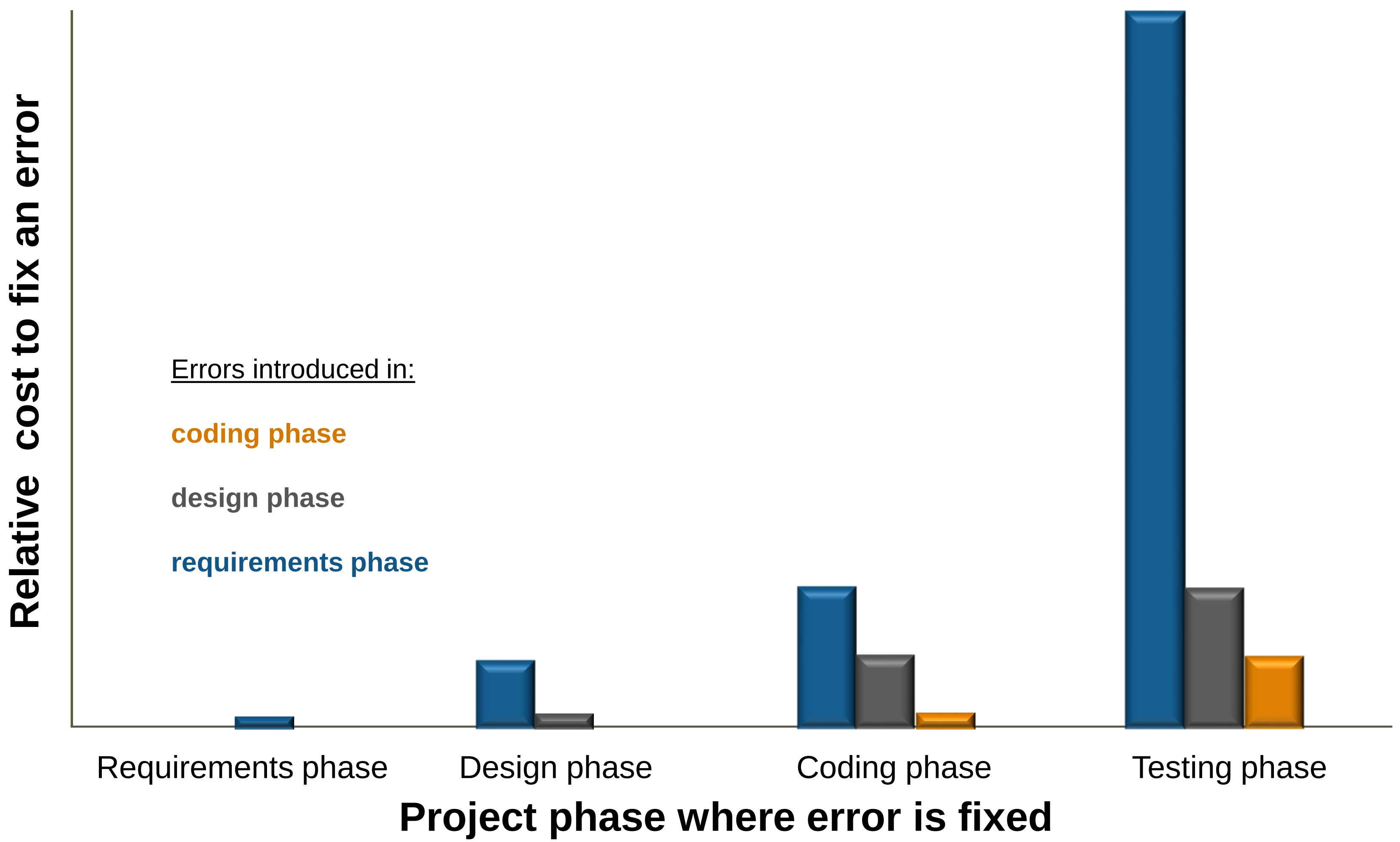
- Half-aircraft model
  - One generator
  - AC bus with loads
  - TRU (Transformer-Rectifier Unit)
  - DC bus with loads and battery
- Breakers open and close during flight cycle



Agenda

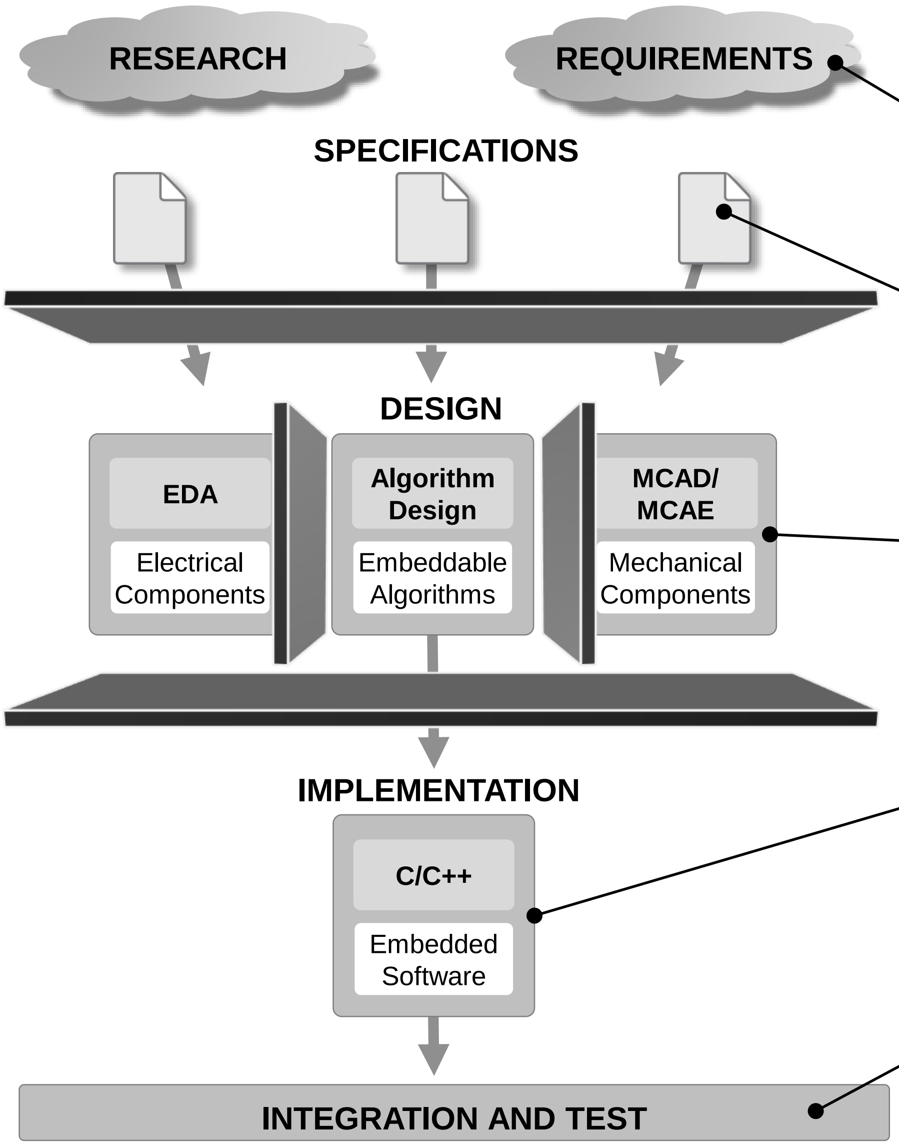
- Intro / Overview
- Aircraft Power Network
- Physical Modeling
- Modeling Electronics and Power Systems
- Summary / Additional Resources

What is the Most Expensive Project Stage to Find Errors In?



Source: Return on Investment for Independent Verification & Validation, NASA, 2004.

Traditional Development Process



Requirement Documents
- Difficult to analyze
- Difficult to manage as they change

Paper Specifications
- Easy to misinterpret
- Difficult to integrate with design

Physical Prototypes
- Incomplete and expensive
- Prevents rapid iteration
- No system-level testing

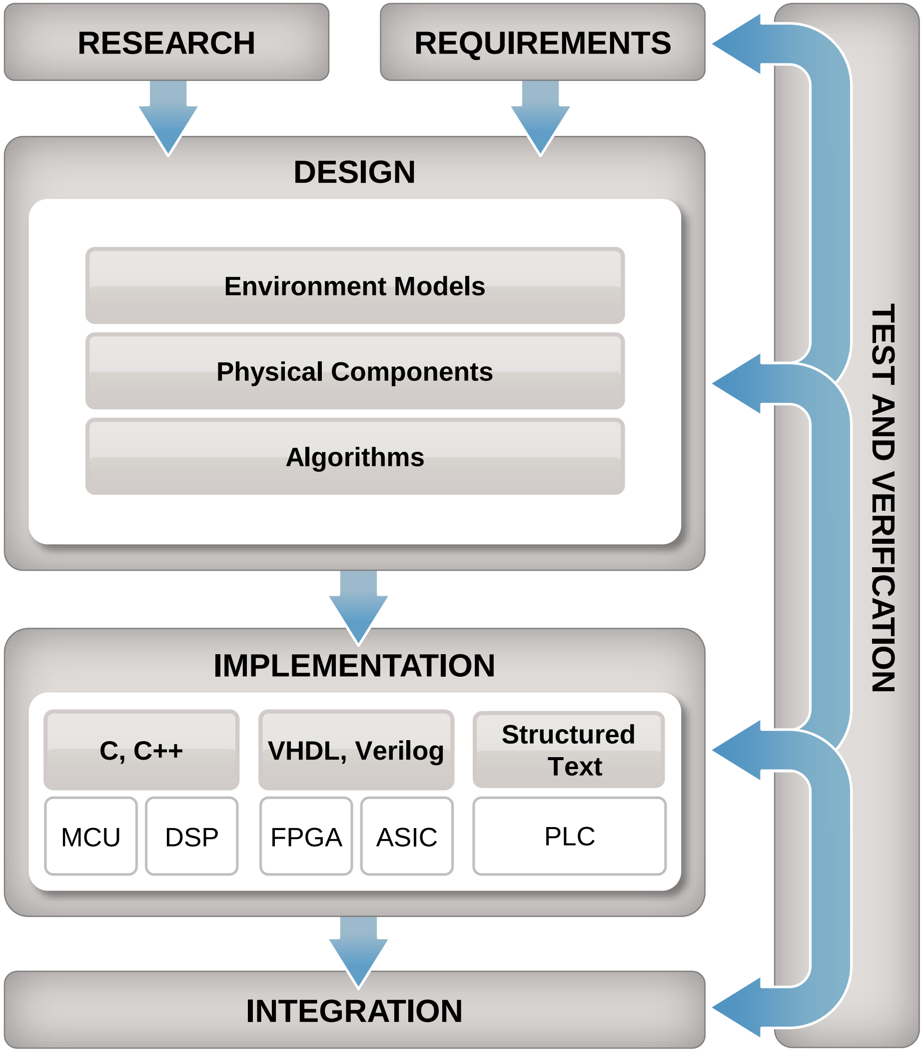
Manual Coding
- Time consuming
- Introduces defects and variance
- Difficult to reuse

Traditional Testing
- Design and integration issues found late
- Difficult to feed insights back into design process
- Traceability

Systems Engineering Categories

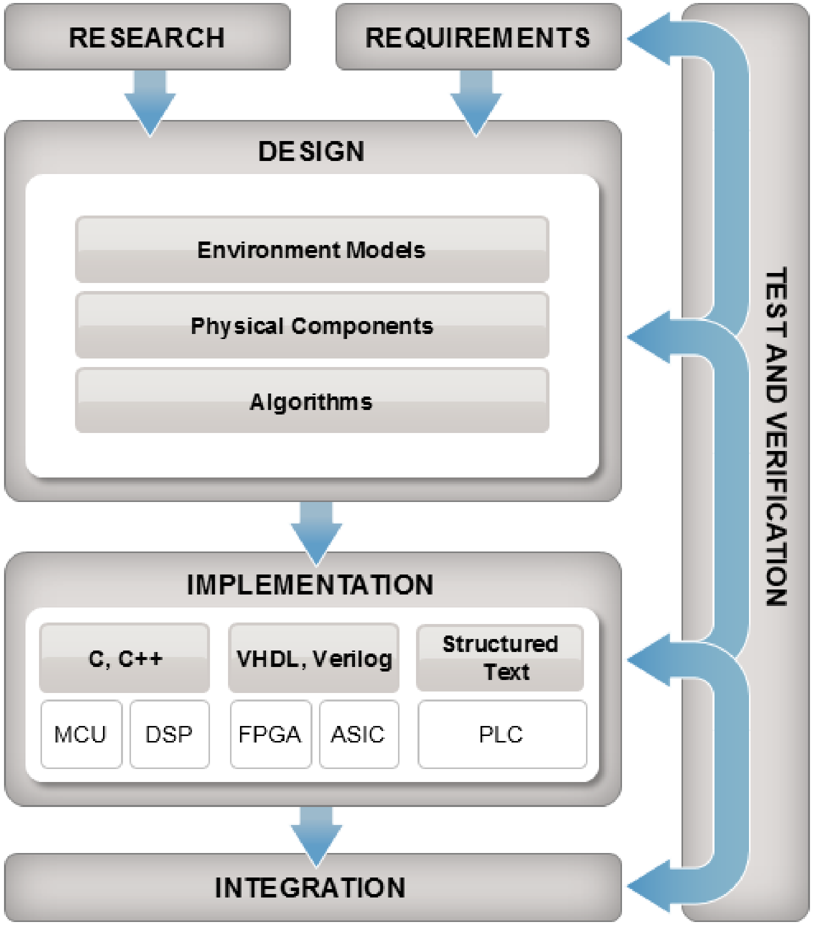
1. Mission / Purpose Definition (MD)
2. Requirements Engineering (RE)
3. System Architecting (SA)
4. System Integration (SI)
5. Verification and Validation (VV)
6. Technical Analysis (TA)
7. Scope Management (SM)
8. Technical Leadership / Management (TM)

Model-Based Design



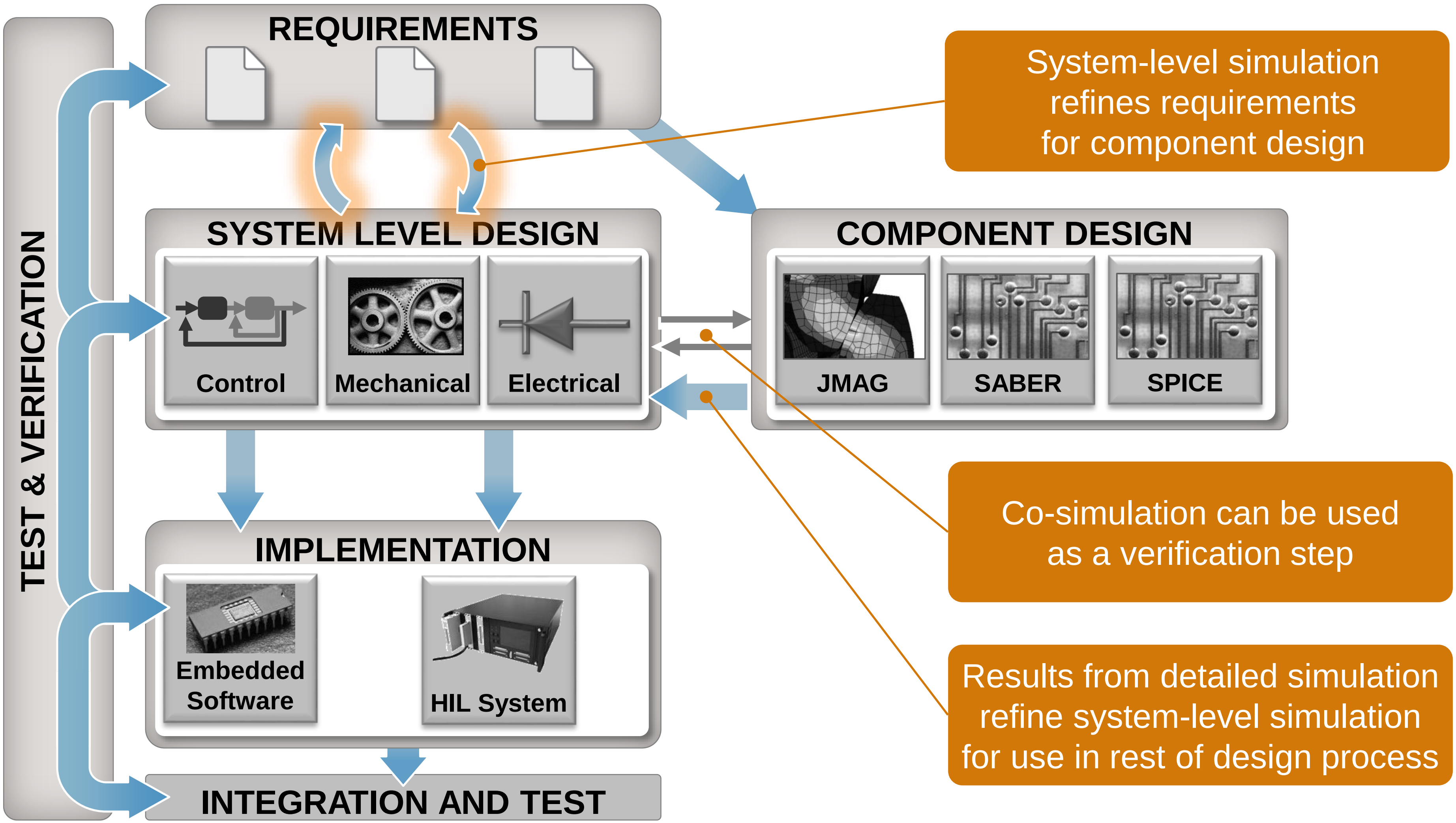
Systems Engineering and MBD

1. Mission
   / Purpose Definition
2. Requirements Engineering
3. System Architecting
4. System Integration
5. Verification and Validation
6. Technical Analysis
7. Scope Management
8. Technical Leadership
   / Management



Model-Based Design

System and Component Level Design



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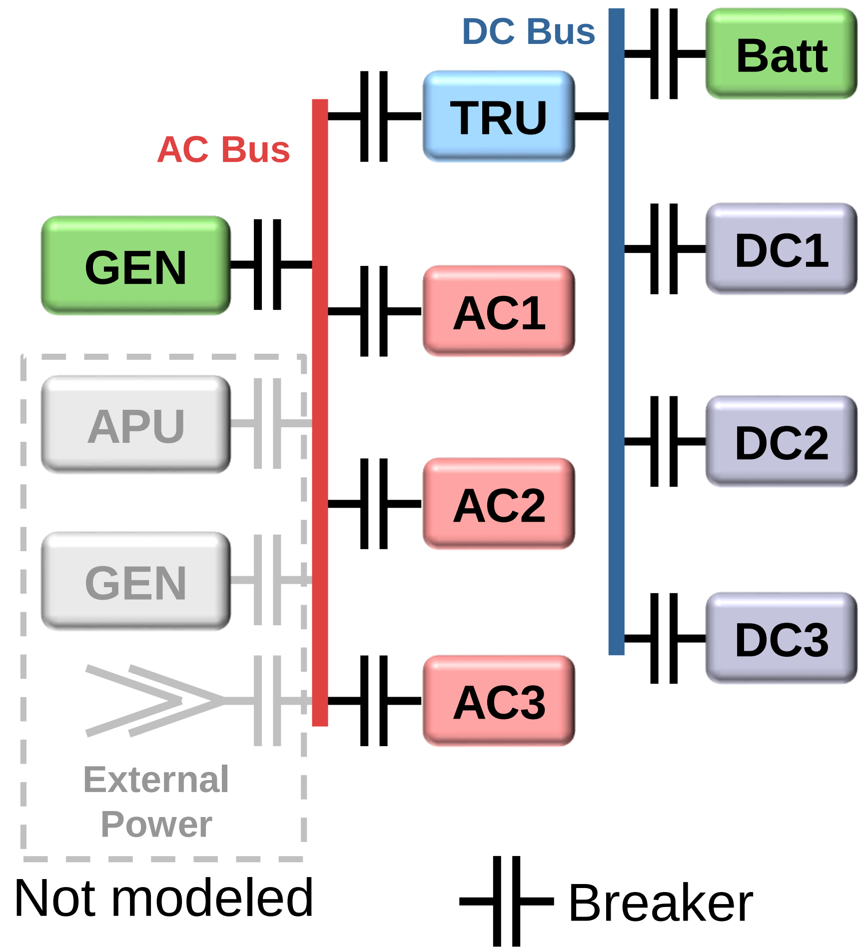
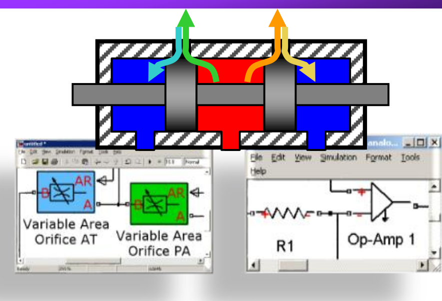


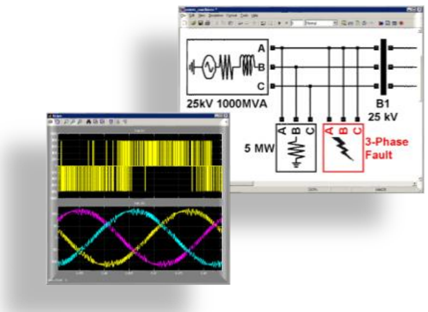
Physical Modeling

Simscape™



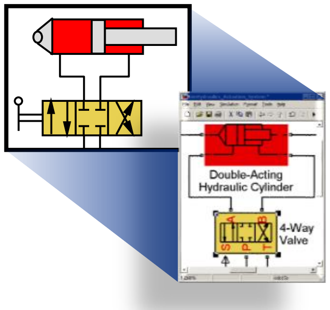
Multi-domain physical systems

SimPowerSystems™



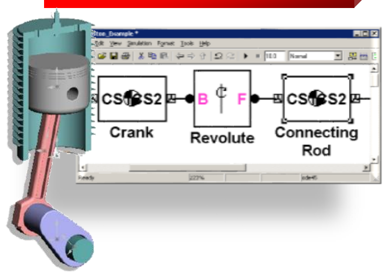
Electrical power systems

SimHydraulics®



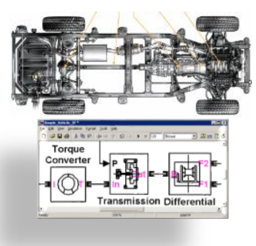
Fluid power and control

SimMechanics™



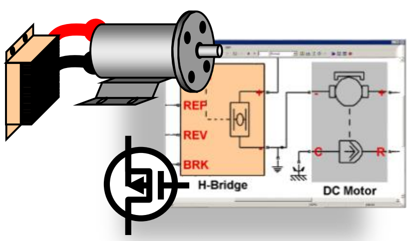
Mechanical dynamics (3-D)

SimDriveline™



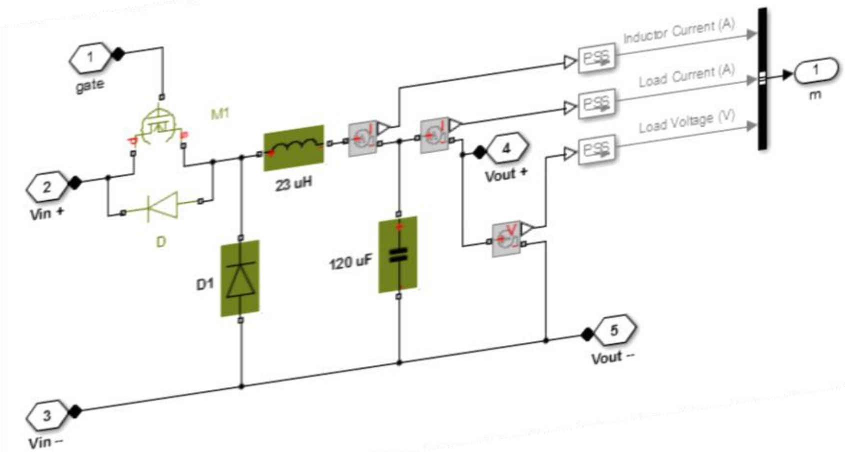
Drivetrain systems (1-D)

SimElectronics™



Electromechanical and electronic systems

Modeling Electronics and Power Systems

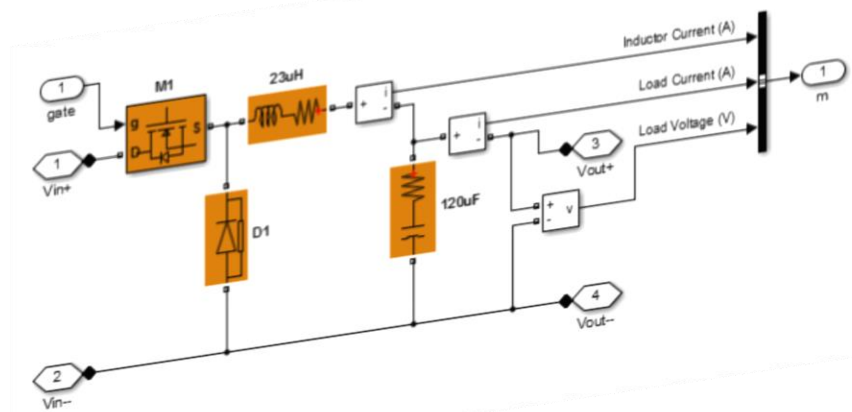


SimElectronics

Simultaneous nonlinear equations solution
SPICE level switching device models
Include switching losses
Include parasitic current effects
Include temperature effects
Higher fidelity simulation

SimPowerSystems

Piecewise linear systems solution
Multiphase bridges and pulse generators
Detailed and average voltage models
Transient and harmonic analysis
Faster simulation

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>> se_dcdcbuckconverter        >> sps_dcdcbuckconverter
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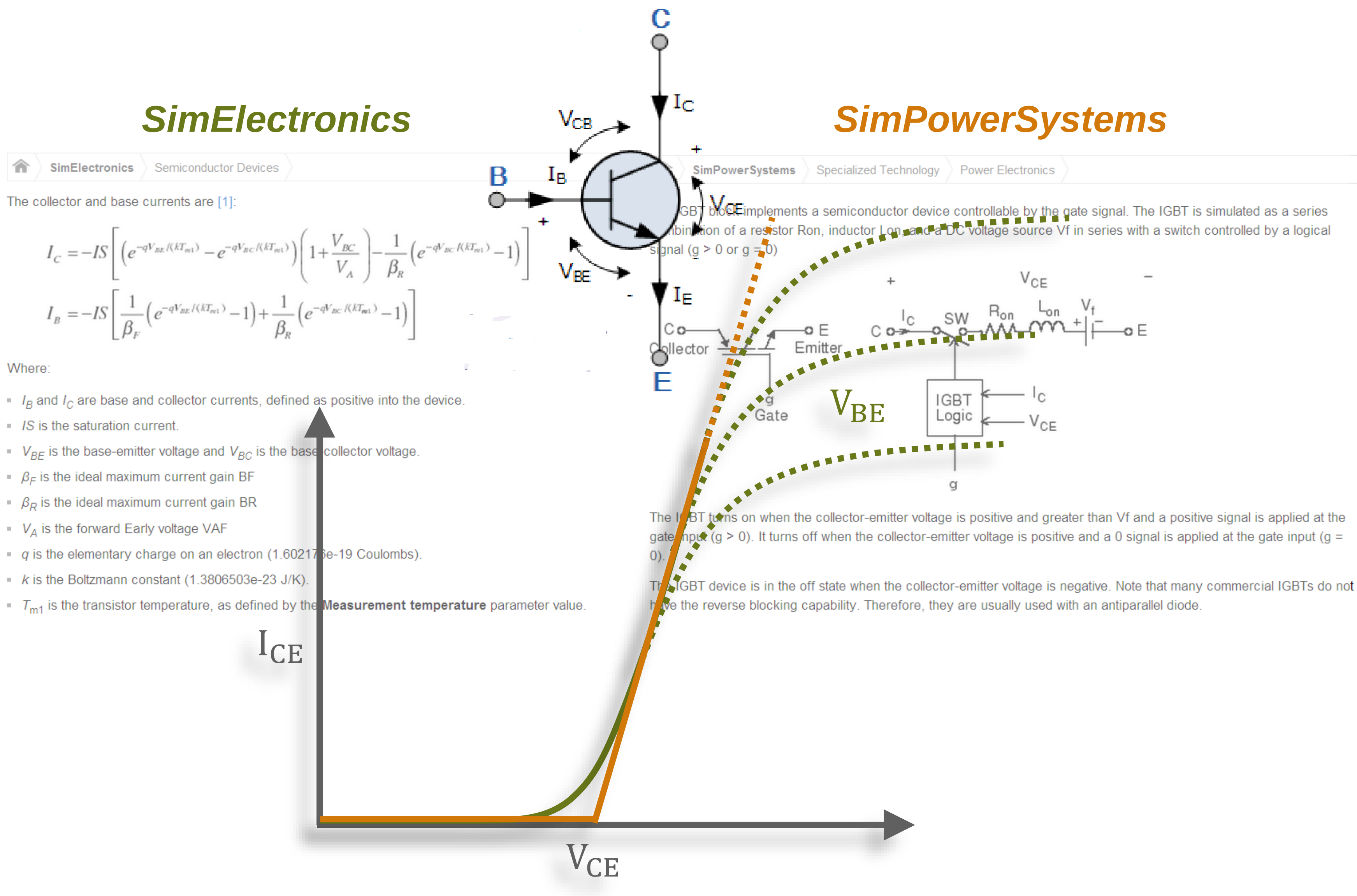
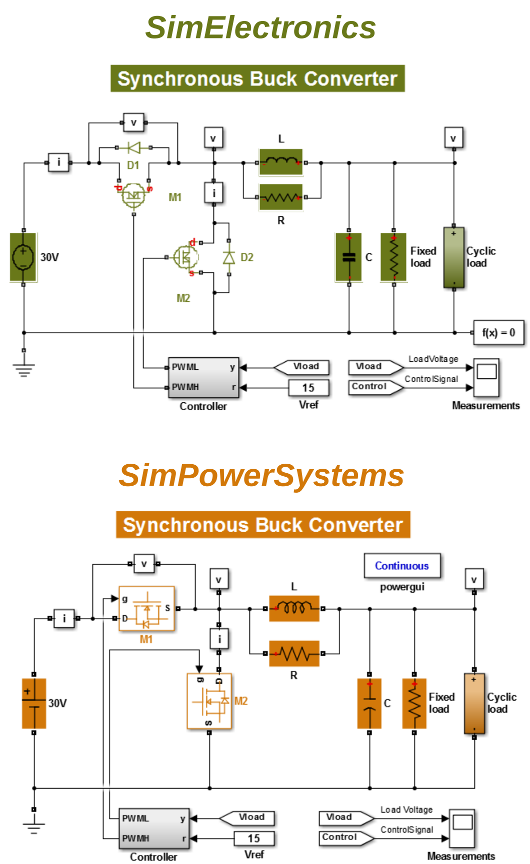
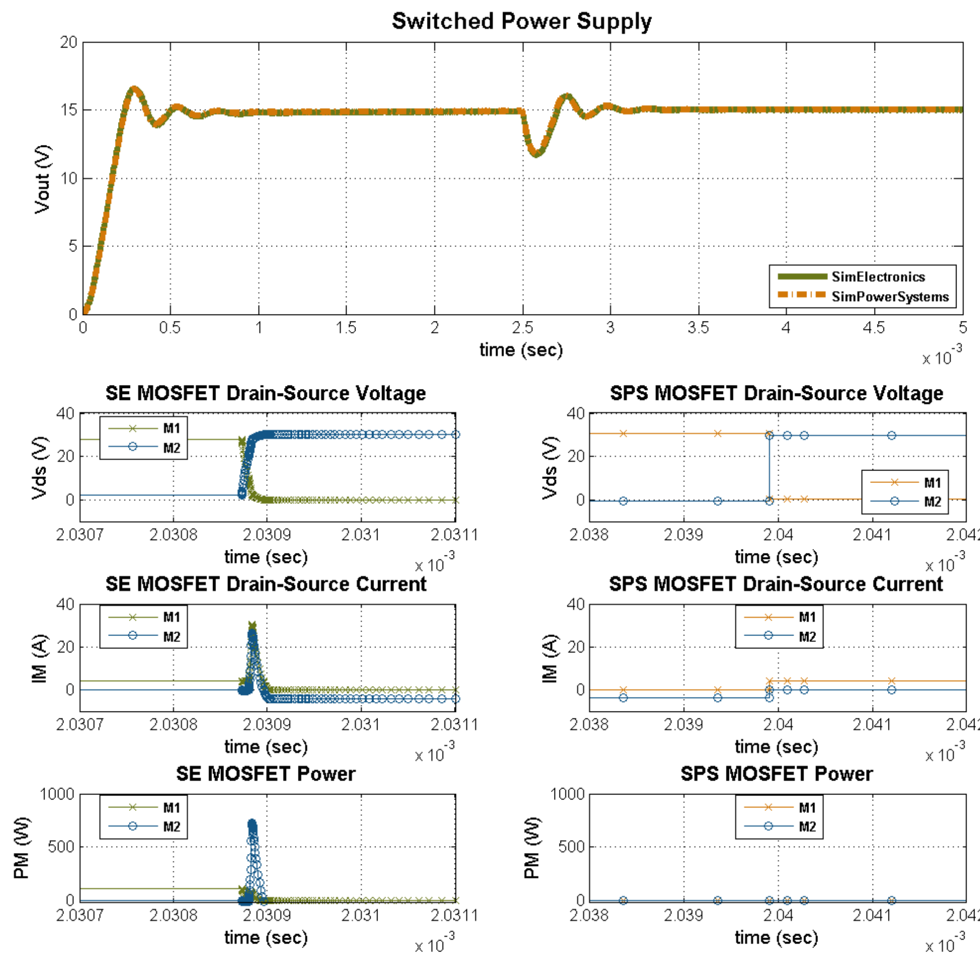
SimElectronics or SimPowerSystems?



SimElectronics or SimPowerSystems?



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>> edit compare_powersupply
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Logic and Controls

- Implement and Debug Logic Graphically
- Develop and Test Controls
- Code Generation

- Examples:
  - Synchronizing Breaker
  - Voltage Regulator

Verification and Validation

- Requirements Traceability
- Design Validation and Analysis
- Test and Verification

- Examples:
  - Aircraft Power Network
  - Managing Requirements for Fault-Tolerant Fuel Control System
  - Code Generation Verification Workflow with Simulink Test

Verification and Validation

- Model and Code Coverage
- Design Error and Bug Detection
- Certification, Standards and Code Proving

- Examples:
  - Top-Level Model Coverage Report
  - Find Defects from the Polyspace Environment
  - Workflow for Tool Qualification

Summary

- Design and Analyze Electrical and Power Systems
- Develop and Implement Logic and Controls
- Perform Verification and Validation

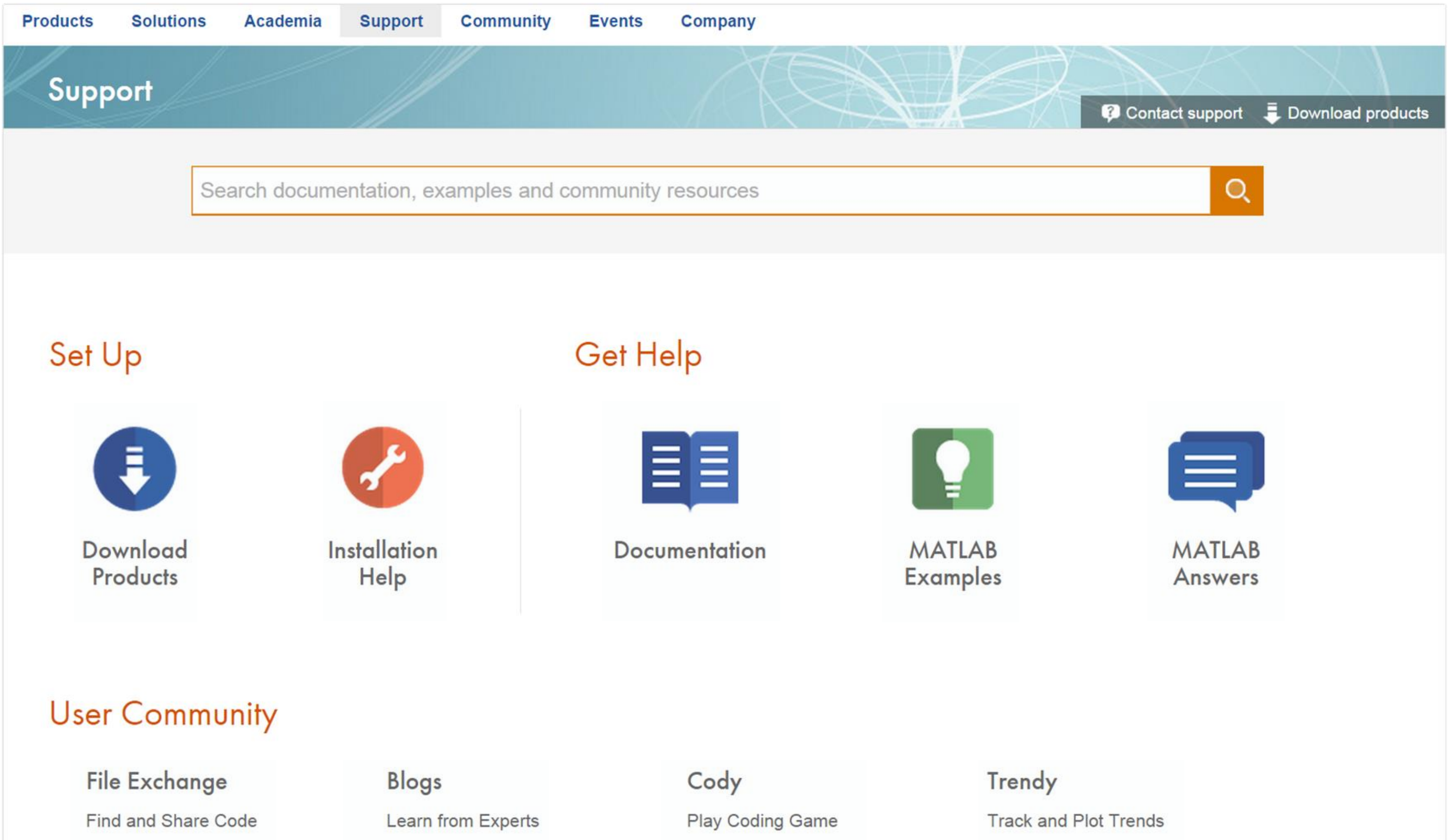
Additional Resources

MathWorks
Accelerating the pace of engineering and science

- Videos and Webinars
  - Aircraft Power Network (4:58)
  - Automatic Report Generation for Aircraft Power Network (2:30)
  - Running Parallel Simulations of Aircraft Flight Cycles (5:00)
  - Aircraft Power Network Development with MBD (46:41)
- Example: Aircraft Power Network on MATLAB Central
- Documentation: (SimElectronics) (SimPowerSystems)
- Tutorials: Build and Simulate a Simple Circuit
- Training: Physical Modeling: Electrical Power Systems
- Consulting: Proven Solutions from MathWorks Consulting

Join the conversation

Support



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Blogs
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Cody
Play Coding Game
Trendy
Track and Plot Trends

Thank You for Attending Today!

- Point of Contact
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  - 508-647-1203

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  - On-Demand Training (self-paced, online)
    - MATLAB Academy (complimentary)
    - MATLAB Fundamentals
    - MATLAB Programming Techniques
    - MATLAB for Data Processing and Visualization

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pick up a give-away

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