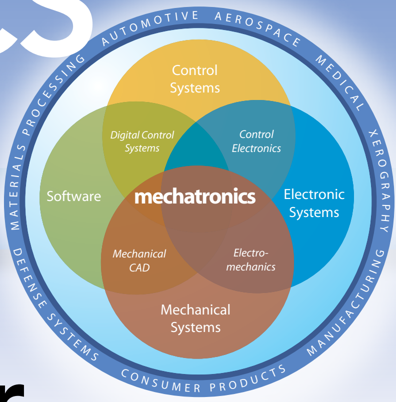
MECHATRONICS IN DESIGN

FRESH IDEAS ON INTEGRATING MECHANICAL SYSTEMS, ELECTRONICS, CONTROL SYSTEMS AND SOFTWARE IN DESIGN



Tools & Techniques for the Practicing Engineer

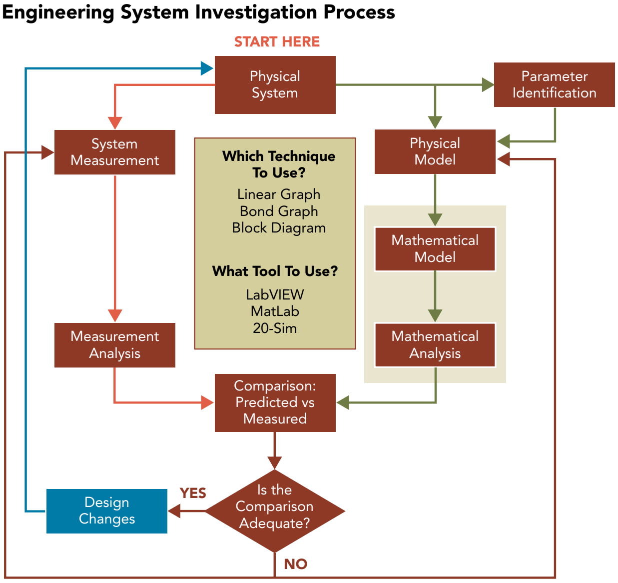
BY KEVIN CRAIG

One of the engineering magazines I read each month, besides *Design News,* of course, is the IEEE *Control Systems* magazine. It should be required reading for all multidisciplinary systems engineers, that is, mechatronics engineers.

In the April 2007 issue, the featured article was "Bond-Graph Modeling." Over the years, I had heard about bond graphs, but had never taught them or used them in engineering work. So, I contacted engineers at Tetra Pak, whom I had worked with at a mechatronics workshop I gave in Italy last March. I asked about their use of bond graphs to model the dynamic systems they designed for their multinational food packaging company. Their answer was a rousing "yes!" Moreover, it was a tool embraced by many engineers within the company. That's vital in mechatronics' design. In this global economy marked by multinational companies with engineers scattered all over the world, confusion reigns and productivity drops if only a few engineers adopt a new tool.

A longtime colleague and friend, Mark Nagurka, a MIT-trained Ph.D. and mechanical engineering professor at Marquette University, also has firsthand knowledge about bond graphs and their inventor, the late MIT Professor Hank Paynter. In fact, he had interviewed Paynter for the August 1994 issue of *Control Systems*.

Engineering System Investigation Process



The engineering system investigation process is the procedure an engineer follows to thoroughly investigate how a dynamic engineering system or device performs.

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We started to discuss the ways engineers create mathematical models from the various physical models of the systems they are investigating or designing. What tools are available to support various techniques? These are most important questions to answer for practicing engineers, since modeling is the single most important activity in the mechatronic system design process. This article is the first in a series on modeling — techniques and tools for the practicing engineer.

There are two distinct models of an actual dynamic physical system — a physical model and a mathematical model. The distinction between them is most important. In general, a physical model is an imaginary physical system, a slice of reality, based on engineering judgment and simplifying assumptions. There is a hierarchy of physical models of varying complexity, from the less-real, less-complex, more easily solved design model to the more-real, more-complex, less easily solved truth model. The complexity of the physical model depends on the particular need, such as system design iteration, control system design, control design verification or physical understanding. Always ask the question — Why am I modeling? An excellent analogy is geographic maps and the varying detail one can display on a map.

Modeling is part of the Engineering System Investigation Process, which I first learned about from the books of two mechatronics pioneers and giants in engineering education, Robert Cannon of Stanford University and Ernie Doebelin of Ohio State. See the diagram, left, of my version of that process. This is the cornerstone of modern engineering practice. It is a procedure an engineer follows to thoroughly investigate, understand, predict and experimentally verify how a dynamic engineering system or device performs, no matter how simple or complex the system may be. It is an iterative process, since there is a hierarchy of physical models possible.

There are techniques and tools to predict model behavior. Just what are they and which ones should an engineer be able to use? Nagurka and I will provide the answers to those questions in future columns.

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