Functional Monitoring & Diagnosis (FMD)

John J Kelly, PhD
Model Software Corporation
www.ModelSoftware.com

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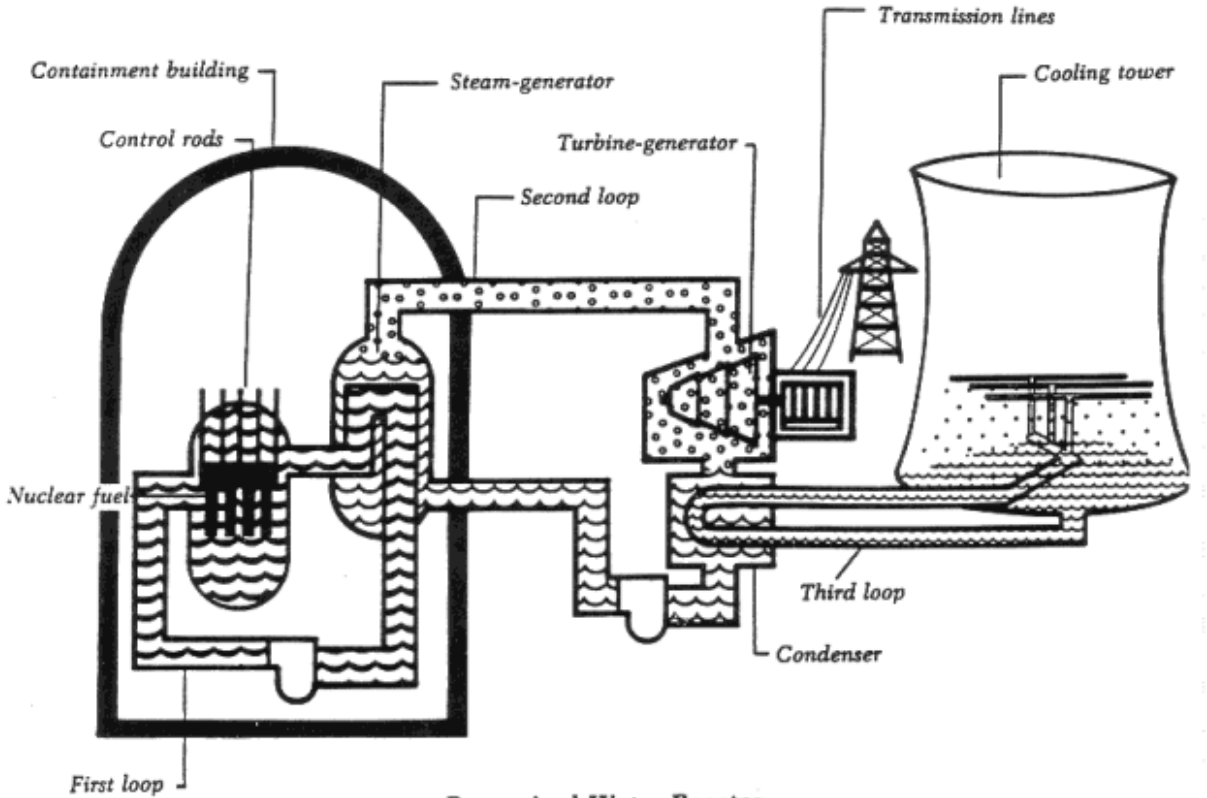
Vision

- Monitor and diagnose any plant in real time based on an operational model of the plant



Pressurized Water Reactor

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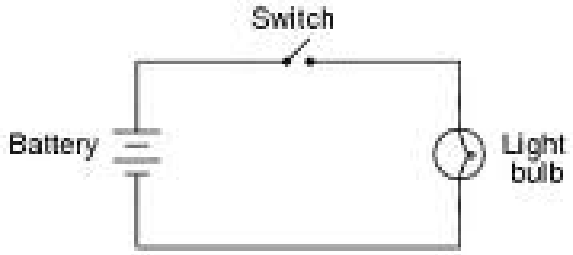
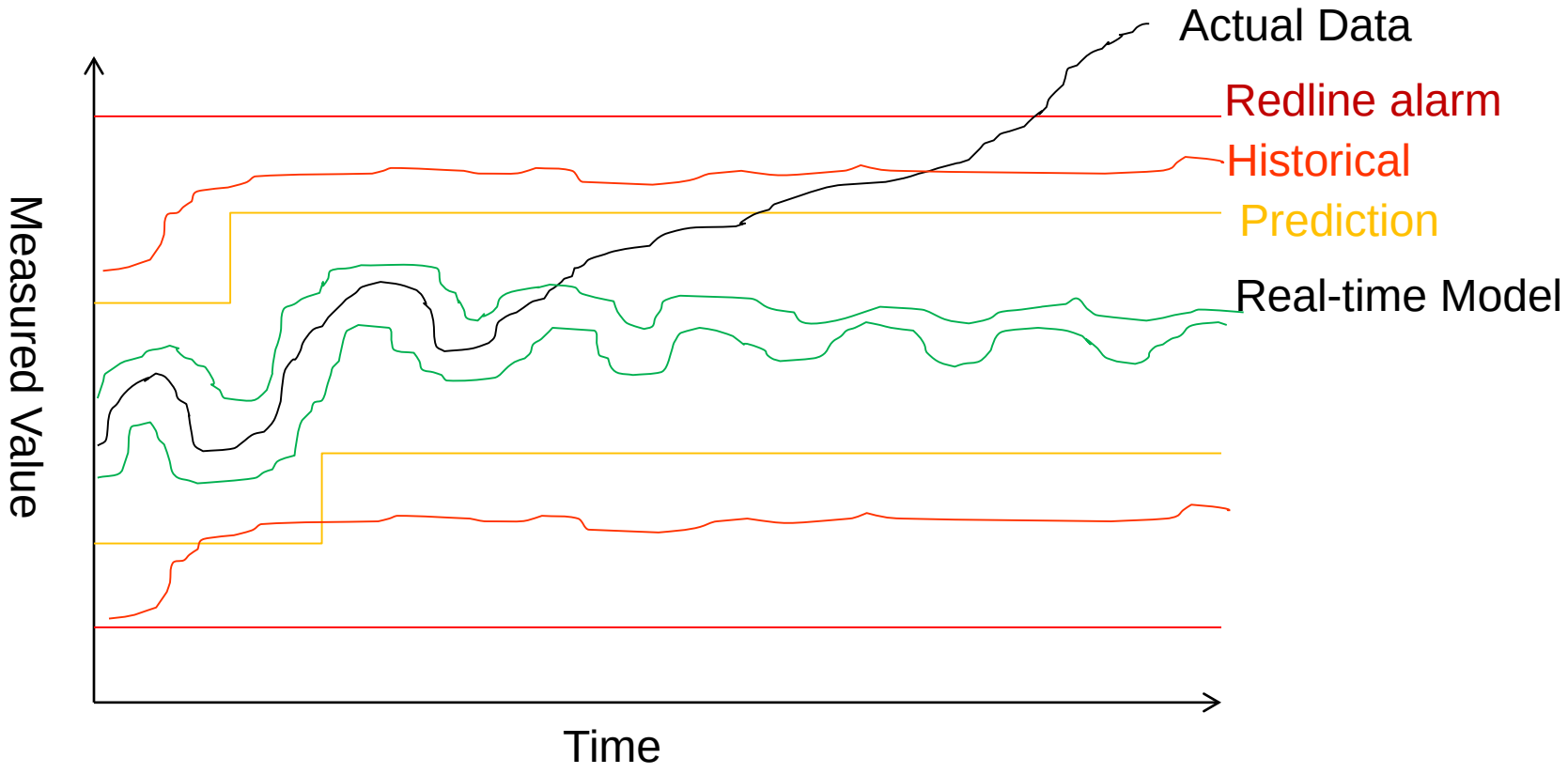
Simplified Example: System & Model



Luminance = c * Power
Power = Voltage * Current
Voltage = Current *Resistance
Resistance = {if S=closed, R1}
{if S=open, ~infinite}
R1 = {if bulb=nominal, 1 ohm}
Voltage = {if battery=nominal, 1.5 volts}

Real-time Detection of Failure



• Using an operating model enables detecting failures earlier than they might otherwise be detected, affording more time to manage them

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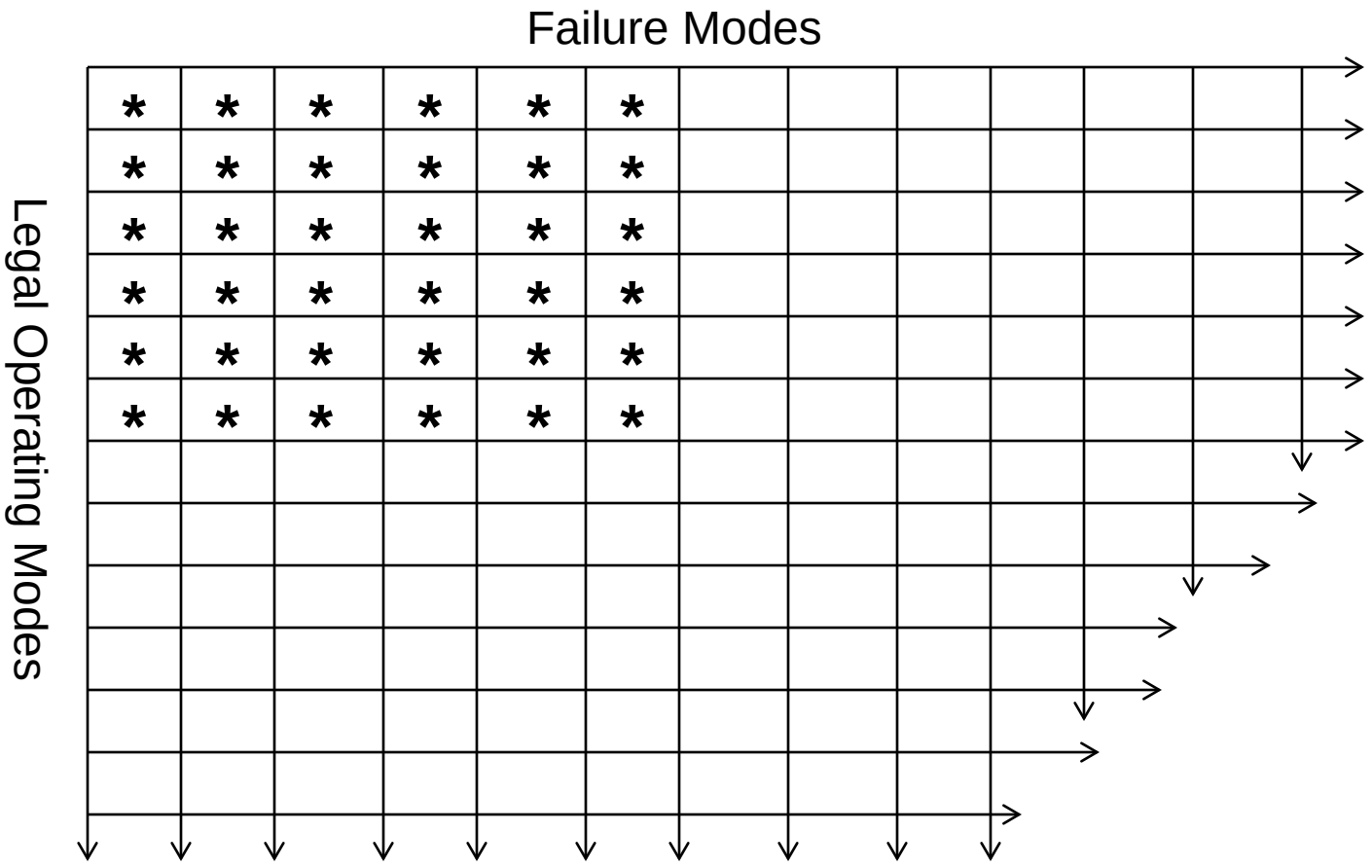
Combinatorial Space of Symptoms



* Defined symptom-fault relation

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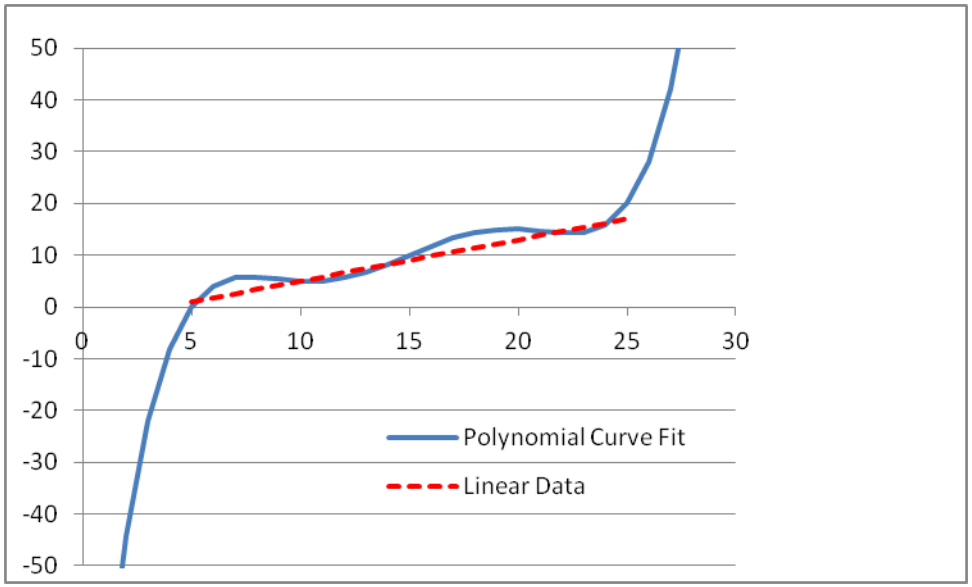
Existing Technologies: Empirical



- Goodness of Fit (Overfitting)
  - Curve-fitting tools are notorious for fitting high-order polynomials to low-order phenomenon, such as for log and square-root functions, or even just simple linear equations that are slightly obscured by noise.
  - While by adding enough high-order terms, there can eventually be a fit, to some criteria, within the data domain of the exemplars, but as soon as the equations are used outside the range of the training exemplars the fit can be extremely bad

Technique Summary

	Handcode	Empirical	Models
Availability of	Expert/Model	Data	Model
Goodness of Fit	Varies	Overfit	As good as it gets
Combinatorics	Limited	Limited	Virtually unlimited
Reliability	Good	Limited	Best
Range of Scenarios	Considered scenarios	Scenarios in exemplar set	Limited only by # of elements in Model

Technicians & Engineers

- The empirical techniques are comparable to using technicians to diagnose equipment
  - Most all the time the technician immediately knows what is wrong – because he has seen it before in actual practice or in training
  - The balance of the time the technician struggles because he doesn't know how to diagnose from first principles
- An engineer can diagnose anything if he has a schematic and some time
  - He is well-versed in the first principles and in reasoning about models
- The downside to using engineers is that they must be kept on call and they do require some time to think about the problem
- FMD software performs essentially the same analysis that an engineer would perform
  - But it is practical to keep the FMD software online 24/7
  - It is able to perform the analysis in less than a second