December 16, 10

SOFTWARE FEEDBACK IN SYSTEMS ENGINEERING THE LIFECYCLE

An Approach for Developing Complex Systems Using Control Theory

Assertion

- Complex Systems can effectively satisfy customers following a flexible software lifecycle approach that couples feedback control concepts with an incremental commitment to a solution

Introduction

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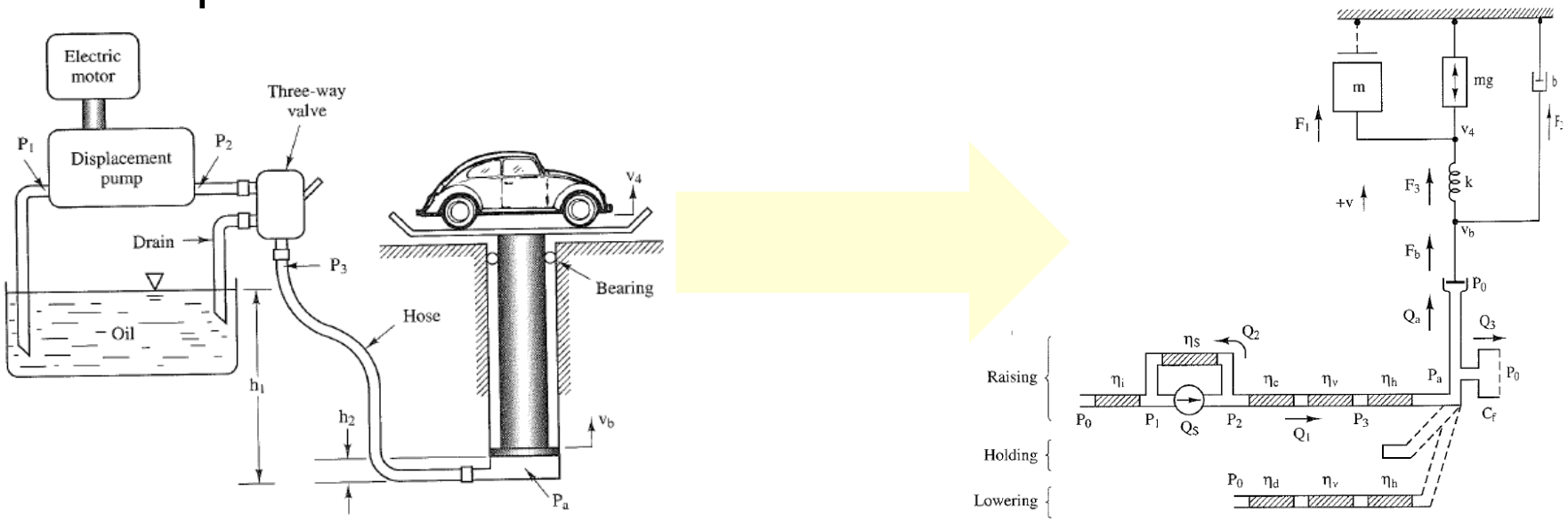
Complex Systems

- A system where the behavior as a whole is not intuitively understood by understanding the components
- Components include:
  - People (most complex variable)
  - Software
  - Electrical/Electronic
  - Mechanical
  - Fluid Flow
  - Thermal

Premise: It is not possible to fully understand a complex system prior to deploying it

System Modeling

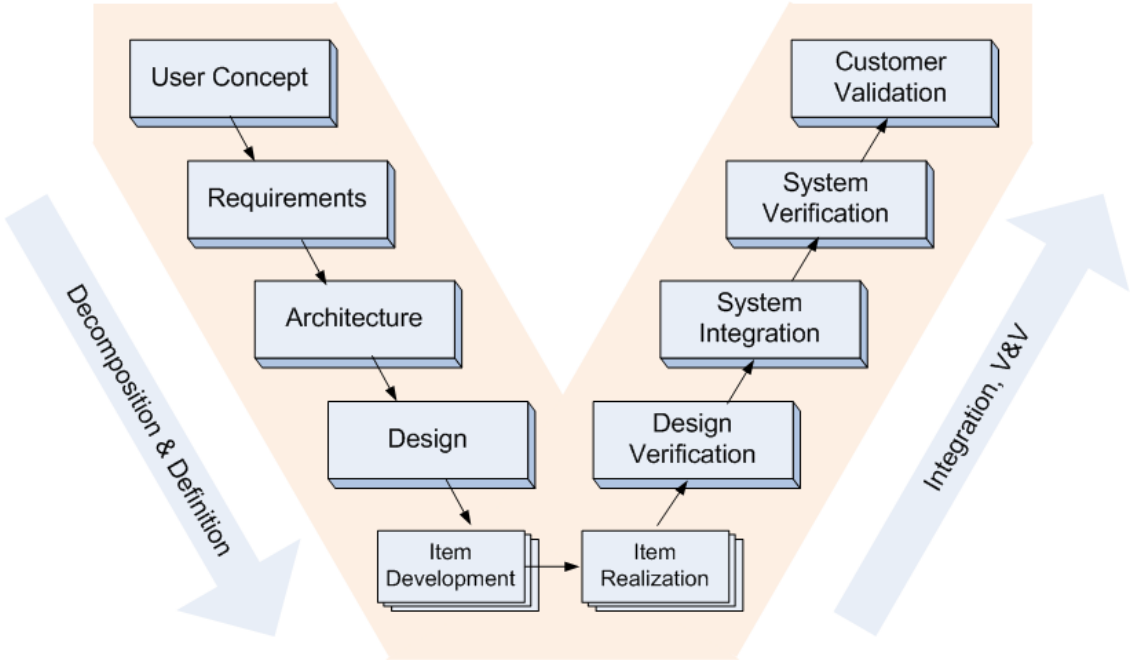
- The purpose of modeling and simulation is to develop insight into how the system will act
- A rich, multi-disciplinary model improves first pass customer satisfaction, but new capability fosters new expectations



Figures used by permission from Dorny, C.N., Understanding Dynamic Systems: Approaches to Modeling, Analysis, and Design, 1993, pg 483-484.

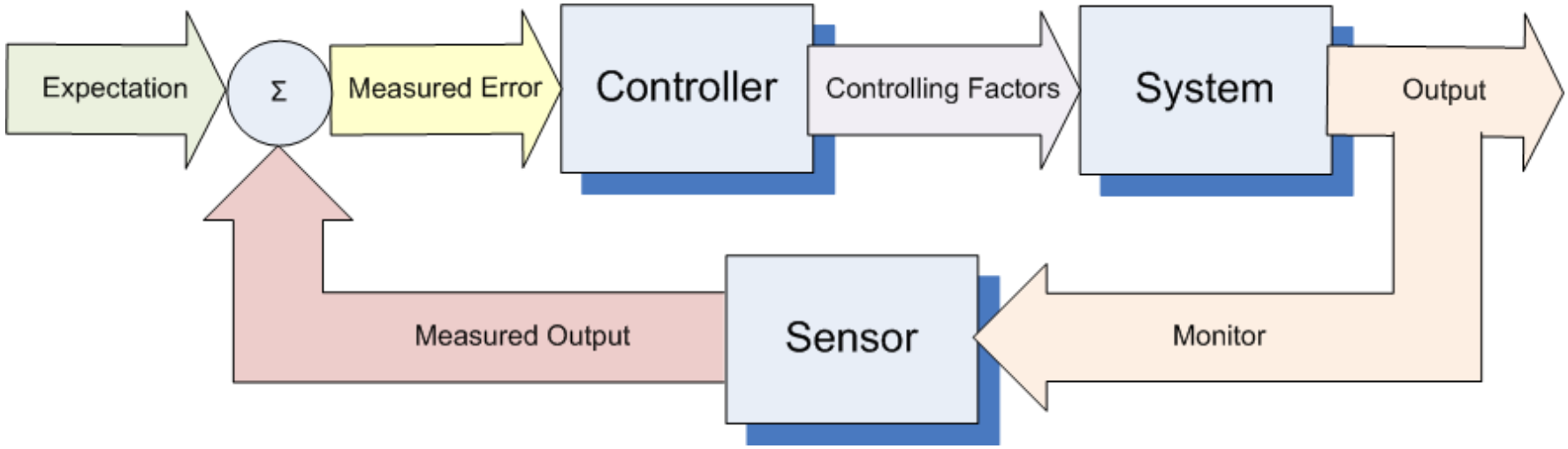
Traditional Systems Engineering Approach

- The classic Vee model insinuates a beginning and an end
- Customer Acceptance ≠ Customer Satisfaction



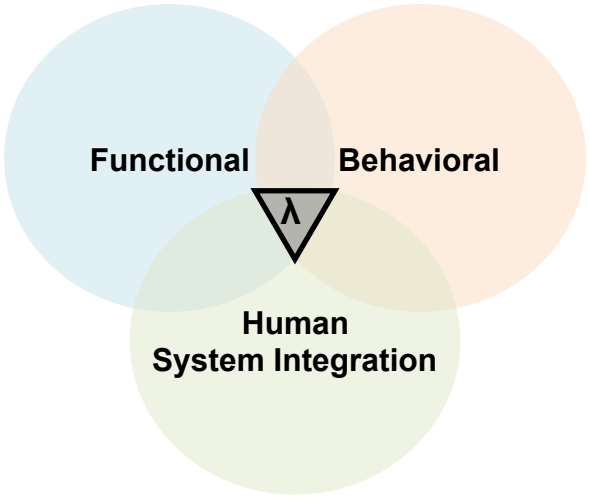
Control System Paradigm

- Provides a self-tuning execution that continuously adjusts for deviation from expectation
- Used because deviations are known to occur but the amount of deviation cannot be known a-priori



Complex System Models

- Four necessary models for complex systems provide the Expectation input:
  - Functional (what the system must do)
  - Behavioral (how the functions flow to fulfill needs)
  - Human (tasks performed using the system)
  - Reliability (what is required to sustain capabilities)



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Incremental Commitment

- "Requirements and commitment cannot be monolithic or fully pre-specifiable for complex, human-intensive systems; increasingly detailed understanding, trust, definition and commitment is achieved through an evolutionary process."[1]
- Not a large single commitment to the capabilities initially envisioned
  - smaller commitments to see whether the prospects of success are favorable
  - increased commitment based on better information on the prospects of success that emerge from each incremental gamble
  - "Satisfice" is the criteria for having progressed enough

[1] Boehm, B., Lane, J., "Using the Incremental Commitment Model to Integrate System Acquisition, Systems Engineering, and Software Engineering".

Usage Analytics

- Web analytics provide a pattern for recognizing customer satisfaction from monitoring the user's behavior
- Analyze
  - How the user arrived at a function
  - How long the user exercised a function
  - Geographical context in use of a function
  - Spatial exercise of a function
  - Demographic user classification
  - Unused or under-utilized functions
  - "Conversion" funnels- where user did not complete the task

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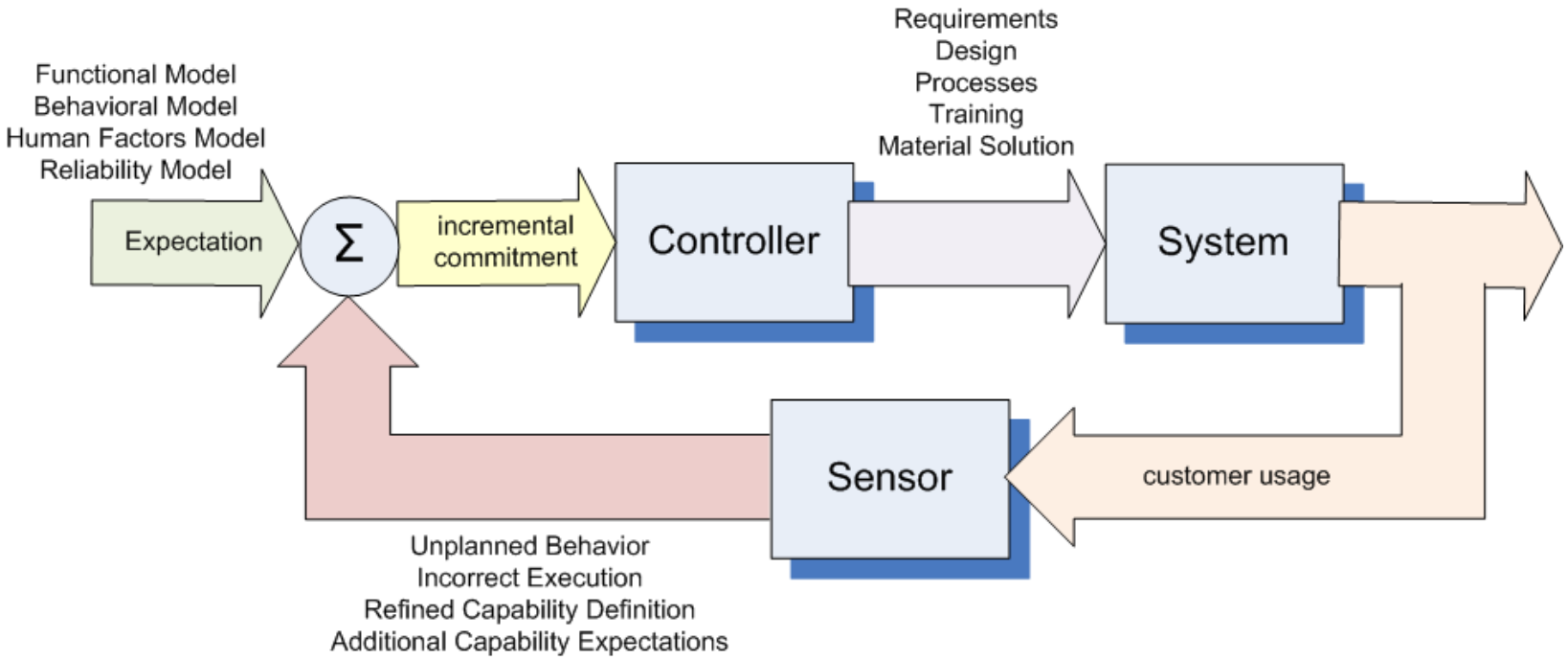
SE Lifecycle Framework

- Incrementally commit to modeled behavior
- Establish next increment based on customer satisfaction use indicators
- Update controlling factors accordingly



Summary

- Complex systems require a closed-loop feedback systems engineering approach to assure products establish and maintain customer satisfaction
- For spaceflight software an incremental commitment to implementation with each increment following the Vee model will result in maturing only the functions that exhibit promising satisfaction indications
- An integrated model-based approach following a controls model establishes the mechanisms for rapid software development with dynamic adjustment to unexpected complex system response