

An Introduction to a Top Down Design Process

Agenda

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- Why You Should Be Concerned
 - » Problems With Product Development
- Introduction to a Systems Approach
 - » What Engineers Should Do
- The Three Pillars of Management
 - » Project Leadership
- The Three Levels of Abstraction
 - » Decomposing Designs
- Graphical Specifications
 - » Better Than Natural Language Documents
- The Experiment
 - » Need for Volunteers

Why You Should Be Concerned

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- Customer Unhappiness Eventually Leads to Regulation
 - » Human Safety Problems Accelerate the Process
- Quality Movements Now Enforce “Design Controls”
 - » ISO-9000
 - » FDA CGMP
- Safety Critical Software Will Be Next

Development Stress Creates Product Risks

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- Development Projects Are Subject to Numerous **Constraints**
 - » Cost
 - » Schedule
 - » Time-to-Market
 - » Technology Limitations
- **Unforeseen** Problems Compromise Product Quality
 - » Surprises Create Opportunities for Confusion
- Lack of **Visibility** on Impacts of Key Decisions Promote Disaster
 - » “It sounded like a good idea at the time...”

Bad Management Causes Problems

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- Many Projects Are **Behind** Schedule/Over Budget
 - » Management Dictated Cost/Schedules
 - » Lack of Planning
 - » Failing to Stay on Top of Projects
- Requirements **Creep** Is a Major Source of Project Problems
 - » Especially for Software
- Lack of Good Historical Project Cost**Metrics**

20th Century Engineering Process Problems

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-
- Most Project Management And Planning Methods Are **Activity Based**
 - » Difficult to Maintain in the Presence of Dynamic Changes
 - Most Product Design Tools Are **Bottom up** or Implementation Oriented
 - » Fail to Capture All Requirements
 - Natural Language Specification Methods Are **Ambiguous**
 - » Difficult to Capture Complex Product Behavior

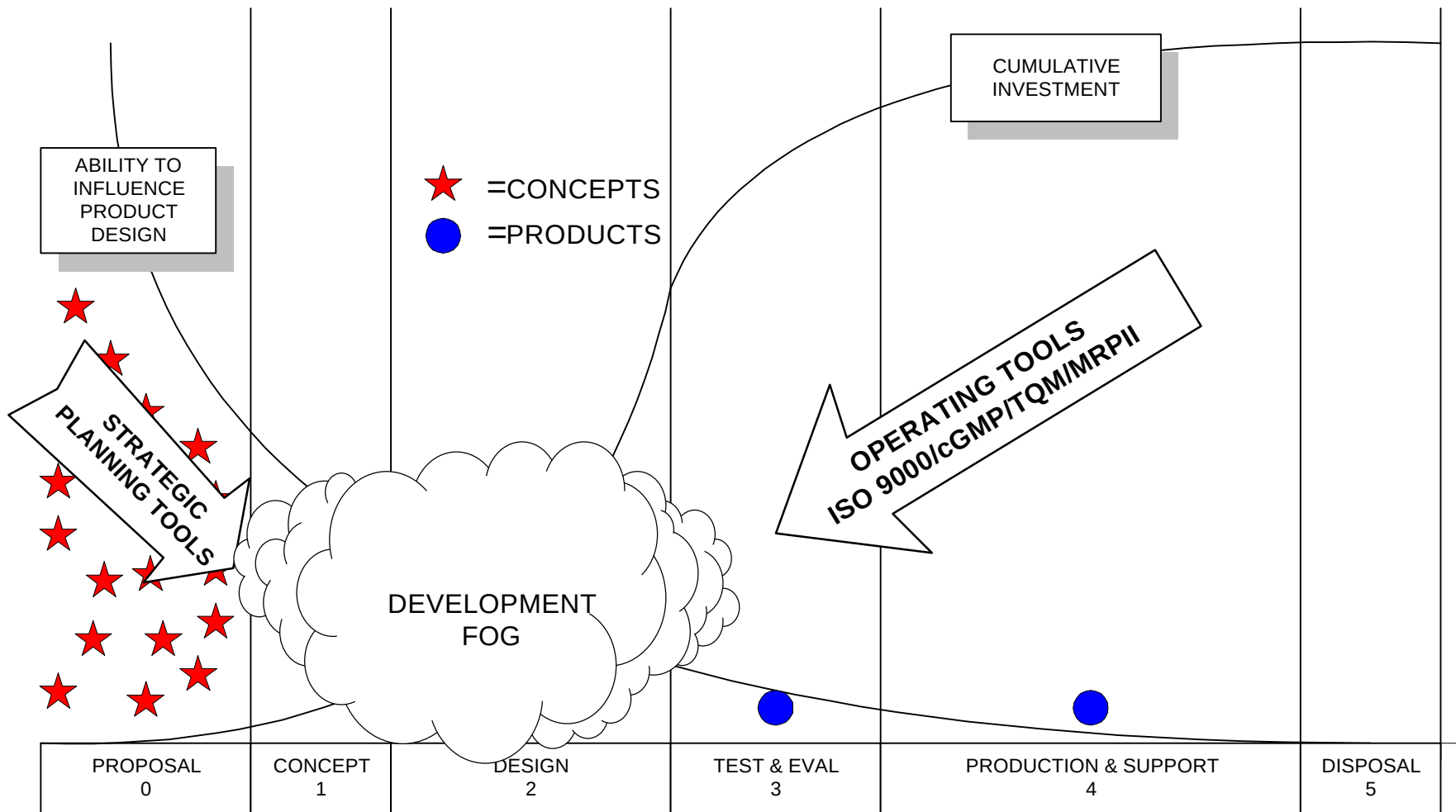
Why Development Continues to Become Harder

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- Lack of a “**Systems**” Approach to Product Development
- **Complexity** of Technology
- **Interdisciplinary** Products
- More **Competition**

The Development Life Cycle

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Why There is a Fog

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Everything Exists Only in the Heads of the Engineers!

- Early Phases Lack **Documentation** Everyone Can Understand
- High Levels of **Abstraction** Are Difficult for Many People to Grasp
- Lack of Clear **Plans** Make Coordination Difficult

Accelerated Product Development sm System

INTRODUCTION
TO
A SYSTEMS APPROACH

Definitions

- Science
 - » The Ability to Create **Mathematical Models** of Natural Behavior
- Mathematics
 - » The **Language** of Science
- Engineering
 - » The Ability to **Apply** Science and Mathematics to Solve Problems
 - » Ability to **Model** Designs
 - » Prove It Will Work **Before** It Is Made
- Design
 - » The **Creative** Process Which Defines a Man Made Device
 - » Does Not Necessarily Require **Engineering** Skills

Engineering Definitions

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- Product Architecture
 - » The Process That Leads to the Creation of Documentation Necessary to Define the Product Function, Behavior and Performance**Requirements**
- Design Engineering
 - » The Process That Leads to the Creation of Documentation Necessary to Define How the Product **IsMade**

What Do Engineers Do?

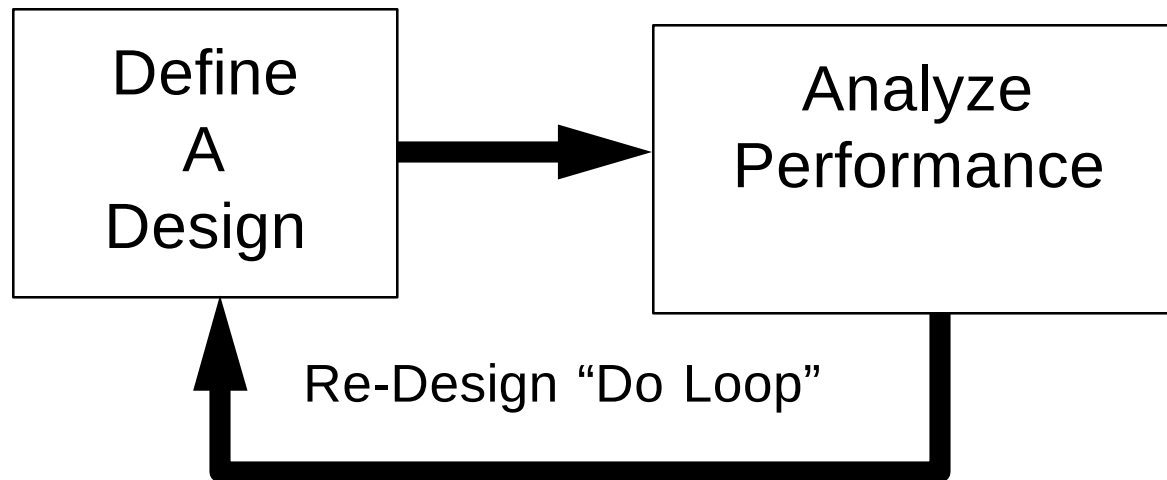
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- **Use** Science and Mathematics to Solve Problems
- Make **Paper** for Someone **Else** to Use

The Way Engineers Are Taught to Think

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Bottom Up Approach



This Approach Is Also Used
by Many Inventors

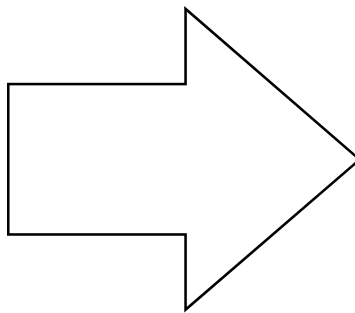
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Inventors Syndrome

Define a Solution



Look for a Problem



The Top Down Approach

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- Necessity Is the Mother of Invention
- Find a Need and Fill It
- “Never Invent Something Unless You Have a Customer Ready to Buy It”
 - » T.A. Edison
- The Architect Model

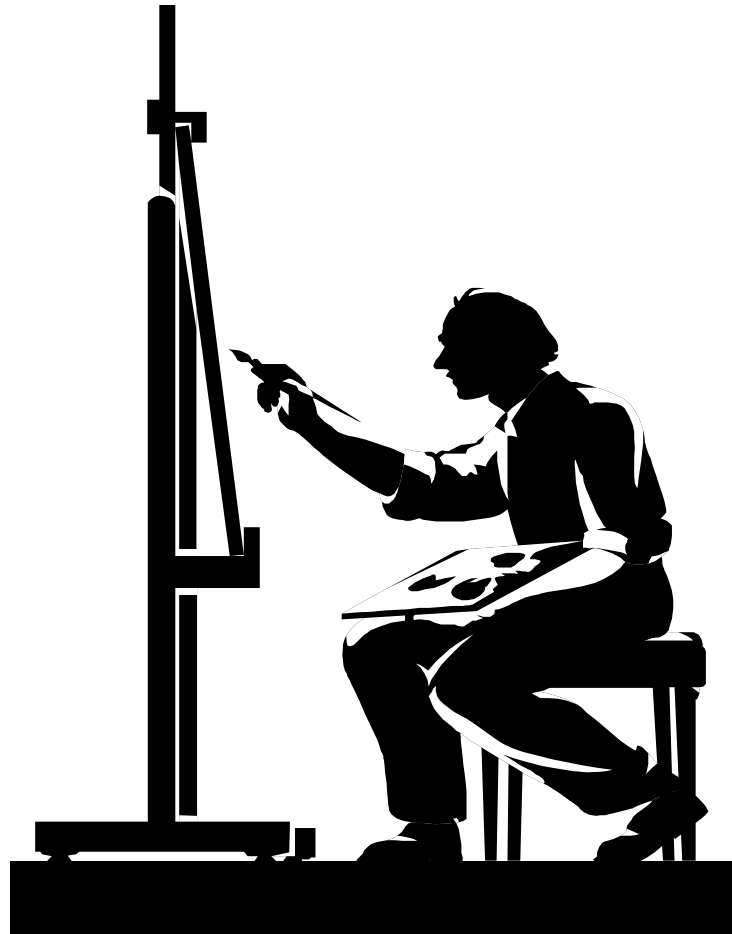
Architects See The Big Picture at the User Level

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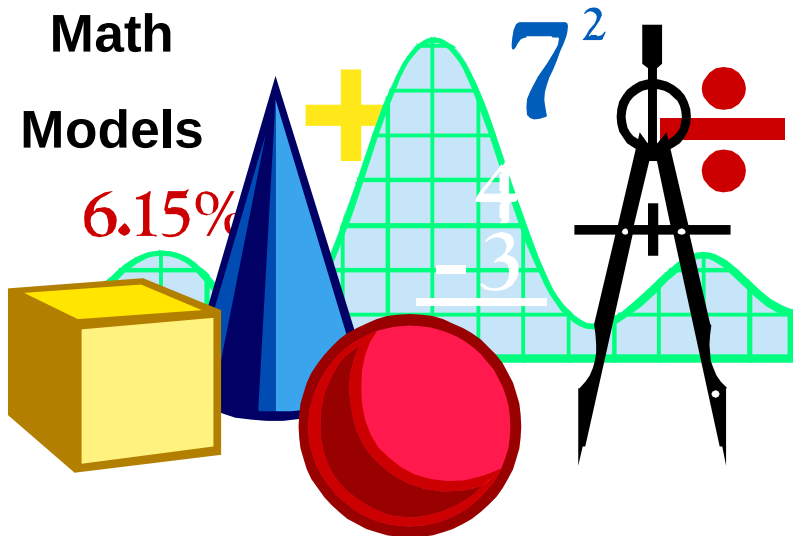
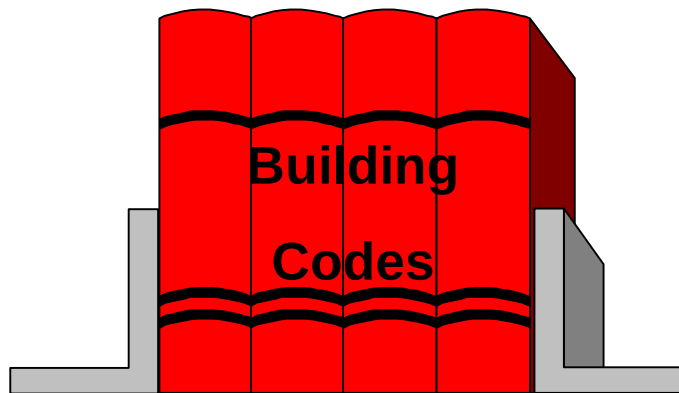
Architect Creates Overall Design Concepts

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Engineers Make It Work

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**Engineering
Calculations**

Architect Shares Plans With Everyone

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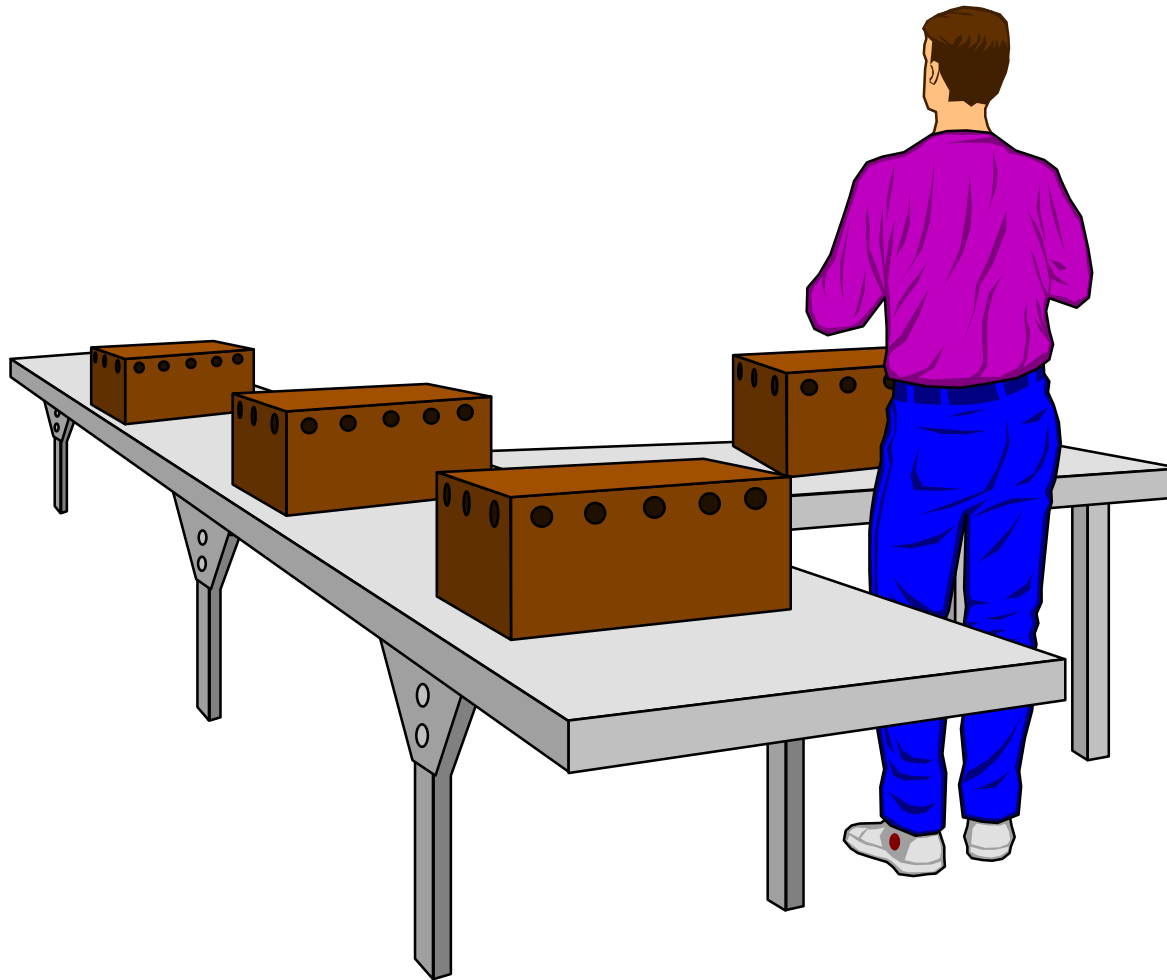
General Contractor Plans And Directs The Job

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Specialists Implement The Design

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Inspectors Check Everything Against The Codes

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The
Result

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A Model for a Solution

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- Architect (Product Architect)
 - » Integrates Function, Esthetics, Performance
- Engineers (Product Analyst)
 - » Designs Structures to Meet Codes
- **A Single Set of Plans Can Be Read by Everyone**
- General Contractor (Project Manager)
 - » Plans and Executes Job
- Specialists (Design Engineers) Build/Install Components
- Inspectors (Test Engineers) Check Each Step Against Codes

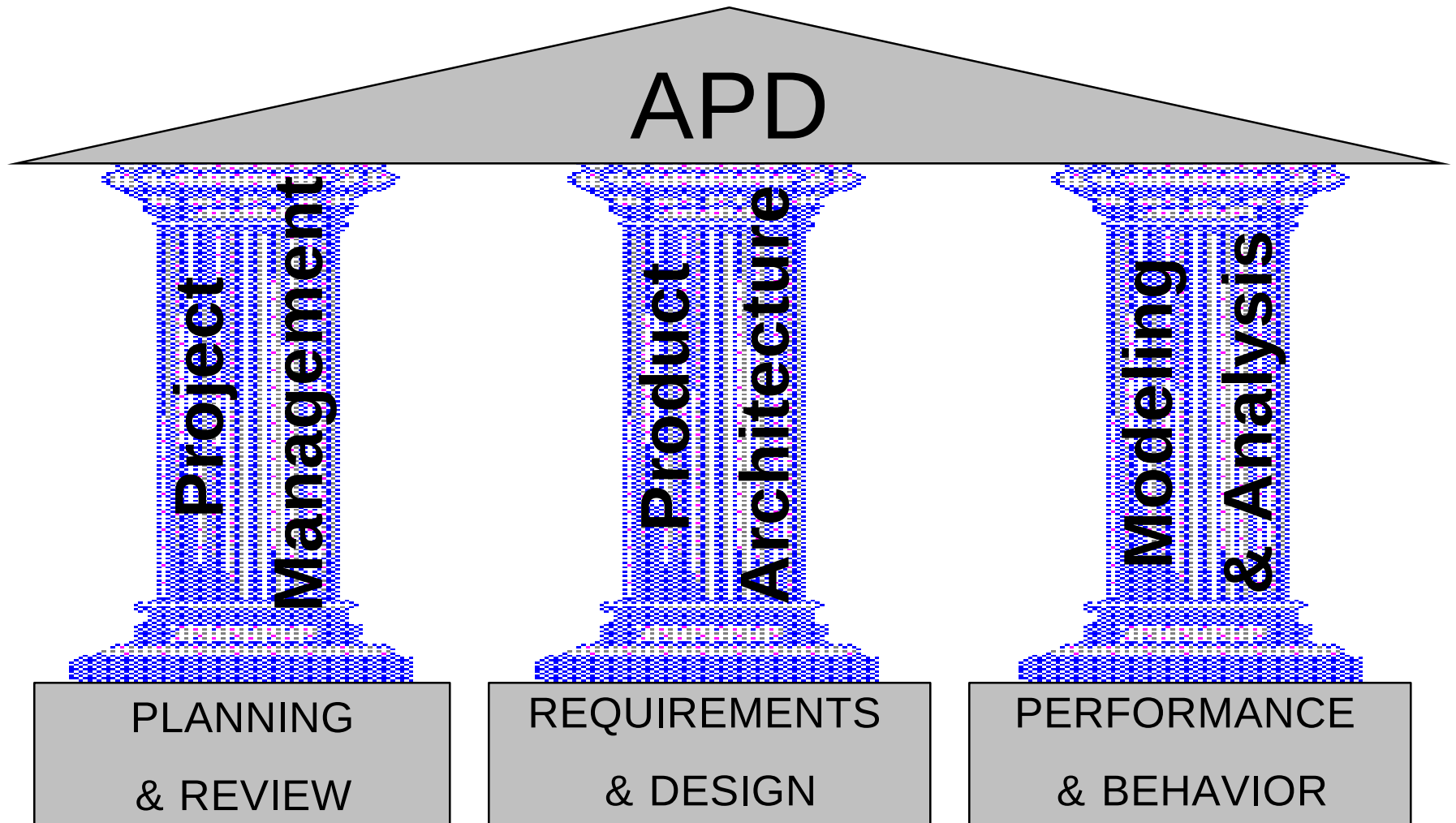
Marketing Interface

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- The Architect Model Works Well If There Is a **Customer** to Talk to
 - » Contract Development Work
- Private Venture Development Work Requires a **Surrogate Customer**
 - » Provided by a Joint Effort With Marketing
- Must Define Customer **Characteristics**
 - » Demographics
 - » User Requirements
 - » Customer ROI

APDsm System
is Founded on 3 Pillars

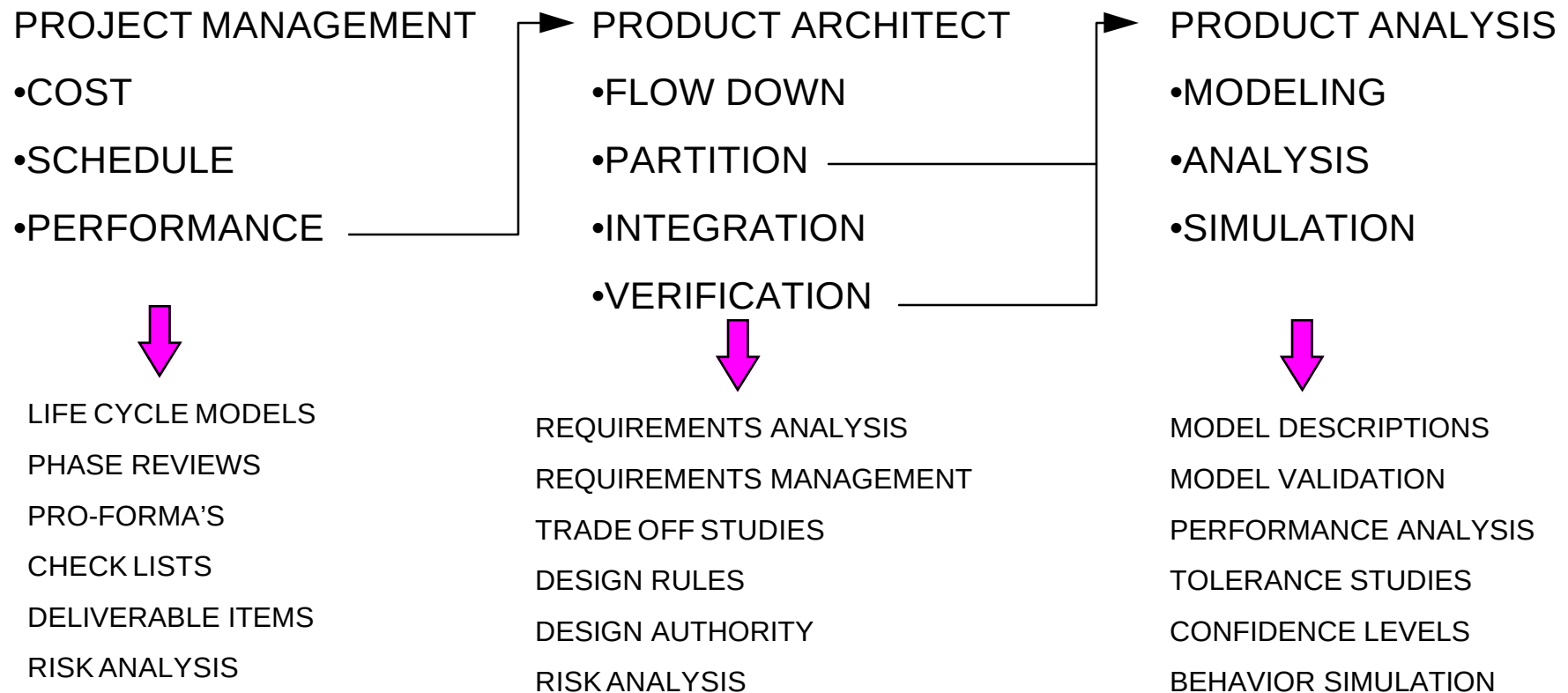
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Introduction to the Systems Approach

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PRODUCT DEVELOPMENT MANAGEMENT



Management Visibility and Control

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- Provides Management with Better **Visibility and Control**
- Life Cycle Planning Templates for **Rapid** Planning and Estimating
- Integrates All **Organizations** Into the Development Process
- **Reduces** Items That “Fall Through The Cracks”
- Measures Percentage **Completion** Not Just Costs
- Early Visibility on **Risks and Tradeoff's**
- Promotes **Faster** Decision Making
- Simple but **Effective** Documentation and Review Methods
- Facilitates Development Team **Communications**
- **Improves** the Managerial Process

Product Architecture

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- Requires a **Life Cycle View** of the Product
- Makes **Visible** Product Function, Behavior and Performance
- Promotes **Alternatives** and Enhances Creativity
- Gets the Design **Right** the First Time
- Reduces Design **Iterations**
- **Shortens** Design and Testing Time
- Allows **Parallel** Development Processes
- **Reduces** Quantity and Skill Levels During Implementation Phases
- Forces **Integration** of Marketing and Engineering Functions

Modeling and Analysis

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- **Validates** Requirements
- Proves Product Will **Work** Before It Is Made
- **Reduces** Test and Evaluation Time and Cost
- Verifies Production Design **Margins**
- Verifies and Validates Designs Outside the **Testable Envelope**
- Reduces Time to **Solve** Production and Quality Problems

How Products Requirements Can Be Modeled

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- Function
 - » What It **Does**
- Behavior
 - » **How** It Does It
- Performance
 - » How **Well** It Achieves Function and Behavior

How Products Can Be Decomposed

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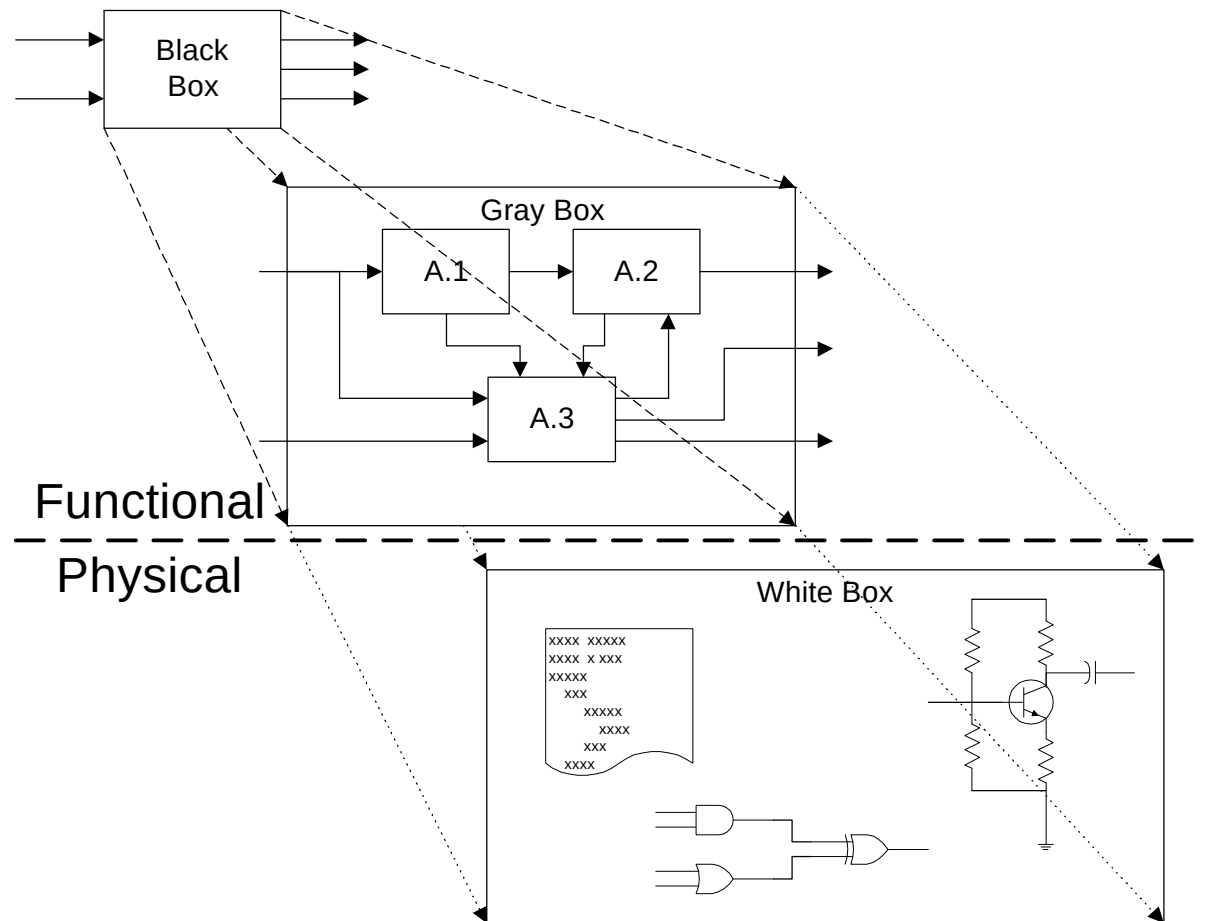
- Black Box
 - » Internal Workings Are **Unknown**
 - » Must Be **Modeled** by External Properties

- Gray Box
 - » Function, Behavior and Performance Can Be **Specified**
 - » **Physical** Implementation May Be Unknown

- White Box
 - » Physical Design Is **Known**
 - » Multiple Functions May Be Implemented by **Same** Physical Objects

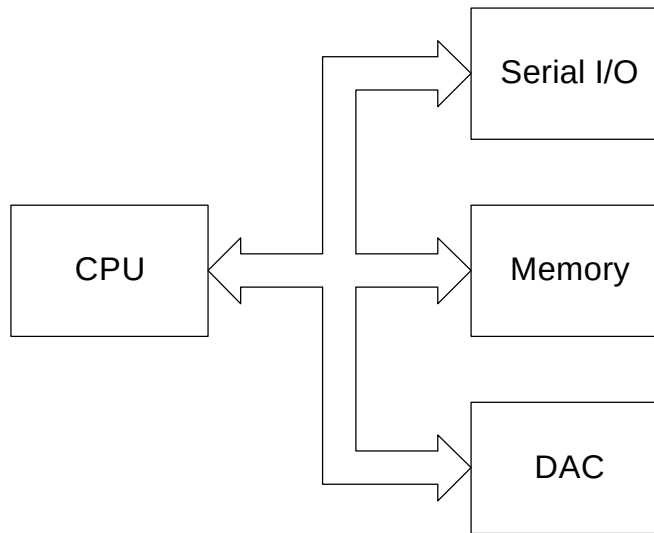
Levels of Abstraction

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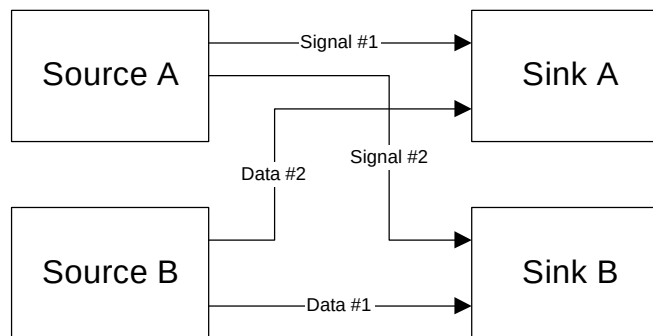
Functional Vs. Physical

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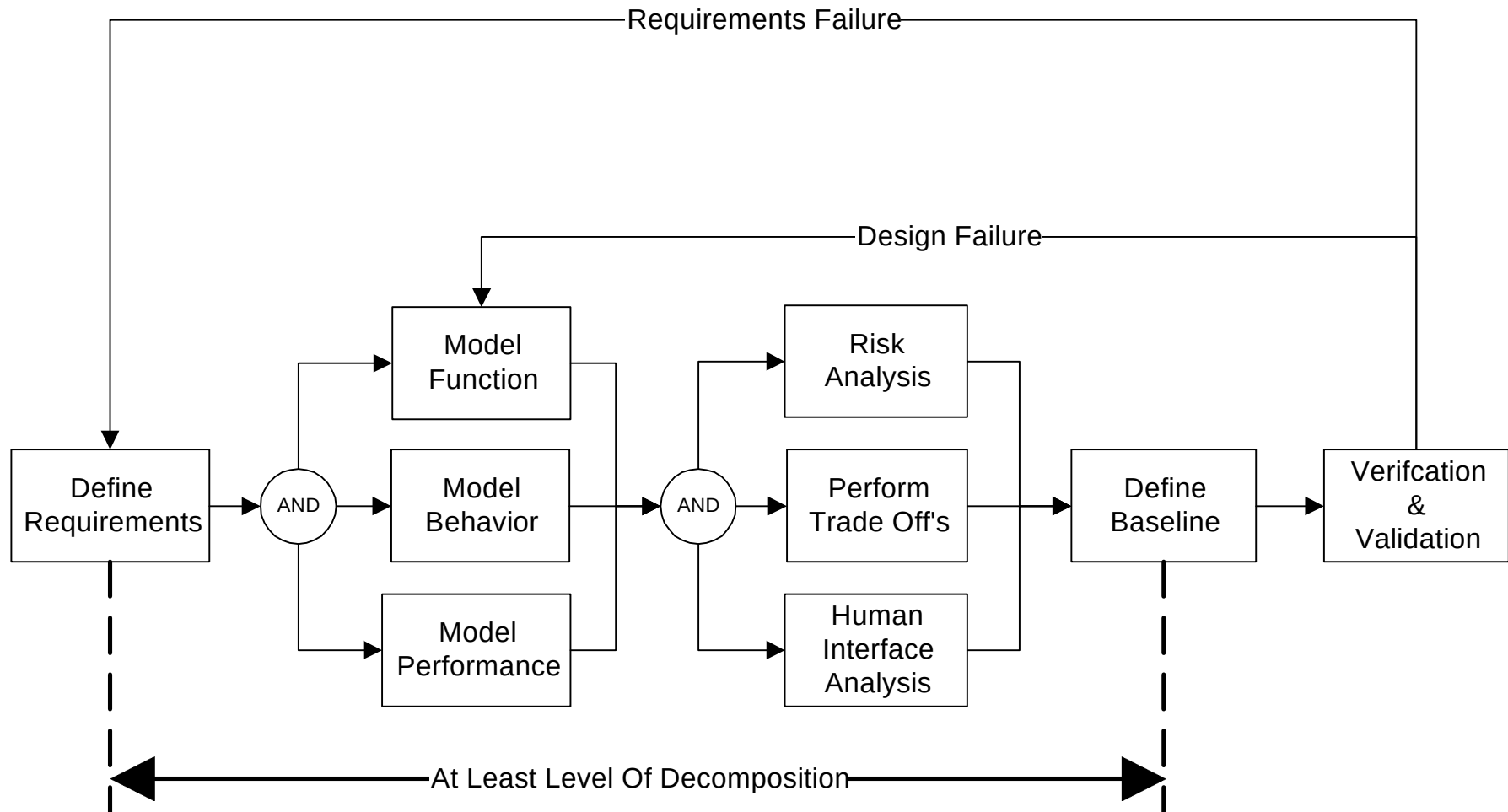
Physical

Functional

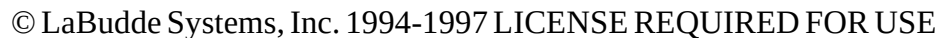


Core Engineering Process

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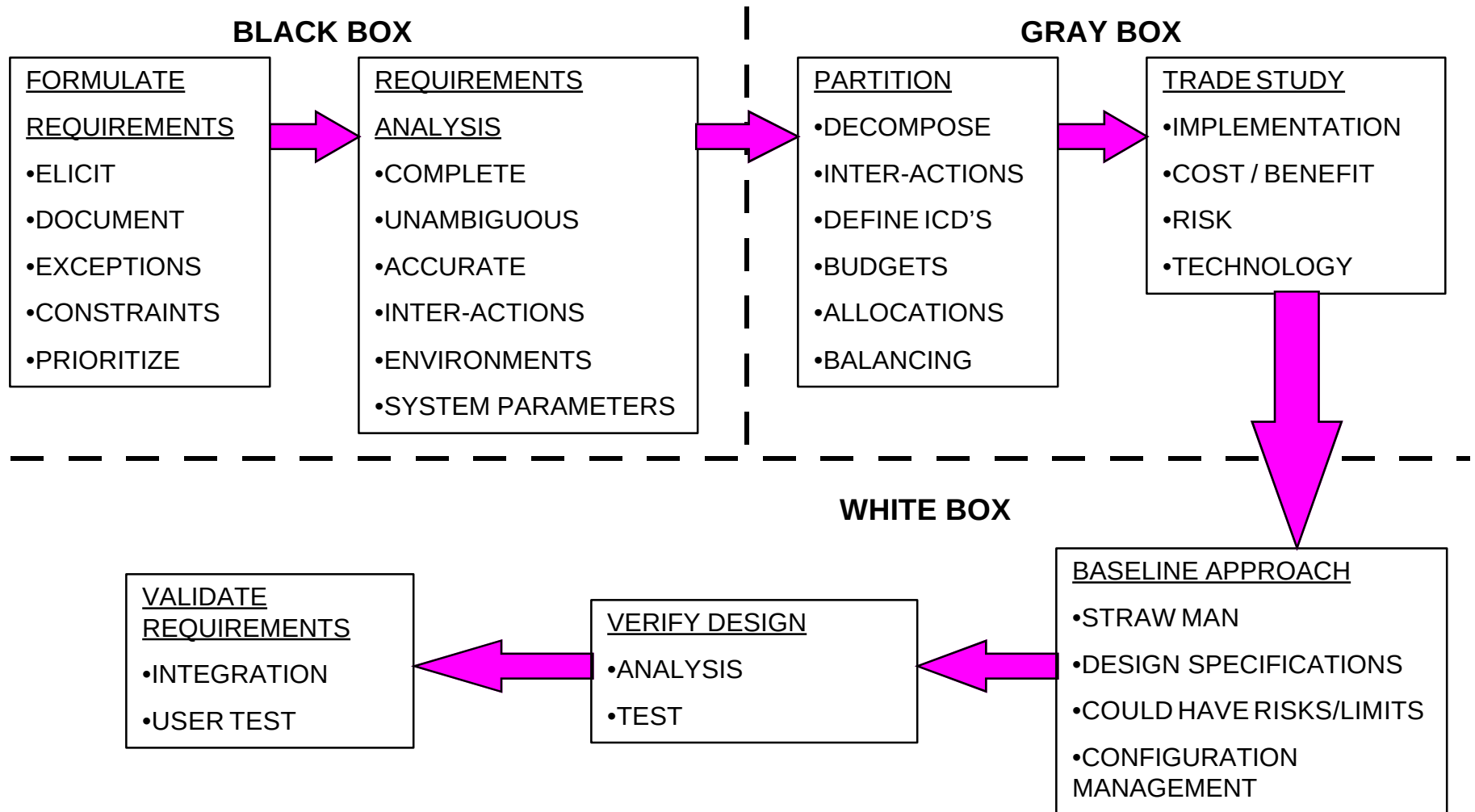


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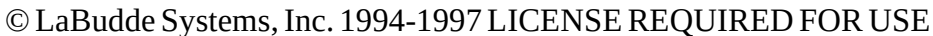


21st Century Product Design Process

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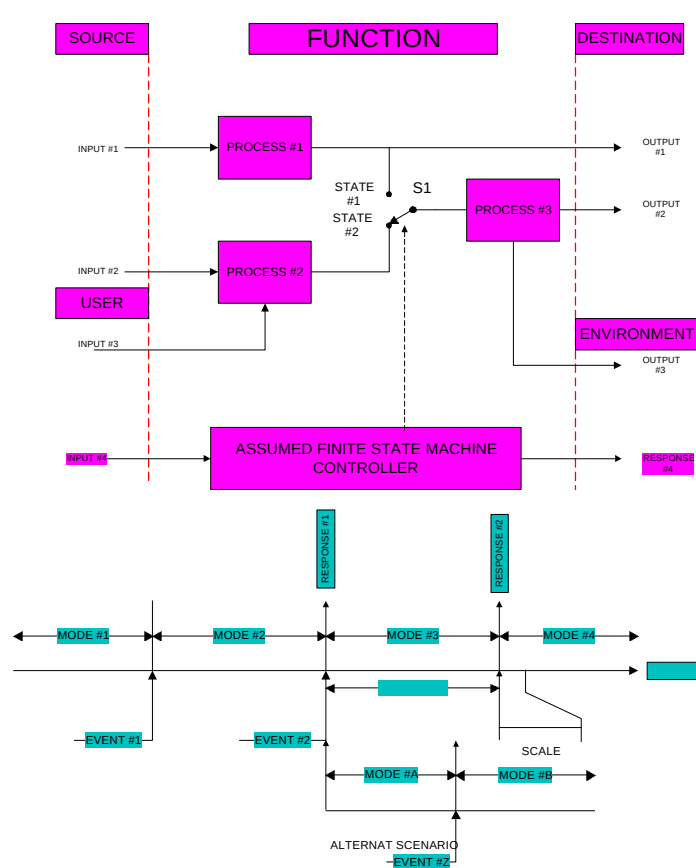


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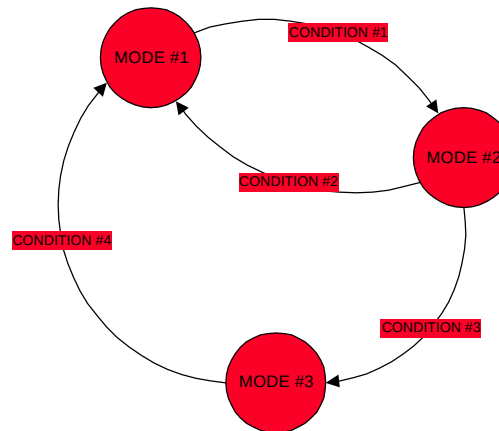


Graphical Description Language *

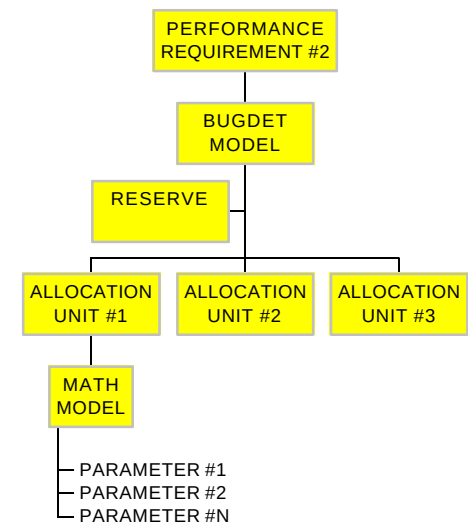
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MODE	OUTPUTS		
	OUTPUT #1	OUTPUT #2	OUTPUT #3
MODE #1	OFF	OPERATE	FAIL
MODE #2	TEST	OFF	OPEN
MODE #3	NORMAL	OPERATE	CLOSE
MODE #4	BYPASS	LATCHED	OPEN



PERFORMANCE TREES



* TM LaBuddle Systems, Inc. *Graphical Description Language: A Solution to the System-Software Interface Problem.* INCOSE 1996

The Benefits

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- **Reduced Risk**
 - » Know It Will Work Before It's Built
 - » Find and Solve Problems on Paper
 - Not in the Lab, Factory Floor, or the Field
- **High Quality Products**
 - » Meets All the Requirements
 - » Fewer Design Flaws
 - » Easier to Produce
 - » Easier to Maintain
- **Better **Competitive** Position**
 - » Time-to-Market
 - » Product Cost
 - » Product Performance

The Experiment

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- At Least **One** Group of Volunteers Are Needed for the CPS 479 Lab Project
- Need to **Fill** the 3 Roles
 - » Project Manager
 - » Product Architect
 - » System Analysts
- Will Be **Trained** in the “Systems” Approach
- Will Use the Approach to **Conduct** the Project
- **Metrics** on Performance Will Be Collected
 - » Visibility
 - » Rework
 - » Quality

Qualities of a Good Project Manager

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- Highly **Goal** Oriented
 - » A Finisher
 - » Expediter
 - » Follow Up
- Good **People** Skills
 - » Negotiator
 - » Empathy
 - » Motivates
 - » Good Communicator
- Well **Organized**
 - » Attention to Details
 - » Foresight

Qualities of a Good Product Architect

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- Broad and **Deep** at the Same Time
 - » Sees the Big Picture
 - » Likes the Details Too
- Good **Technical** Skills
 - » Has Excellent Creative Skills
 - » Mastered at Least Two Disciplines
 - » Understands High Levels of Abstractions
 - » A Good Communicator
- **User** Oriented
 - » Life cycle Oriented
 - » Understands the Application
 - » Focus on the Right Product
 - » Can Take Objective Feedback

Qualities of a Good Product Analyst

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- Strong **Analytical** Orientation
 - » Need for Quantitative Understanding
 - » Uses Analysis to Find and Solve Problems
- Good **Mathematical** Skills
 - » Has Excellent Analytical Skills
 - » Mastered All Engineering Analysis Methods
 - » Uses Automation Tools
- Focused on Getting **Results**
 - » When Good Enough Is Good Enough
 - » A Good Communicator