Test Case Module

Field	Type	Req'd?	Inherit	Description
Object_ID	Index	Auto	N/A	Prefix w/number assigned by DOORS
Test_Name	Text	Yes	No	Shorthand nomenclature for test case
Document	Test	Yes	Inherited	(From Suite)
Reference	Text	Yes	No	Paragraph reference within the governing document
Cookbook	Text	Yes	No	Specific procedural reference to cookbook paragraphs
Result_DVT	Enum/1	No	No	Value= Pass, Conditional Pass, Fail, N/A
Value_DVT	Text	No	No	Values, with units, of measured test results
Issue_DVT	Test	No	No	Description of conditional pass results or issues encountered in test conduct
Result_EVT	Enum/1	No	No	Value= Pass, Conditional Pass, Fail, N/A
Value_EVT	Text	No	No	Values, with units, of measured test results
Issue_EVT	Test	No	No	Description of conditional pass results or issues encountered in test conduct

Commercial Systems Engineering Process

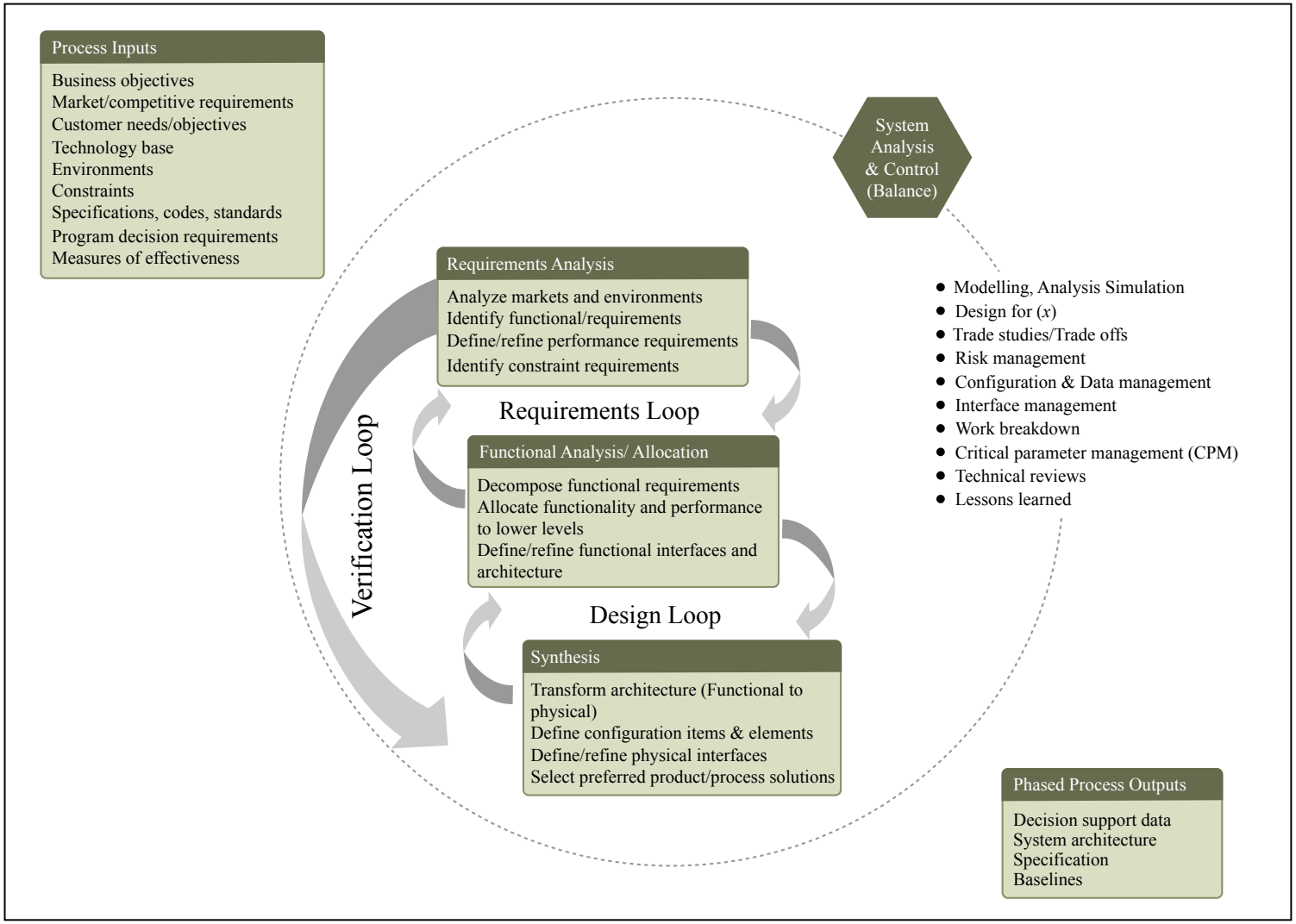
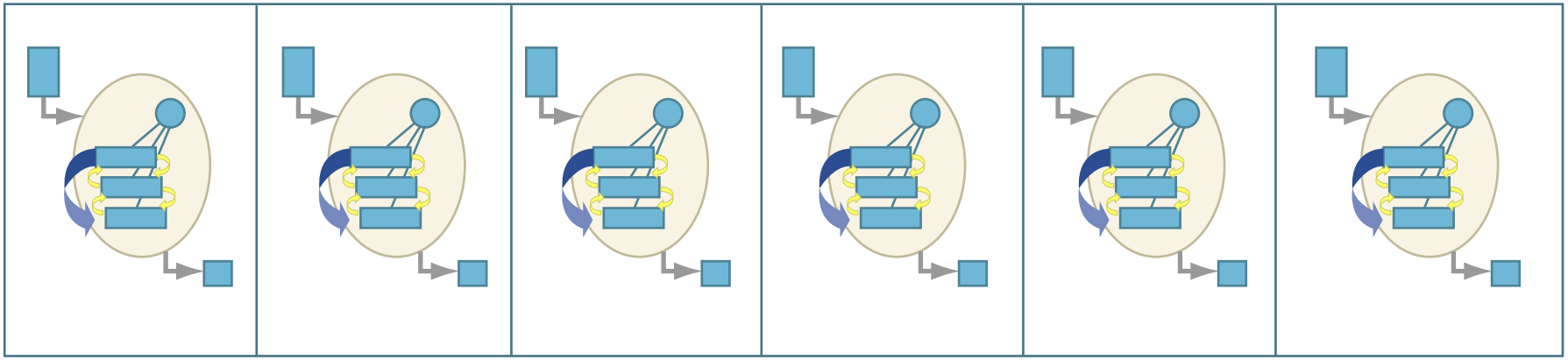


Image by MIT OpenCourseWare.

Systems Engineering cycles iterated in each development phase

Product Commercialization Phases 1-6:

Concept	Design	Optimize Subsystems	Optimize System	Verify Product Design	Verify Production Process



Iterations of the systems engineering process....

Key areas for impact

Requirements Analysis
Analyze Markets and Environments
Identify Functional Requirements
Define / Refine Performance and Design Constraint Requirements

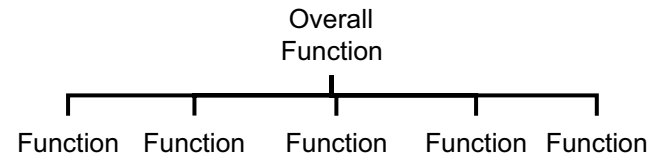
- Requirements come from many stakeholder classes
- Upstream processes feed in business requirements
- As important as needs are constraints
- Don't forget 'non-functional' requirements
- QFD is a proven method to translate needs to requirements

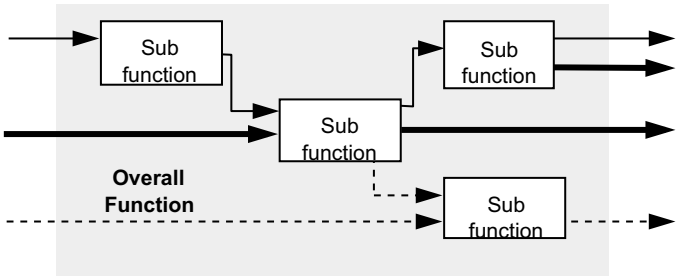
QFD Quick Review & Functional Modeling

Customer-Focused Design

Map customer needs to functional descriptions

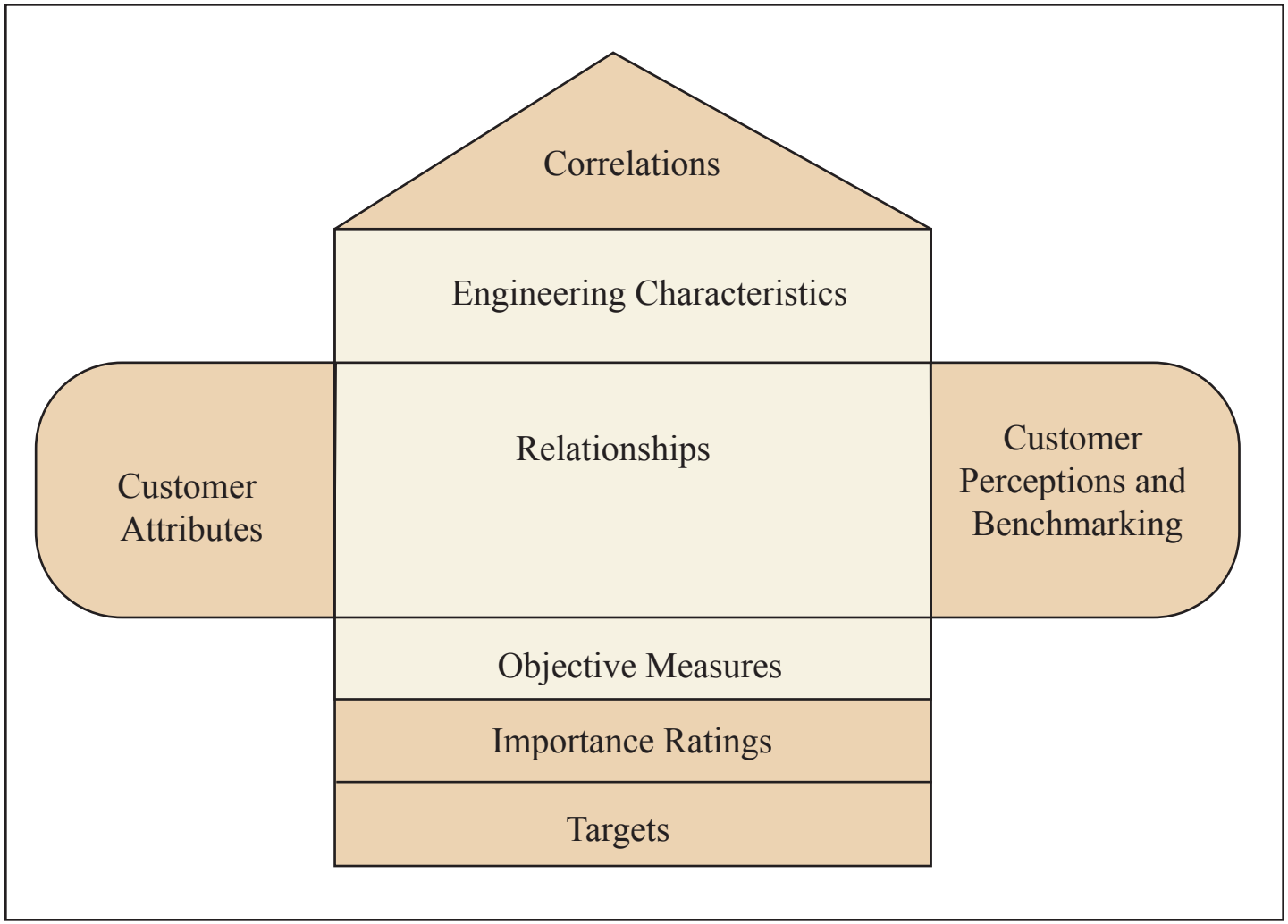
- Focus on “what” needs to be achieved not “how”
- Helps to organize teams, tasks and processes
- Enhances creativity by decomposing problems





- Function or function sets derived from customer needs defines subsystems that minimize the number of internal interfaces (system engineering)
- Interface specifications and protocols definition can begin prior to form design

“Rooms” in the House of Quality



Example Relationship Matrix

- ✓ Indicates a strong positive relationship
- ✓ Indicates a medium positive relationship
- X Indicates a strong negative relationship
- X Indicates a medium negative relationship

Note the objective measures of ECs

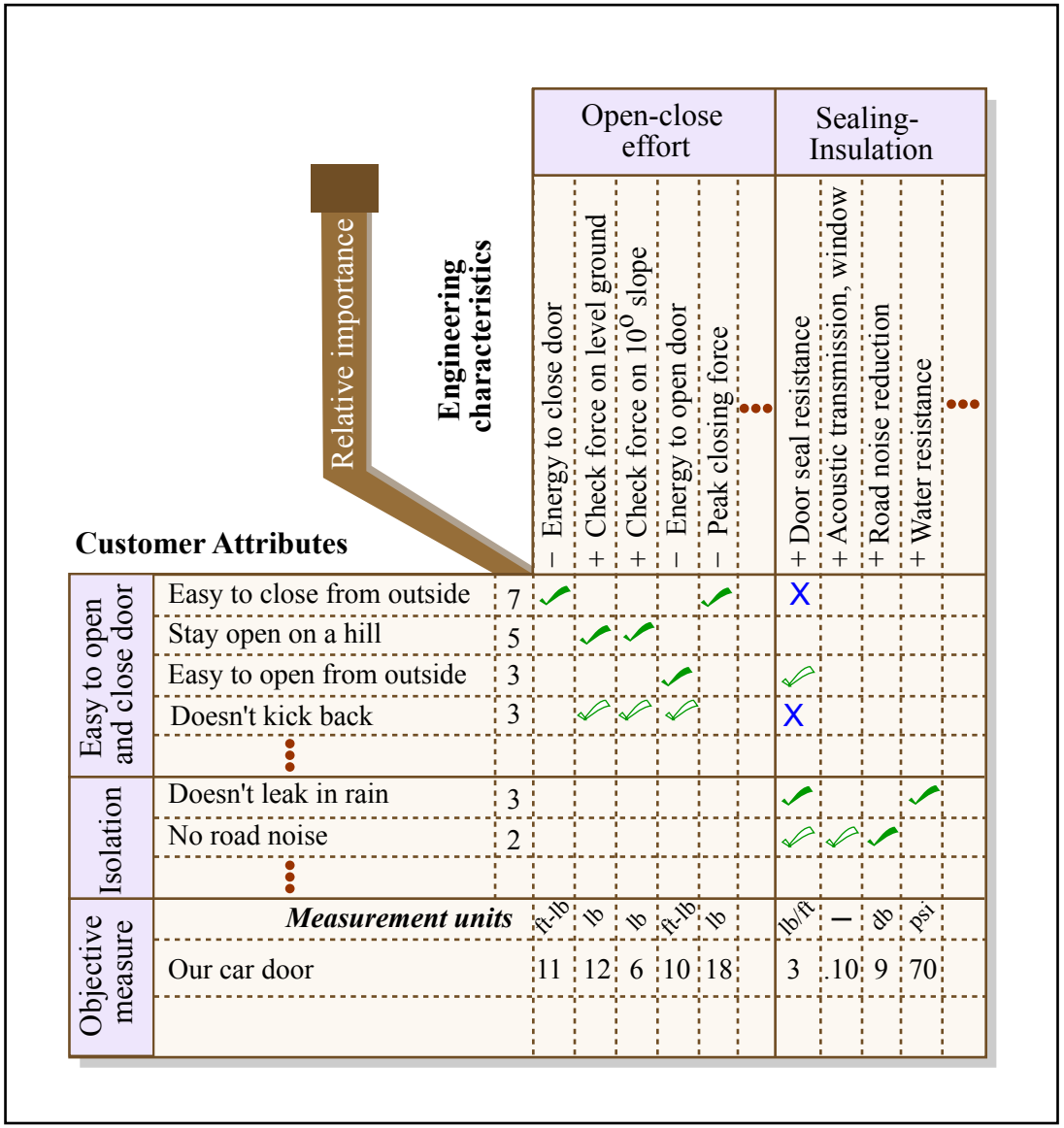
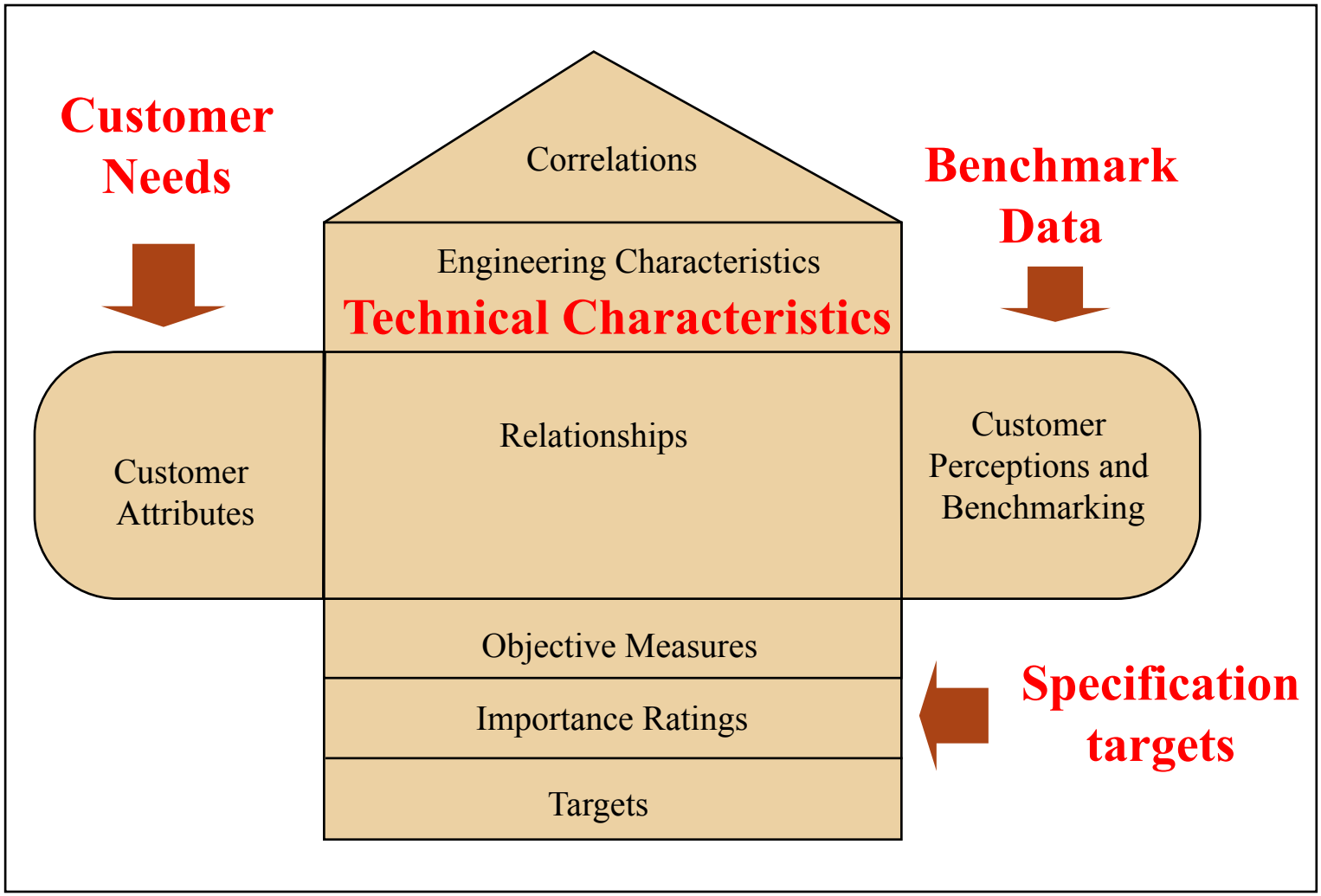


Image by MIT OpenCourseWare.

After Hauser & Clausing, 1988

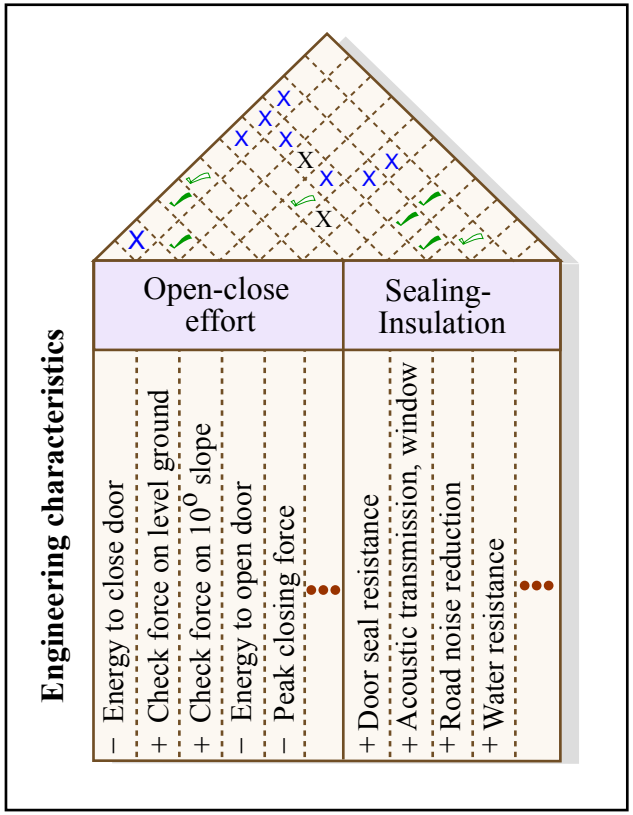
QFD Context



(Figure from Lou Cohen)

The Roof of the House

- ✓ Indicates a positive relationship
- X Indicates a negative relationship
- Is the roof matrix a function of the relationships matrix?
- Is it an Axiomatic Design matrix?
- Is it a Design Structure Matrix?



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“Rooms” in the House of Quality

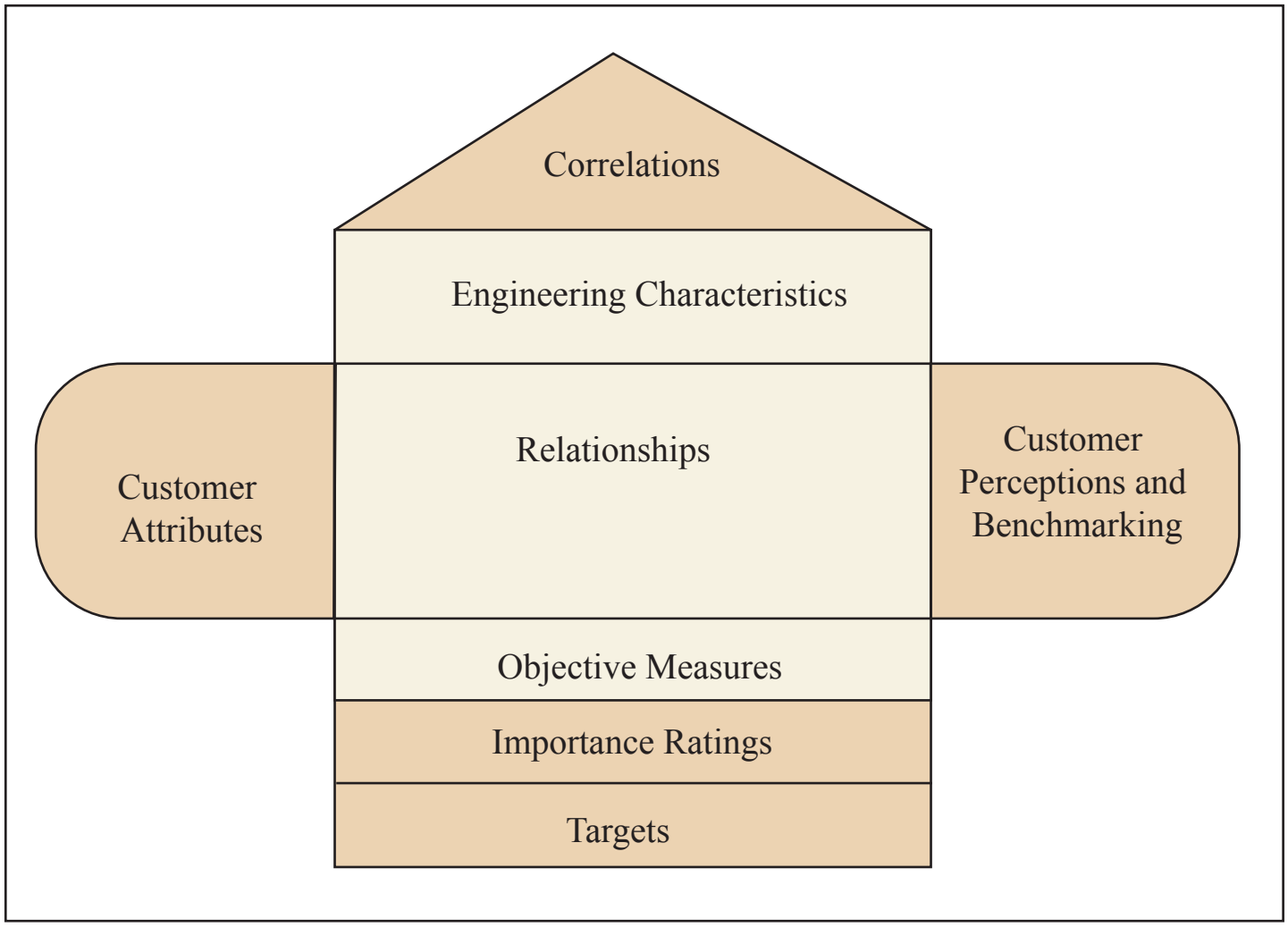
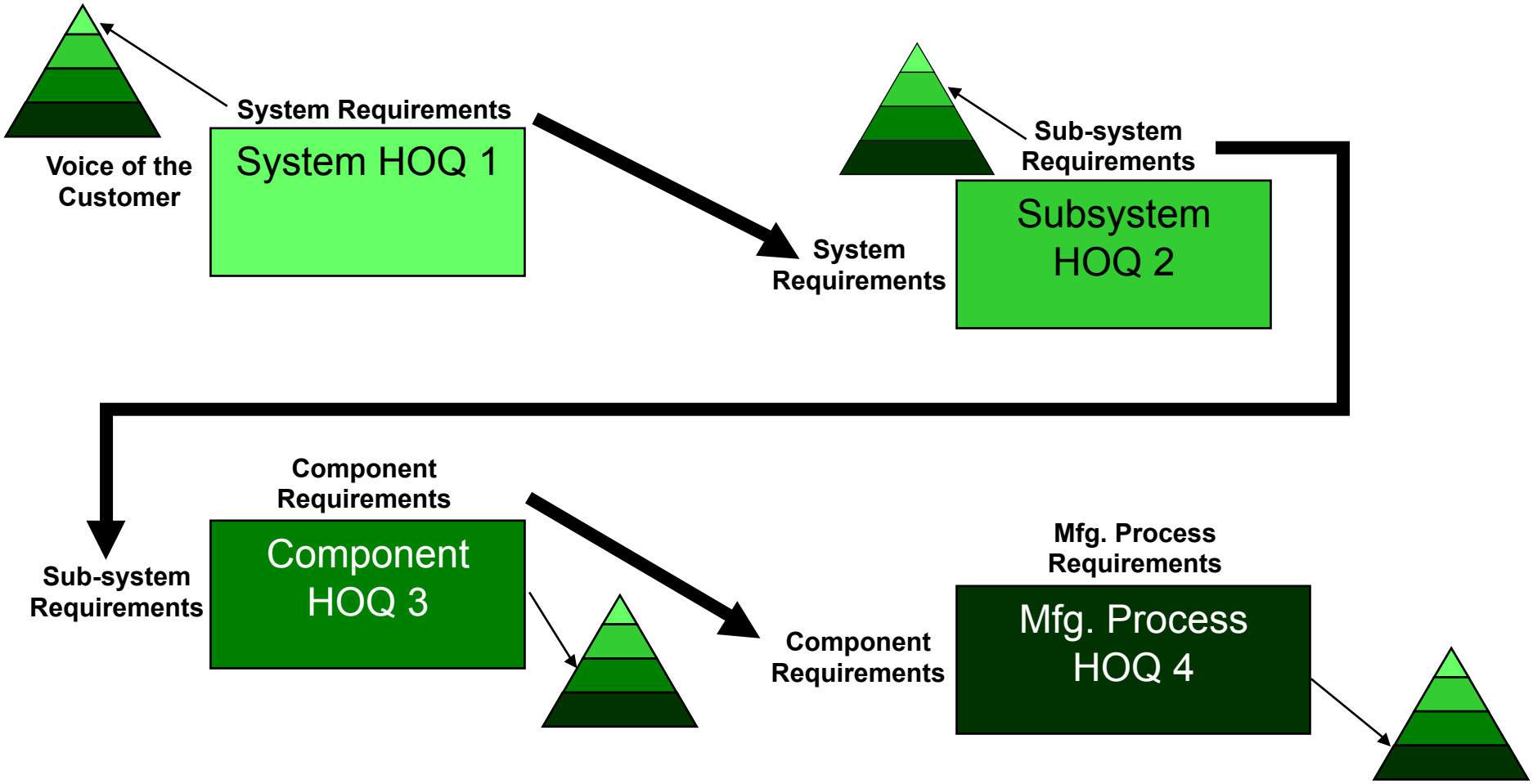


Figure from Lou Cohen.

Flow Down Requirements from the System House of Quality



What is the QFD for?

QFD is for

- Coordinating skills within an organization
  - Serves as a lingua franca
  - Helps break down the functional silos
  - Encourages real teamwork
- Designing goods that customers want to purchase
  - Creates external focus
  - Provides immersion in the specifications
- Target setting for mature products

QFD is NOT for

- Automatic decision making
  - "the house absolves no one of the responsibility of making tough decisions"
- Implementing a quick fix
  - "None of this is simple…"
  - "An elegant idea ultimately decays into process…"
  - "What is also not simple is creating an organization capable of absorbing elegant ideas"
- More difficult to use for highly novel / unprecedented functions

Hauser and Clausing, 1988, "The House of Quality", *Harvard Business Review*

Functional & Analytical Modeling

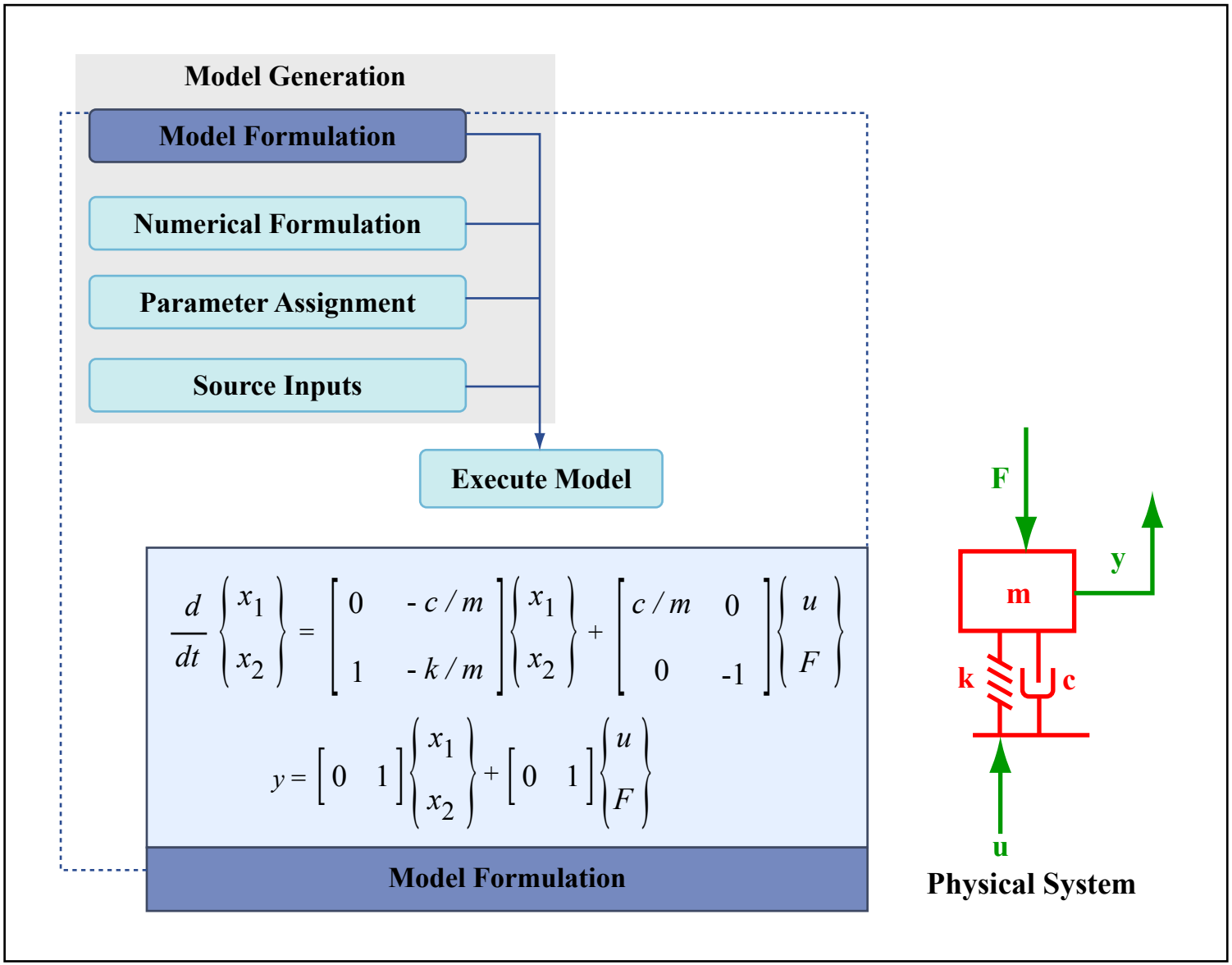


Image by MIT OpenCourseWare.

Functions

Functions should be expressed in terms of measurable effects

Typical function expression: **active verb – noun**

"increase pressure"
"transfer torque"
"store energy"
"cool liquid"

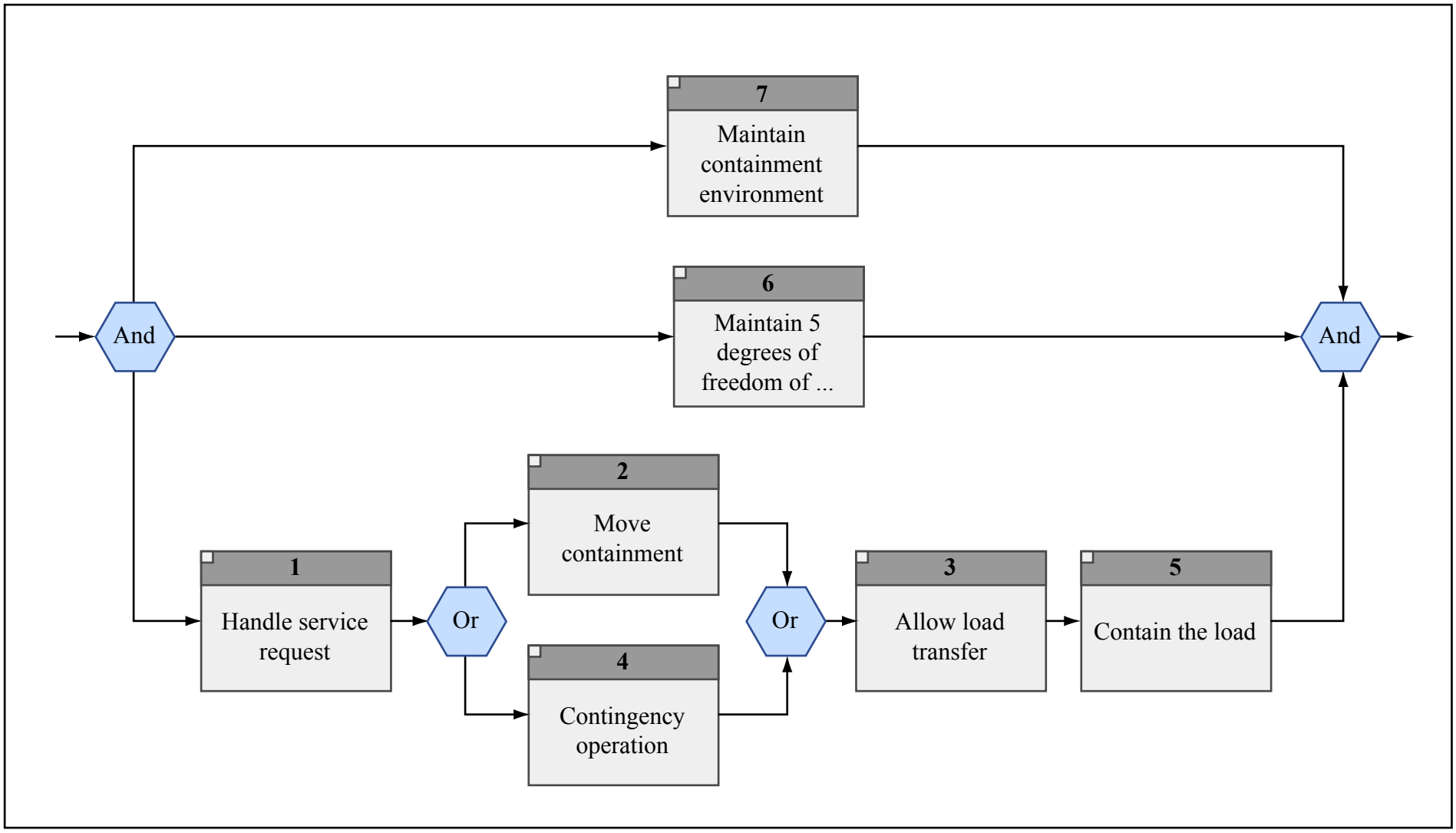
Function Modeling Basics

Product Function – What the product does. A statement of the relationship between available input and desired output, independent of any particular form. (Overall Function)

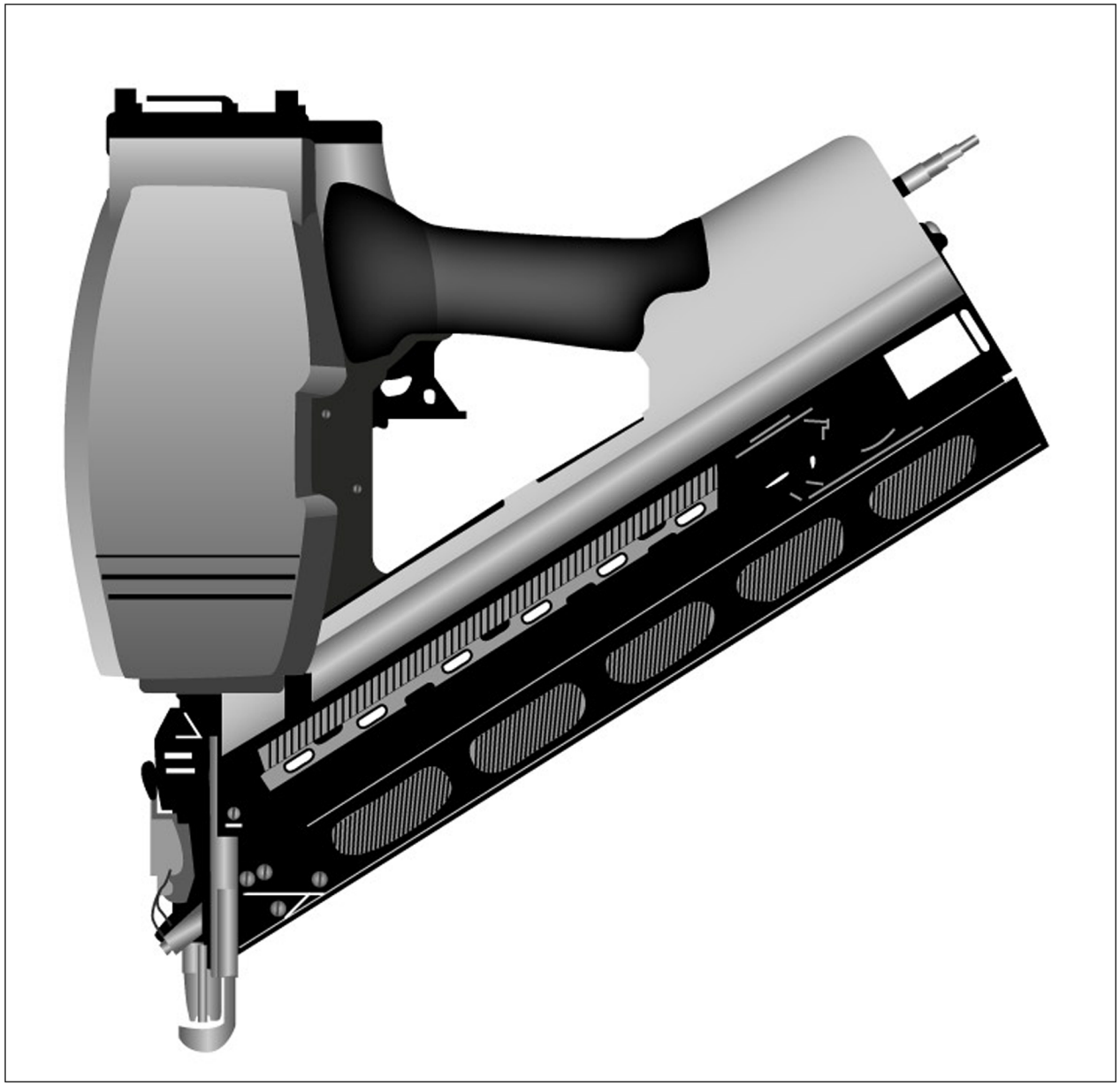
Make prints Tell time Water Turf Generate BHP Stop Vehicle

Chop Beans	Transport People	Accept Human

NORMAL RUN SCENARIO



Functional Modeling Example: Power Nailer



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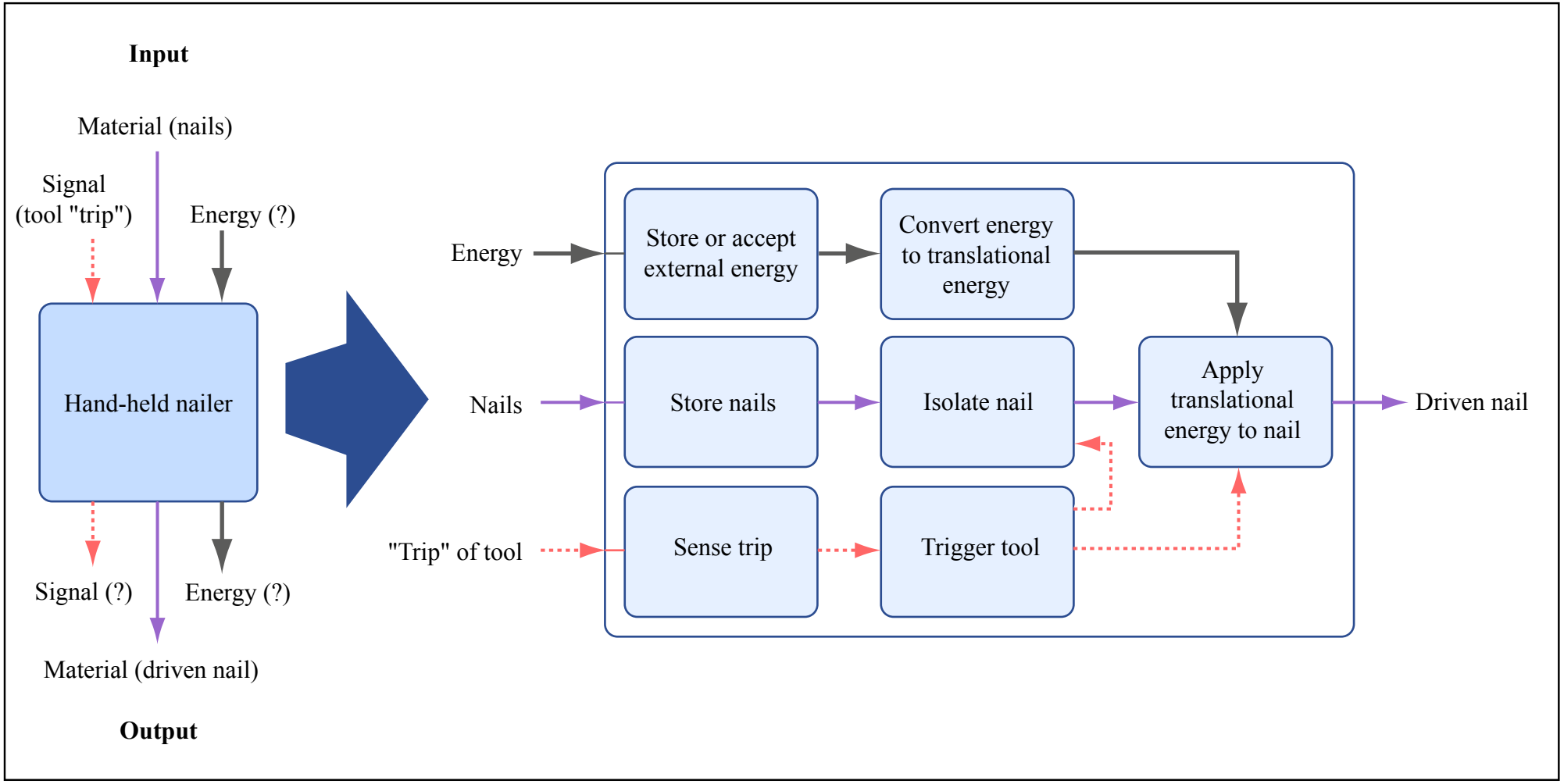
Problem Decomposition:
Function Diagram



Functional Modeling for CPM uses Conservative Law Based Metrics…

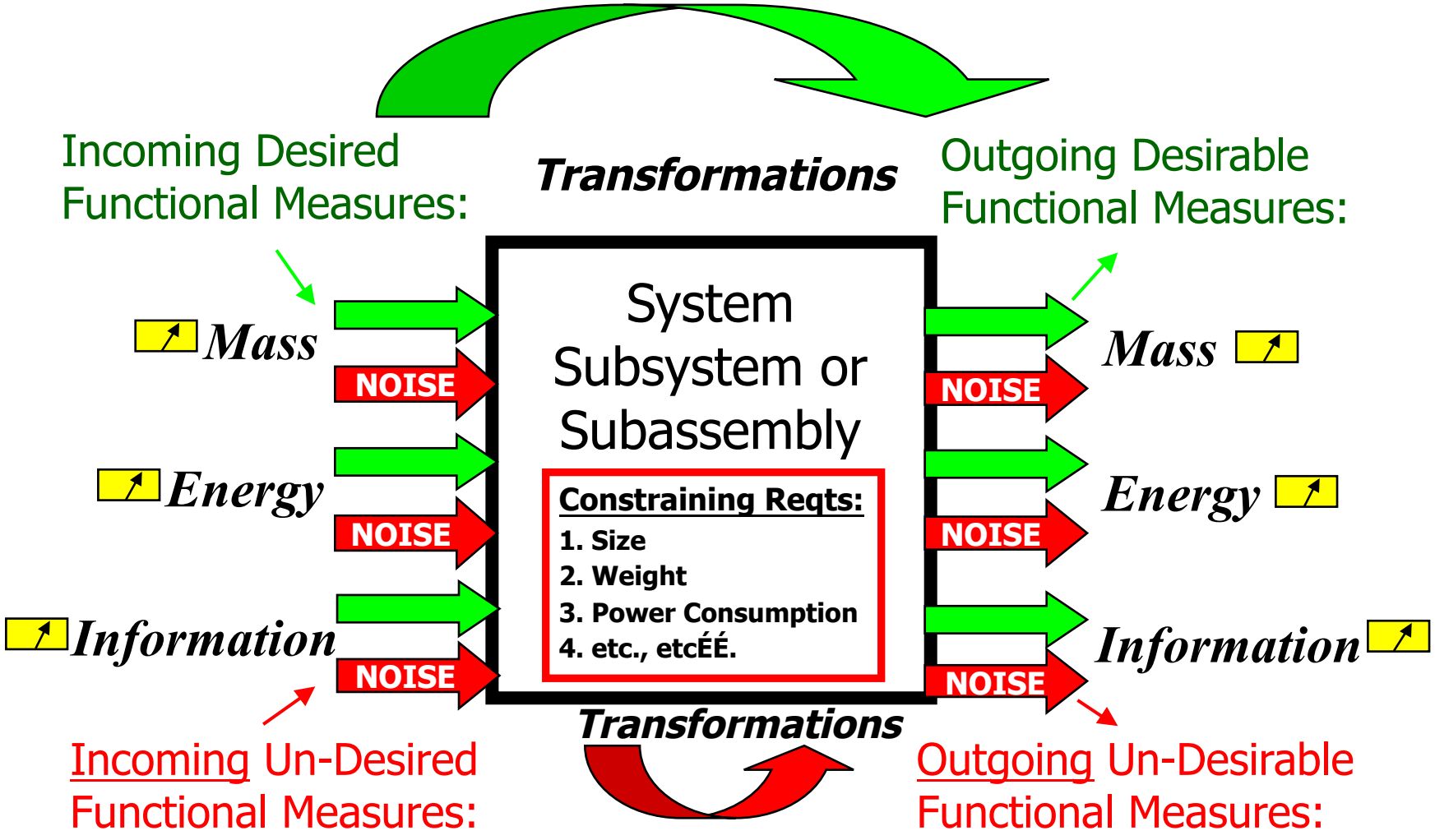
- **Energy:** …measure the flow, transformation & state of energy (mechanical, magnetic, electrical, chemical, thermal, fluidic…)

- **Mass:** …measure the dynamic or static state of the flow & transformation of mass (material deflection, elongation, volumetric or mass flow rates, liquid-to-gas, solid-to-liquid & solid-to-gas transformations…)

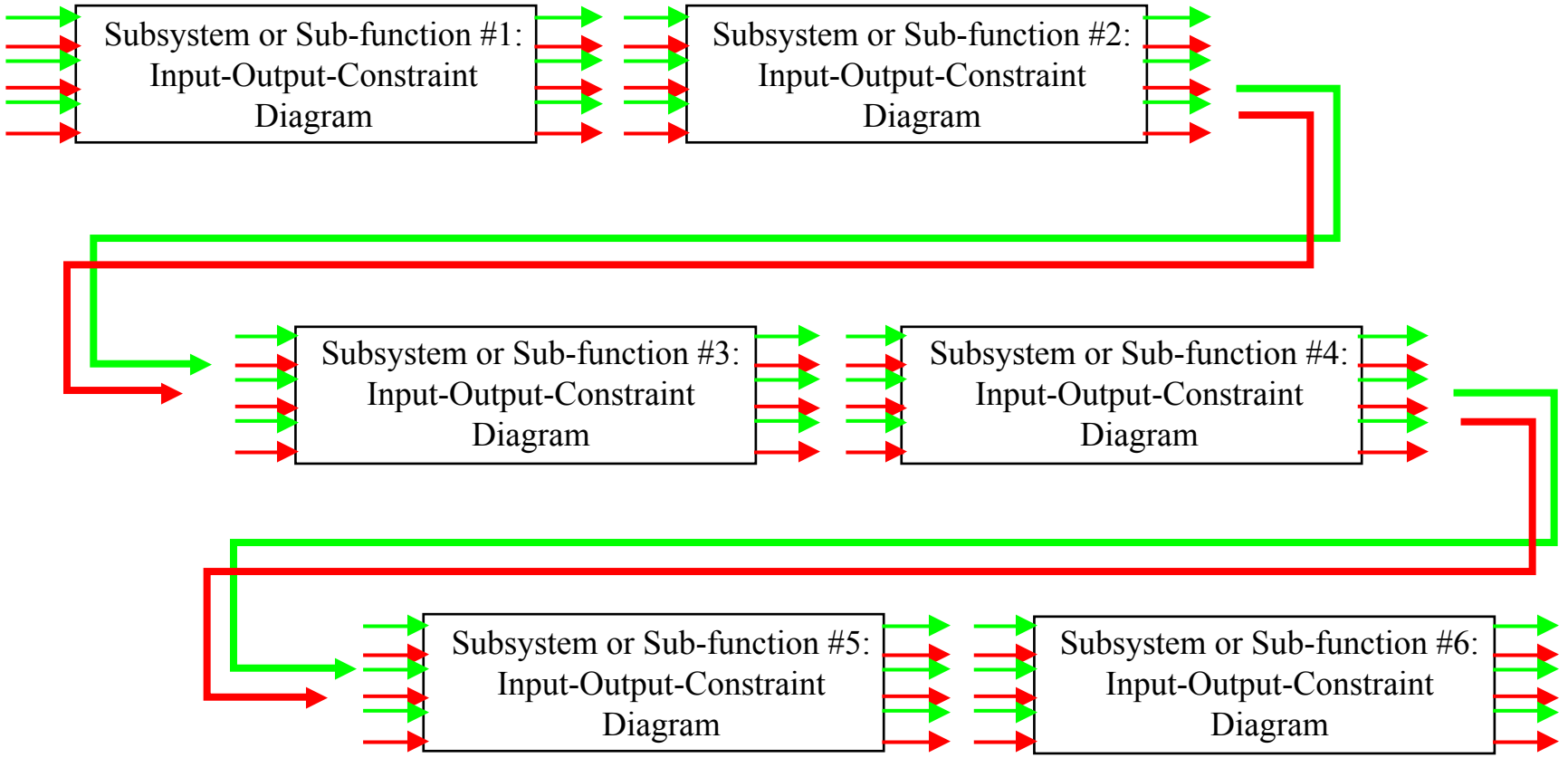
- **Information:** …measure the flow & transformation of digital & analog electronic, mechanical, magnetic, photonic, etc. *signals* intended to control a function related to mass &/or energy transformation & flow.

Defining Critical Input/Output Parameters for Design Projects

Input-Output-Constraint (IOC[N]) Diagrams…



Functional Flow Diagrams can be created by linking I-O-C Diagrams



Function Classes – Basic Functions

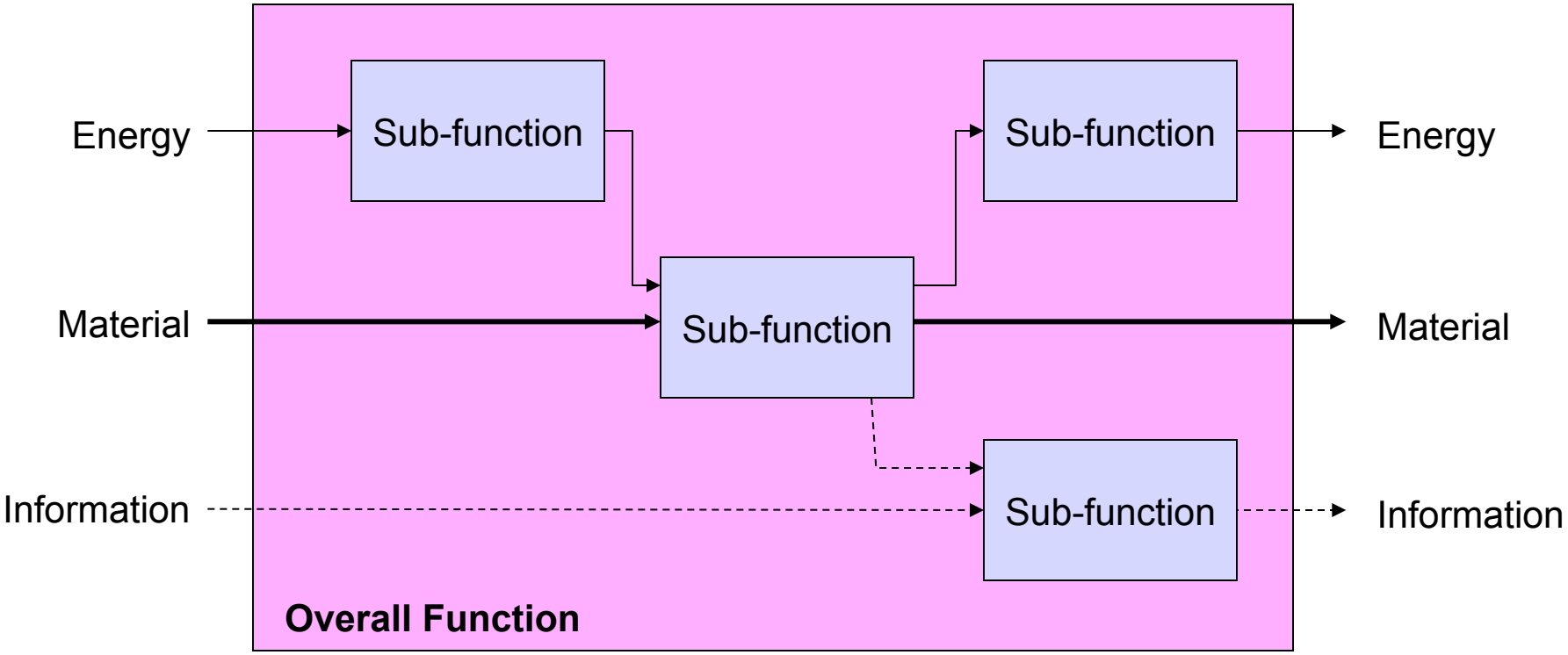
Class	Basic	Flow class restricted	Synonyms
Channel	Import		Input, Receive, *Allow*, Form Entrance, *Capture*
	Export		Discharge, Eject, Dispose, Remove
	Transfer	Transport (M)	Lift, Move
		Transmit (E)	Conduct, Convey
	Guide	Translate	Direct, Straighten, Steer
		Rotate	Turn, Spin
		Allow DOF	Constrain, Unlock
Support	Stop		Insulate, Protect, *Prevent*, Shield, Inhibit
	Stabilize		Steady
	Secure		*Attach*, Mount, Lock, Fasten, Hold
	Position		Orient, Align, Locate
Connect	Couple		Join, Assemble, *Attach*
	Mix		Combine, Blend, Add, Pack, Coalesce
Branch	Separate		Switch, Divide, Release, Detach, Disconnect, Disassemble, Subtract, Valve
		Remove (M)	Cut, Polish, Sand, Drill, Lathe
	Refine		Purify, Strain, Filter, Percolate, Clear
	Distribute		Diverge, Scatter, Disperse, *Diffuse*, Empty
	Dissipate		Absorb, Dampen, Dispel, *Diffuse*, Resist
Provision	Store		Contain, Collect, Reserve, *Capture*
	Supply		Fill, Provide, Replenish, Expose
	Extract		
Control Magnitude	Actuate		Start, Initiate
	Regulate		Control, *Allow*, *Prevent*, Enable/Disable, Limit, Interrupt
	Change		Increase, Decrease, Amplify, Reduce, Magnify, Normalize, Multiply, Scale, Rectify, Adjust
	Form		Compact, Crush, Shape, Compress, Pierce
Convert	Convert		Transform, Liquefy, Solidify, Evaporate, Condense, Integrate, Differentiate, Process
Signal	Sense		Perceive, Recognize, Discern, Check, Locate
	Indicate		Mark
	Display		
	Measure		Calculate

Summary of System Analogs

From Lewis, "Modeling Engineering Systems"

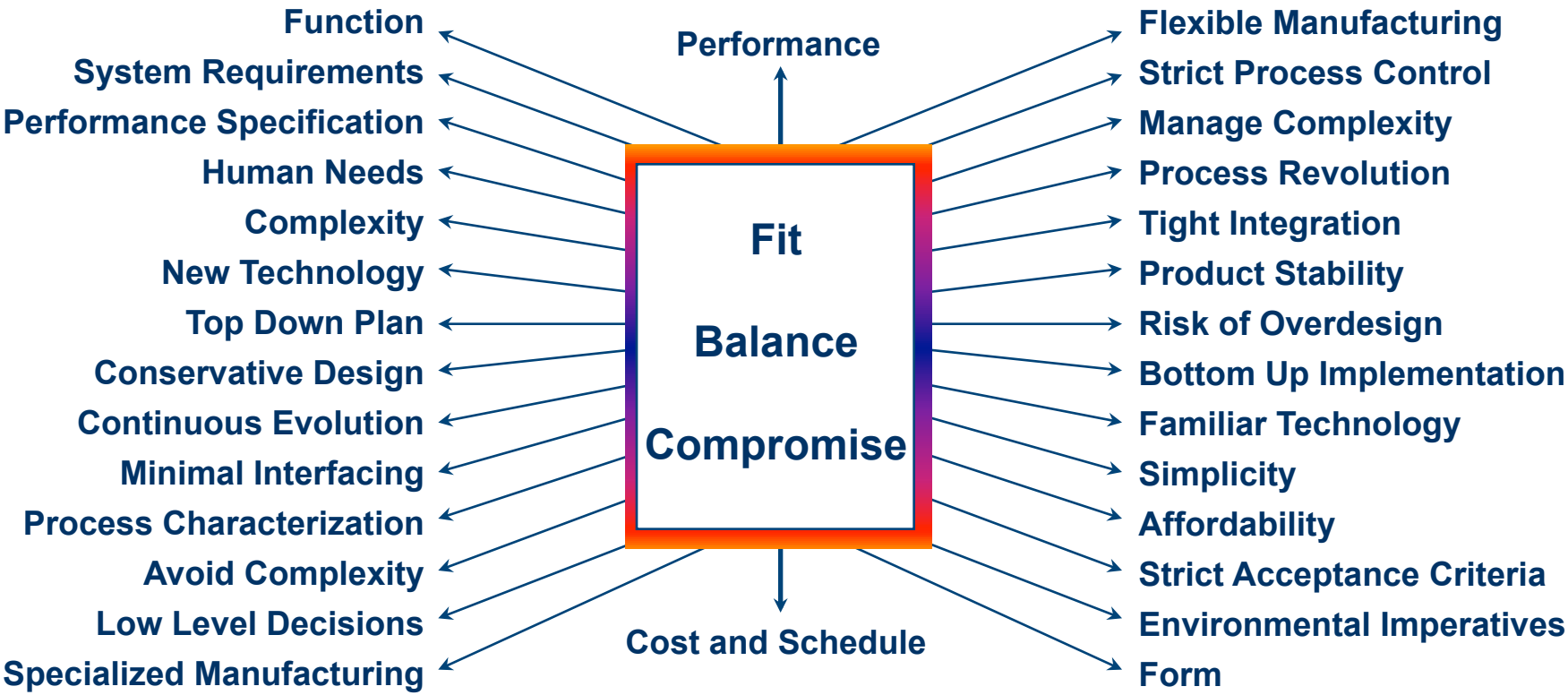
System	Across Variable	Through Variable	Power Equation	Resistor Equation	Capacitor Equation	Inductor Equation
Electrical	Voltage (V)	Current (i)	Vi	$V = Ri$	$i = C\frac{dV}{dt}$	$V = L\frac{di}{dt}$
Mech. (Trans)	Velocity (v)	Force (F)	vF	$v = \frac{1}{b}F$	$F = m\frac{dv}{dt}$	$v = \frac{1}{k}\frac{dF}{dt}$
Mech. (Rotation)	Angular Velocity (w)	Torque (Q)	ωQ	$\omega = \frac{1}{B}Q$	$Q = I\frac{d\omega}{dt}$	$\omega = \frac{1}{K}\frac{dQ}{dt}$
Fluidic	Pressure (p)	Flow Rate (q_v)	pq_v	$p = R_f q_v$	$q_v = C_f\frac{dp}{dt}$	$p = I_f\frac{dq_v}{dt}$
Thermal	Temperature (T)	Heat Flow Rate (q_h)	q_h	$T = R_t q_h$	$q_h = C_t\frac{dT}{dt}$	None

Function Structure



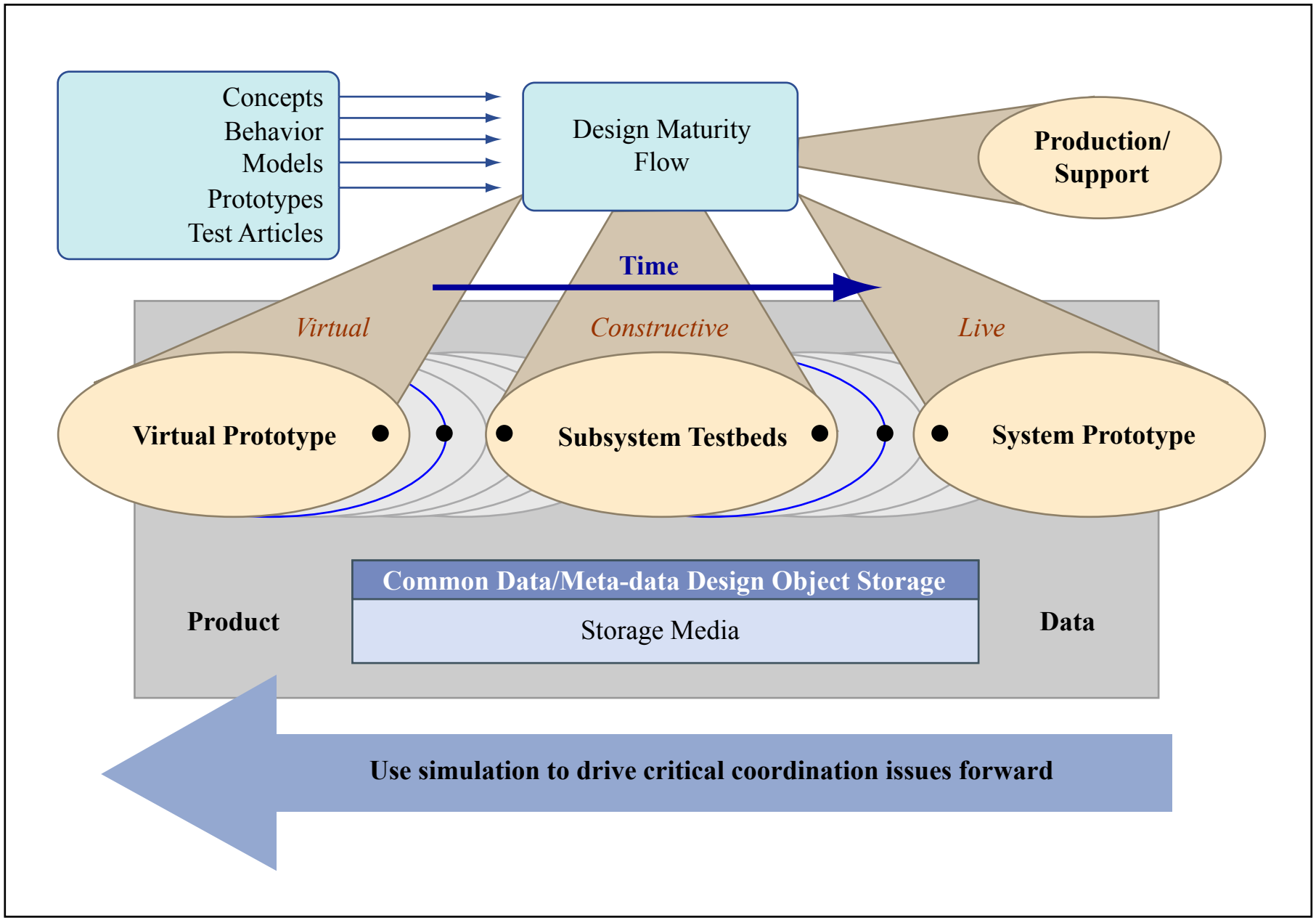
We show composition with area boundaries, not links. We show physics of the functions with flows, to initiate our development of the critical parameter trees. The flows can be measured.

Stresses in Systems Engineering



Adapted from Systems Engineering lecture slides at University of Witwatersrand, Johannesburg, South Africa (Dr. R. Siriram)

Simulation



ESD.33 Systems Engineering

Summer 2010