

Creative Convergence

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What is engineering?

ABET (Accreditation Board of Engineering and Technology):

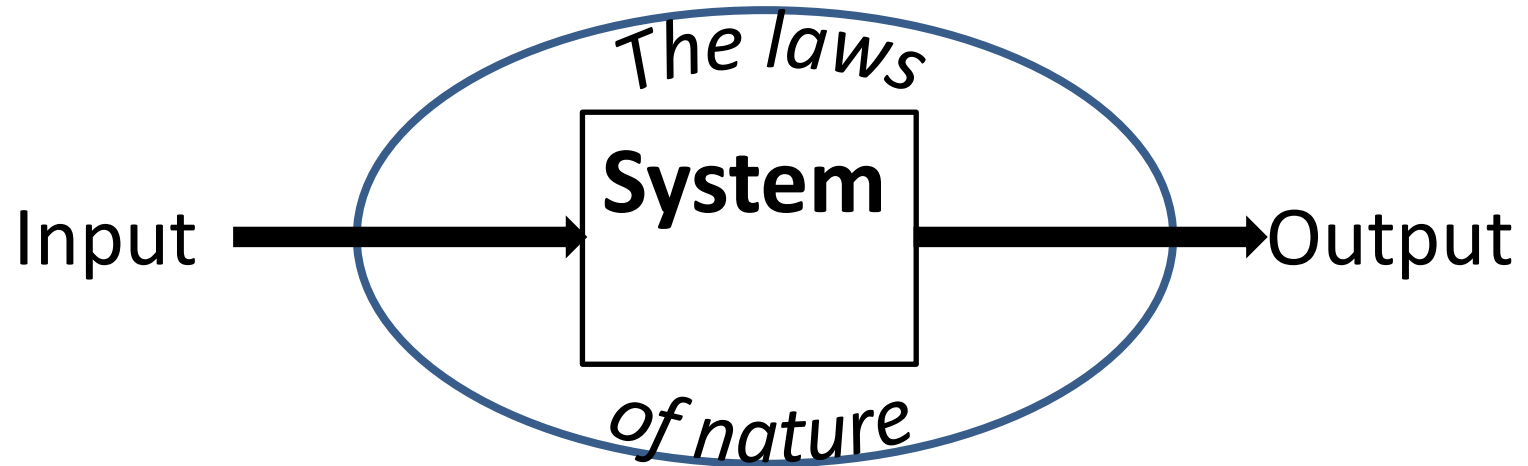
Deduction

“Engineering is the profession in which a knowledge of the mathematical and natural sciences, gained by study, experience, and practice, is applied with judgment to develop ways to utilize, economically, the materials and forces of nature for the benefit of mankind.”

Induction

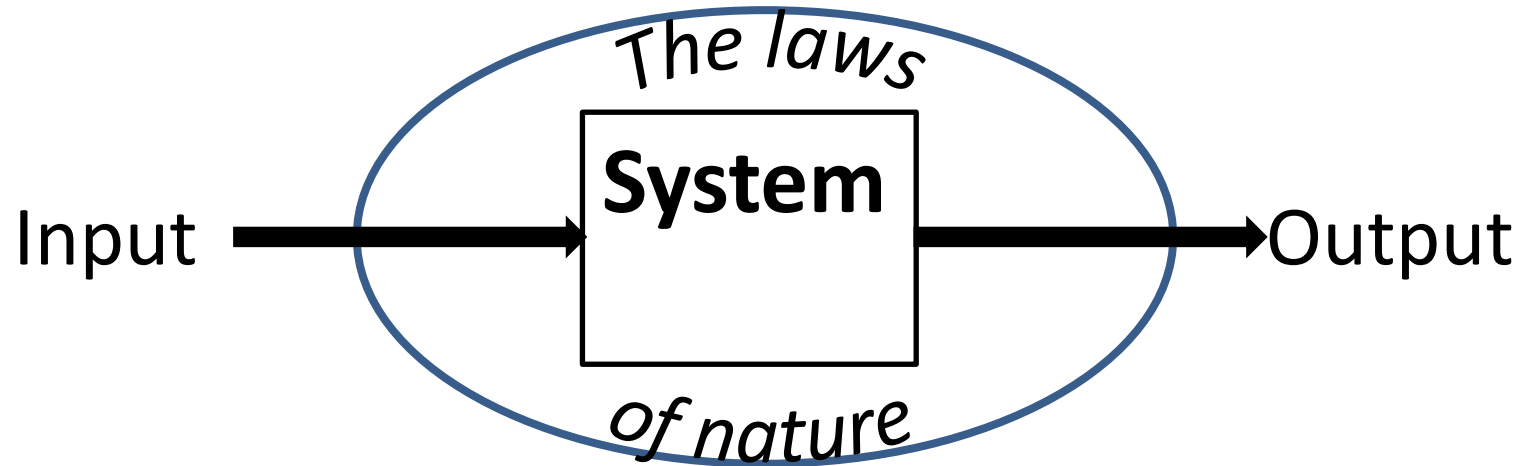
A more formal model

[due to CR Mischke, *Mathematical Model Building*, (1980)]



A more formal model

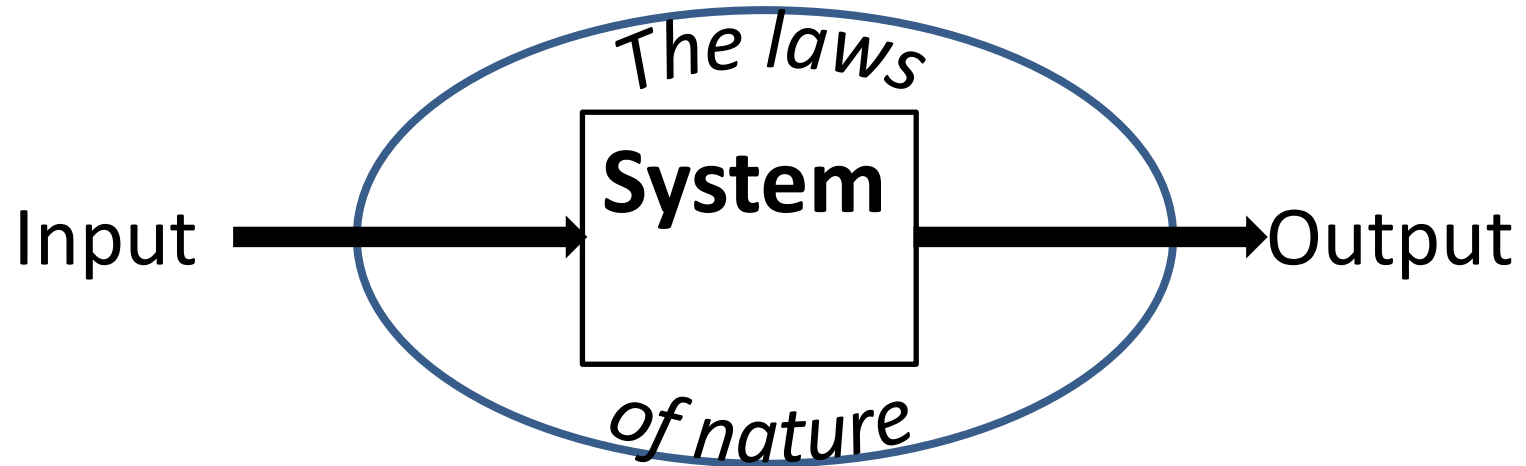
[due to CR Mischke, *Mathematical Model Building*, (1980)]



Given...	To find...	Skill needed	Name of the Game
System, Input, Laws	Output	Deduction	Analysis
System, Output, Laws	Input	Deduction	Reverse Analysis

A more formal model

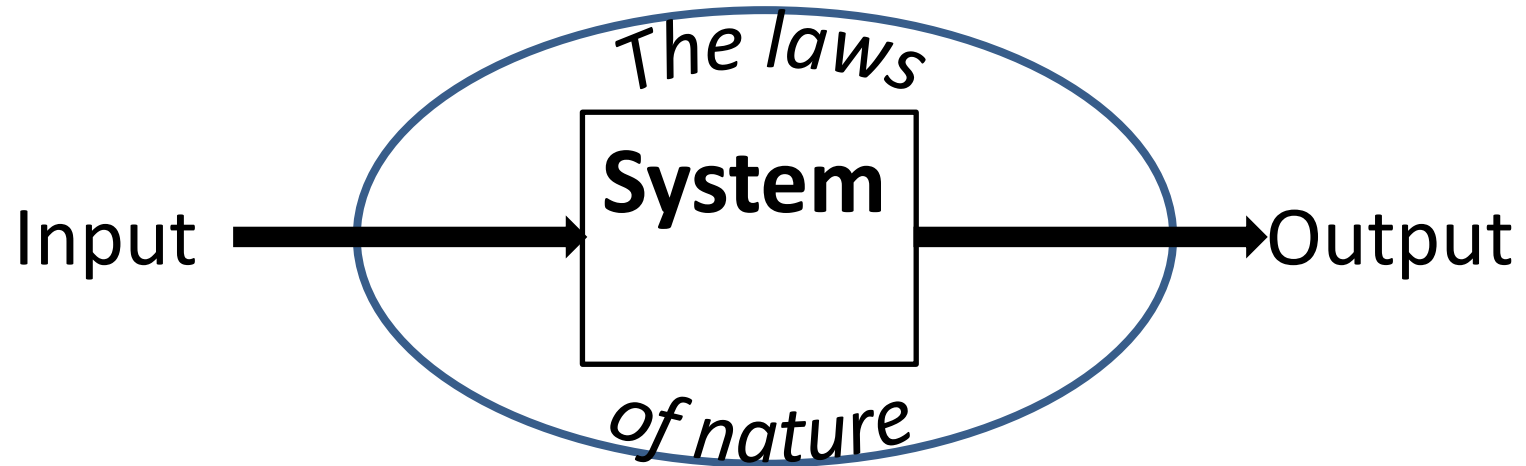
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Given...	To find...	Skill needed	Name of the Game
System, Input, Laws	Output	Deduction	Analysis
System, Output, Laws	Input	Deduction	Reverse Analysis
Input, System, Output	Laws	Induction	Science

A more formal model

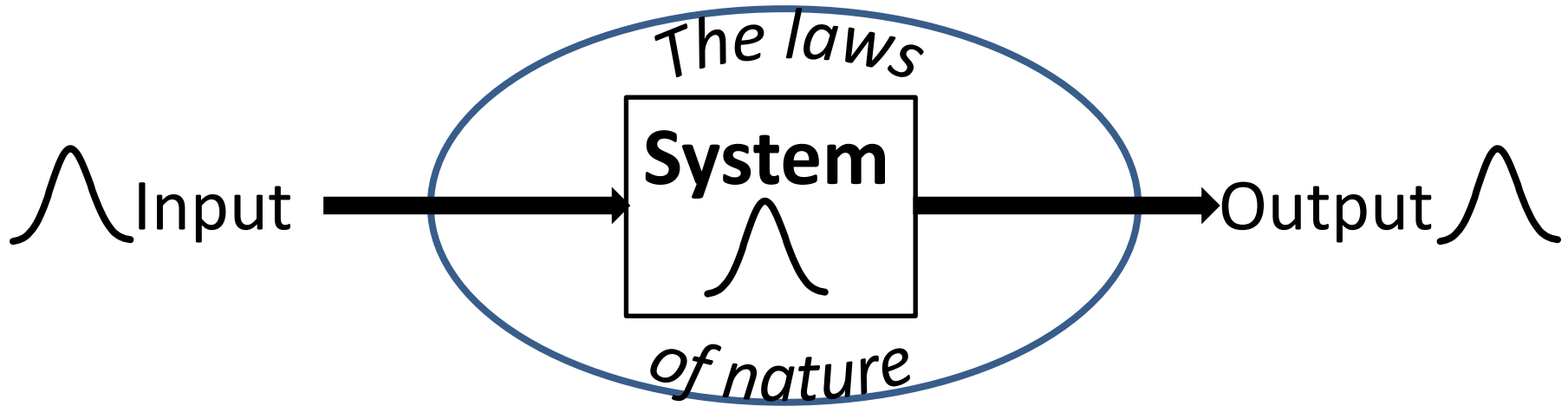
[due to CR Mischke, *Mathematical Model Building*, (1980)]



Given...	To find...	Skill needed	Name of the Game
System, Input, Laws	Output	Deduction	Analysis
System, Output, Laws	Input	Deduction	Reverse Analysis
Input, System, Output	Laws	Induction	Science
Input, Output, Laws	System	Synthesis	Engineering

A more formal model

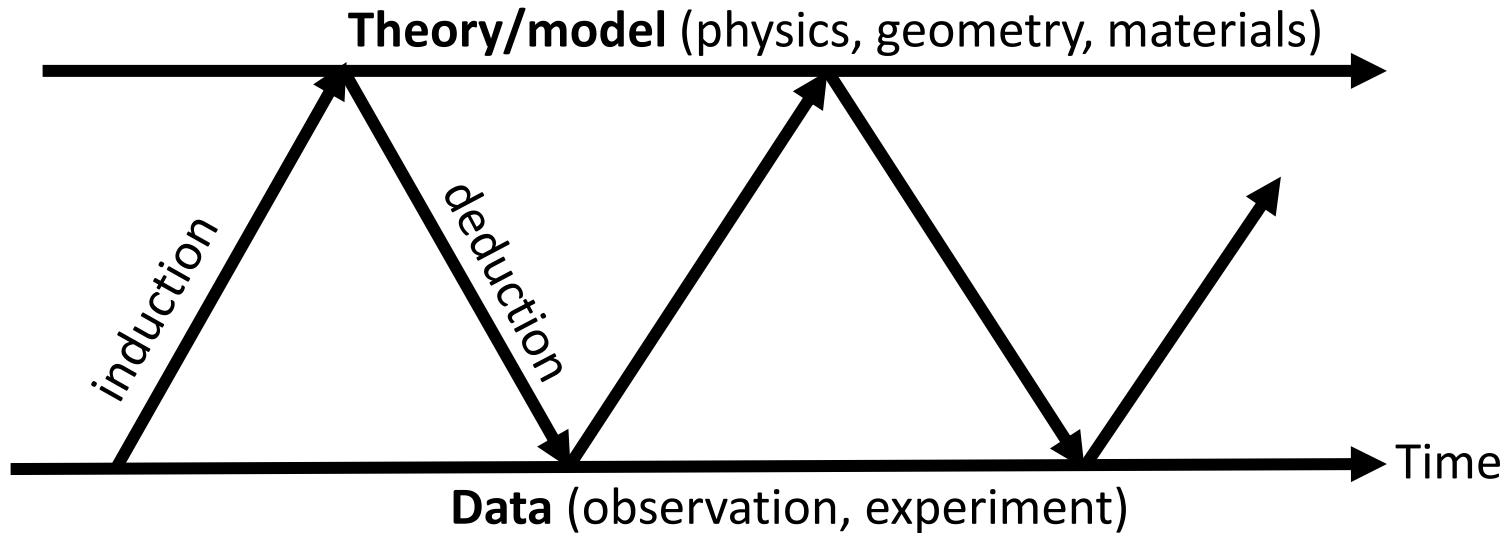
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Given...	To find...	Skill needed	Name of the Game
System, Input, Laws	Output	Deduction	Analysis
System, Output, Laws	Input	Deduction	Reverse Analysis
Input, System, Output	Laws	Induction	Science
Input, Output, Laws	System	Synthesis	<i>Statistical Engineering</i>

The iterative learning process

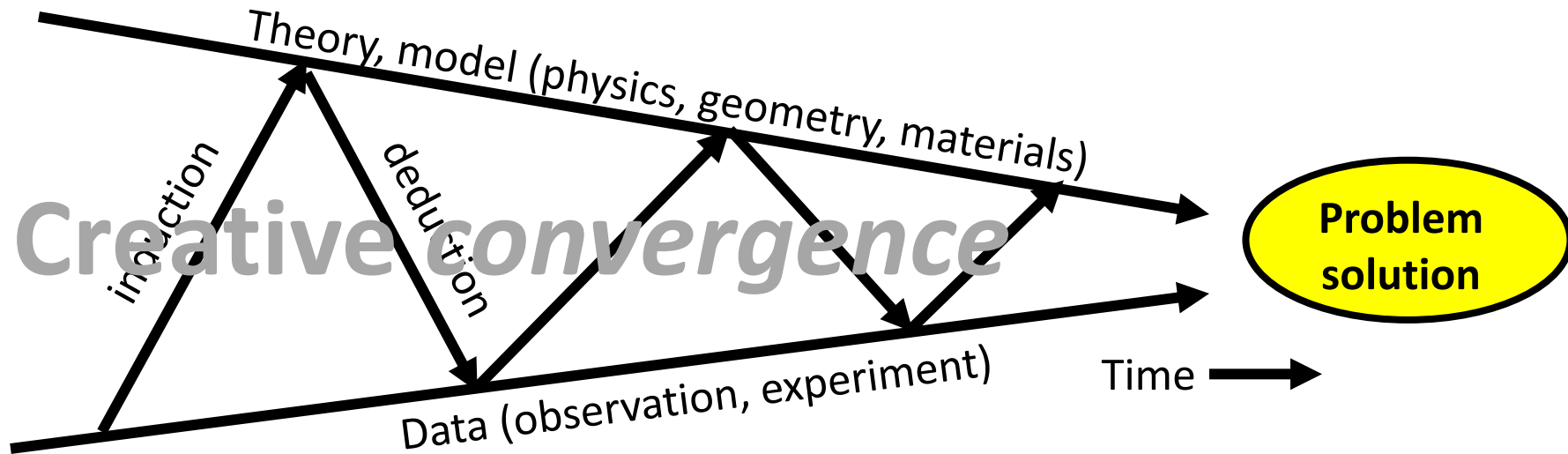
[GEP Box, *Science & Statistics* (1976)]



- Statistical Science is unique – it provides the catalyst for the “reaction” between deduction and induction.
- Context is crucial.

The iterative learning process

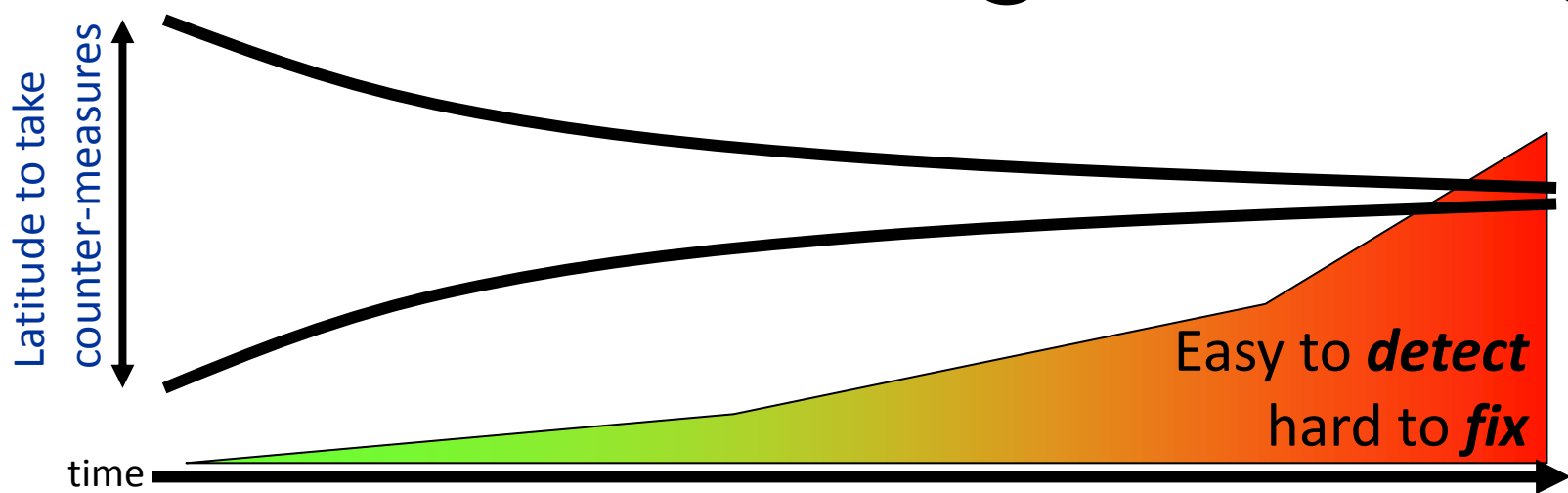
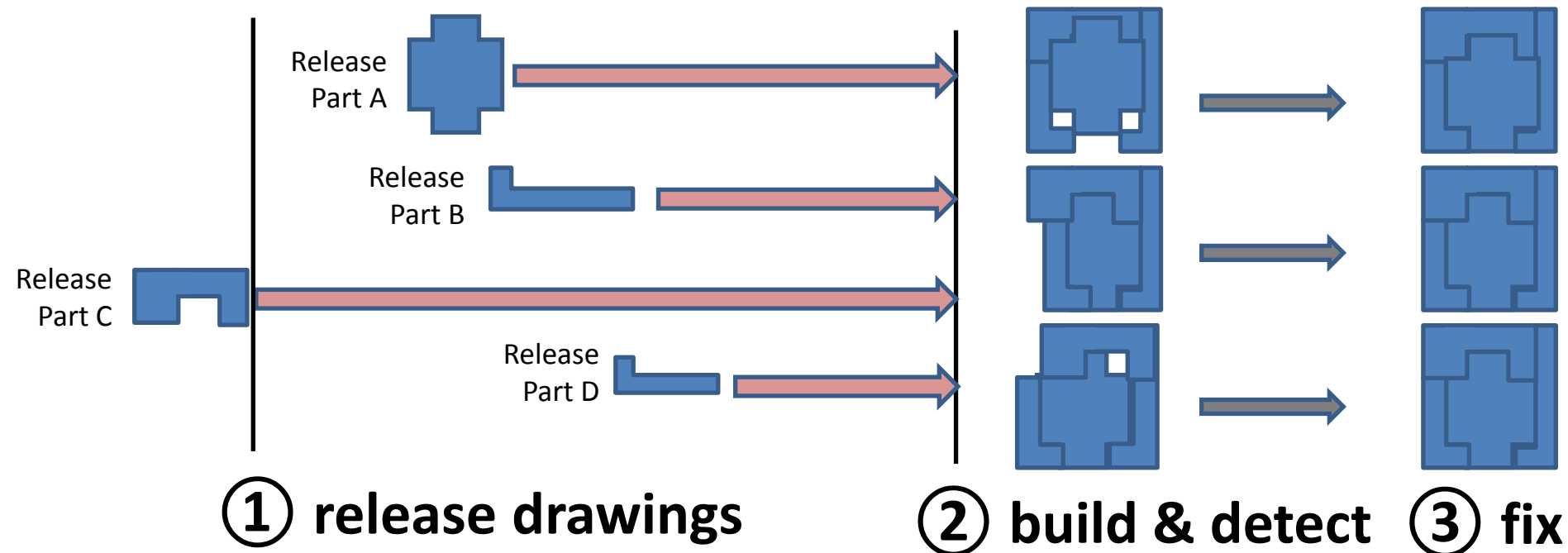
[TP Davis, *Science, Engineering, & Statistics* (2006)]



- **Pugh** (*Total Design* – “controlled convergence”)
- **Feynman** (*The Character of Physical Law*– “what we need is imagination, but imagination in a... straightjacket”)

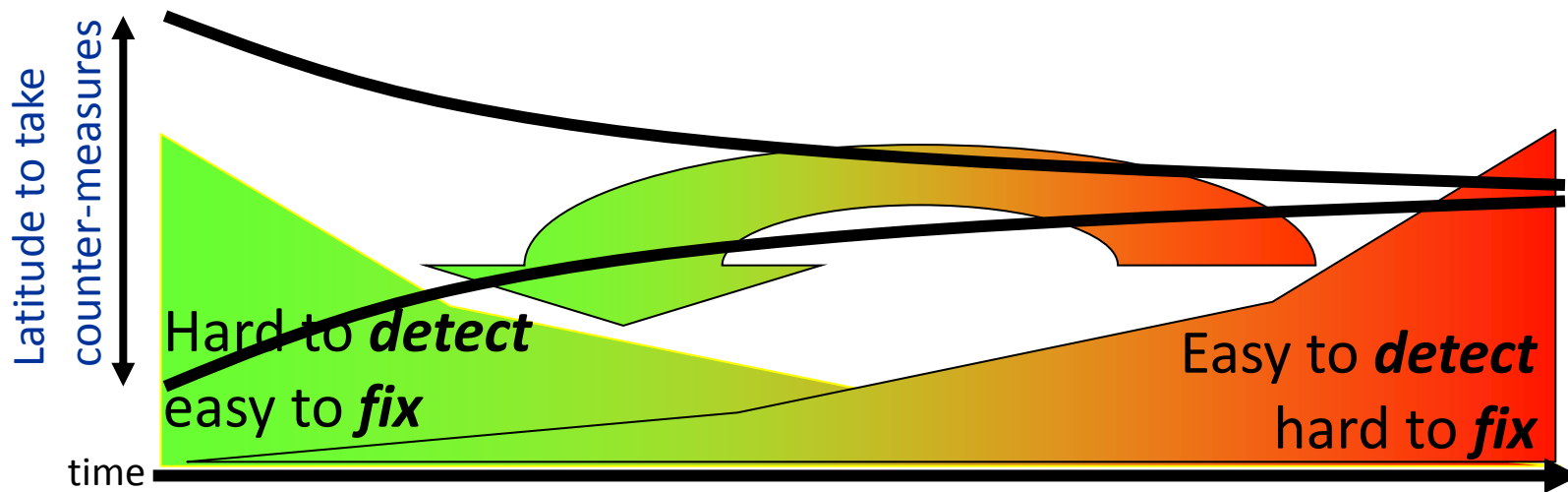
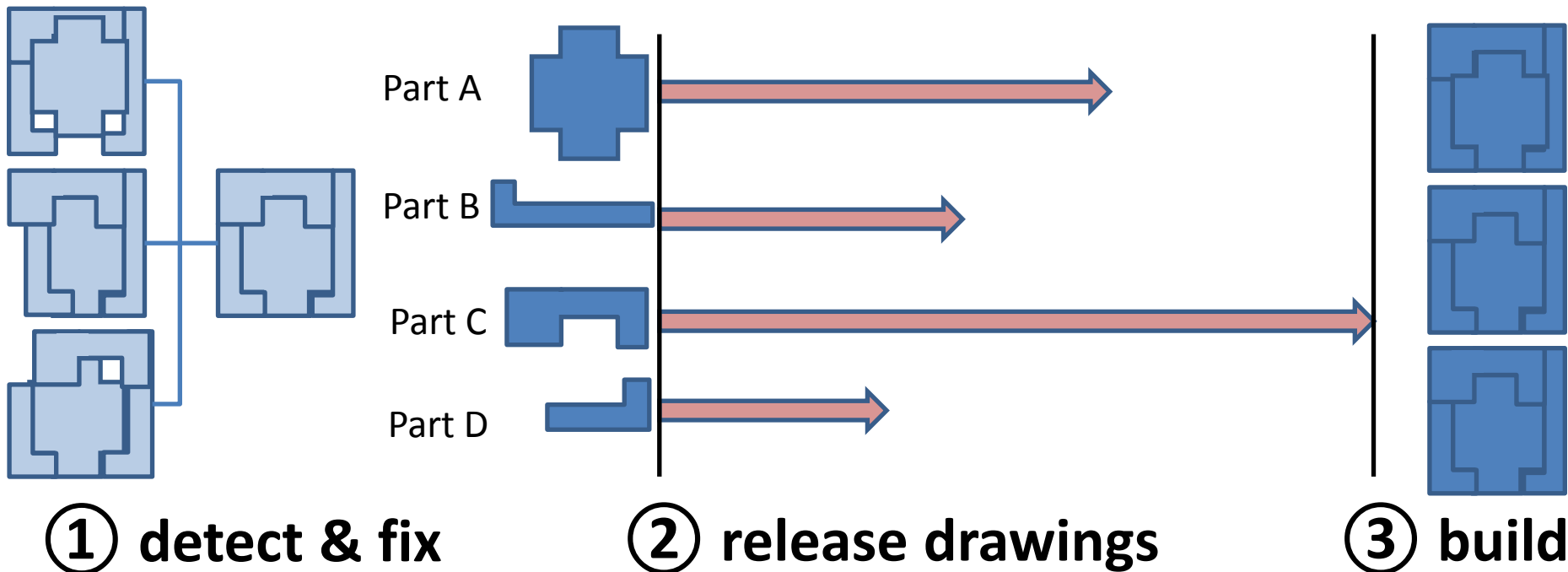
Product & Technology development

Asynchronous material and information flow

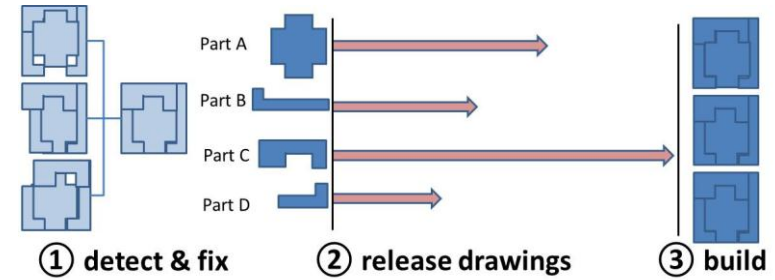
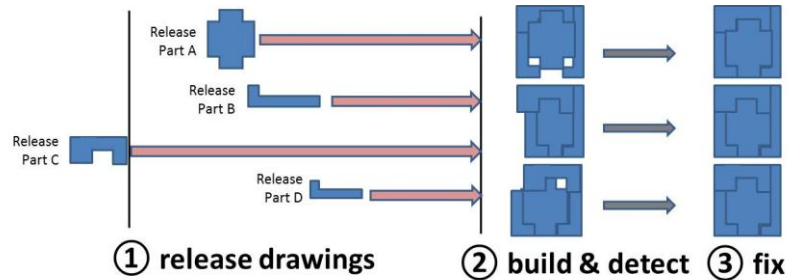


Product & Technology development

Synchronous material and information flow



The order of things has been “flipped”



Conventional Elevator

- ① Get into the elevator car
(*any* elevator car)
- ② Select Floor required
- ③ Change mind mid-journey if necessary

Destination Elevator

- ① Select the floor required
- ② Get into the elevator car
(but *not any* car)
- ③ Can't change mind mid-journey

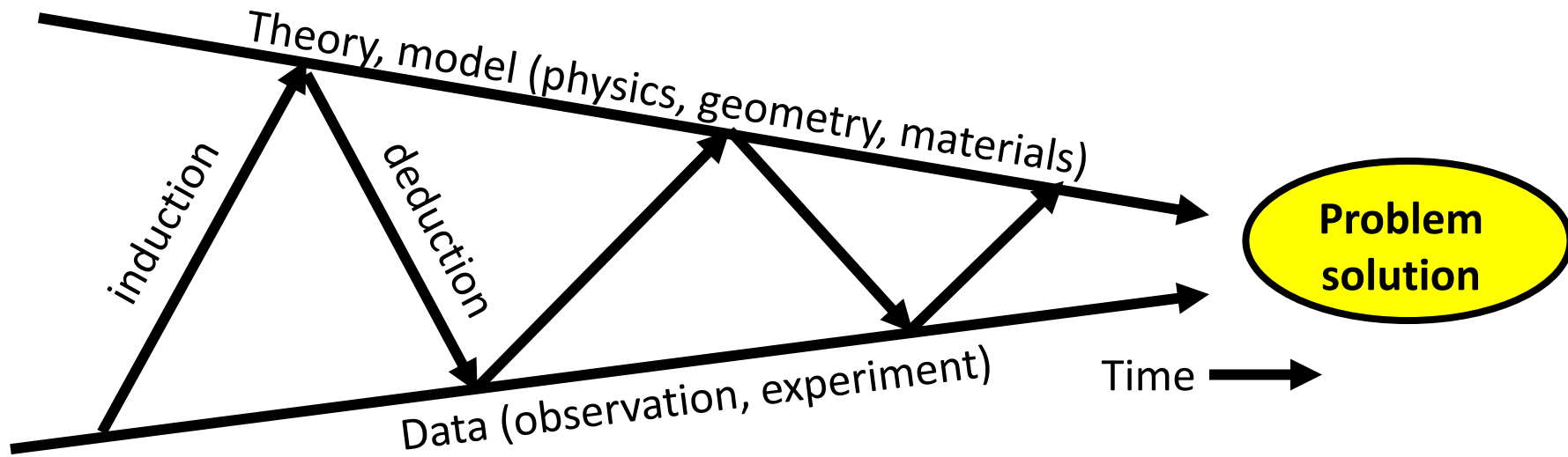
The instructions are understood – getting them in the right order is key to avoiding failure!

Failure Mode Avoidance



- We are taking on Mother Nature at her own game - the creation of failure modes in engineering design, technology development, & process optimization is inevitable;
- This is probably the single biggest reason that creates divergence and slows down product development time;
- We have some brilliant statistical tools - but do we always use them at the right place, at the right time, or in the right order?
- **Avoid Type III errors!**

Creative Convergence



Our role (actually, ***our responsibility***) as statistical collaborators in engineering investigations, technology development, and process optimization, is to

a) encourage creativity,

and

b) to ensure convergence.