Industry Needs for Academic Systems Knowledge

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Abstract

Many complex systems are multi-disciplinary. The multi-disciplinarity is further complicating the design of these systems. Academic knowledge tends to be developed within disciplinary fields. We will discuss what systems needs are present in industry to stimulate academia to research these multi-disiciplinary system needs.

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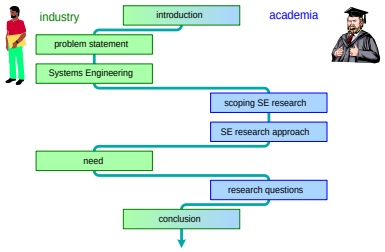

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from Boderc: Tension or Opportunity?

$$\ddot{e}_s = -(B_i + \Delta B_i)\underline{\dot{u}} - W_i\underline{\dot{v}} \quad \text{for} \quad (x_{s,r} - \begin{bmatrix} 1 & 0 & 0 \end{bmatrix}\underline{q}) \in \mathcal{X}_i, i \in \mathcal{I}. \tag{14.7}$$

Next, the control input $\underline{u}$ and the disturbance $\underline{v}$ are replaced by the control input and disturbance in error-space, which are defined as

$$\underline{\mu} = \underline{\dot{u}} \tag{14.8}$$

and

$$\underline{\nu} = \underline{\dot{v}}. \tag{14.9}$$

respectively. When we define the state vector of the error dynamics as

$$\underline{q} = \begin{bmatrix} e_s & \dot{e}_s & \ddot{e}_s \end{bmatrix}^T, \tag{14.10}$$

we can write the error dynamics in standard state-variable form:

$$\begin{aligned} \dot{\underline{q}} &= F\underline{q} + (G_i + \Delta G_i)\underline{\mu} + V_i\underline{\nu} \quad \text{for} \quad (x_{s,r} - \begin{bmatrix} 1 & 0 & 0 \end{bmatrix}\underline{q}) \in \mathcal{X}_i, i \in \mathcal{I} \\ \underline{z} &= H\underline{q}. \end{aligned} \tag{14.11}$$

time first delivery

power

cost

accuracy

focus

needs
constraints

opportunities
unconventional techniques

unfreeze

Problem Statement

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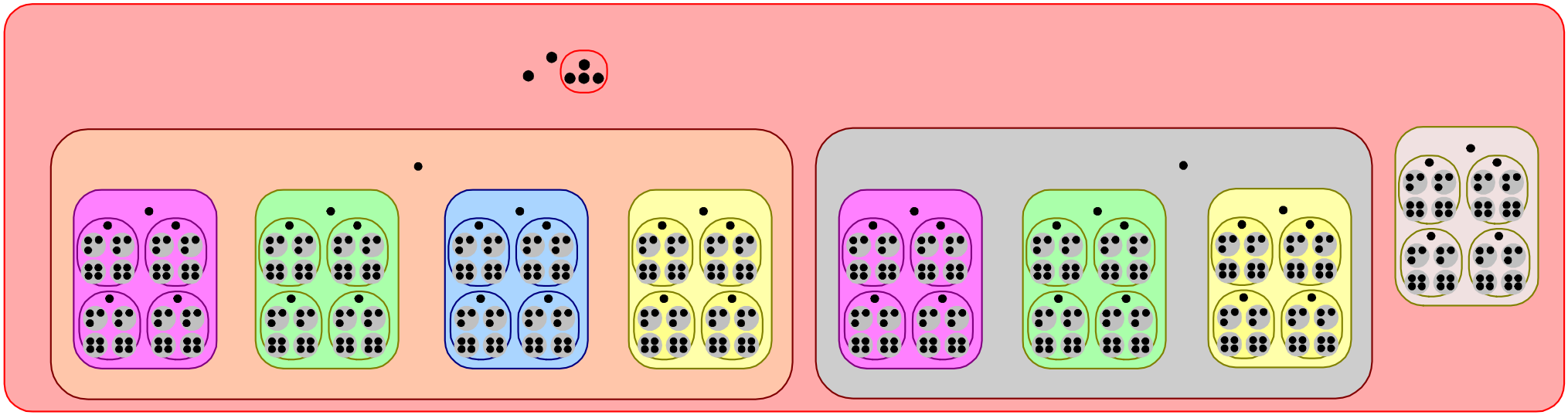
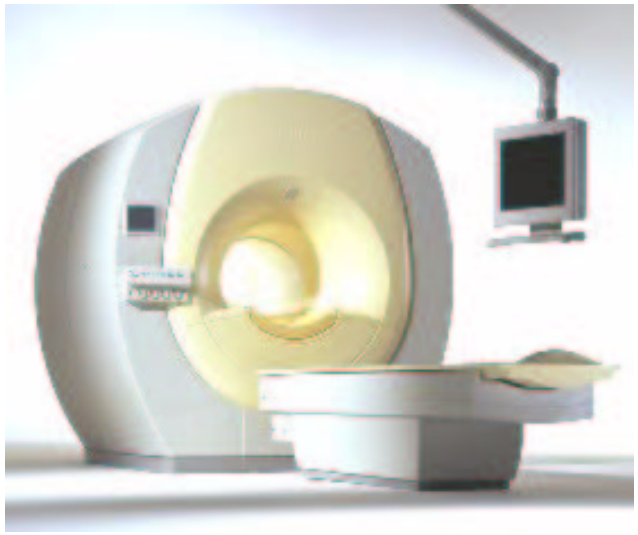
Problem Statement: Organization Size and Specialization

512 employees
many disciplines
distributed over multiple sites/countries



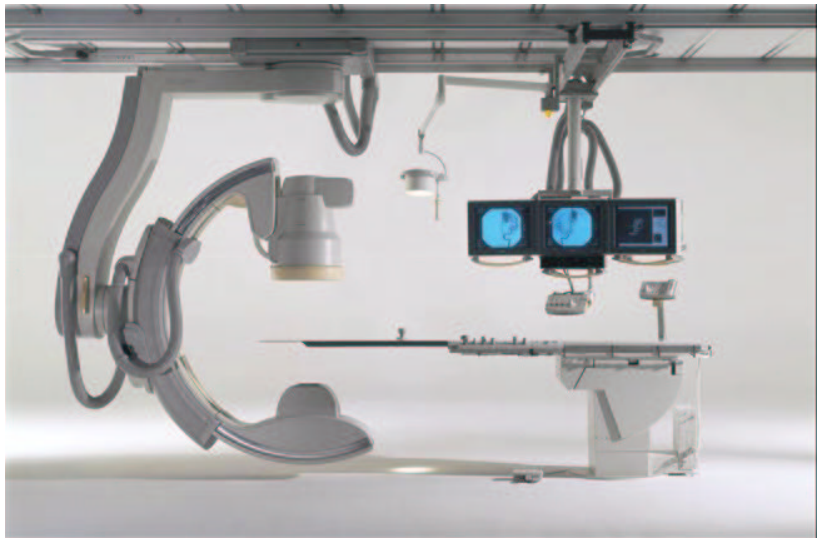
How will these 512 individual experts develop a single consistent well-functioning system?

Examples of Complex Systems



MRI scanner

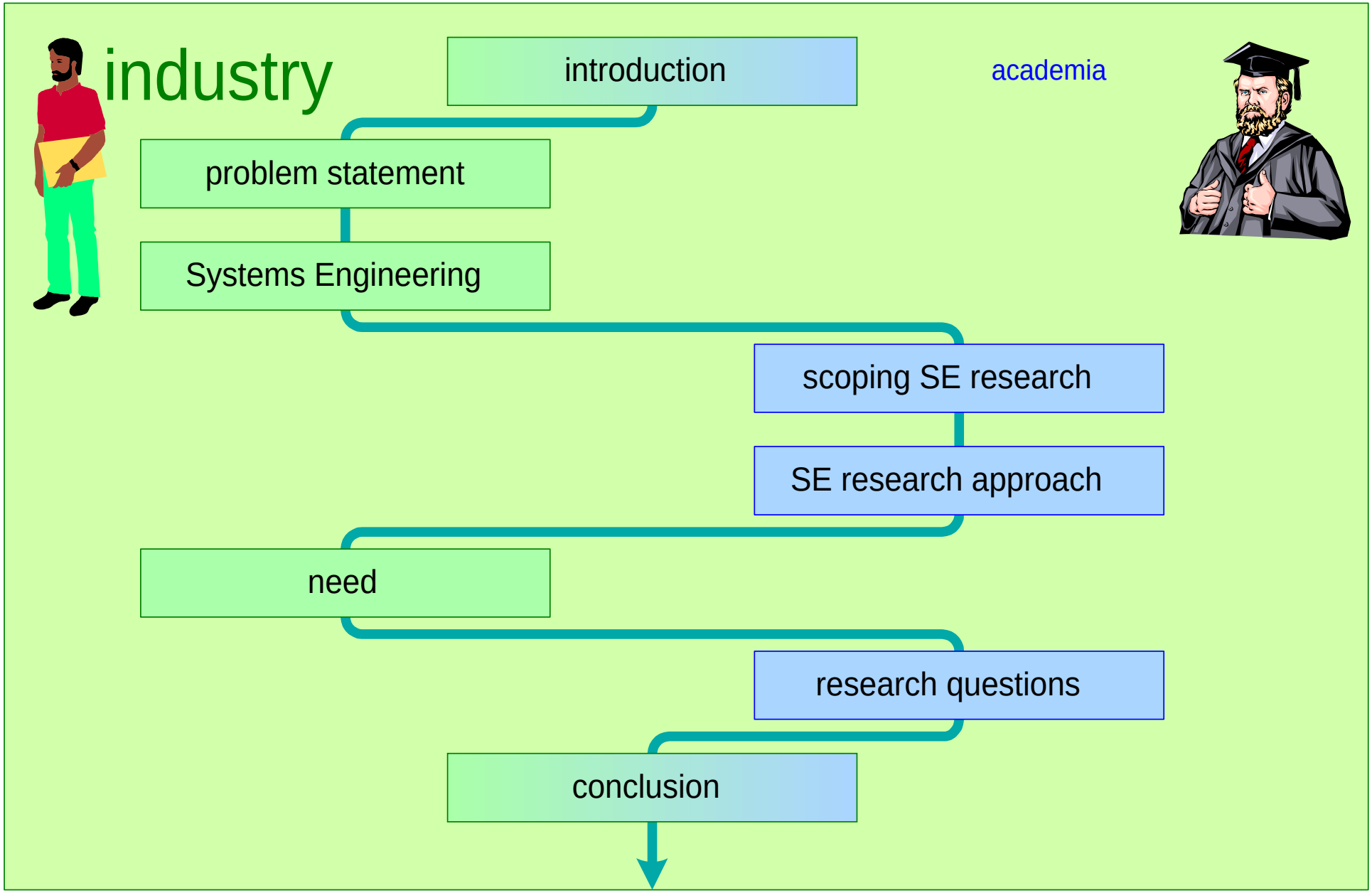
wafer stepper



Cardio Vascular Xray

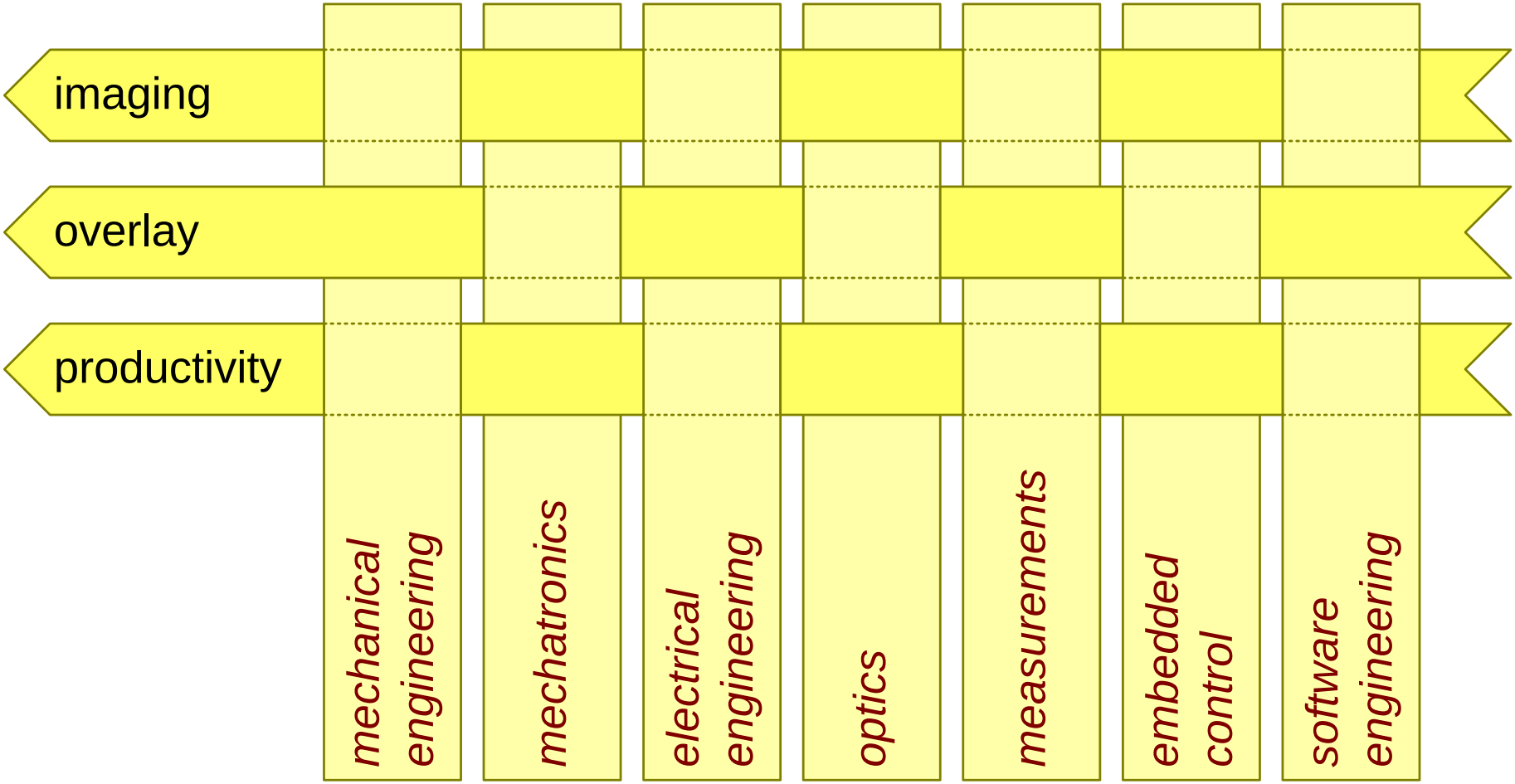
volume printer

Systems Engineering



Systems Engineering Contribution

Systems Engineering: responsible for customer key drivers and key performance parameters of system



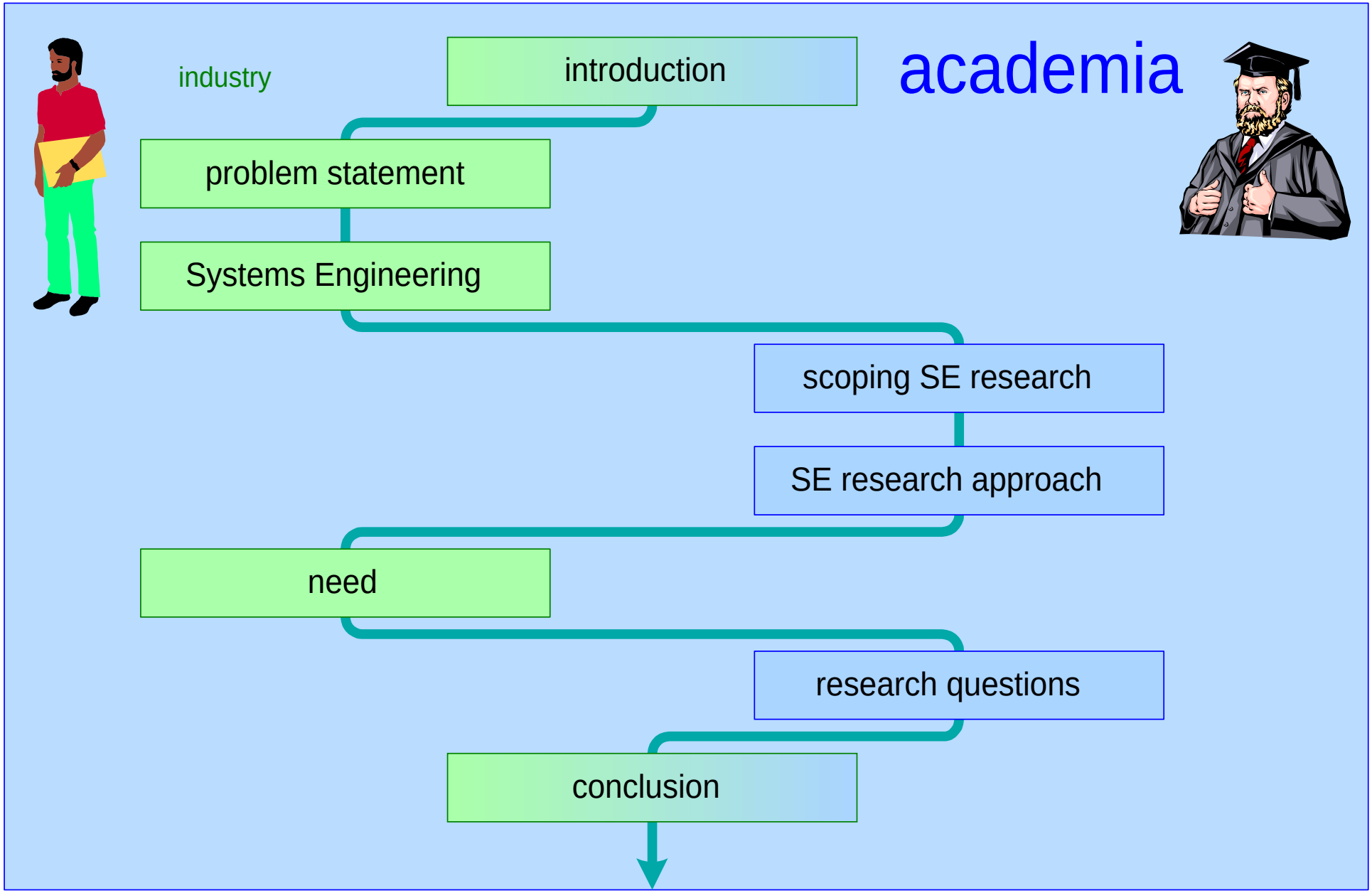
Example of SE job

daily meeting
at 4 o'clock (natural pressure to make progress)
on invitation:
- system engineers
- project leaders
- relevant experts

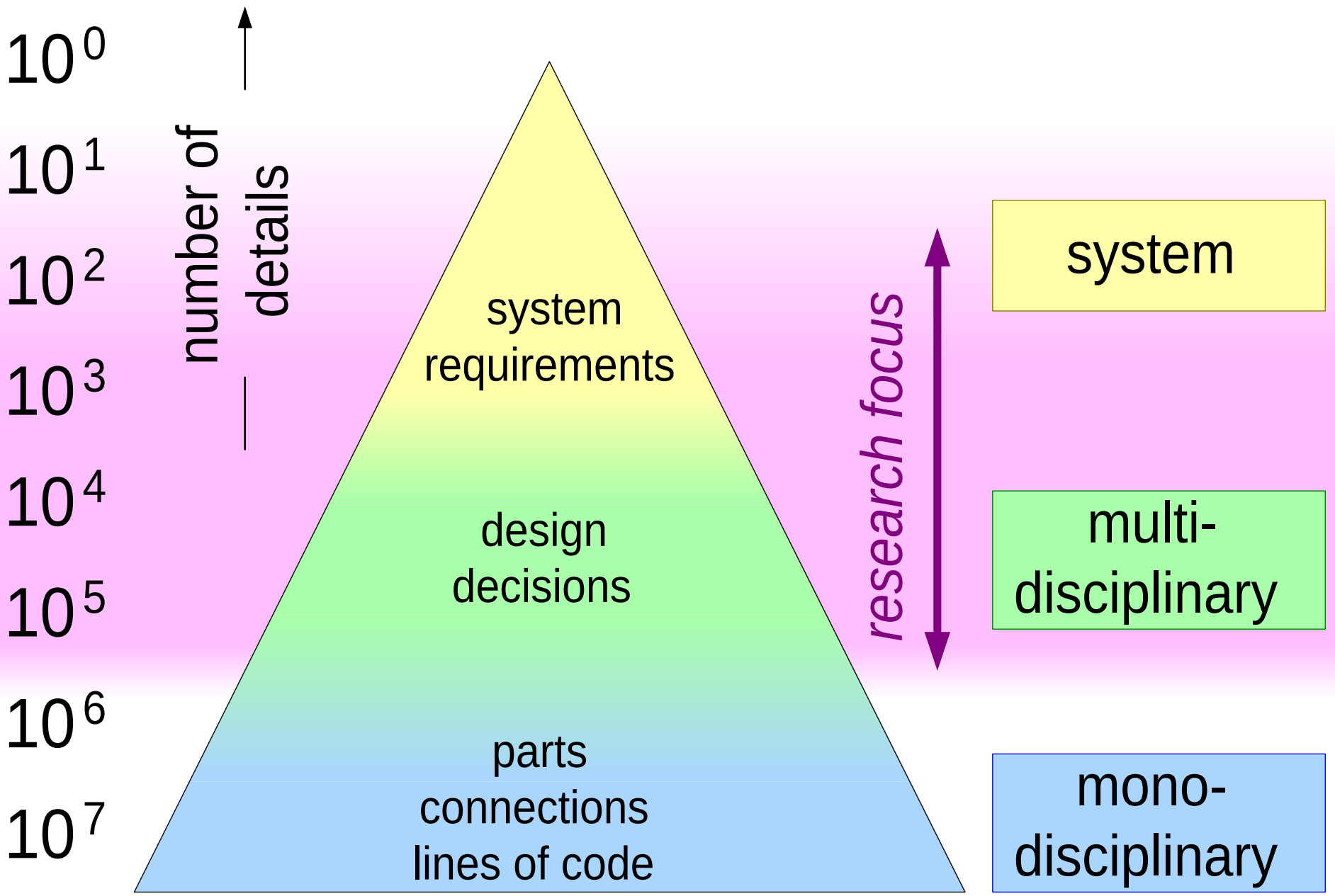
result oriented

overlay budget
wafer flatness
transport
stage concept
synchronization
system adjustments
lens specification
productivity model
integration plan
sensor concept

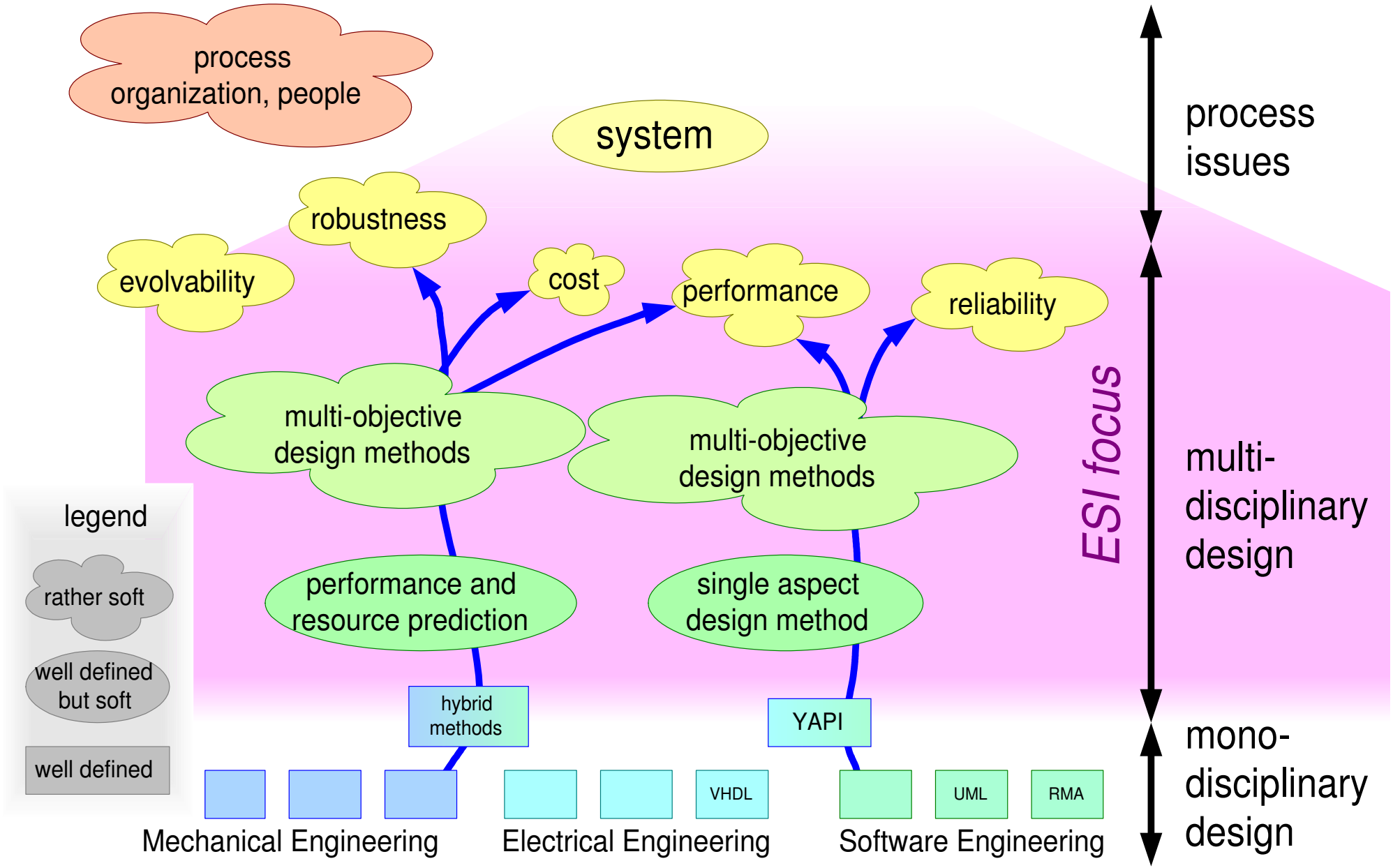
Scoping SE Research



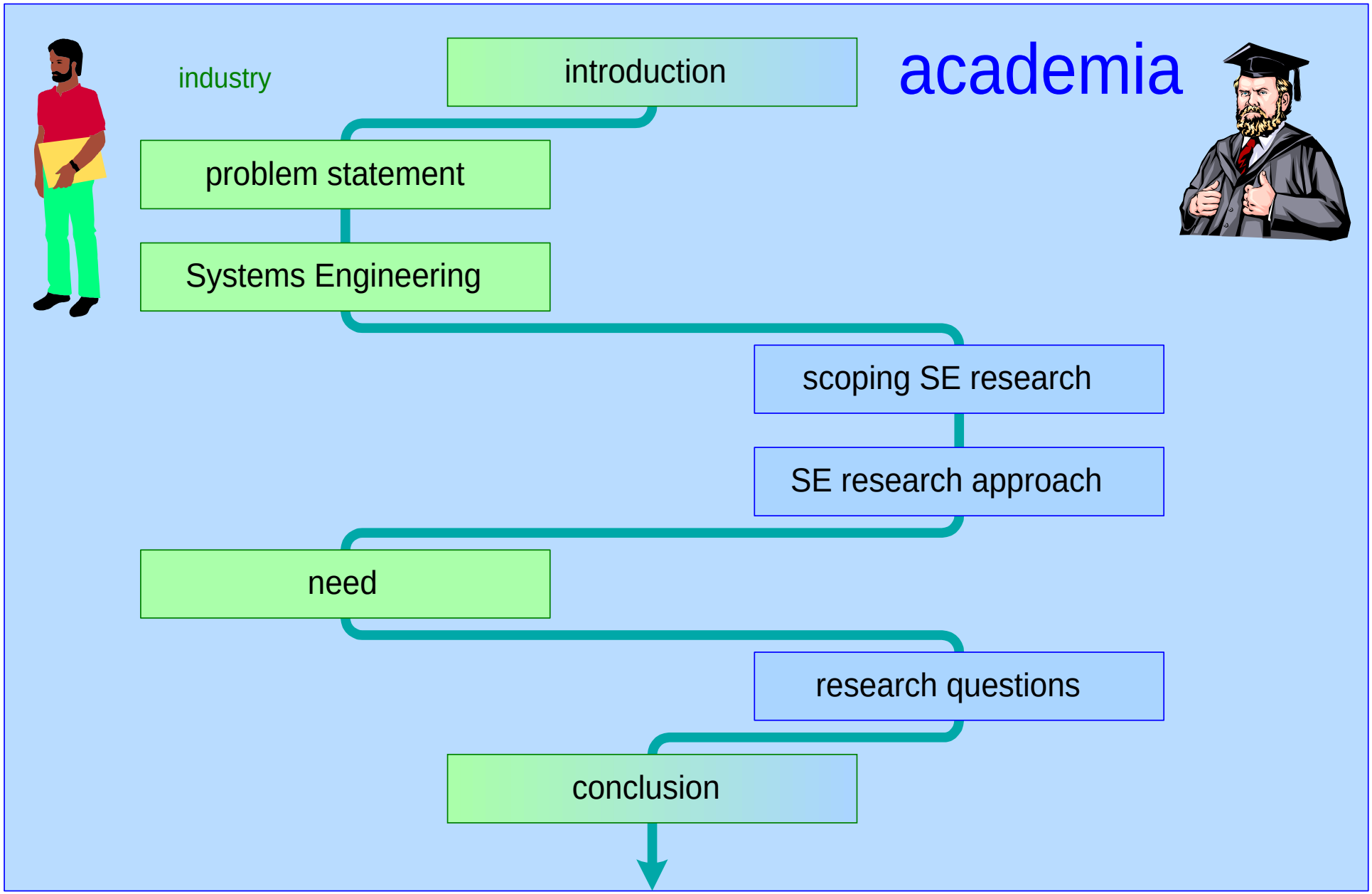
Exponential Pyramid, from requirement to bolts and nuts



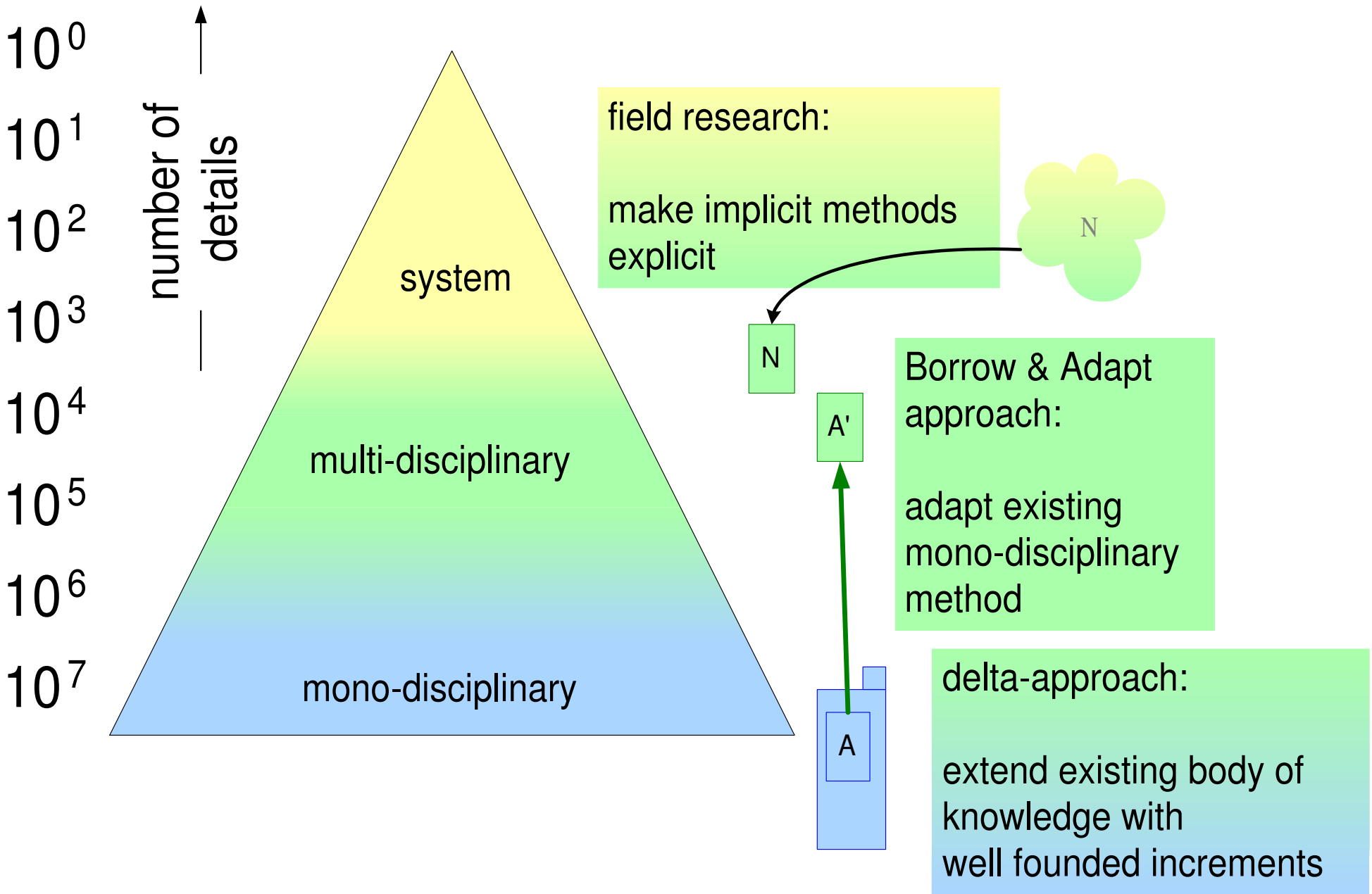
From Mono-Disciplinary to System



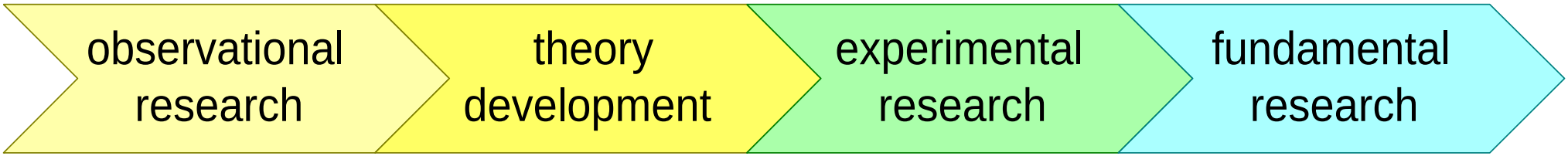
SE Research Approach



Research Methods

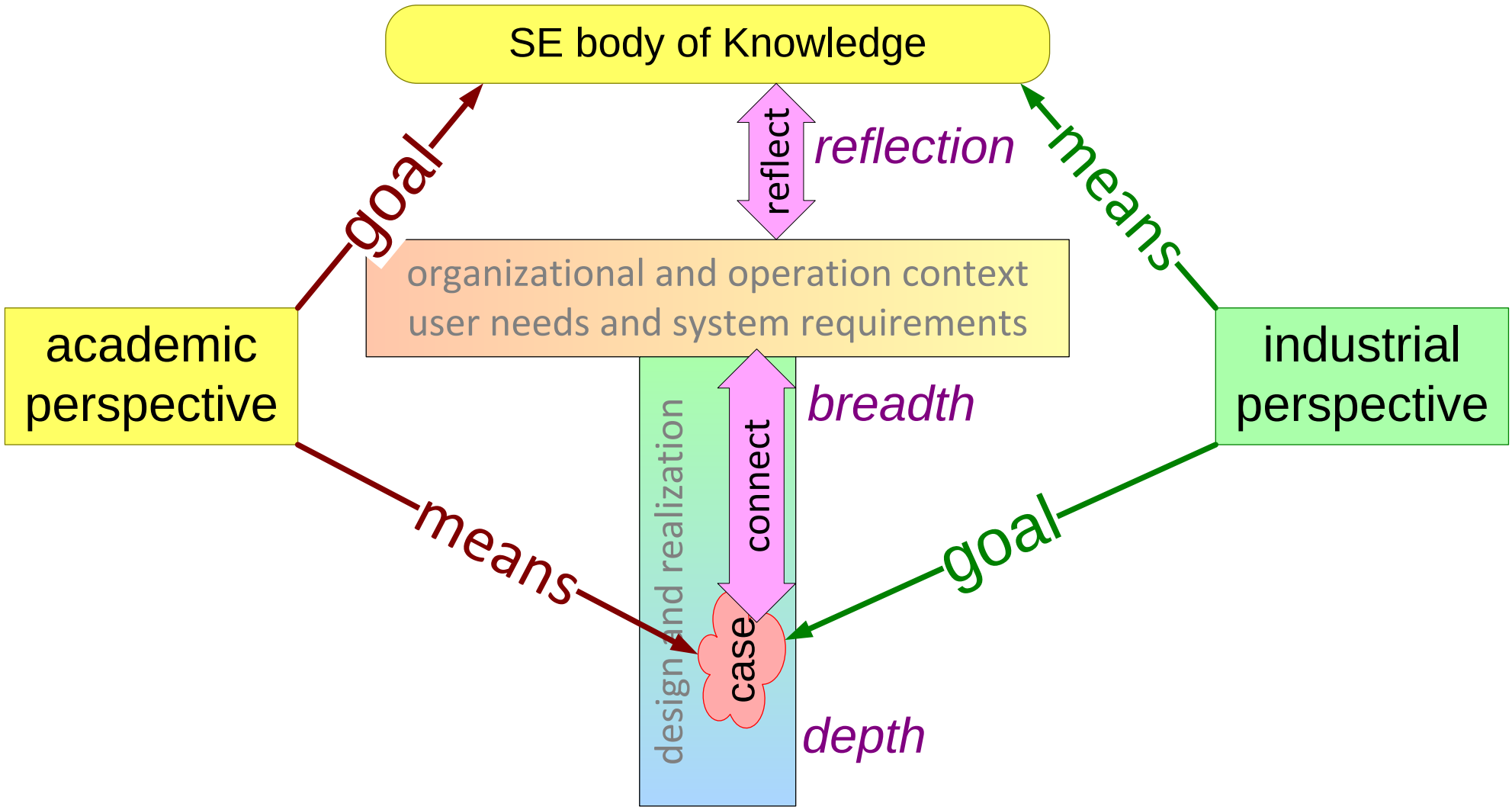


Systems Engineering is Young Field

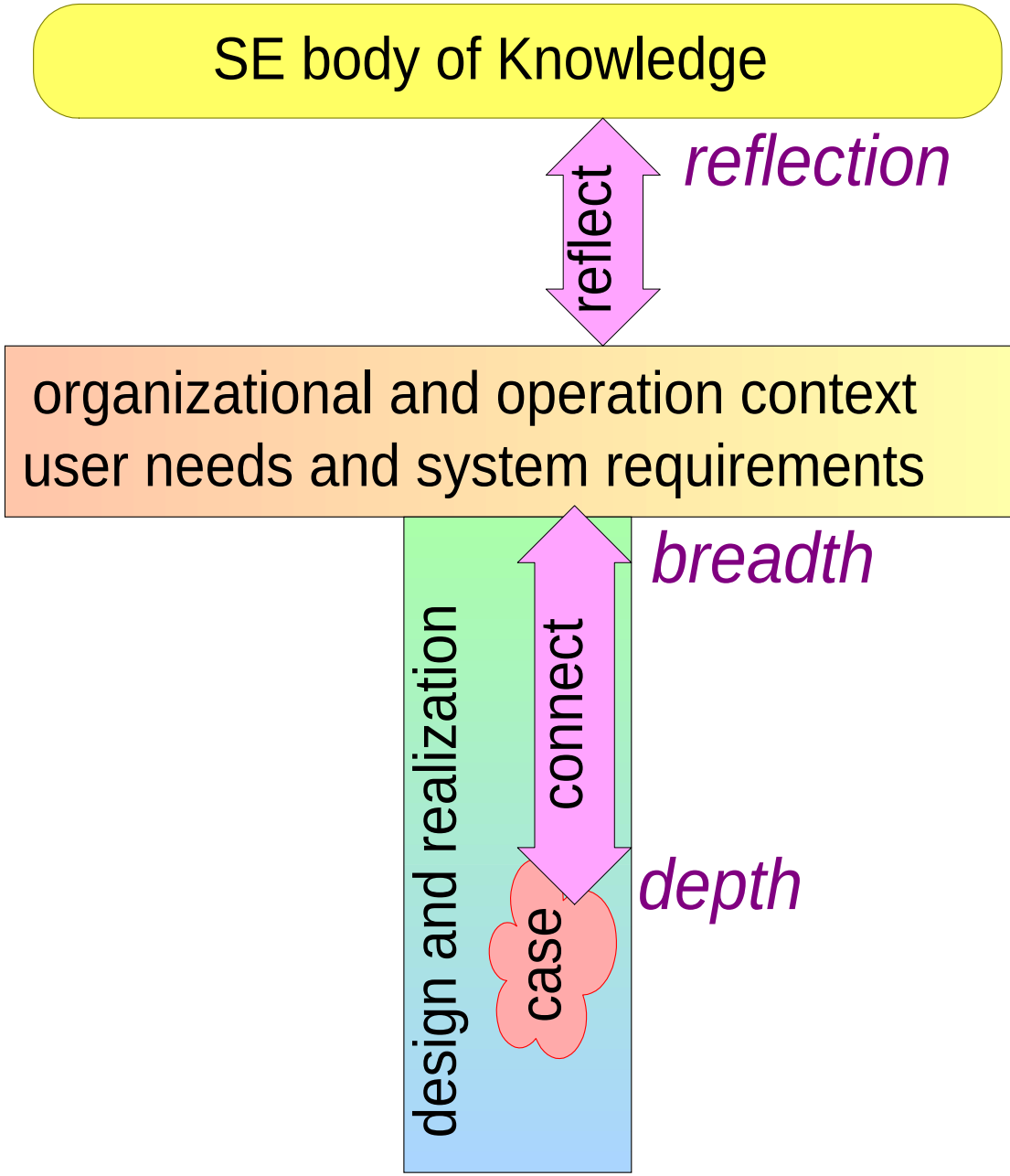


observational research	theory development	experimental research	fundamental research
best practices	metrics	theory evaluation	optimizations
heuristics	formalisms	theory evolution	rigorous proofs
classification	techniques	fundamentals	first principle based
ontology	models	principles	
	methods	methodologies	

Goal-Means Inversion



Counter Intuitive Spending of Time/Effort



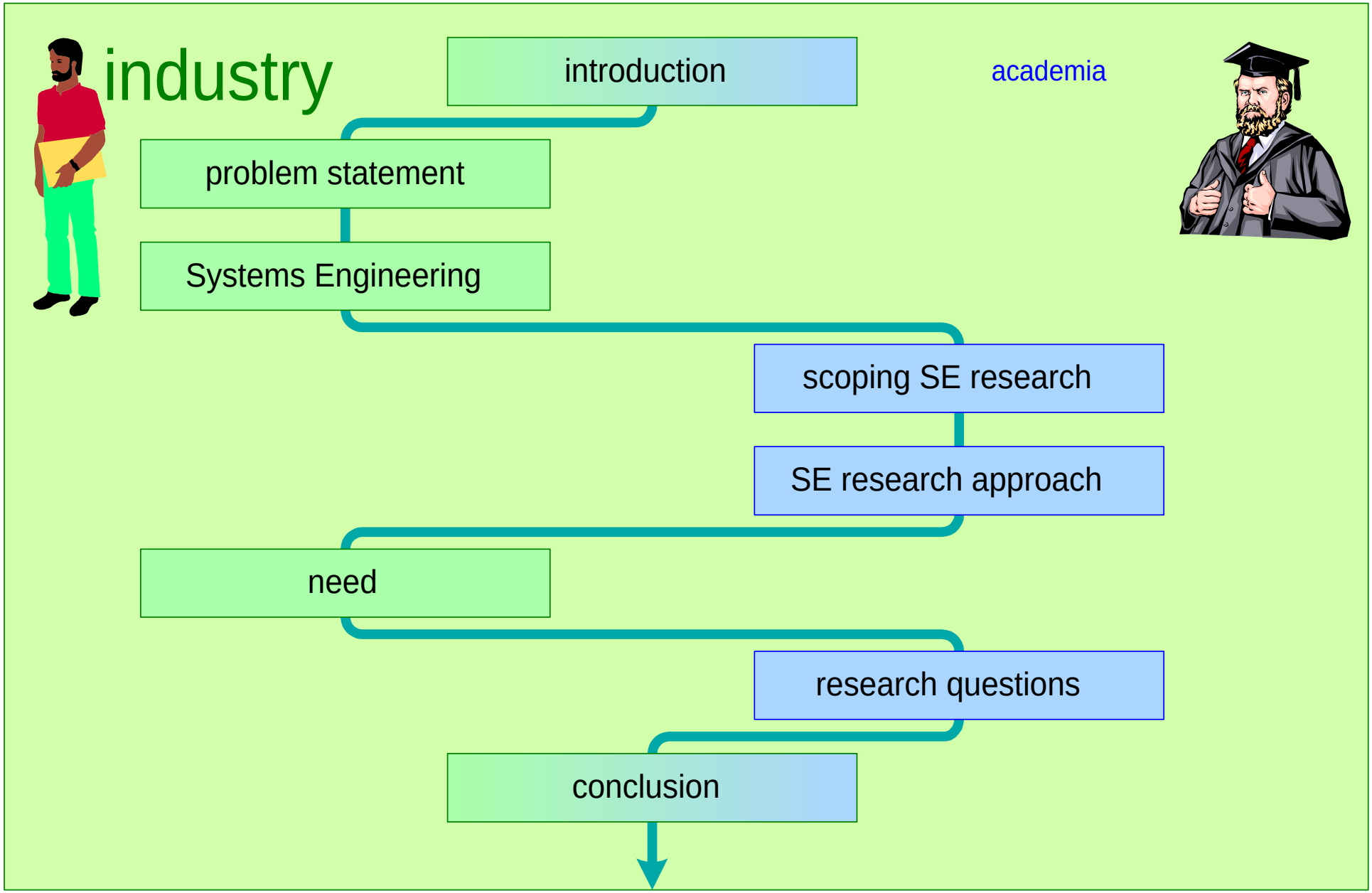
10%
reflection
academic achievement

20%
context
facilitation
lubrication

+

70%
blood, sweat,
and tears

Need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Designers in the Field (Industry)

How many views are used during design?

"one"-dimensional	few dimensional	many dimensional	too many	chaotic
e.g. one of	e.g. three of	e.g. ~10 of	e.g. >20	e.g. >50

object oriented	interfaces	time	maintenance	performance	business	power	operations
functional	physical	space	life cycle	reliability	process	energy	exceptions
behavioral	work break down	flow	installation	safety	organization	cooling	disposal
vibrations	planning	cost	manufacturing	security	people	efficiency	sustainability

et cetera, et cetera

majority of designers

better designers

experienced architects

analysis paralysis

Many Steps from Key Performance to Engineering Detail

context : other systems, environment, fab-infrastructure, operators, IC-products, wafers, reticles, process, ...

productivity, overlay, imaging = f(*context* , ~10 main *functions*)

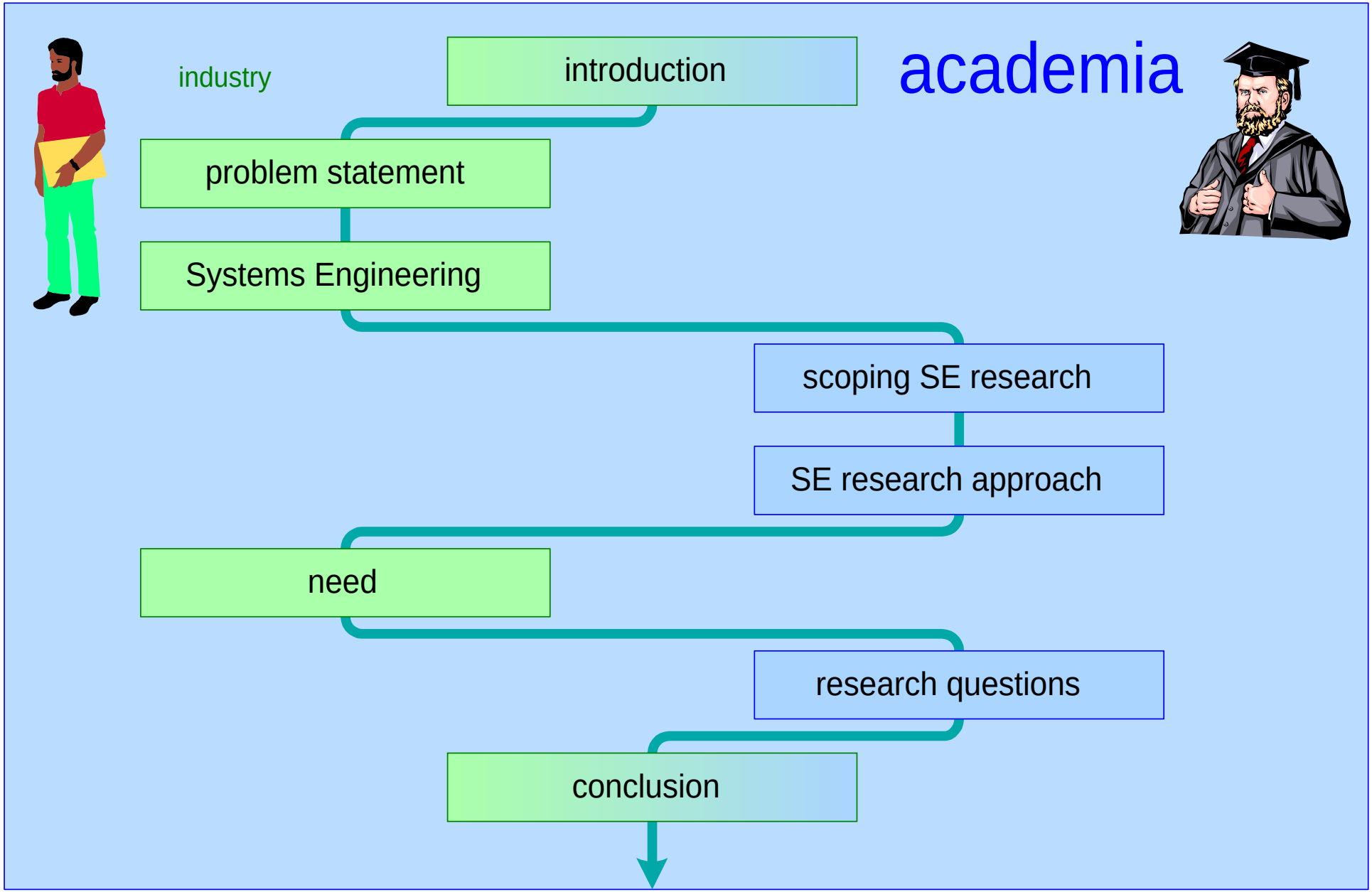
functions , e.g. align, position, level, focus, expose, load, unload, climate condition, ... = g(15 *subsystems*)

subsystems , e.g. wafer stage, reticle stage, lens, illuminator, laser, ... = h(1k+ of *subsubsystems*)

subsubsystems = i(10k..100k+ of hardware and software *components*)

components = j(1M+ *statements* , *connections* , *sizes* , *materials* , ...)

Research Questions



Example Research Questions

What makes good systems architects successful?

How to design in many dimensional space?

How to cope with heterogeneous dimensions?

How to distribute work over many designers?

What design methods prevent integration surprises?

What models support the multi-disciplinary design?

et cetera

et cetera

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Industry and Systems Research

industry	systems reseach
=	requires:
field (to be observed)	open/perceptive attitude
laboratory (to experiment)	critical attitude
customer (to benefit)	large dynamic range

isn't that the meaning of academic?