

A VISION ON THE FUTURE OF SYSTEMS ENGINEERING, WHAT CAPABILITIES WILL WE NEED?

Keynote at TNO-ESI symposium 2025

Gerrit Muller

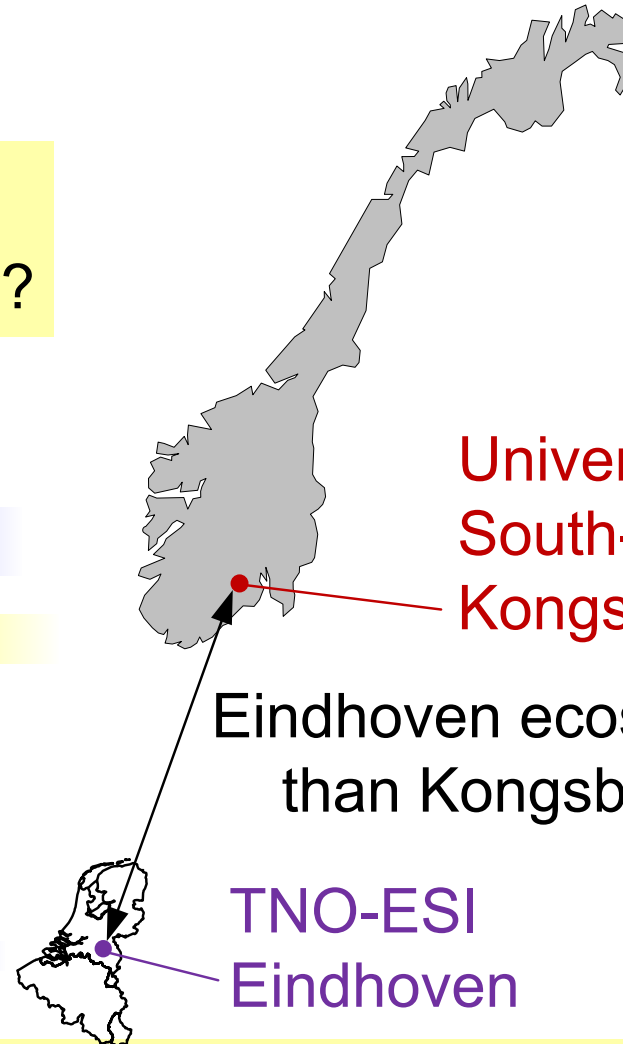
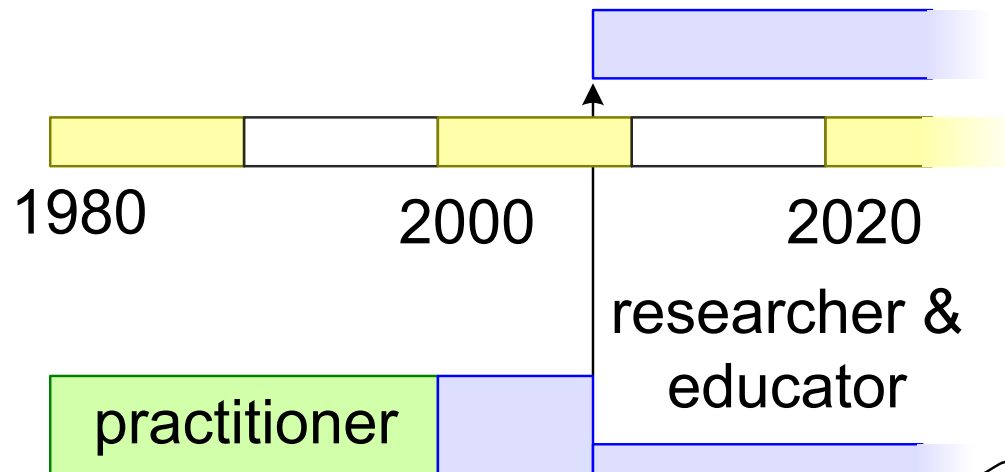
GERRIT: 26 YEARS OF INDUSTRY-AS-LABORATORY

practitioner and **academic**



research focus: how to
develop systems effectively?

Dutch and **Norwegian**



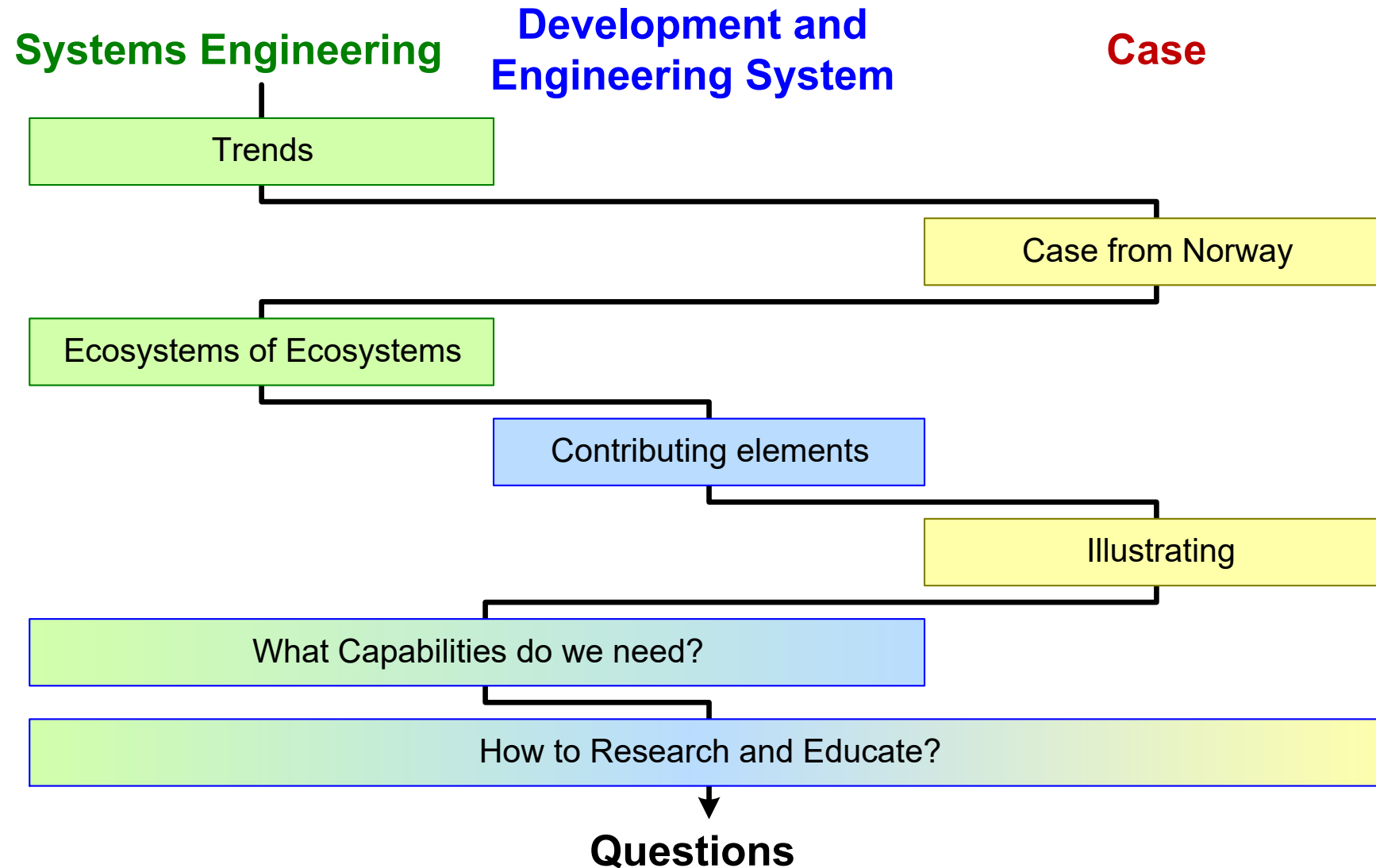
University of
South-Eastern Norway
Kongsberg

Eindhoven ecosystem 10* larger
than Kongsberg ecosystem

TNO-ESI
Eindhoven

Henk Obbink proposed in 1999 Potts' Industry-as-Laboratory^{A, B}

FIGURE OF CONTENT



MAJOR TRENDS IN SYSTEMS ENGINEERING

- anno 2025, systems are **socio-technical cyber-physical systems-of-systems**
- these systems operate in **extensive ecosystems**
- **humans and organizations** cause **complexity**
- climate emergency: **sustainability** is an additional container of qualities
- political emergency: **security** is critical
- **digital technologies** enable capabilities across constituent systems
- biological, clinical, pharmaceutical, material science, **and many more technologies** change rapidly

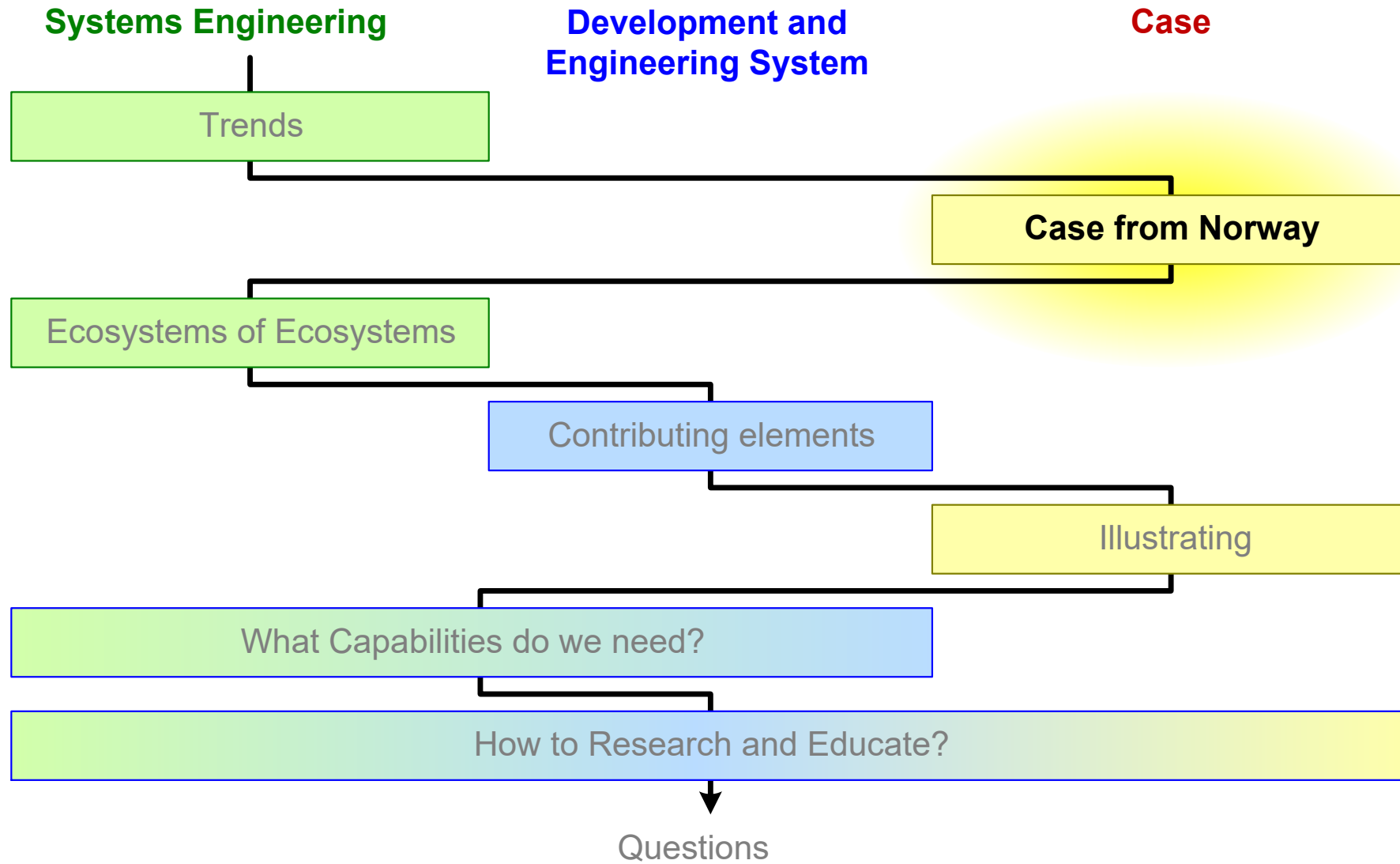
legend

social

technical

integral

LEARNING FROM THE NORWEGIAN OIL AND GAS INDUSTRY



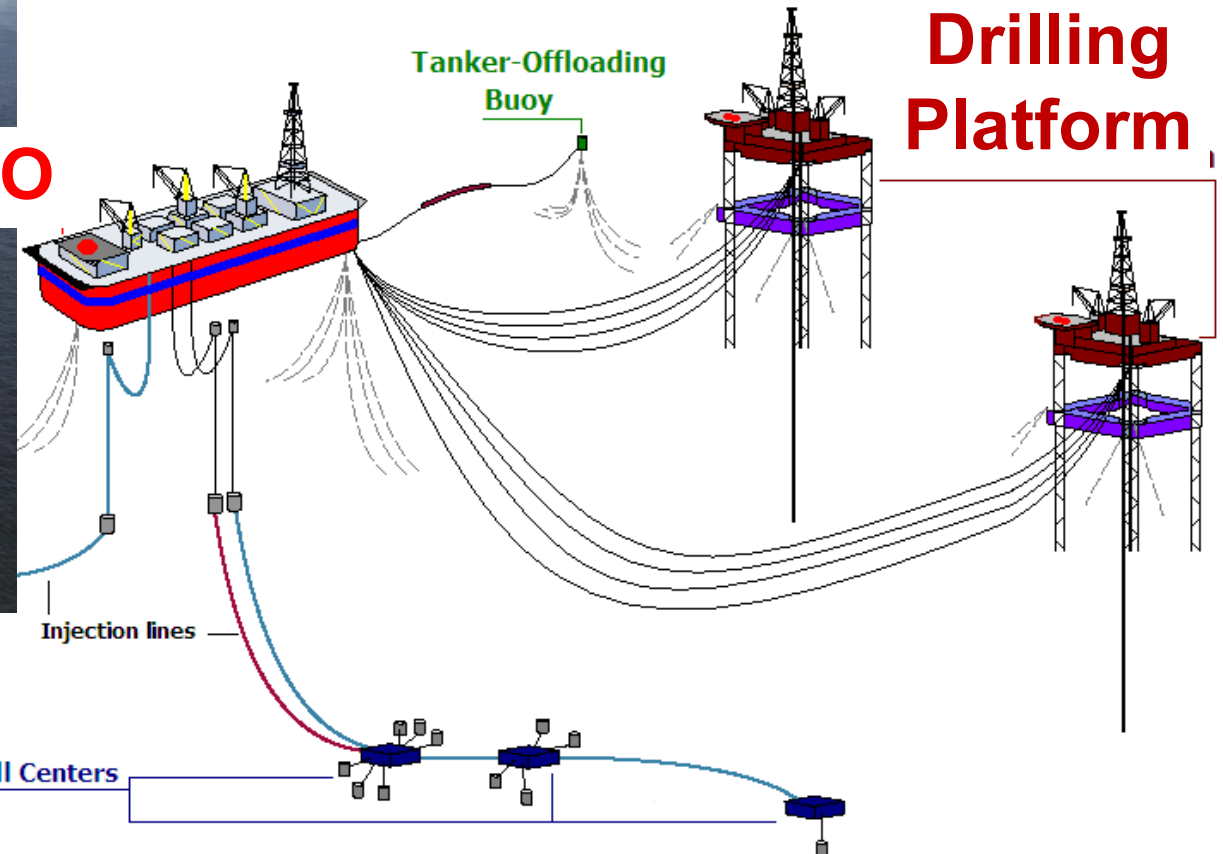
FLOATING PRODUCTION STORAGE & OFFLOADING AND OIL FIELD



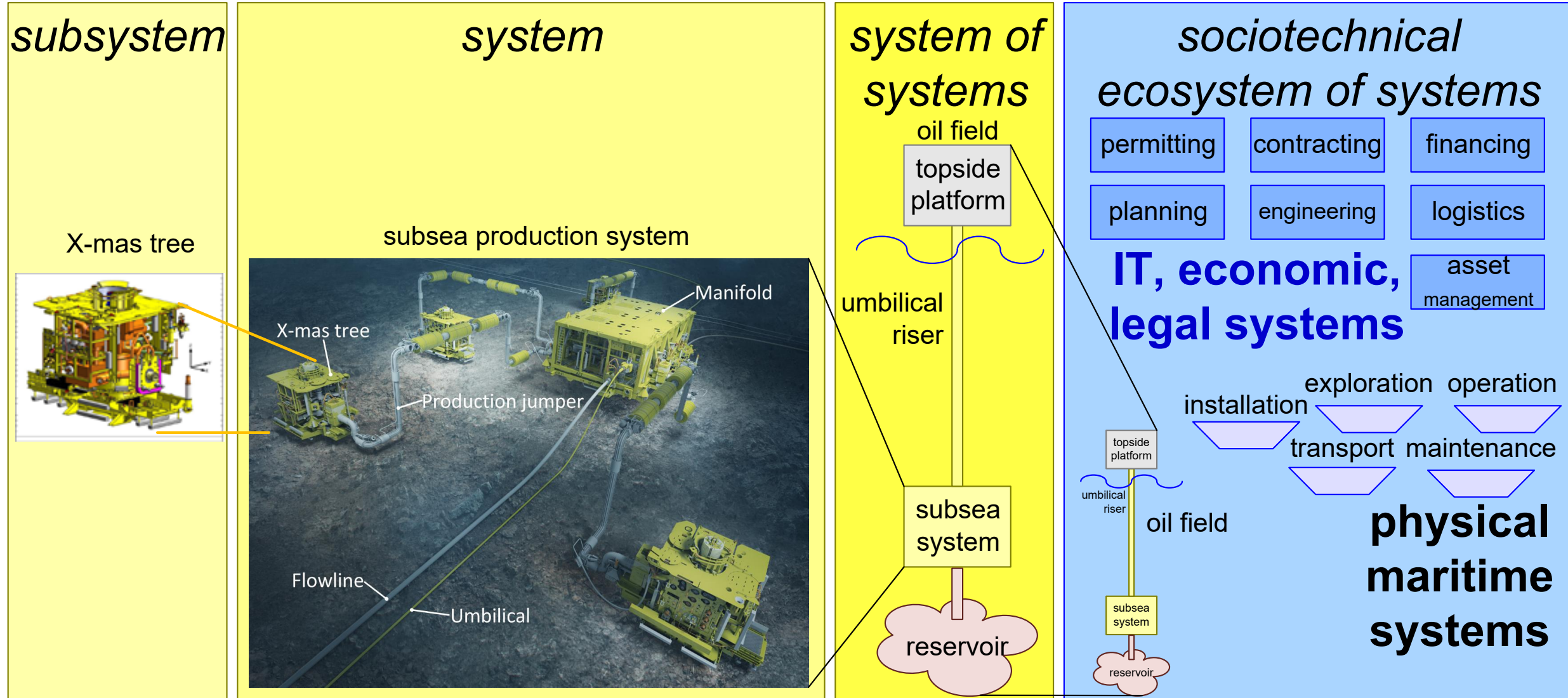
FPSO

By Edersguerri - Own work, CC BY-SA 3.0, <https://commons.wikimedia.org/w/index.php?curid=22172352>

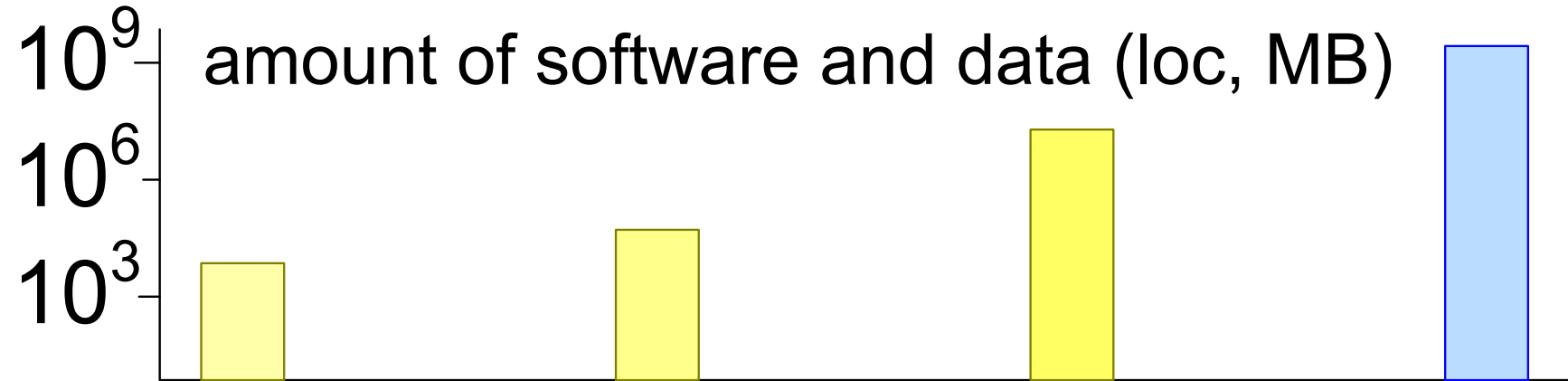
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FROM SYSTEM TO OIL AND GAS ECOSYSTEM

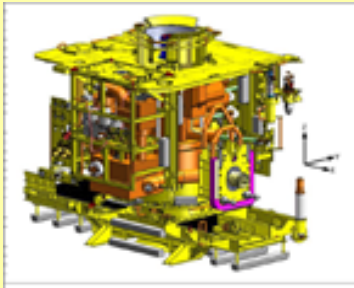


EXPONENTIAL INCREASE OF AMOUNT OF SOFTWARE AND DATA



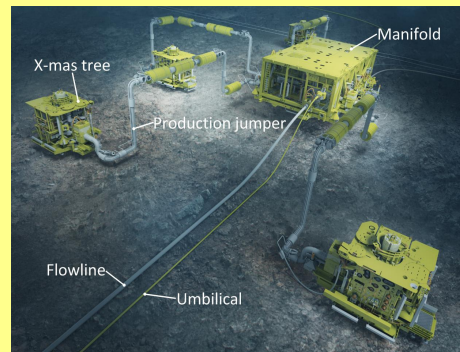
subsystem

X-mas tree



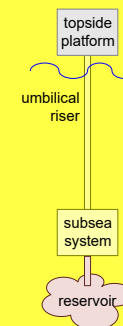
system

subsea production



system of systems

oil field



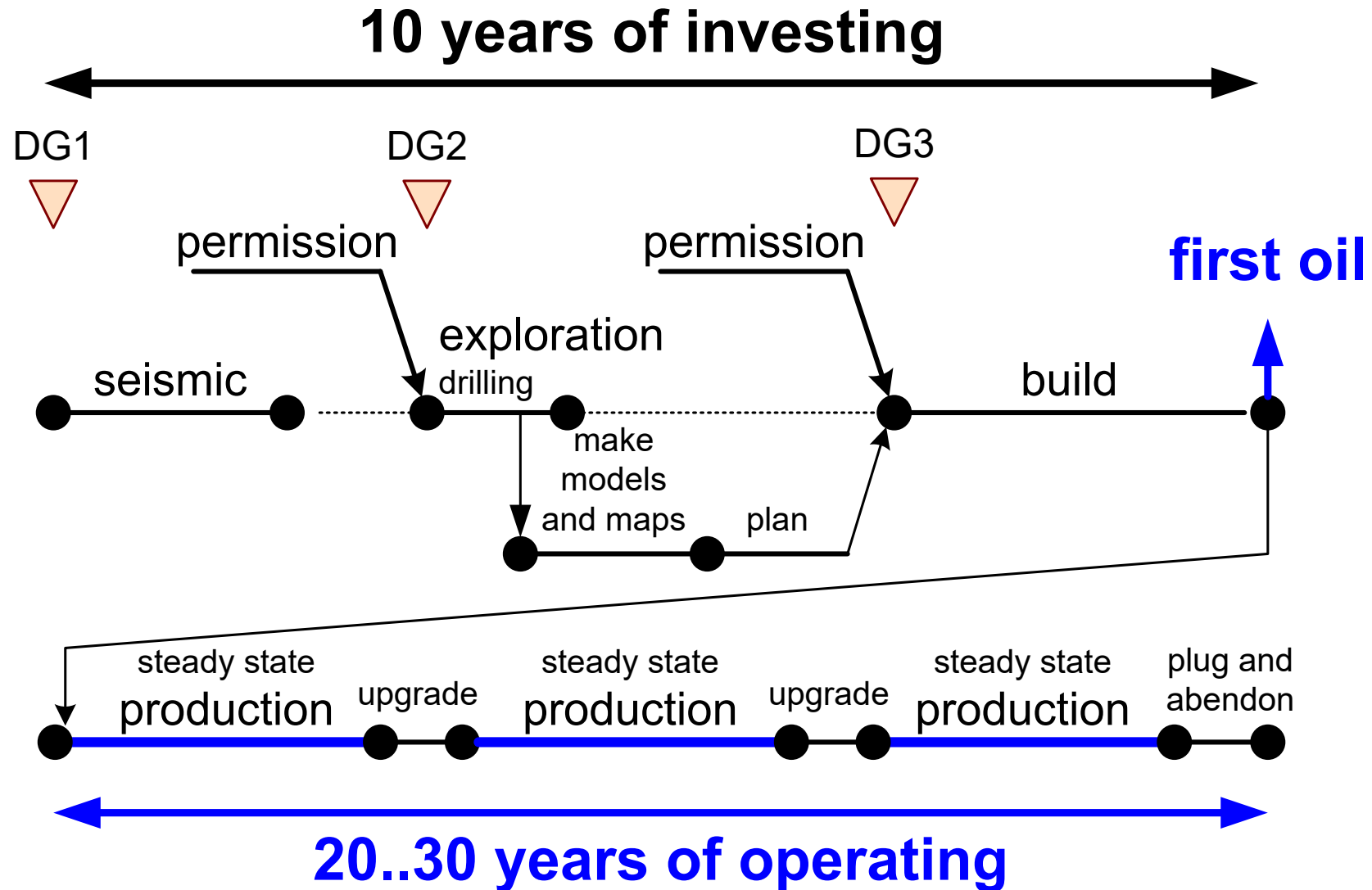
sociotechnical ecosystem of systems

**IT, economic,
legal**

**oil
field**

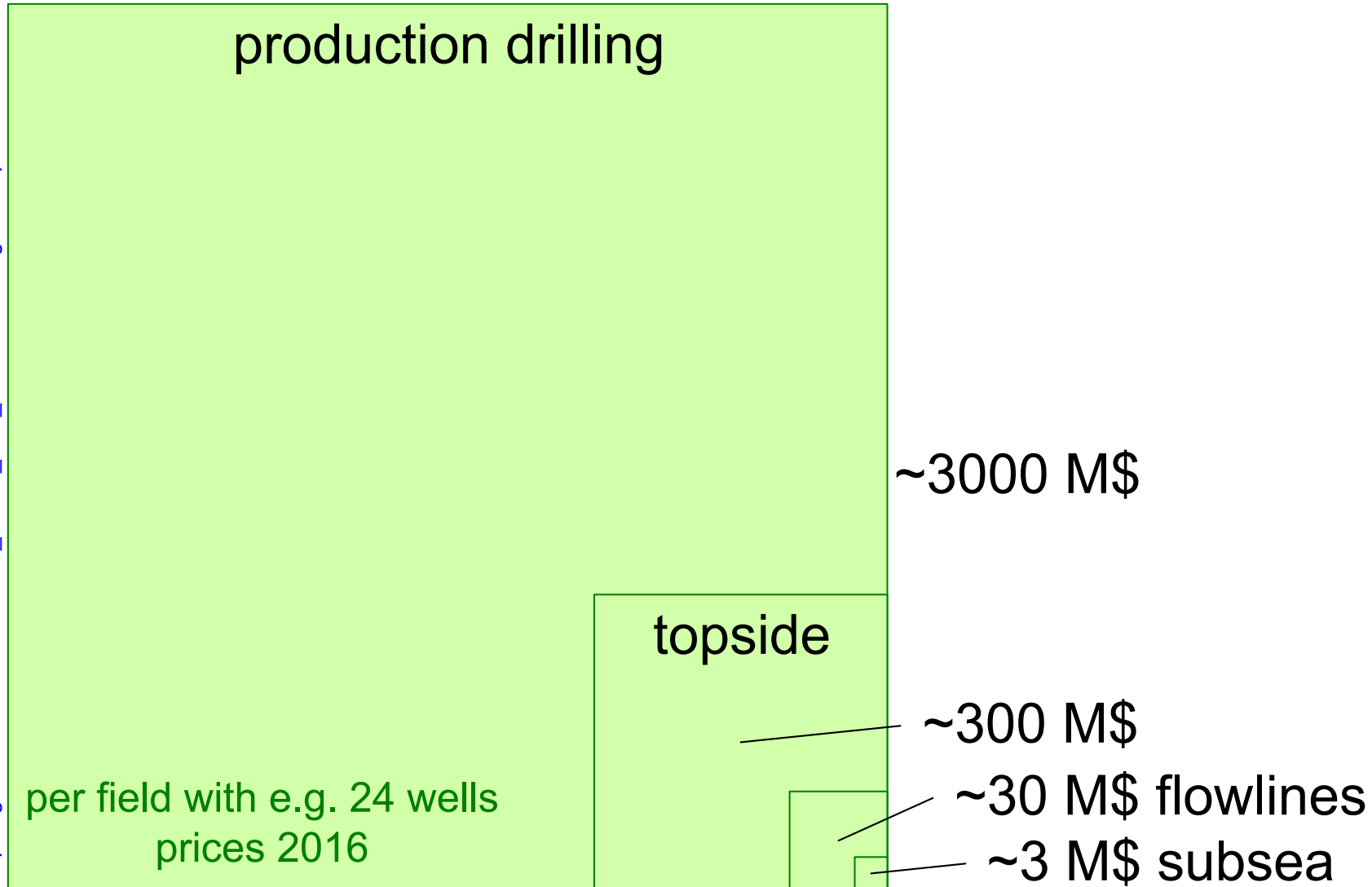
**physical
maritime**

LIFE CYCLE OF AN OIL AND GAS FIELD

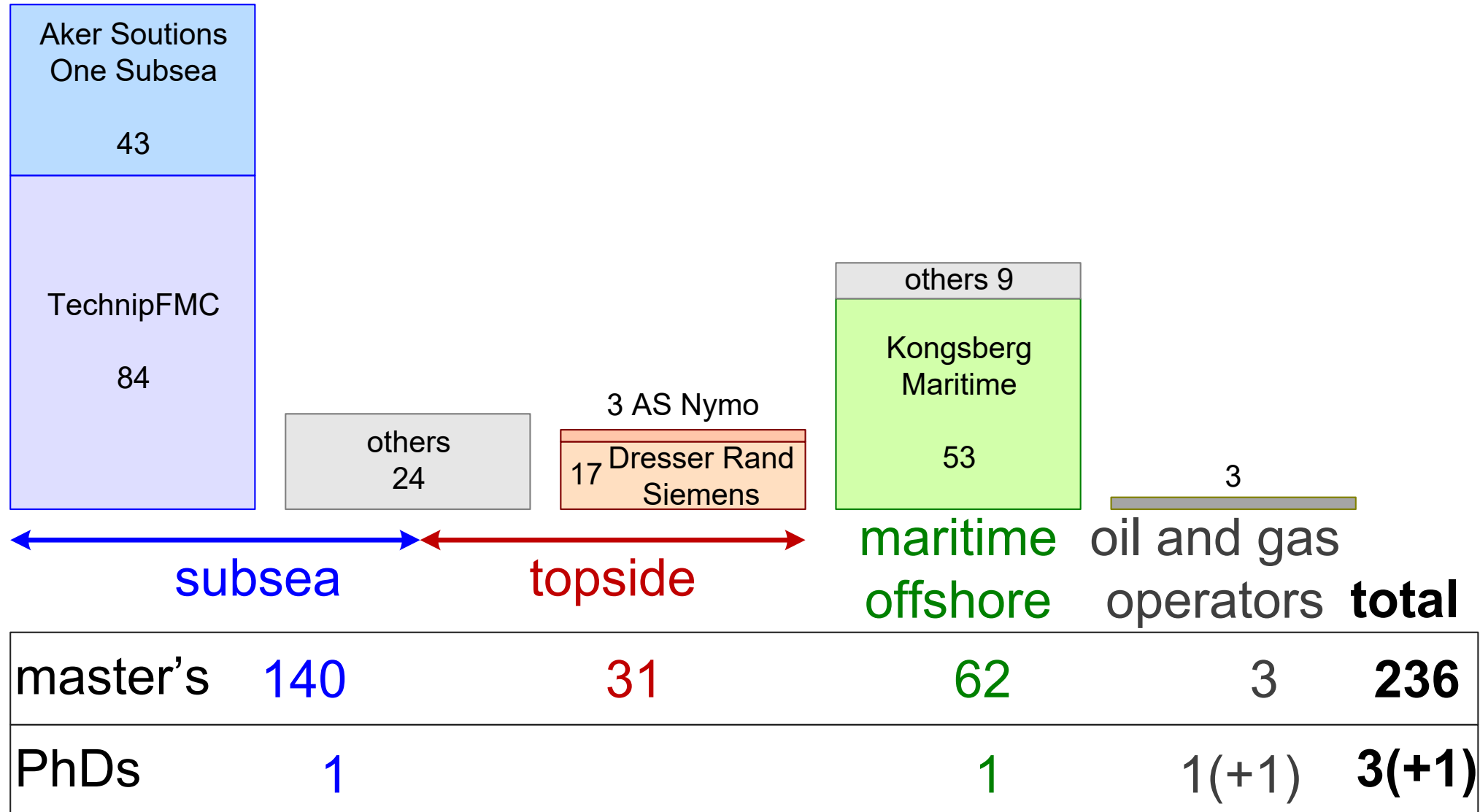


BUILD COST DECOMPOSITION OIL AND GAS FIELD

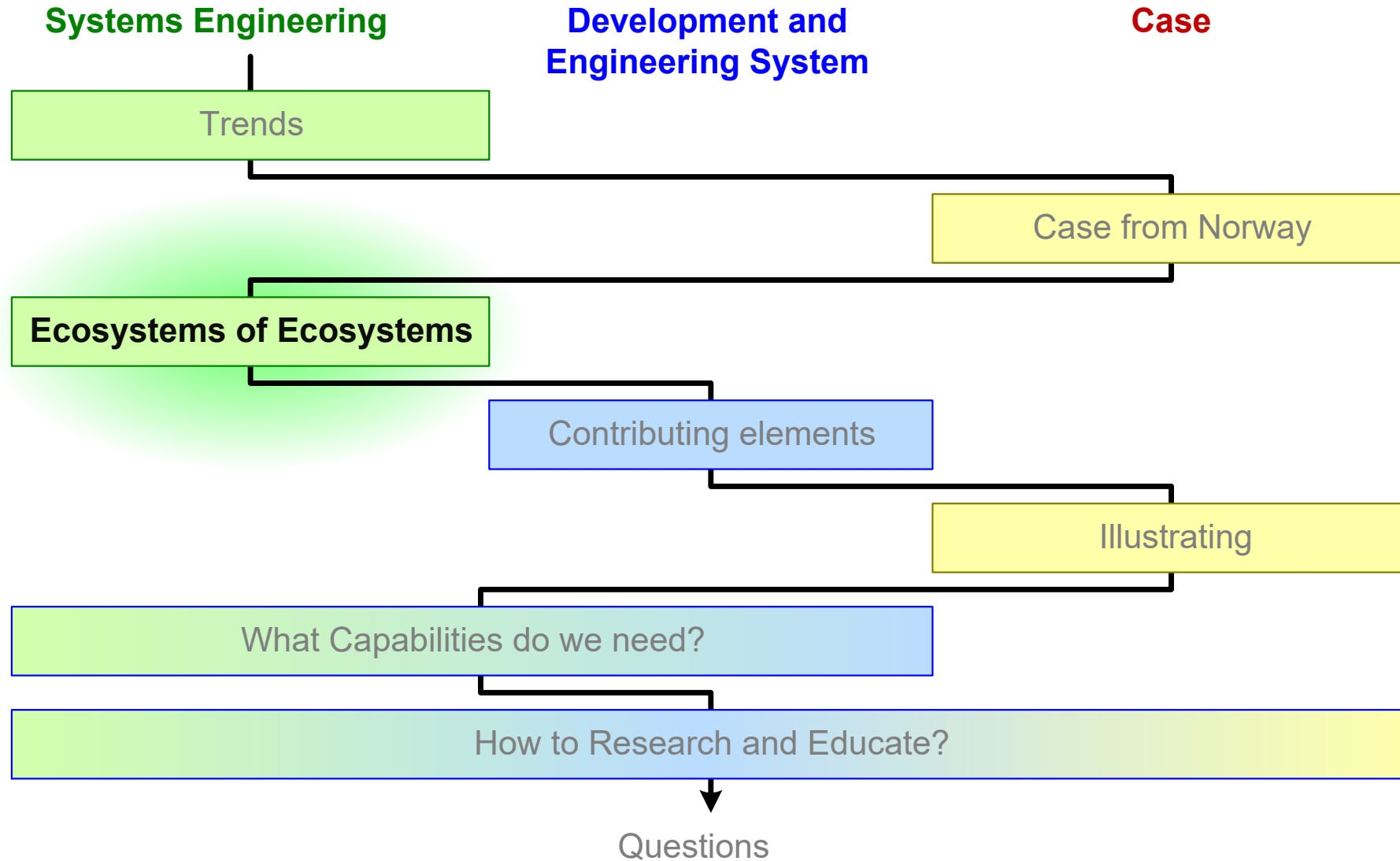
based on: Reducing Project Cost Growth Through Early
Implementation of Interface Management, Nilsen et al, INCOSE 2018,
https://gaudisite.nl/INCOSE2018_Nilsen_Falk_InterfaceManagement.pdf



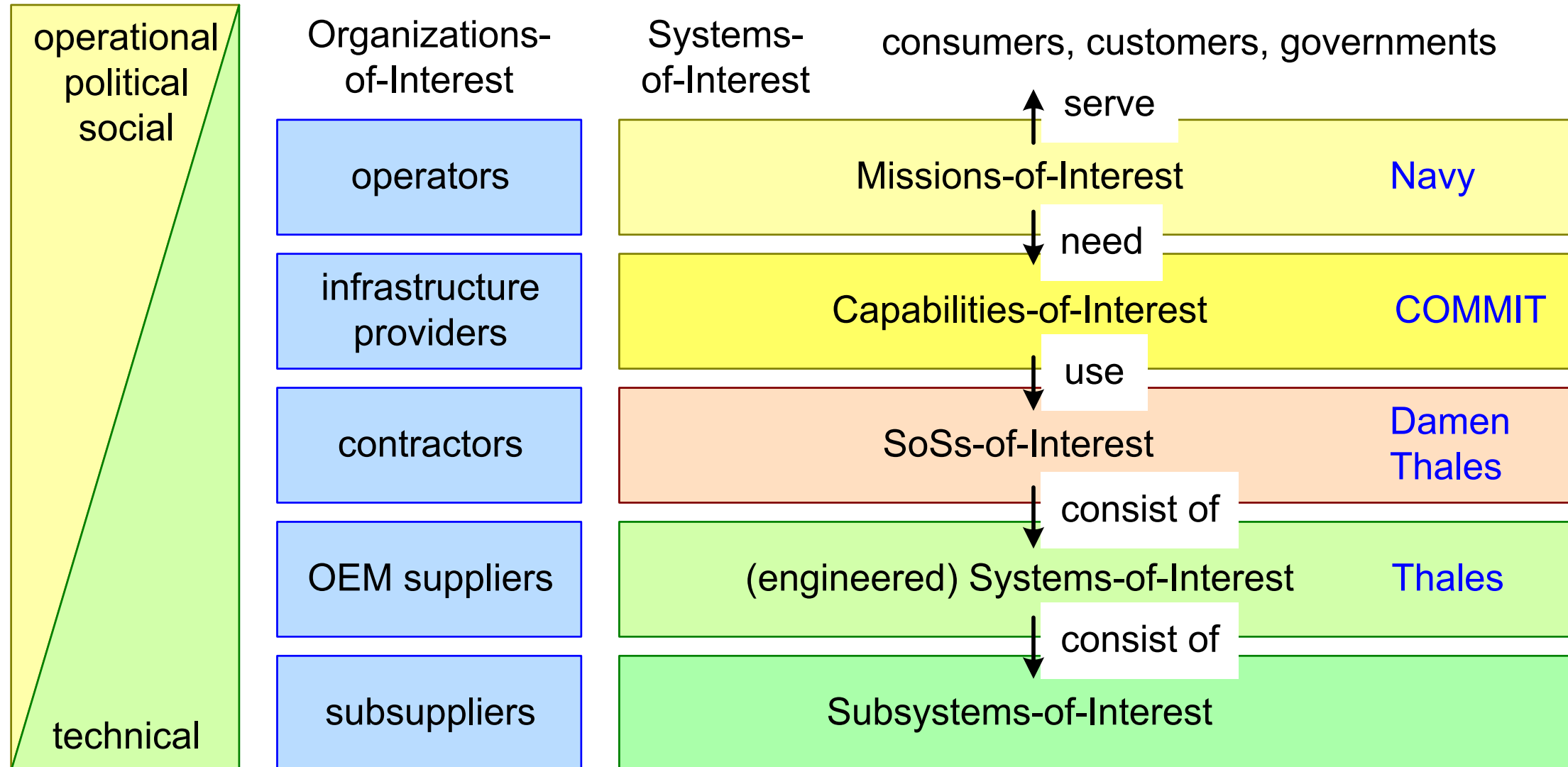
NUMBER OF MASTER STUDENTS IN O&G DOMAIN SINCE 2006



ECOSYSTEMS OF ECOSYSTEMS



THE PERSPECTIVE CHANGES WHEN GOING UP IN THE VALUE CHAIN



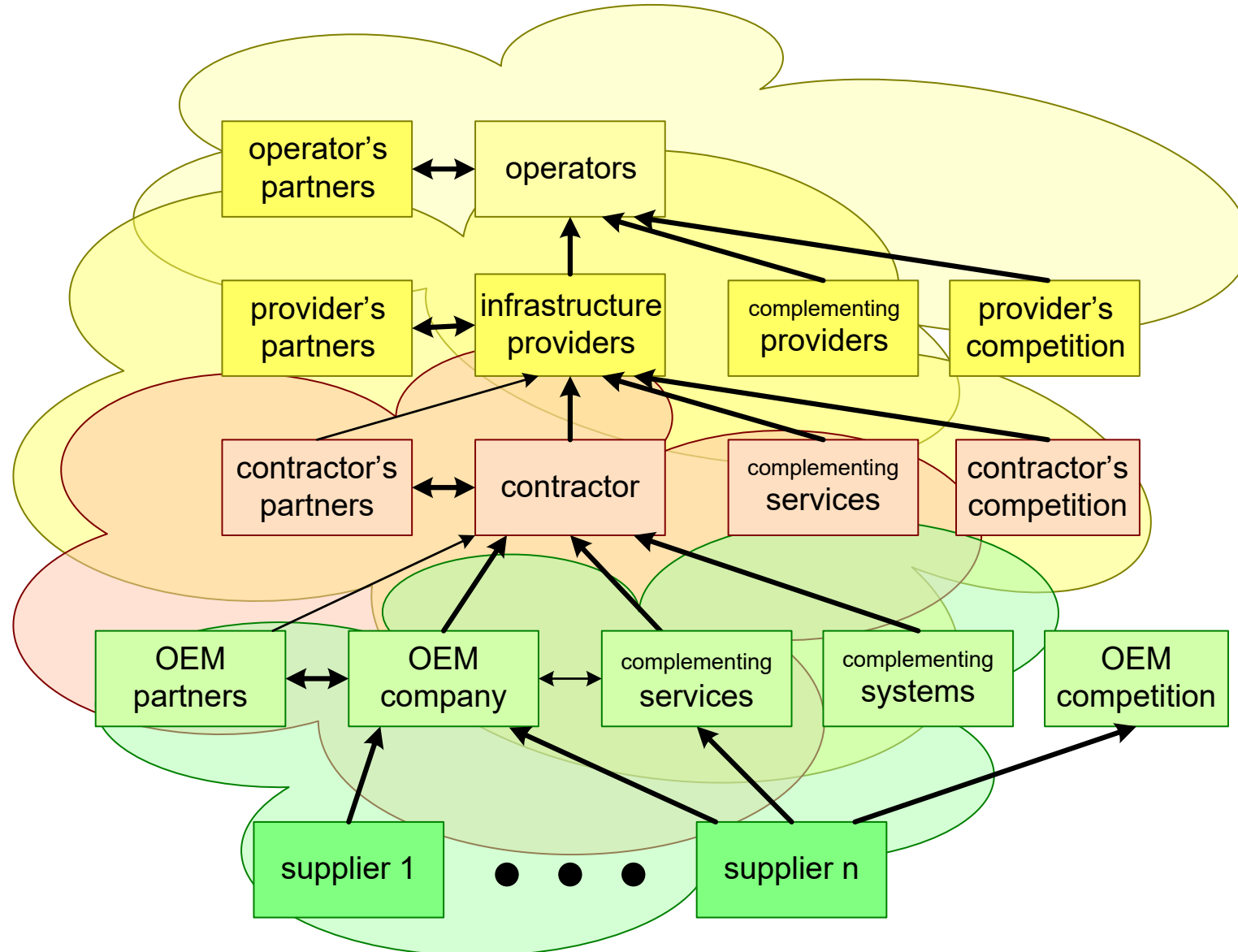
EACH LAYER IS AN ECOSYSTEM

**operator
ecosystem**

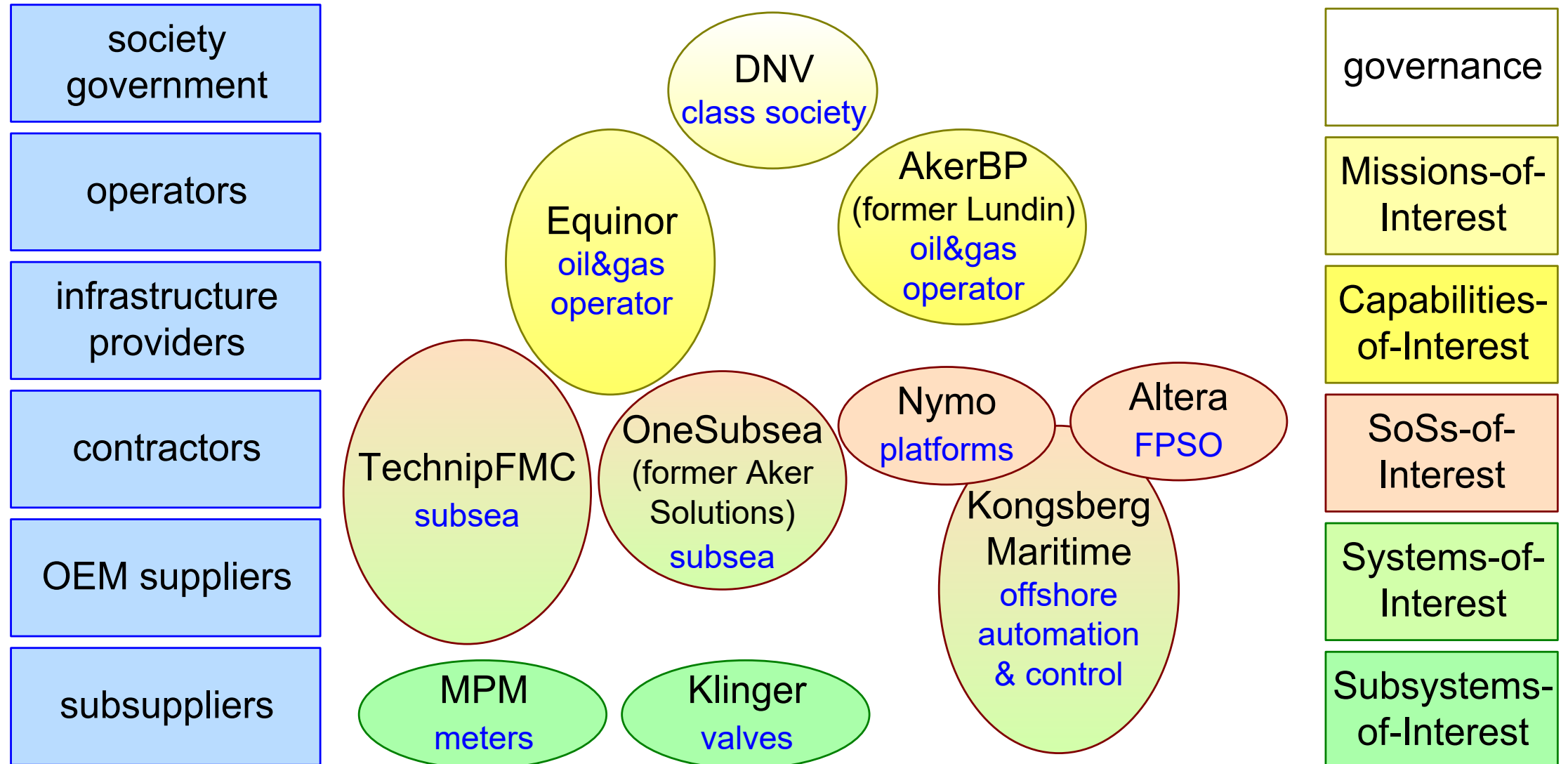
**provider
ecosystem**

**contractor
ecosystem**

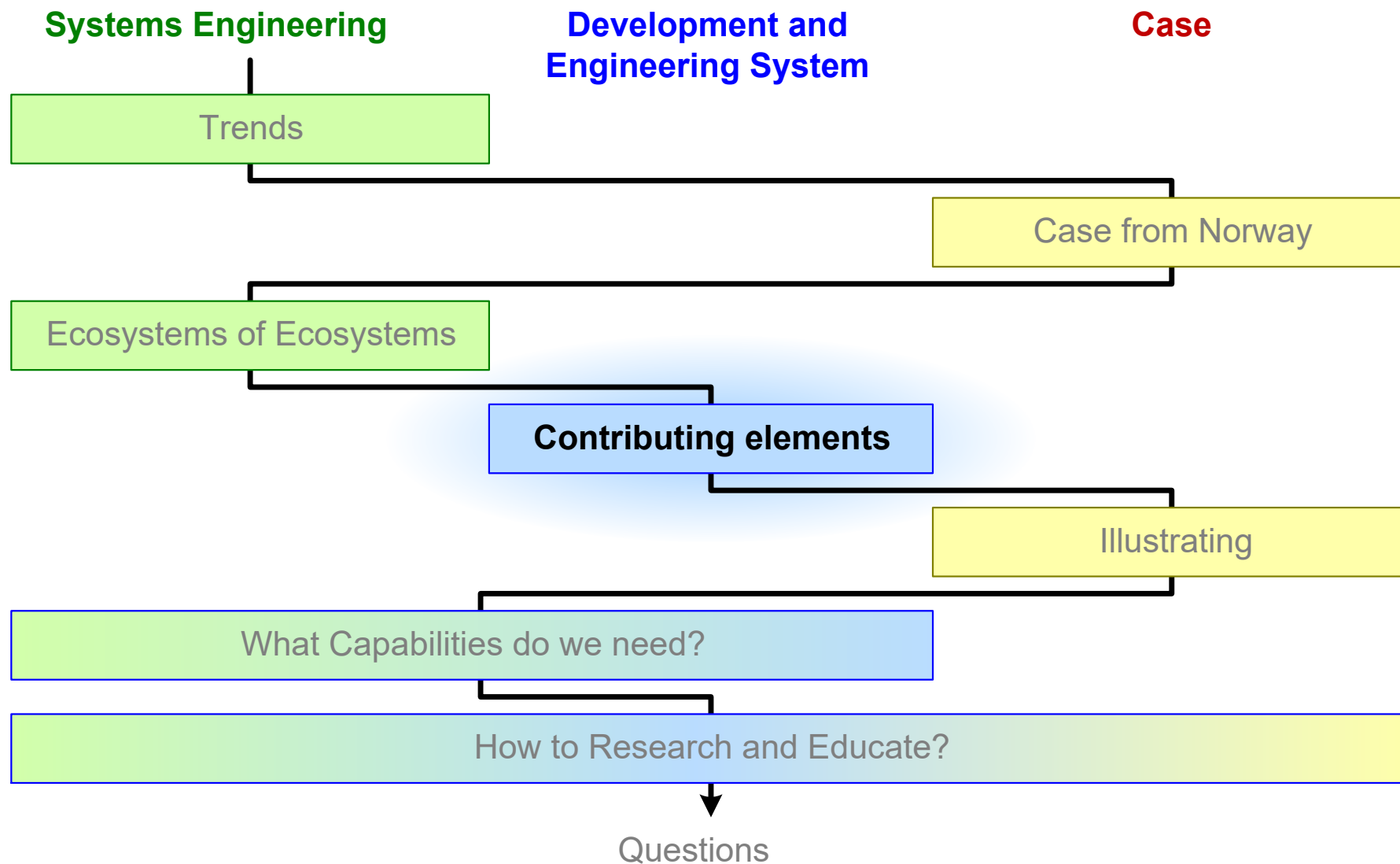
**OEM
ecosystem**



NORWEGIAN OIL AND GAS MAPPED ON THE LAYERS



WHAT CONTRIBUTES TO DEVELOPMENT AND ENGINEERING SYSTEM?



DEVELOPING THE DEVELOPMENT AND ENGINEERING SYSTEM

research & education focus: how to develop systems effectively?



role models

systems engineering
systems architecting
systems integration
configuration man.

**capabilities
competencies**

stakeholder engagement
conceptual modeling
writing requirements
foundational knowledge

product creation
change management
quality management

**process
organization**

line management
program structure

repositories
access control
authentication

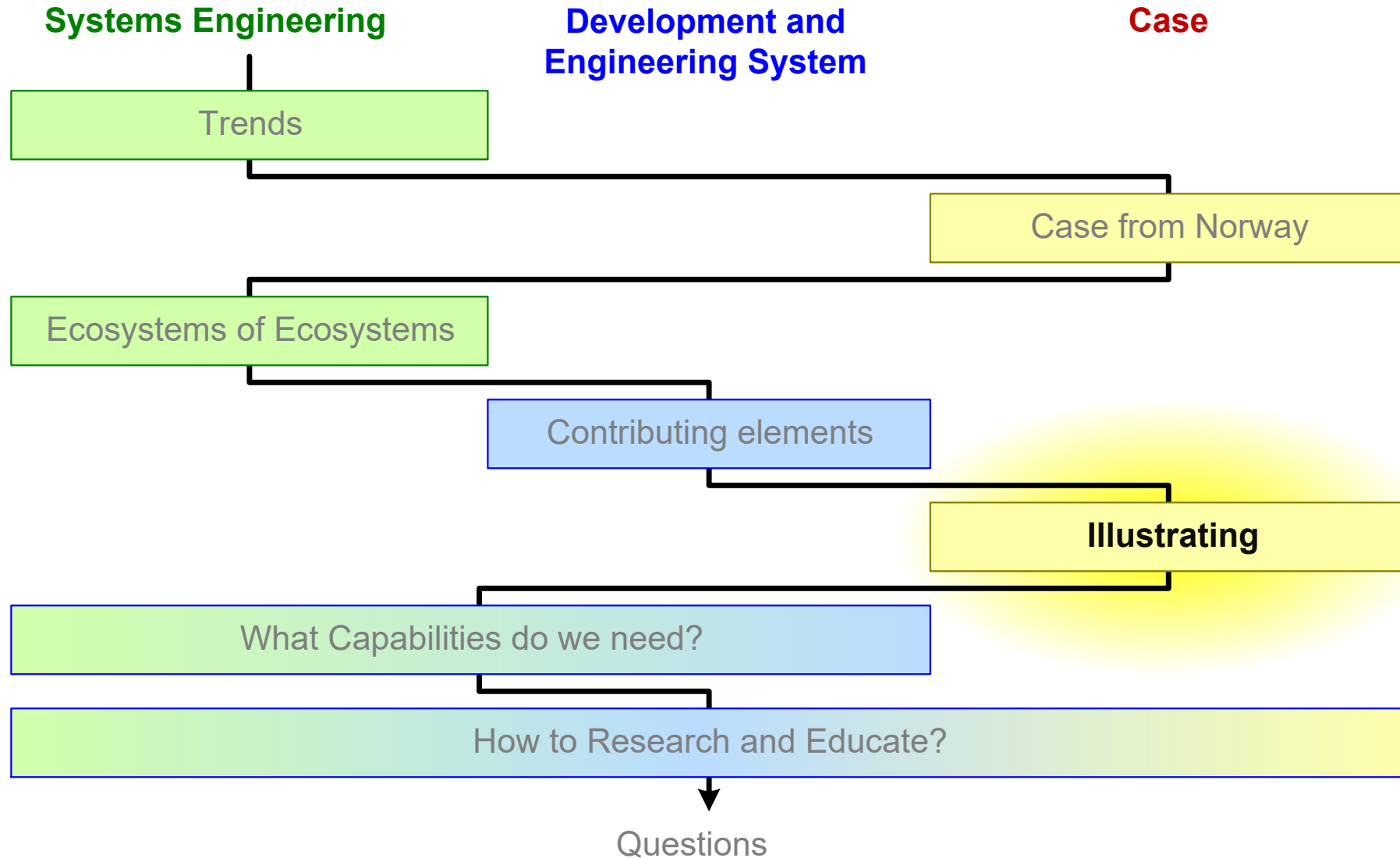
**infrastructure
tools**

MBSE
ERP
CAD

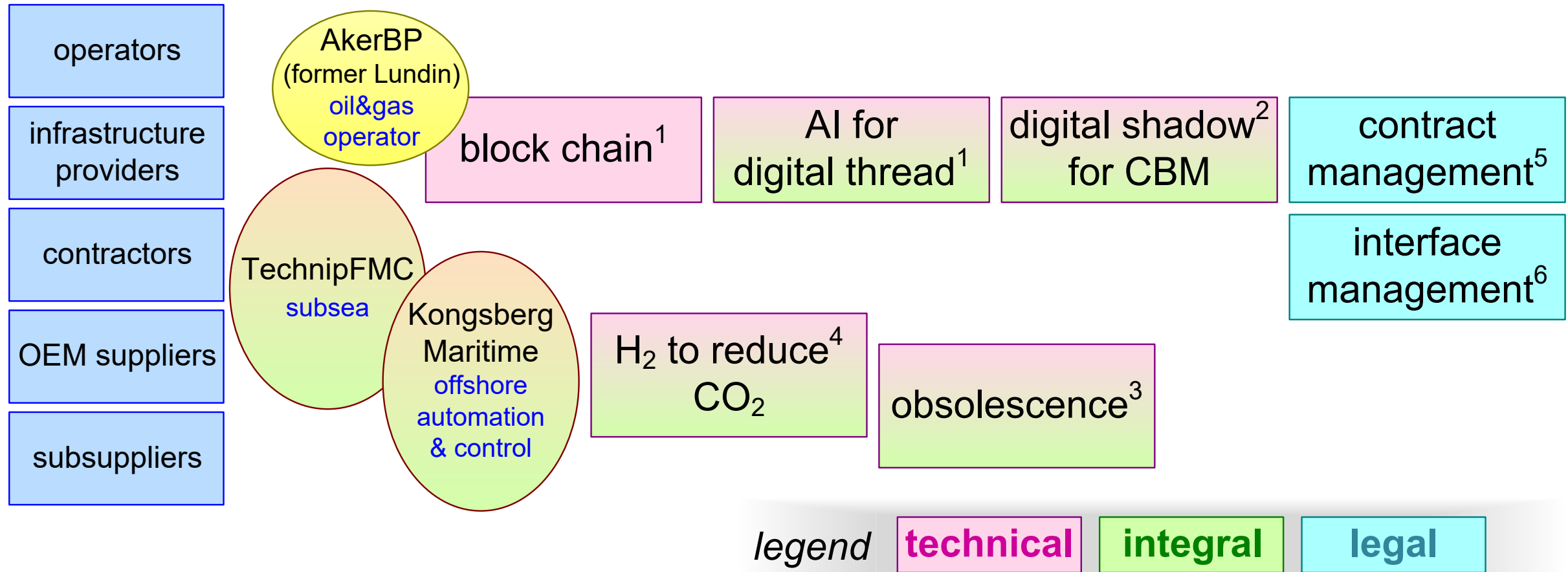
social

technical

ILLUSTRATING WITH NORWEGIAN OFFSHORE



NORWEGIAN OFFSHORE CASES



DIGITAL TRANSFORMATION IN OFFSHORE; AI FOR DIGITAL THREAD

AkerBP
(former Lundin)
oil&gas
operator

block chain¹

Karen Czachorowski's PhD research started as

“What can block chain bring?” (Gerri't's paraphrase)

However, it turned into a study of the needs and potential of the

Digital Transformation in Exploration and Production supply chain operations

AI for
digital thread¹

Acquisition

Delivery

Operation

infrastructure
providers

Must: digital
documentation

infrastructure
providers

digital thread

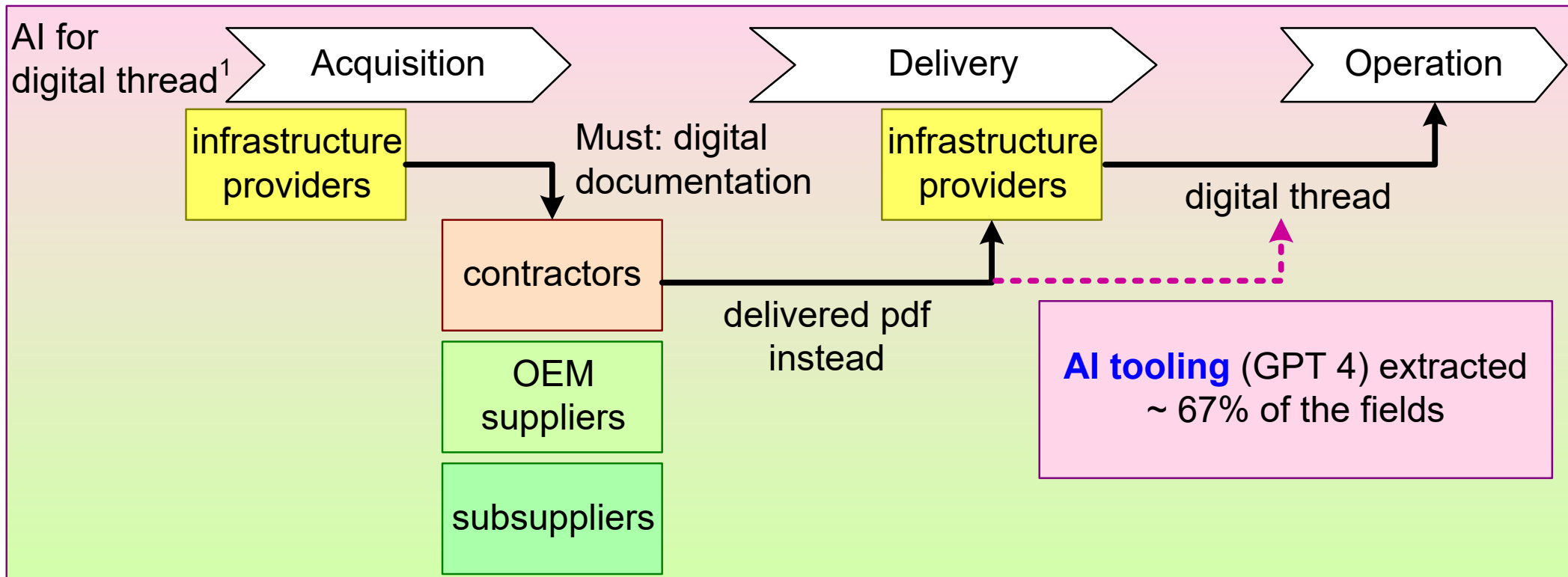
contractors

delivered pdf
instead

OEM
suppliers

subsuppliers

AI tooling (GPT 4) extracted
~ 67% of the fields



DIGITAL SHADOW TO IMPROVE OPERATION AND MAINTENANCE

AkerBP
(former Lundin)
oil&gas
operator

digital shadow² for Condition-Based Maintenance

Kim Jørgensen: “Only about 15% to 20% of equipment failures are age related”

Periodic Maintenance risks

- Too frequent maintenance
- Increased risk of maintenance induced failures
- Infant mortality issues
- Safety issues?!

Condition monitoring of 3678 field units, based upon approx. 43 000 signals

“**We have to become better at learning of failures.**”

Voice-over: **regulation mandates most periodic maintenance**

FROM OBSOLESCENCE TO CONTRACT MANAGEMENT

AkerBP
(former Lundin)
oil&gas
operator

Lasse moved
↗

contract management⁵

Anno 2025, managing **over 50 contracts** for **support services** of O&G installations

- Living for **decades**
- However **evolving** continuously

Kongsberg
Maritime
offshore
automation
& control

obsolescence³

Lasse Sletaker master's thesis:

Total Cost Model for Last Time Buy Estimation
for **obsolescence** of a **controller chip**

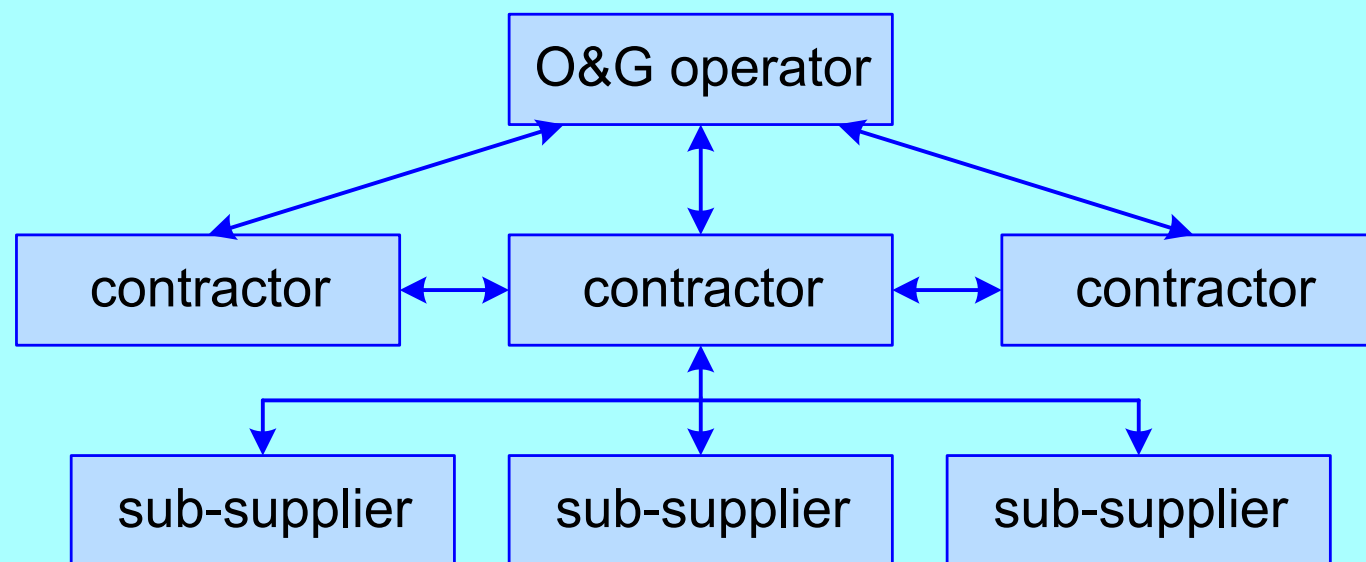
INTERFACE MANAGEMENT AS LEGAL PERSPECTIVE

TechnipFMC
subsea

interface management⁶

Magnus André Nilsen's master's thesis

researching **cost of Variation Orders** and impact of Interface Management

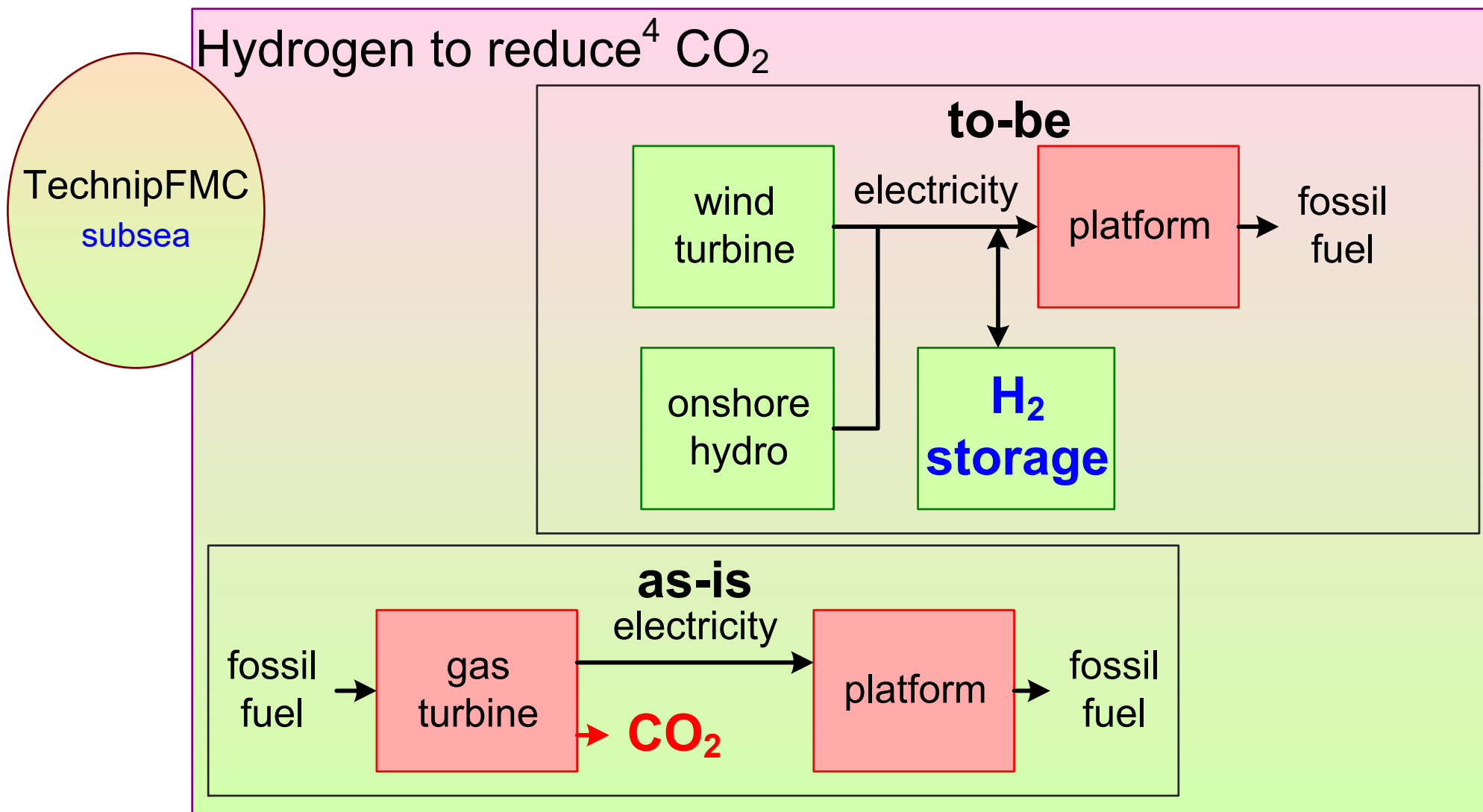


in Oil and gas domain,

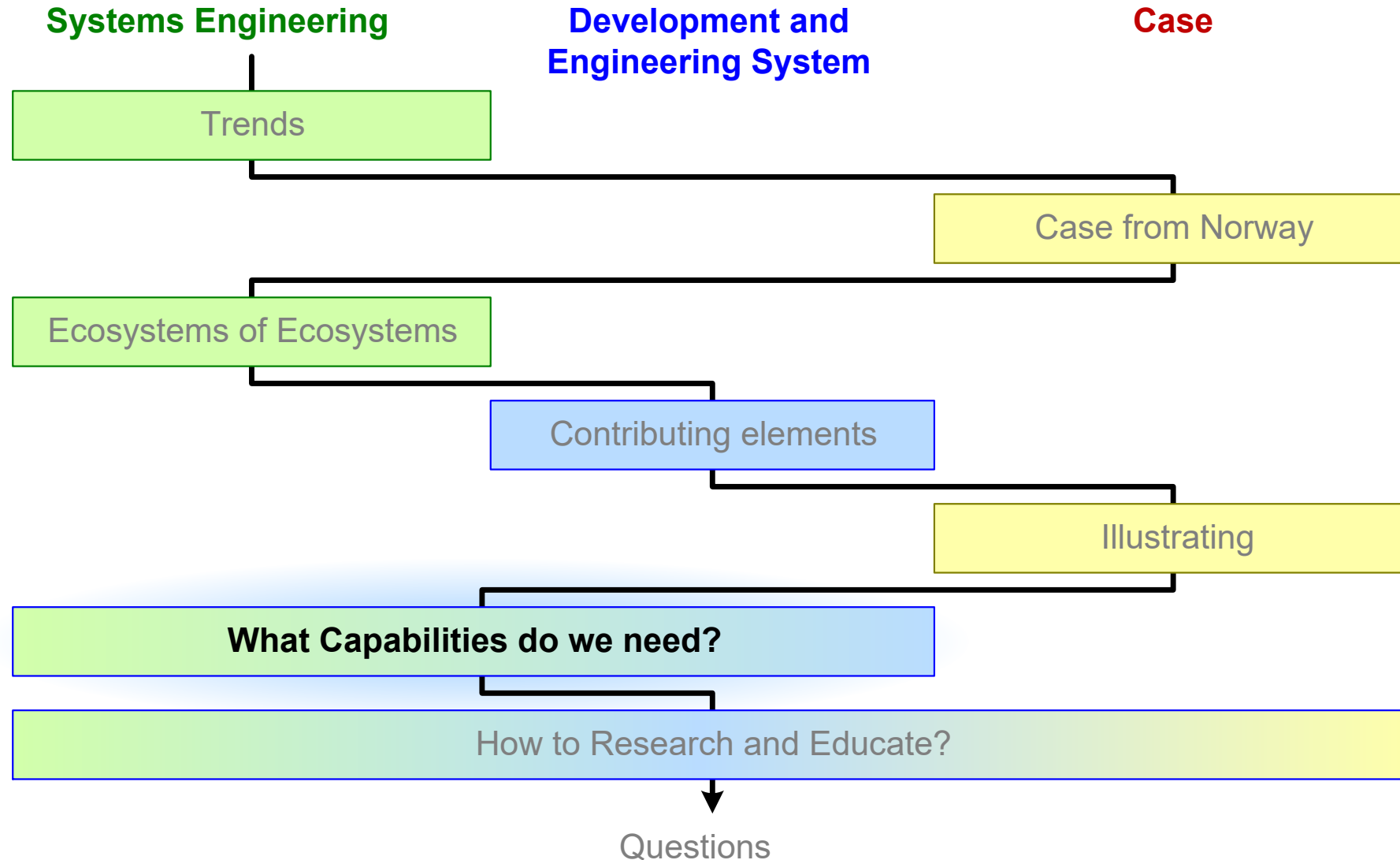
Interface Management = formal inter-organization communication

formal in terms of **contracts** and **legally** defined

HOW TO MAKE FOSSILS LESS UNSUSTAINABLE?



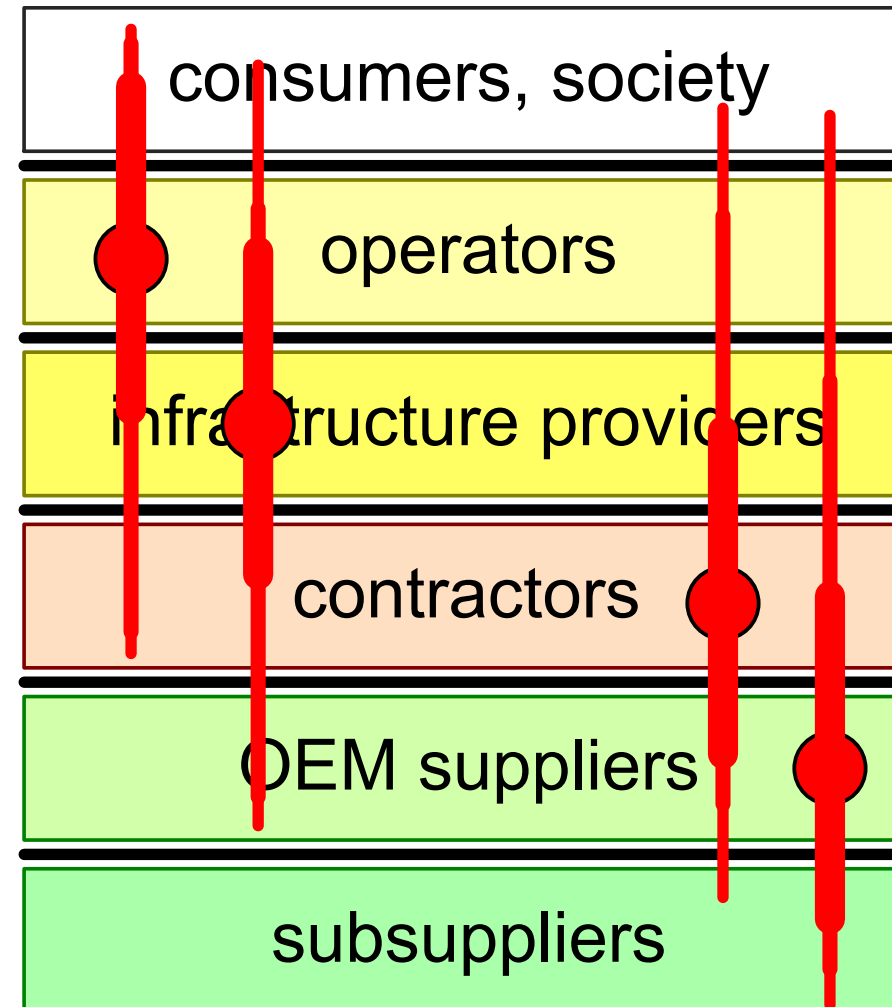
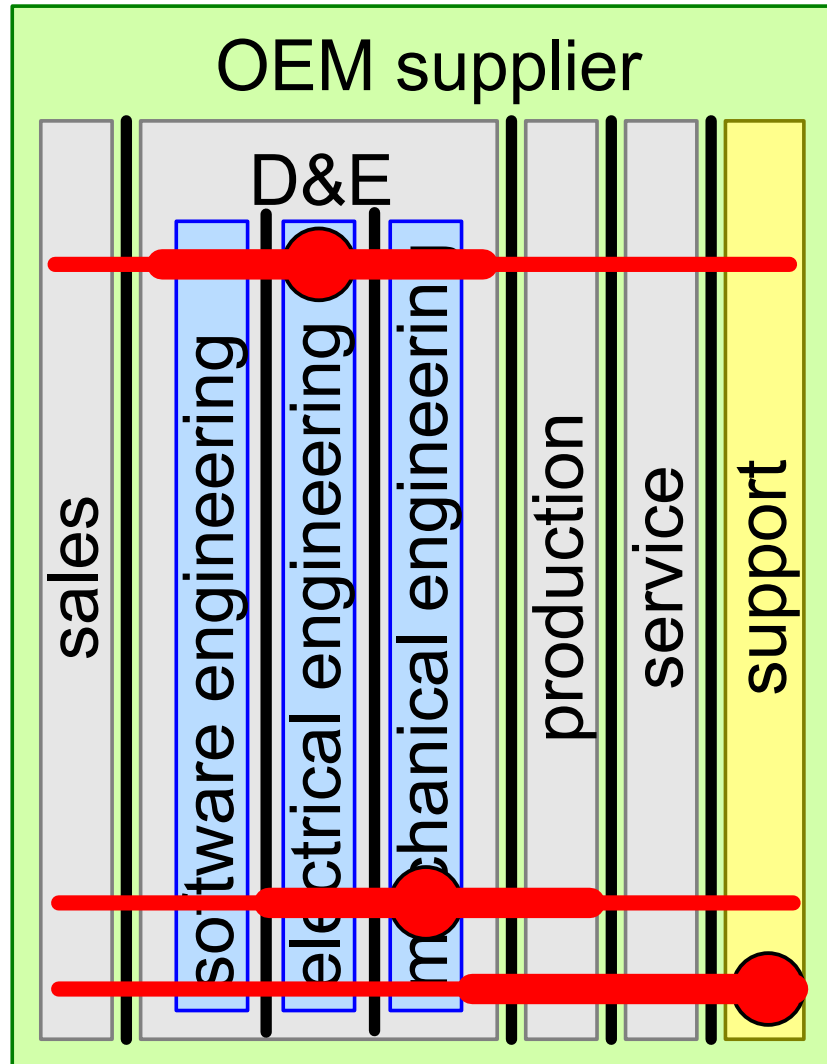
WHAT CAPABILITIES DO WE NEED?



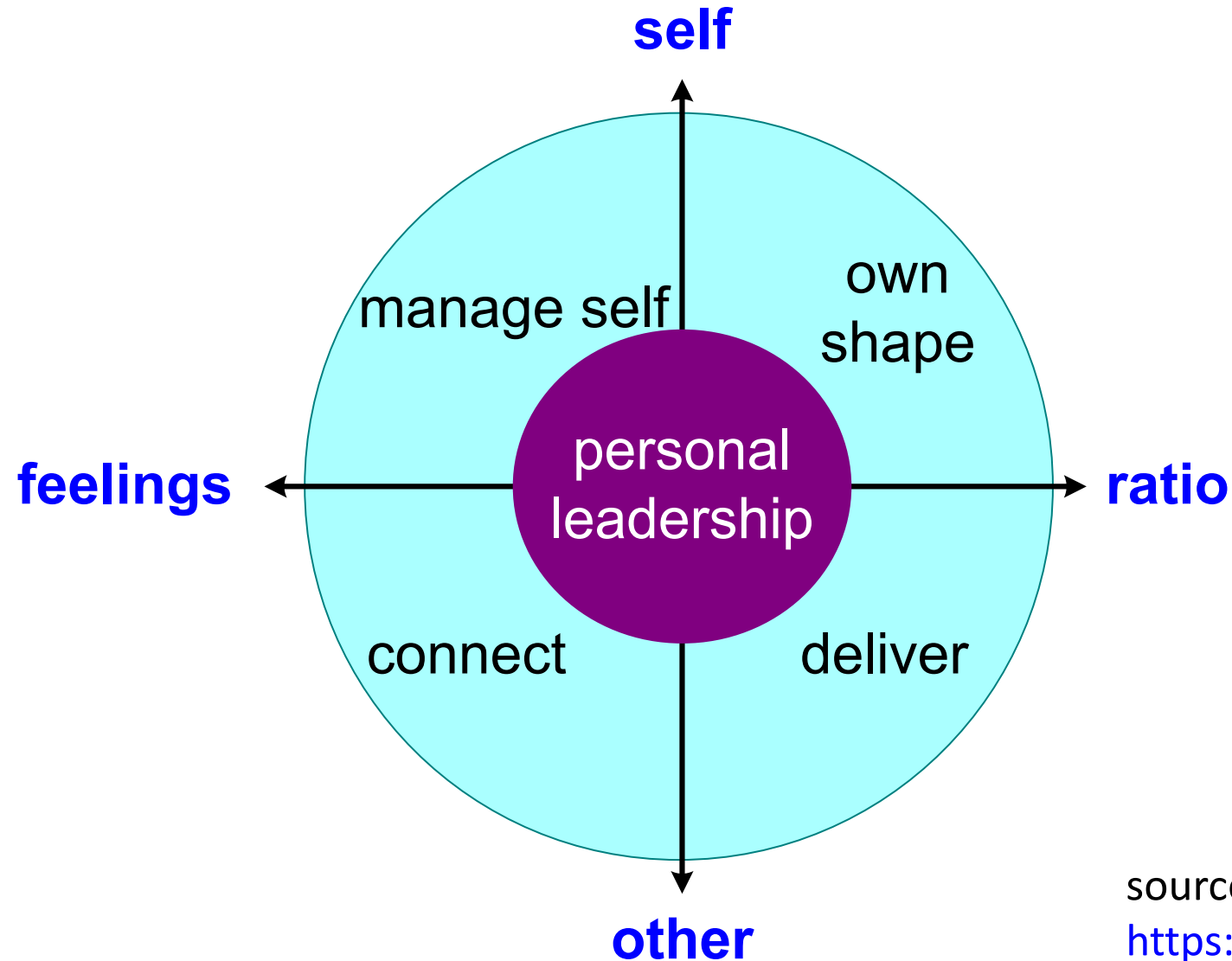
ORCHESTRATING CONTENT AND STAKEHOLDERS ACROSS ORGANIZATIONS

- **Orchestrating** is the competence to **proactively nudge** involved **parties** towards a **fitting solution**.
- Orchestrating requires the abilities:
 - to relate with a wide **variety of stakeholders**, to understand their **interests** and **concerns**, to **connect** with them such that they can **influence** them
 - to **understand** the **problem and solution space** sufficiently
 - coping with **ecosystem complexity**, **uncertainties** and **unknowns**, and helping stakeholders to navigate them
- Orchestrating requires the attitudes:
 - to see the **big picture**, while still have an eye for the devilish details
 - to **own**
 - to be **pro-active**
 - to be **genuinely interested** in stakeholders

MOST ORGANIZATIONS NEED ORCHESTRATORS

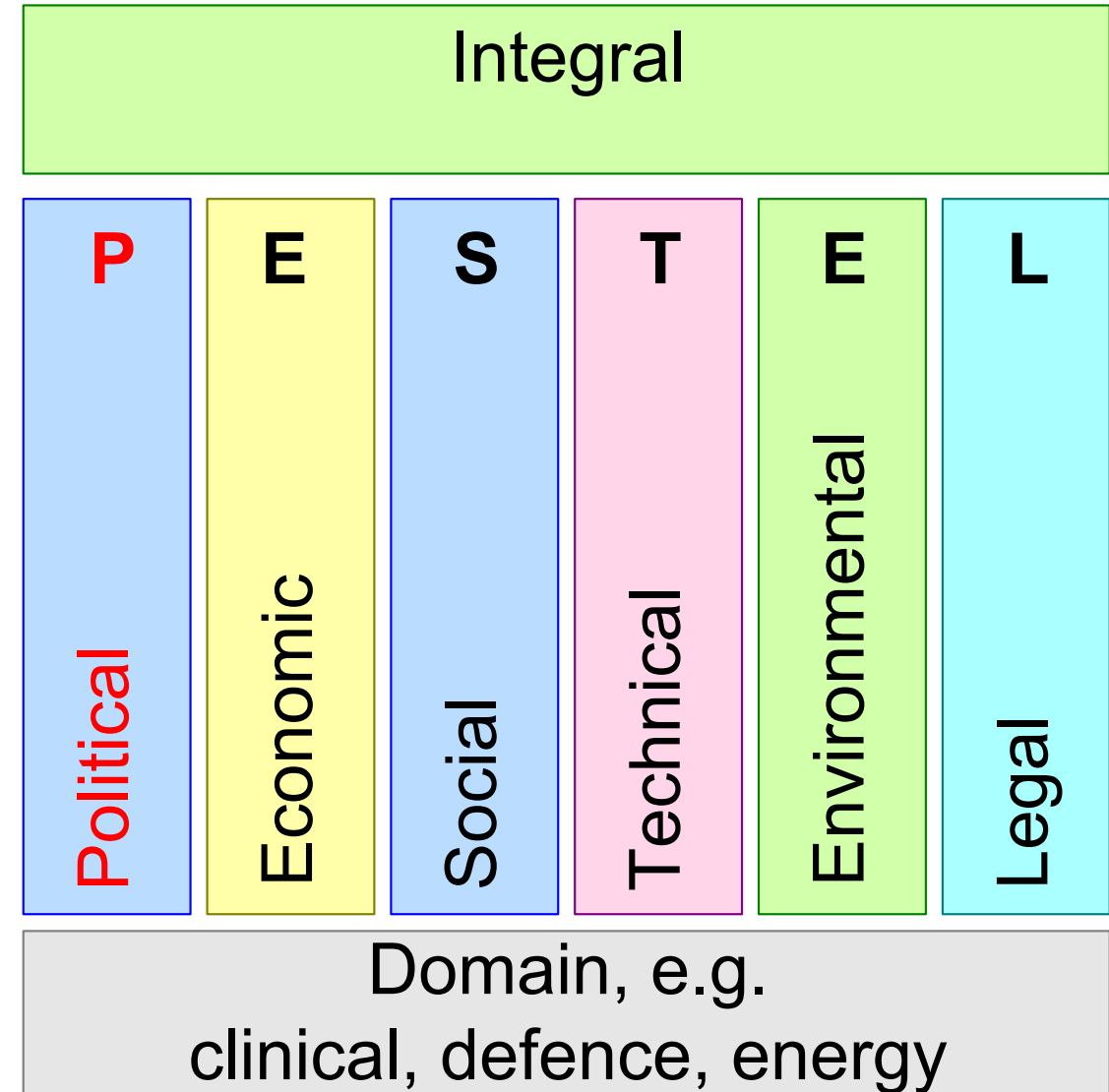


ORCHESTRATION BUILDS ON LEADERSHIP, AS WE TEACH IT



source: the LMS group
<https://thelmsgroup.nl/en/>

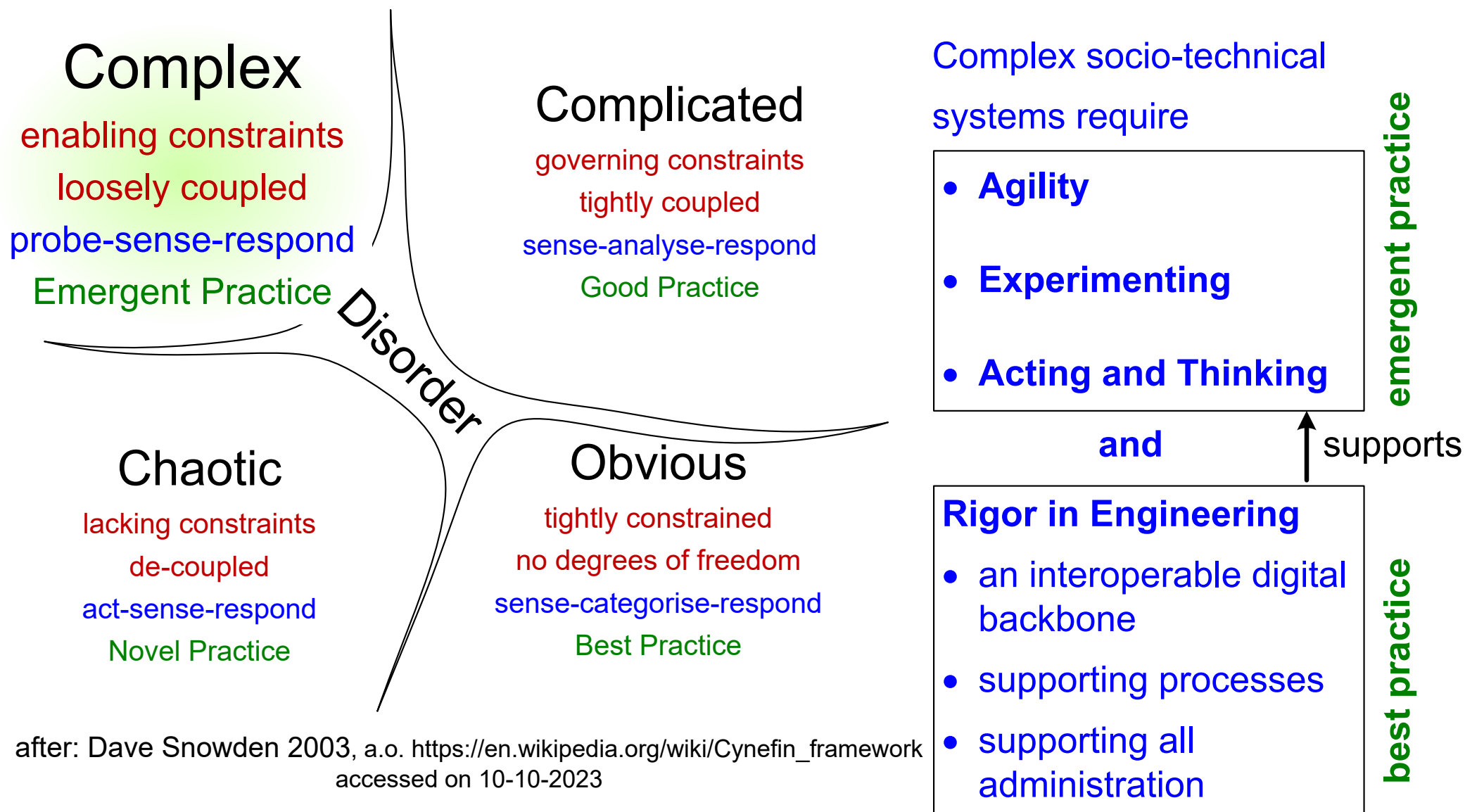
CAPABILITY TO HANDLE A BREADTH OF CONTENT



SIGNIFICANT GROWTH NEEDED!

	0/+ Integral					
	P	E	S	T	E	L
Today's systems engineer	--	0	-	++	0	-
	Political	Economic	Social	Technical	Environmental	Legal
	0/+ Domain, e.g. nical, defence, energy					

NEED: FAST RESPONDING TO DISRUPTIVE CHANGES: AGILITY!

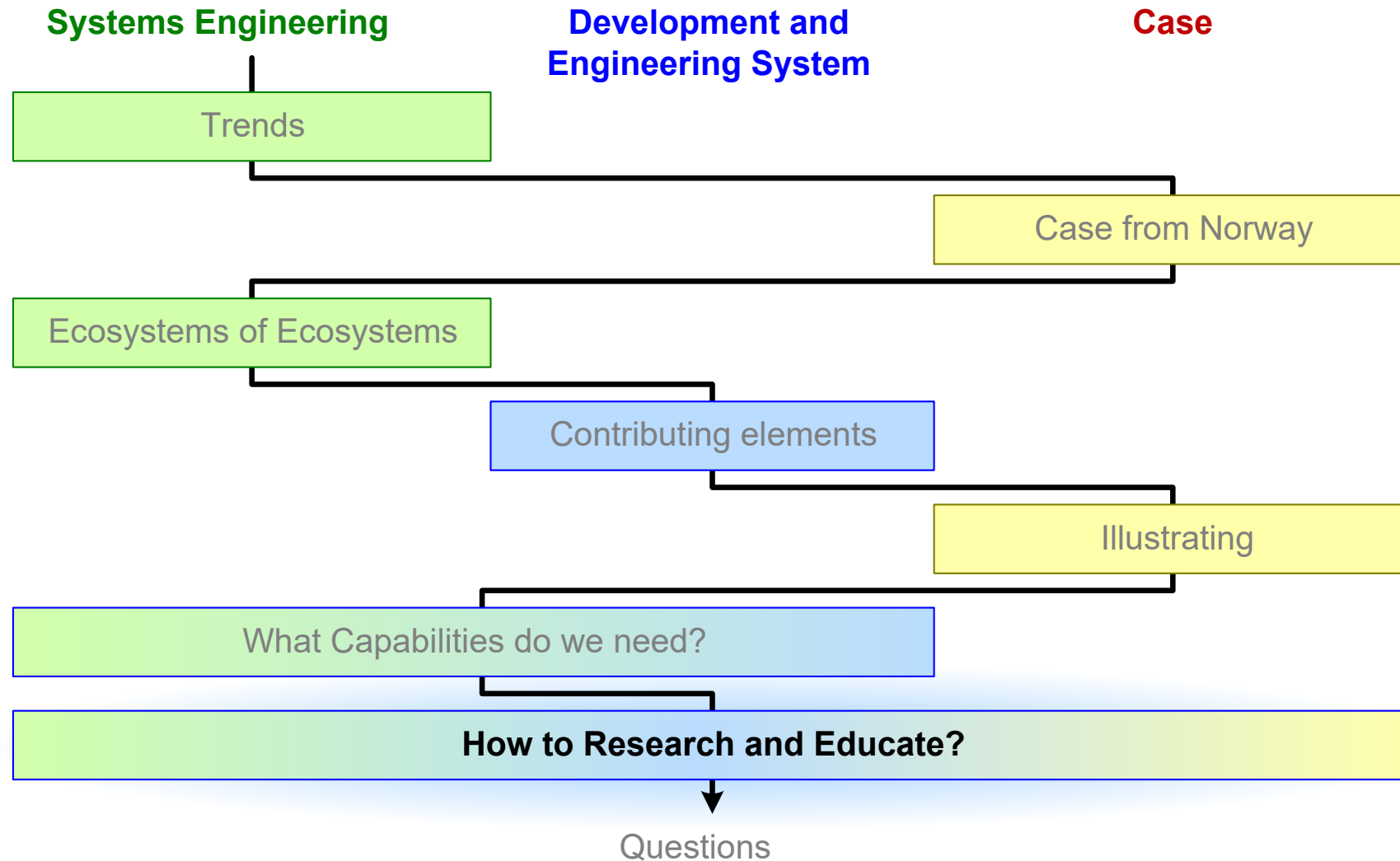


after: Dave Snowden 2003, a.o. https://en.wikipedia.org/wiki/Cynefin_framework
accessed on 10-10-2023

CAPABILITY SUMMARY

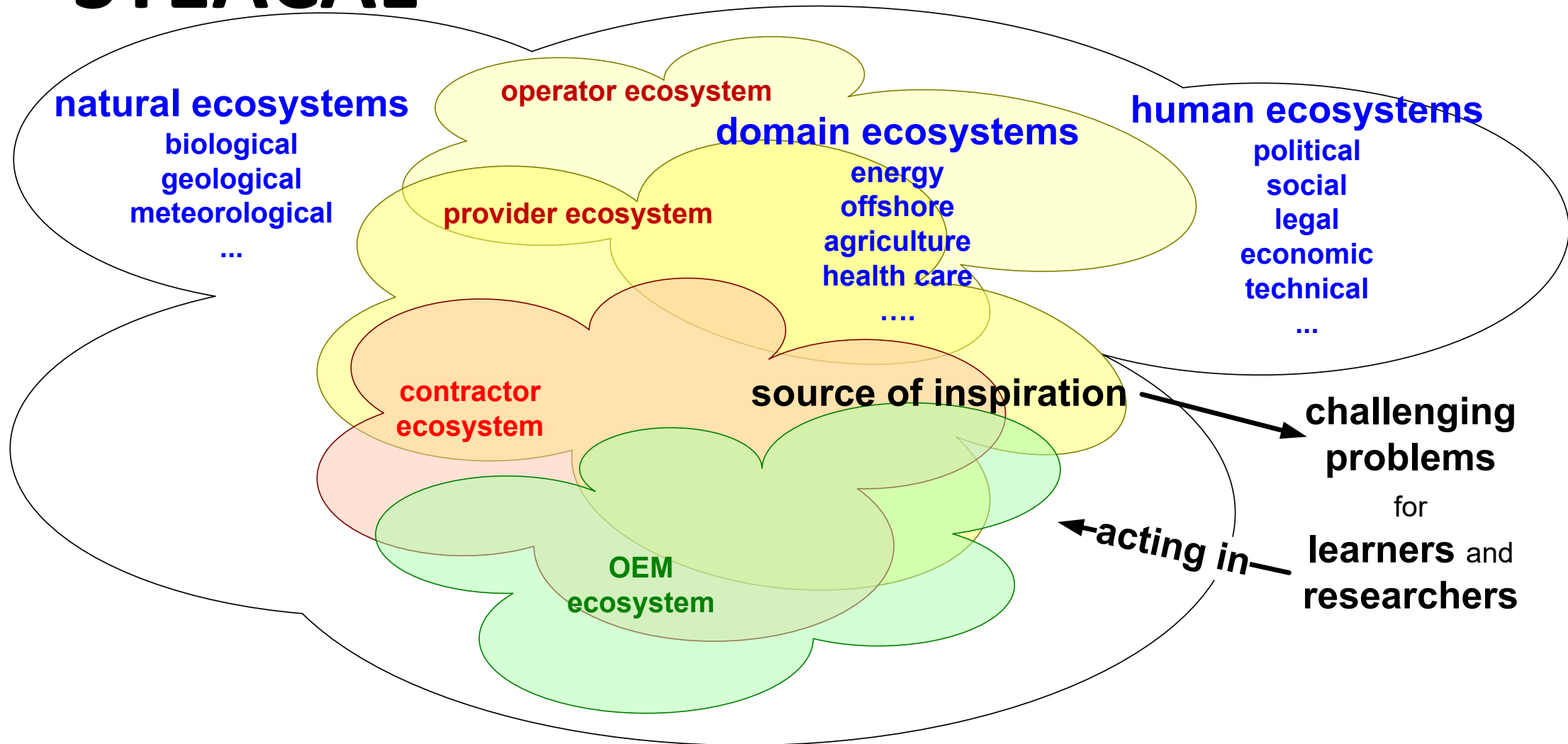
- **orchestration**, which requires **leadership**
- **content** breadth: integral, PESTEL, domain
- **Experiment, Act**, and **Think** to respond fast, **rigor** in engineering management

HOW TO RESEARCH AND EDUCATE DEVELOPMENT SYSTEMS?

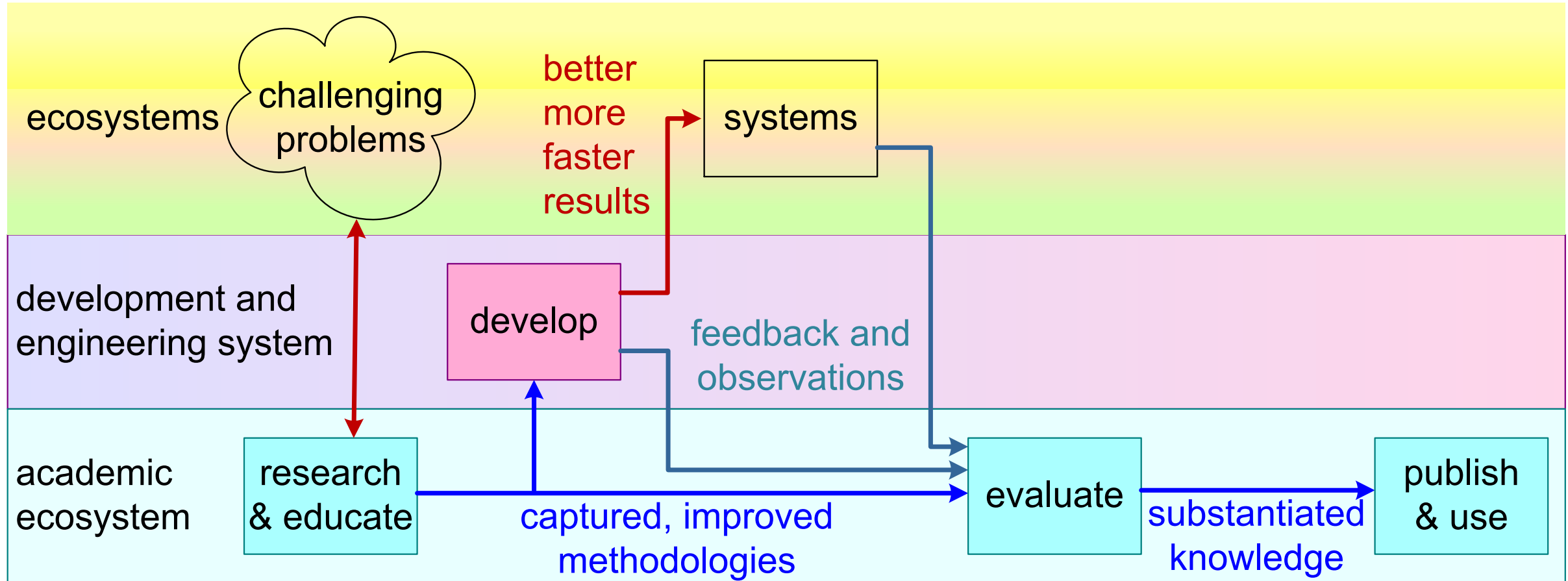


SOCIO TECHNICAL ECOSYSTEMS AS CLASSROOM AND LABORATORY

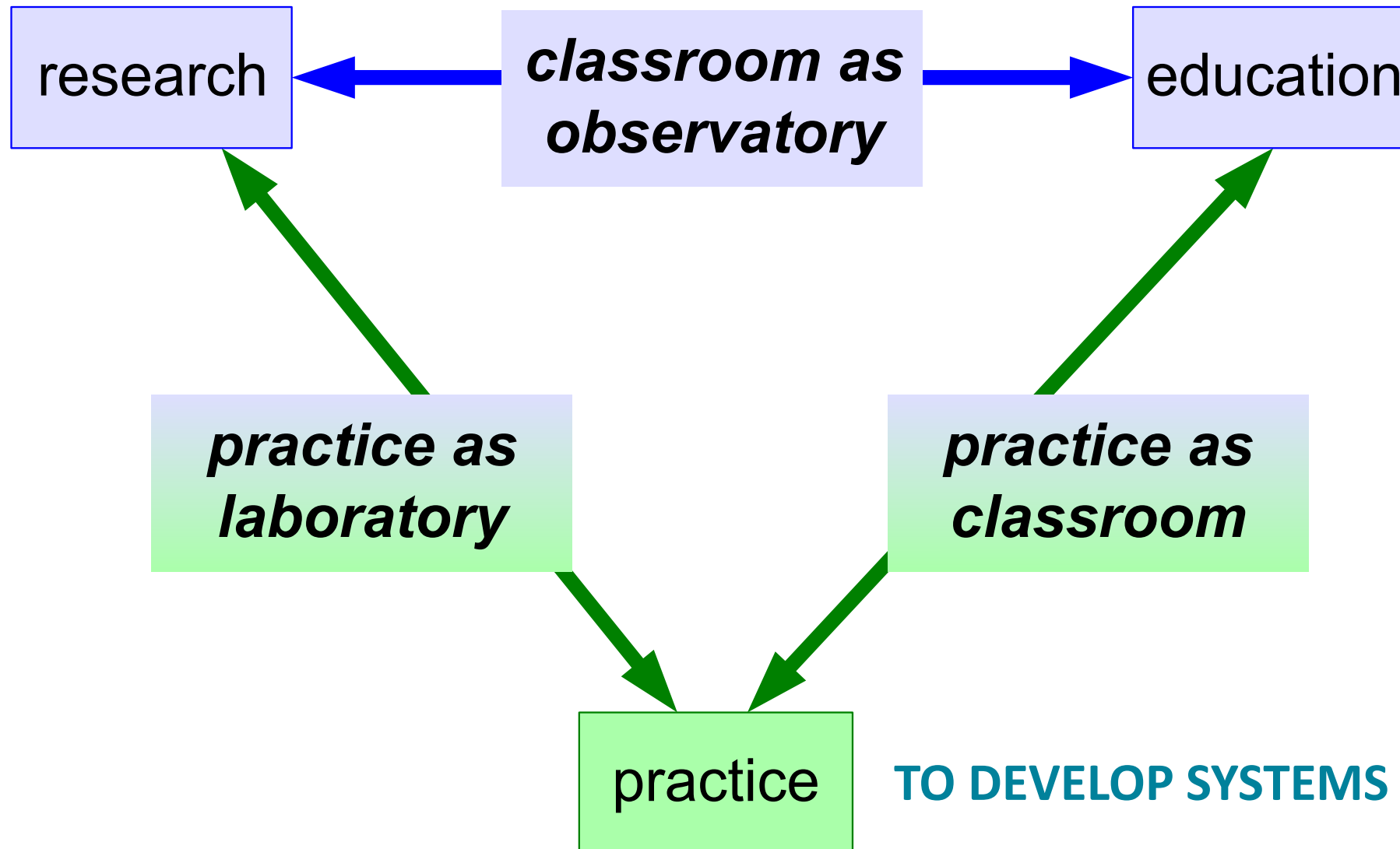
STEACAL



STEACAL VALUE PROPOSITIONS

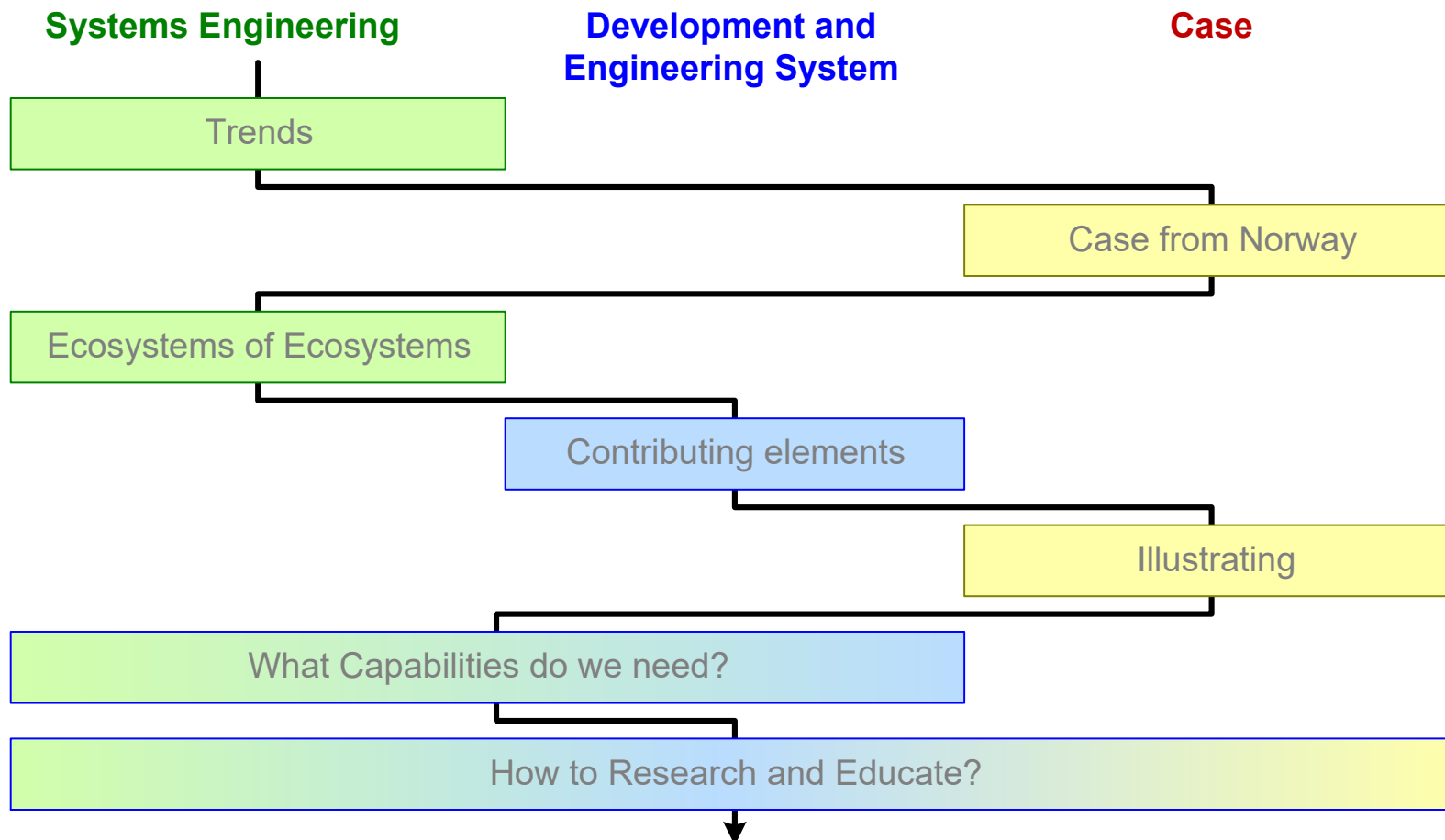


KEEP RESEARCH, EDUCATION, AND PRACTICE WELL CONNECTED!



TO DEVELOP SYSTEMS EFFECTIVELY

KEEP RESEARCH, EDUCATION, AND PRACTICE WELL CONNECTED!



Questions ?

^AColin Potts. Software-engineering research revisited. IEEE Software, Vol. 10, No. 5:19–28, September/October 1993

^BGerrit Muller and Maurice Heemels, Five Years of Multi-Disciplinary Academic and Industrial Research: Lessons Learned, CSER 2007 in Hoboken NJ, https://www.gaudisite.nl/CSER2007_MullerHeemels_LessonsLearned.pdf

¹ Karen Czachorowski,, AkerBP, Digital Transformation in the Offshore Oil and Gas Exploration and Production supply chain operations https://openarchive.usn.no/usn-xmlui/bitstream/handle/11250/2994521/2022_122_Czachorowski_dissertation.pdf and KSEE 2023 presentation “Future trends and innovations in software for E&P and the challenges in software and data integration during system development. ”

² Kim Alexander Jørgensen, Lundin, Condition Based Maintenance, webinar April 2020, https://gaudisite.nl/SESG_JorgensenConditonBasedMaintenance.pdf

³ Lasse Andre Sletaker, KM, Creating and Applying Total Cost Model: A Case Study at Maritime Company for Last Time Buy Estimation, INCOSE 2020 https://gaudisite.nl/INCOSE2020_SletakerEtAl.pdf Lasse Andre Sletaker, AkerBP, Lasse in Action https://www.gaudisite.nl/SESG_SletakerEcosystems.pdf

⁴ Yayun Chen, Managing Knowledge Transfer in Innovative Complex Systems Development: Case Study of Renewable Energy Project in the Oil and Gas Industry, INCOSE 2023, https://gaudisite.nl/INCOSE2023_ChenEtAl_KnowledgeTransfer.pdf and <https://www.technipfmc.com/en/campaign/deep-purple-1/>

⁵ private communciation with Lasse Sletaker, contract manager AkerBP, May 2025

⁶ Magnus André Nilsen, Reducing Project Cost Growth Through Early Implementation of Interface Management, INCOSE 2018 https://gaudisite.nl/INCOSE2018_Nilsen_Falk_InterfaceManagement.pdf

Omid Razbani, Gerrit Muller, Satyanarayana Kokkula, and Kristin Falk. Enhancing Competency and Industry Integration: A Case Study of Collaborative Systems Engineering Education for Future Success, MDPI Systems 2023, 11(9), 463; <https://doi.org/10.3390/systems11090463>