Flight Testing Tomorrow's Complex Systems

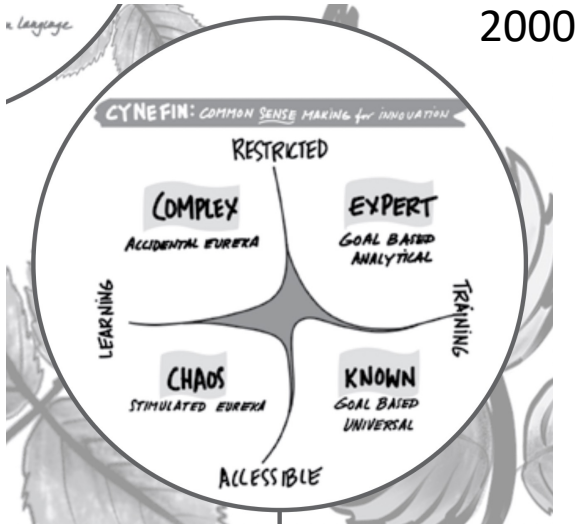
The advent of safety domains and why they help

Ben Luther

Content is the opinion of the author and
not necessarily the position of any organisation

Safety Domains: Why?

ROE



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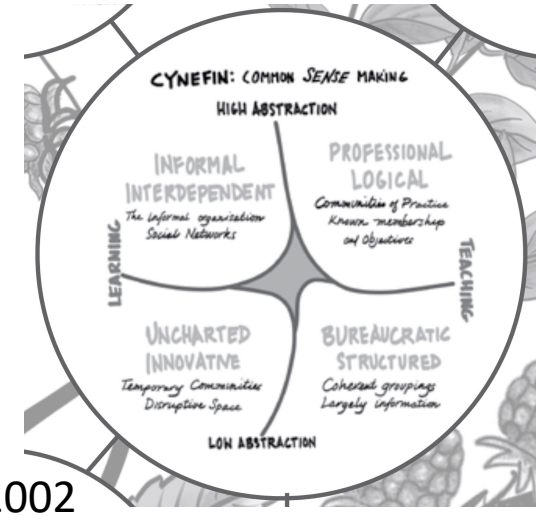

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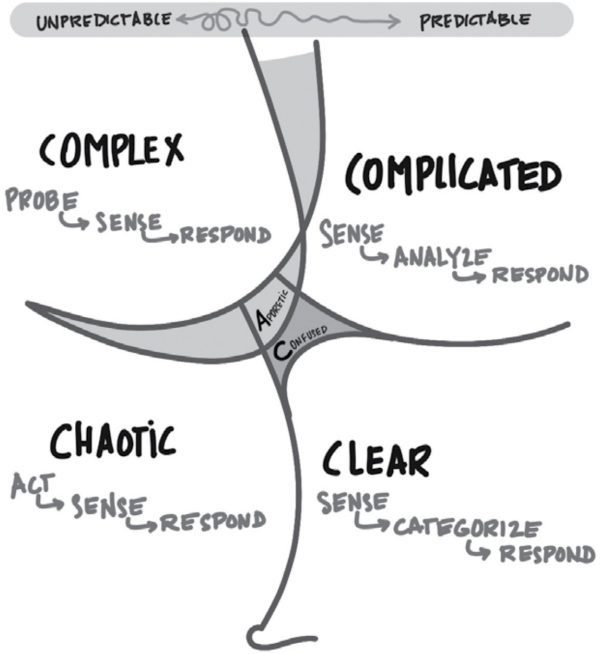
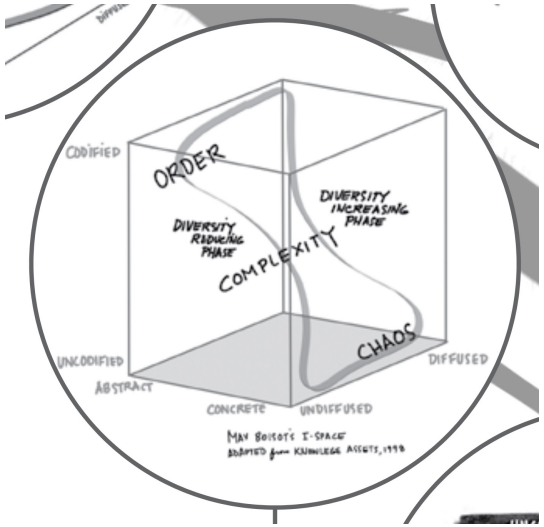
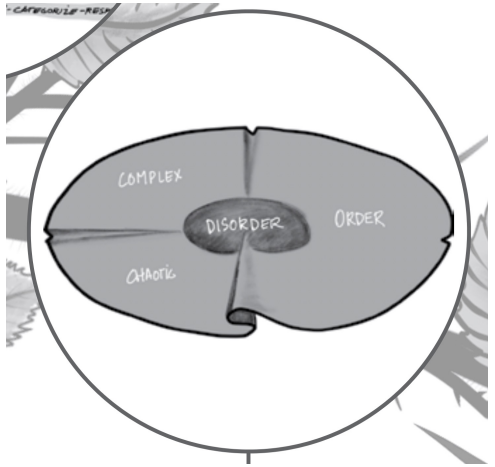


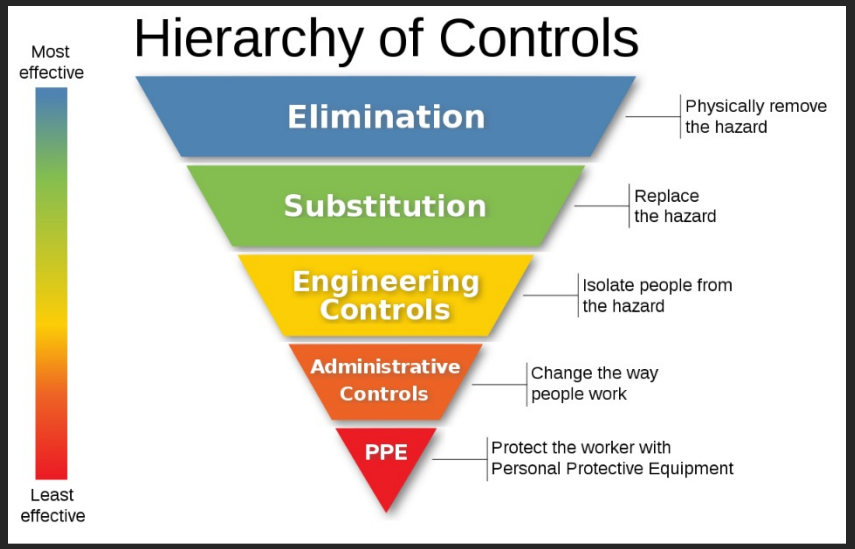
2020

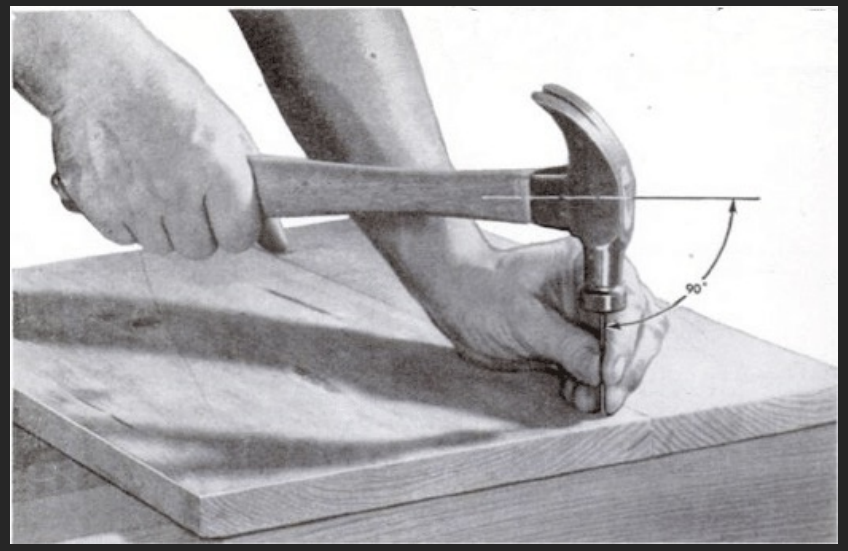


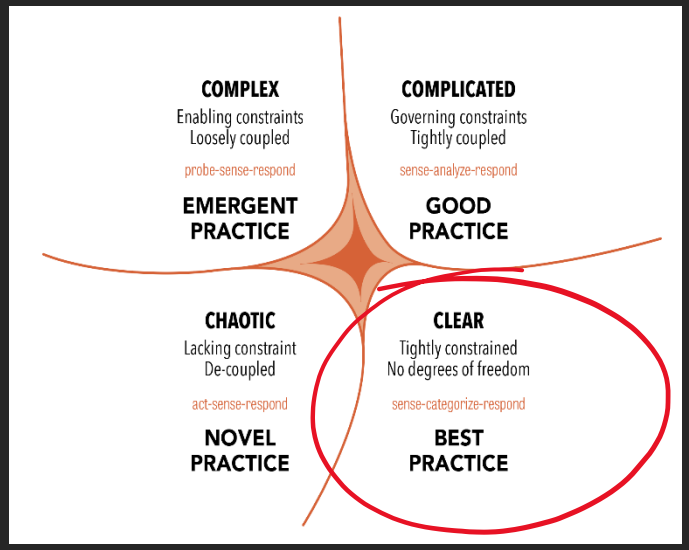


2010

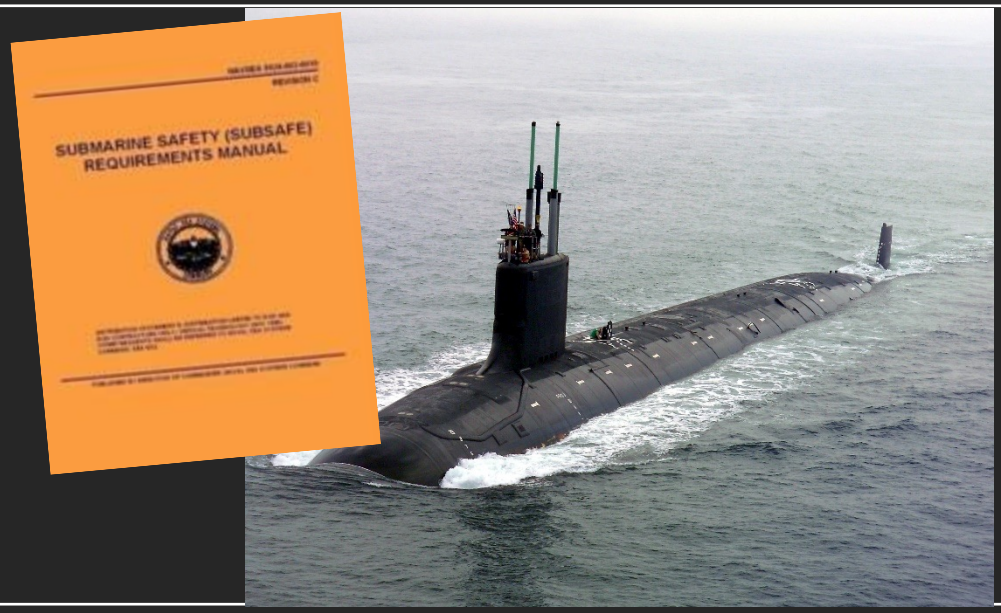
Snowden, D. et. al. (2021) Cynefin: *Weaving sense-making into the fabric of our world.* Cognitive Edge. Singapore.

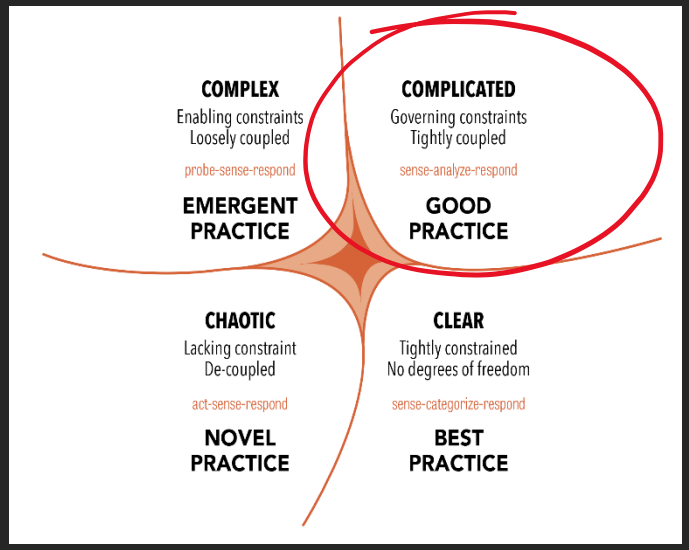

Hierarchy of Controls
Most effective
Least effective
Elimination
Physically remove the hazard
Substitution
Replace the hazard
Engineering Controls
Isolate people from the hazard
Administrative Controls
Change the way people work
PPE
Protect the worker with Personal Protective Equipment


90°


COMPLEX
Enabling constraints
Loosely coupled
probe-sense-respond
EMERGENT PRACTICE
COMPLICATED
Governing constraints
Tightly coupled
sense-analyze-respond
GOOD PRACTICE
CHAOTIC
Lacking constraint
De-coupled
act-sense-respond
NOVEL PRACTICE
CLEAR
Tightly constrained
No degrees of freedom
sense-categorize-respond
BEST PRACTICE

AIR CARRIER OPERATIONS
Mark J. Holt & Phillip J. Poynor
AIRFRANCE


SUBMARINE SAFETY (SUBSAFE)
REQUIREMENTS MANUAL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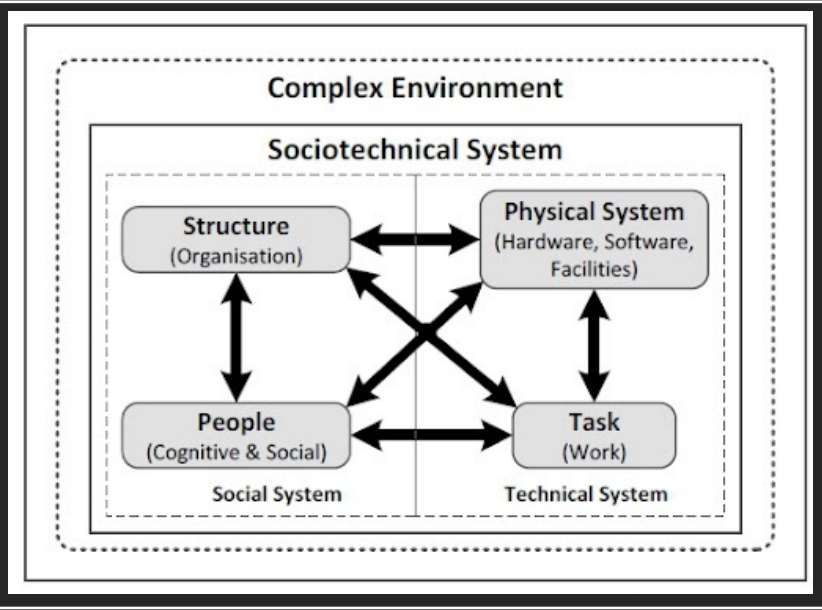
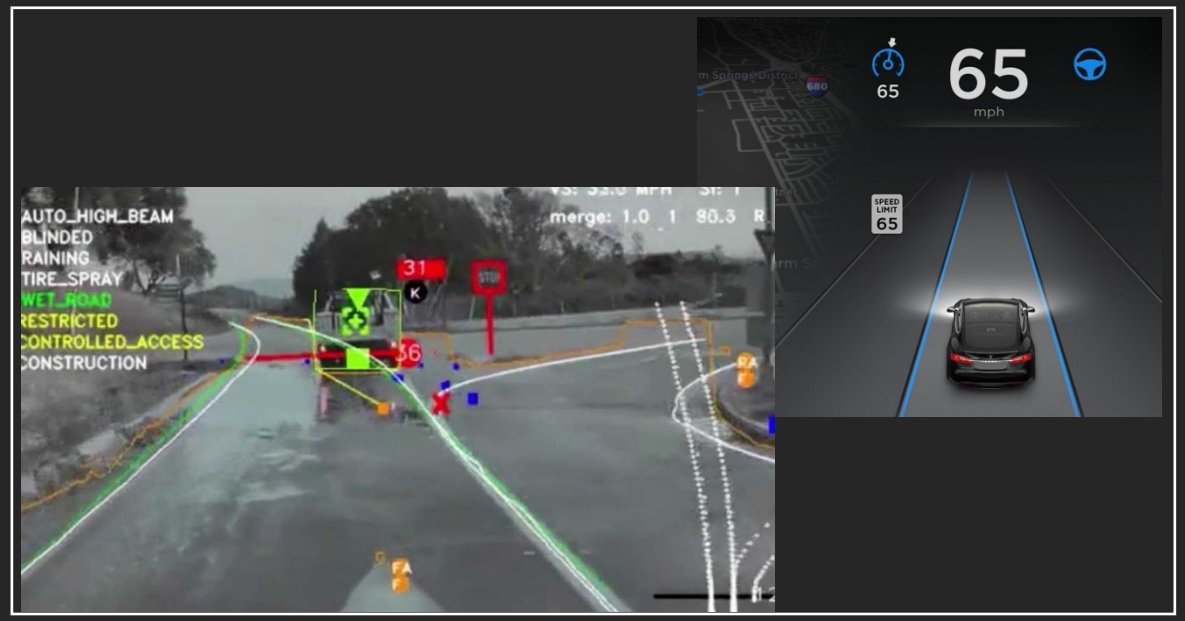
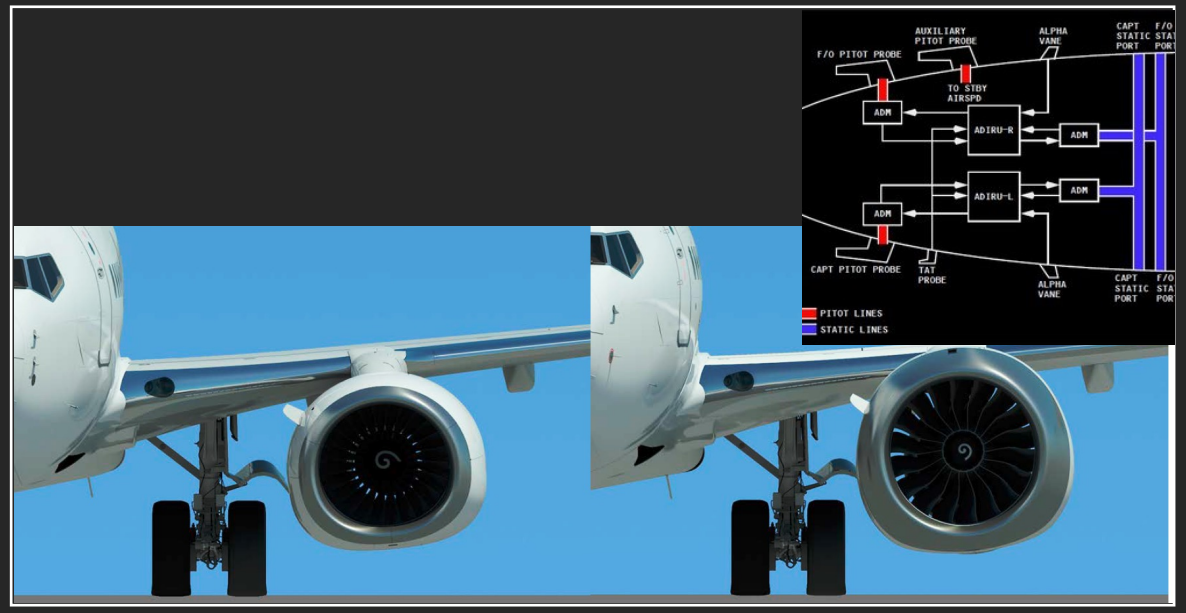
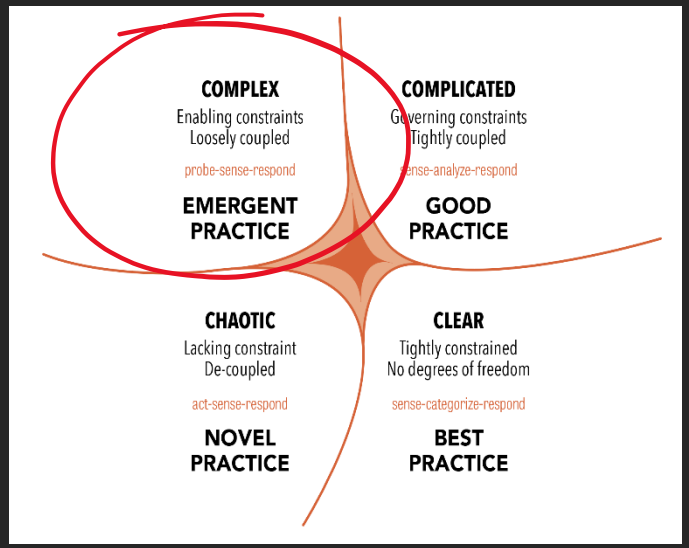

Complex Environment
Sociotechnical System
Structure
(Organisation)
Physical System
(Hardware, Software,
Facilities)
People
(Cognitive & Social)
Task
(Work)
Social System
Technical System


AUTO_HIGH_BEAM
BLINDED
RAINING
TIRE_SPRAY
WET_ROAD
RESTRICTED
CONTROLLED_ACCESS
CONSTRUCTION
merge: 1.0
65
mph
SPEED LIMIT
65


F/O PITOT PROBE
AUXILIARY PITOT PROBE
ALPHA VANE
CAPT STATIC PORT
TO STBY AIRSPD
ADM
ADIRU-R
ADIRU-L
CAPT PITOT PROBE
TAT PROBE
PITOT LINES
STATIC LINES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BEST PRACTICE

Non-Statistical Approaches

Statistical Approaches

Stability

Latency

Extended latency

Instantaneous

Unique occurrences

Repetitive outcomes

COMPLEX
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Loosely coupled
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EMERGENT PRACTICE

COMPLICATED
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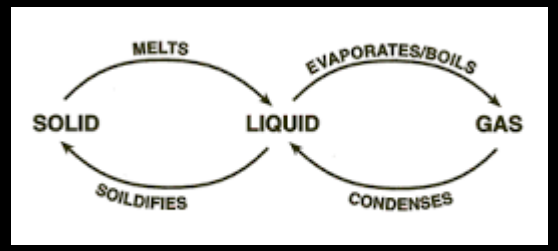
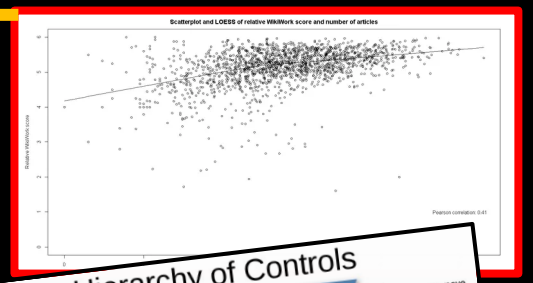
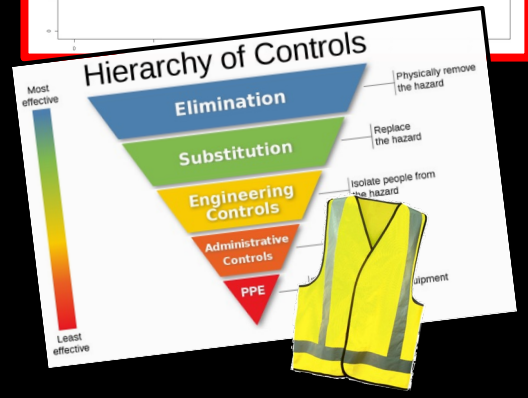
BEST PRACTICE

State changes



Crisis leadership



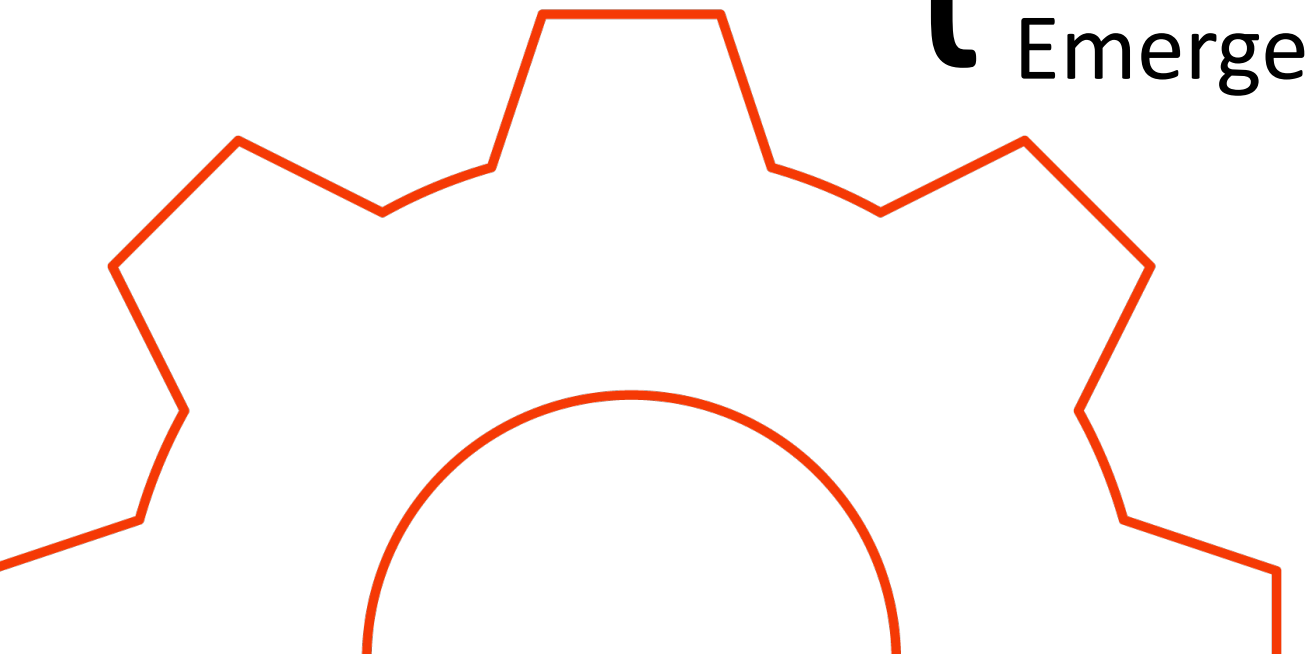


https://engineering.osu.edu/news/2017/08/ohio-state-sets-drone-world-speed-record#

Break to Complexity

Complicated ≠ Complex

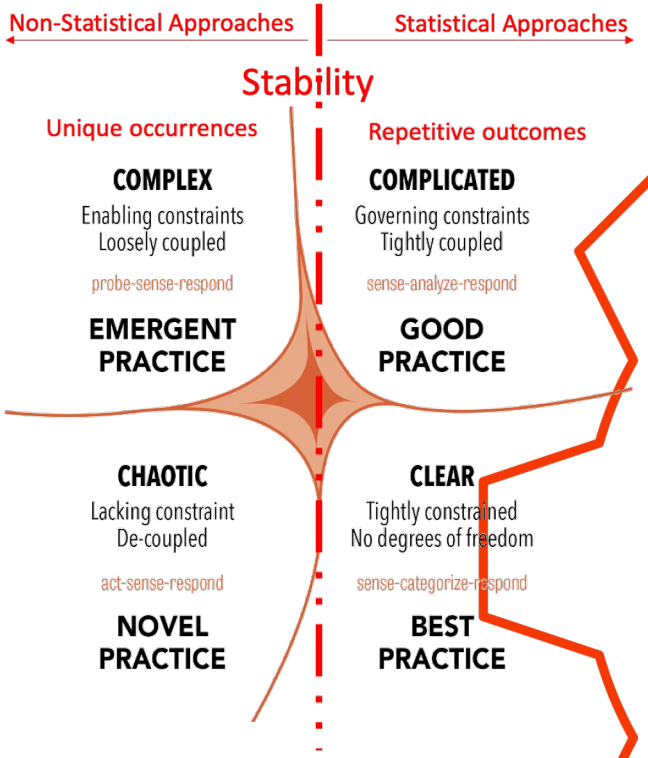
Complex is:
- Dynamic (Sterman)
- Unknowable *a priori* (Snowden)
- Emergent functions (Leveson)



Impact on risk assessment

Universe of potential outcomes is unknown

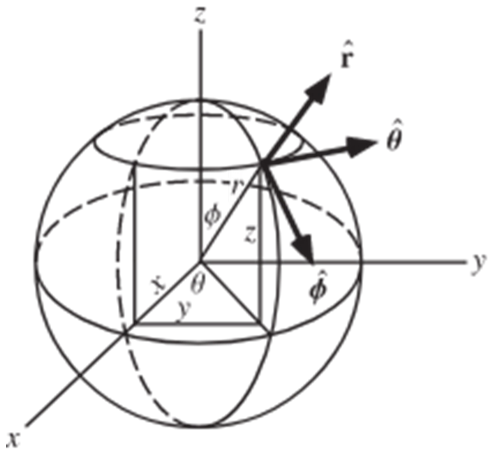
- Probability is unknowable
- Physics-envy



Statistical basis is moot

- can't use a risk register

Radical Uncertainty, Kay & King (2020)



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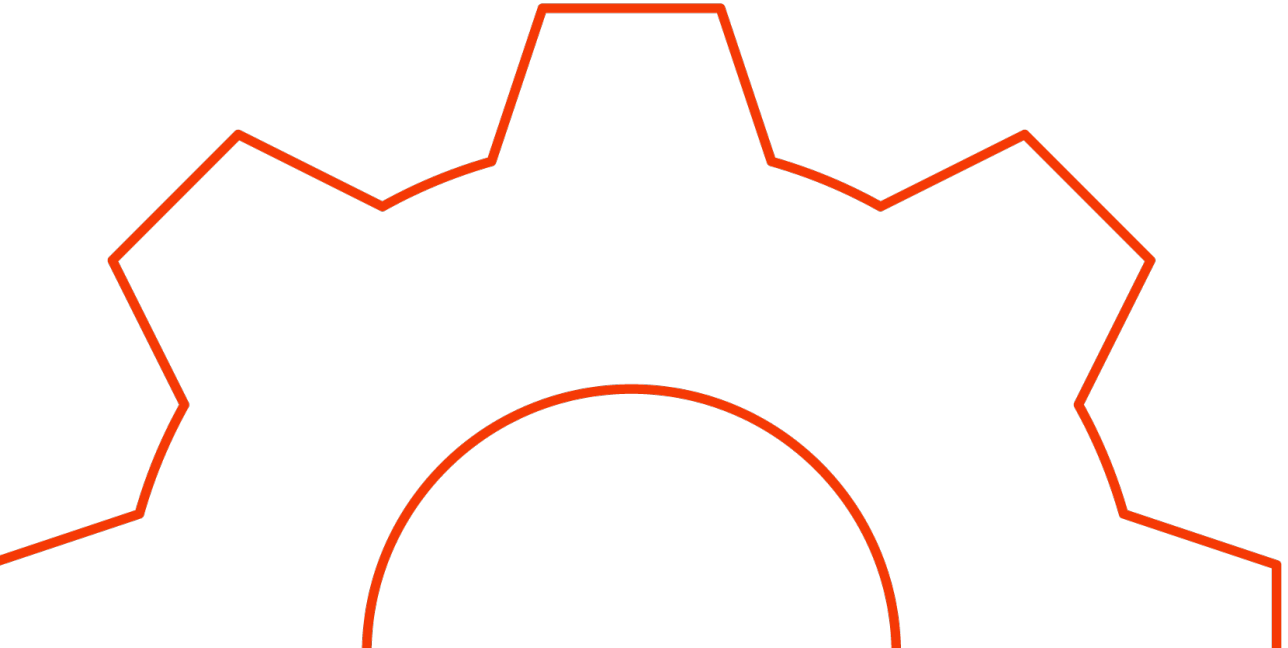
Impact on test point matrix

Massive (unachievable) number of test points

- Emergent behaviour – what to test?
- Unknowable – what baseline performance?
- Prior testing invalid for future configuration



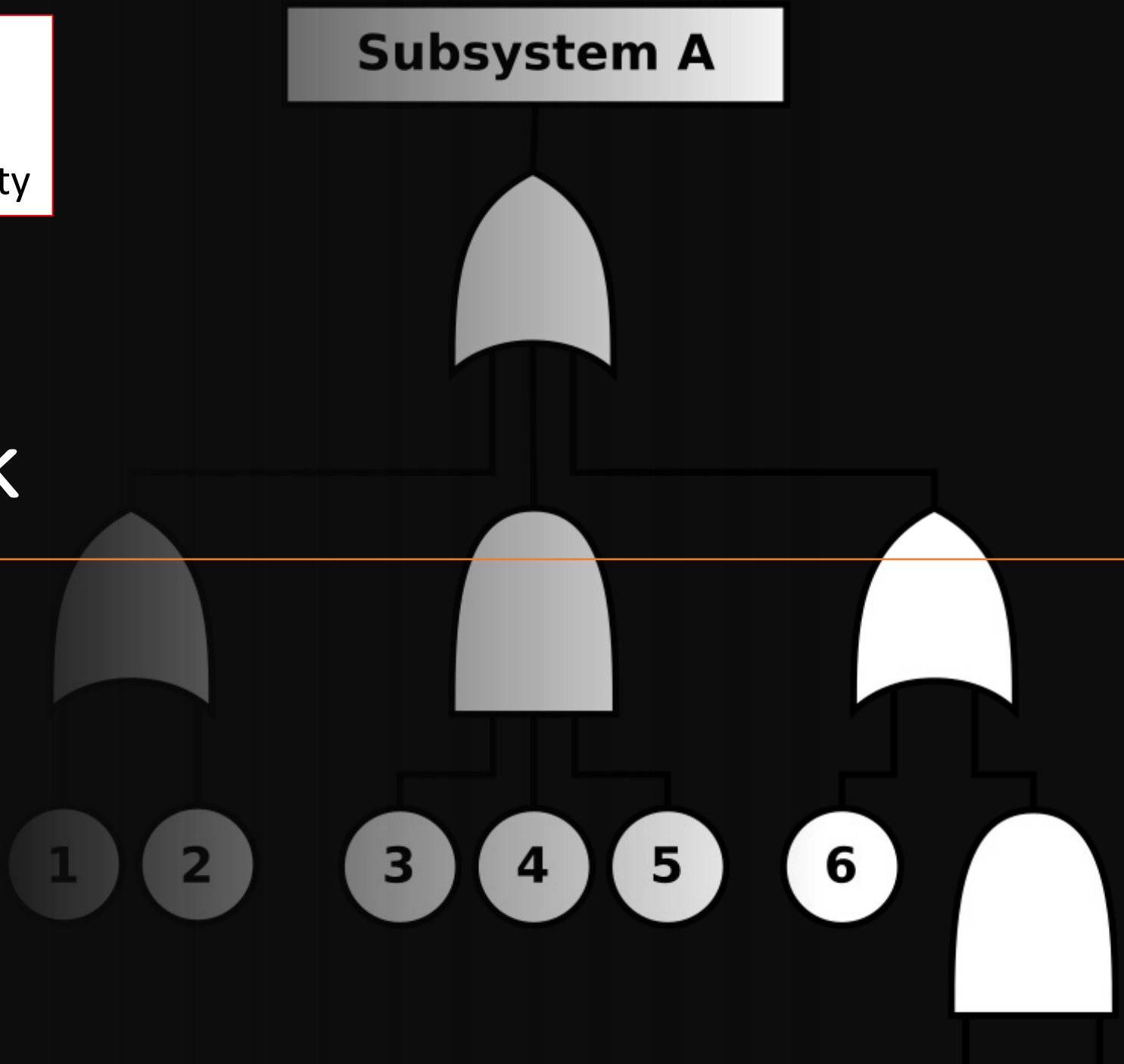
Effective against complicated systems.

But isn’t enough.

Must-have before addressing complexity

Tools that work

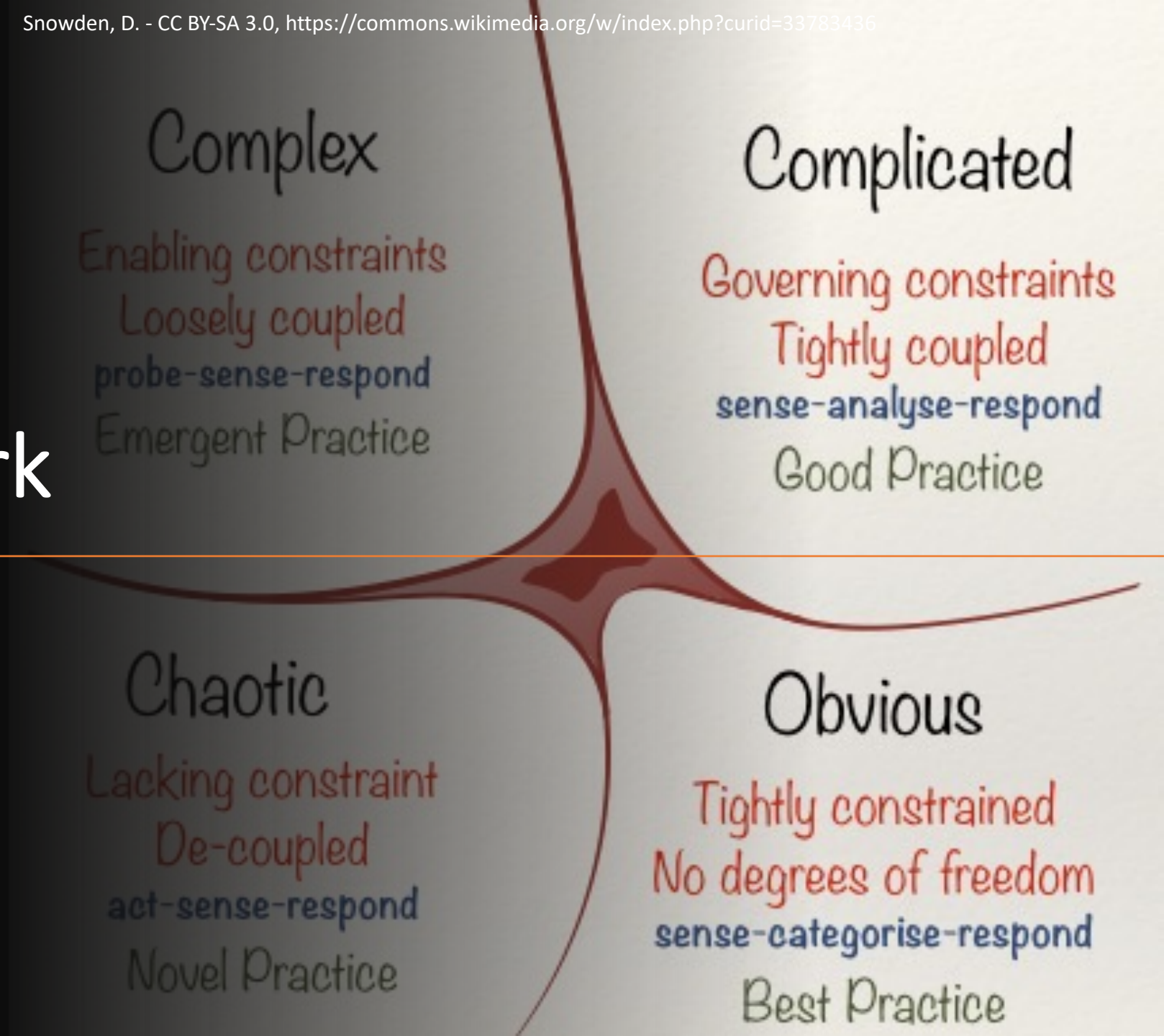
System Safety



Snowden, D. - CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=33783436

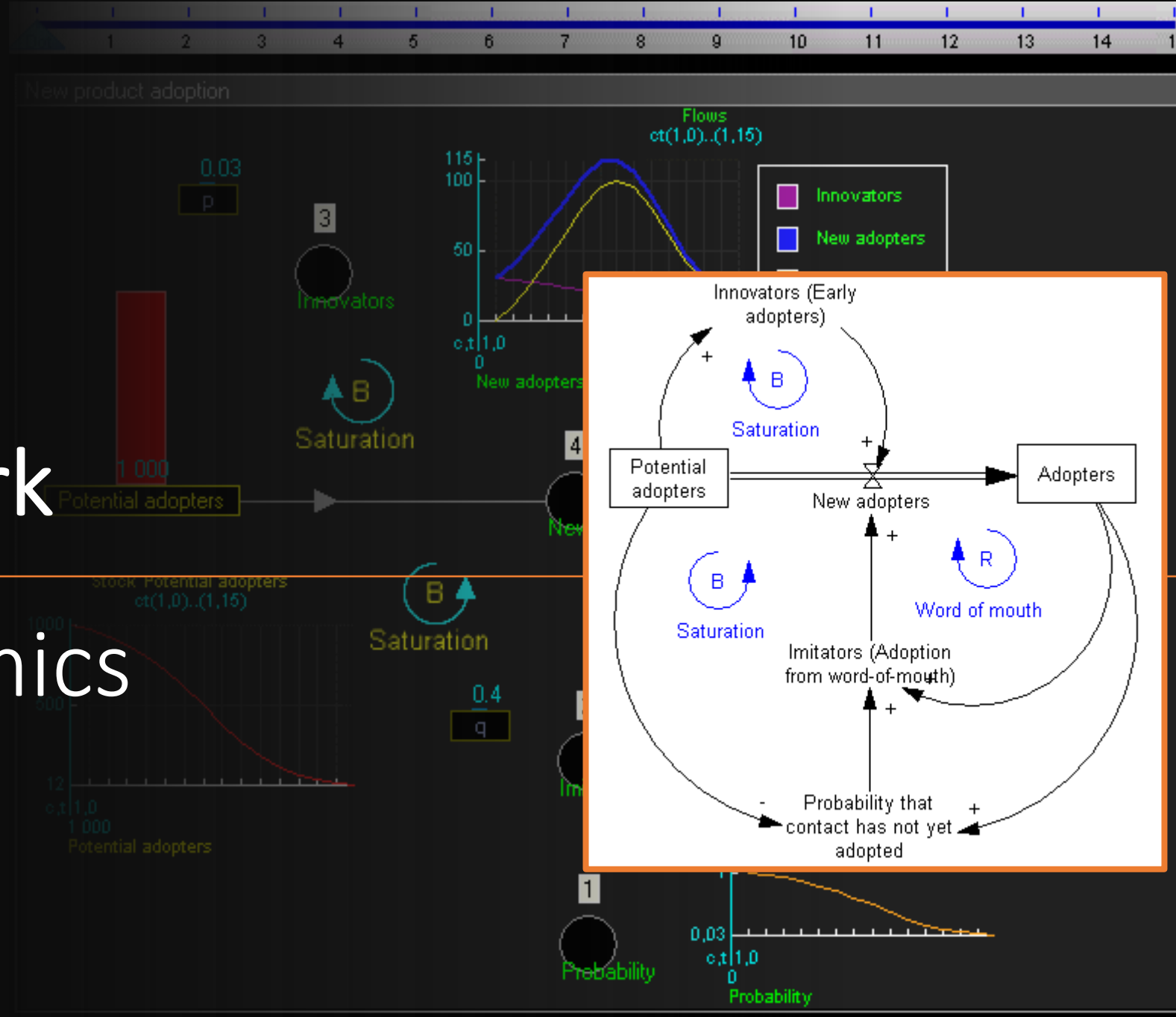
Tools that work

Cynefin



Tools that work

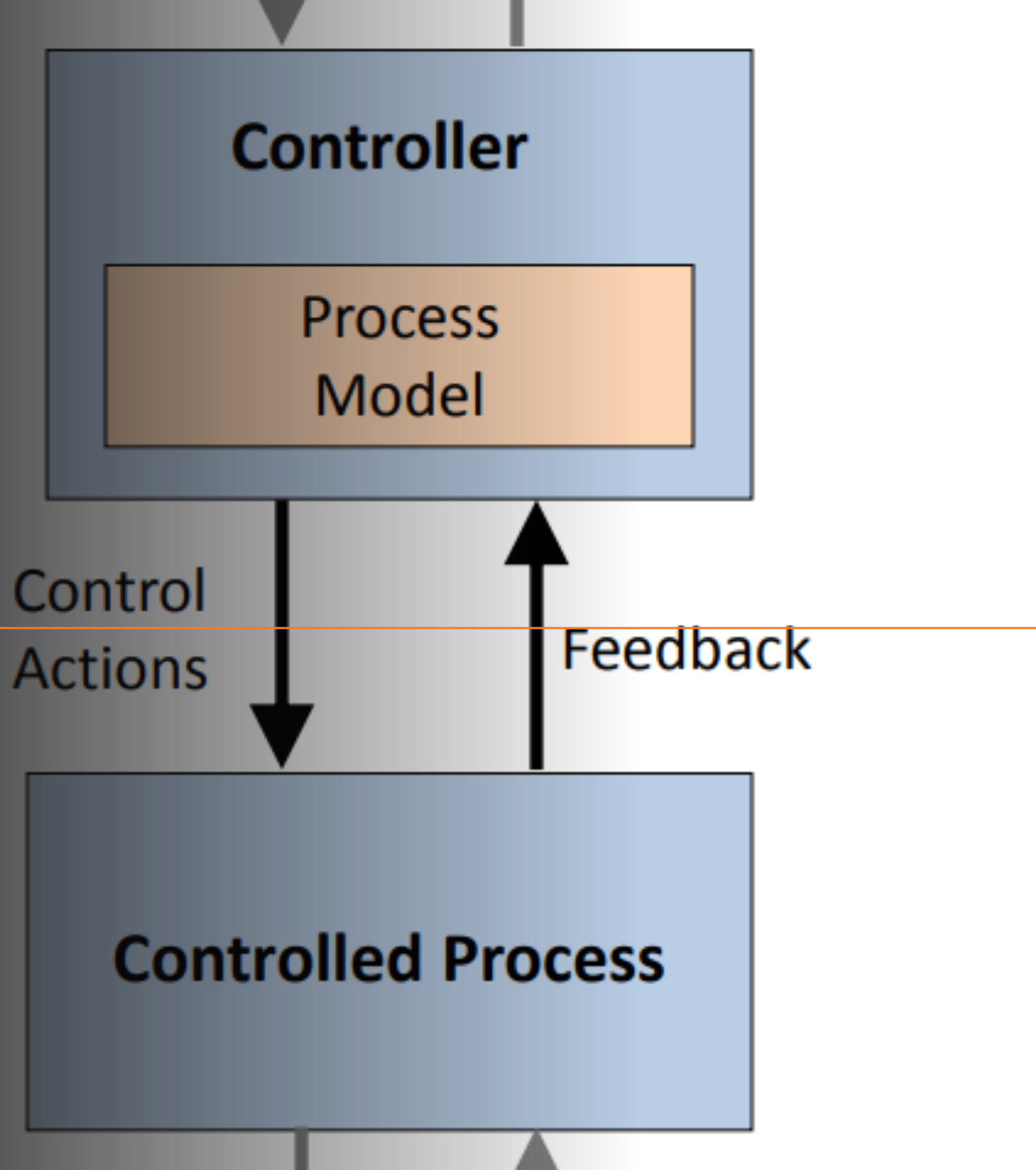
System Dynamics



Patrhoue - CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=7196368

Tools that work

STPA

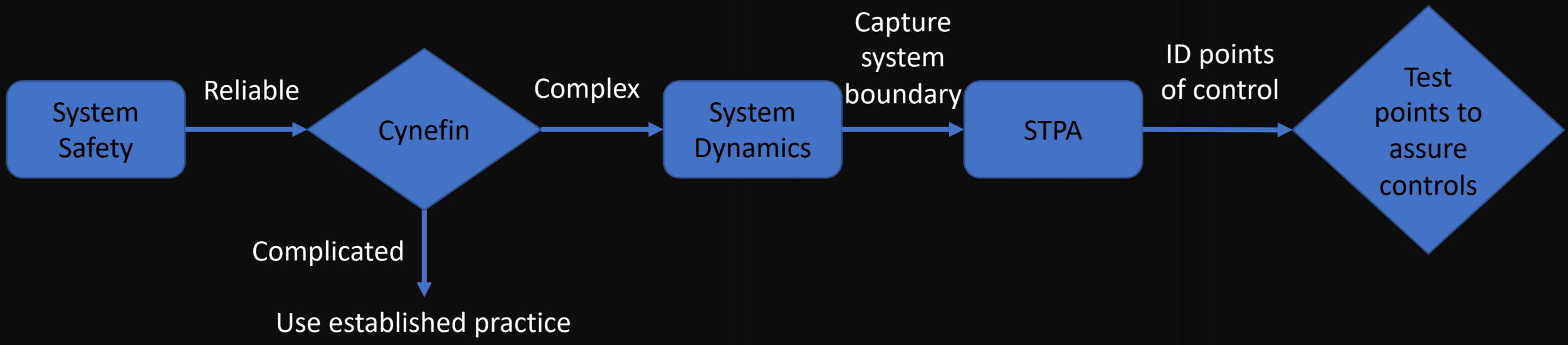


Tools that work

Test the controls

Noe Bojorge, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=32524889

Test point matrix design



Conclusion

Complicated and Complex are different

- Extant practice for complicated systems
- Compound approach to complexity

Risk

- Don’t use statistical approaches with complexity

Test

- Assure points of control
- Accept variable performance

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Discussion

Research Survey

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