# Where next for Systems Engineering?

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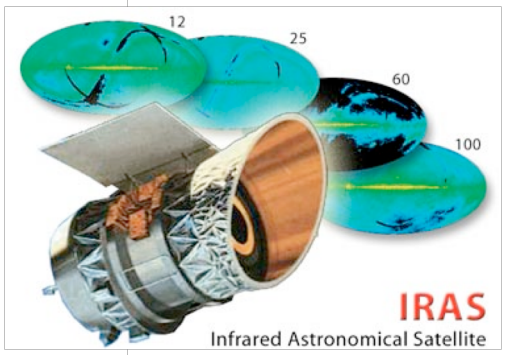
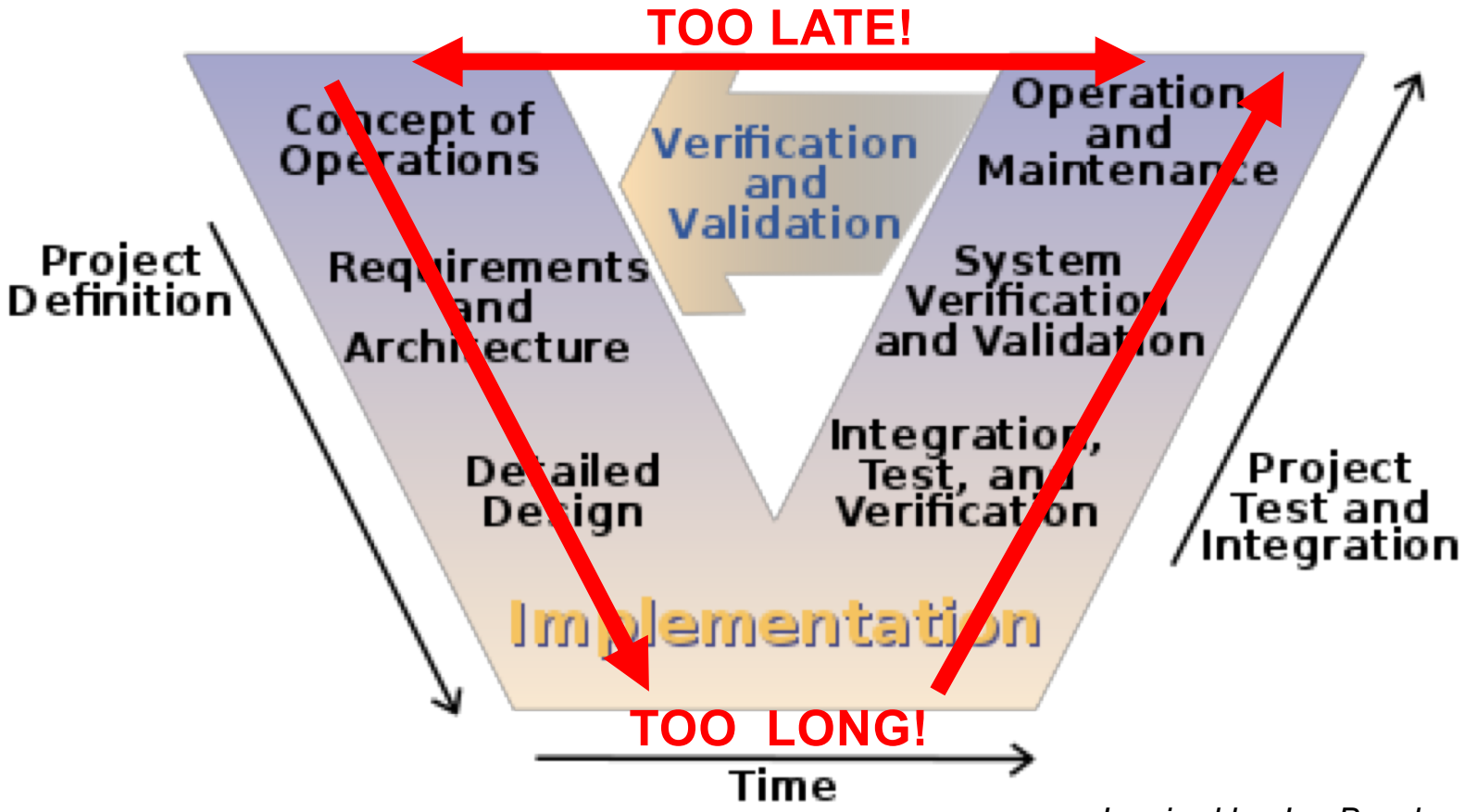
# The 'good old days' of SE

Green-field
Long-lived
Waterfall

Aerospace
Deterministic
Electromechanical
Document-centric
Top-down
Stand-alone
Defense



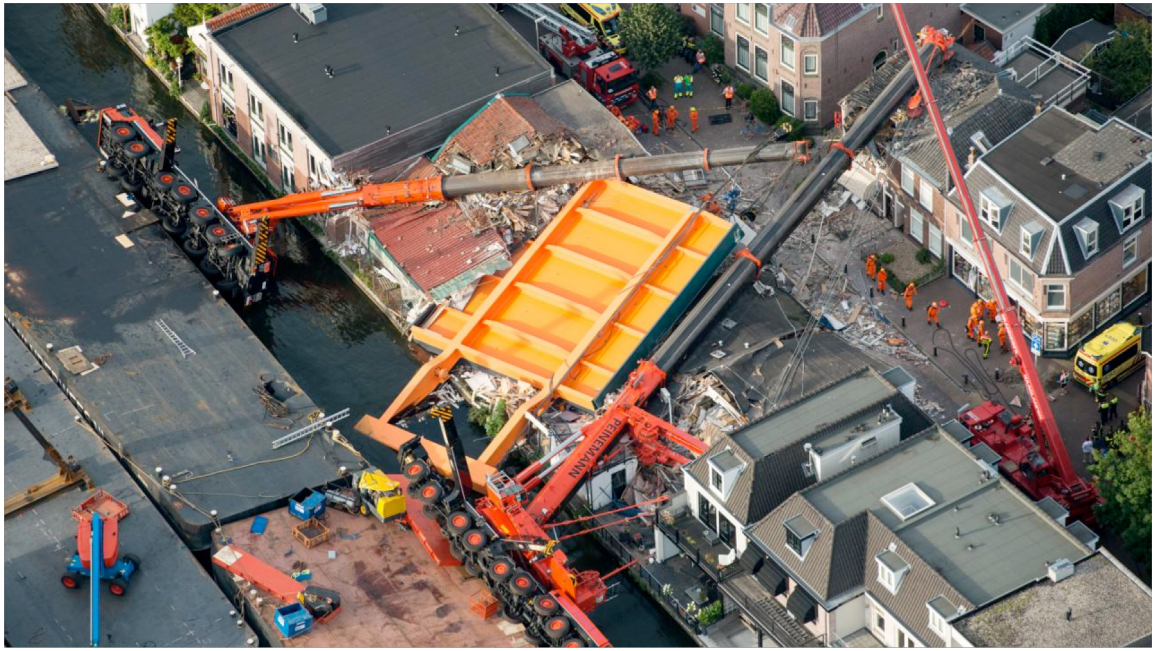

# Traditional SE




*Inspired by Jan Bosch*

# V&V, early and often


Subtle



Not very subtle

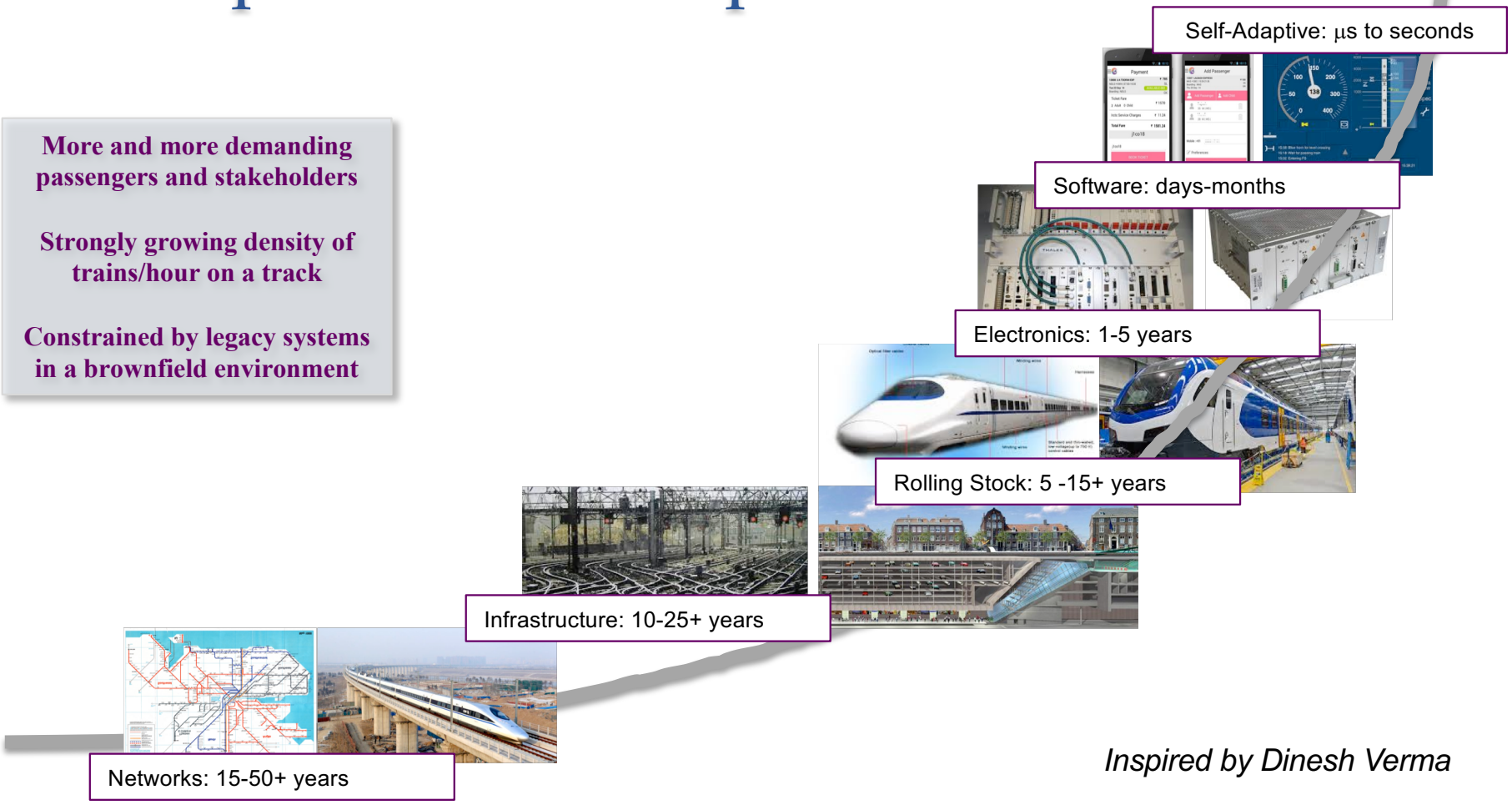
https://www.youtube.com/watch?v=LJevke4_i5Y

# Speed in development rate

**More and more demanding passengers and stakeholders**

**Strongly growing density of trains/hour on a track**

**Constrained by legacy systems in a brownfield environment**

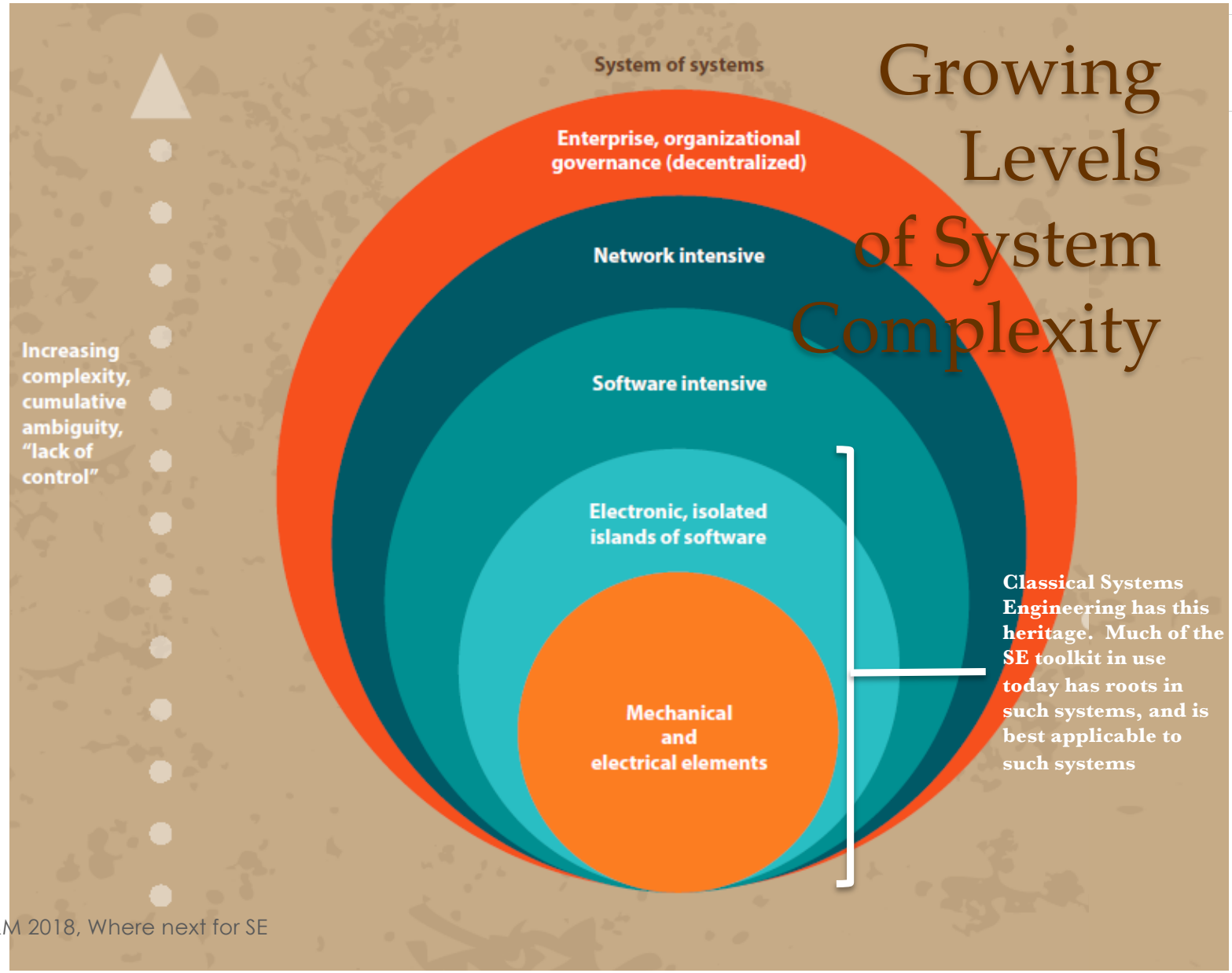



*Inspired by Dinesh Verma*

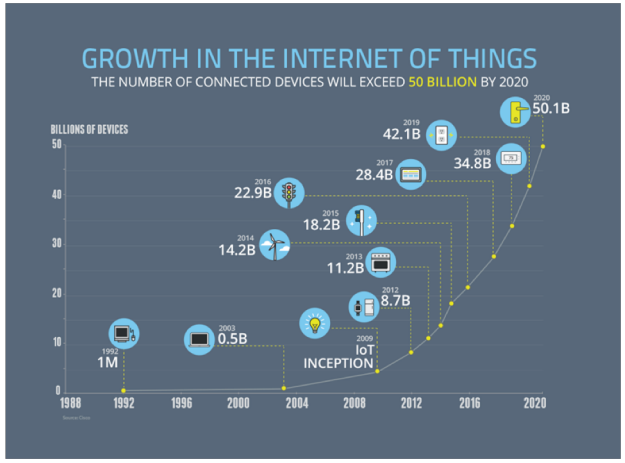
# The changing environment for SE

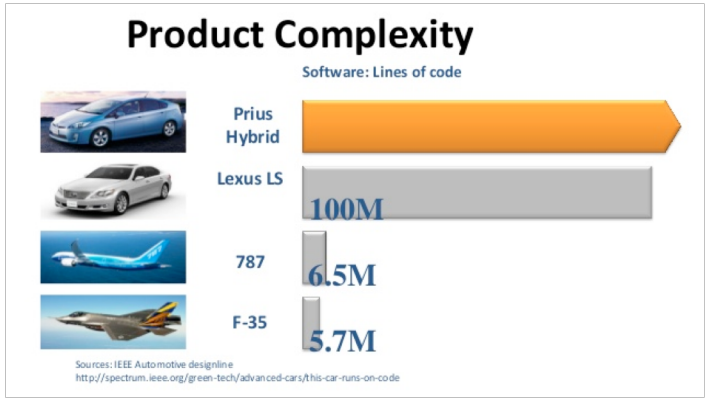
Model-centric
Electronics
Aerospace
Interconnected
Cyber-physical
Non-deterministic
Varying-lifespan
Change
Brown-field
Automotive
Agility
Defense
Stand-alone
Infrastructure
Medical

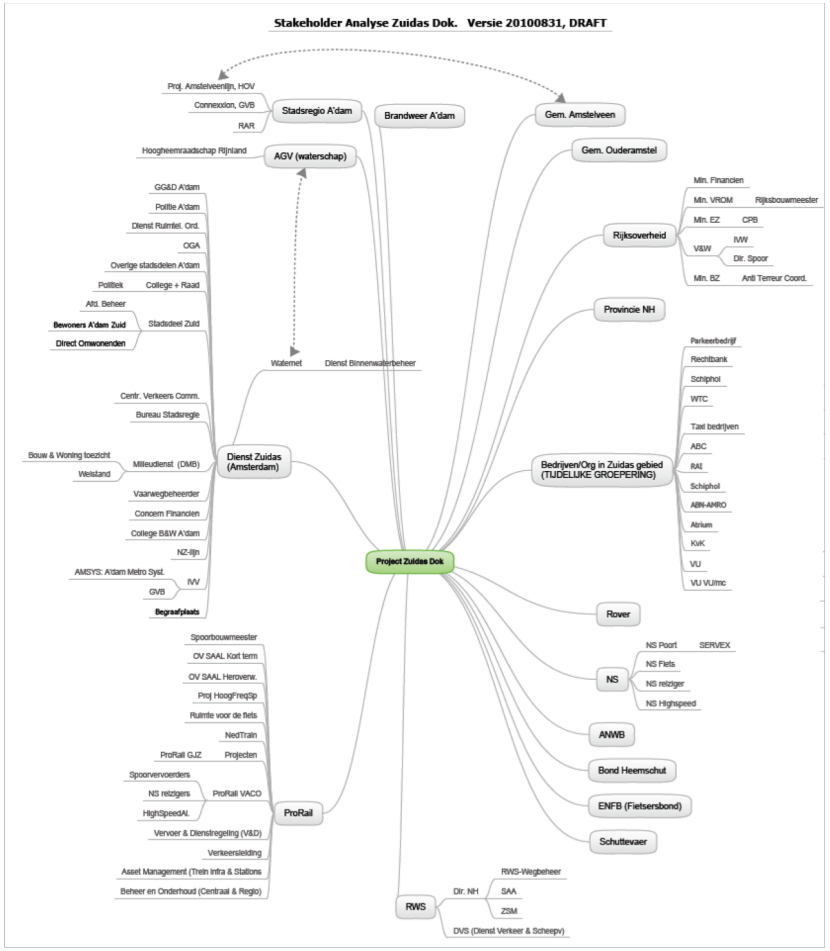
# Growing Levels of System Complexity



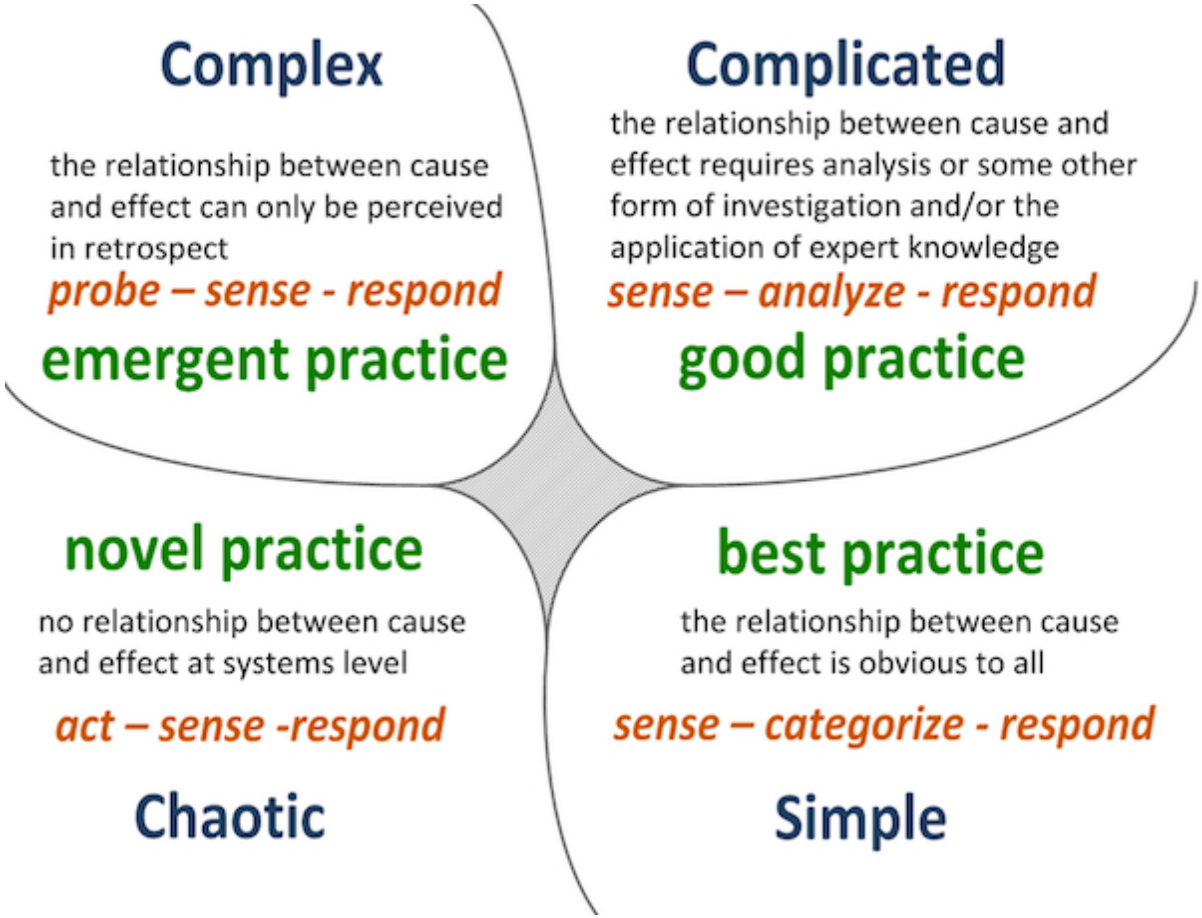
# Growth of complexity



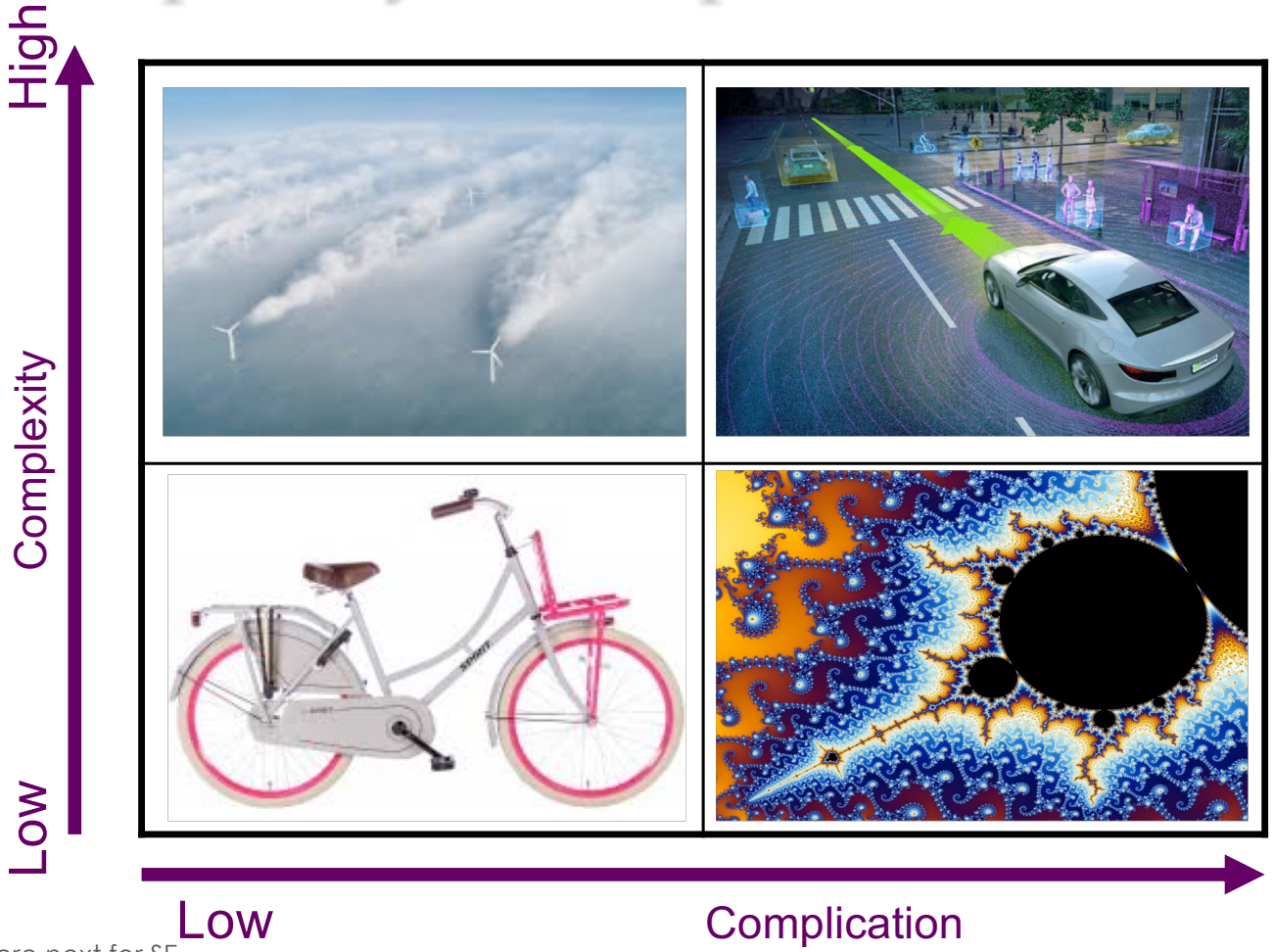



# Types of systems




Cynefin Framework (source: Kurtz & Snowden)

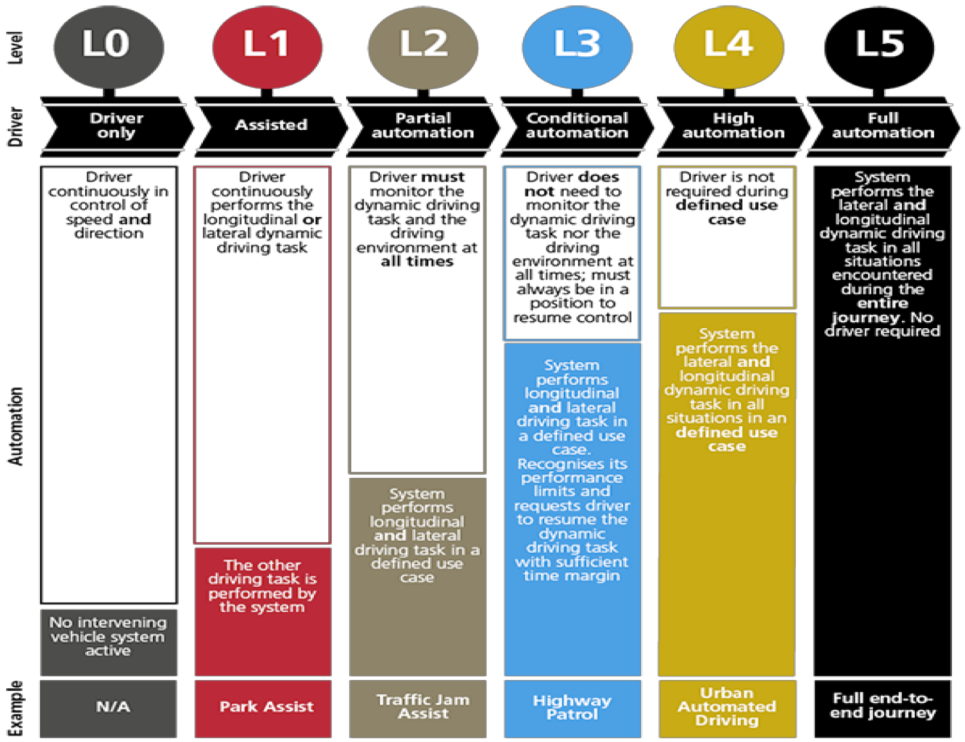
# Complexity / Complication




*Inspired by Dinesh Verma*

# Complexity; Systems with a non-deterministic nature

- Autonomous vehicles
  - Liability issues
  - Comply with the regulations; Adaptive behaviour of other users
  - Ethical issues; Decision making by the car to minimize number of casualties



# Growing the SE workforce

The future generation of Systems Engineers

# System Thinking; fundamental for (systems) engineers

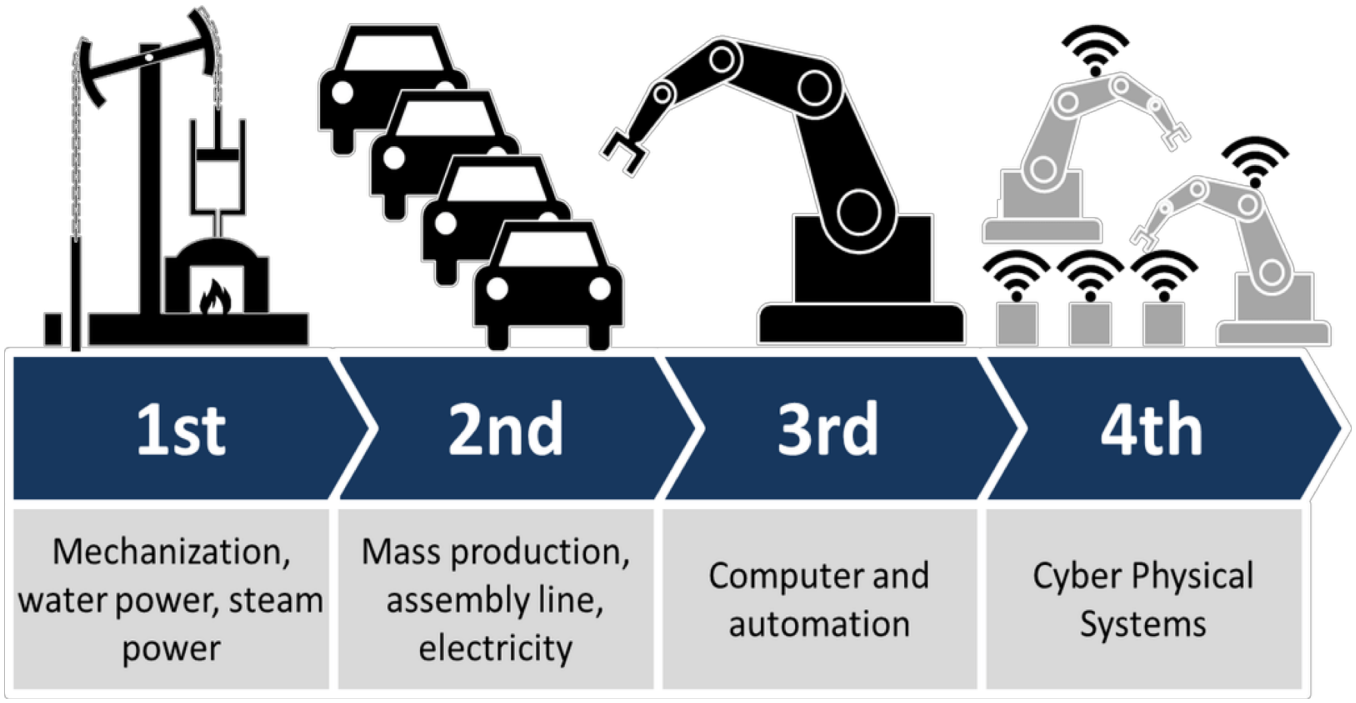
- Every student -from an early as possible age- should have understanding of the concepts of systems thinking

- Why not start before  K12 to encourage system thinking

# Looking Forward

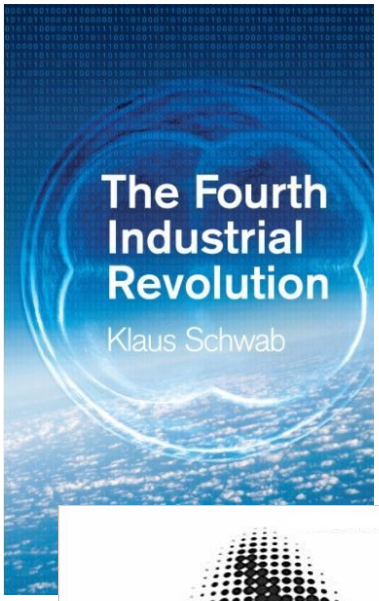
2019 and Beyond

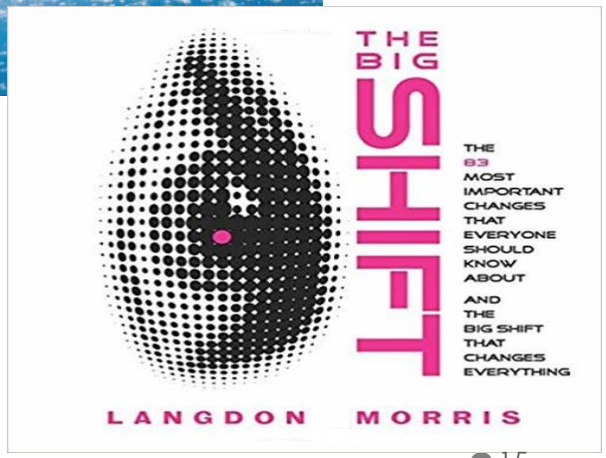
# A storm is coming…





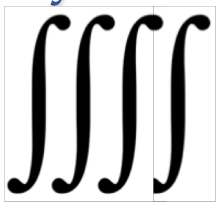

1700s 1800s 1900s 2000s



# Systems Engineering of the Future

## Systems of Systems Challenges



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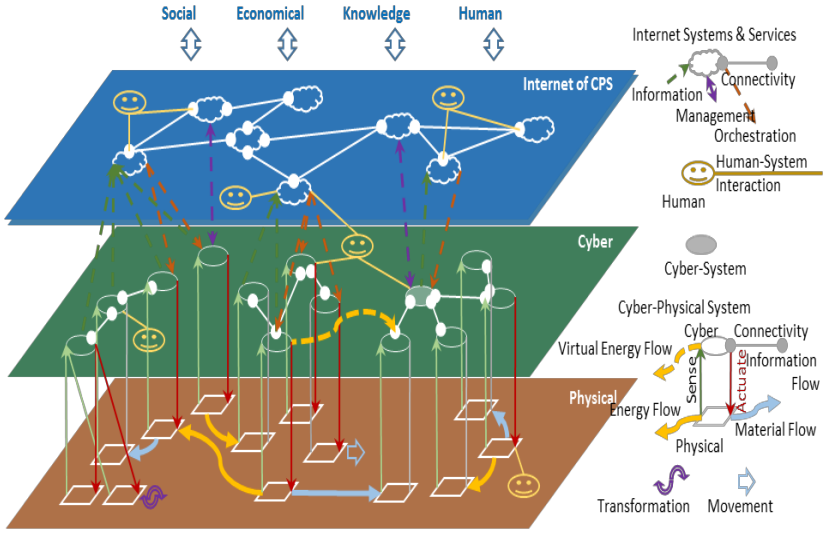



NIST 2016

Cyber-physical, complex adaptive, socio-technical systems:

Flows & conversions of energy, materials, signals/information

Transforming materials → objects → goods & services

Moving from programmed automation to autonomous systems

Applying deep learning and artificial intelligence

| Deterministic | → | Non-deterministic |
|---|---|---|
| Linear | | Evolutionary |
| Predictable | | Stochastic |

INCOSE FuSE
Future of Systems Engineering

Evolving application of systems engineering that enables us to leverage the new technologies that drive us fully into a dynamic, nondeterministic, and evolutionary environment




# The Future Systems Engineering
## A Systems World Perspective of Context

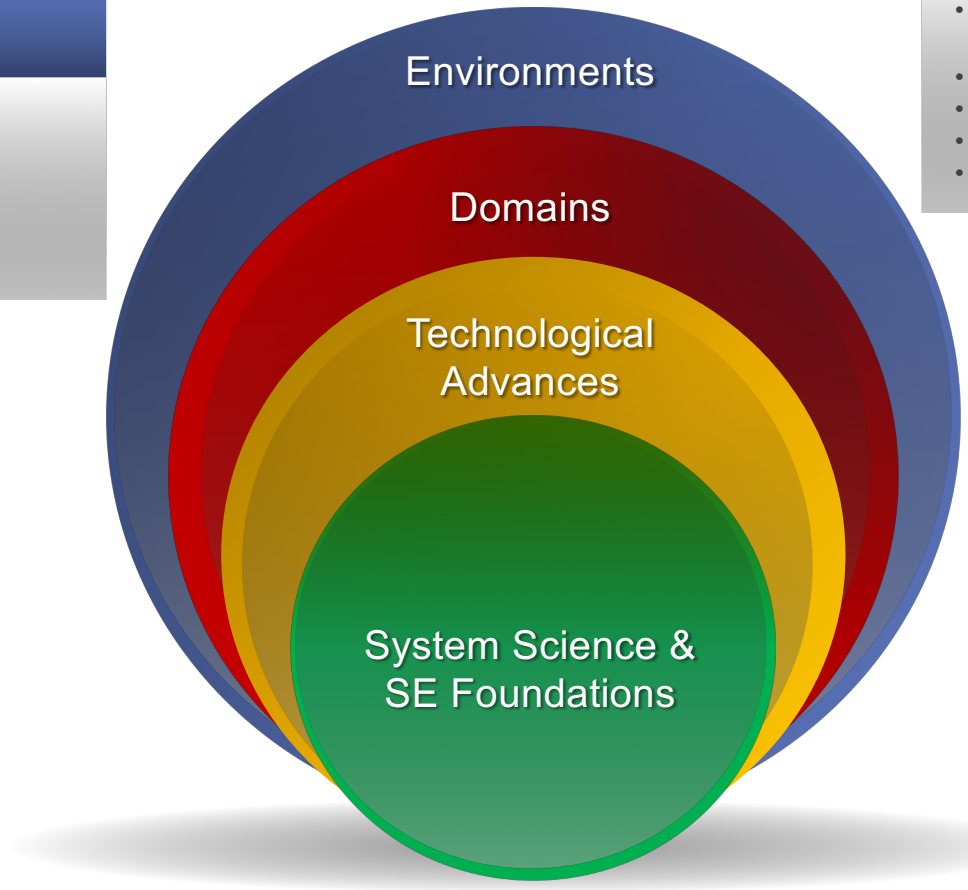
INCOSE FuSE
Future of Systems Engineering

### Environments

- Ecosystems– Natural & Artificial/Manmade
- Economical Environment
- Political Environment
- Health Environment

### Domains

- Defense
- Space
- Healthcare
- Games – serious games
- Transportation
- Communications
- Information
- Consumer Electronics
- Public Policy
- Biomedical
- Housing




### System Science & SE Foundations

- Processes, Methods & Guidelines
- Models & Tools
- Standards
- Tailoring Guidance
- System Research & Theories

### Technological Advances

- Artificial Intelligence (AI)
- Autonomy
- Big Data
- Internet of Things (IoT) / Smart Things
- Smart X (eg Smart Cities)
- Cloud Computing
- Ubiquitous Access to Information
- Power/Energy
- Augmented Virtual Reality
- Simulation/Stimulation
- Sustainment/Elegant Systems
- 3D Printing
- Cyber-Physical Systems
- Ability to find Unique (Old) via eBay, Amazon, etc

# Systems Engineering of the Future

## A New Collaborative Initiative

- Imperative to address current and future systems challenges – "Adapt or be irrelevant"
- Intended Outcome – Evolving systems engineering that enables us to leverage the new technologies that drive us fully into a dynamic, nondeterministic, and evolutionary environment
- Draft Framework:
  - Define problem statement
  - Define the challenges that are driving change
  - Identify impacts to systems engineering
  - Establish roadmaps matching systems engineering capabilities to match the challenges
  - Initiate actions, projects, research, benchmarking, training/education, and communications – short term, mid-term, and long-term

# Thank You

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