Fostering Convergence and Integration in ICT – For a French-Greek Cooperation in Space Industry

New European Space Era -- Cooperation opportunities between Greece & France

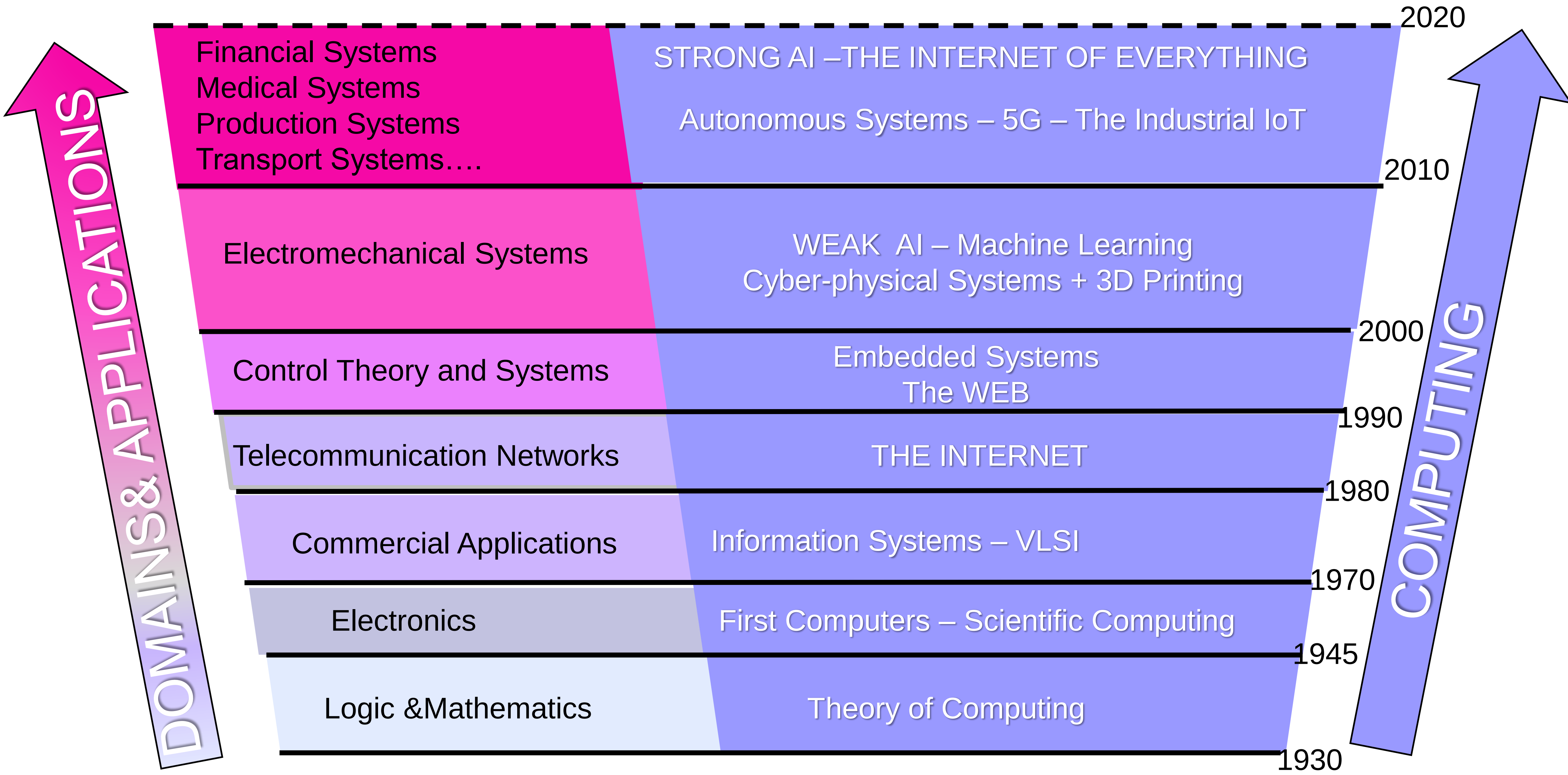
Athens, September 23, 2021

Joseph Sifakis
Verimag Laboratory, Grenoble

O V E R V I E W

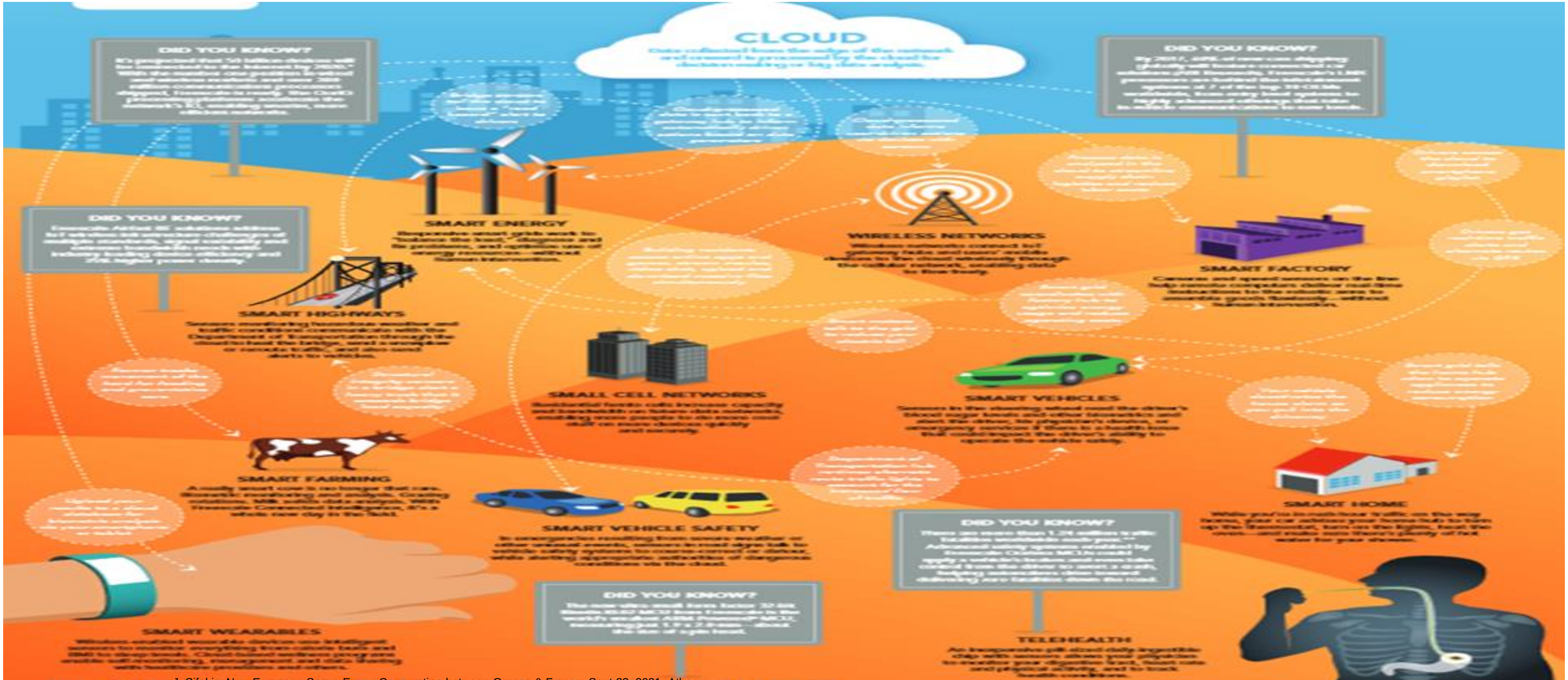
- Convergence and Integration in ICT
- Autonomous Systems
- The Systems Engineering Challenge
- International Scientific&Technical Cooperation

The Digital Revolution – Technological Convergence and Integration in ICT



The IoT Vision – Technological Convergence and Integration in ICT

The IoT allows objects to be sensed or controlled remotely across a network infrastructure, achieving more direct integration of the physical world into computer-based systems, and resulting in improved efficiency and predictability.



The IoT Vision – Autonomous Systems

The Internet of Things

Industrial IoT	Human IoT
Autonomous	**Interactive**
Rules can be changed, but human-driven changes are external to normal behavior	People's explicit or arbitrary actions dynamically trigger control sequences or rule changes
Autonomous transport systems Industry 4.0 Smart grids Autonomous space systems	Intelligent services Semantic web

Building cost-effectively autonomous systems is the Big Challenge in Systems Engineering for the next decade

OVERVIEW

- Convergence and Integration in ICT
- Autonomous Systems
- The Systems Engineering Challenge
- International Scientific&Technical Cooperation

Autonomous systems – Toward Strong AI

<u>Autonomous systems</u> are intelligent systems that are essential for reaching the Industrial IoT vision.

- They emerge from the needs to further automate existing organizations by progressive and incremental replacement of human operators by autonomous agents.
  - Very different from game-playing robots or intelligent personal assistants.

- They are often <u>critical</u> and should exhibit "broad intelligence" by handling knowledge in order to
  - Manage dynamically changing sets of possibly conflicting <u>goals</u>
  - Cope with uncertainty of complex, unpredictable <u>cyber physical environments</u>.
  - Harmoniously collaborate with <u>human agents</u> e.g. "symbiotic" autonomy.
- They require a move
  - from single task, single goal, single domain e.g. intelligent personal assistant, chess player,
  - to reactive/proactive intelligent systems integrating many coordinated tasks e.g. self-driving cars,

- Autonomy goes far beyond the current AI vision:
  - It is a big step toward closing the gap between machine and human intelligence.
  - it requires a new scientific and engineering foundation integrating knowledge from traditional engineering and computing disciplines.

Autonomous Systems – From Automation to Autonomy

Thermostat

Automatic train shuttle

Chess-playing robot
(Weak AI)

Soccer-playing robot

Robocar
(Autonomy – Broad AI)

Each system consists of agents acting as controllers on their environment and pursuing individual goals so that the collective behavior meets the system global goals.

Autonomous Systems – From Automation to Autonomy

	Environment	Stimuli	Meeting Goals
Thermostat	Room + Heating/cooling device	Temperature	Explicit controller Single goal
Shuttle	Cars + Passengers+ equipment	Dynamic configuration of cars+ State of equipment	Explicit controller + on line adaptation Many fixed goals
Chess robot	Chess board + pawns	Static configuration of pawns	On-line planning+ stored knowledge Dyn. Changing goals
Soccer robot	Regions in the field + Players + Ball	Dynamic configuration of players/ball	On-line planning+ stored/generated knowledge Dyn. changing goals
Robocar	Vehicles/obstacles + Road/communication equipment	Dynamic configuration of vehicles/obstacles + State of equipment	On-line planning+ stored/generated knowledge Dyn. changing goals
		AI for Awareness	AI for Decision Making

Autonomous Systems – Model-based vs. Data-based Knowledge

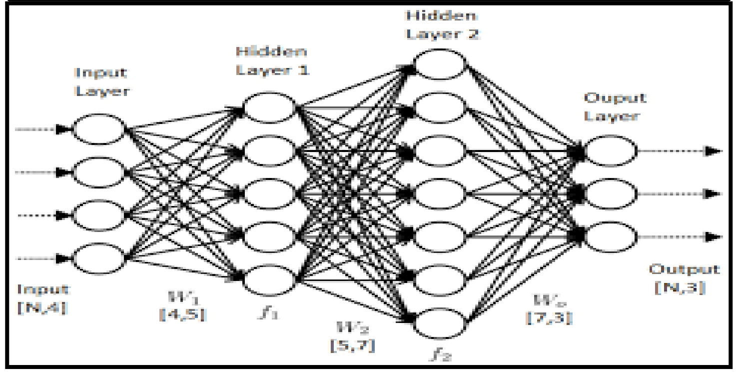
Fast thinking vs. Slow thinking (D. Kahneman's "Thinking Fast and Slow")

System 1: "Fast" Thinking
- Non-conscious – automatic – effortless;
- Without self-awareness or control;
- Handles all kind of empirical implicit knowledge e.g. walking, speaking or playing the piano.

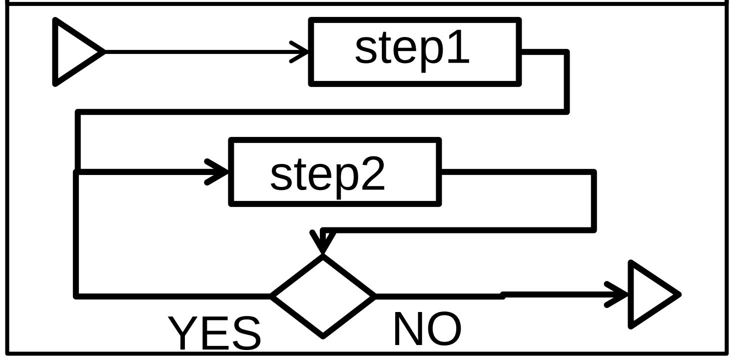
System 2: "Slow" Thinking
- Conscious – controlled– effortful;
- With self-awareness and control;
- Is the source of any reasoned knowledge e.g. mathematical, scientific, technical.

Neural Networks vs. Conventional Computers

NEURAL NETWORK



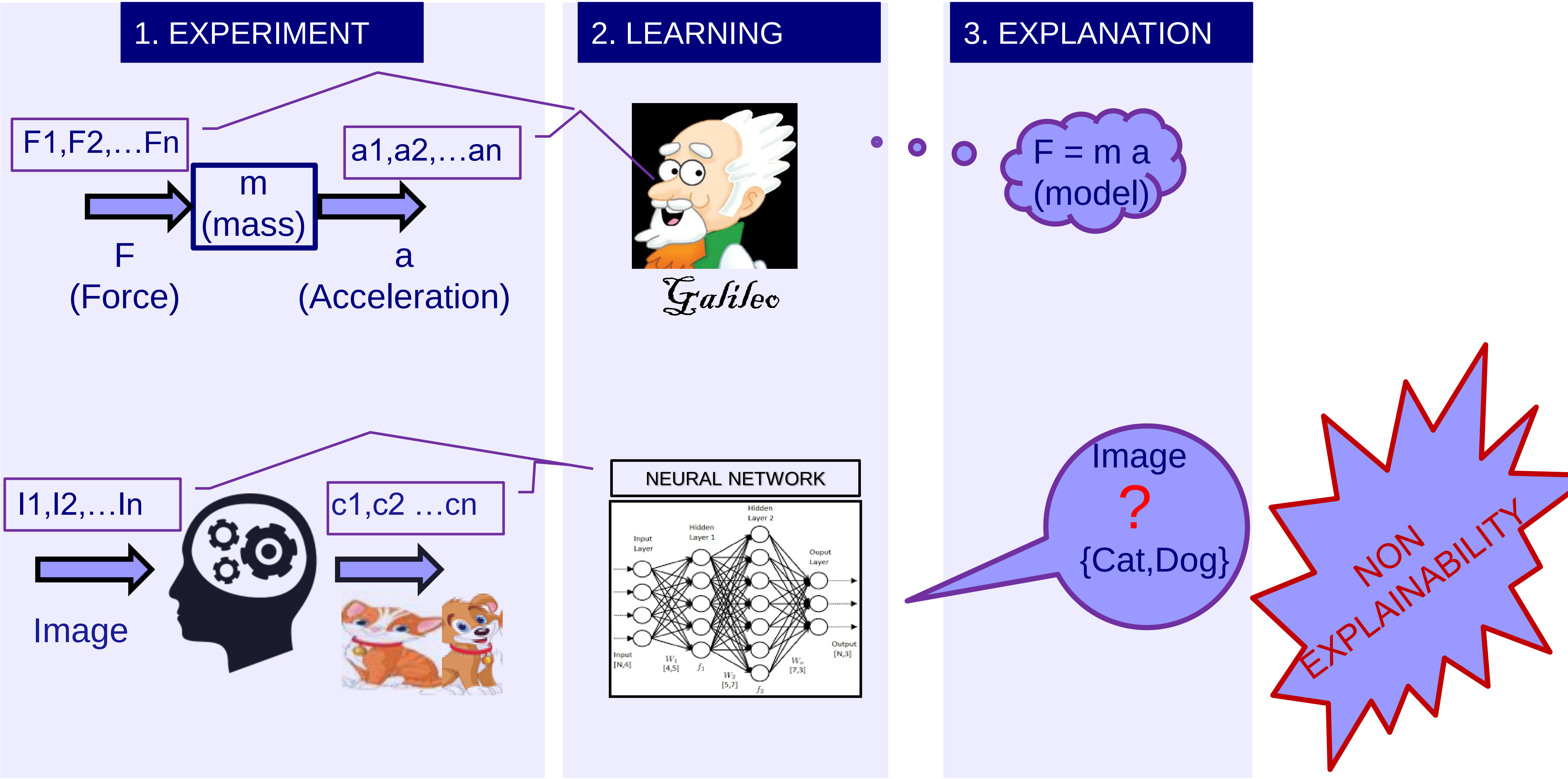
COMPUTER



- Generate empirical knowledge after training (<u>Data-based</u> knowledge).
- Distinguish "cats from dogs" exactly as kids do – Cannot be verified!

- Execute algorithms (<u>Model-based</u> knowledge).
- Deal with explicitly formalized knowledge – Can be verified!

Autonomous Systems – Scientific vs. ML-generated Knowledge



O
V
E
R
V
I
E
W

- Convergence and Integration in ICT

- Autonomous Systems

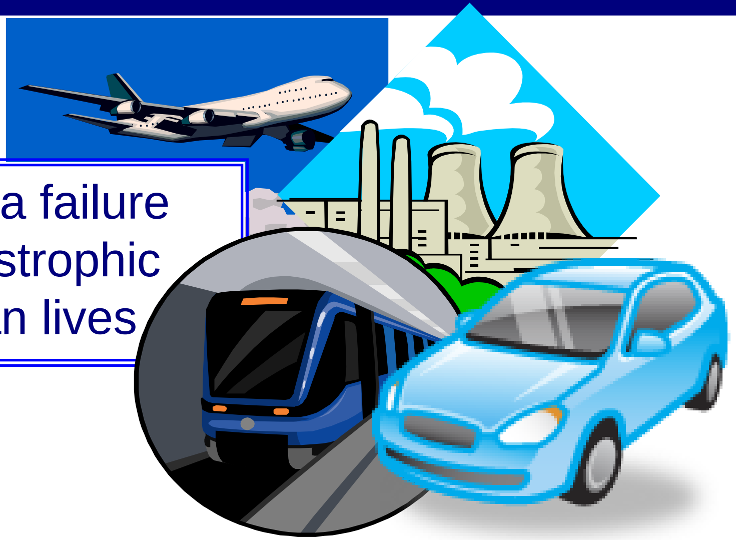
- The Systems Engineering Challenge

- International Scientific&Technical Cooperation

The Systems Engineering Challenge – Trustworthy vs. Cost-effective Design

10^{-9}

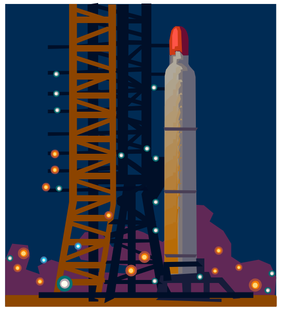
Safety critical: a failure may be a catastrophic threat to human lives

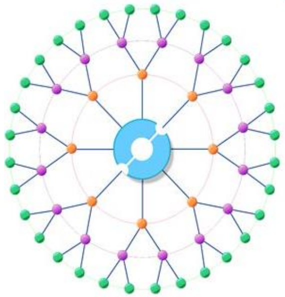


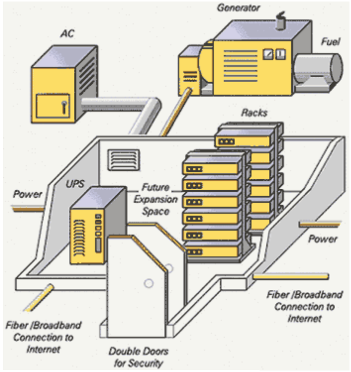
Security critical: harmful unauthorized access

10^{-6}

Mission critical: system availability is essential for the proper running of an organization or of a larger system







10^{-4}

Best-effort: optimized use of resources for an acceptable level of trustworthiness

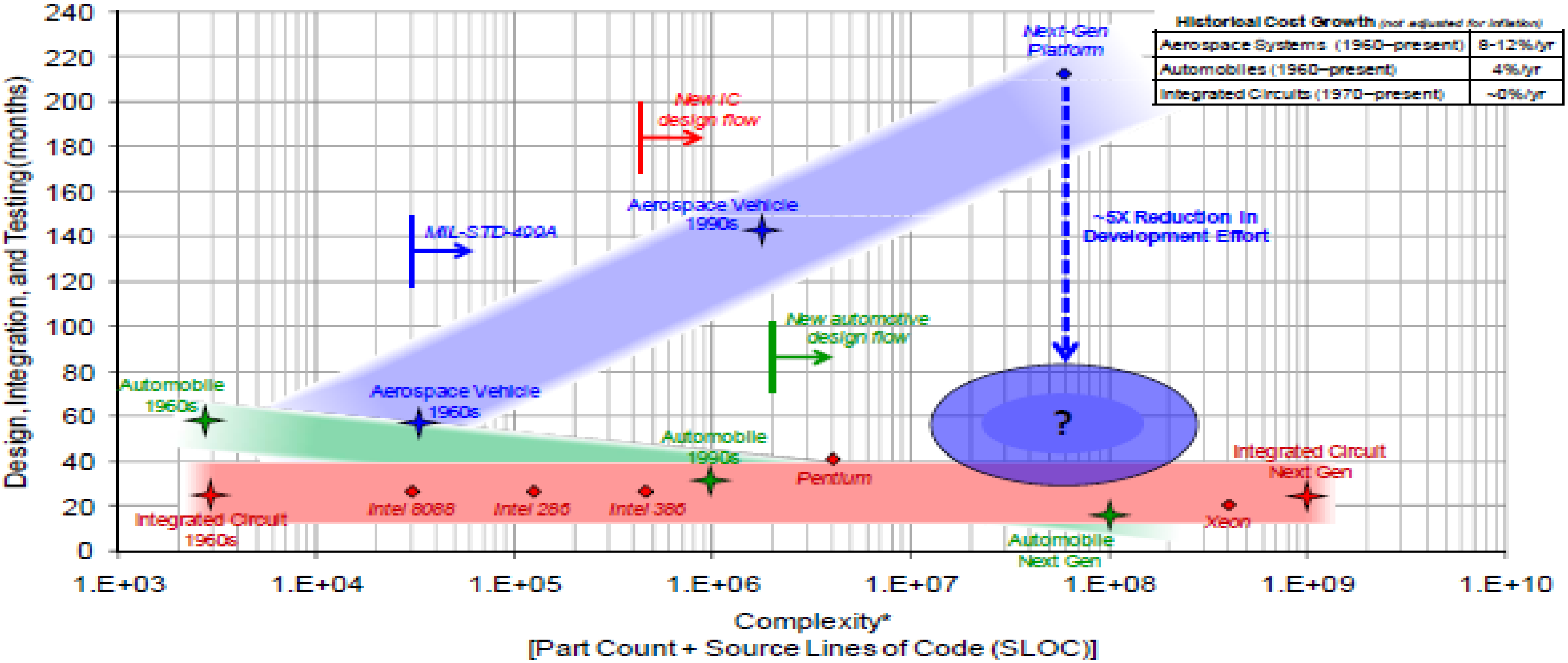
amazon.com Google Y!

Increasing reliability by one order of magnitude implies exponential increase of development costs!

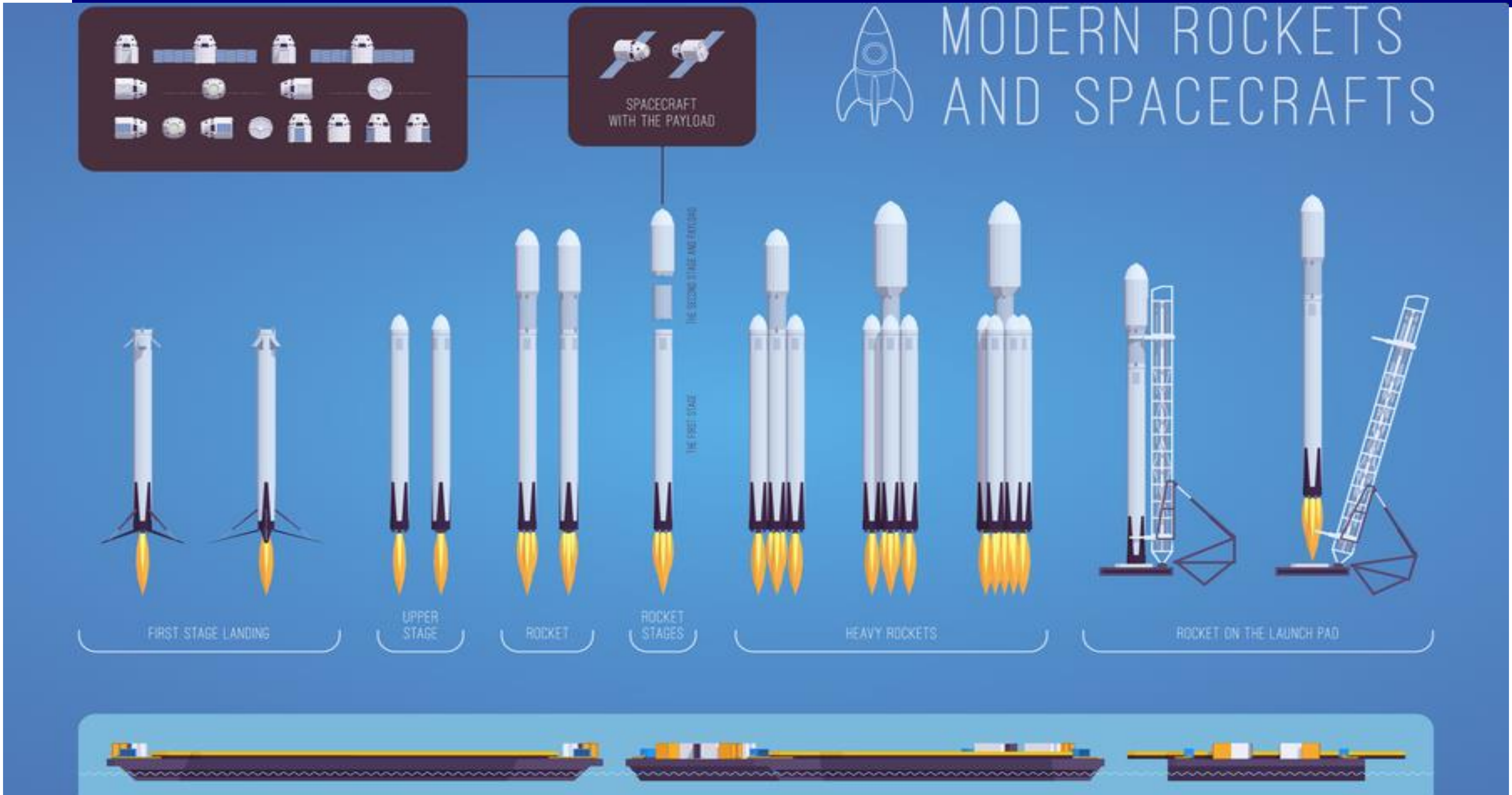
The Systems Engineering Challenge – The Cost of Trustworthiness

APPROVED FOR PUBLIC RELEASE. DISTRIBUTION UNLIMITED.

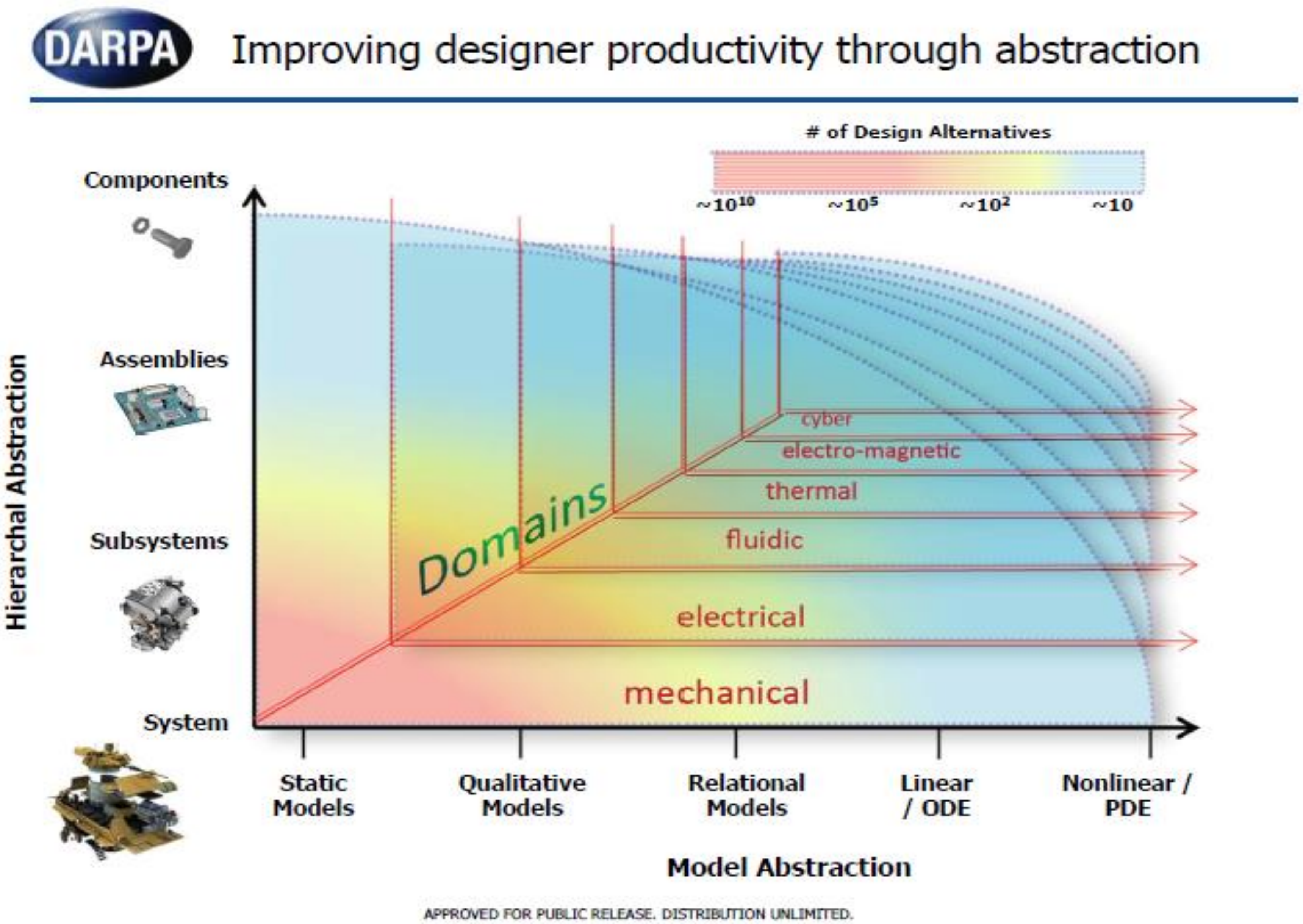
DARPA Historical schedule trends with complexity



The Systems Engineering Challenge – Modular, Reusable and Scalable Design



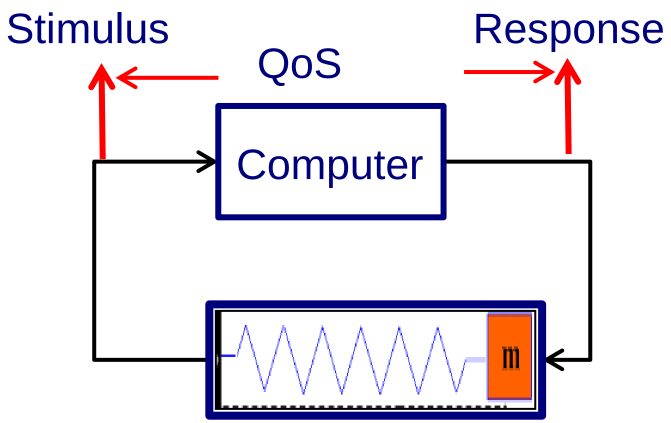
The Systems Engineering Challenge – Modular, Reusable and Scalable Design



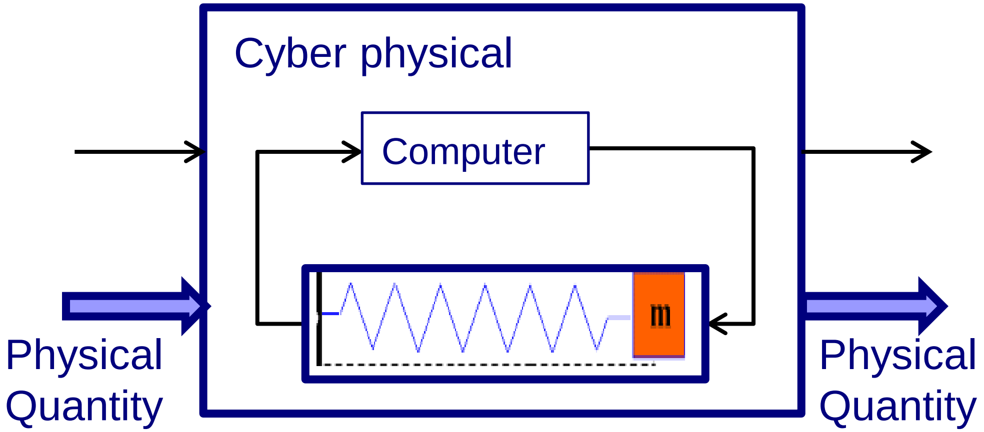
The Systems Engineering Challenge – Cyber Physical Systems

Cyber-physical systems refer to the next generation of engineered systems requiring tight integration of computing, communication, and control technologies.

- tightly combine the continuous dynamics (systems of differential equations) with the discrete dynamics of cyber systems (SW+HW).
- are important in overcoming many challenges in energy, environment, transportation, and health care e.g., to achieve stability, performance, reliability, robustness, and efficiency´.



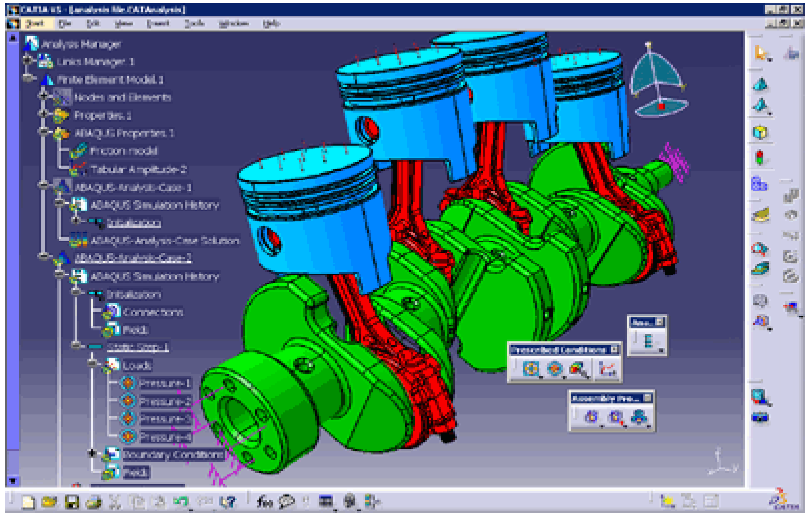
Embedded component
e.g. Flight controller

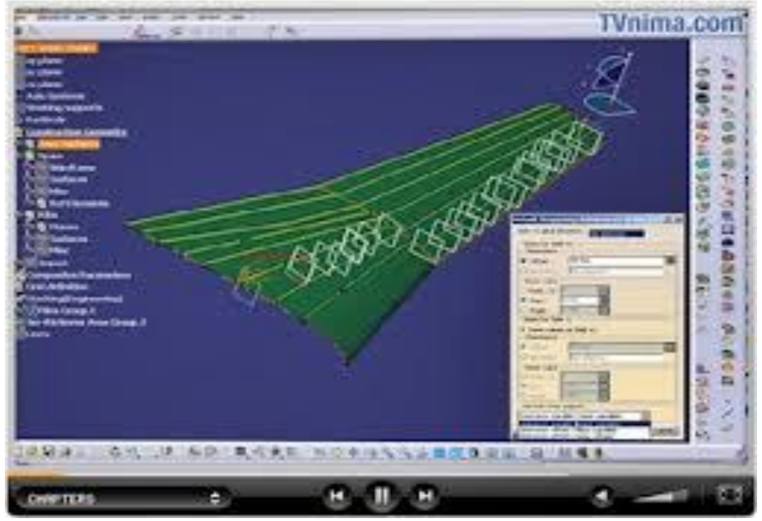


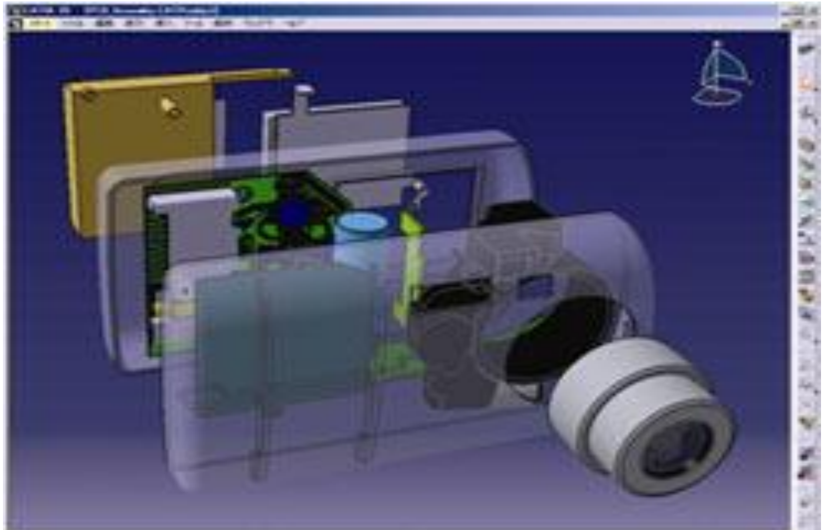
Cyber physical component
e.g. Self-driving car, Modular avionics, Modular Reusable Spacecraft, Cubesats

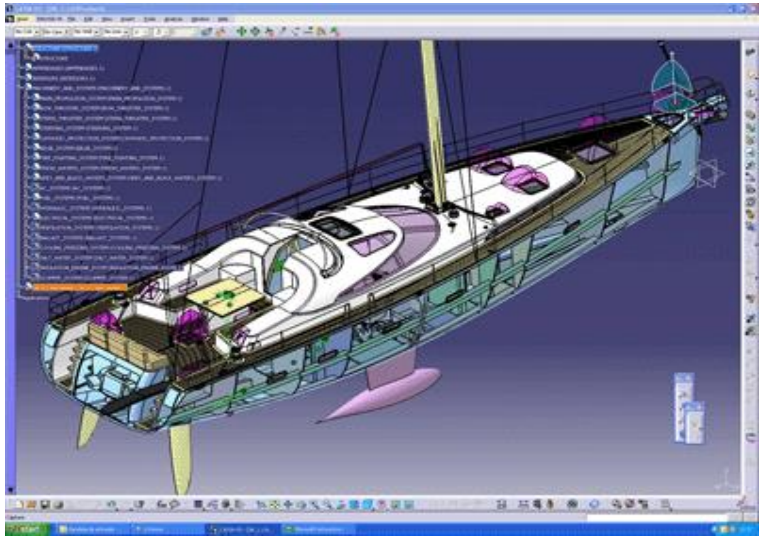
The Systems Engineering Challenge – Extending the 3D Printing Paradigm

Building smart systems as the composition of components whose cyber and physical parts are concurrently designed.

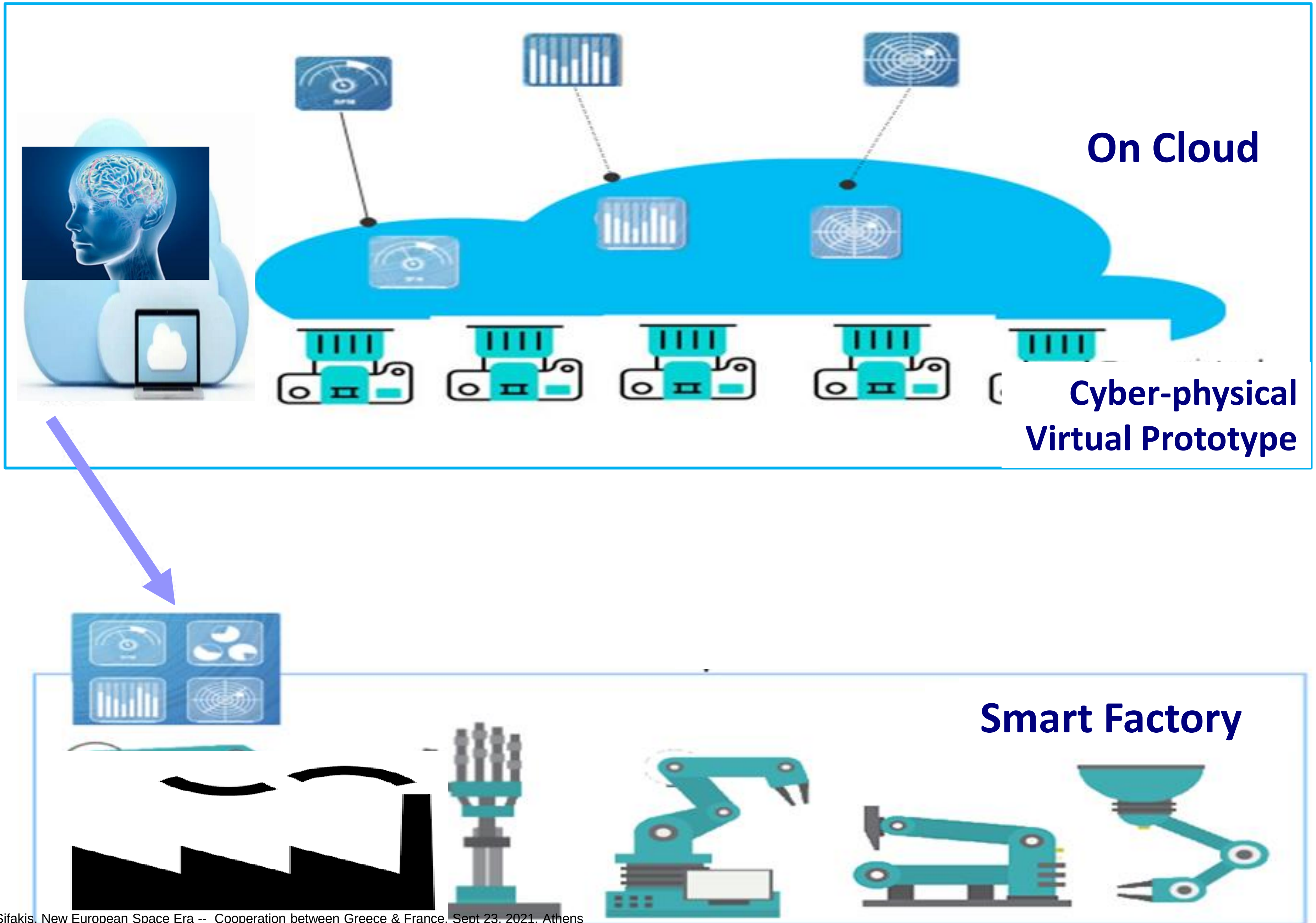








The Systems Engineering Challenge – Modular, Reusable and Scalable Design

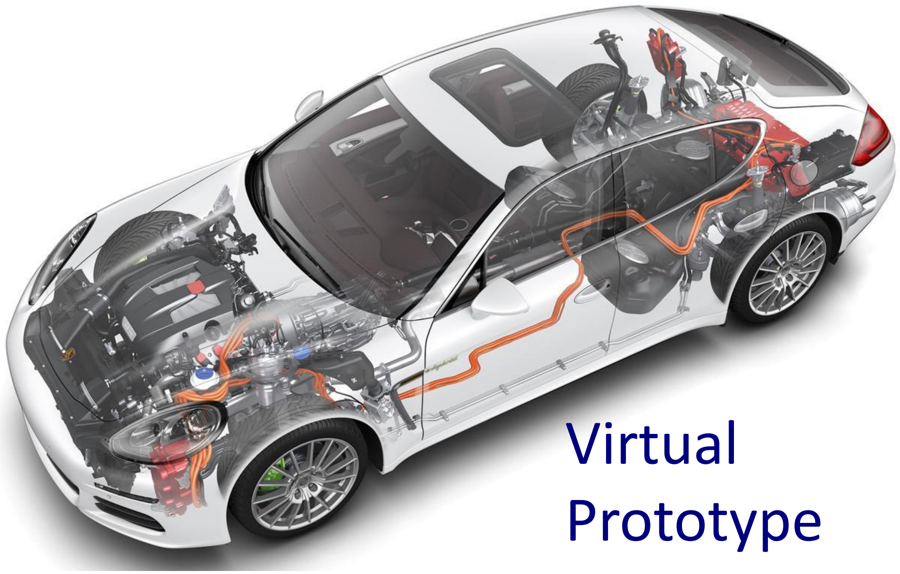


The Systems Engineering Challenge – Modular, Reusable and Scalable Design

ON CLOUD

Library of Components

Factory



Virtual Prototype

- Convergence and Integration in ICT
- Autonomous Systems
- The Systems Engineering Challenge
- International Scientific&Technical Cooperation

O V E R V I E W

Scientific and Technical Cooperation

Technological Convergence is the catalyzer for Convergence of issues, of interests and of solutions in the context of global development

- where problems are so complex, large and persistent that they require cooperation and a wide range of approaches
- privileging collaborative rather than aid-driven action to bring the desired outcomes more quickly, in more scalable and more sustainable ways.

- Scientific and Technical cooperation is a must in the global digital and knowledge-based economy and society:
  - Sharing RTD and infrastructure costs;
  - Wider intellectual pool: innovation that is domestically generated can produce added value and more incentives at the international level; mutual cross-fertilization through complementary approaches;
  - Benefit from international networking and market recognition.

We observe changing attitudes in favor of more international cooperation that may be attributed to the following considerations:

- Big Tech companies are interested to participate in successful national or regional innovation ecosystems (e.g. Barcelona, Ireland);
- It is now becoming more and more accepted, especially at the level of the more advanced economies, that their excellence and supremacy in innovation production is not threatened by international cooperation and exchanges;
- The many mutual benefits from cooperation far outweigh potential threats and dis-benefits;
- Extensive use of digital technology and Digital Platforms in particular.

Scientific and Technical Cooperation – Digital Platforms and Ecosystems

- Digital Platforms integrate a shared set of technologies, components, services, architectures, and relationships that serve as a common foundation for diverse sets of partners to converge and create value e.g.
  - service platforms (Uber, Airbnb) and retail platforms (Amazon)
  - but also technical platforms such as Apple's iOS platform, Cloud platforms, automotive platforms, IoT platforms, blockchain platforms e.g. Ethereum, drone development platforms, etc.

- Platform-based ecosystems transcending borders, locations, and industries gather together partners that
  - share platform resources and synergize on common goals orchestrated by the platform leader
  - collaborate and exhibit varying types of mutual dependencies borne out of their co-specialization and complementarities in the platform context

- **New ways of internationalization:** ecosystem-specific advantages are often portable across borders as they typically arise from the common or shared assets of the platform; shift in focus from inter-firm competition to inter-platform competition;
- **New ways of building knowledge and relationships:** combiner of knowledge derived from multiple sites and brought together in some centralized process; shared set of underlying sets of standards, processes, and governance systems;
- **New ways of creating and delivering values to global customers:** flexibility in refashioning value propositions and associated business models; fostering open innovation creating avenues for new business models and novel value propositions.

Scientific and Technical Cooperation – For a French-Greek Cooperation

- Greece can be for France a partner of choice:
  - Highly available, skilled and qualified scientific and technical workforce with strong links to a thriving Greek scientific and technical diaspora;
  - Strong historical and cultural links between the two countries;
  - Greece's potential to play a transregional role looking outward from Europe to the Mediterranean, Balkan and Eurasia countries;
  - Converging geopolitical interests within the European Union and the Mediterranean scene.

- All the conditions are in place for setting up a fruitful, innovative and lasting cooperation program between France and Greece in the area of space and telecommunications
  - France's cutting-edge space industry
  - Thriving Greek startup space industry ecosystem

Should have happened long time ago – but it is never too late to do the right thing!

THANK YOU