PSI 3442

PROJETO DE SISTEMAS EMBARCADOS

Segunda Aula

2019

Objetivo da Disciplina

Orientar os alunos a:

- Entender os aspectos de Projeto de um Sistema Embarcado
- Incorporar Conceitos Fundamentais
- Desenvolver Um projeto na Área de Projeto de Sistemas Embarcados

Motivação

Vamos falar sobre nossas disciplinas da Poli
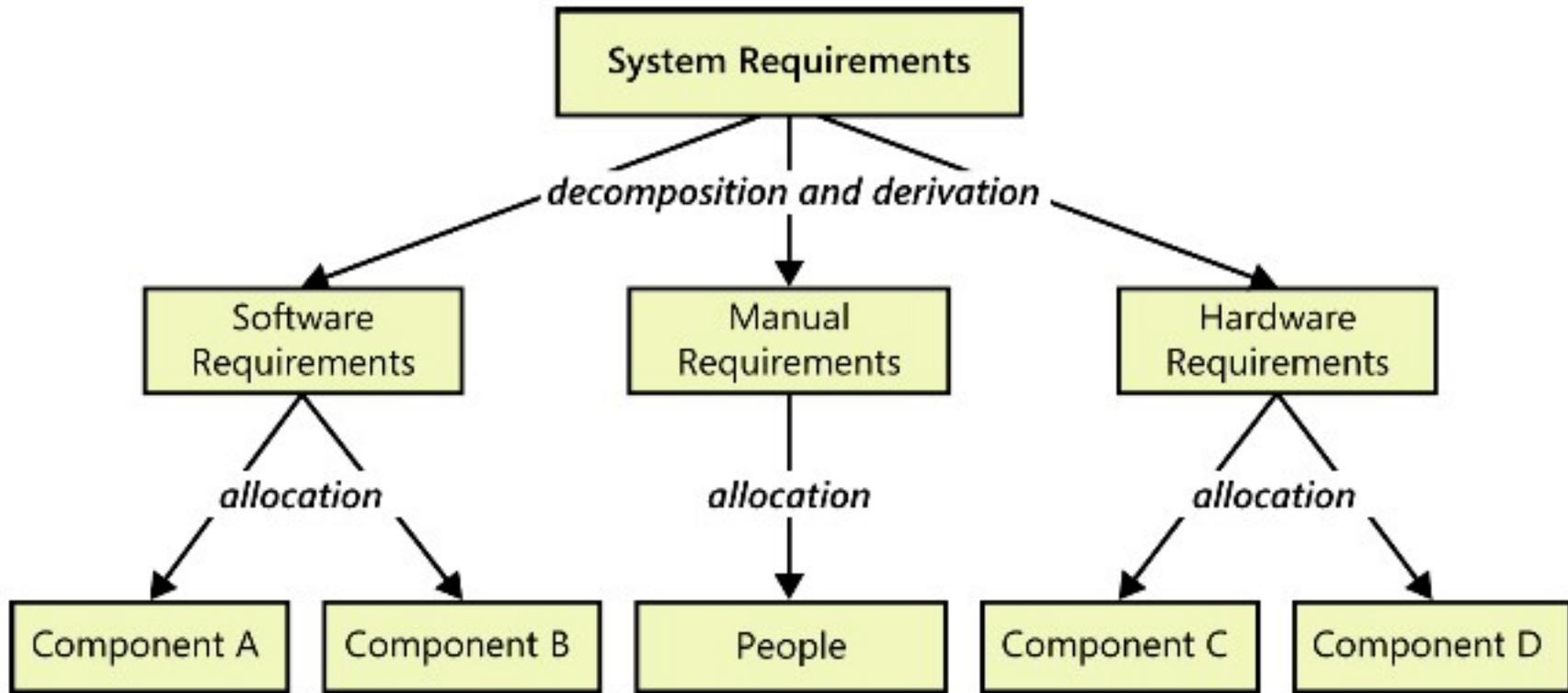
Embedded Systems

Cyber Physical Systems

Module 1:
Motivation: Cyber Physical Systems
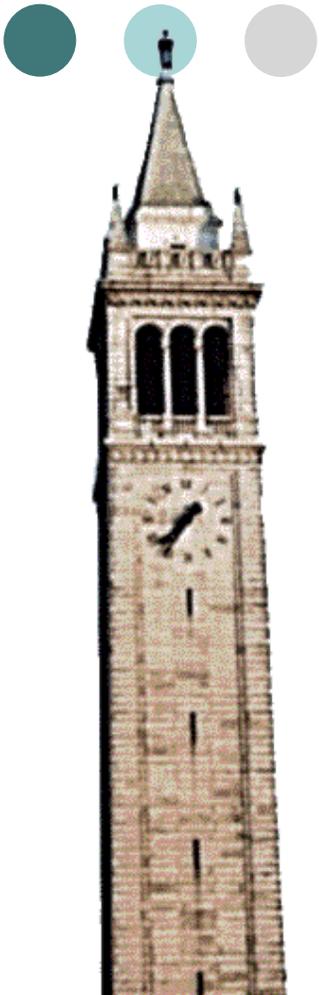
Focus on Cyber-Physical Systems
Full of Contradictory Requirements

It's not just information technology anymore:

- Cyber + Physical
- Computation + Dynamics
- Security + Safety

Contradictions:

- Adaptability vs. Repeatability
- High connectivity vs. Security and Privacy
- High performance vs. Low Energy
- Asynchrony vs. Coordination/Cooperation
- Scalability vs. Reliability and Predictability
- Laws and Regulations vs. Technical Possibilities
- Economies of scale (cloud) vs. Locality (fog)
- Open vs. Proprietary
- Algorithms vs. Dynamics

Innovation:

Cyber-physical systems require new engineering methods and models to address these contradictions.

Lee, Berkeley

EECS 149/249

Automotive

Energy

Biomedical

Avionics

Military

Manufacturing

Buildings
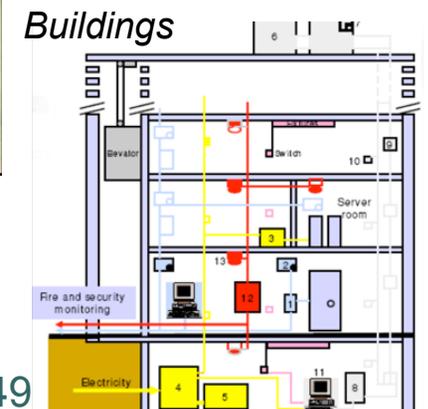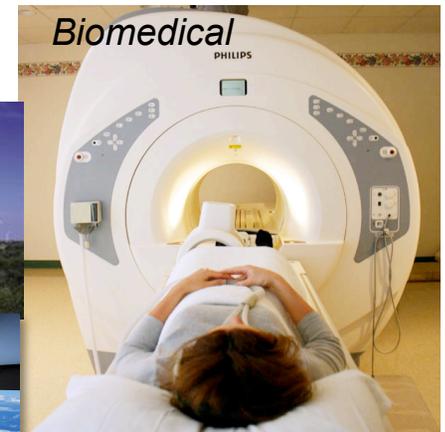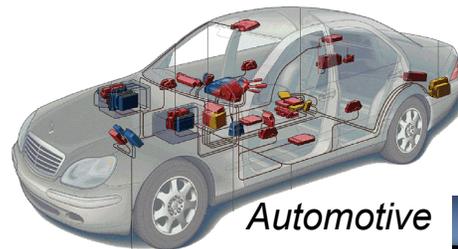
E Pluribus Unum: Out of Many, One
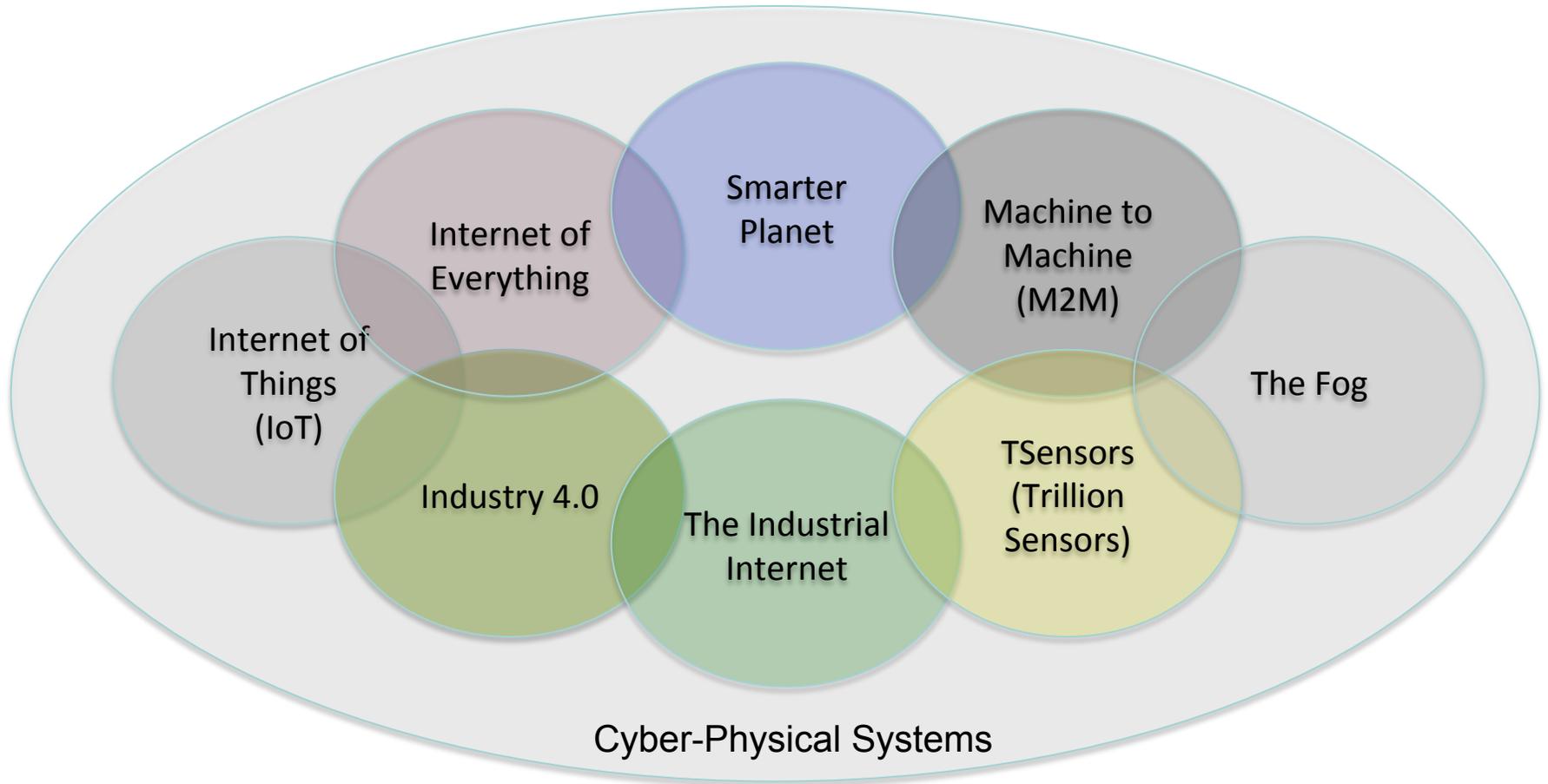
Cyber-Physical Systems

- Internet of Things (IoT)
- Internet of Everything
- Smarter Planet
- Machine to Machine (M2M)
- The Fog
- Industry 4.0
- The Industrial Internet
- TSensors (Trillion Sensors)

The Hype Around
The Internet of Things

Using Internet technology to connect physical devices ("things").

http://www.gartner.com/technology/research/hype-cycles/

The Hype Around
The Internet of Things
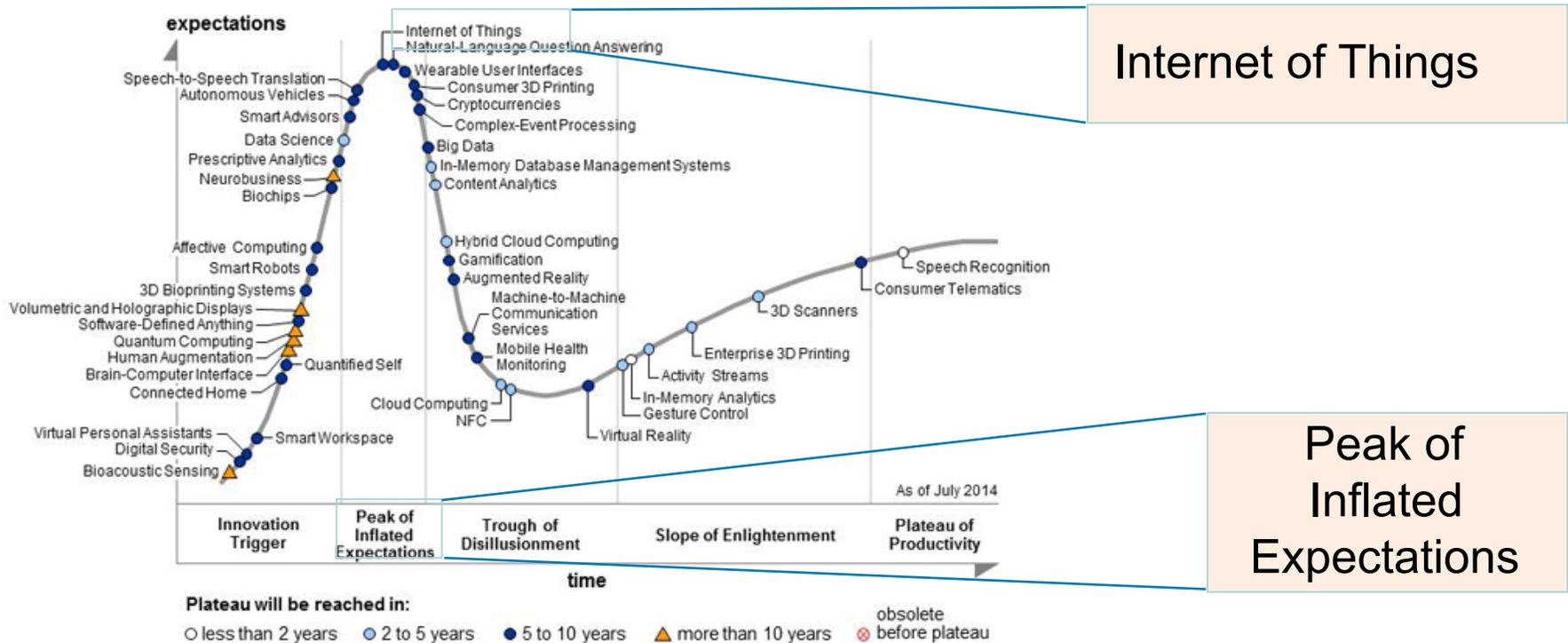
Using Internet technology to connect physical devices ("things").

http://www.gartner.com/technology/research/hype-cycles/
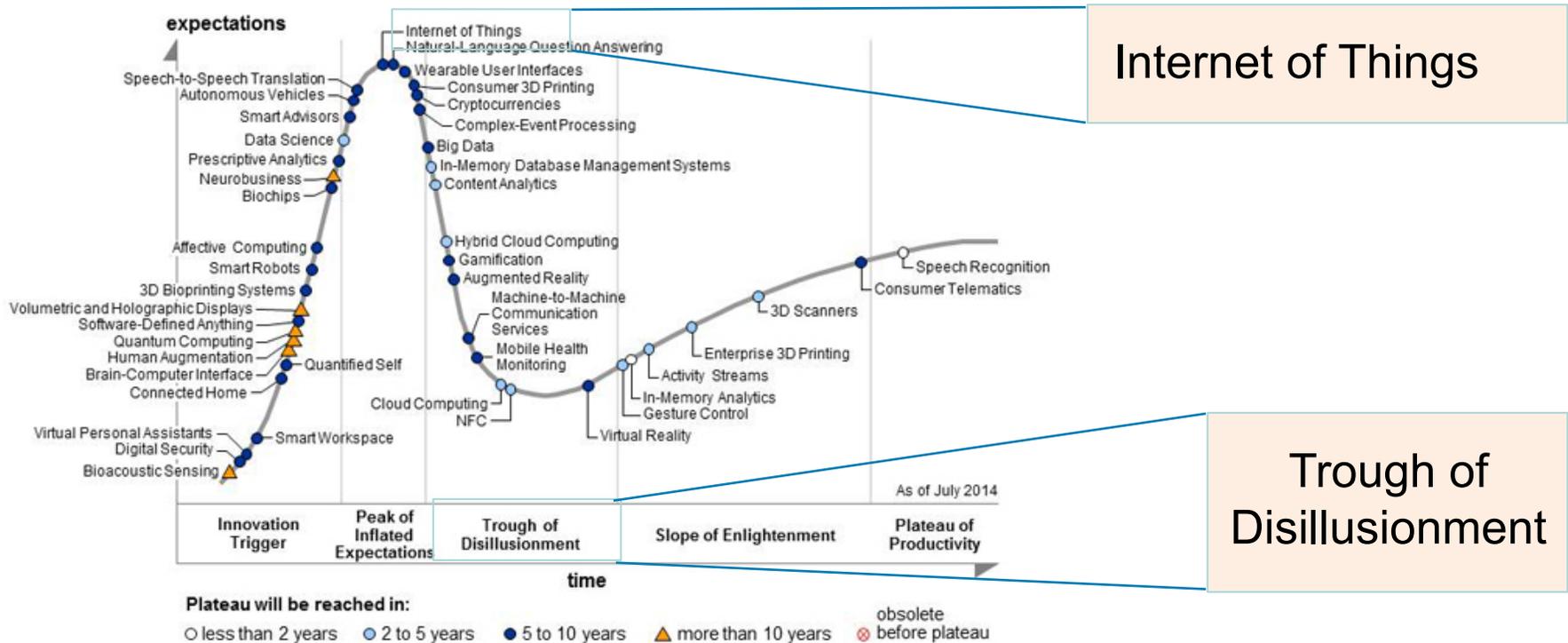
IoT is the use of Internet technology for Cyber-Physical Systems

Industrial automation example from 2008: Bosch-Rexroth printing press.

The term "IoT" includes the technical solution "Internet technology" in the problem statement "connect things".

*The term CPS does not.*

Lee, Berkeley

This Bosch Rexroth printing press is a cyber-physical factory using Ethernet and TCP/IP with high-precision clock synchronization (IEEE 1588) on an isolated LAN.

Example – Flying Paster

Sensor top dead center

G

Drive roller

Dancer

Idle roller

B

D

A

Reserve paper feed

F

A

B

Idle roller

C

Flying paster

H

E

J

I

Paper cutter

Active paper feed

Source: http://offsetpressman.blogspot.com/2011/03/how-flying-paster-works.html
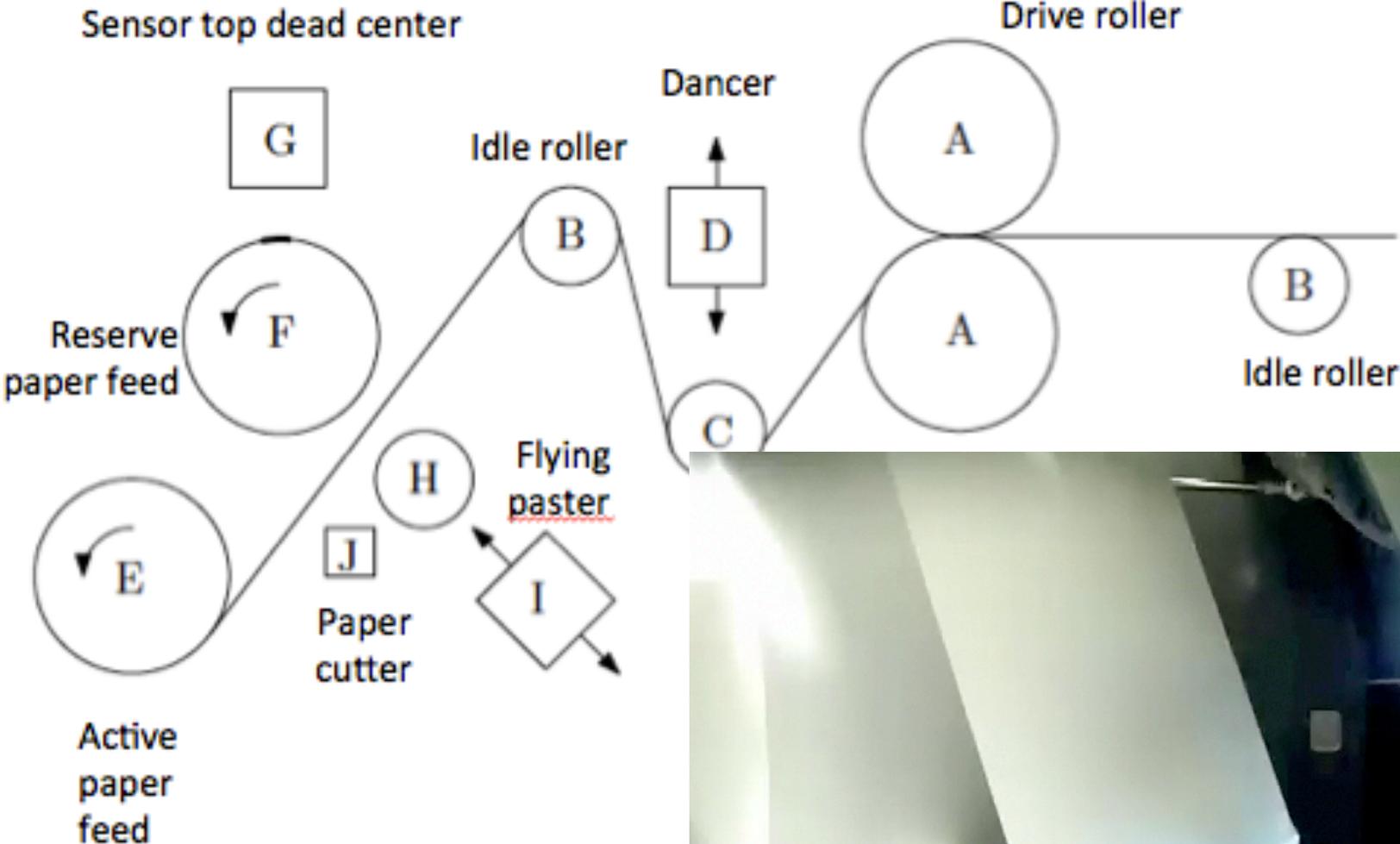
Flying Paster

CPS Challenge Problem: Prevent This
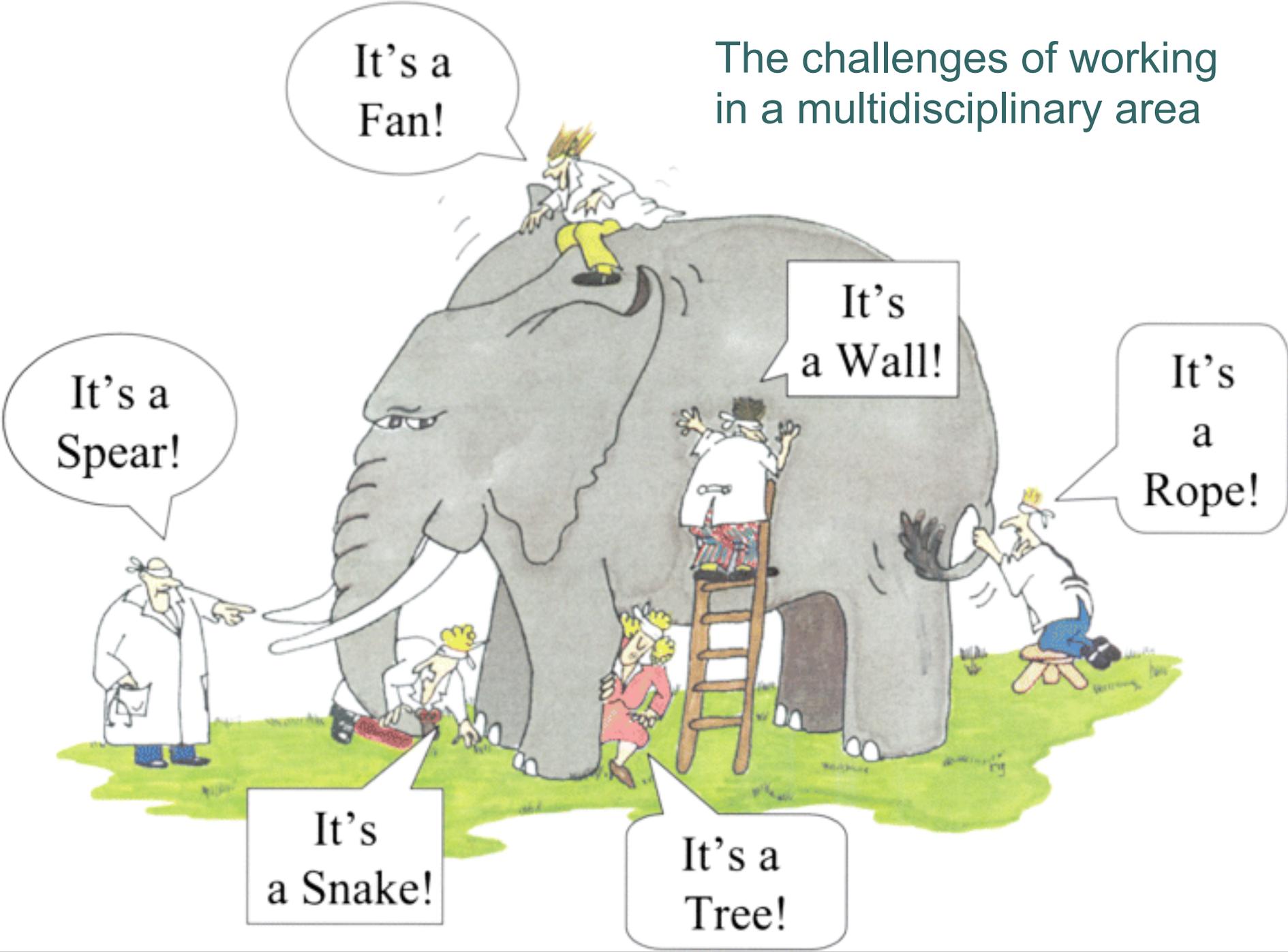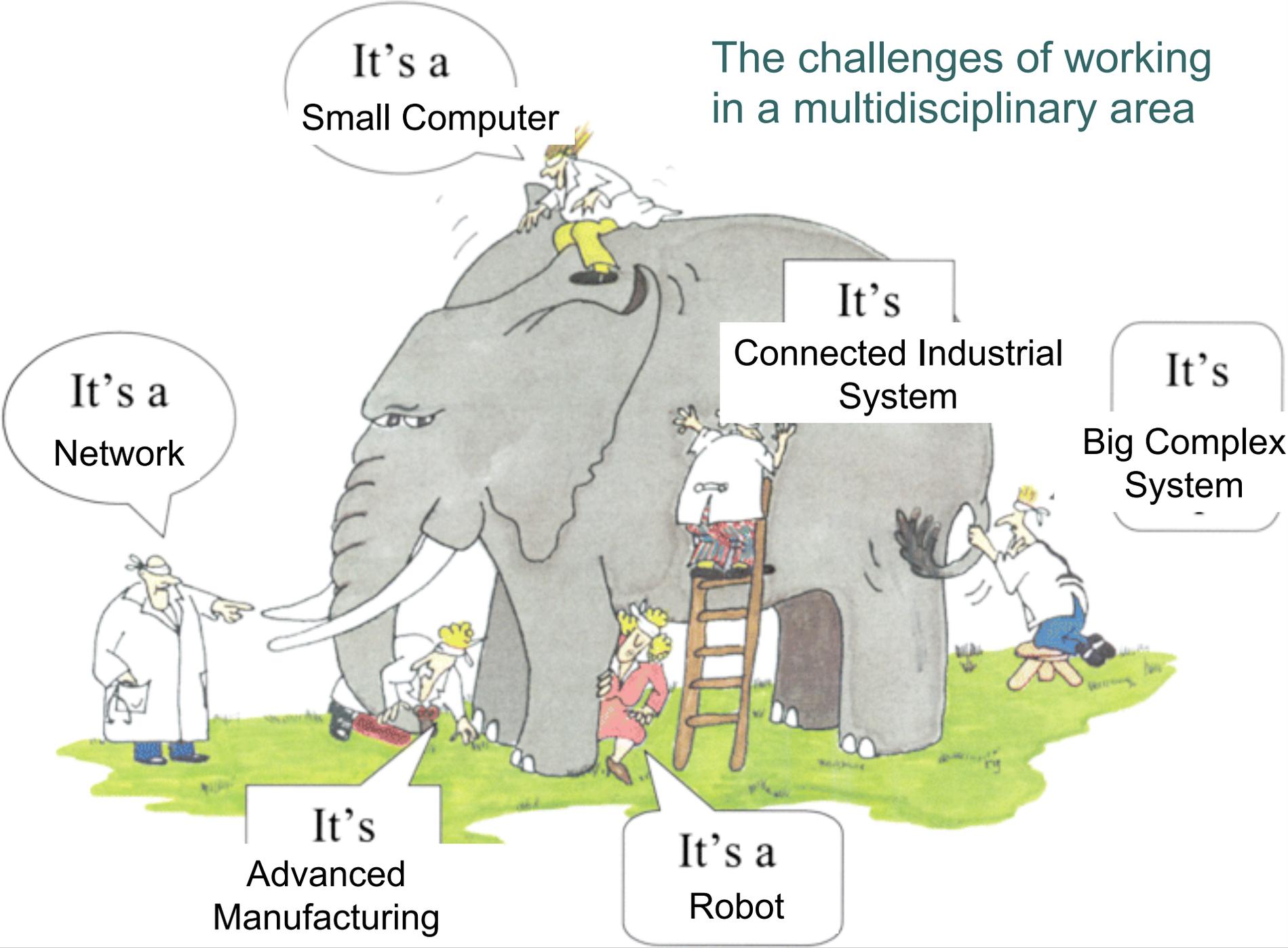
Automotive CPS and Societal Challenges

- Safer Transportation
- Reduced Emissions
- Smart Transportation
- Energy Efficiency
- Climate Change
- Human-Robot Collaboration
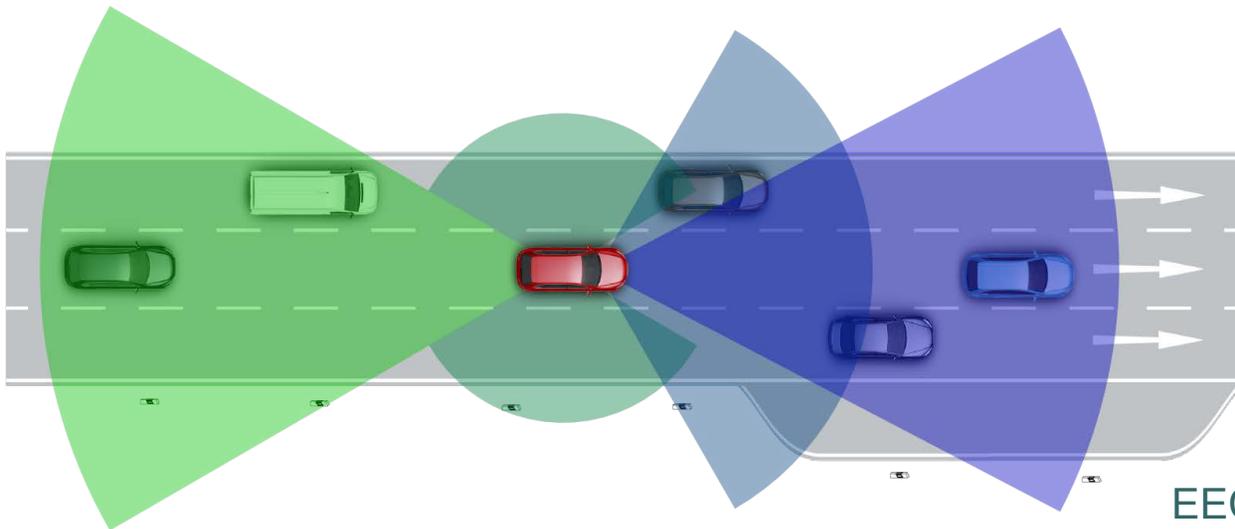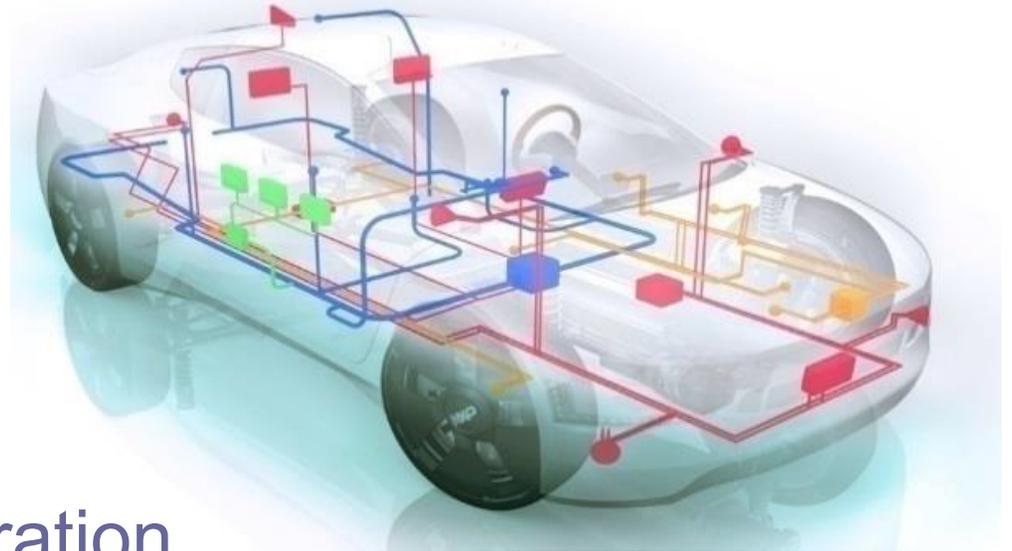
Example: Air-Fuel ratio control to reduce emissions

‣ Catalytic converters reduce CH_4, CO_2, and NO_x emissions

‣ Conversion efficiency optimal at stoichiometric value
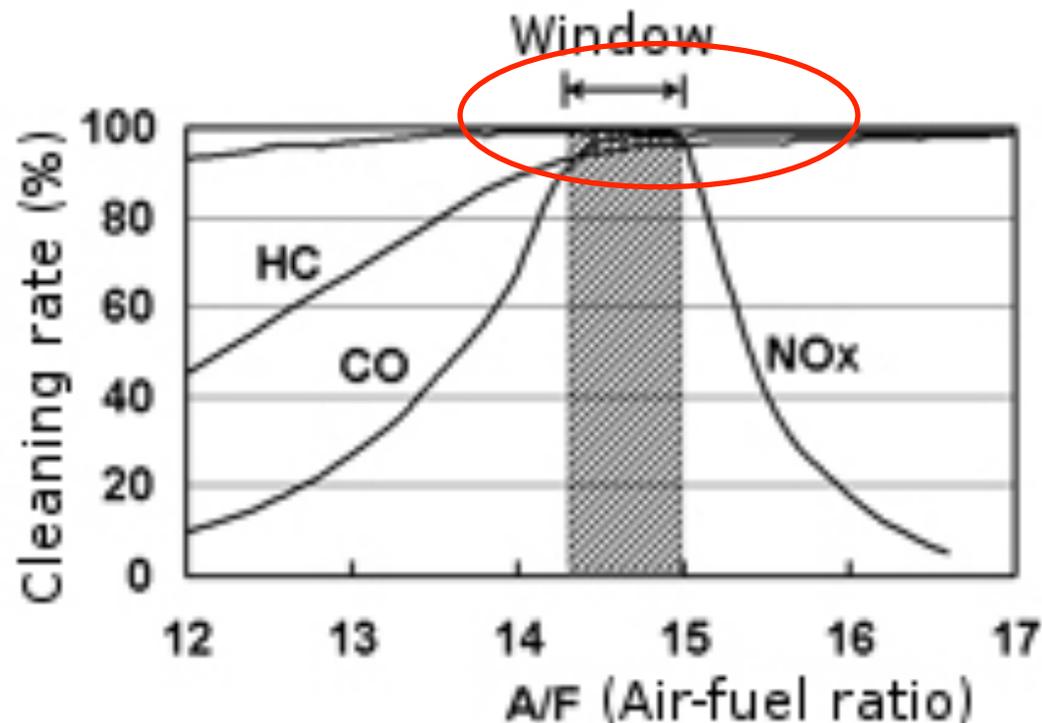
See:
Jin. Kapinski. Deshmukh,
Ueda, Butts,
"Powertrain Control Verification
Benchmark,"
HSCC 2014

Air-Fuel ratio control: Gasoline Engine setting
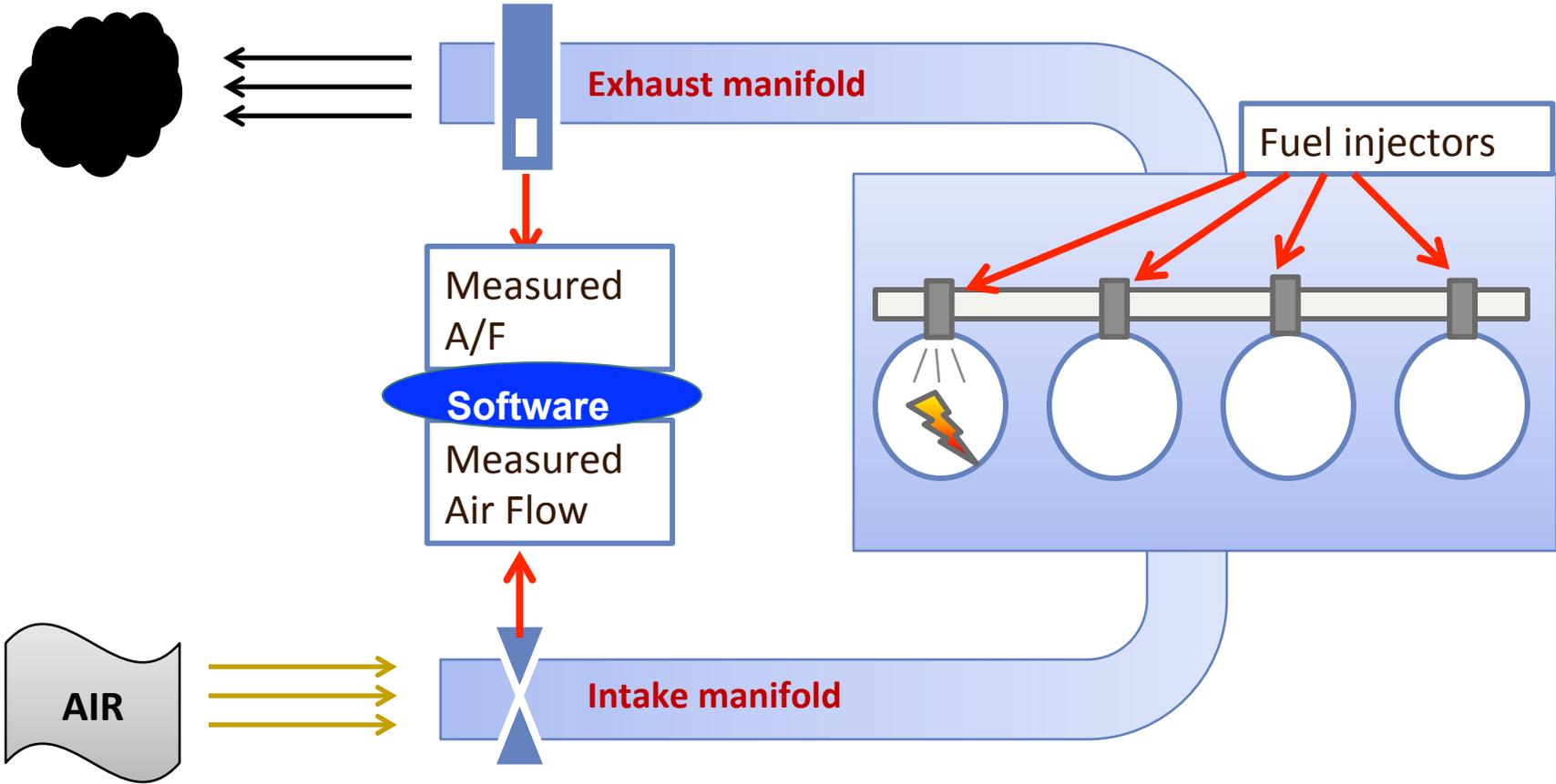
Report: McKinsey Global Institute
Disruptive technologies:
Advances that will transform life, business, and the global economy
May 2013   … with major CPS components

Twelve potentially economically disruptive technologies

|		
Mobile Internet	Increasingly inexpensive and capable mobile computing devices and Internet connectivity	
Automation of knowledge work	Intelligent software systems that can perform knowledge work tasks involving unstructured commands and subtle judgments	
The Internet of Things	Networks of low-cost sensors and actuators for data collection, monitoring, decision making, and process optimization	
Cloud technology	Use of computer hardware and software resources delivered over a network or the Internet, often as a service	
Advanced robotics	Increasingly capable robots with enhanced senses, dexterity, and intelligence used to automate tasks or augment humans	
Autonomous and near-autonomous vehicles	Vehicles that can navigate and operate with reduced or no human intervention	

Next-generation genomics	Fast, low-cost gene sequencing, advanced big data analytics, and synthetic biology ("writing" DNA)	
Energy storage	Devices or systems that store energy for later use, including batteries	
3D printing	Additive manufacturing techniques to create objects by printing layers of material based on digital models	
Advanced materials	Materials designed to have superior characteristics (e.g., strength, weight, conductivity) or functionality	
Advanced oil and gas exploration and recovery	Exploration and recovery techniques that make extraction of unconventional oil and gas economical	
Renewable energy	Generation of electricity from renewable sources with reduced harmful climate impact	
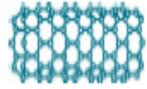
Economic Potential

The Internet of Things	**300%** Increase in connected machine-to-machine devices over past 5 years **80–90%** Price decline in MEMS (microelectromechanical systems) sensors in past 5 years	**1 trillion** Things that could be connected to the Internet across industries such as manufacturing, health care, and mining **100 million** Global machine to machine (M2M) device connections across sectors like transportation, security, health care, and utilities	**$36 trillion** Operating costs of key affected industries (manufacturing, health care, and mining)
Cloud technology	**18 months** Time to double server performance per dollar **3x** Monthly cost of owning a server vs. renting in the cloud	**2 billion** Global users of cloud-based email services like Gmail, Yahoo, and Hotmail **80%** North American institutions hosting or planning to host critical applications on the cloud	**$1.7 trillion** GDP related to the Internet **$3 trillion** Enterprise IT spend
Advanced robotics	**75–85%** Lower price for Baxter[9] than a typical industrial robot **170%** Growth in sales of industrial robots, 2009–11	**320 million** Manufacturing workers, 12% of global workforce **250 million** Annual major surgeries	**$6 trillion** Manufacturing worker employment costs, 19% of global employment costs **$2–3 trillion** Cost of major surgeries
Autonomous and near-autonomous vehicles	**7** Miles driven by top-performing driverless car in 2004 DARPA Grand Challenge along a 150-mile route **1,540** Miles cumulatively driven by cars competing in 2005 Grand Challenge **300,000+** Miles driven by Google's autonomous cars with only 1 accident (which was human-caused)	**1 billion** Cars and trucks globally **450,000** Civilian, military, and general aviation aircraft in the world	**$4 trillion** Automobile industry revenue **$155 billion** Revenue from sales of civilian, military, and general aviation aircraft

Google Strategy

Google closes $3.2 billion purchase of Nest

The acquisition brings with it the Learning Thermostat and the Protect smoke and CO detector as Google looks to make its mark in the smart home.

by Lance Whitney   @lancewhit / February 12, 2014 5:00 AM PST
/ Updated: February 12, 2014 5:19 AM PST

theguardian | TheObserver

Search

Google's drive into robotics should concern us all

The company's expansion into robotics was developed in tandem with the US military. Where will its power play stop?

John Naughton
The Observer, Sunday 29 December 2013

Google's robotic cars have about $150,000 in equipment including a $70,000 LIDAR (laser radar) system. The range finder mounted on the top is a Velodyne 64-beam laser. This laser allows the vehicle to generate a detailed 3D map of its environment. The car then takes these generated maps and combines them with high-resolution maps of the world, producing different types of data models that allow it to drive itself.

Google and Facebook

Artist's rendering of Titan's Solara 50, which in theory at least, can stay aloft for years.

Wall Street Journal:

By Alistair Barr and Reed Albergotti
April 14, 2014

Google Inc. on Monday acquired a maker of solar-powered drones—a startup that Facebook Inc. had also considered acquiring—as the technology giants battle to extend their influence and find new users in the far corners of the earth.

Tesla Gigafactory

Artists conception of battery factory under construction in Nevada.
From: https://www.tesla.com/gigafactory
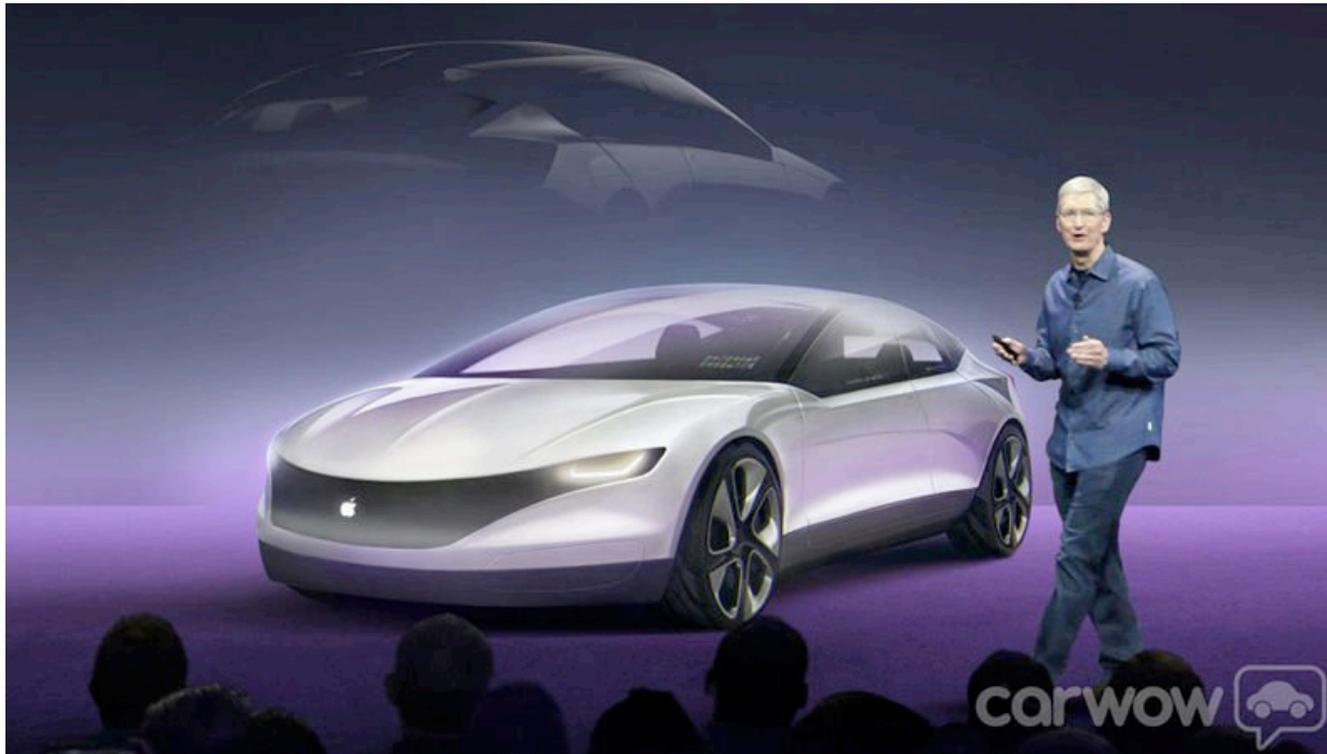
Apple iCar?

Macworld, Aug. 10, 2016:
Reports suggest that Apple is developing an electric iCar to rival Tesla. With reports that Apple is negotiating with BMW, and poaching Samsung employees (especially battery specialists) and reassigning large numbers of staff for its Project Titan, is Apple manufacturing an iCar, and when will the iCar be launched?

The Emerging IT Scene

The Cloud!

Infrastructural core

Sensory swarm

Mobile access

What this course is about

A principled, scientific approach to designing and implementing embedded systems

Not just hacking!!

Hacking can be fun, but it can also be very painful when things go wrong…

Focus on *model-based system design*, and on *embedded software*

Modeling, Design, Analysis

Modeling is the process of gaining a deeper understanding of a system through imitation. Models express **what** a system does or should do.

Design is the structured creation of artifacts. It specifies **how** a system does what it does.

Analysis is the process of gaining a deeper understanding of a system through dissection. It specifies **why** a system does what it does (or fails to do what a model says it should do).
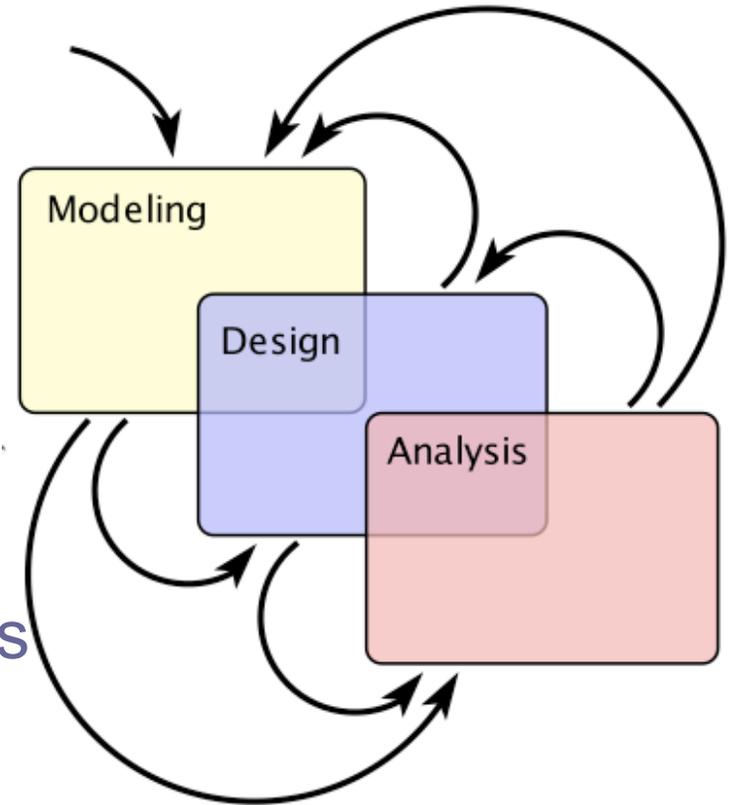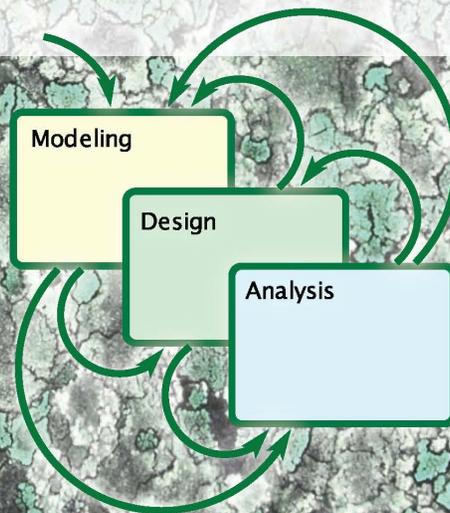
Your textbook, written for this course, strives to identify and introduce the *durable intellectual ideas* of embedded systems as a technology and as a subject of study. The emphasis is on modeling, design, and analysis of cyber-physical systems, which integrate computing, networking, and physical processes.

http://LeeSeshia.org

Book Map

Part I: Modeling   **Part II: Design**   **Part III: Analysis**

1. Introduction

2. Continuous Dynamics

7. Sensors and Actuators

3. Discrete Dynamics

8. Embedded Processors

4. Hybrid Systems

9. Memory Architectures

13. Invariants and Temporal Logic

5. Composition of State Machines

10. Input and Output

6. Concurrent Models of Computation

14. Equivalence and Refinement

11. Multitasking

15. Reachability Analysis and Model Checking

12. Scheduling

16. Quantitative Analysis

17. Security and Privacy

The three threads are designed to be read concurrently and fit nicely within a 15-week semester.

Motivating Example of a Cyber-Physical System
(see Chapter 1 in book)

STARMAC quadrotor aircraft (Tomlin, et al.)

- Introductory Video:
  http://www.youtube.com/watch?v=rJ9r2orcaYo
- Back-Flip Manuever:
  http://www.youtube.com/watch?v=iD3QgGpzzIM

Modeling:
- Flight dynamics (ch2)
- Modes of operation (ch3)
- Transitions between modes (ch4)
- Composition of behaviors (ch5)
- Multi-vehicle interaction (ch6)

Design:
- Sensors and Actuators (ch7)
- Processors (ch8)
- Memory system (ch9)
- Sensor interfacing (ch10)
- Concurrent software (ch11)
- Real-time scheduling (ch12)

Analysis
- Specifying safe behavior (ch13)
- Achieving safe behavior (ch14)
- Verifying safe behavior (ch15)
- Guaranteeing timeliness (ch16)
- Security and privacy (ch17)

STARMAC Design Block Diagram

LIDAR
URG-04LX
10 Hz ranges

Stereo Cam
Videre STOC
30 fps 320x240

RS232
115 kbps

Firewire
480 Mbps

PC/104
Pentium M
1GB RAM, 1.8GHz
Est. & control

USB 2
480 Mbps

**WiFi
802.11g+**
≤ 54 Mbps

GPS
Superstar II
10 Hz

UART
19.2 kbps

RS232

Stargate 1.0
Intel PXA255
64MB RAM, 400MHz
Supervisor, GPS

CF
100 Mbps

**WiFi
802.11b**
≤ 5 Mbps

IMU
3DMG-X1
76 or 100 Hz

UART
115 kbps

UART
115 Kbps

UART

Ranger
SRF08
13 Hz Altitude

I^2C
400 kbps

Robostix
Atmega128
Low level control

Ranger
Mini-AE
10-50 Hz Altitude

*Timing/
Analog*

Analog

PPM
100 Hz

Beacon
Tracker/DTS
1 Hz

ESC & Motors
Phoenix-25, Axi 2208/26

A Theme in This Course:
Think Critically

Any course that purports to teach you how to design embedded systems is misleading you.

The technology will change!

Our goal is to teach you how things are done today, and why that is not good enough. So you will not be surprised by the changes that *are* coming.