# On Some CPS Challenges

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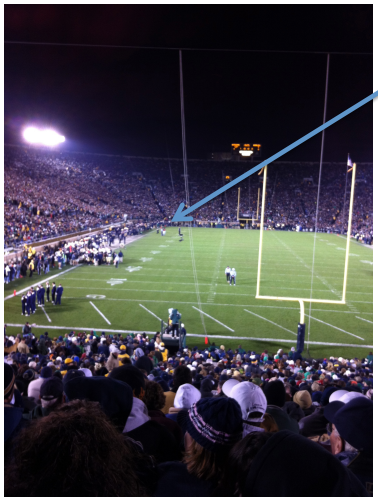
- How do we get the **society** to understand the importance of CPS?
- How to derive layered CPS **architectures**?
- How to distribute control based on limited physical **model information**?
- How to develop **cyber-secure** control of CPS?

# How do we get the society to understand the importance of CPS?



Panos Antsaklis' achievements recognized on the football field in front of 85,000 fans

Speaker reporting:

ear, multi- million dollar research project funded by the National Science Foundation. This research focuses on cyber-physical systems, which are crucial to the functioning of technologies that re used in applications from automatic pilots in airplanes, to tability controls in automobiles and to health care monitoring.

# Special Issue in IEEE TAC on Control of Cyber-Physical Systems

Submission deadline: February 1, 2013.

Cyber-physical systems are engineered systems whose operations are monitored, coordinated, controlled, and integrated by computing and communication cores interacting with the physical environment. Cyber-physical systems transform how we interact with the physical world just like the Internet has transformed how we interact with one another. Advances in this field will have an enormous societal impact and economic benefit in areas such as energy, transportation, manufacturing, health, agriculture and many more.

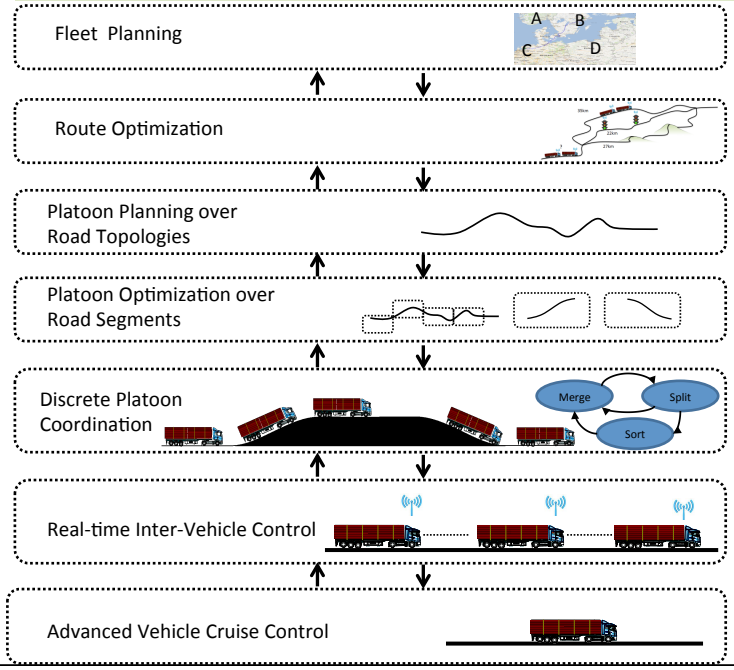
Recently there has been an enormous scientific and industrial interest in cyber-physical systems. Consequently theories, tools, and practices for the design and operation of these systems are emerging. The aim of this special issue is to capture the latest developments in the fundamentals and applications of control of cyber-physical systems. We solicit papers on the following topics:

- Abstractions and heterogeneous models for cyber-physical systems
- Architectures for cyber-physical systems
- High-confidence and safety-critical networked control systems
- Modular and component-based design of cyber-physical systems
- Embedded computing and communication in cyber-physical systems
- Optimization and resource allocation in cyber-physical systems
- Real-time scheduling and performance of cyber-physical systems
- Distributed implementation and fault detection in cyber-physical systems
- Verification and run-time monitoring of cyber-physical systems
- Cyber-security and trust in control of cyber-physical systems

We expect that some of the papers will describe emerging applications in intelligent transportation, power systems, smart buildings, medical devices, mobile robotics, process industry etc.

http://www.nd.edu/~ieeetac/special.html

## How to develop layered CPS architectures?

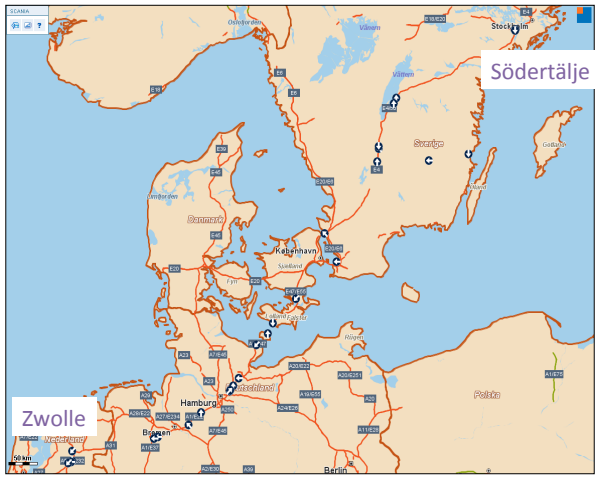



Alam et al., 2012

## iQFleet Testsite Södertälje- Zwolle

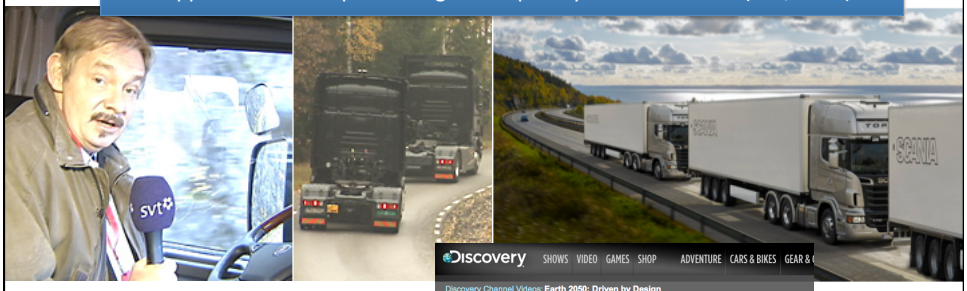
- Real-time fleet management
- Platooning in real traffic
- Fuel reductions and safety
- Driver acceptance
- Public acceptance

**Scania Transport Lab** (internal haulage company)
20 trucks, 360.000 km/year
75 trailers, 92% loaded
65 drivers, 40 h work/week



# Heavy Duty Vehicle Platooning Demos

*Rapport* on vehicle platooning developed by KTH and Scania (Oct, 2011)





PhD student Assad Alam on *Discovery Channel* (Jan, 2012)

# How to distribute control based on limited model information?

**Complexity**

Controllers are easier to implement and maintain if they mainly depend on local model information



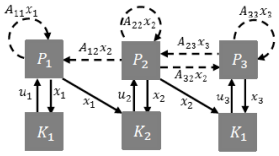
**Availability**

The model of other subsystems is not available at the time of design


**Privacy**

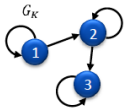
Competitive advantages not to share private model information

# Control design with limited plan model information

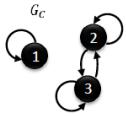




Plant Graph




Control Graph




Design Graph

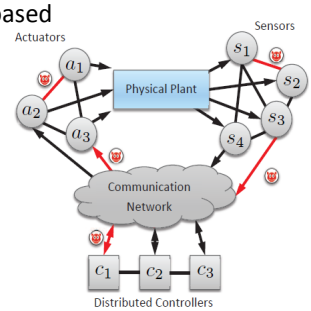
Run-time physical, network, control limitations

Design-time model information limitations

Farokhi et al., 2011

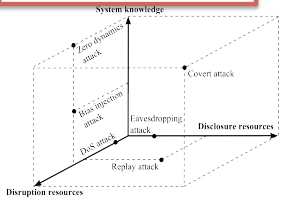
# How do develop cyber-secure control of CPS?

- Networked control systems are to a growing extent based on **open communication and software technology**
- Leads to **increased vulnerability** to cyber-threats with many potential points of attacks




- How to model attacks?
- How to measure vulnerability?
- How to compute consequences?
- How to design secure control systems?

Adversary Resource Models




- Traditional computer and information security do not provide answers these questions
- Need for theory and tools for secure control systems

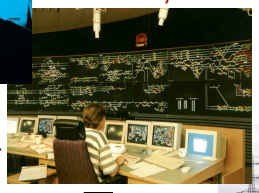
Sandberg et al., 2010

## From Resilience and Security to Societal Cost

Cyber attacks & faults

Northeast U.S. Blackout of August 14th, 2003:
55 million people affected

Control system



Power network

Societal cost

http://www.vikingproject.eu

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http://www.ee.kth.se/~kallej