

Robust design of CPS



prof. dr. ir. Gerard J.M. Smit, University of Twente

prof. dr. ir. Twan Basten, TU Eindhoven & ESI



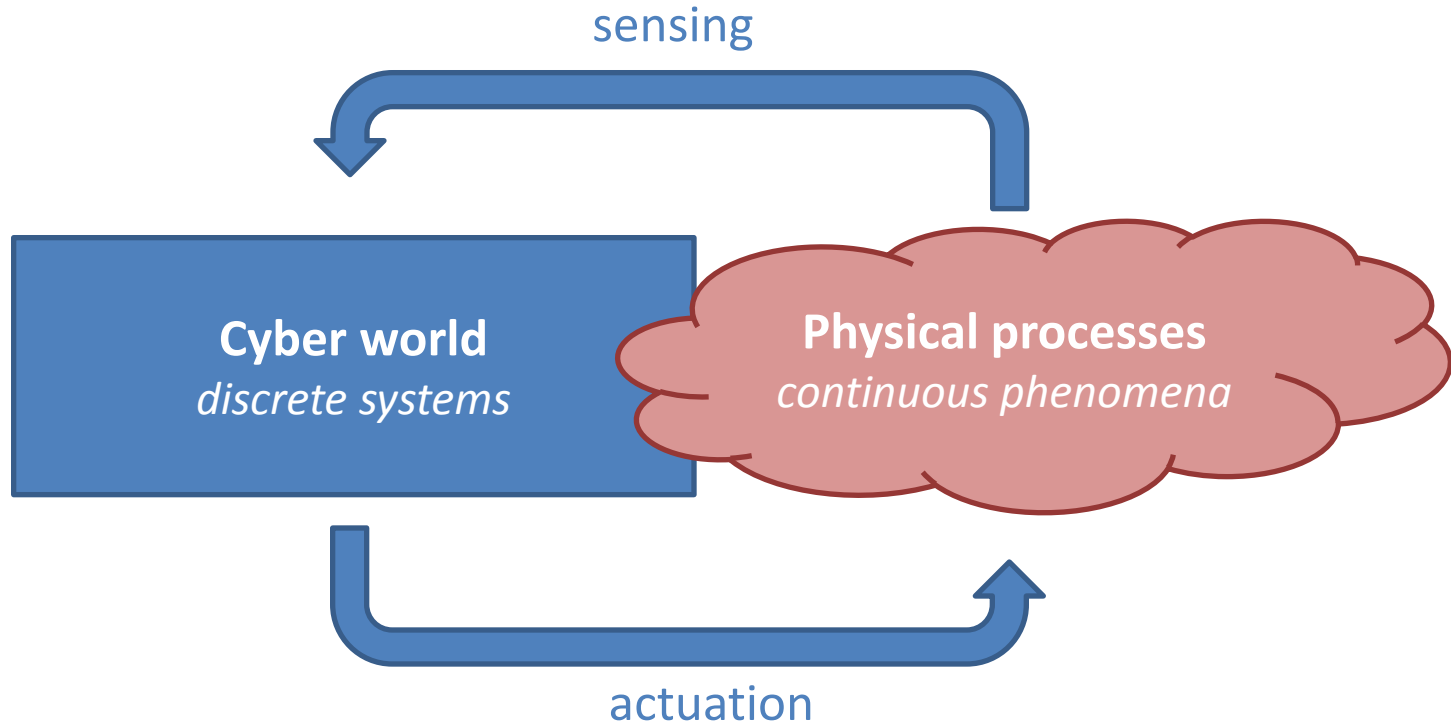
prof. dr. ir. Bart De Schutter, TU Delft



ir. Paul Hilkens, vice-president Océ R&D

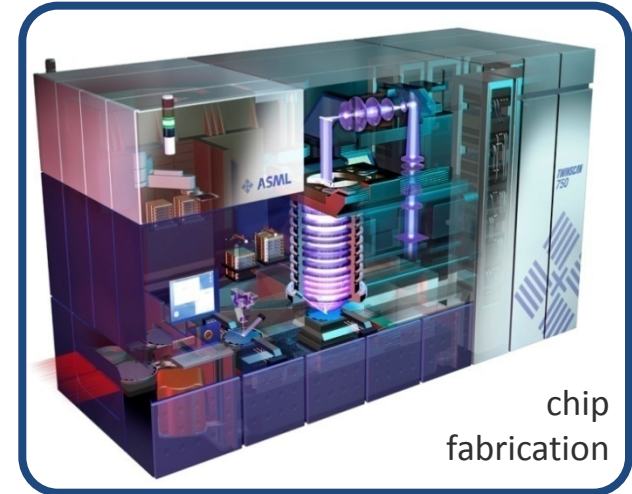


Cyber-Physical Systems



Feedback control loop

Cyber-Physical Systems



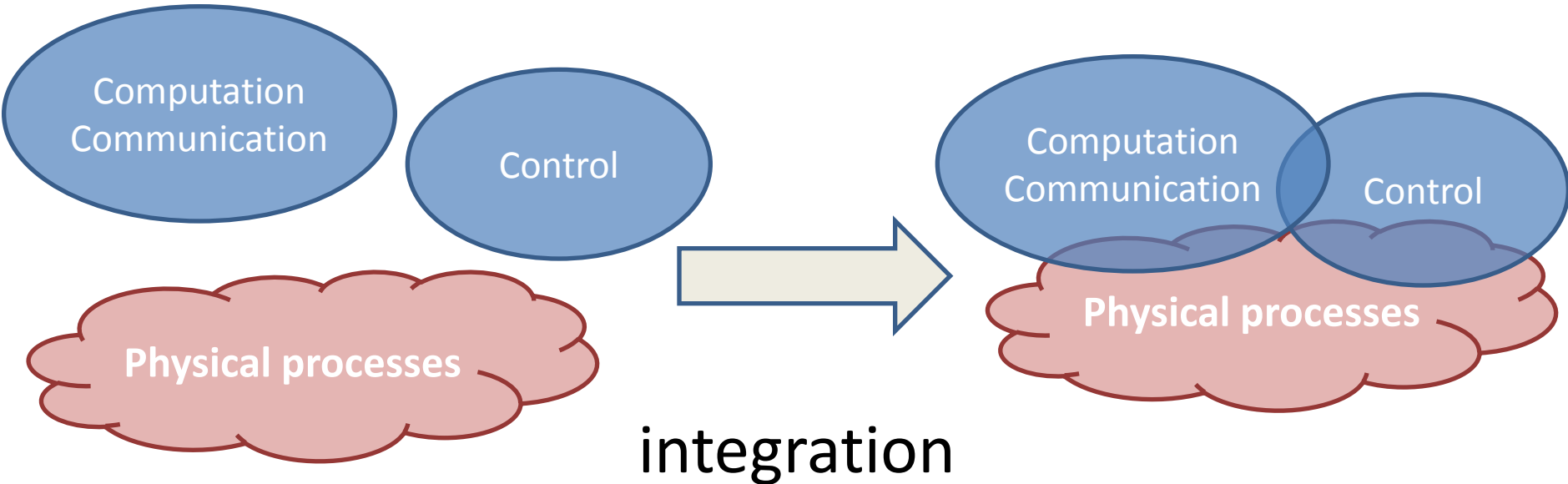
Challenges in CPS

robustness

dealing with **complexity & uncertainty**

1000s of sensors & actuators
parallelism
connectedness

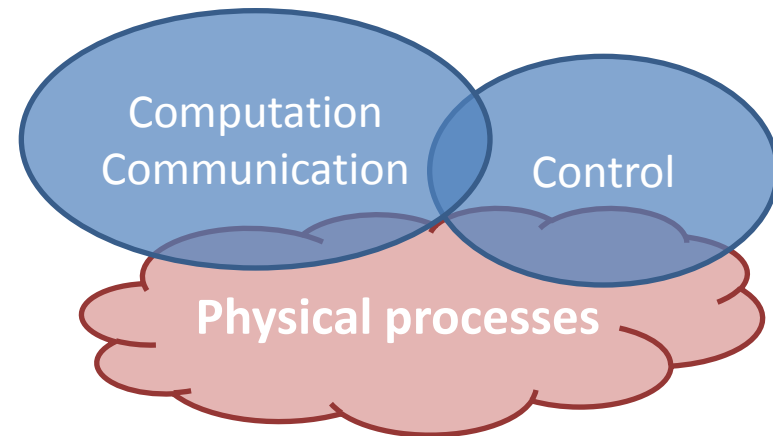
communication errors
variability
weather
resource availability



integration

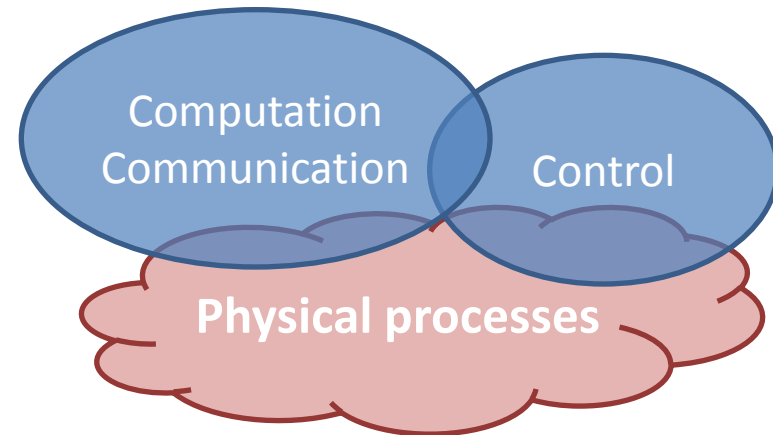
Vision

INTEGRATION of individual techniques into multi-disciplinary system-wide methods



Scientific research lines

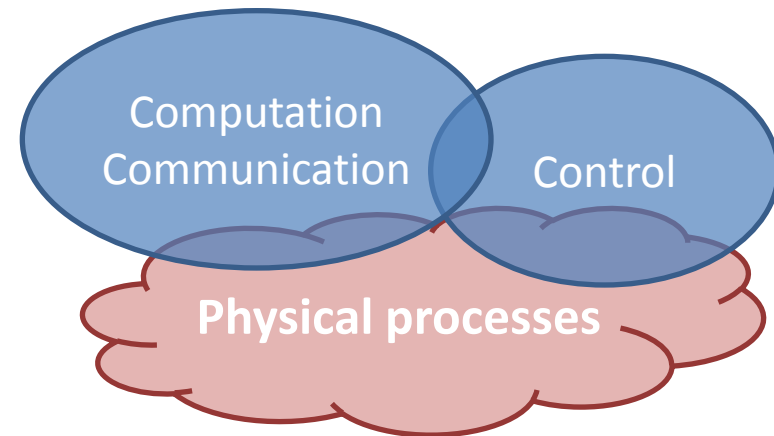
- RL1. Hierarchical multi-domain modeling, analysis & synthesis
- RL2. Stochastic analysis and synthesis
- RL3. Control over communication networks
- RL4. Distributed control
- RL5. Energy-constrained sensing and actuation



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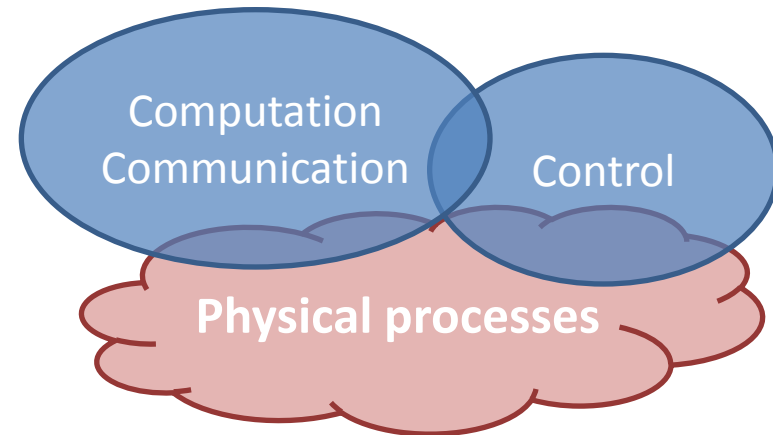
complexity



Scientific research lines

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uncertainty



Research projects

| Proj.nr. | Title | Application domain | Industrial partners |
|----------|--|--------------------------|---------------------|
| P1 | Integrated scheduling & control | Professional printing | Océ, ESI |
| P2 | High-performance control for nano-precision control | Lithography | ASML, ESI |
| P3 | Energy-efficient computer-brain interaction | Medical | Holst, Recore |
| P4 | Cooperative networked systems | Server farms | INCAS3, Target |
| P5 | Control based on data-intensive sensing | Microscopy | Technolution |
| P6 | Safety-critical real-time automotive systems | Automotive, mechatronics | NXP |
| P7 | Cyber-physical co-design for safety-critical systems | Robotics, medical | Demcon, Tass, CLP |
| P8 | Energy-autonomous smart micro-grids | Energy infrastructures | Alliander |
| P9 | Robust motion control | Medical | Philips Healthcare |

Matrix organization

| Research Lines | PhD effort in person months | | | | |
|--|-----------------------------|------------|------------|------------|------------|
| RL1: Hierarchical multi-domain modelling (leader Basten) | | | | | |
| RL2: Stochastic analysis and synthesis (leader Voeten) | | | | | |
| RL3: Control over communication networks (leader Heemels) | | | | | |
| RL4: Distributed control (leader De Persis) | | | | | |
| RL5: Energy-constrained sensing and actuation (leader Smit) | | | | | |
| Research projects and first industrial users | RL1 | RL2 | RL3 | RL4 | RL5 |
| P1: Integrated scheduling & control (Oce + ESI) | 60 | 12 | 12 | 60 | |
| P2: Nano-precision control (ASML + ESI) | 48 | 48 | 48 | 48 | |
| P3: Energy-efficient computer-brain interaction (Holst + Recore) | 48 | 48 | | | 96 |
| P4: Cooperative networked systems (INCAS3 + Target) | 48 | | 60 | 72 | 60 |
| P5: Data-intensive control (Technolotion) | 48 | | 48 | 48 | |
| P6: Safety-critical automotive systems (NXP) | | 96 | 48 | | |
| P7: Cyber-physical co-design (TASS + Demcon + CLP) | 48 | | | 48 | |
| P8: Energy-autonomous smart micro grids (Alliander) | | 48 | 48 | | 48 |
| P9: Robust motion control (Philips Healthcare) | 48 | | | 48 | |
| Totals | 348 | 252 | 264 | 324 | 204 |

Matrix organization

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Strategic importance

- At the core of top sector High-Tech Systems & Materials
- Contributions to top sectors
 - Energy
 - Life Sciences & Health
- Crucial to Dutch & European industry and economy
 - Needs highly qualified engineers and researchers
 - Needs cross-disciplinary design methods
 - Urgent
- Taking the international lead
- Building the CPS eco system

Robust CPS eco system



UNIVERSITY OF TWENTE.



ASML



UNIVERSITEIT VAN AMSTERDAM



PHILIPS



Universiteit Leiden



university of groningen



TSS TECHNOLOGY SOLUTIONS

alliander

Embedded Systems
INSTITUTE



where science meets industry



Holst Centre

Open Innovation by imec and TNO



RECORE



DEMCON



Technolution

25



TARGET
holding

Robust CPS eco system



Utilisation

- Long term: the program
 - Generic cross-disciplinary methods, techniques & tools
 - The CPS eco system
- Short term: the projects
 - Carrying Industrial Partner model
 - Industrial participation: 38% co-funding
- Industrial Advisory Board

In conclusion

- Unique window of opportunity
- Multi-disciplinary
- At the center of the High-Tech Systems & Materials top sector
- Strong industry support
- Excellent fit with STW perspective
- Strategic importance for Dutch academia, industry & economy

