Industrial Applications and Cyber-physical Systems

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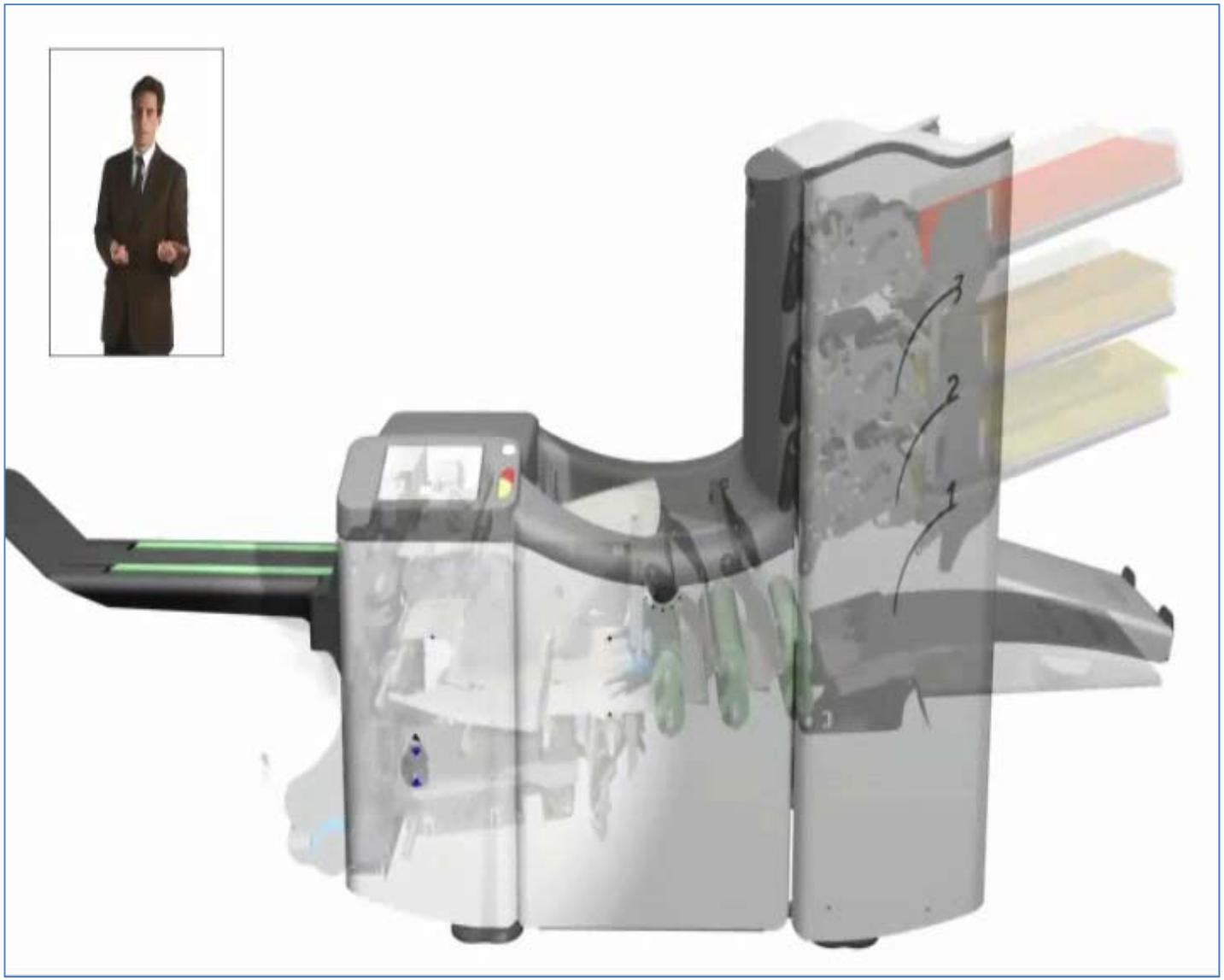
Industrial Case Studies

- Three substantial case studies, done by the companies

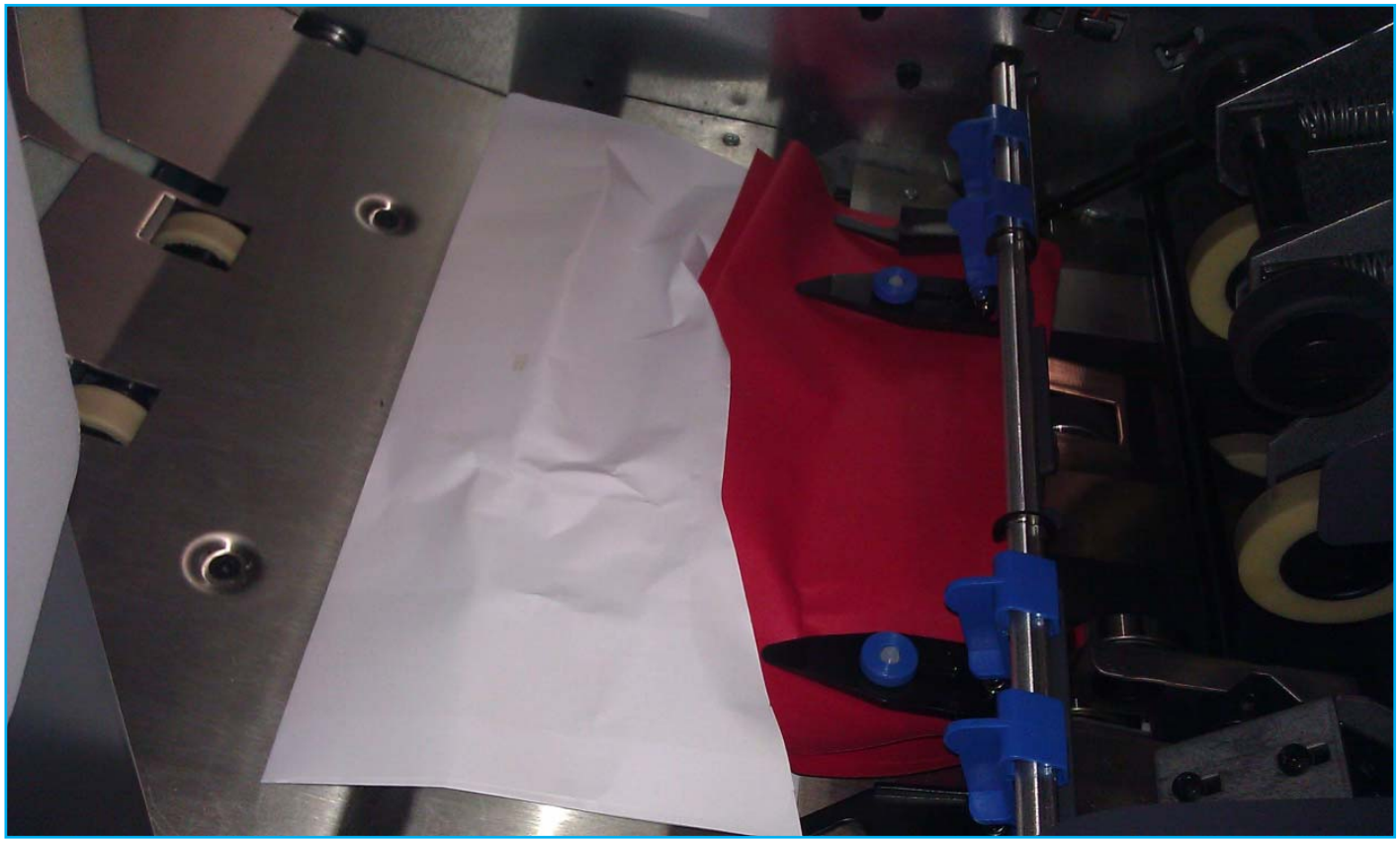
Application	Document Handling	Dredging Excavator	Self-balancing Scooter
Company	Neopost	Verhaert	Chess WISE & Chess iX
Challenge	Concurrent design	Product robustness	Manage complexity
Fault Source	Error handling	Operator error	Design faults
Improvement	Model-in-loop sim	Design exploration	Reliability analysis
Approach	DE-first	CT-first	DE-first, CT-first & contract-first
Prior	20-sim	-	VDM & 20-sim

- Smaller challenges, mainly done by the project team
  - Flare Dispensing System (Terma)
  - Tilt Tray Conveyor System (Crisplant)
  - Planetary Rover (ESA ESTEC)

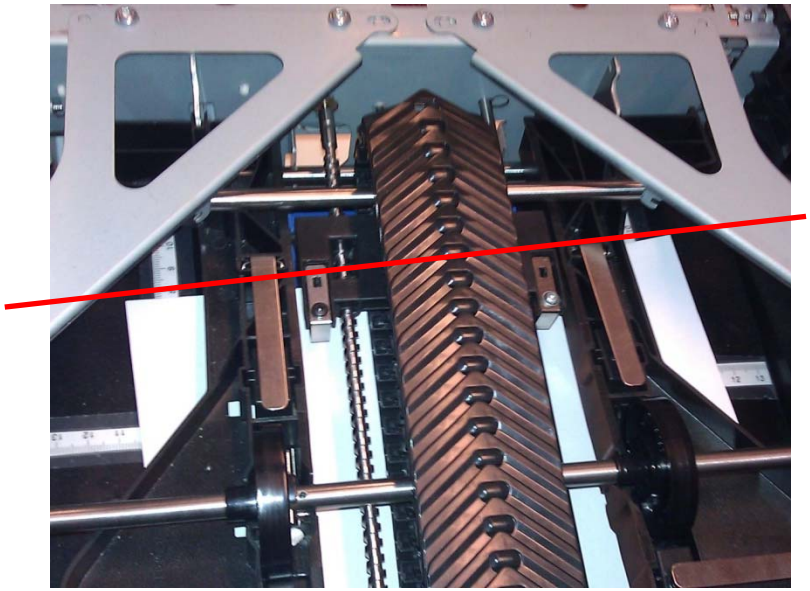
Document Handling: context

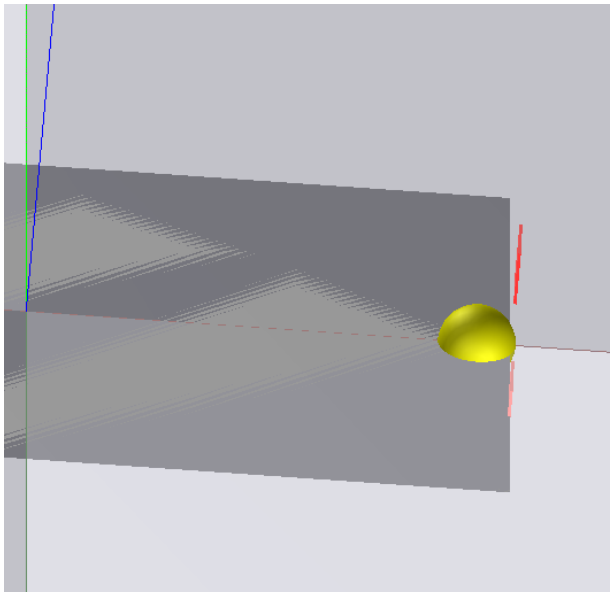


Document Handling: failure



Document handling: error discovery



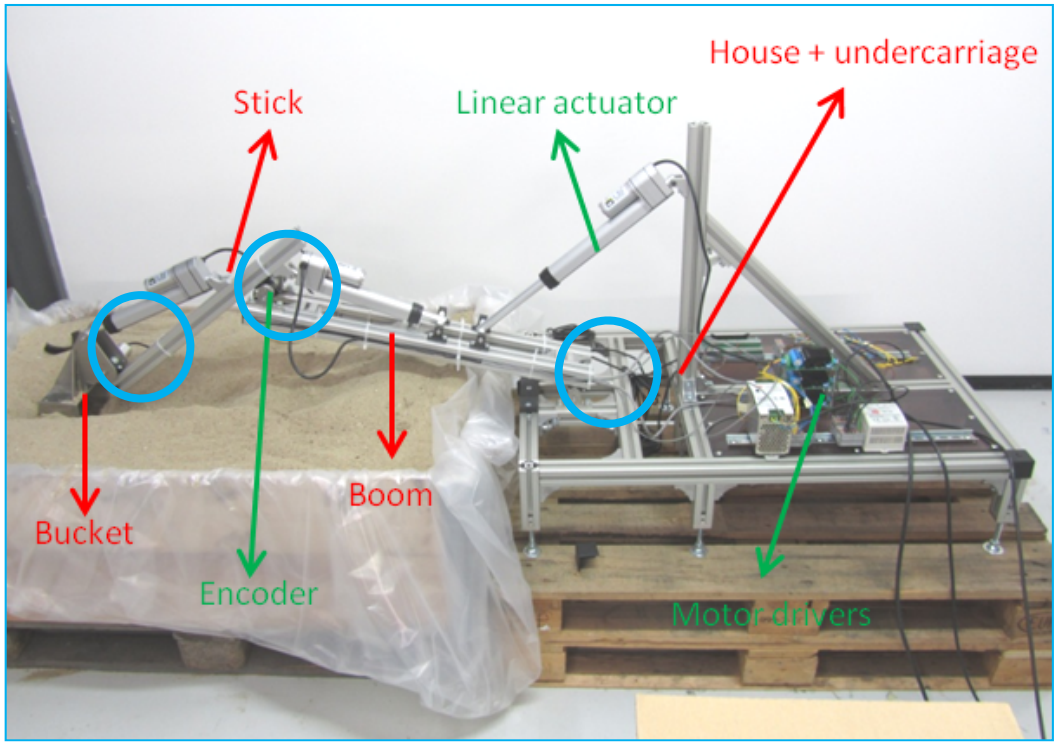


- Mechanical design error was spotted before first prototype
- A competent sheet alignment co-model was developed
- Simulation model was (re)used to validate control software

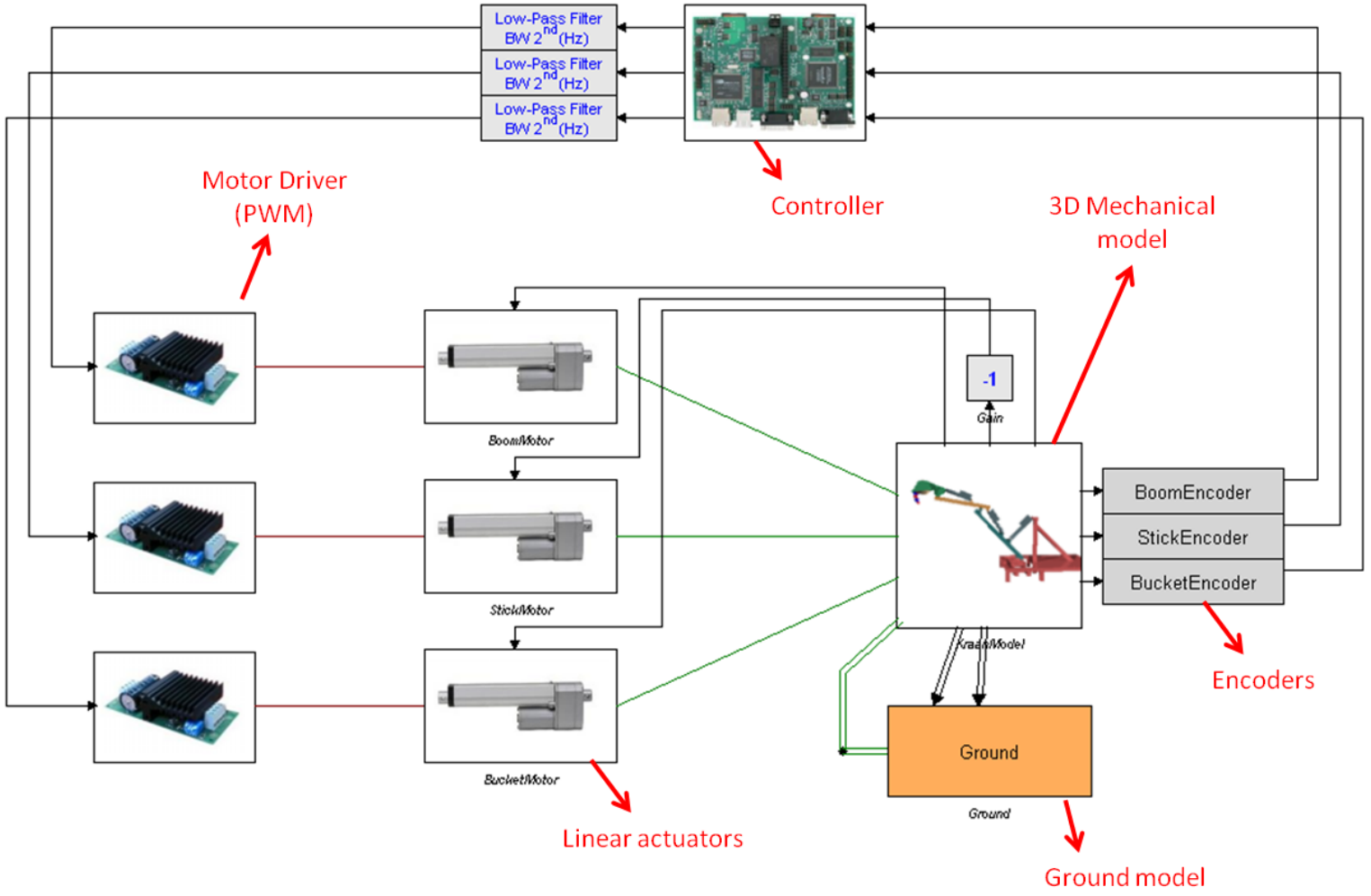
Document Handling: it works!

Dredging Excavator

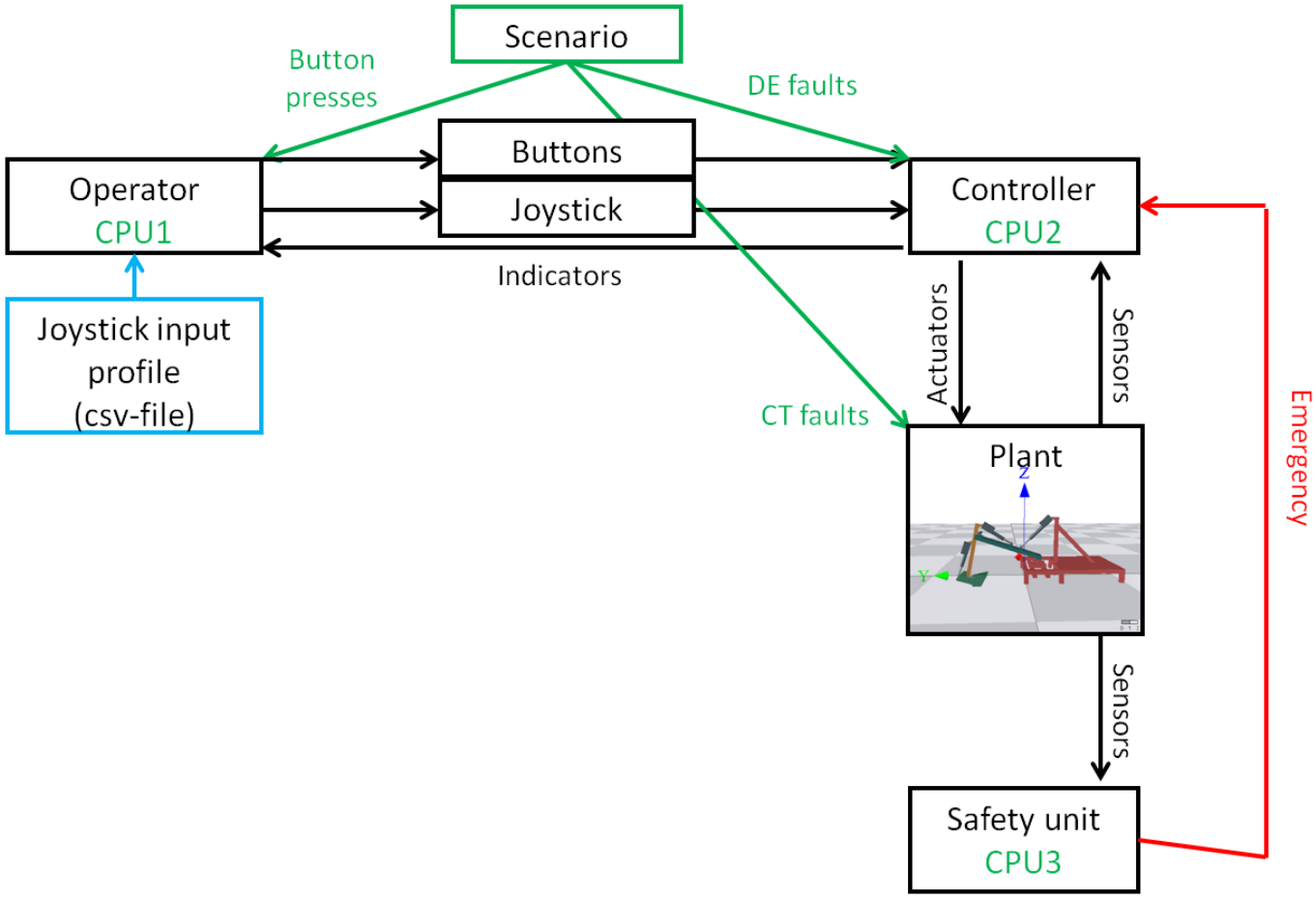
Dredging Excavator



Dredging Excavator (CT model)



Dredging Excavator (DE model)



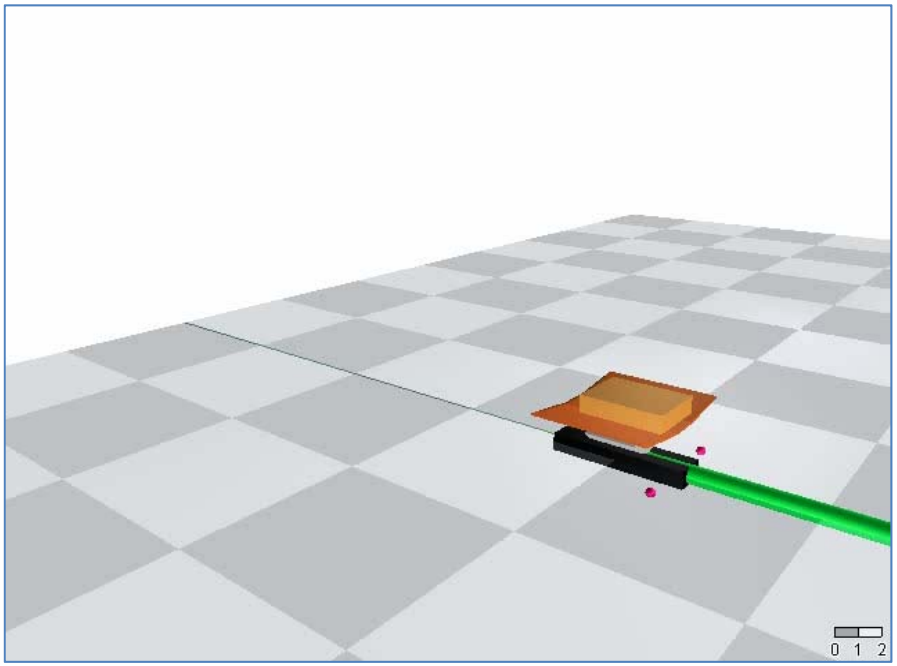
Dredging Excavator (Assisted Mode)

- DSE to optimise end-stop protection parameters
- Emergency Switch controller behaviour validated
- Assisted Mode-specification validated on scale model

Self-balancing Scooter

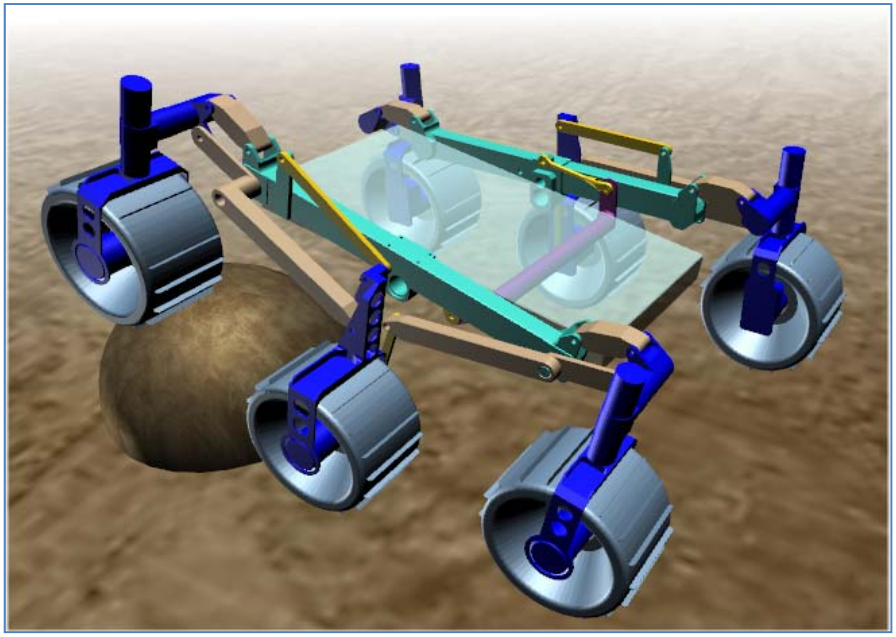
- Several design conflicts discovered and resolved
- Behaviour with integrated fault handling validated
- Test and integration phase was very short
  - almost “first time right”

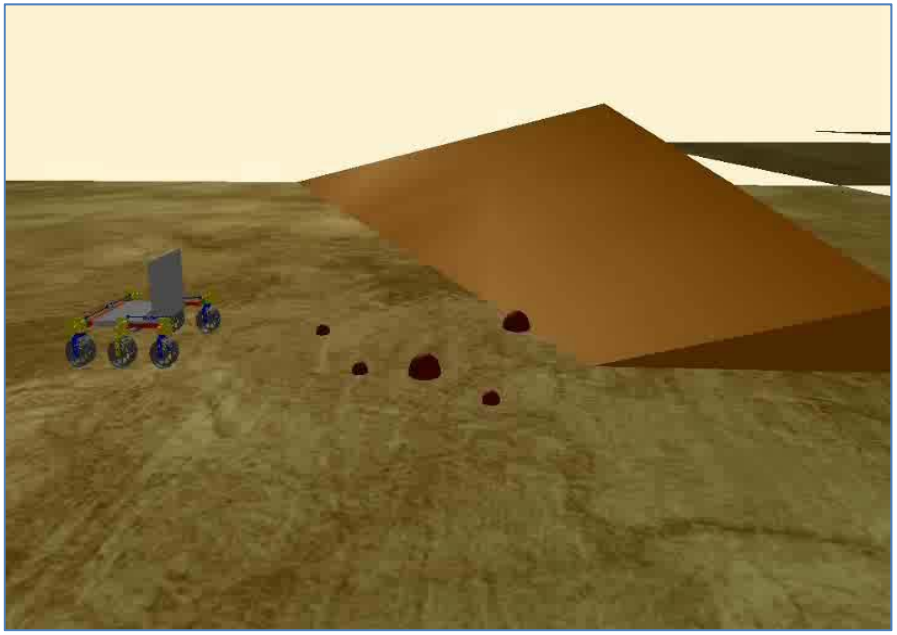
Tilt Tray Conveyor System



- Co-simulation model of the banking function
- Described behaviour of parcels on a moving 3-D banking device
- A good contact model between parcel / tray is essential

Planetary Rover





- Existing CT model extended with DE model of locomotion
- Contact models helped investigate behaviour on obstacles
- Simple safety controller added

Deployment Experience

"Simulation will become increasingly important for Neopost. Test setups and physical prototypes will become more costly and have less availability. … The most critical current drawback of the Crescendo technology is the incompatibility with the tools we use for generating the code for the embedded platform."

"We see great potential in the Crescendo technology during the development of complex systems …that are difficult to test due to high risk, cost, timing constraints. … Adding a GUI could broaden the use of the tool to non-software engineers. Graphical tools for visual validation of discrete behaviour … would be beneficial as well... Finally, an increase in simulation speed would of course be a welcome improvement."

"The complexity of embedded systems is ever increasing with the focus on: error handling, safety, and added functionality. This cannot be overseen by a single lead engineer or engineering team. To avoid making expensive mistakes, modern systems cannot be developed anymore without utilising modelling ... When following this sort of concurrent and holistic model-based development principles, a technology like Crescendo is a critical enabler."

Future Plans for Research & Innovation in Cyber-Physical Systems

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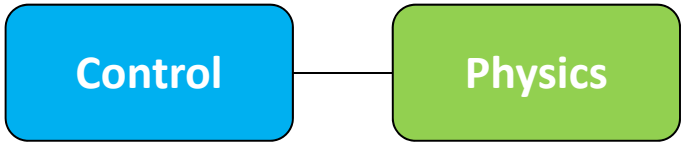
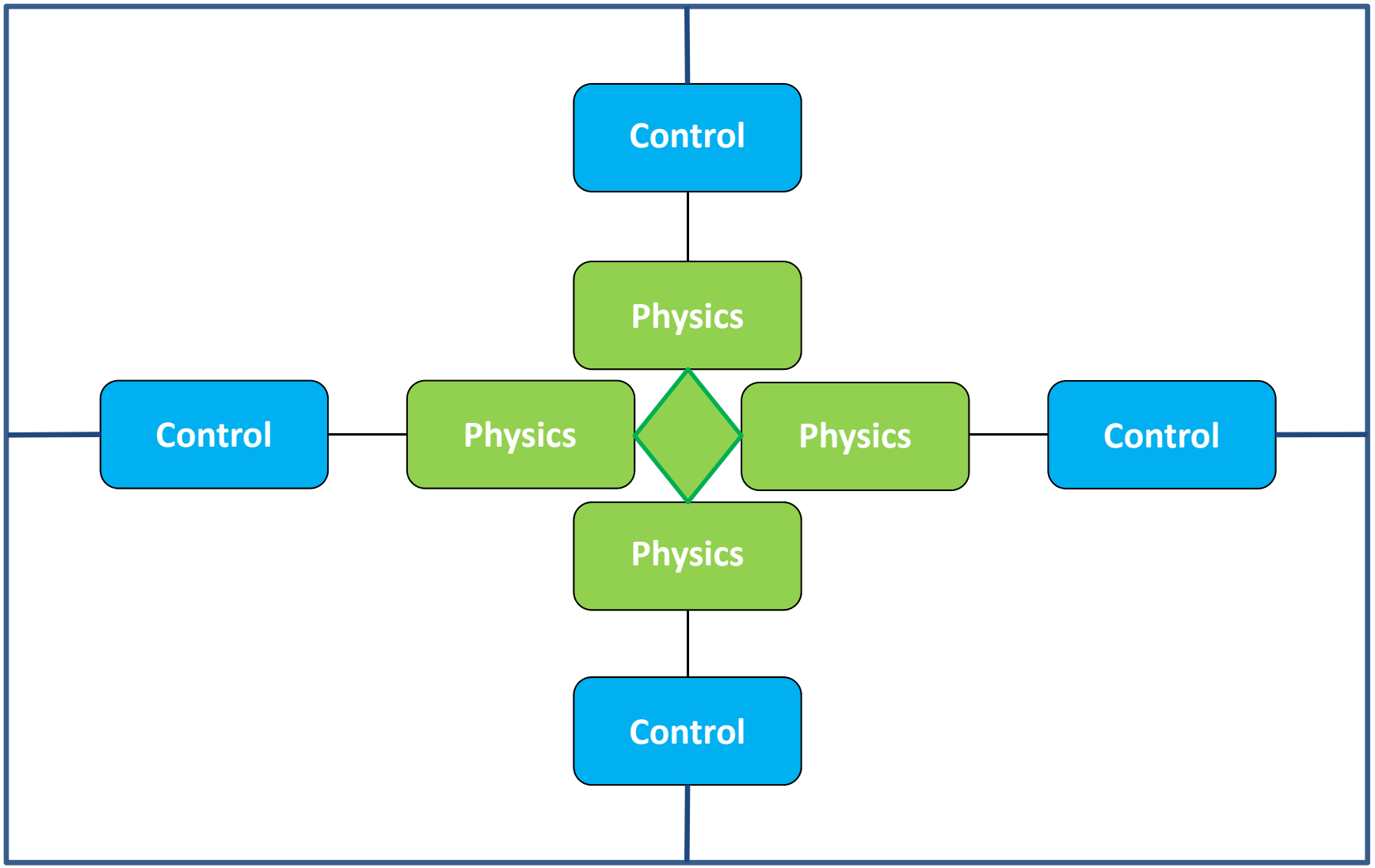
Cyber-Physical Systems



- We have looked at individual embedded systems
- CPSs are networked groupings of digital devices
- … which may require more elaborate co-models!

Cyber-Physical Systems



Cyber-Physical Systems

Agricultural Logistics

- Integrating sensed, environmental, economic monitoring
- Process re-planning
- Reduced development cost of automated precision equipment to optimise growing yields.

Smarter Building Design

- Beyond simple sensing & control
- Integration of sensed and external (e.g. weather) data
- Dynamic adaptation to maximise comfort for different activities, weather, seasons, building usage.

Cyber-Physical Challenges

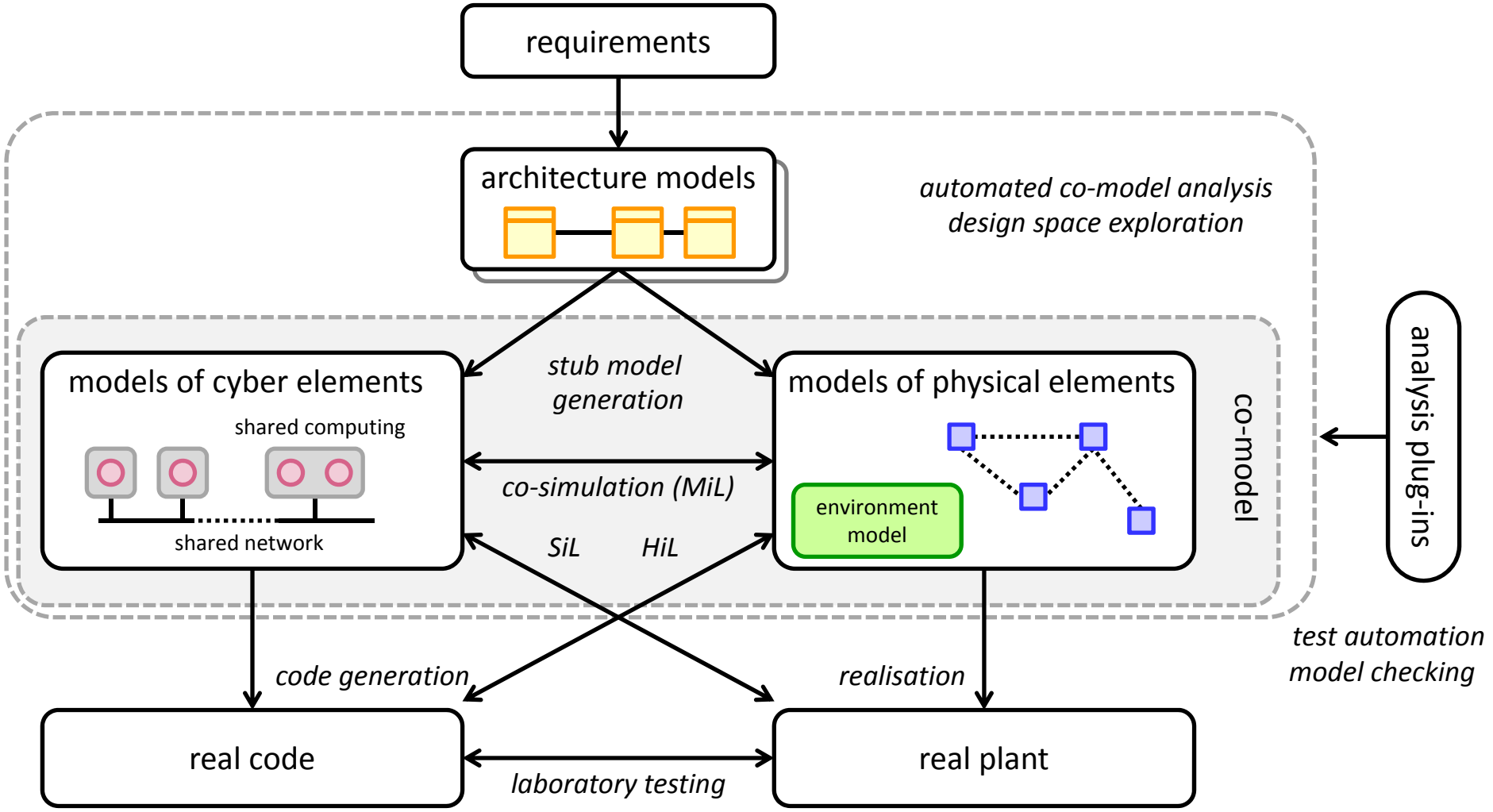
Agricultural Logistics

- Need to model control and planning/re-planning
- Models of locality and mobility
- Real-time behaviour modelling
- Domain-specific reference models

Smarter Building Design

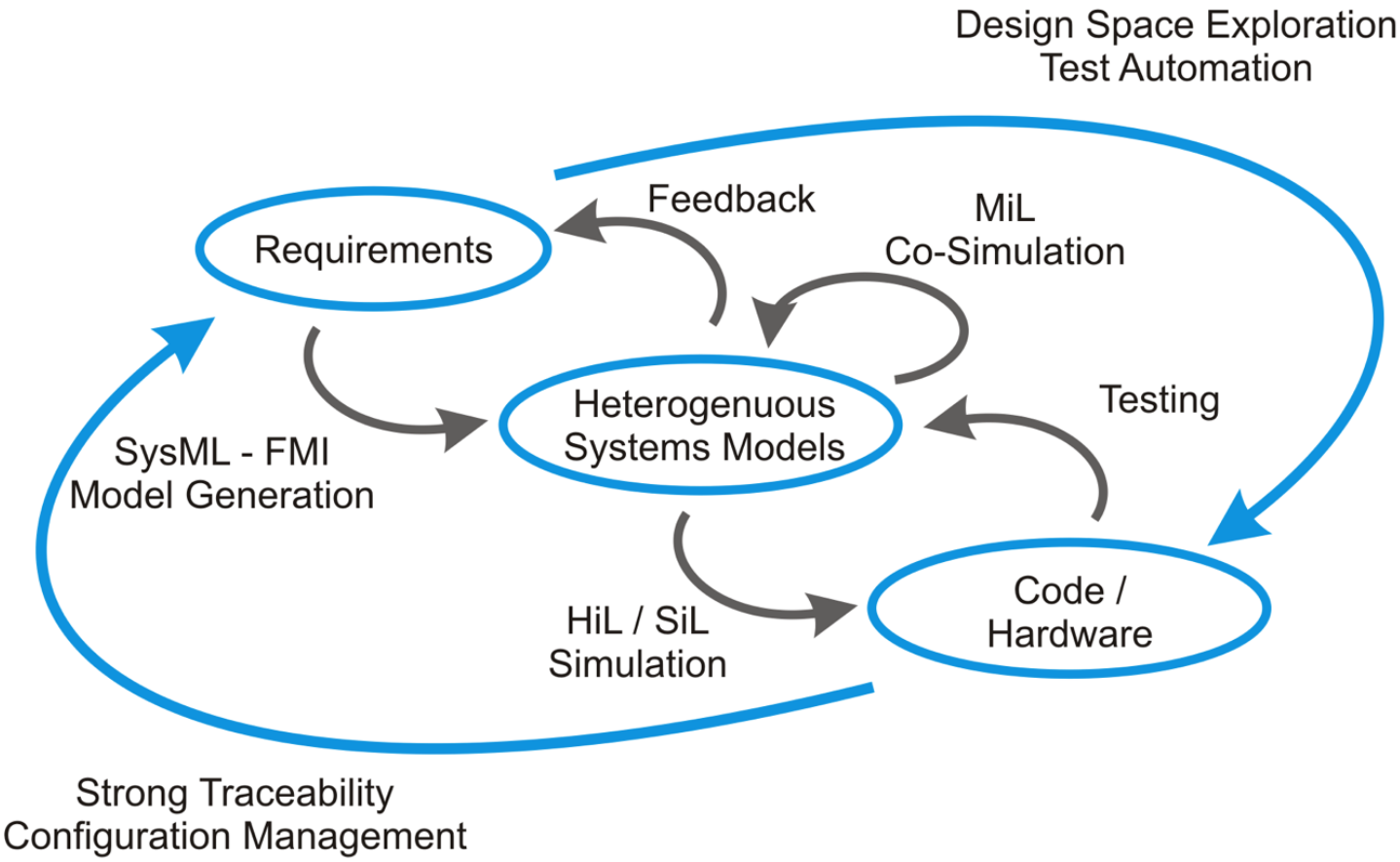
- Models of large-scale, open, diverse data integration
- … coupled with models of physics
- Need to model learning behaviour
- Possible integration of models of human behaviour

CPS co-modelling



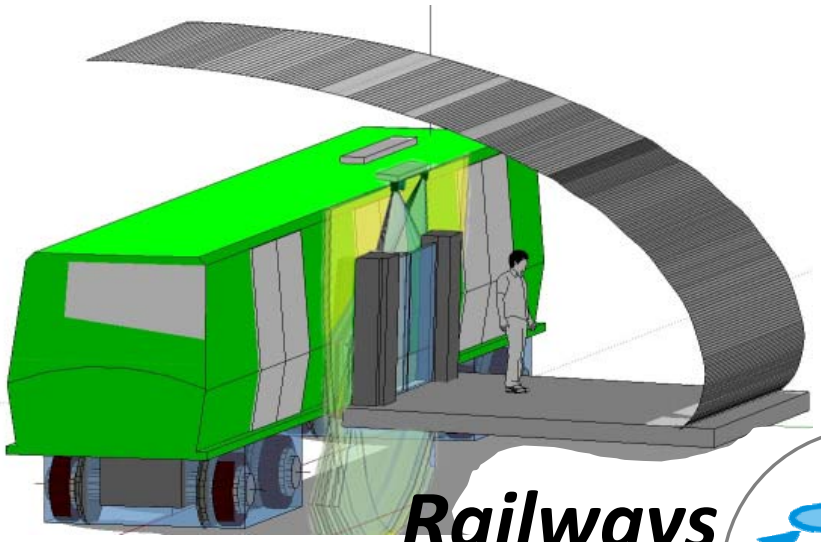
Follow-up Project: INTO-CPS

- 8 M€ new research project under Horizon 2020

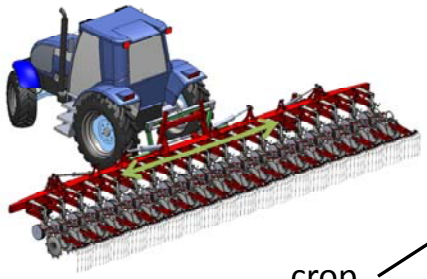


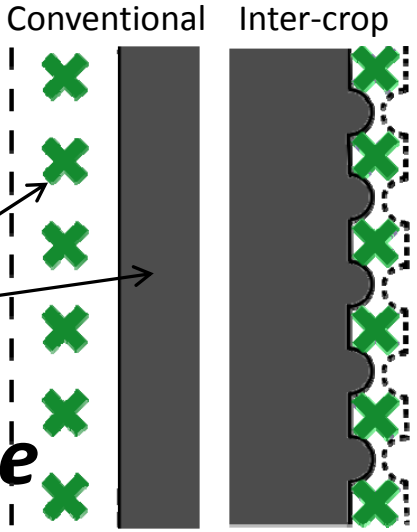
INTO-CPS Consortium

- Aarhus University, Denmark (coordinator)
- Newcastle University, UK
- University of York, UK
- Linköping University, Sweden
- Verified Systems International GmbH, Germany
- Controllab Products, Netherlands
- ClearSy, France
- TWT GmbH, Germany
- Kongskilde Industries, Denmark
- United Technologies, Ireland
- Softeam, France



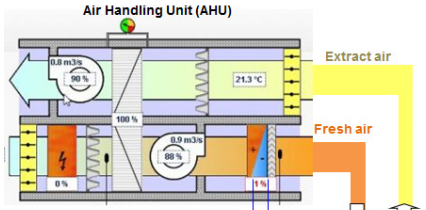
Railways



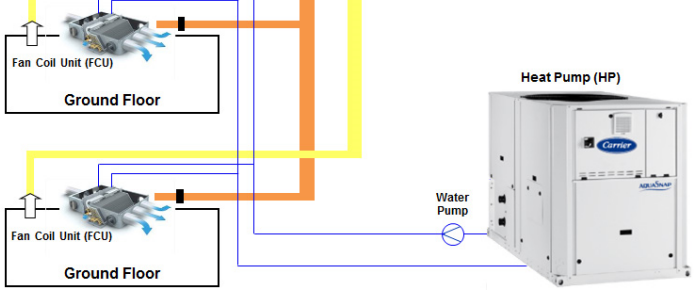


Agriculture

INTO-CPS



Building Automation



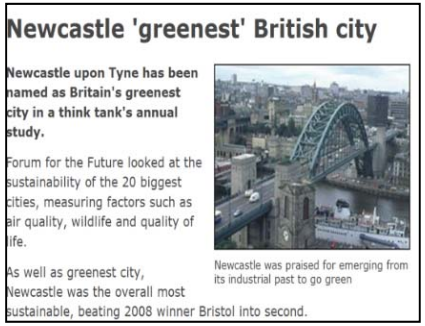
Automotive

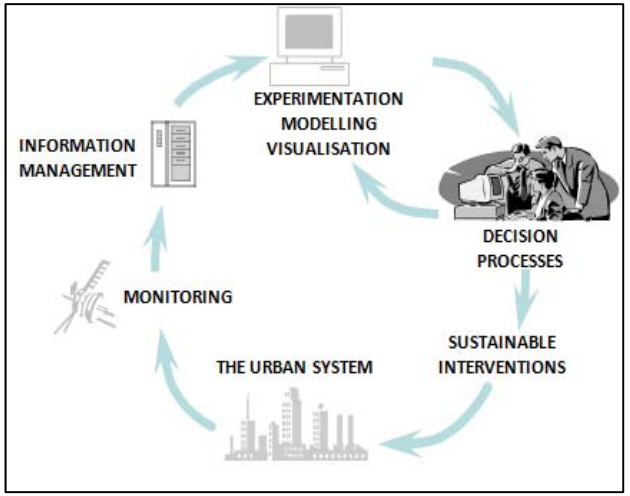
Initial Industrial Follower Group

- AGCO, Denmark
- Alcatel-Lucent, Ireland
- Almende, Netherlands
- Altran, UK
- Bachmann electronic, Netherlands
- Bakker Sliedrecht Electro Industrie, Netherlands
- Carrier, France
- CeTIM, Netherlands
- Chemring TS, UK
- Conpleks Innovation, Denmark
- Dredging International, Belgium
- DSTL, UK
- Goodrich, UK
- Grundfos, Denmark
- GN Resound, Denmark
- HMF, Denmark
- Huisman Equipment, Netherlands
- Irmato Industrial Solutions, Netherlands
- Jaguar Land Rover, UK
- **National Institute of Informatics, Japan**
- ONERA, France
- Rockwell-Collins, France
- Seluxit, Denmark
- Siemens, Sweden
- Terma, Denmark:
- Thales, France
- UTC Aerospace Systems, UK
- West Consulting, Netherlands

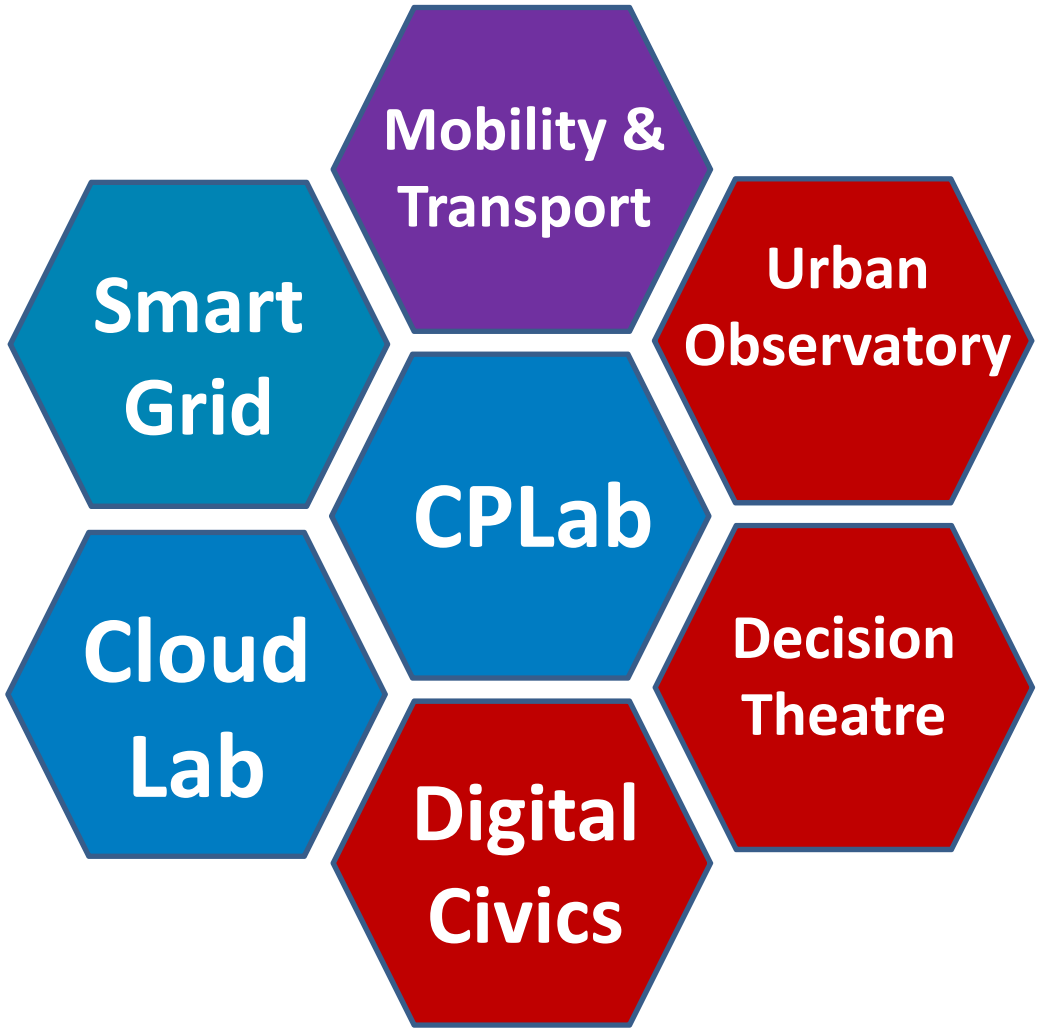
Urban CPSs

- CPS potential to improve quality of life
- £58m investment: building now
- **Core programme: Digitally Enabled Urban Sustainability**
- Urban Sustainability problems require collaborative systems solutions:
  - Technical Interventions
  - Community decision making (Digital Civics)





CPLab Newcastle



ScienceCentral
CENTRAL TO NEWCASTLE SCIENCE CITY

Newcastle University

NORTHERN POWERGRID

SIEMENS

PHILIPS

NORTHUMBRIAN WATER living water

Newcastle University

AARHUS UNIVERSITY

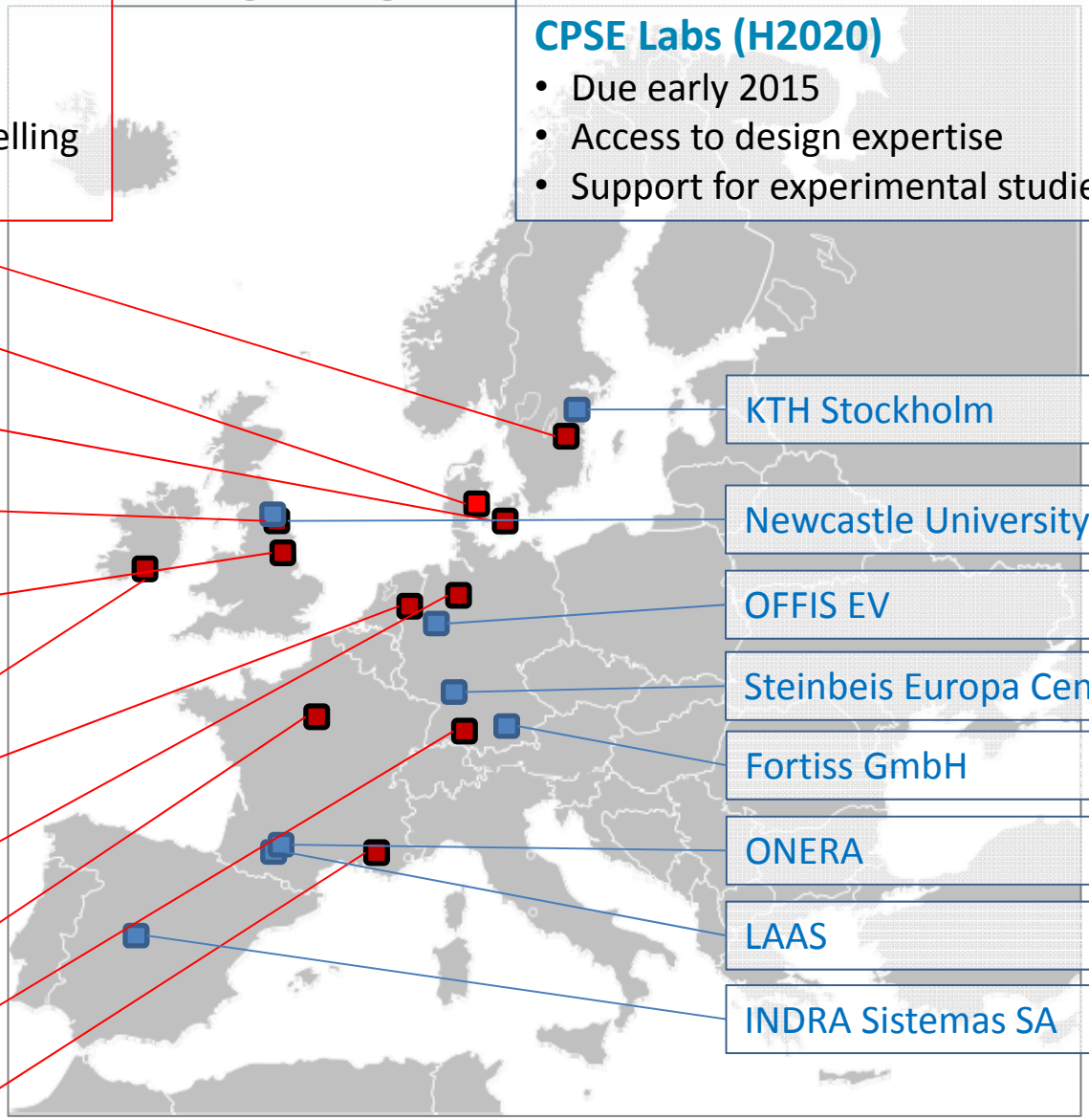
CPLab Newcastle

An emerging network

INTO-CPS
- Due early 2015
- Pushing capabilities of co-modelling
- Traceable development flows

CPSE Labs (H2020)
- Due early 2015
- Access to design expertise
- Support for experimental studies

Linköping University
Aarhus University
Kongskilde Industries
Newcastle University
University of York
United Technologies
Controllab Products
Verified Systems Intl GmbH
Softeam
TWT GmbH
Clearsy



KTH Stockholm
Newcastle University
OFFIS EV
Steinbeis Europa Centrum
Fortiss GmbH
ONERA
LAAS
INDRA Sistemas SA

The Challenges

- Extending collaborative modelling capability up and down development processes
- Semantic Foundations:
  - Increased range of “safely” integrated models
  - Location, security, control, planning, stochastic aspects
- Methods:
  - Of model construction, contract (re-)negotiation
  - Design for verifiable resilience and dynamic reconfiguration
  - Model interchange will encourage methodologies to develop

The Challenges

- Tools:
  - Extending the range of analyses
  - Experiment design and trade-off analysis
  - Pragmatics, including performance!
- Encouraging “Cyber-Physical Thinking”
  - Moving easily across engineering domains, trading off between them
- Dependability and Trust
  - Classical technical solutions must be complemented by advances in human-centred design

Your Thoughts, Please!

- Thank you for your time today.
- Have we met your expectations?
- Do you think this work addresses real challenges?
- What do you see as the barriers to deploying more collaborative modelling and design techniques?
- Please join our INTO-CPS Industry Follower Group

Collaborative Modelling and Co-simulation

Tools and Techniques for Designing Embedded Systems

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