Preliminary survey on Cyber-Physical Systems testing in various domains of the industry

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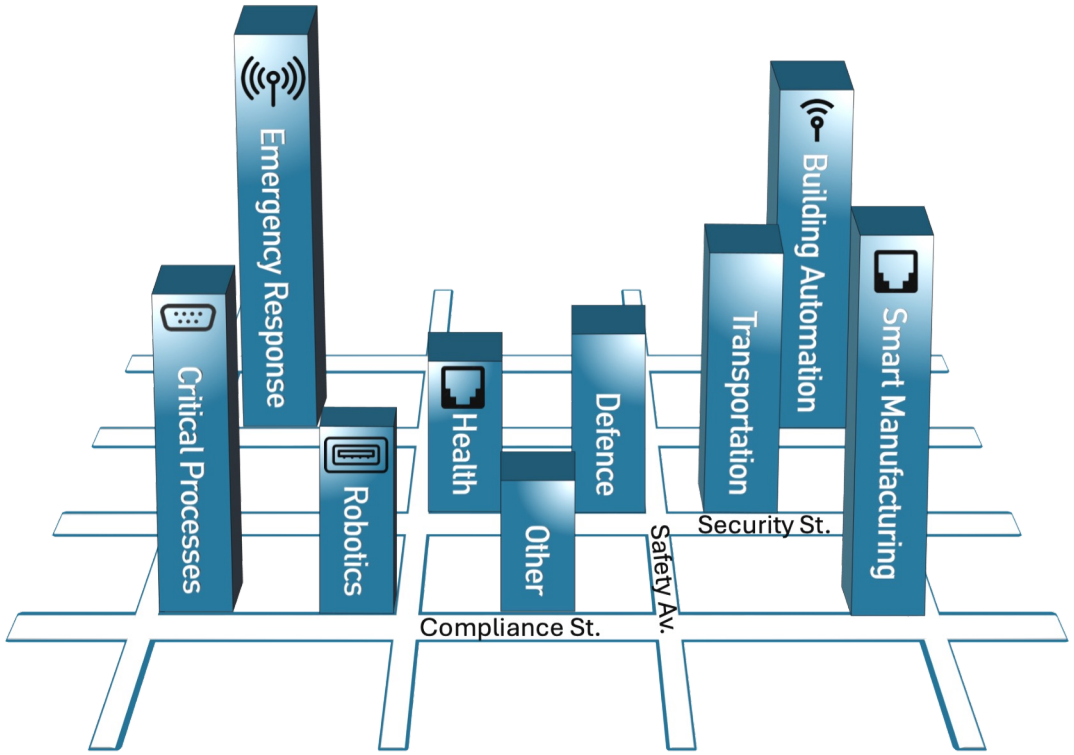
Cyber-Physical Systems

"*CPS are physical and engineered systems whose operations are monitored, coordinated, controlled, and integrated by a computing and communication core.*"

Ragunathan Rajkumar, Insup Lee, Lui Sha, and John Stankovic. 2010. Cyber-physical systems: the next computing revolution. In Proceedings of the 47th Design Automation Conference (DAC '10). ACM, 731–736. https://doi.org/10.1145/1837274.1837461

Cyber-Physical Systems



- Unmanned vehicles
- Interconnection
- Internet connection
- Autonomous
- Control and Monitor
- Adaptivity
- Individualization

State-of-the-art v.s. state-of-the-practice

Literature

- Security during the design phase
- Continuous testing
- Regularly check fitness of installations
- Resource monitoring and segmentation
- Secure protocols
- Heavier workload for deployments
- Industry specific

Industry

- If it works, it does not need fixing
- Pushing new products
- Long homologation processes for devices
- Unfitness of IT processes to OT (audits)
- Open protocols
- Safety risks and Cyber Security risks collide
- Many different technologies working together for a single product
- Product specific

Testing Cyber-Physical Systems

- Conformance testing
- Robustness testing
- Security testing
- Fragility testing
- Model-based testing
- Search-based testing
- Online monitoring
- Fault Injection
- Big data driven testing
- Cloud testing

X. Zhou, X. Gou, T. Huang and S. Yang, Review on Testing of Cyber Physical Systems: Methods and Testbeds," in IEEE Access, vol. 6, pp. 52179-52194, 2018, https://doi.org/10.1109/ACCESS.2018.2869834.

Survey

- Target
  - People working for Belgian (or European) companies
  - In charge of CPS design, development, test, or production
- 53-questions questionnaire via Drag n Survey
  - English, French, and Dutch
- Convenience sampling
  - Via LinkedIn post and LinkedIn direct messages
  - Contact lists from the Belgian CyberExcellence project and the Computer Science Faculty
  - Participated in 4 industrial forums (2 local and 2 international) to interact with relevant companies directly

Data processing

- Data preprocessing
  - Extract and consolidate all the rows from all questionnaires
  - Remove NA rows and participants stating they couldn’t answer the questionnaire
  - Identify dropouts and delete responses
- 9 exploitable responses after soliciting respondents for 5 months
- Targeted personnel with high technical knowledge of the systems and corporate and regulatory expertise

Overview of CPSs context by industry

Question	Other	Process Control	Robotic Service	Smart Manufacturing	Transportation
Number of devices	1,000 to 10,000	>10,000	1,000 to 10,000	100; >10,000	10; >10,000
Device interaction	No	Yes	No	Yes	Yes
Avg. devices interacting		10 to 100; 100 to 500		10 to 100; 100 to 500	1 to 10; 10 to 100
Number of systems		>100		<10; >100	<10; >100
Systems with devices from different manufacturers		50 to 90%		10; >90%	10 to 50%
Industrial computer used		Yes		Yes	Yes
Same department manages systems		Yes		depends	No
Number of departments				1; >3	>3

Testing levels and types by industry

	Other	Process Control	Robotic Service	Smart Manufacturing	Transportation
System tests		Yes	Yes	Yes	Yes
Integration tests		Yes	Yes	Yes	Yes
Unit tests		Yes		Yes	Yes

- Functional and non-functional tests
- Most carry out tests before integrating a new device
- Quality insurance tests

Testing time per development phase

Design	Development	Prototyping	Production
• 1 week to 1 month • 1 day to 1 year (depending on case)	• 1 day to 1 week • 1 day to 1 year (depending on case)	• 1 week to 1 month • 1 day to 1 year (depending on case)	• <1 hour • 1 day to 1 year (depending on case) • <1 hour to 1 year (depending on case)

Challenges

Various application domains

Multiple and various components and technologies for a single “product”

Narrow test windows

OT oriented systems

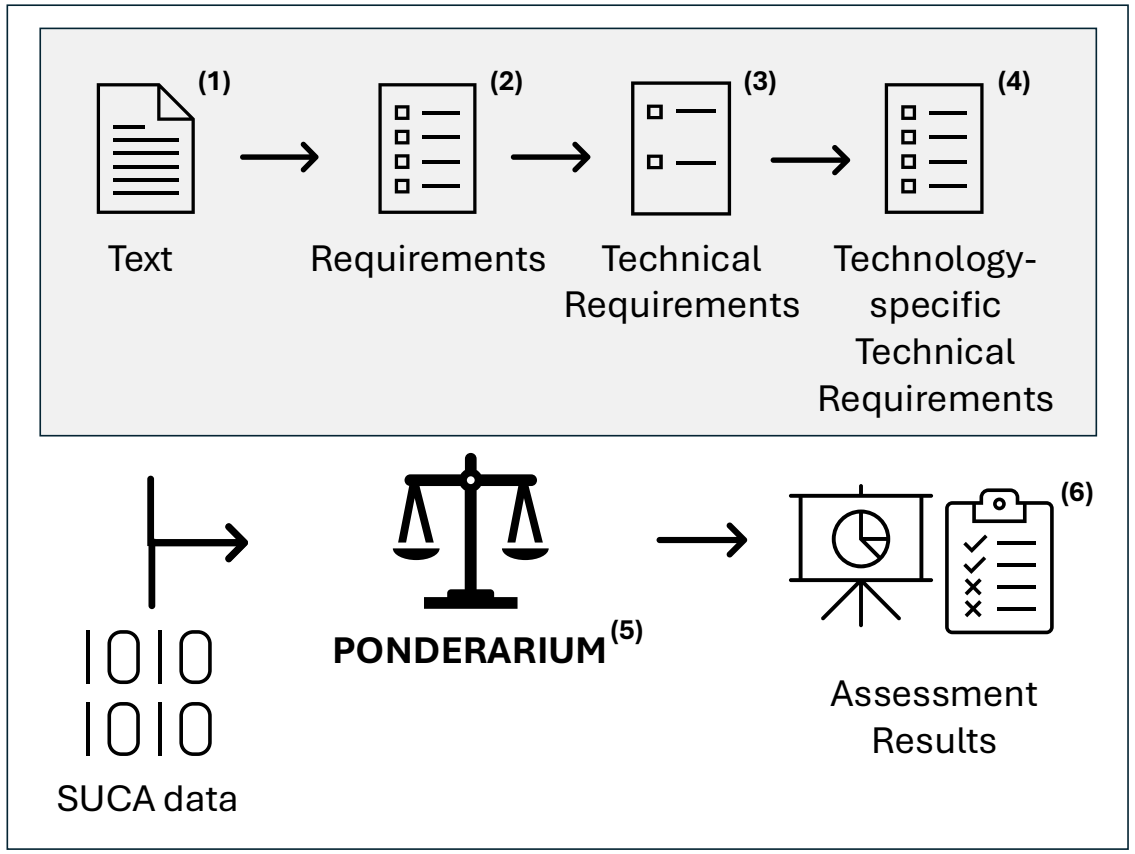
Test orchestration

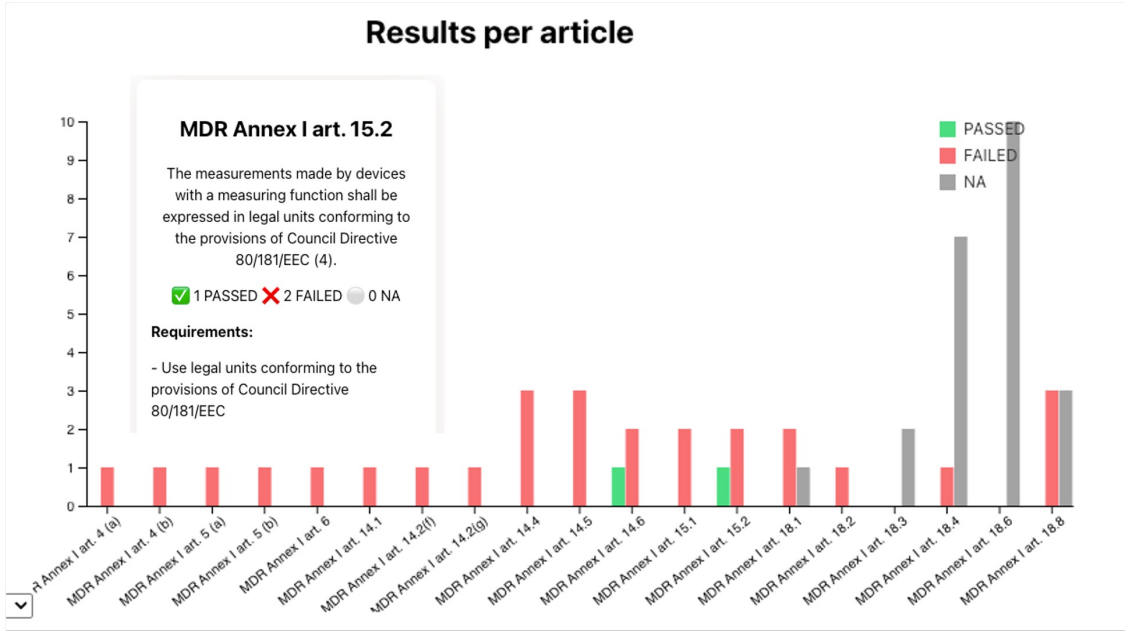
Internal and external review for component introduction

Risk Analysis

IEC international standards and conformity

There is one more thing…





Nguyen, G., Sacré, A., Simonofski, A., & Devroey, X. (2025, August). Ponderarium, a place for Cyber Physical System conformity assessment. In 59th Hawaii International Conference on System Sciences.

Software Normalization Assessment and Improvement Lab

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