Extending Life Time of Railway Systems

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September 9 , 2021

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Extending the Life-Time of Railway Systems

The Challenges.

- **Railway Systems today are cyber-physical Systems**

  - Hardware which usually degrades with time
  - But also software, which becomes obsolescent, has its own ‘degradation’patterns **and interacts with hardware**

- **… which interface other systems (such energy generation and communication) to form a systems of systems**

- **and are subject (in the medium-long term) to hard-to-predict changes in use conditions and regulations**

  - Example : 5 years ago, who would have predicted the distanciation rules (COVID) ,or the repeated floodings (Germany, Belgium, China) due to climate change ?

  …and vulnerable to evolving threats (e.g. cyber-terrorism)

Not just a ‘ simple’ reliability and maintenance question

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Some Directions for Research

- **Deep understanding of (hardware) degradation mechanisms at system level (data-enhanced physics-based models)**
- **Fleet level preventive/ predictive maintenance→ avoid simultaneous failures of all elements**

- **Sustainable Resilience**

  - Absorptive (withstand 'shocks') → throughout life cycle (design/ redesign , maintenance policy evolution)
  - Adaptive (graceful degradation)
  - Quickly recovering

- **Digital Twins as a tool for Life-Cycle management and Lifetime Extension**

  - **simulation of degradation patterns but also enhancements of physical system to dynamically adapt to evolving conditions**
  - **Some functions implemented in cyberspace and thus hardware independent**

- **PHM for Software : predicting/ avoiding 'software crashes' and other soft failures**
- **Maintenance efficiency as a life extender**
- **In-depth study of Safety impact of PHM→ essential condition for adoption for key subsystems**

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