Sustainable performance: a paradigm inducing new needs of interoperability between maintenance and scheduling activities in manufacturing

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The main focus

Balance	Manufacturing	Interoperability

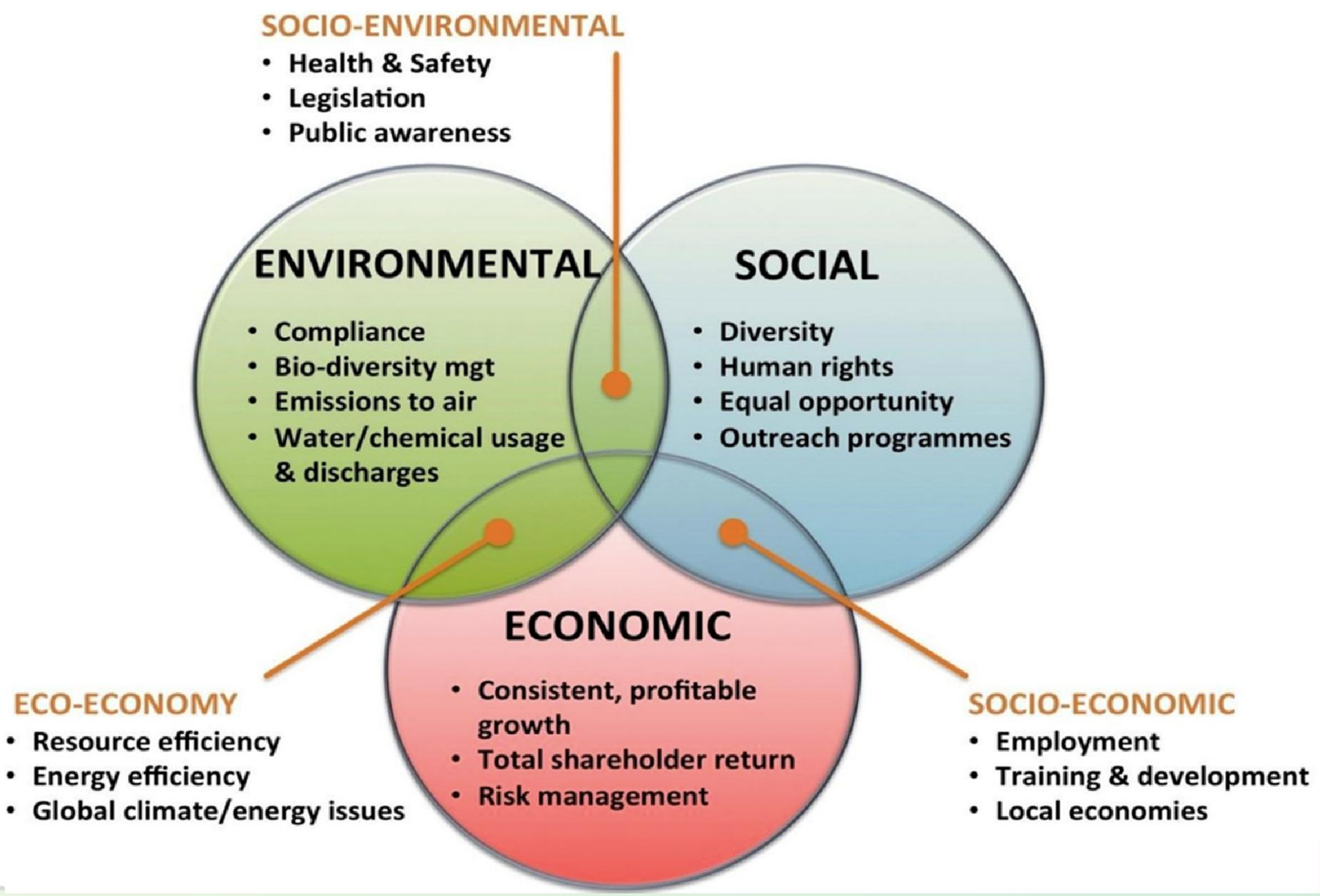
• Scheduling and Maintenance
• Study:
  • (i) Sustainable manufacturing scheduling
  • (ii) Sustainable maintenance for sustainable-efficiency
	• Short-term manufacturing decisions/operations
	  • (i) Energy (most important drive in short-term decision);
	  • (ii) Risk of unsustainability (manufacturing processes);
		• Barriers and concerns
		• Common understanding between scheduling and maintenance functions

Sustainable performance

- Corporate strategy directions (Krechovská and Procházková 2014):
  - Integrate sustainability into the **business process management**
    - Sustainability must become an integral part of strategic management and business planning,
  - Integrate sustainability into the **measurement and performance management**
    - Quantify the effects of sustainable activities in the financial performance and its impact on the growth of shareholder value,
  - Identify appropriate **business performance metrics**
    - Identification of social, environmental and economic indicators that influence the success of an organization.

- Sustainable performance is a long term performance hinged on three dimensions: Triple Bottom Line (Elkington 1998 and Asselot 2011)

Triple Bottom Line



SCHEDULING without any attention paid to maintenance:

- A trade-off (balance) between effectiveness and efficiency indicators is realized; (Zhang et al., 2012)
  - minimizing input means consumption while maintaining the global performance as a compromise
- Effectiveness is optimized under efficiency as hard constraints; (Bruzzone et al., 2012)
  - a maximum peak power value to be respected
- Effectiveness is maintained as the main objective, while efficiency is optimized in a second stage (Mashaei and Lennartson, 2013);
  - **opportunistic energy savings** are relevant to this approach.

SCHEDULING with attention paid to maintenance

- **Gao el al., 2006** - proposed a hybrid genetic algorithm to schedule jobs and maintenance activities in flexible job shop aiming to minimize time-related criteria (**effectiveness-oriented**, no attention paid to efficiency).

- **Xu et al., 2015** - proposed a single-machine scheduling problem with workload-dependent maintenance duration where the objective is to minimize total completion time (**efficiency-related criteria are not considered**).

SCHEDULING Function Conclusions

- Few works addressed maintenance and sustainability simultaneously
  - « Scheduling plus sustainability » (no attention paid to maintenance)
  - « scheduling plus maintenance » (no attention paid to sustainability)
- Effectiveness-oriented objectives used to design scheduling methods are by essence conflictual with the ones from maintenance

Sustainable MAINTENANCE without attention paid to manufacturing scheduling

- Industrial Ecology
  - Maintenance activity in the perspective of the whole LCP and so rarely in short-term manufacturing decisions.
- Green Maintenance
  - Eliminate waste streams associated to maintenance
  - Integration of Product Design issues with maintenance planning and execution
- Life-Cycle Maintenance
  - Consists, for a given product, in managing maintenance and deploying in a effective way throughout its life cycle

MAINTENANCE Strategies covering:

short-term and sustainable decisions

Maintenance Strategy

- **TPM**
  - . Optim. Equi. Effectiveness
  - . Eliminates Breakdown
  - . Autonomous Maintenance
  - **OEE**
    - . Availability
    - . Quality
    - . Performance
  - **Social dimension**
    - . Improv. Safety (elimin. Hazardous)
    - . Improv. Moral (employees'knowldege, involvement)
    - . Social Relations (coop. production & maintenance)
- **OM**
  - . Most adapted to Lean Manufacturing
  - **Maintenance and Scheduling**
    - Aim to reach a tradeoff between equip. Availab & maint. cost

We suggest to extrapolating opportune maintenance to opportune manufacturing, considering jointly prognostics on manufacturing fluctuations and on failures of equipment to adjust joint manufacturing / maintenance scheduling

Interoperability Concerns and Barriers between maintenance and manufacturing

- In the context of Life Cycle Engineering (LCE): one of the main problems for **integrating sustainability concepts** is to **formalize** and define these **concepts** based on **integrated data management**.
- Drawbacks of integrating maintenance into enterprise systems (ERP, MES, CMMS, SCADA, CRM, …):
  - Enterprise architectures are based on **heterogeneous subsystems** and **different data structures**
  - **Models** represent complementary knowledge but express redundancy and inconsistency.
- Users of the maintenance and manufacturing systems need to have "*the right information in the right format in order for the right people to do the right things at the right time*".
  - **During collaboration** in or across enterprises, a mutual understanding between all the maintenance support systems operated by different stakeholders is required

Interoperability Concerns and Barriers between maintenance and manufacturing

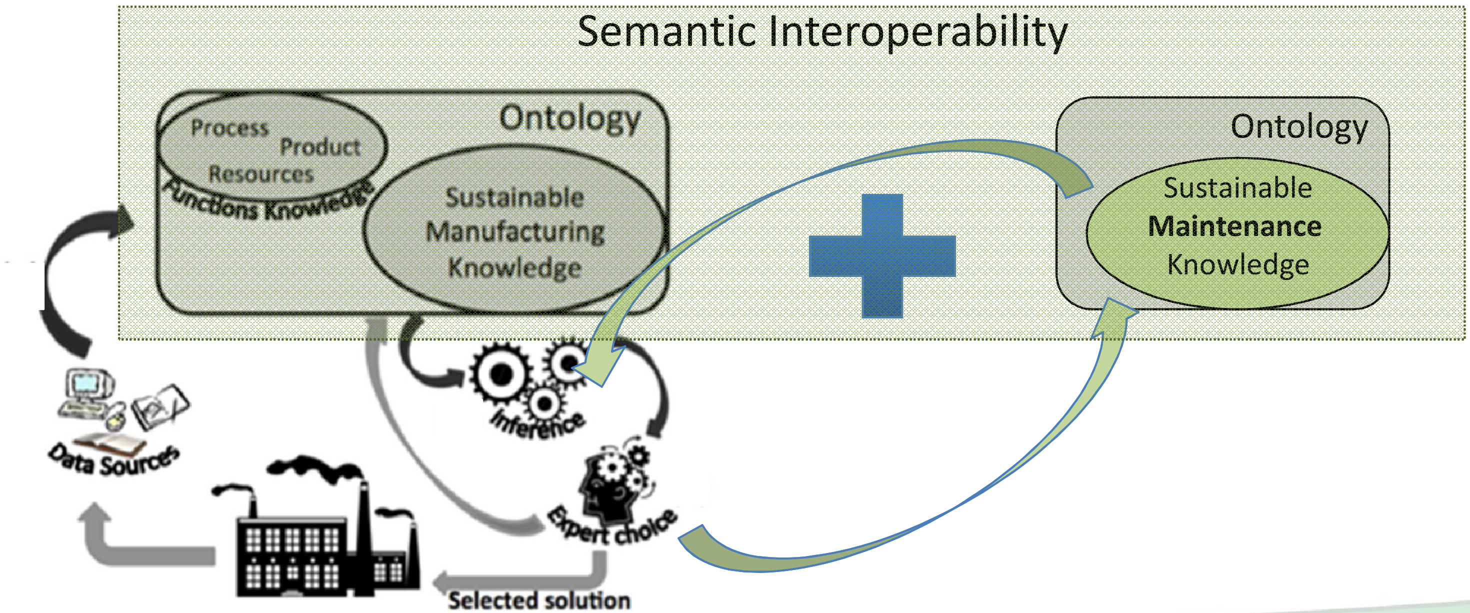
- **Interoperability** means the *ability of two or more systems or components to exchange information and to use the information that has been exchanged*
- **Interoperability** in or across **manufacturing enterprises**, has been widely accepted as one of the important **factor affecting industrial efficiency**
- Different **initiatives** have arisen in recent decades in an attempt to integrate the requirements of **maintenance function into collaborative environments**.
  - MIMOSA (Machinery Information Management Open Systems Alliance)
  - PROTEUS project from the e-maintenance concept emerged
  - PROMISE (Product Lifecycle Management and Information Tracking Using Smart Embedded Systems): features related to e-maintenance capabilities
  - DYNAMITE (Dynamic Decisions in Maintenance): distributed and remote capabilities as wireless telemetry and online instrumentation.

Interoperability Concerns and Barriers in Sustainable Maintenance

- Many studies related to interoperability have been carried out to support the exchange, transformation, discovery, and reuse of information.
  - Semantic heterogeneity is a central issue.
- In order to **improve semantic interoperability**, **maintenance support systems** must evolve their knowledge management capabilities in order to facilitate understanding and knowledge sharing.
- To overcome the semantic barriers in industrial maintenance, **ontological approaches** have become one of the most important directions in research.
  - IMAMO (Industrial MAintenance Management Ontology), based on MENTHOLOGY proposes a maintenance development process (*specification*, *conceptualization*, *formalization*, *implementation* and *maintenance*)

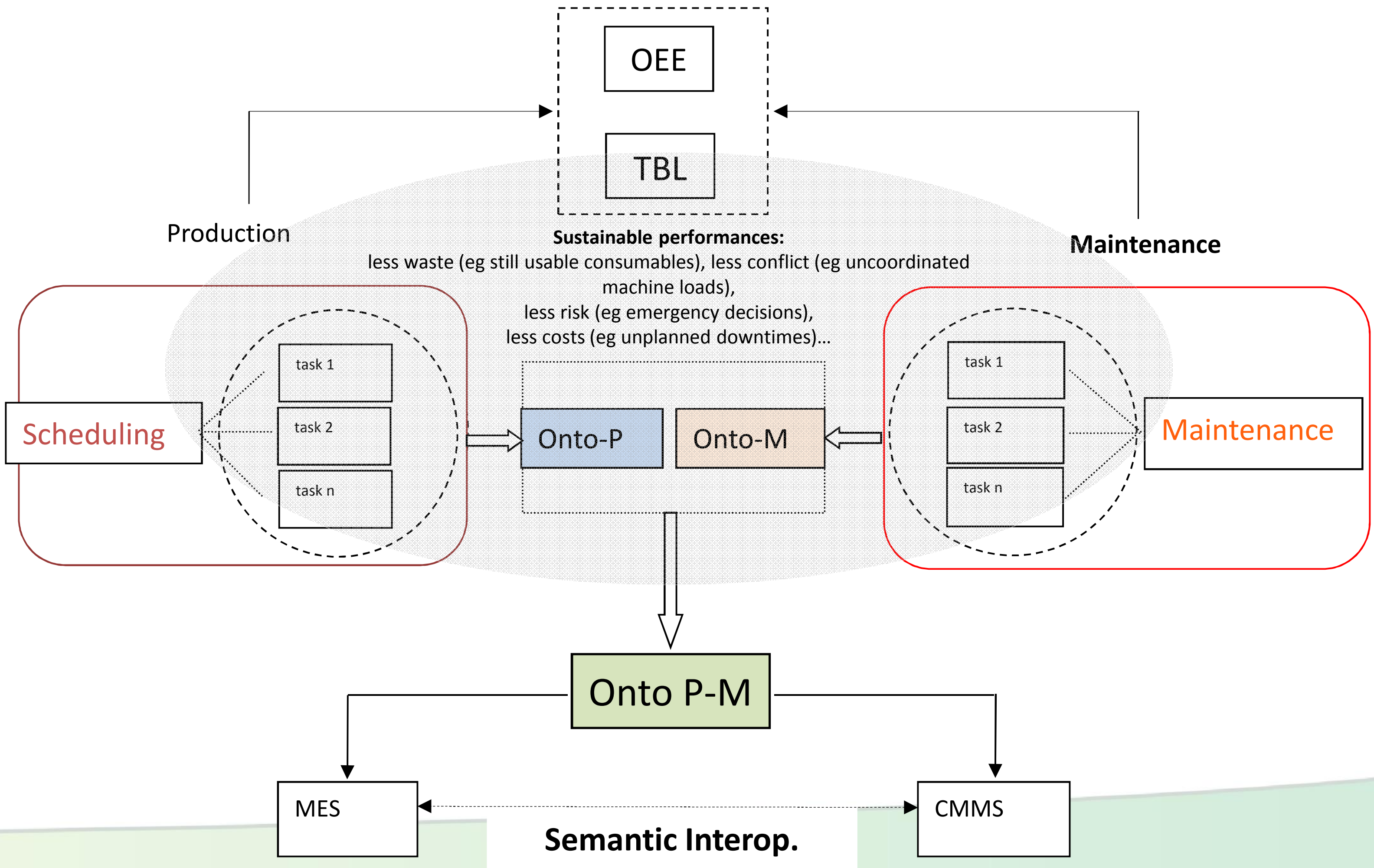
Motivation and Perspectives

The divergence of **concerns and languages** represents a central issue around a **common understanding** of **economic, environmental, and social performances** between **production and maintenance managers and systems**.



Giovaninni et al. 2012
Ontology-Based System for supporting Manufacturing Sustainability

Conceptual Framework



Thank You for Your Attention!