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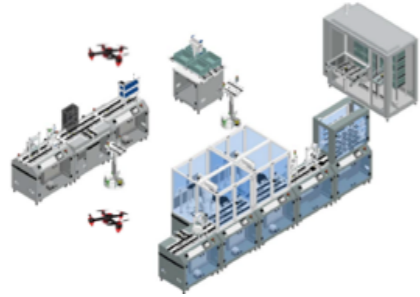
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Model-based system engineering approach for the conception of flexible production systems

Puviarasu S A, Catherine DA CUNHA, Farouk BELKADI, Alain BERNARD, Abdelhamid CHRIETTE

Background and Motivations

LS2N-Smart factory reflects industry 4.0 production paradigm by offering modular networked factory. This smart factory was the use case of this research work



Smart factory

Objectives and Methods

Problems

- Transforming Industries facing the issues of reliable transportation to reach the process flexible in shop floor environment.
- The highly competitive customised and personalised market demands made industries to face pressurised situation in all aspect of value chain.

Objectives of the work

- To incorporate a new drone system in the factory to replace human transportation and to handle customisation operations.
- To offer customisation and personalisation to customers and investigate the repercussions and impacts on the factory system.

Methodology followed

- Systems Engineering (MBSE)
- PROMETHEE decision making methods (subjective and objective approach)
- Deductive, inductive and abductive scientific reasoning
- Experimental Investigation

Findings and Results

I. Systems of systems (SOS) Integration

1) Feasibility and stakeholders preferences

- Stakeholder categorisation and feasibility analysis

$$SC_n = \begin{bmatrix} SC_1 & SC_2 & SC_3 \\ SC_4 & SC_5 & SC_6 \\ \dots & \dots & \dots \end{bmatrix} \quad SC_k = \begin{bmatrix} Sh_{11} & Sh_{12} & \dots & Sh_{1n} \\ Sh_{21} & Sh_{22} & \dots & Sh_{2n} \\ Sh_{31} & Sh_{32} & \dots & Sh_{3n} \\ Sh_{41} & Sh_{42} & \dots & Sh_{4n} \\ Sh_{51} & Sh_{52} & \dots & Sh_{5n} \end{bmatrix}$$

- Stakeholders Preferences on Alternatives

PROMETHEE degree function

$$P_j(d_j) = \begin{cases} 0 & \text{if } |d_j| \leq \psi_j \\ 1 & \text{if } |d_j| > \psi_j \end{cases} \quad P_j(d_j) = \begin{cases} 0 & \text{if } |d_j| \leq \psi_j \\ 1 & \text{if } |d_j| > \psi_j \end{cases}$$

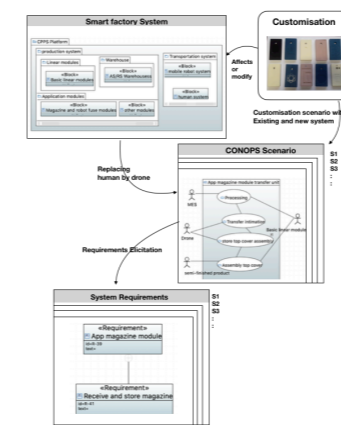
Objective decision making,

$$d_k(a_i, a_j) = f_k(a_i) - f_k(a_j)$$

Stakeholder (SC_i, SC_k) on UAV Attributes



2) Concept of operation analysis



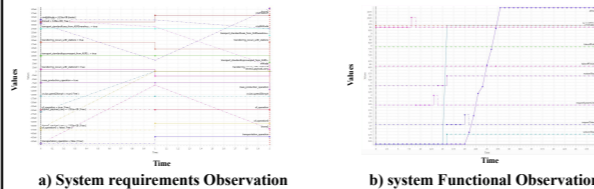
- Concept of operation of system (drone) integration with the platform

- CONOPS analysis is done based on the scenarios of assembly operation and Production system reconfigurability level

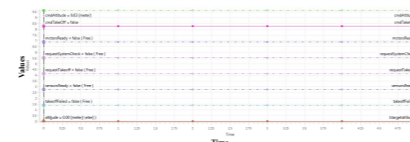
- Requirement Elicitation from scenarios

3) System Observations and Test harness

- Systems observations based on the scenarios from abstract level to element level



a) System requirements Observation b) system Functional Observation

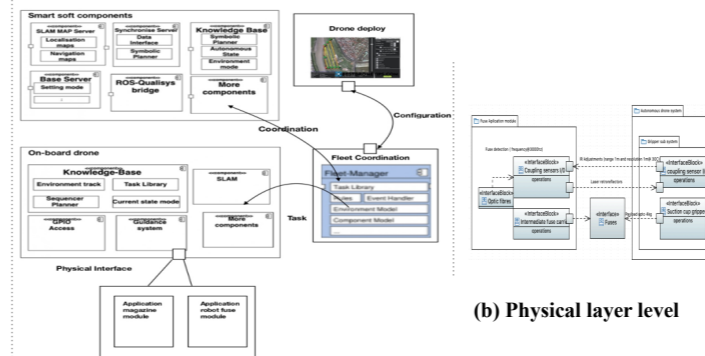


c) Simple system test harness

Static test harness shows that System logical solutions satisfies the system requirements according to CONOPS

4) Interface Architecture

- Proposed interface model of system of system (SOS) integration at black box level.



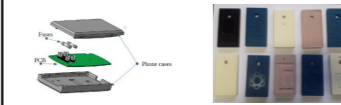
(a) Cyber layer level

(b) Physical layer level

II. Customisation offers

Adding option to products has repercussion on complete production system

1) Products portfolio



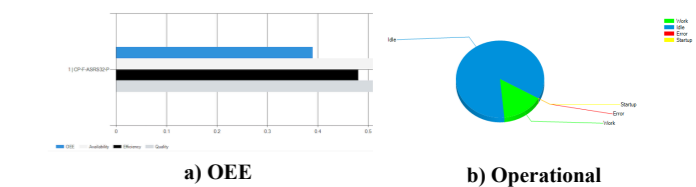
a) Standardised b) Customised

2) Repercussion on dimensions

- System and their operations
- Processes; Alternate routings, Inspection Condition
- Key performance Indicators

3) Repercussion and KPI Impacts

- Operation Impacts



a) OEE

b) Operational

- Sustainability Impacts

	Social	Environmental	Economic
Impacts of customisation	Working conditions Customers satisfaction	Energy	OEE

Conclusions

- The feasibility study, observations and test harness of each scenario of the system is analysed and is proposed the interface model at cyber and physical level of integrated system
- Adding options to products (customised and personalised) in the factory and investigate repercussion of the system by monitoring the KPI.

Perspectives

- It helps to bring new transportation strategies for future industrial context 4.0.
- The highly competitive markets demands and repercussion impacts on the shop-floor system helps industry/smart factory to improve on future stages.

Published As

- Puviarasu S. A, F. Belkadi, C. da Cunha, A. Chriette, A. Bernard, A semantic interface model to support the integration of drones in a cyber-physical factory, 10th International conference on interoperability for enterprise systems and applications - IESA2020, Tarbes (France), 2020
- Puviarasu S. A, F. Belkadi, C. da Cunha, A. Chriette, A Requirement framework for customization strategies in Cyber-physical production system, International conference on Changeable, Agile, Reconfigurable and Virtual Production Conference – CARV2020, Aalborg (Denmark), 2020.
- Puviarasu S. A, C. da Cunha, F. Belkadi, Introducing customization offer in a Learning Factory 4.0, 10th International conference on World Mass Customization & Personalization – MCPC2020, Aalborg (Denmark), 2020