Italian National Agency for New Technologies,
Energy and Sustainable Economic Development

A framework for the development of Human-Centred Safety Crowd-Sensitive Indicators in Enterprises (H(CS)^{2}I)

6th SAF€RA Symposium

Safety in the new economy and energy transition

Rome, 19th-20th May, 2022

Antonio De Nicola (ENEA, Italy)

H(CS)^{2}I Project

- International project funded by INAIL (IT) and IOSH (UK) under the SAF€RA 2018 Funding Scheme
- Call Topic: T2 Measuring and monitoring safety performance
- Project duration: July 2019 – June 2022
- Overall budget: € 259,500.00

H(CS)²I Partners and Project Team

Project coordinator

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Giordano Vicoli

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Mark Sujan

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Process Safety

- Process safety indicators are mostly based on accident causation models (i.e., on how we assume accidents happen).

- New paradigms suggest that accidents in modern, complex socio-technical systems can arise from everyday performance variability and from unanticipated and dysfunctional interactions

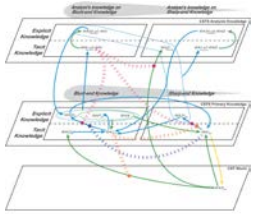
H(CS)^{2}I Project Goals

- The challenge is to identify safety indicators efficiently based on this newer type of thinking.

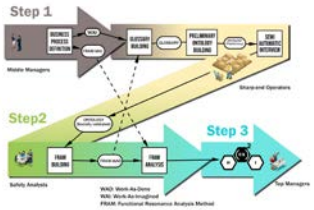
- This project set out to:
  - Define an approach for the development of safety indicators based on Resilience Engineering thinking.
  - Partly automate this approach to enhance its efficiency and quality.
  - Test the feasibility of the approach in an industrial case study.

Project Results

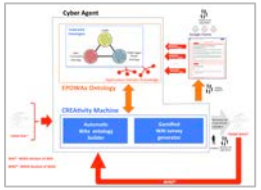
- WAx (Work-As-x) conceptual framework



- H(CS)²I Framework



- WAx software platform for analysis of cyber-socio-technical processes

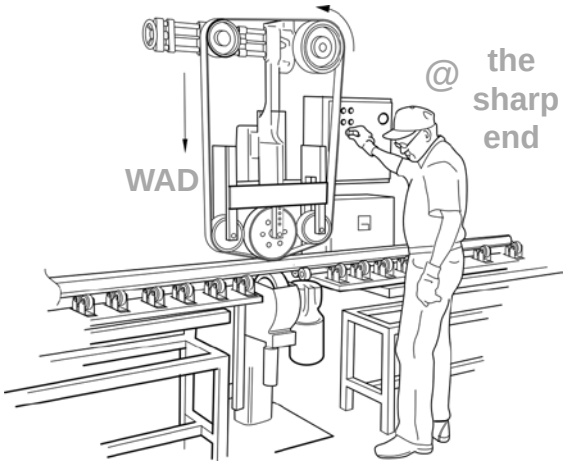


- 2 Pilots
  - “Big pharma” industry (UK)
  - An industry in the aluminium sector (IT)

Multi-perspective varieties of work

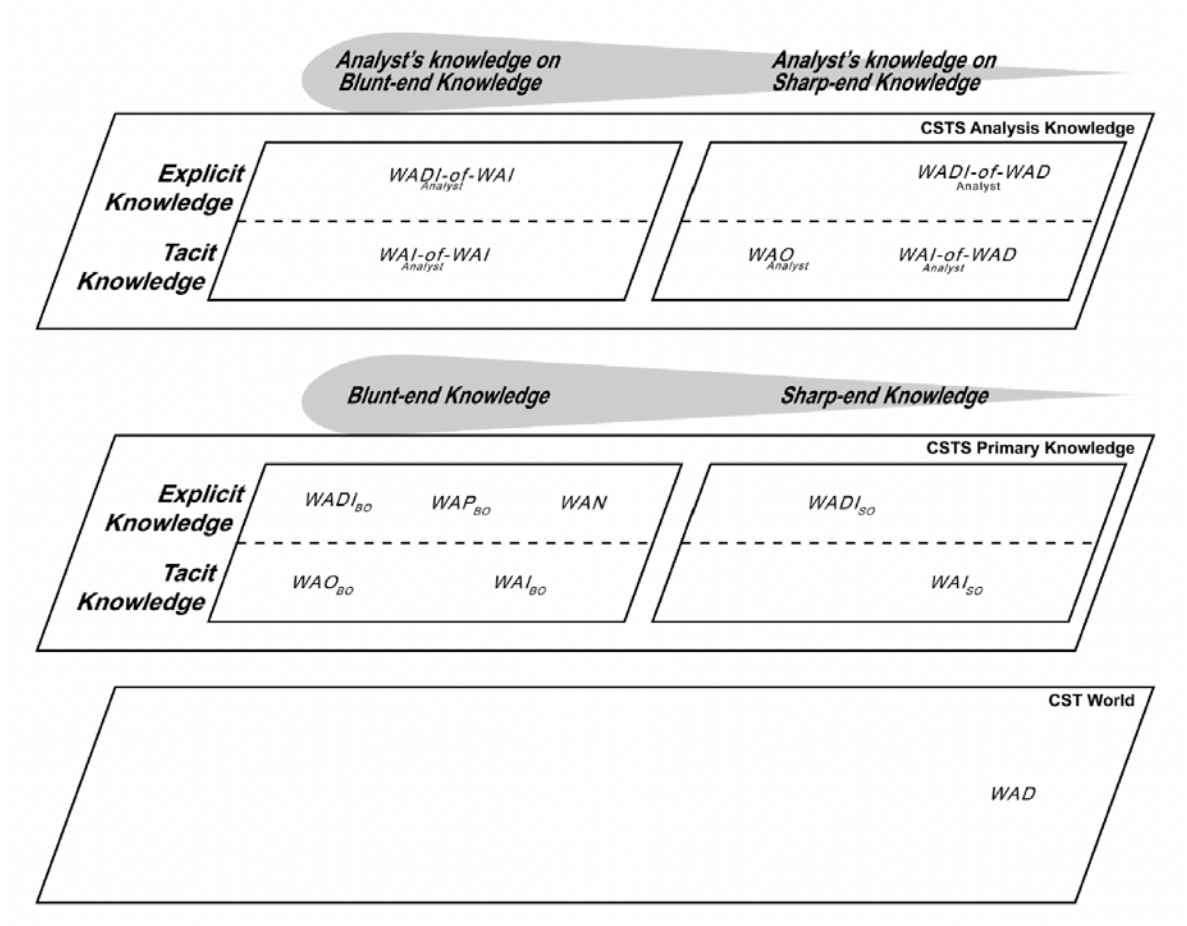
Work-As-Imagined (WAI)
(at the Blunt-End)

Work-As-Done (WAD)
(at the Sharp-End)



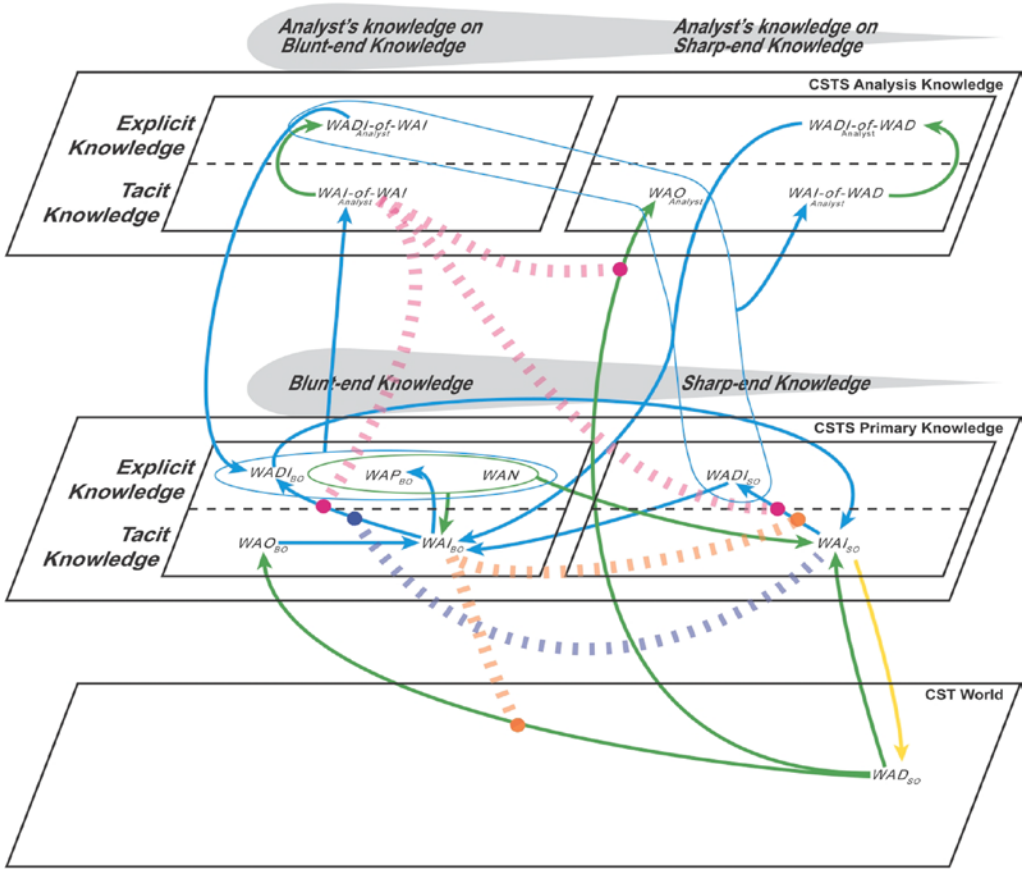
Moppett, I.K., Shorrock, S.T., 2018. **Working out wrong-side blocks**. Anaesthesia 73, 407–420. https://doi.org/10.1111/anae.14165.

The WAx Conceptual Framework: Structure



R. Patriarca, A. Falegnami, F. Costantino, G. Di Gravio, A. De Nicola, M. L. Villani. **WAx: An integrated conceptual framework for the analysis of cyber-socio-technical systems.** Safety Science, vol. 136, April 2021, 105-142, https://doi.org/10.1016/j.ssci.2020.105142

The WAx Conceptual Framework: Dynamics



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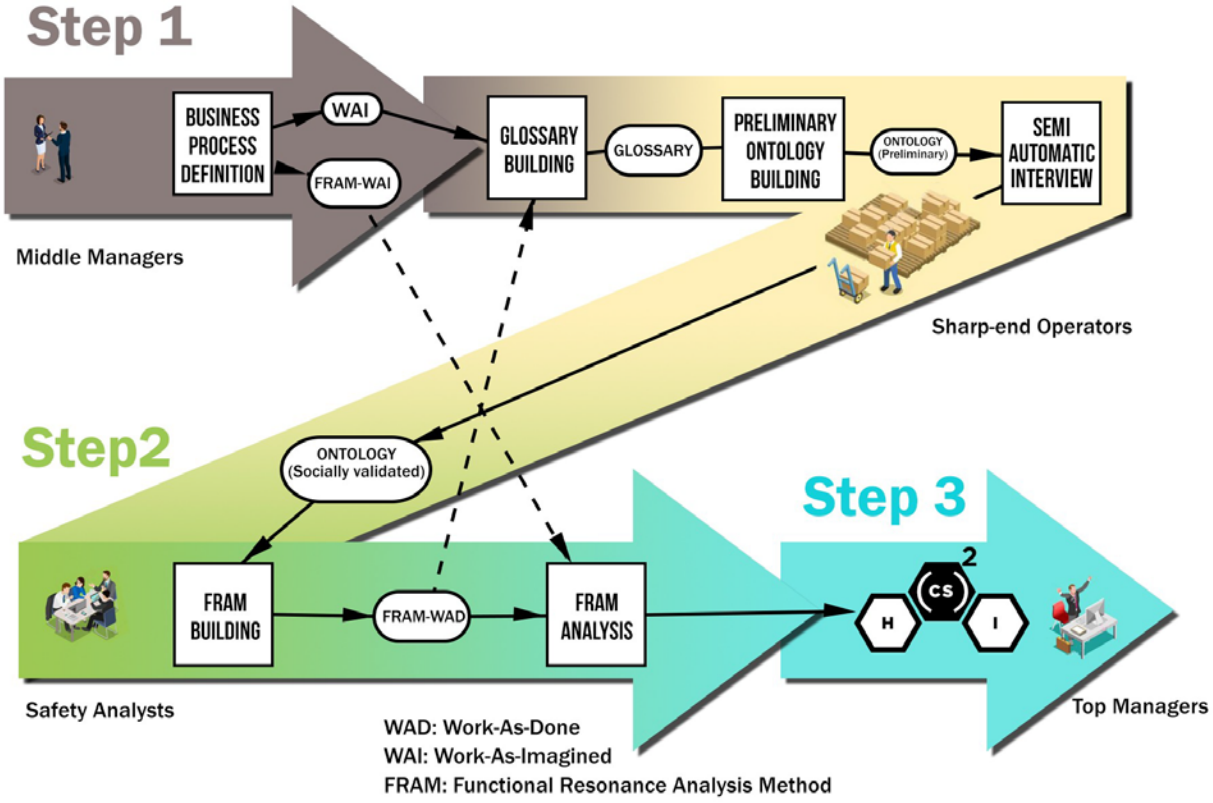
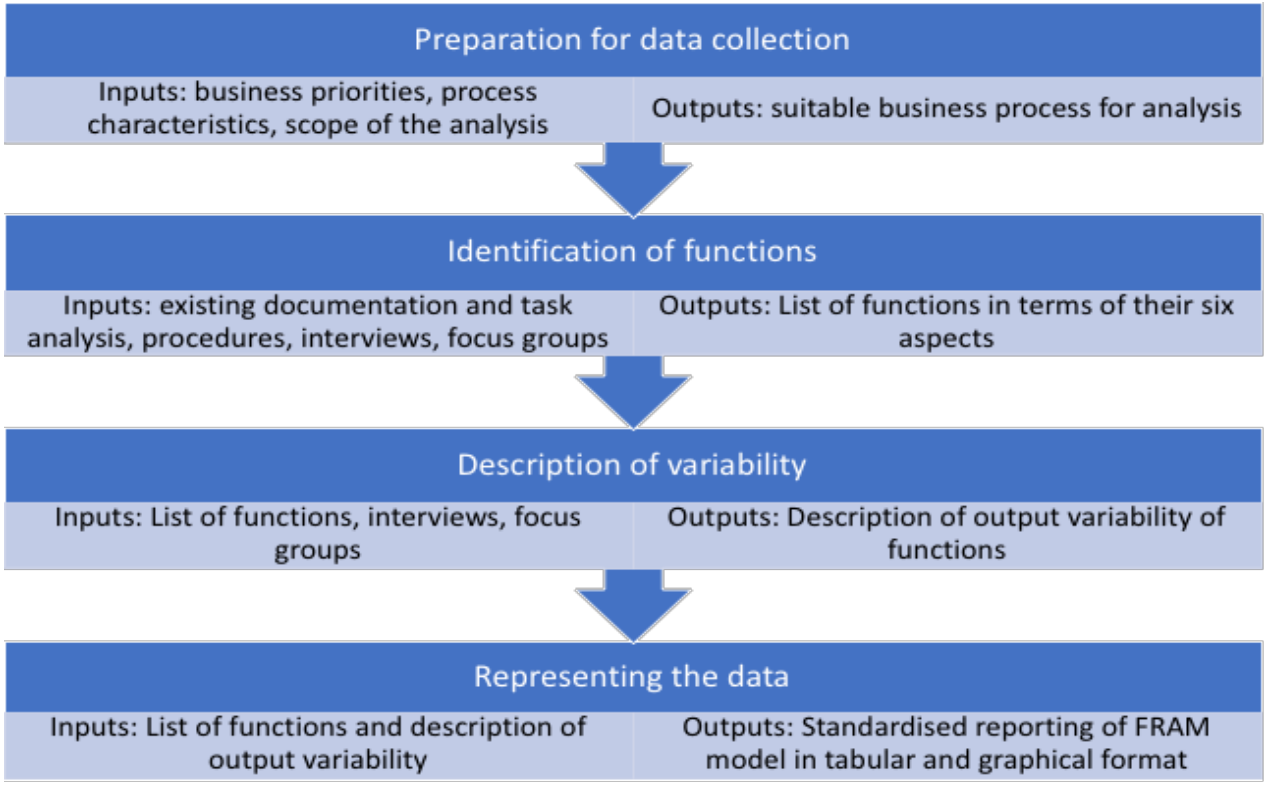
H(CS)²I Framework



Collecting knowledge in an enterprise: Work-As-Imagined (WAI)



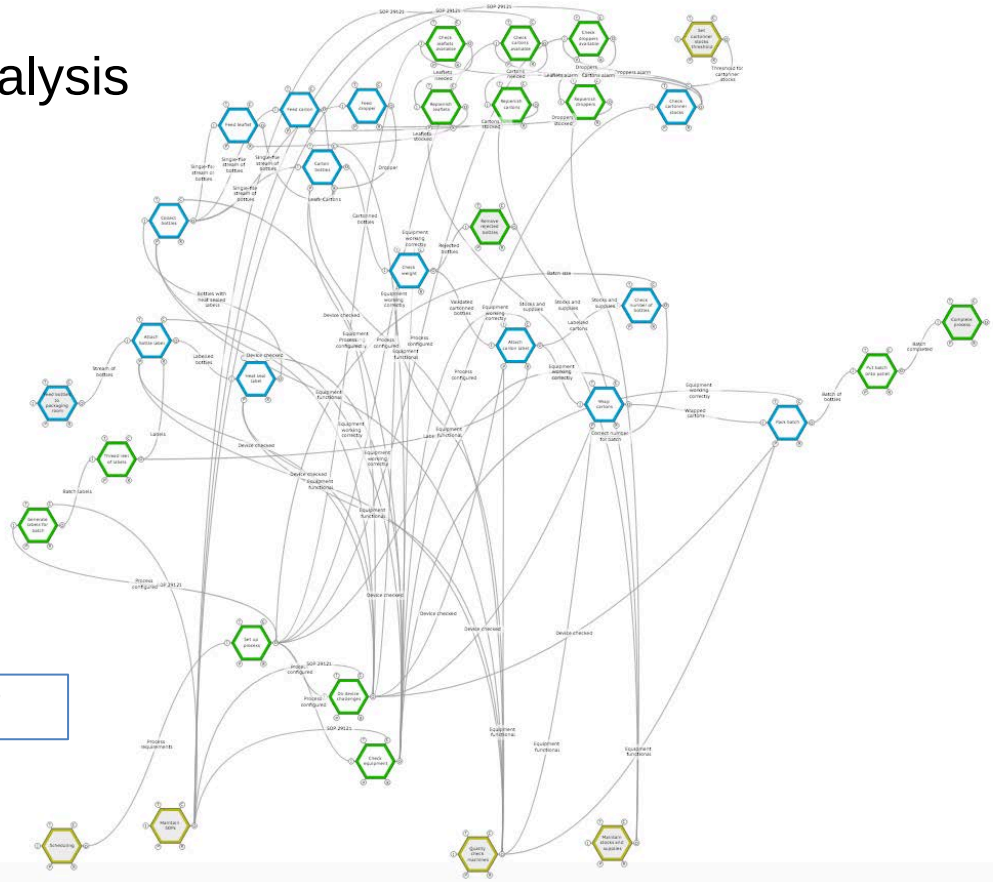
Case Study Process: Pharma Industry

Packaging of liquid inhalation product

FRAM (Functional Resonance Analysis Method) **process instance**

Functions by type:

- Automated
- Human
- Organisational



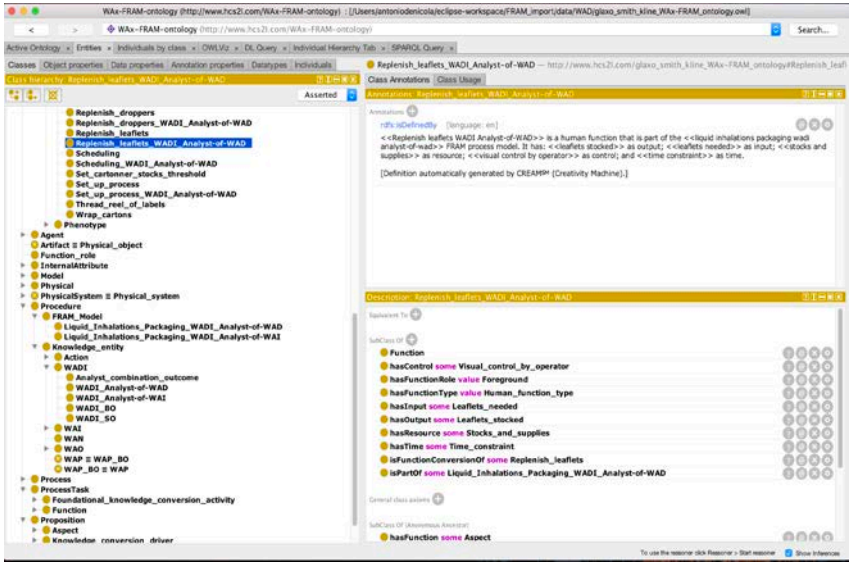
Hollnagel, E., 2012. **FRAM: The Functional Resonance Analysis Method** – Modelling Complex Socio-technical Systems. Ashgate.

Collecting knowledge in an enterprise: Work-As-Done (WAD)

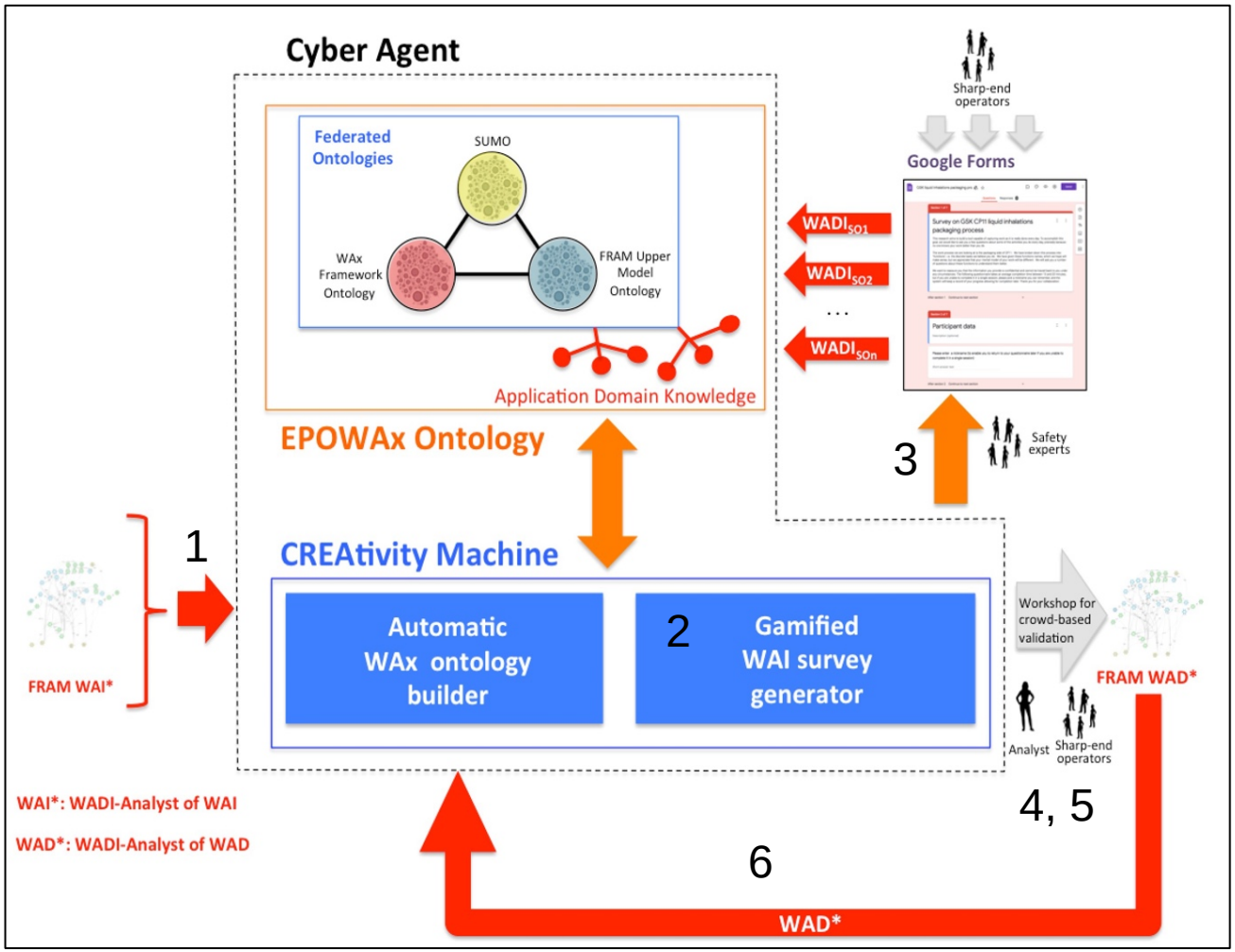
1. Automatic population of the EPOWAx ontology from FRAM WAI
2. Partially automated creation of the gamified WAI survey
3. Sharp-end operators respond to the survey
4. Workshop for "crowd-based validation"
5. Analyst designs FRAM WAD
6. Automatic population of the EPOWAx ontology from FRAM WAD

The EPOWAx Ontology

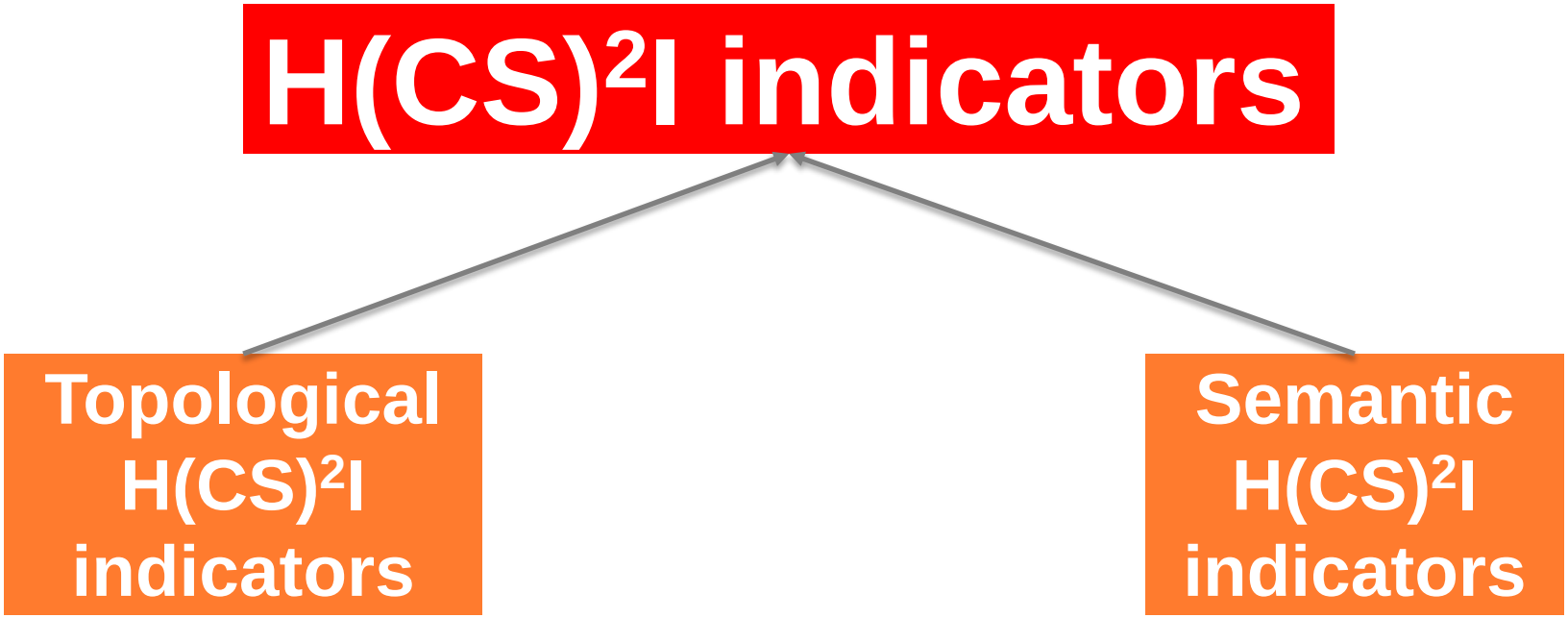
- An ontology is a formal specification of a shared conceptualization [Gruber93, Borst97]
- **EPOWAx**: Enterprise Production Ontology based on the WAx framework
- Based on the EPOWAx Upper Ontology model, which consists of:
  - The **Suggested Upper Merged Ontology** (**SUMO**)
  - The **WAx Framework Ontology**
  - The **FRAM Upper Model (FUM)** ontology



Creation of the FRAM WAD: Overall Approach



H(CS)²I indicators

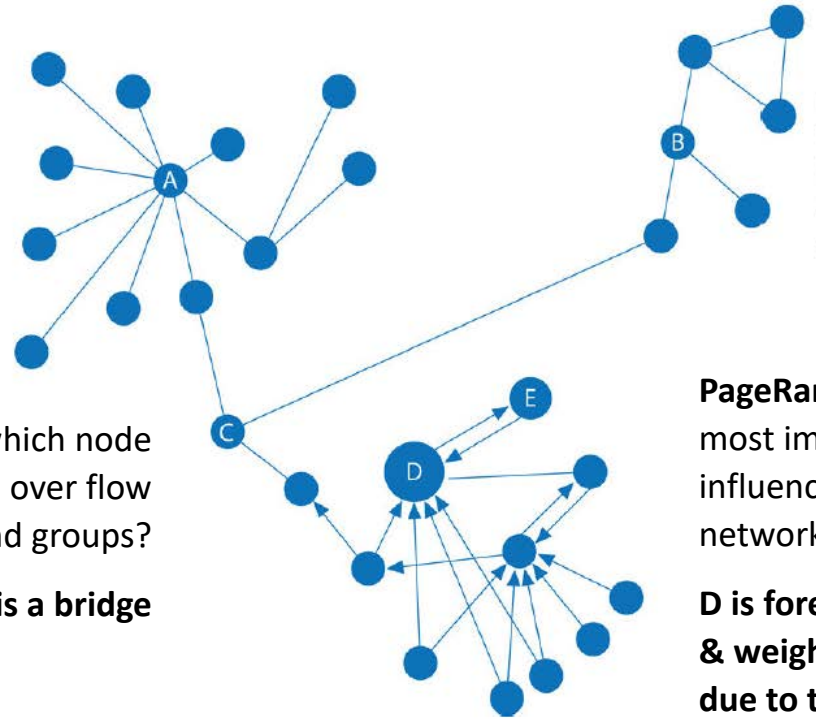


Topological H(CS)²I indicators

- Leveraging network representation of processes to identify the **key nodes**

Degree who is the most connected? (Baseline local metric)

A has the highest degree



Closeness which node can most easily reach all other nodes in the network?

B is closest with the fewest hops in its subgraph

Betweenness which node exhibits most control over flow between nodes and groups?

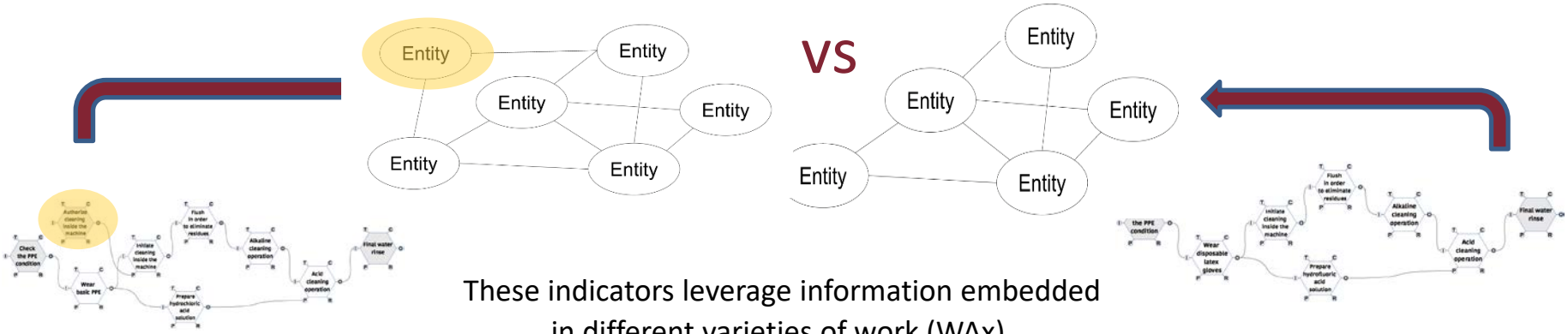
C is a bridge

PageRank which node is the most important? (overall influence over the entire network)

D is foremost based on number & weighing of in-links; E is next, due to the influence of D's link

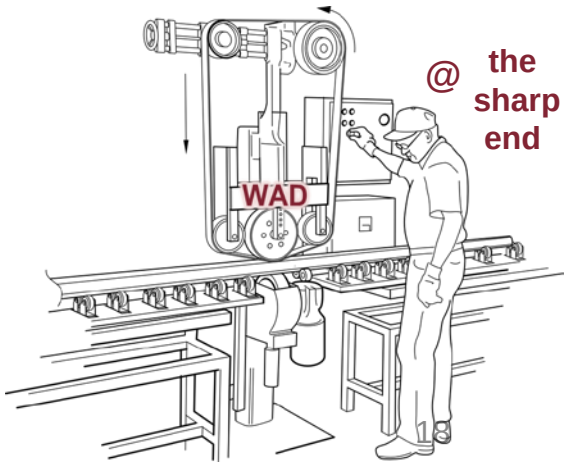
Id	Function	Type	Degree	Closeness	Betweenness	PageRank	Authority	Hub
1	Feed bottles to packaging room	Technological	6	4.17582E+14	30	2.07589E+14	9.44725E+14	1.43319E+14

Semantic H(CS)²I indicators



These indicators leverage information embedded in different varieties of work (WAx).

Main Case Study	
General	0.8714
Control	0.8720
Input	0.9154
Output	0.9162
Precondition	0.9235
Resource	0.8462
Time	0.8850
Human	0.8762
Technological	1.0000
Organizational	0.9888



Defining H(CS)²I Indicators: Steps

STEP 1

- Produce topological and semantic representations for each WAx entity

STEP 2

- Calculate absolute and relative network prominence indices for each WAx variety

STEP 3

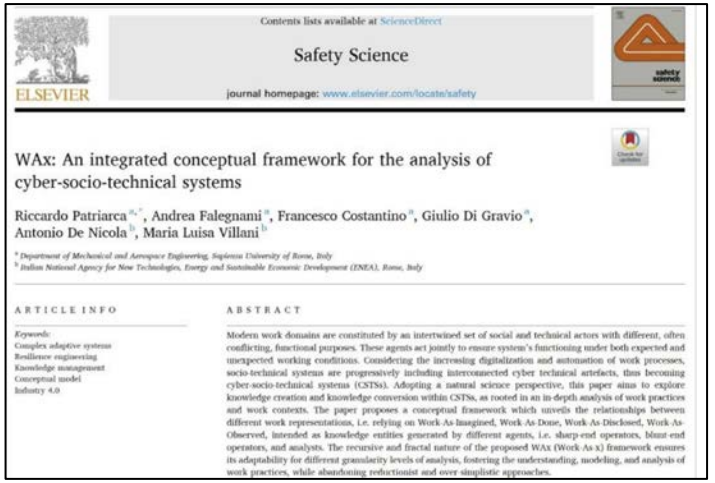
- Define the context-specific KPIs relative to the identified functions

STEP 4

- Calculate semantic similarity

Publications & Deliverables

- 1 journal paper
- 8 conference papers (Best Paper Award @ IESA-2022 Conference)
- 3 Workshop papers
- 2 Newsletters
- 14 project deliverables



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WAx: An integrated conceptual framework for the analysis of cyber-socio-technical systems

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ABSTRACT

Modern work domains are constituted by an intertwined set of social and technical actors with different, often conflicting, functional purposes. These agents act jointly to ensure system's functioning under both expected and unexpected working conditions. Considering the increasing digitalization and automation of work processes, socio-technical systems are progressively including interconnected cyber technical artefacts, thus becoming cyber-socio-technical systems (CSTSs). Adopting a natural science perspective, this paper aims to explore knowledge creation and knowledge conversion within CSTSs, as rooted in an in-depth analysis of work practices and work contexts. The paper proposes a conceptual framework which unveils the relationships between different work representations, i.e. relying on Work-As-Imagined, Work-As-Done, Work-As-Disclosed, Work-As-Observed, intended as knowledge entities generated by different agents, i.e. sharp-end operators, blunt-end operators, and analysts. The recursive and fractal nature of the proposed WAx (Work-As-x) framework ensures its adaptability for different granularity levels of analysis, fostering the understanding, modeling, and analysis of work practices, while abandoning reductionist and over simplistic approaches.

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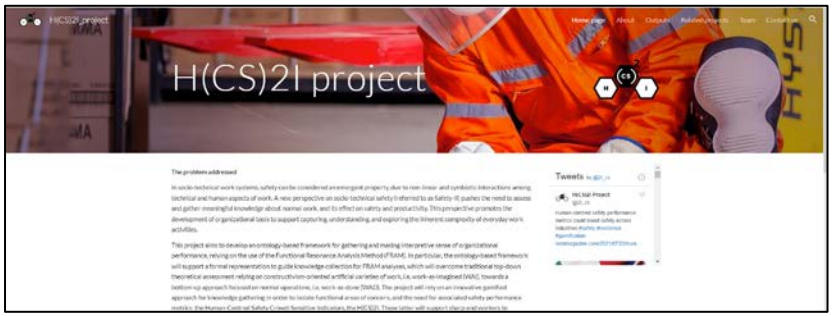
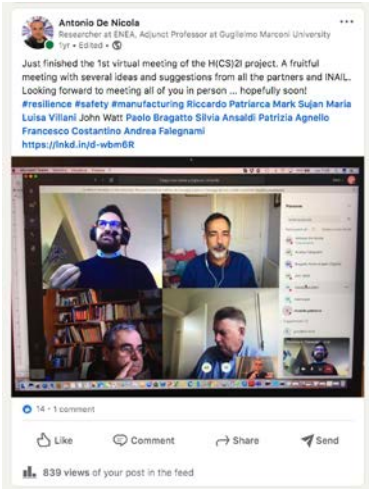
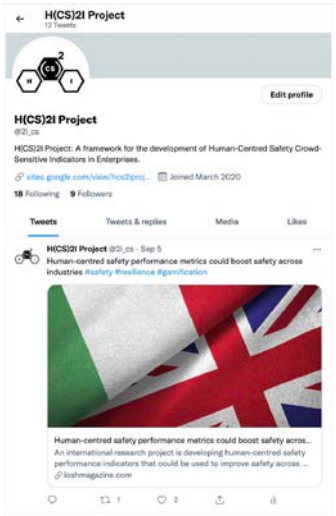
Websites & Social Media







Websites

https://projects.safera.eu/project/24

https://sites.google.com/view/hcs2iproject/

LinkedIn

https://www.linkedin.com/groups/8910868/

Twitter

https://twitter.com/2i_cs

ResearchGate

https://www.researchgate.net/project/A-framework-for-the-development-of-Human-Centred-Safety-Crowd-Sensitive-Indicators-in-Enterprises-HCS2I

Thank you!

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https://sites.google.com/view/hcs2iproject/home-page