Le risorse di Horizon Europe per il remanufacturing

Piacenza (Consorzio MUSP), 22 settembre 2022 – Paolo Albertelli – Politecnico di Milano
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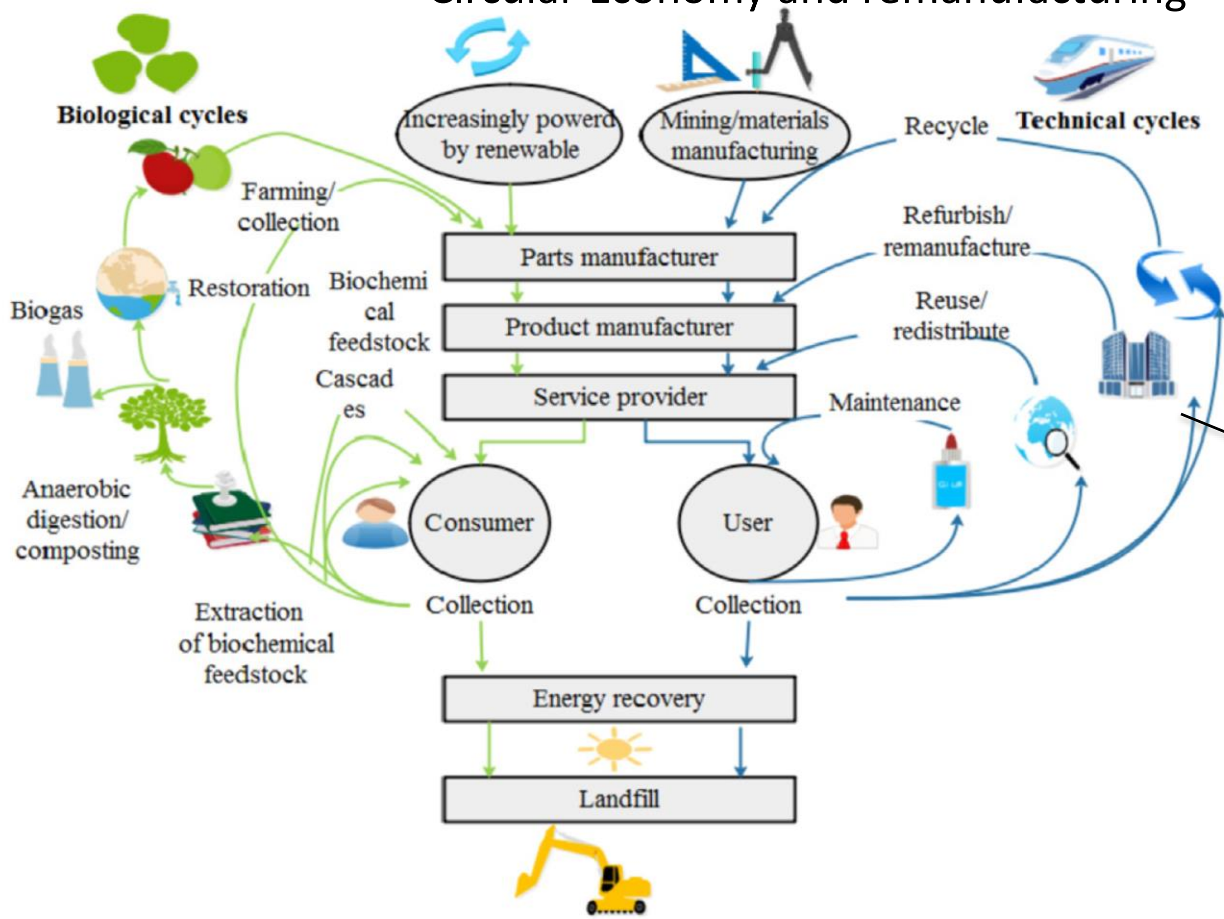
Agenda

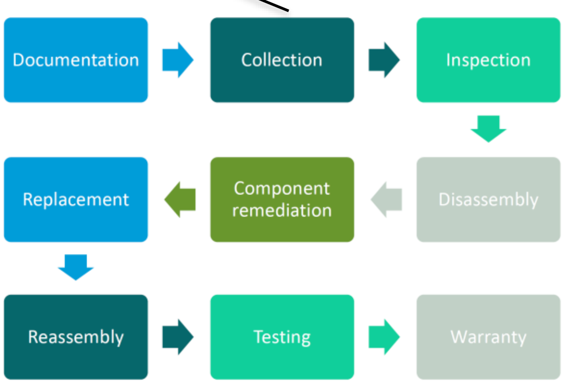
- Remanufacturing – introduction
- Horizon Europe – framework
- Some relevant calls
- Trends and keywords
- Remanufacturing and other key enabling technologies
- Examples: the cutting tool test cases.

Introduction

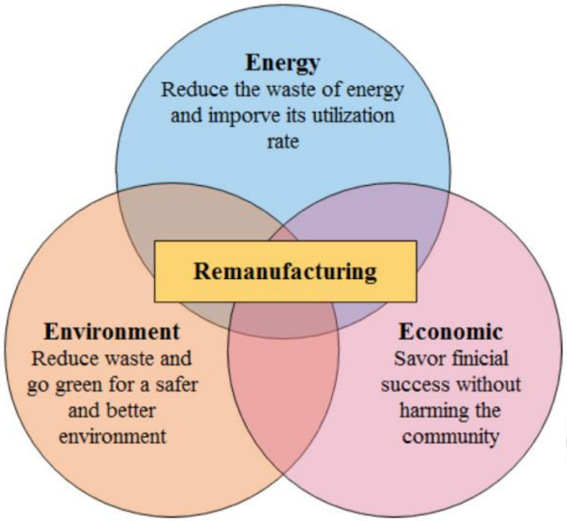
Circular Economy and remanufacturing



Xugang Zhang, Mingyue Zhang, Hua Zhang, Zhigang Jiang, Conghu Liu, Wei Cai, A review on energy, environment and economic assessment in remanufacturing based on life cycle assessment method, Journal of Cleaner Production, Volume 255, 2020,



Introduction



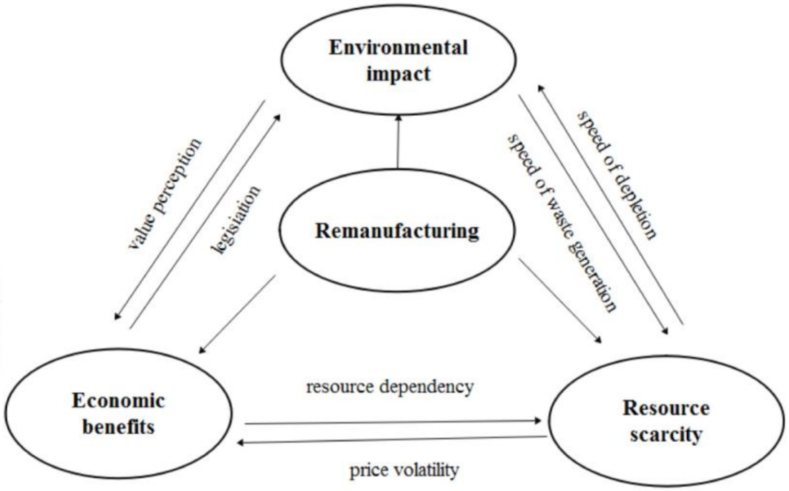


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Table 6
Environmental pollution during engine manufacturing (Kg/Per) (Mao et al., 2009).

Air pollutant	Emissions	Water pollutant	Emissions
Dust	1.97	Waste water	20510
SO_2	6.27	Suspended solids	0.31
HCHO	0.01	Oil, grease	0.12
CO	1.45	BOD_5	0.02
NO_x	2.10	COD_{cr}	0.06
CH_4	0.11	Manganese	0.02
CO_2	996.5	Iron	0.53
NMHC	0.02	Copper	0.01

Table 7
Environmental pollution during engine remanufacturing (Kg/Per) (Mao et al., 2009).

Emissions	Quantity	Emissions	Quantity	Emissions	Quantity
Dust	0.09	CO	0.07	SO_2	0.126
NO_x	0.028	CO_2	7.51	BOD	0.0042
Suspended solids	0.007	Hydrocarbon	0.0028	Heavy metal	0.0034

Environmental Impact (engine manufacturing)

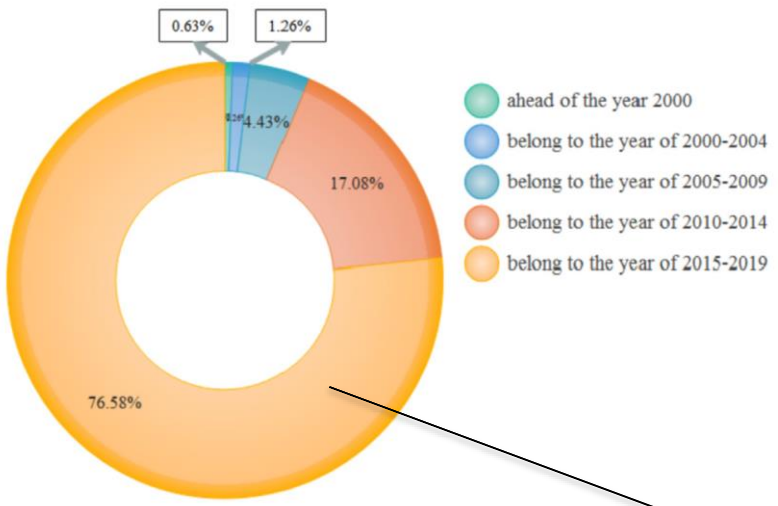
- NO_x: 2.10 Vs 0.028 Kg/per
- CO_2: 996.5 Vs 7.51 Kg/per

Energy (engine manufacturing)

- Saved Energy: 4/5 o the overall energy

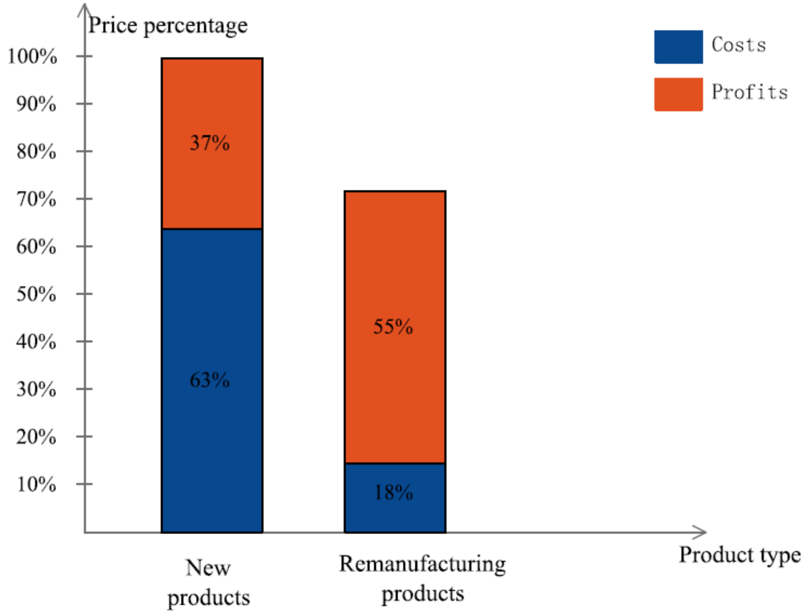
Introduction

Scientific and research activities



last 4 years (2015-2019)

Industrial perspective: **Costs and Profits**



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Remanufacturing challenges

Potentialities

+ material saving
+ energy saving
+ CO_2 saving
+ reduced costs
+ lower prices
+ higher profits

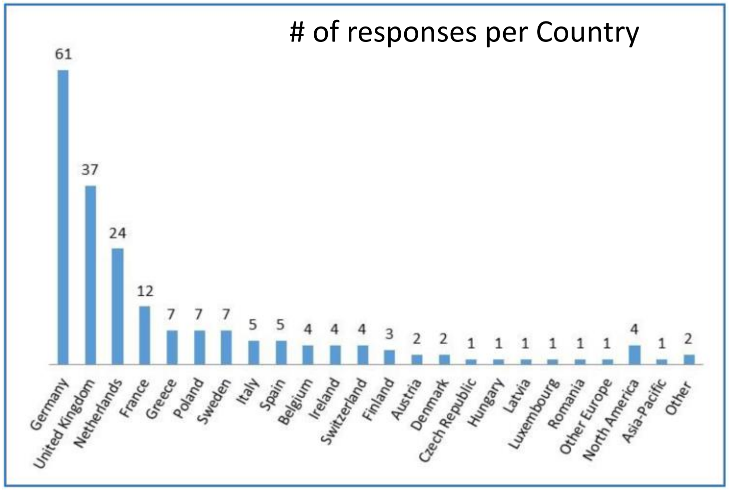
Challenges

- Lack of Data about the Condition of the Returned Product
- Complex disassembly processes
- Lack of a Methodology for Deciding the Best End-of-Life Scenario
- Investment analysis
- Supply chain
- Remanufacturing processes (agile, etc.)

↓

Industry 4.0 – digitalization and other Key Enabling Technologies: Artificial Intelligence

Sectors	Turnover (€bn)	Firms	Employm't ('000)	Core[2] ('000)	Intensity
Aerospace	12.4	1,000	71	5,160	11.5%
Automotive	7.4	2,363	43	27,286	1.1%
EEE	3.1	2,502	28	87,925	1.1%
Furniture	0.3	147	4	2,173	0.4%
HDOR	4.1	581	31	7,390	2.9%
Machinery	1.0	513	6	1,010	0.7%
Marine	0.1	7	1	83	0.3%
Medical equipment	1.0	60	7	1,005	2.8%
Rail	0.3	30	3	374	1.1%
Total	**29.8**	**7,204**	**192**	**132,405**	**1.9%**



Estimated savings

Sectors	Materials ('000 t)	CO_2e ('000 t)
Aerospace	136	356
Automotive	587	2,099
EEE	299	1,070
Furniture	16	129
Heavy duty and off road equipment	42	83
Machinery	76	131
Marine	663	2,724
Medical equipment	192	734
Rail	107	91
Total	**2,260**	**8,255**

Source: ERN European Market Study Horizon 2020

Scenarios and Future Trends

Basic Case (Hp: remanufacturing sectors growing under the following conditions)

- Low (0.5% p.a.) Heavy duty, Machinery and Marine
- Steady (3% p.a.) Aereospace, Automotive, Rail
- High (5% p.a.) EEE, Furniture, Medical Equipment

Stretch (with appropriate policies and promotional activities)

- Low (25% p.a.) Heavy duty, Machinery and Marine
- Steady (50% p.a.) Aereospace, Automotive, Rail
- High (100% p.a.) EEE, Furniture, Medical Equipment

Transformation (characterized by investment, strong policy support, large scale propotion)

- Low (50% p.a.) Heavy duty, Machinery and Marine
- Steady (100% p.a.) Aereospace, Automotive, Rail
- High (200% p.a.) EEE, Furniture, Medical Equipment

Source: ERN European Market Study
Horizon 2020

EU fundings – Horizon Europe structure

Pillar I
Excellent Science

Bottom-UP

- European Research Council
- Marie Skłodowska-Curie Actions
- Research Infrastructures

Pillar II
Global Challenges and European Industrial Competitiveness

Top-Down

Clusters
- Health
- Culture, Creativity and Inclusive Society
- Civil Security for Society
- Digital, Industry and Space
- Climate, Energy and Mobility
- Food, Bioeconomy, Natural Resources, Agriculture and Environment

Joint Research Centre

Pillar III
Innovative Europe

Bottom-UP

- European innovation Council
- European innovation ecosystems
- European Institute of Innovation and Technology

Bottom-UP **Widening Participation and Strenghtening the European research Area** Top-Down

- Widening participation and spreading excellence
- Reforming and Enhancing the European R&I system

Actions in Pillar II

- Research and Innovation Action (RIA): to establish new knowledge or explore the feasibility of new technologies

- Innovation Action (IA): produce plans or design improved process and product

- Coordination and Support Action (CSA): Contribute to the objective of Horizon EU (standardisation, dissemination,…)

EU fundings - structure

	Pilar II - Global Challenges and Industrial Competitiveness HEU	56%, €53.8 bn
Clusters	Health	8%, €7.9 bn
	Inclusive and Creative Society	2%, €2.2 bn
	Secure Society	2%, €1.8 bn
	Digital, Industry and Space	16%, €15.5 bn
	Climate energy and mobility	16%, €15.2 bn
	Food, Natural Resources and Agriculture	9%, €8.9 bn
	Joint Research Centers	2%, €1.9 bn

	Industrial Leadership H2020	22%, €17 bn
LEIT	ICT	17.6%, €13.6 bn
	Space	
	NMBP	
Access to Risk Finance		3.6%, €2.8 bn
Innovation in SMEs		0.7%, €0.6 bn

Societal Challenges H2020	38%, €29.7bn
Health	9.7%, €7.5bn
Agrifood	5%, €3.9bn
Energy	7.6%, €5.9bn
Transport	8%, €6.3bn
Climate	4%, €3.1bn
Inclusive Societies	1.6%, €1.3bn
Security	2.2%, €1.7bn

Horizon 2020 Related Pillars Budget: €43.5 br

Horizon Europe Budget: €95.5 bn

Calls and remanufacturing

HORIZON-CL4-2022-TWIN-TRANSITION-01-07: Digital tools to support the engineering of a Circular Economy

- Provide a range of **support solutions** and innovative **digital tools** for engineers, technicians and operators on the factory floor, in order to build **agile, sustainable and responsive production environment** and supply chains, with specific focus on areas such as **material saving, repair, refurbishing, re-manufacturing, recycling**, and reuse of products and components;
- **Reduction of the dependency from imported raw materials or harmful materials** for the European manufacturing sector (e.g. by material consumption reduction, material substitution and use of secondary raw materials);
- Define specifications and **standards for data**, products, and/or business processes, that can be agreed and commonly used by many industrial actors and across different industry sectors; and f**acilitate industry agreements on circularity and sustainability through increased data exchange** among value chain actors and enable the development of new types of businesses;
- **Reduce the skills and knowledge gap** for the actors involved.

RemaNet project

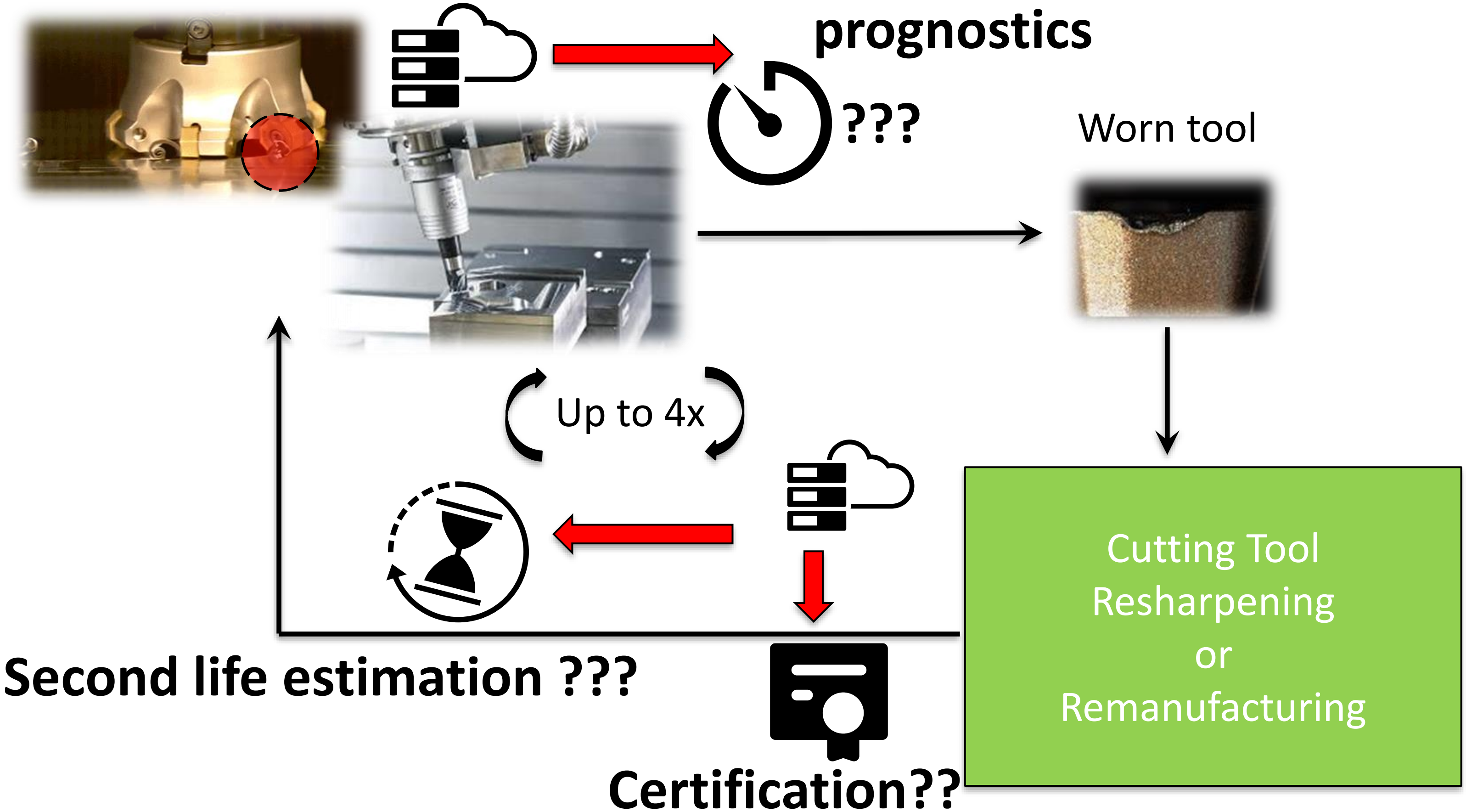
REMANET
it remains

Other potential keywords/topics:

- decentralised manufacturing
- improvements in small-series, customised production costs in decentralised environments
- Zero-defect manufacturing
- Improve Flexible production capabilities
- Promote circular economy by closing the material and energy cycles in cities
- Use of innovative modelling and simulation software that allow real time process control and manufacture monitoring
- Predictive and data analytics for processing huge amount of data achieving a much deeper understanding of customer needs

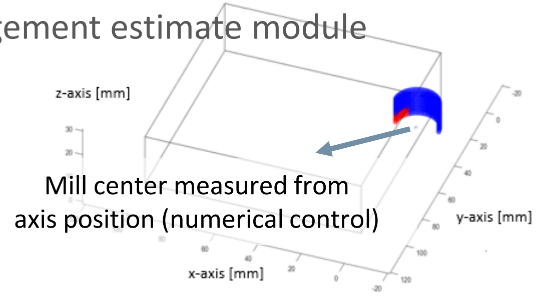
Examples

Remanufacturing of cutting Tools



Prognostics

1) Engagement estimate module



Variability of **working conditions** → **Specific Force Coefficients (SFC)**

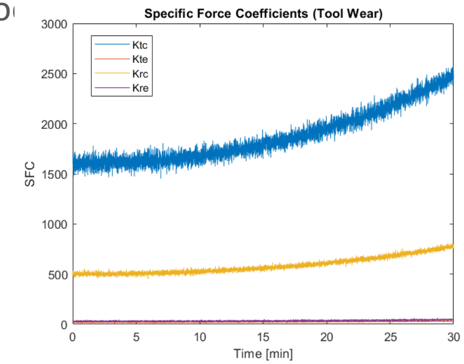
2) *SFC* identification mo

Engagement estimate module

SFC

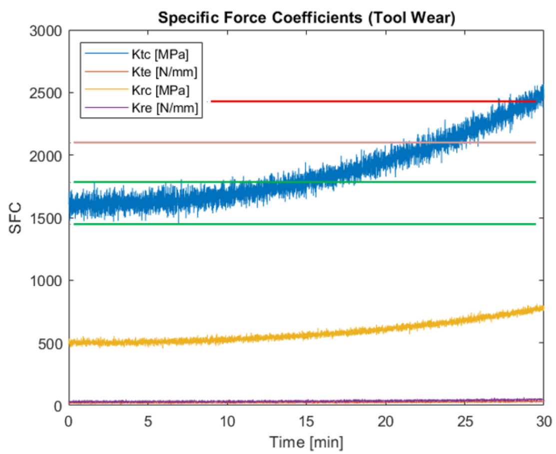
$$F_t = \sum_j g(\phi_j)\, a_p \left(f_z \sin(\phi_j) K_{t,c} + K_{t,e}\right)$$

$$F_r = \sum_j g(\phi_j)\, a_p \left(f_z \sin(\phi_j) K_{r,c} + K_{r,e}\right)$$



Residual Variability → **Growing Self Organizing Maps & PCR**

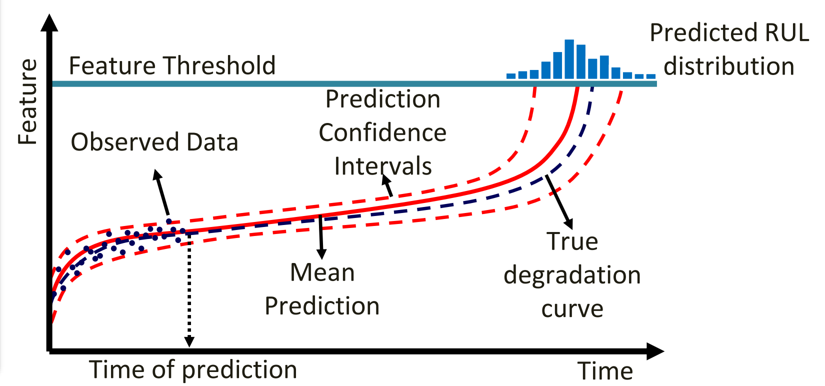
3) Monitoring module



SoA Challenges:

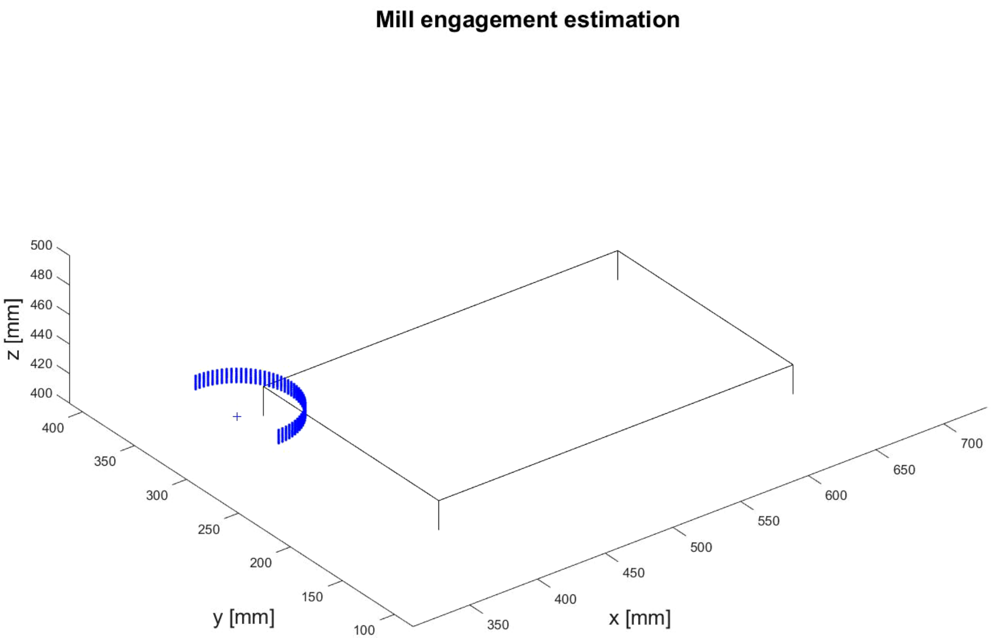
- **Working condition independence**
- **SFC istantaneous identification**
- **RUL pdf estimation**

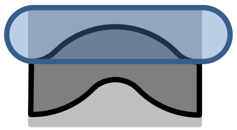
4) Prognosis module

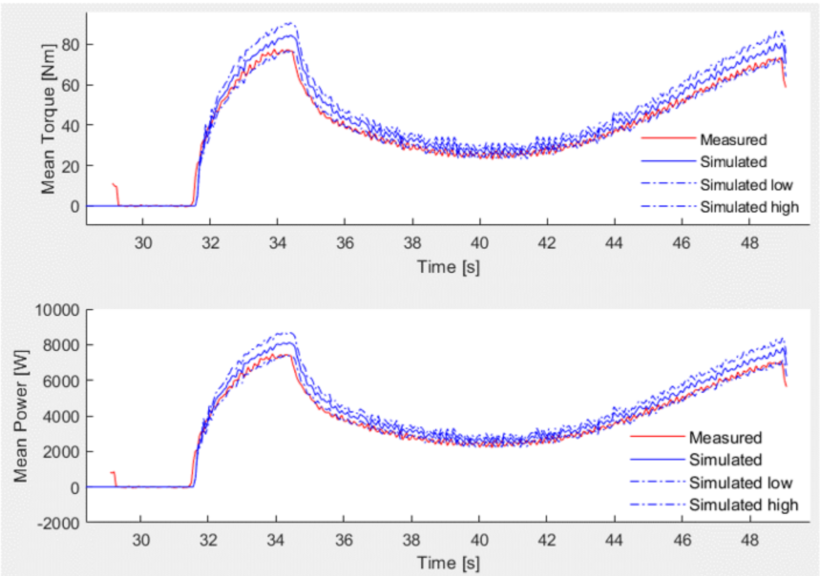


Adaptivity to **loading stress** → **Bayesian** update of **Artificial Neural Network**

Prognostics







FUTURE WORKS:

- Adaptive estimation of engagement

Prognostics

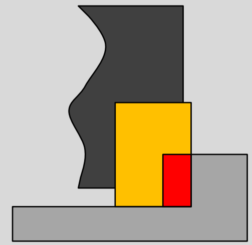
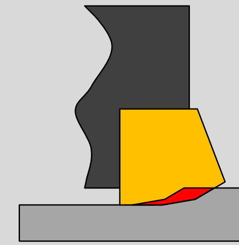
2) SFC identification module

Engagement estimate module

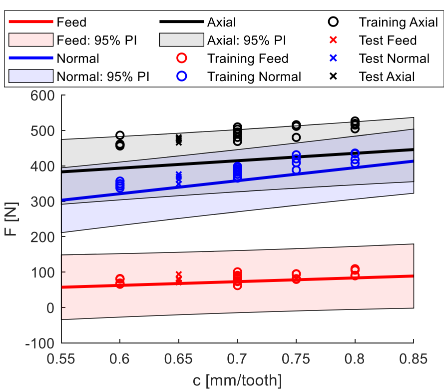
SFC

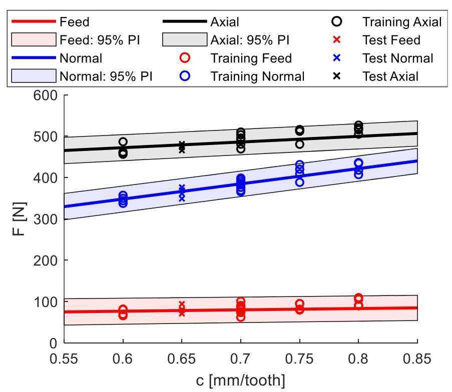
$$F_t = \sum_j g(\phi_j)\, a_p \left(f_z \sin(\phi_j) K_{t,c} + K_{t,e}\right)$$

$$F_r = \sum_j g(\phi_j)\, a_p \left(f_z \sin(\phi_j) K_{r,c} + K_{r,e}\right)$$

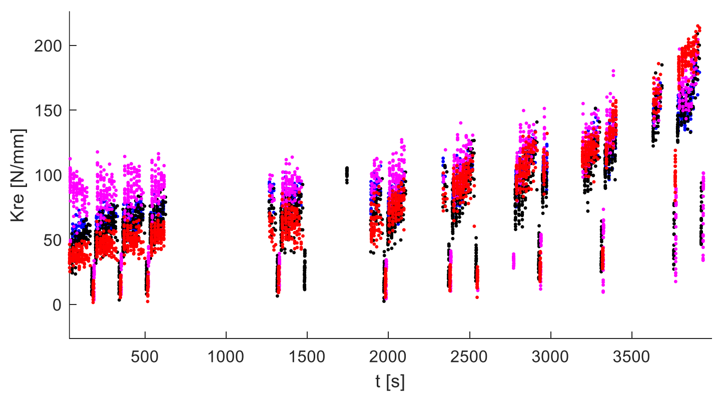
CLASSICAL MODEL	PROPOSED MODEL
 	 

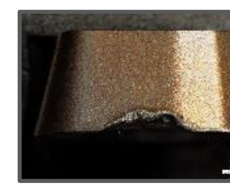
Mean Identification



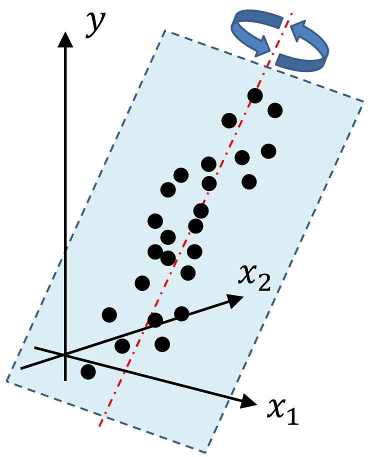


Instantaneous Identification



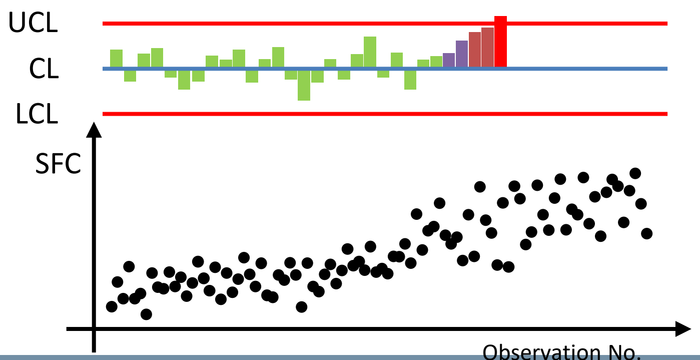


a) Principal Component Regression + Self-starting Control Charts



Principal Components Regression

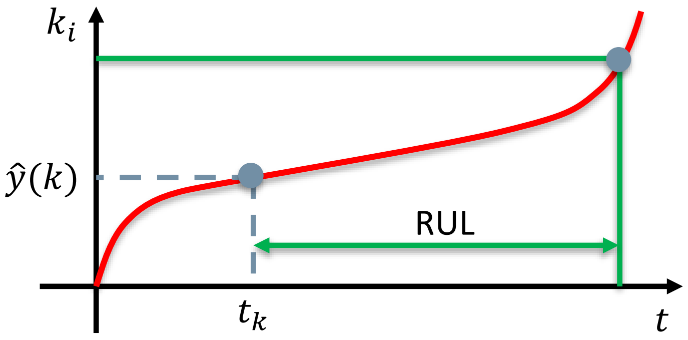
- Removes variability due to multicollinearity
- Performs Principal Components analysis on regressors
- Regression coefficients can be scaled back to the original meaning (keeping the physical information)



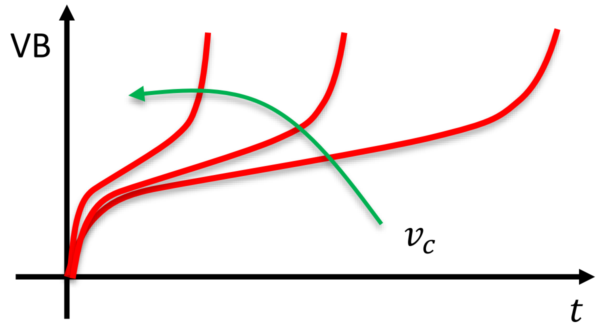
Self-starting Tabular Cusum Control Chart

- Self-starting → design phase not needed. Built on ongoing observations
- Tabular Cusum → monitoring cumulative small deviations from the expected process mean

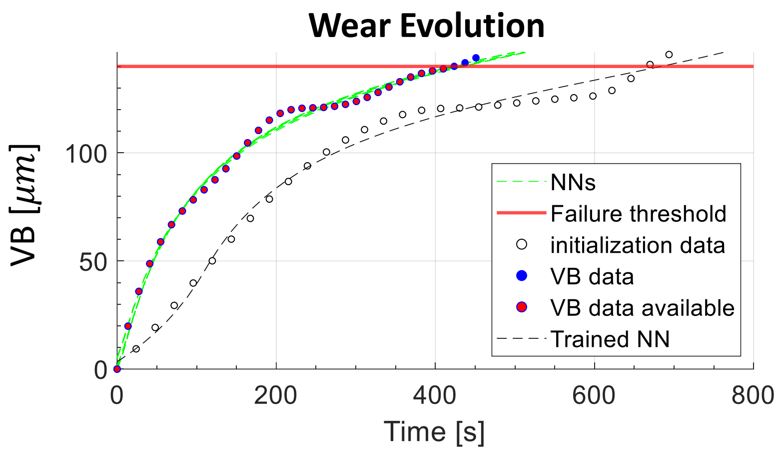
Prognostics

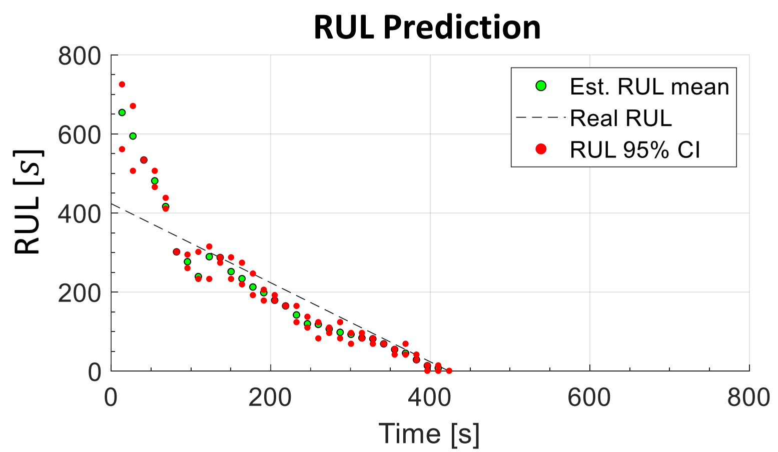


Residual Useful Life (RUL)



- Different cutting speeds
- Different lubricating conditions
- Different materials





Thanks for the attention

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