(Gen)AI for plastics and composites

Dr T.Timan

CT-IPC

tjerk.timan@ct-ipc.com

Centre Technique Industriel
de la Plasturgie et des Composites

National Technical Center for plastics and composites converting industry

Liberté • Égalité • Fraternité
RÉPUBLIQUE FRANÇAISE
MINISTÈRE DE L'ÉCONOMIE, DES FINANCES ET DE LA SOUVERAINETÉ INDUSTRIELLE ET NUMÉRIQUE

IPC

« Enhance the competitiveness of French plastics and composites converters…

… by carrying R&D and technological transfers…

… an generate knowledge to be shared amongst stakeholders »

TRL 4 ➔ TRL 7-8

For an Ethical, Responsible and Environmentally-friendly plastics industry

Axe 1 Ecological and Energy Transition

1. Improving the **eco-design** of plastic products and develop **new usage models** (ex. reuse)
2. Ensuring the **quality of Recycled Materials** (PCR)
3. Developoing **low environmental impact** alternative solutions for a **sovereign industry**
4. Protecting **human** health and natural **ecosystems**

Axe 2 Digital Transition and Industry of the Future

1. Developing **new processes and tooling** to produce better, in France
2. Implementing **digital solutions** for design, production and control
3. Creating **high-quality databases** and **secure their exchange** for a resilient industry
4. Deploying **new digital applications** to support efficient production

Axe 3 High value-added products

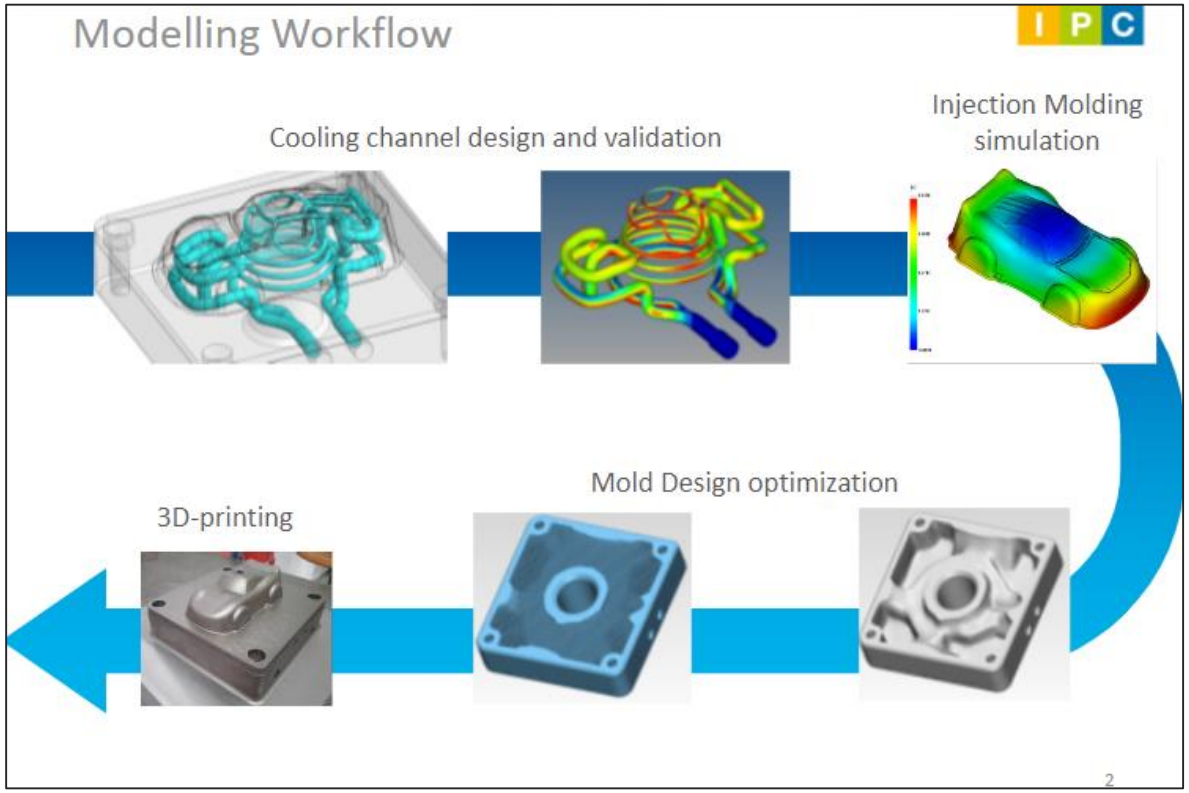
1. Improving the **life cycle of composites** from design to end-of-life
2. Enhance the technical, functional and environmental **performance of composites**
3. Deploy **plastronics** in an innovative and **responsible way**
4. Give **new properties and functionalities** to the surfaces and volumes of plastic object

Overview of opportunities along the value chain

Product design	Generative design tools + AI (lessons-learnt)
Materials and parts	GenAI for materials, Optimisation algorithms for mould design and cooling
Production process design	AI (not Gen) for material rerouting and shopfloor optimisation
Process monitoring and quality control	GenAI for simulation data and transfer learning + human feedback loops
Product lifecycle monitoring (including R strategies	GenAI for impact modeling and LCA gaps

Example 1: Gen AI for design optimisation

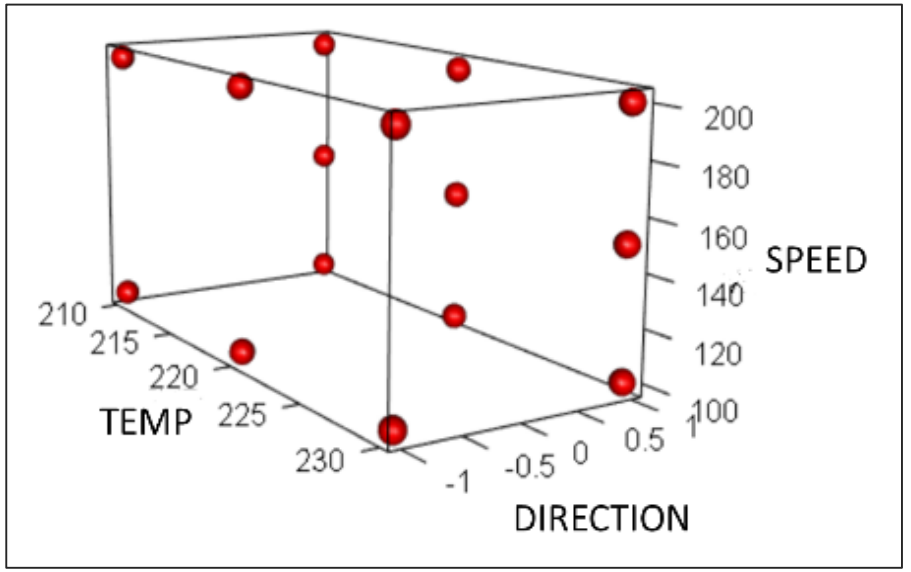
- Goal: use algorithms to optimize cool flow tubes around a mold
- Generate options based on simulation data and practical experience
- Test virtually and optimize flow rates depending on several parameters (temp, visc, geometry etc).



Example 2: transfer learning for injection moulding

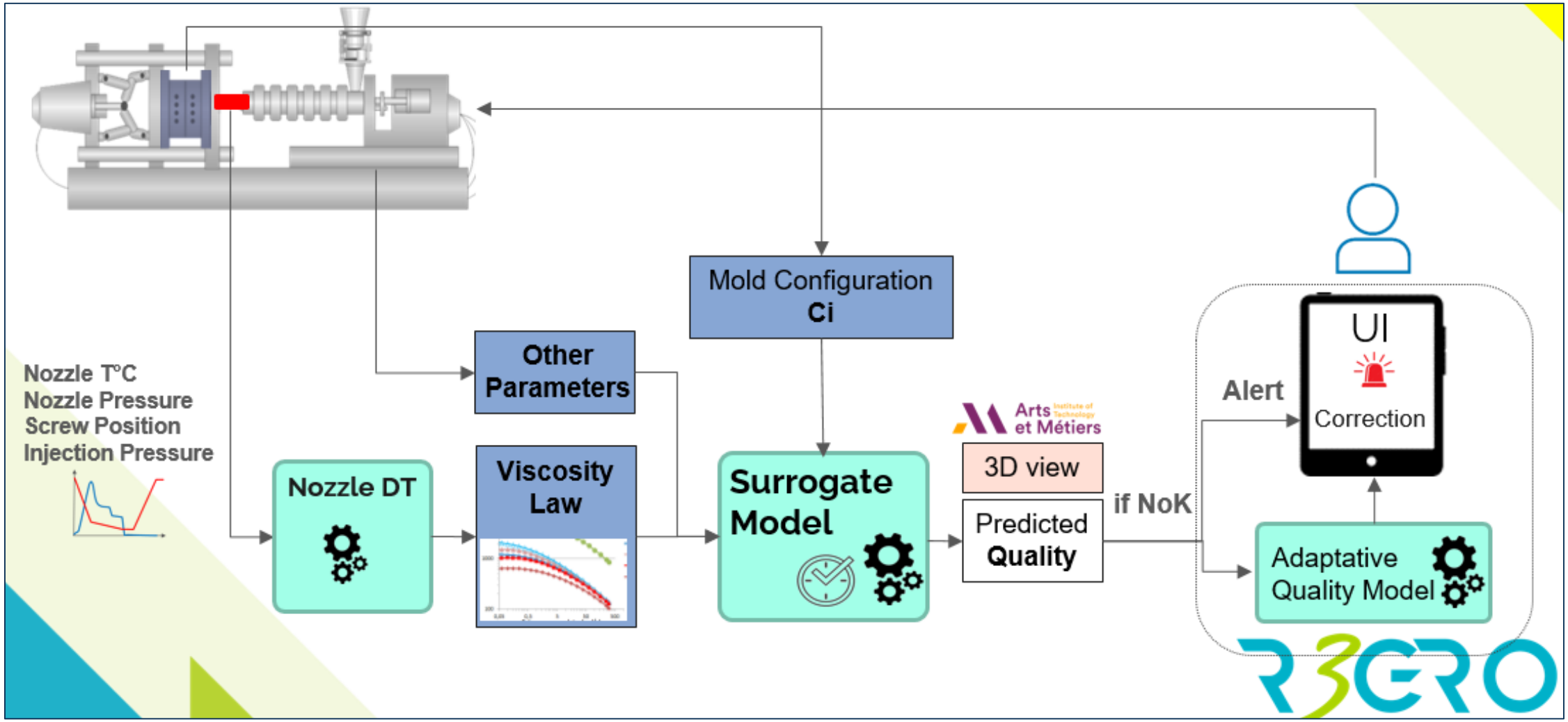
- Goal: optimize quality prediction and 'recipe' changes for process control
- Based on new sensors (IoT) and existing data on viscocity, temp and others (database IPC, moldflow) develop and train predictive model
- Digital DoE - generate data to optimize via NNs

Putting in place multiple DoEs



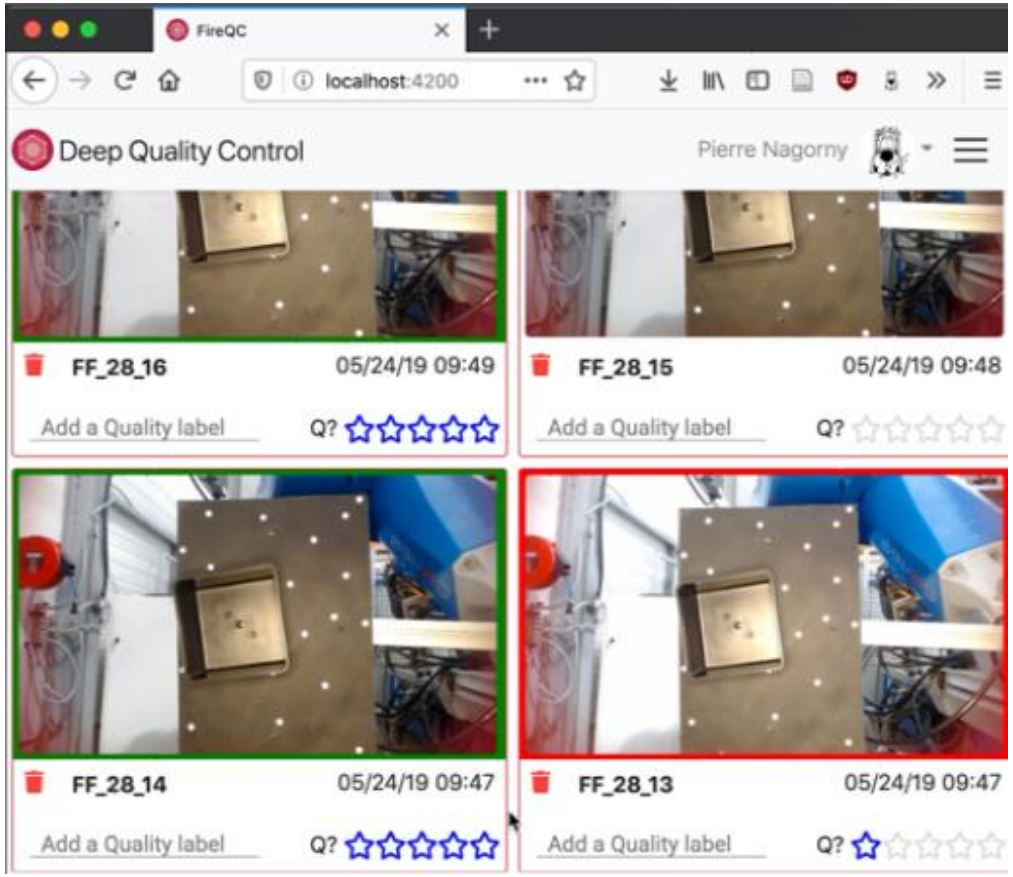
3 variables :
- Temperature
- Rotation speeds of the injection screw
- Material mix

2 states :
- static
- dynamic

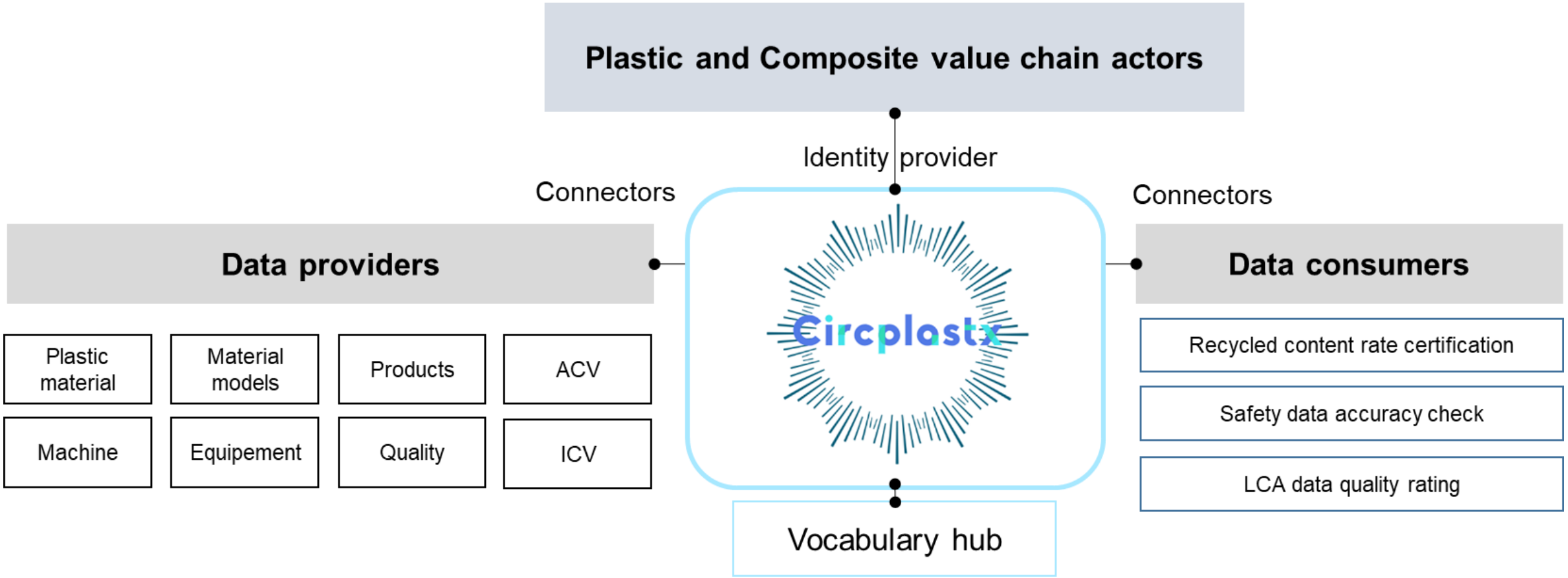

Nozzle T°C
Nozzle Pressure
Screw Position
Injection Pressure
Other Parameters
Mold Configuration
Ci
Nozzle DT
Viscosity Law
Surrogate Model
Arts et Métiers
3D view
Predicted Quality
if NoK
UI
Alert
Correction
Adaptative Quality Model
R3GRO

Example 3: human in the loop

- Goal: improving quality inspection through human feedback
- GAN to generate thermal images
- Source of real thermal images
- Scoring of outcomes on quality inspection by algorithm – second layer of learning by humans in the loop
- Thesis project hosted at IPC
- Work continues in R3group project



No AI without data...



Limitations, Challenges and Outlook

Limitations & Challenges

- Lack of data (but we have a data space for that!)
- Machine data still hard to work with (data act implementation?)
- No AI without understanding of the field (and hypotheses)
- Optimisation yes, discovery still low TRL

Outlook

- Building high quality datasets
- DoEs for transfer learning
- LLM based process instructor
- Connection to actuators and closed loop production (difficult in some areas such as IM)