AI·PROFICIENT

Artificial *in*telligence
for improved *pro*duction eff*ici*ency,
quality and mai*nt*enance

AI-PROFICIENT (Horizon 2020)

EFFRA event, The Manufacturing Partnership Day

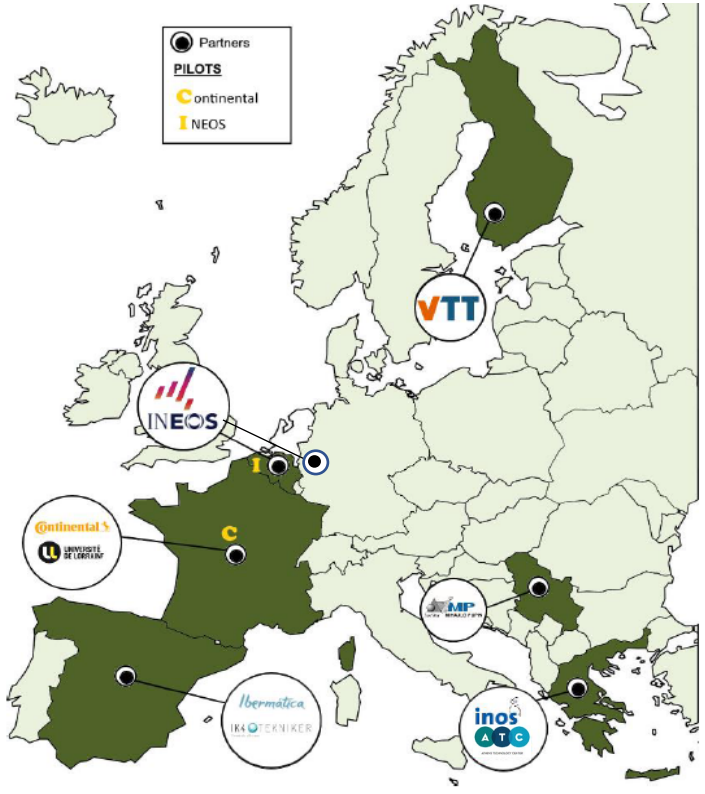
2023, September 26th, Brussels, Belgium

George Triantafyllou (Athens Technology Center)

This product is part of a project that has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 957391.

About us … AI-PROFICIENT Identity

- **A**rtificial **I**ntelligence for improved **PRO**duction ef**FICI**ency, quality and mai**NT**enance



BUDGET: 5,47 M€
DURATION: 3 YEARS (STARTED 1ST NOVEMBER 2020)
PILOT SITES: 3 (TYRE MANUFACTURING; POLYETHYLENE/POLYPROPYLENE)
MAN/MONTH: 718
TRL: 3 – 7
P.O: ELENA ANGIOLINI

1 UNIVERSITY (UL- COORDINATOR) – 3 RESEARCH CENTRES

UNIVERSITÉ DE LORRAINE
CRAN
Loria
VTT
Tekniker
MEMBER OF BASQUE RESEARCH & TECHNOLOGY ALLIANCE
institut MIHAJLO PUPIN

6 INDUSTRIAL COMPANIES (2 END-USERS; 2 LARGE ENTERPRISE – 2 SMES)

Continental
INEOS
Ibermática
inos
TENFORCE
ATC
ATHENS TECHNOLOGY CENTER

Project Objectives – Technology outline

Project Outline – Objectives

Technology outline

- Integrate
  - Advanced AI technologies
  - Manufacturing needs/technologies
- Aims at
  - Investigating disruptive technological solutions
  - AI for the implementation of optimized strategies
- Goal
  - Improve production planning / execution
  - Enhance efficiency, quality and maintenance
  - Facilitate the collaboration between humans and machines

Project Outline – Objectives

Technology complemented by Ethics

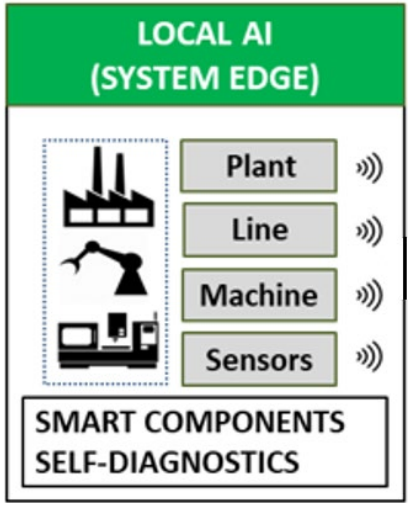
- Ethics by design
  - Human at the center of the implementation
  - Consider ethical aspects
  - Relation to operational actors
  - Ethics at the center of the service design

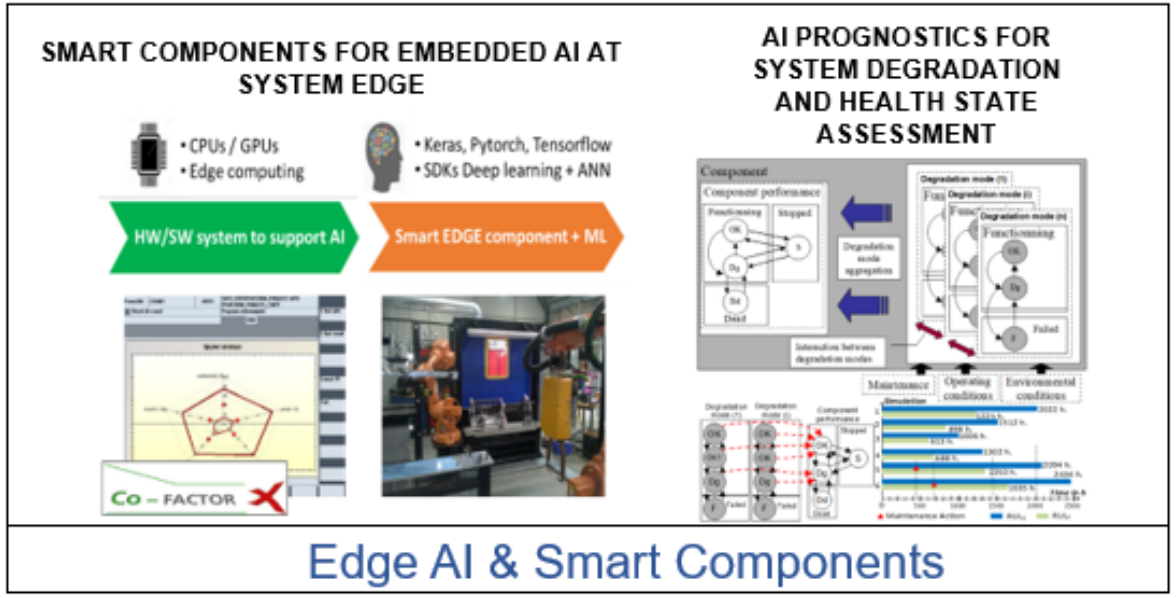
Enabler Technologies

System-Edge Services

- IIoT installation

- Smart components for embedded AI at system edge and also AI detection

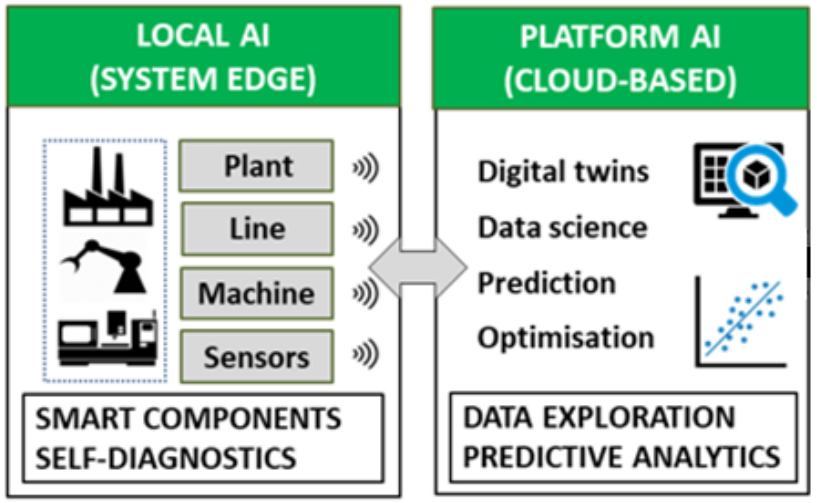


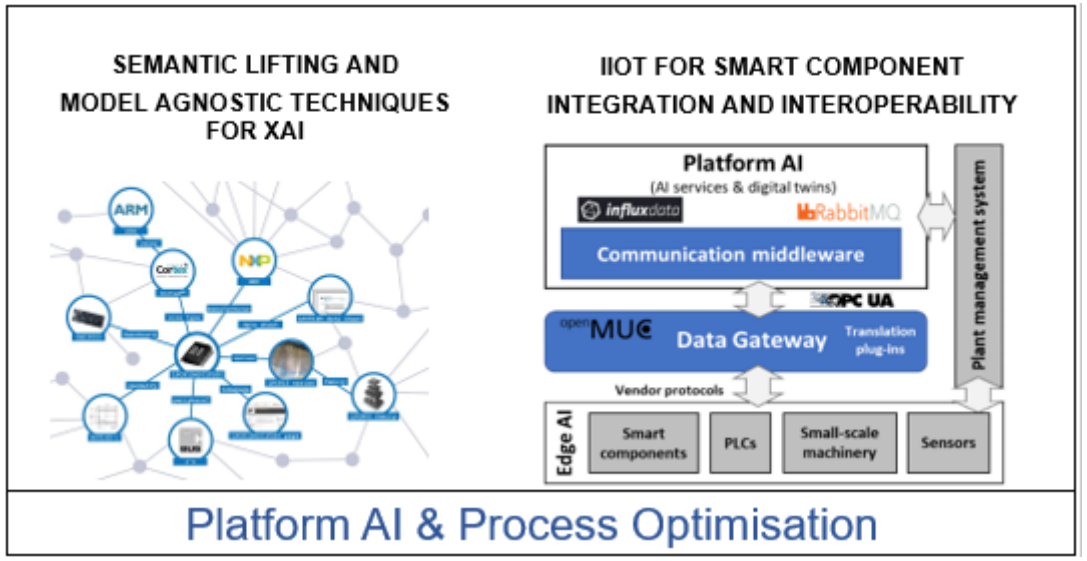


Enabler Technologies

AI Collective Services

- Platform-based tool operation
- Process Optimization / Quality Assurance



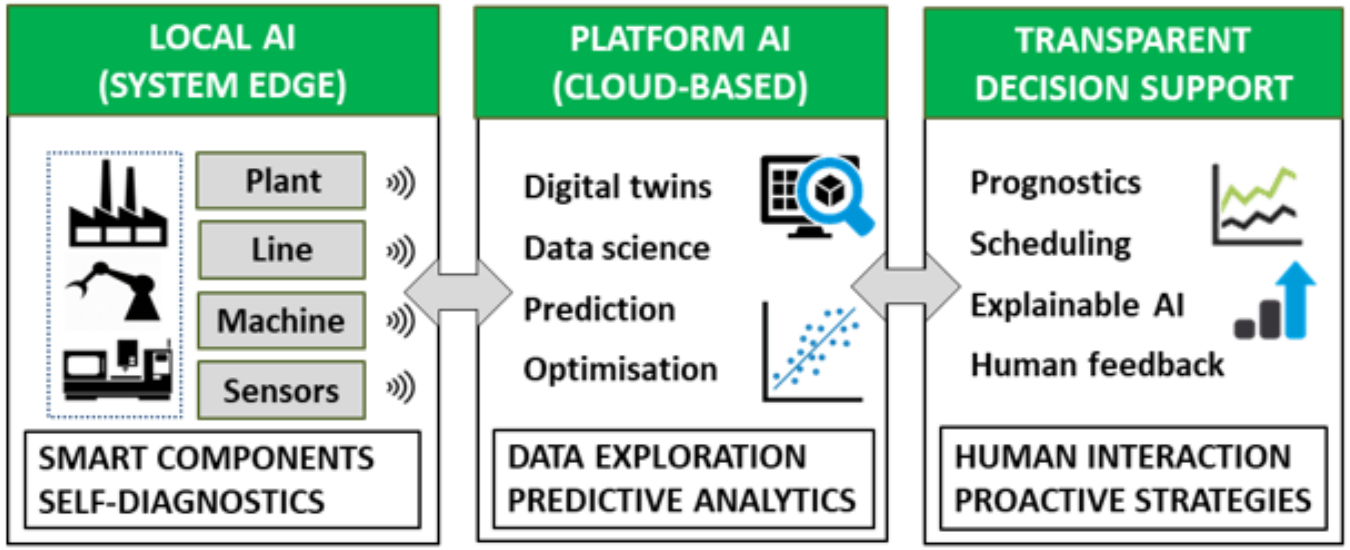


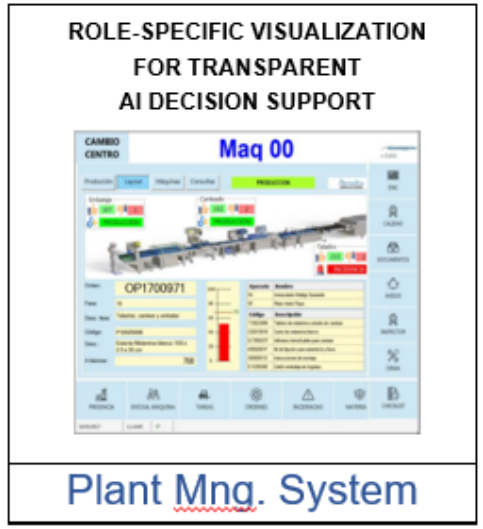
Enabler Technologies

Integrated Services

- AI-enabled Decision Support System

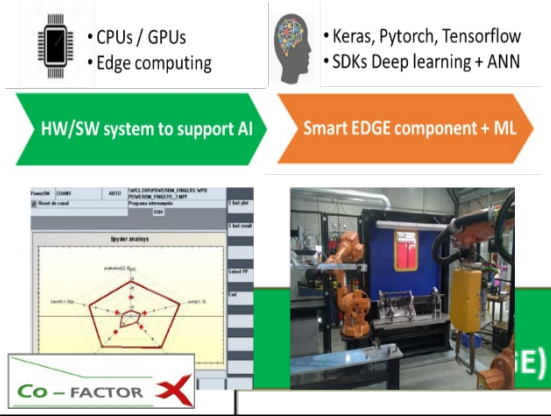
- Comprehensive HMI Interface



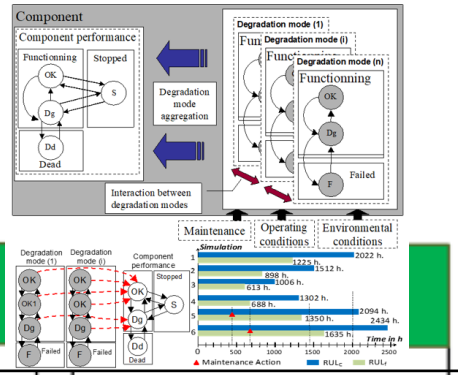


System Components and Architecture

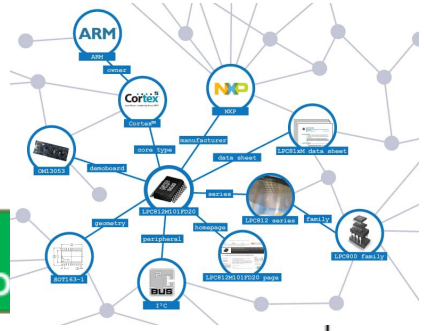
SMART COMPONENTS FOR EMBEDDED AI AT SYSTEM EDGE



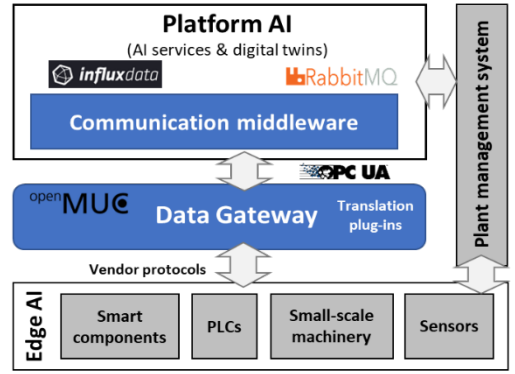
AI PROGNOSTICS FOR SYSTEM DEGRADATION AND HEALTH STATE ASSESSMENT



SEMANTIC LIFTING AND MODEL AGNOSTIC TECHNIQUES FOR XAI



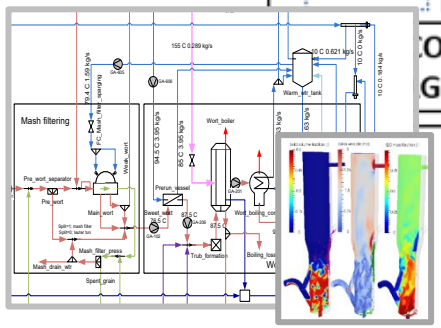
IIOT FOR SMART COMPONENT INTEGRATION AND INTEROPERABILITY



Edge AI & Smart Components

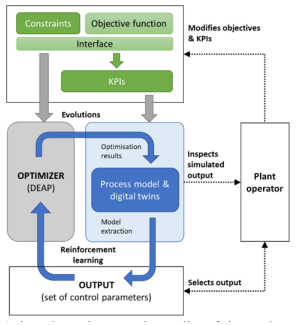
System integration & HMI Interfacing

HYBRID DIGITAL TWINS AND PROCESS MODELLING



AI ENABLED DECISION-MAKING FOR QUALITY ASSURANCE

GENERATIVE OPTIMISATION OF PRODUCTION PROCESSES (HUMAN IN THE LOOP)



ROLE-SPECIFIC VISUALIZATION FOR TRANSPARENT AI DECISION SUPPORT

Process Modelling & DT

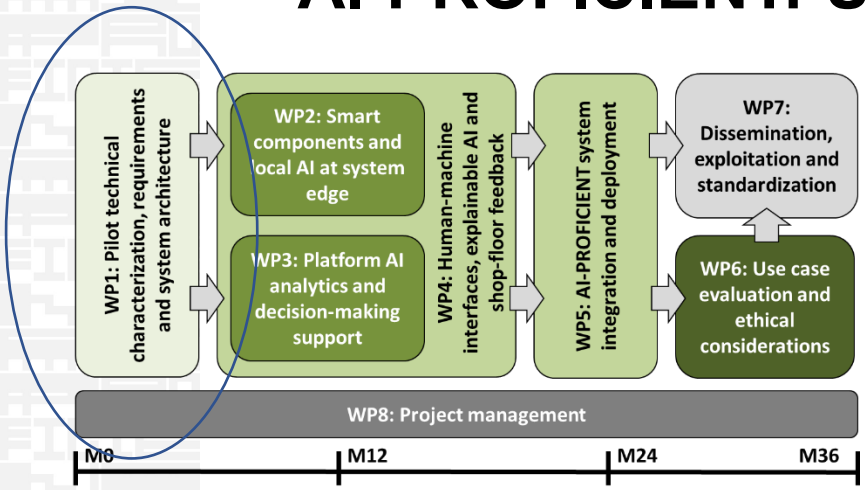
Platform AI & Process Optimisation

Plant Mng. System

Ethics by Design

Consortium Achievements

AI-PROFICIENT: UseCases (cross fertilisation between WPs)

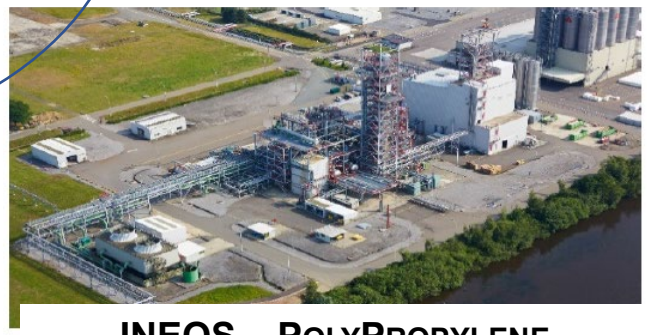


DEFINITION OF 13 USECASES
-
8 SELECTED TO UNDERLINE SCENARIOS WHERE AI CAN IMPROVE OPERATION

PRODUCTION
EFFICIENCY
QUALITY
MAINTENANCE

INEOS

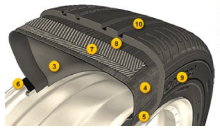
INEOS - POLYETHYLENE, COLOGNE - GERMANY



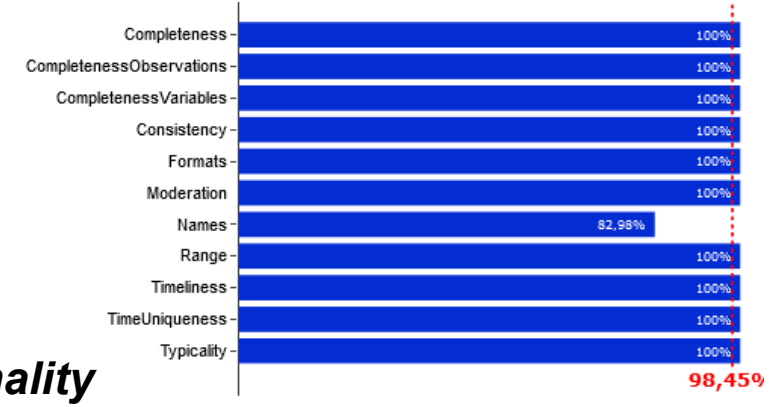
INEOS – POLYPROPYLENE GEEL - BELGIUM

Continental

TYRE MANUFACTURING SARREGUEMINES - FRANCE



CONTI-2, TEKNIKER

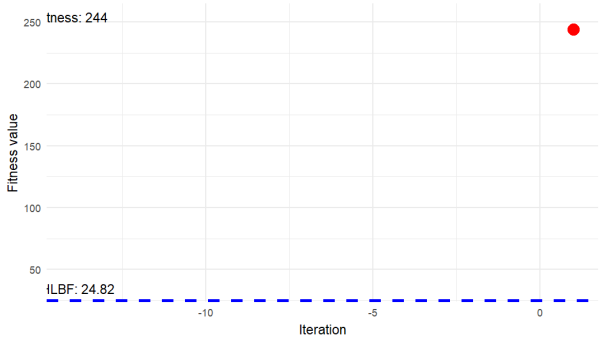


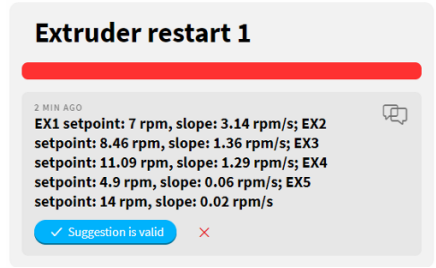
Modules

- Data Quality analysis module – ***GO-QData***
- Process anomaly detection – ***GOQ-QNormality***
- Dialogued Natural Human-Computer Interaction
- Semantic accountability Tool - ***FIDES***

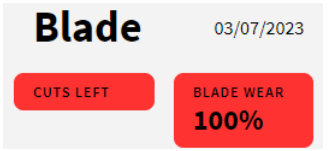
Use Case related results

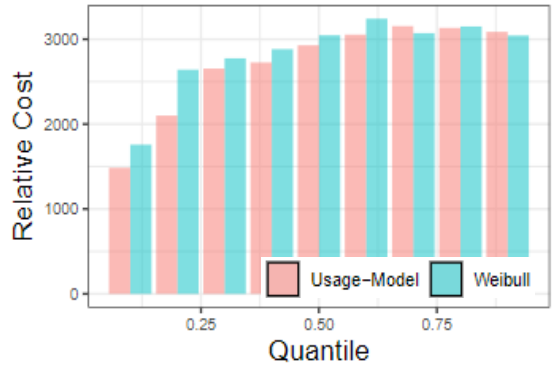
- ***Surrogate model-based extrusion optimization engine***
  - *Virtually mimics the operation of the extruder*
  - *Detects extruder readiness and notifies operator*
  - *Provides operator the optimal speed setpoints*
  - *Integrates operator feedback*



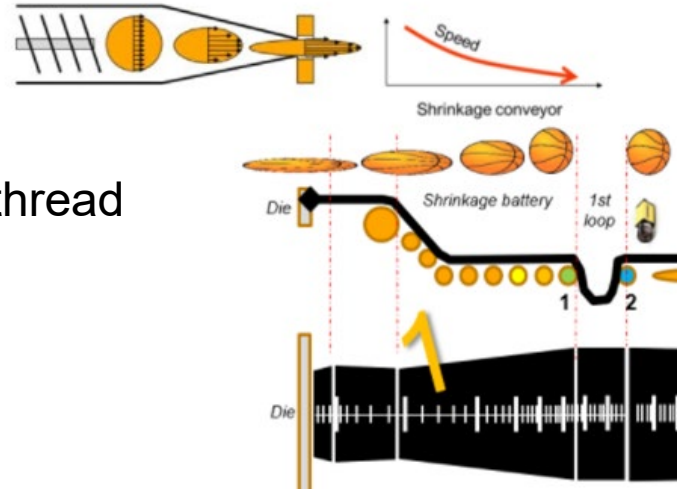


- ***Blade wear assessment system***
  - *Estimates current and prospect blade wear for the operator*
  - *Integrates operator feedback*
  - *Simulates potential impact of blade replacement schedule change*

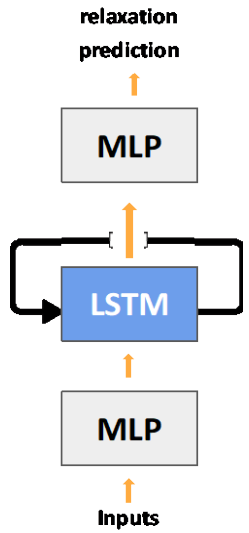


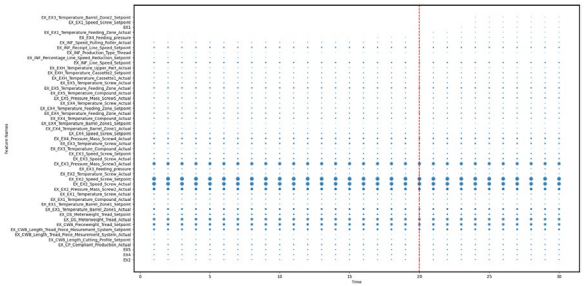


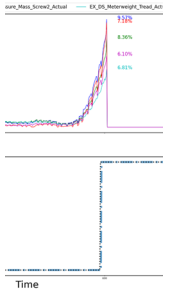
CONTI-3, UL: Released extrusion optimisation



- **Problem :**
  - Thread extrusion may lead to have mechanical constrains in the thread
  - These constrains lead to downstream processes failure.
- **Continental expectations:**
  - AI must alarm operators in advance if the hot area isn't relaxed
  - AI must provide which parameters impact the relaxation level
- **Proposed AI-model:**
  - Prediction of the time before non-relaxed product : Deep Learning model based on MLP-LSTM-MLP architecture
  - Analysis of the contributors to the non-relaxed product with Integrated gradient method

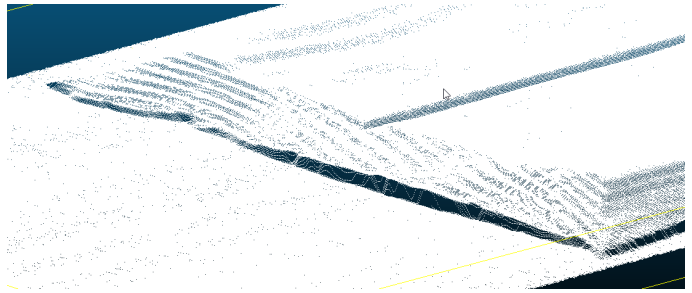




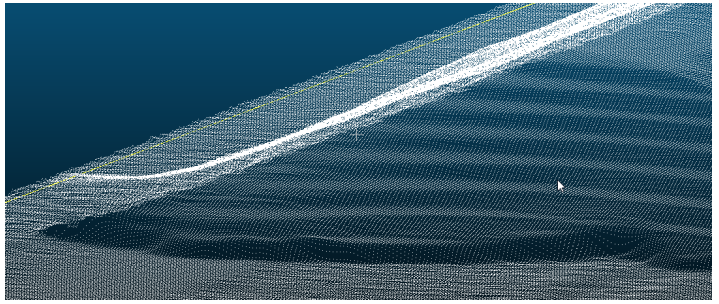


CONTI-5, INOS: Vision based tread cut quality detection

- **Problem :**
  - The primary method used to detect cutting blade wear in the tire tread cutting station are current measurements on the cutting motor. A secondary method was envisioned to use AI to identify cut quality degradation using laser scans of the tread cut.

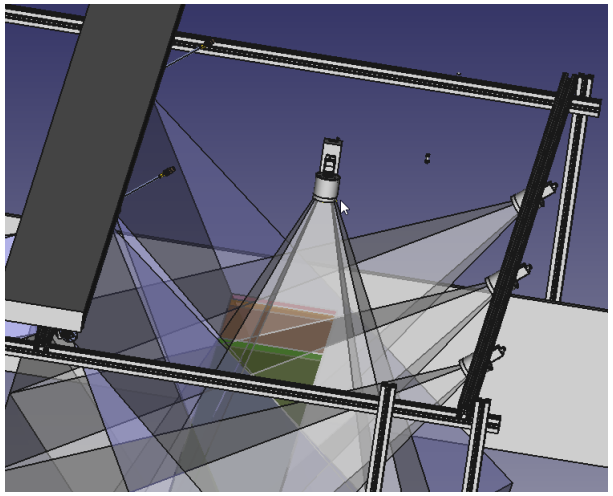


- **Continental expectations:**
  - AI must provide feedback to the primary blade wear detection model



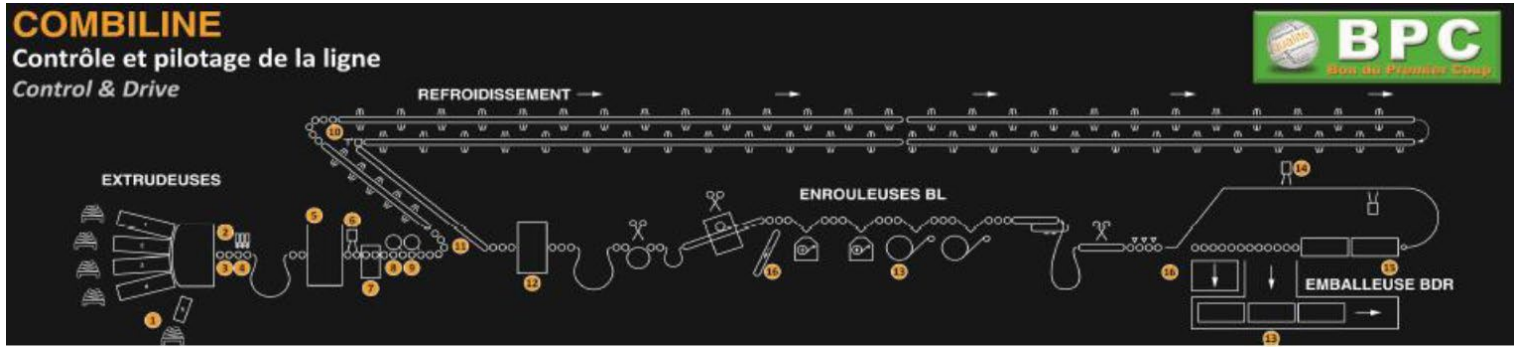
- **Proposed Solution and AI-model:**
  - A laser triangulation based scanned would be used to obtain a 3D image of the tread cut.
  - A convolutional DNN would detect bad cuts even though the material is flexible and there is variation in the shape detected
  - We obtained laboratory detection results but have not integrated in factory

CONTI-7, INOS: Transfer belt wear identification

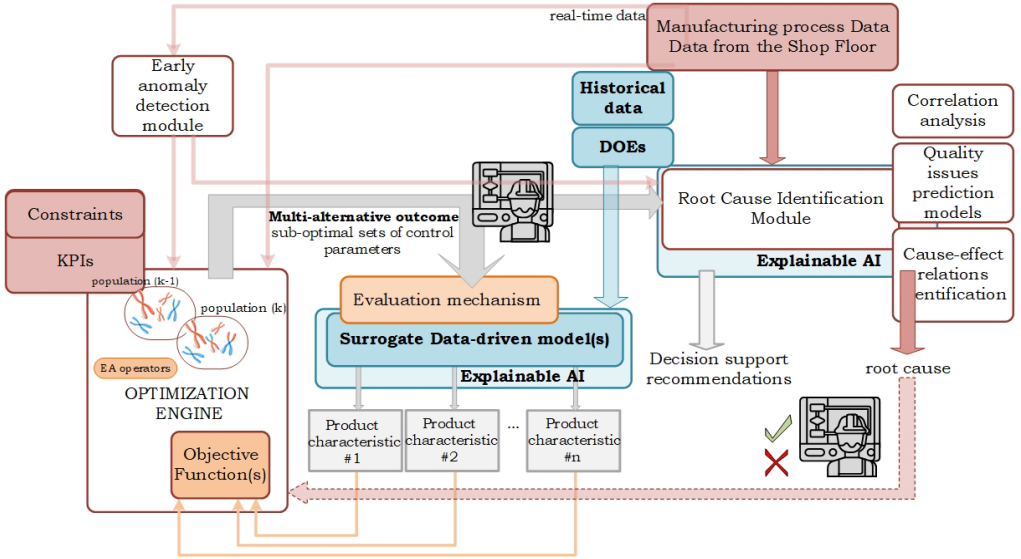


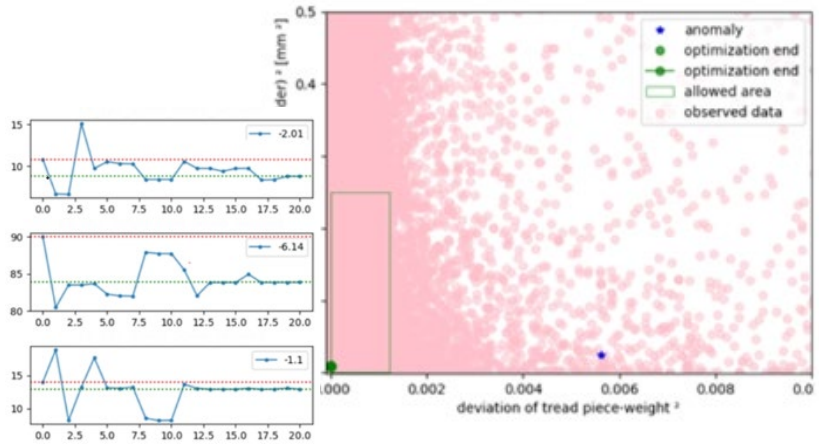
- **Problem :**
  - Partially overlapping transfer belts move tire treads from a feeder roller belt to a packing station. When the belts are worn, tire treads are incorrectly positioned on a transfer trolley.
- **Continental expectations:**
  - AI must alarm operators when the tread position tendency is ready to move out of tolerance
  - AI must identify which bets are worn
- **Proposed Solution and AI-model:**
  - A camera and controlled shadow generation vision system installed above the belt mechanism detects the tread positions
  - Prediction of the tire tread position and orientation drift.
  - Detection of the belt responsible for the drift
  - Small convolutional DNN running at the edge can be used to locally detect operational degradation

CONTI-10, IMP: Thread production



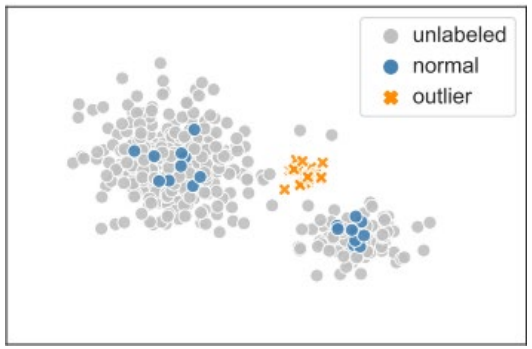
- Focus on the line for thread production in the Continental factory
- The main goals of this use case were:
  - the development of a quality analysis tool for the improvement of final product quality characteristics
  - automation of the process of investigating the causes of quality deviations and providing proactive suggestions for preventing degradation
- Recommendation system:
  - **Generative holistic optimization (GHO)** - (close to) real-time optimization of current process set up with the aim of preventing degradation or restoring product quality
  - **Surrogate data-driven module (SDDM)** - (early) anomaly detection module for estimating expected degradation or detecting the existing one in (close to) real-time environment

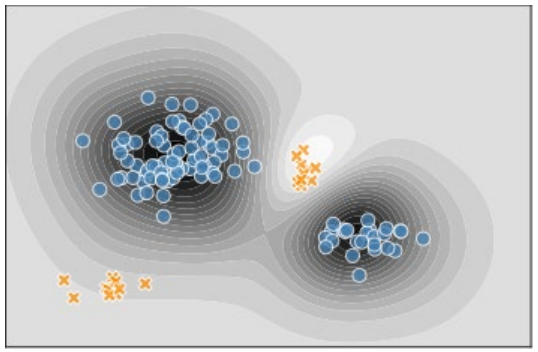


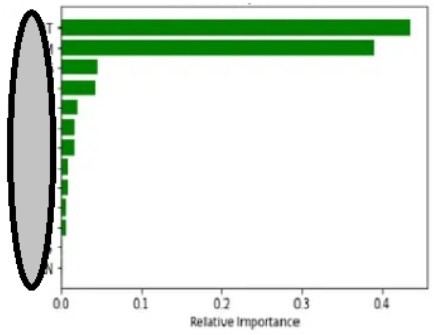


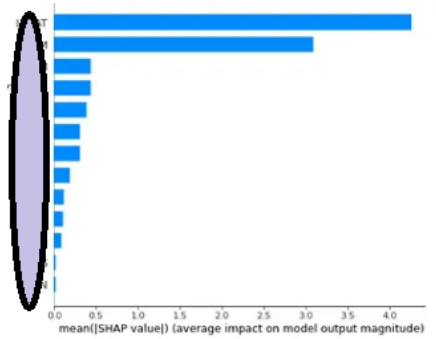
CONTI-10, ATC: SPAA tool

- Speech-to-text module
- Optical Character Recognition module
- Short-term Post-hock Anomaly Detection tool
  - Anomaly Detection – Deep Semi-supervised Anomaly Detection (Deep SAD)
  - Root-cause Analysis – Shapley Additive Explanations (SHAP)
  - Reinforcement Learning (RL by human feedback)



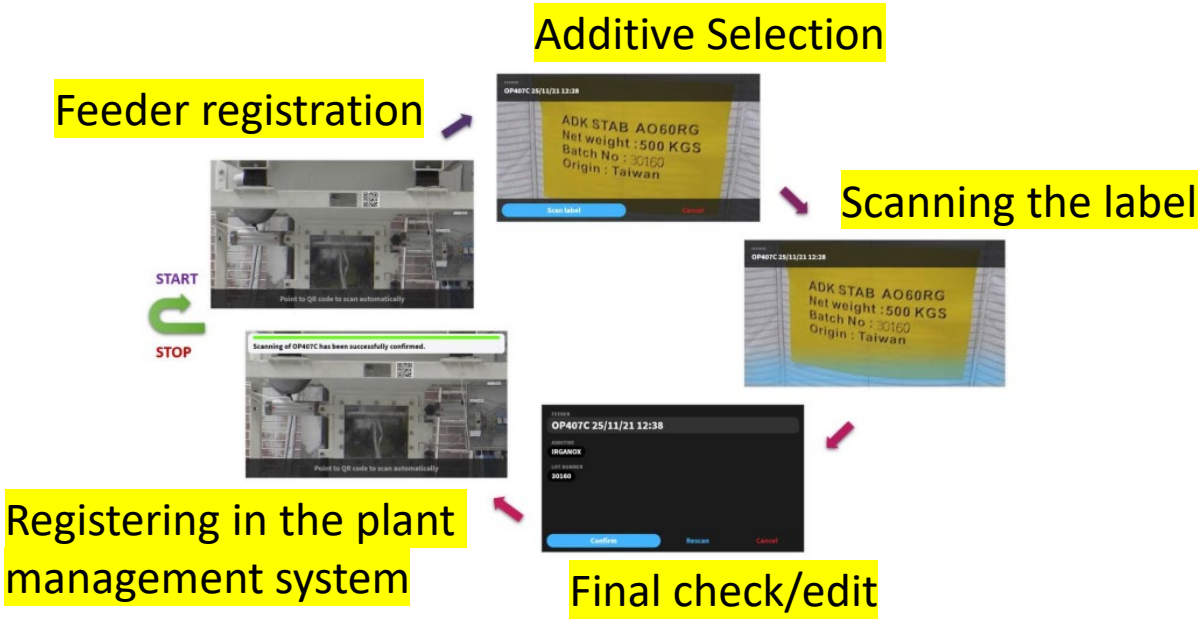


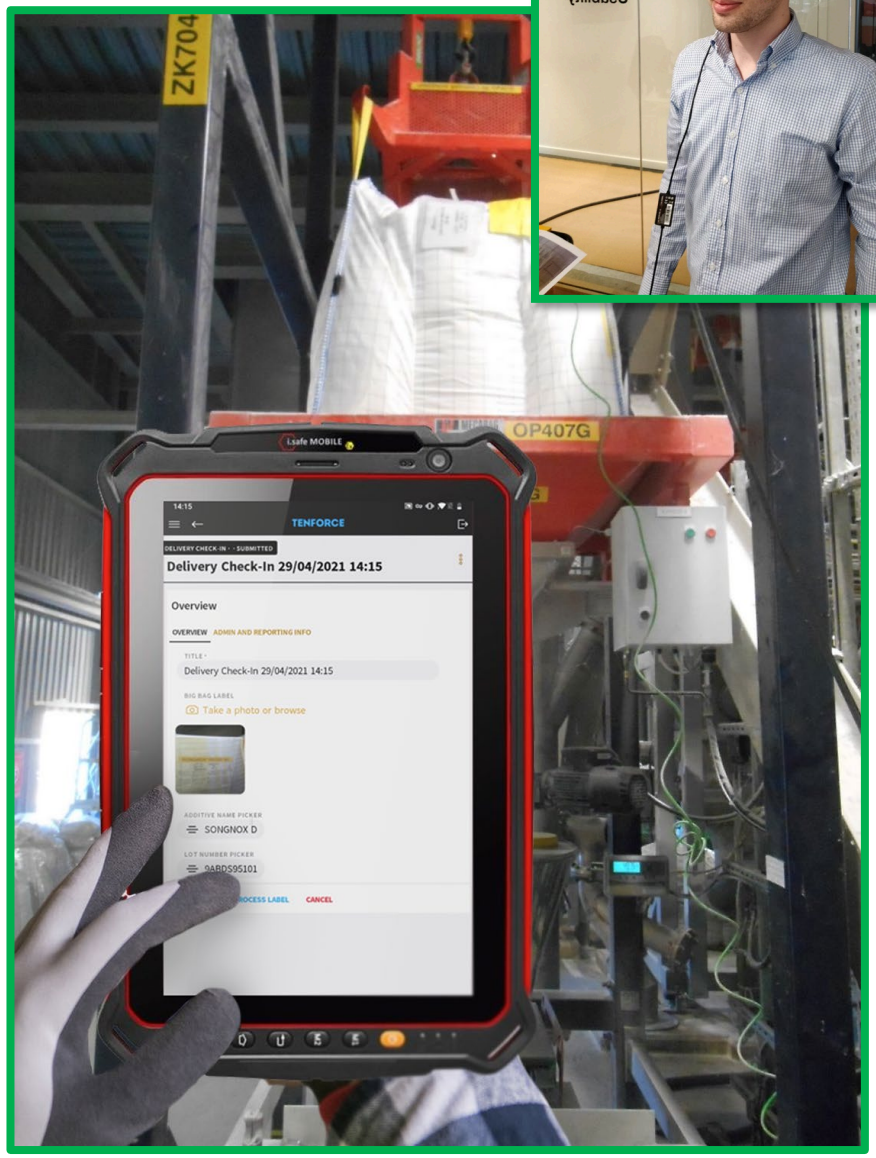




INEOS-2, TF: Connected Worker – Using AI-ML and Extended Reality Interfaces on Factory Floor

- Process Visibility and Control
- Distributed Workforce supported by AI
- Mobile and Wearable implementation
- Stock and Assets Monitoring





Expected Project Outcomes & Achievements

Innovations and achievements

- Integration in the same IIoT environment of
  - Advanced AI technologies
  - Production process
- AI to achieve
  - Early detection of process anomalies
  - Provision of fault diagnostics
  - Decision support to operators
  - Proactive maintenance: component / system level
- Demonstrators as case studies and early adopters
- Joint human-machine approach to improve production planning and execution
- Ethical and legal aspects recommendation for effective human-machine collaboration

AI-based expected improvements

- Optimization of machine control setting and set-up of product parameters
  - Reduction of production failures due to system breakage/disturbance
  - Minimizing low quality products due to system degradation
- Improved model operation due to data drift identification
  - Operator-on-the-loop
  - Increase product quality
- Intelligent image recognition → Optimize use of raw materials
- AI-based operations will achieve increased raw material conversion

Key exploitable results

- Smart data handling
- Human-machine interface (the connected worker)
- Data quality analysis module
- Machine vision analysis
- AI for machinery diagnostics
- Data-driven predictive AI analytics for prognostics based on DL
- Data-driven predictive AI analytics for maintenance Strategy optimization
- Dialogued Natural Human-Computer Interaction
- Process anomaly detection
- Multi-objective optimizer
- Process models and digital twins (assets and processes)
- Semantic Accountability Tool

Project unique points, innovations, moving EU industry forward

Unique points

- Human centered approach
  - Anthropocentric approach instead of technology-centered
  - Ethics by design in central project position – not a constraint
- AI-based technological solutions considering:
  - Particularities of the application field (manufacturing)
  - Data scarcity
  - Data uncertainty
  - Representativeness
  - Manufacturing systems dynamics

Unique points

- AI solutions with advanced properties
  - Different abstraction levels (Edge, Flog, Cloud, Decision)
  - Anticipation
  - Proactivity
  - Overall performance
- AI solutions tested in
  - Operating environment with real conditions
  - Enabling to measure industrial credibility/benefits
  - Scalability under severe conditions

Future plans, successes and difficulties

Gaps & Challenges

- **Integration of AI technologies:**
  - Enable plant level automated operation
  - Achieve decision making detached from the operator's experience
  - Support human interaction (operator) – integrate to service/UC pipelines
  - Establish AI as enabler for solution development
- **Data-driven predictive AI-analytics to develop maintenance Strategy**
- **Anomaly detection for:**
  - Early prevention of faulty Product characteristics
  - Early detection of process failure to minimize loss of raw material and avoid energy consumption
- **Real-time decision-making and advanced edge deployments**:
  - Addressing monitoring quality, meeting customer delivery dates, and more → Immediate decisions making
  - Streaming analytics and real-time prediction services → act immediately prevent undesirable consequences
  - Ability to deploy predictive models on the edge devices → critical to enable smart manufacturing applications

Gaps & Challenges

- **Data quality**:
  - Access to clean, meaningful, high-quality data
  - This can be a challenge in manufacturing
- **Correlation between Data and Physics**:
  - Descriptive and predictive correlations of data → design and operation of manufacturing systems
  - Laws of physics to be implicit in the data → sufficient to produce relationships and operating laws
- **Self-Capabilities**:
  - Incorporate artificial intelligence techniques → high level of autonomy → adaptability and resilience.
  - Applicable to Component, Machine and Production System levels → Self-Aware, Self-Predict, Self-Compare, Self-Maintain, Self-Organize
- **Sustainability instrumentation**:
  - Systematic deployment in manufacturing systems → collecting environmental data
  - To be encouraged → processing by artificial intelligence algorithms

Q & A Session

AI·PROFICIENT

Artificial intelligence
for improved production efficiency,
quality and maintenance

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UNIVERSITÉ DE LORRAINE

Continental
The Future in Motion

Tekniker
MEMBER OF BASQUE RESEARCH & TECHNOLOGY ALLIANCE

INEOS

TENFORCE

VTT

INOS

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institut MIHAJLO PUPIN

ATC
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Artificial *in*telligence
for improved *pro*duction eff*ici*ency,
quality and main*t*enance

Thank you for your attention

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Athens Technology Center

This product is part of a project that has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 957391.