UPTIME
UNIFIED PREDICTIVE MAINTENANCE

Towards a Unified Predictive Maintenance System - A Use Case in Cold Rolling Steel Straps

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Horizon 2020
European Union Funding
for Research & Innovation

Workshop on Predictive Maintenance

Philips, Drachten, NL, 24.01.19

Agenda

1. Introduction to the UPTIME Project
   - The UPTIME Approach
   - The UPTIME Solution
   - The UPTIME Components
   - Industrial Use Cases - Overview
2. Cold Rolling Steel Straps Business Case
   - Presentation of Maillis Group
   - Introduction to Steel Strap Production
   - Objectives of the Business Case
   - UPTIME Implementation Progress
3. Next Steps

General Information

- **Topic** FOF-09-2017

  Novel design and predictive maintenance technologies for increased operating life of product systems
- **Type** IA
- **Duration** 36 Months
- **Start** 01.09.2017
- **End** 31.08.2020
- **Total costs** € 6,248,367.50
- **Max grant** € 4,847,836.25

  (77.59% of total costs)
- **PO** Ivan Scannapiecoro

The UPTIME Approach

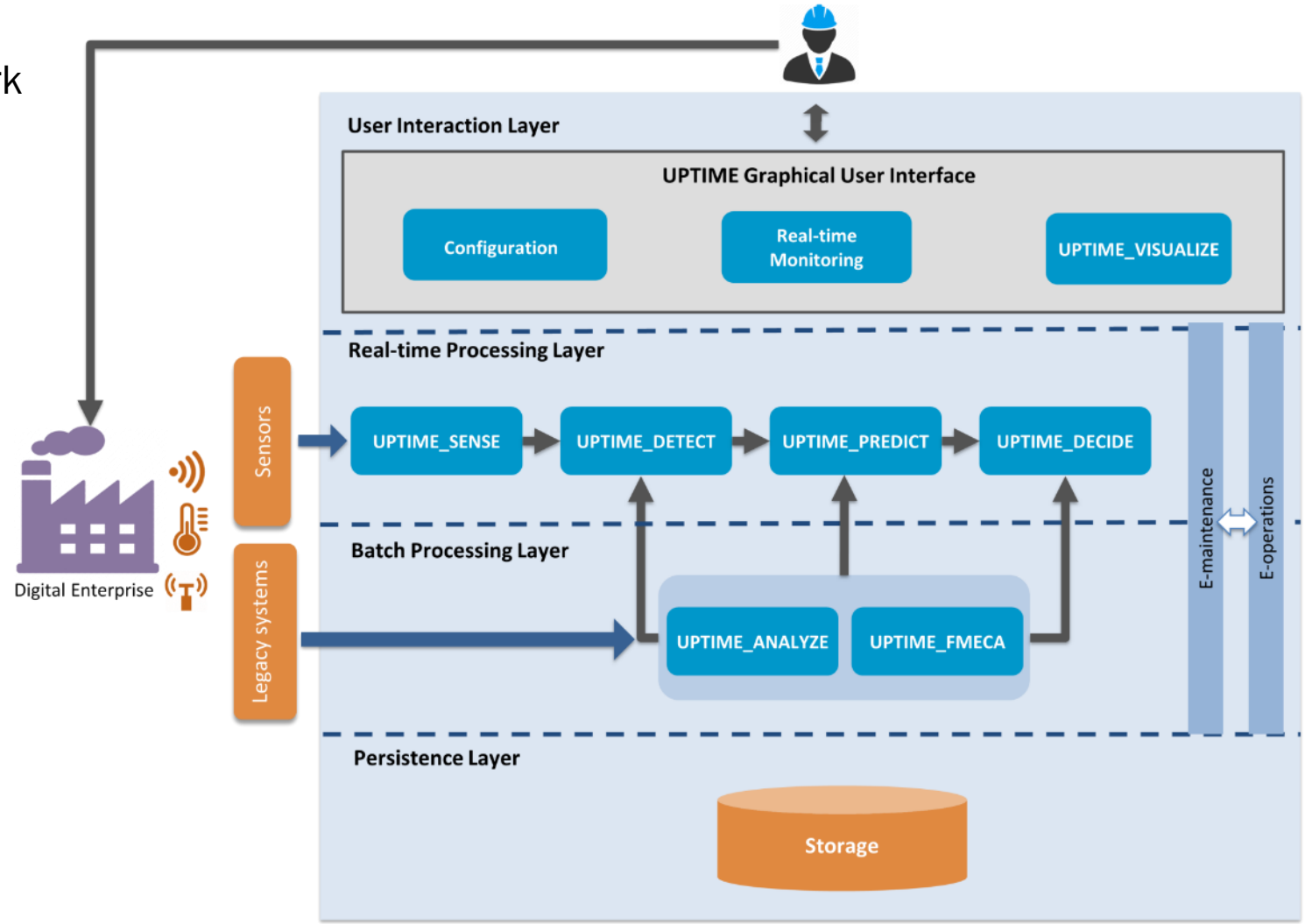
	Phase I	Phase II	Phase III	Phase IV	Phase V
Predictive Maintenance	Signal Processing	Diagnosis	Prognosis (Failure Mode Analysis)	Decision Making	
Proactive Computing		Detect	Predict	Decide	Act
Industrial Analytics Maturity	Monitor	Diagnose and Control	Manage	Optimise	
MIMOSA OSA-CBM (ISO 13374)	S1 - Data Acquistion S2 - Data Manipulation	S3 - State Detection S4 - Health Assessment	S5 - Prognosis Assessment	S6 - Advisory Generation	
UNIFIED PREDICTIVE MAINTENANCE CONCEPT	VISUALIZE				MAINTENANCE STAKEHOLDERS
	SENSE	DETECT	PREDICT	DECIDE	
	FMECA				
	ANALYZE				

- Definition of UPTIME unified predictive maintenance concept
  - ISO 13374 as implemented by MIMOSA OSA-CBM, RAMI4.0 for compliance with Industry 4.0 standards
  - Phases of predictive maintenance and proactive computing
  - Phases of industrial analytics maturity

The UPTIME Solution

- UPTIME_SENSE serves as a modular data acquisition and integration device framework
  [An extension of BIBA's USG]
- UPTIME_DETECT and UPTIME_PREDICT detect and predict the state of a system
  [An extension of BIBA's preInO]
- UPTIME_DECIDE proactively recommends maintenance actions and the plans
  [An extension of ICCS's PANDDA]
- UPTIME_VISUALISE aggregates data, analyses and visualizes it
  [An extension of Pumacy's SeaBAR]
- UPTIME_FMECA identifies failure modes, effects and criticalities based on the data
  [An extension of RINA's DRIFT]

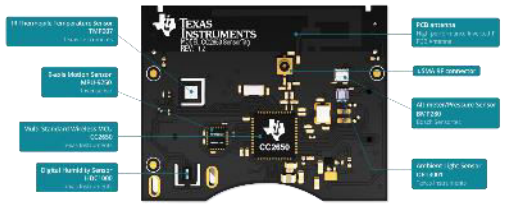
+ UPTIME_ANALYZE …
  [A new tool developed by Suite5]

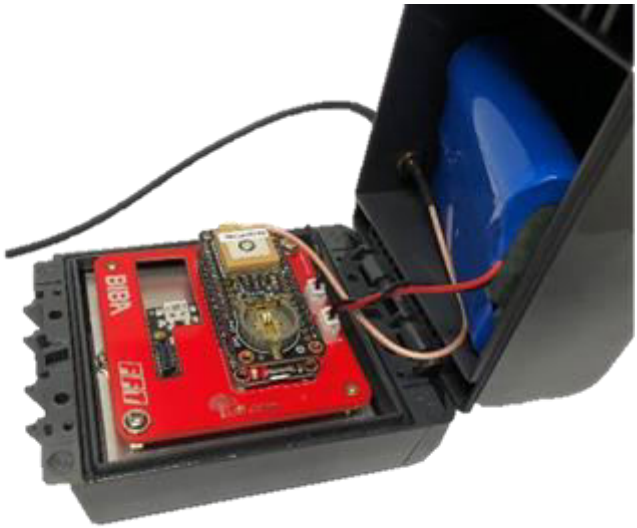


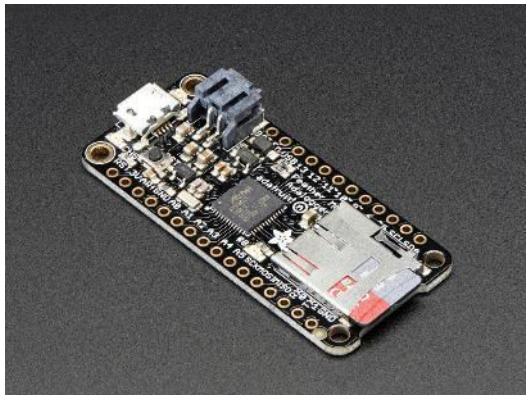
Simplified view of the UPTIME draft architecture

The UPTIME Components

- Prototype development platform for designing and testing dedicated hardware solution
- Used for test data acquisition in customer approval process
- Low-power solution required for flight approval
- Based on Texas Instruments SimpleLink CC2650 SensorTag
  - BLE (Bluetooth low energy)
  - Sensor Controller
  - Micro Controller
  - Environment & motion sensors
  - Adalogger M0 Feather
  - GPS Shield
  - SD Card storage





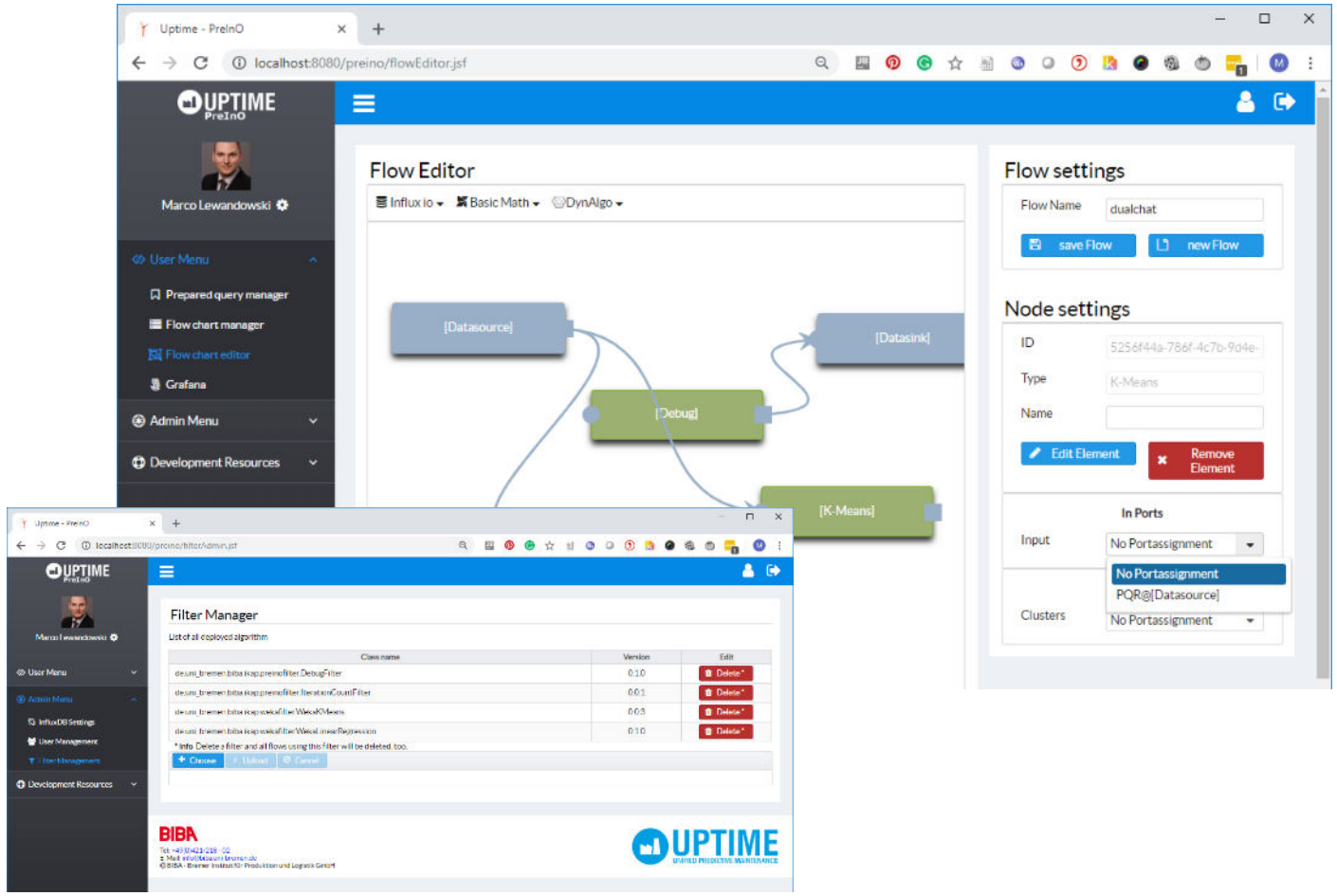


SENSE | DETECT/PREDICT | DECIDE | VISUALISE | FMECA | ANALYSE

The UPTIME Components

Flexible state detection and prediction engine:

- Graphical flow editor
  - Create custom flows
  - Save and load existing flows
- Extensible algorithm library
  - Plug-in system for algorithms
  - Definition of own algorithms
- Flexible trigger mechanisms
  - Automated recurring flow triggers
  - Event-based triggers
- Output & export analysis results
  - To influx database (UPTIME persistence module)
  - To other UPTIME modules (e.g. DECIDE)

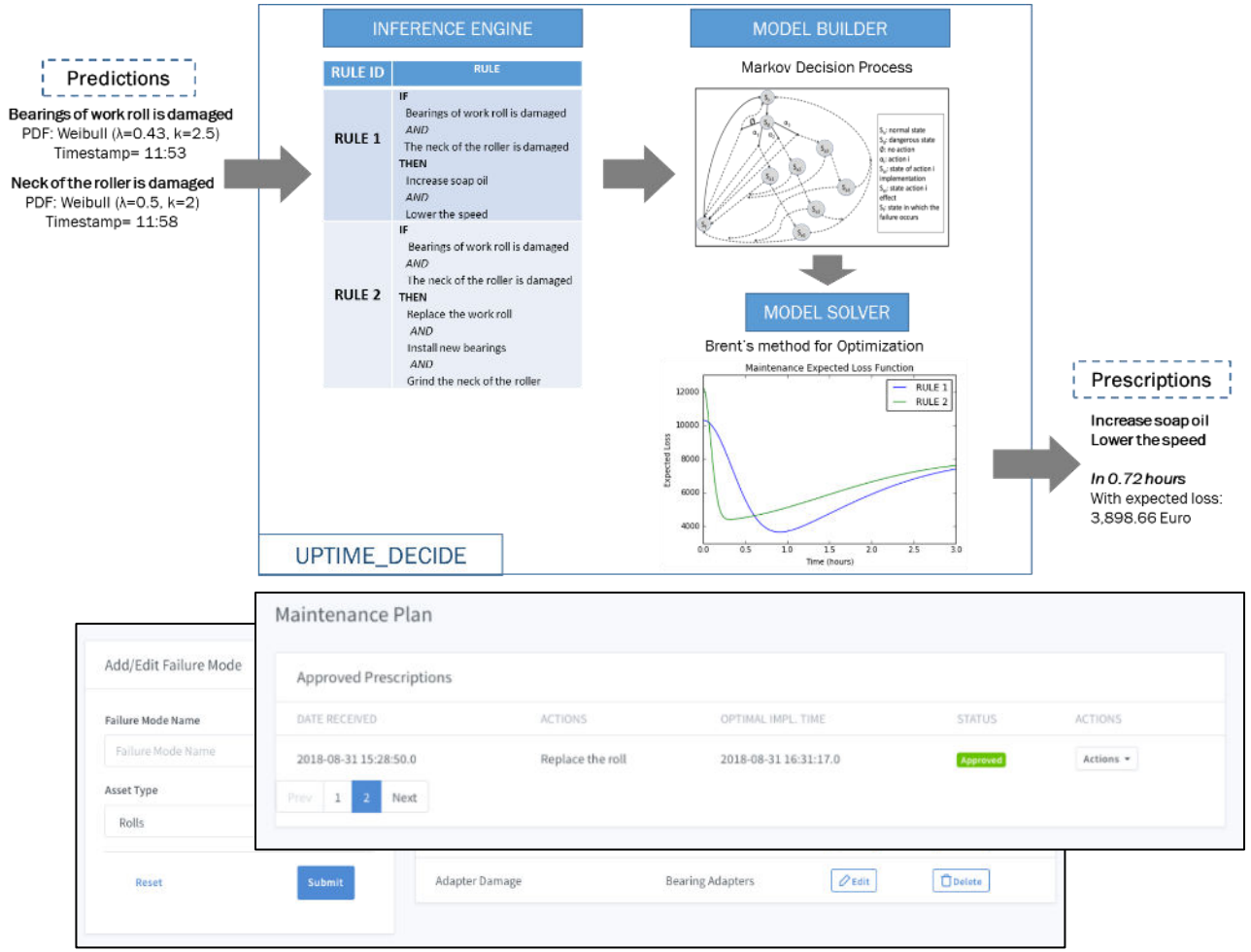


Flow Editor and Filter/Algorithm Management screens in UPTIME_DETECT/PREDICT (M9)

SENSE | DETECT/PREDICT | DECIDE | VISUALISE | FMECA | ANALYSE

The UPTIME Components

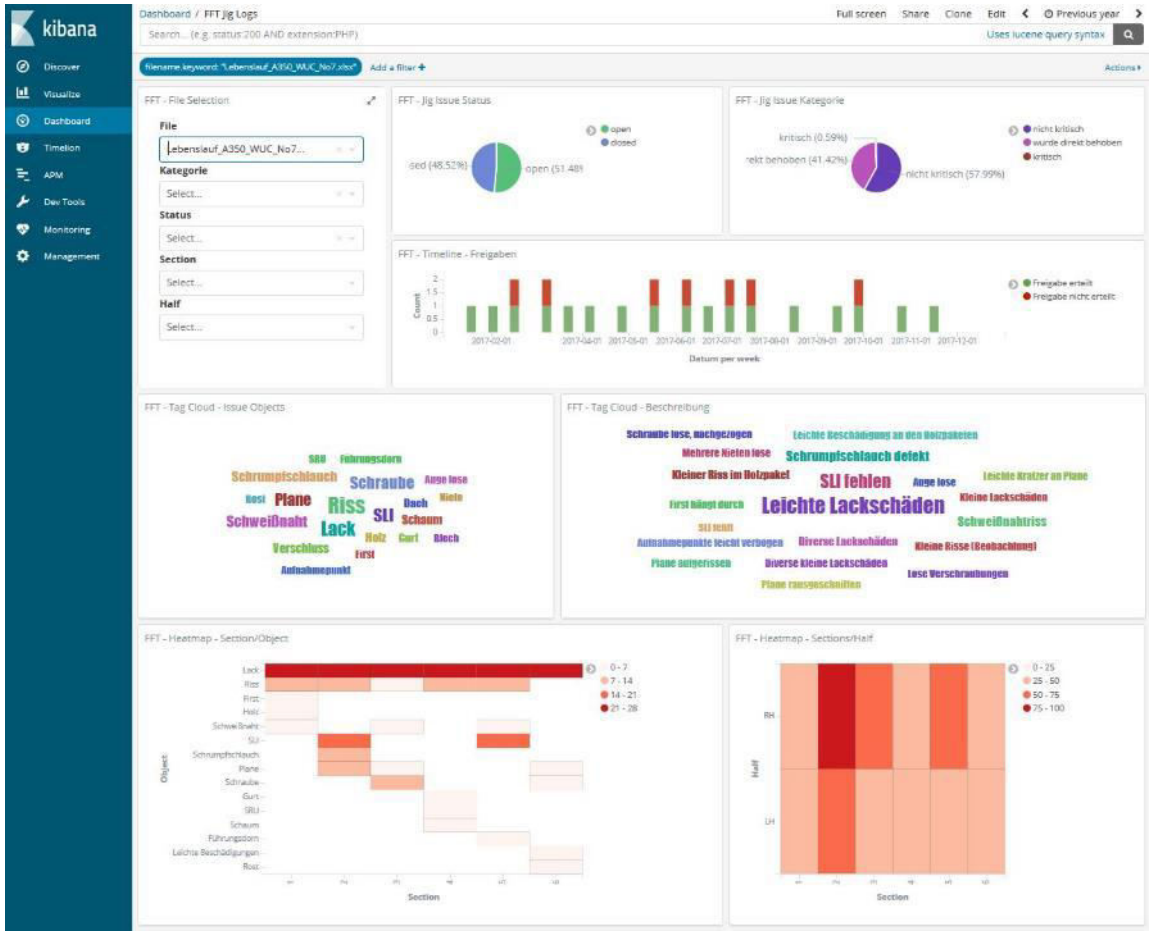
- DECIDE Prototype
  - Generates actionable maintenance recommendations
  - Incorporates predictive analytics output
  - Utilizes artificial intelligence, optimization algorithms and expert systems in a probabilistic context
  - Provides adaptive, automated, constrained, time-dependent and optimal decisions



Failure Modes, Rules and Maintenance Plan screens in UPTIME_DECIDE (M9)

The UPTIME Components

- UPTIME visualisation dashboard
  - One-stop-shop for all UPTIME visualisation needs
    - Integration of UPTIME UI widgets into one web-based dashboard
    - Single sign-in
    - Roles and rights management
  - Stakeholder-specific views
    - Deep visualisation and customisation options
    - Intuitive data analysis
  - Prototype visualisation of use case data test campaign
    - Limited amount of test campaign data

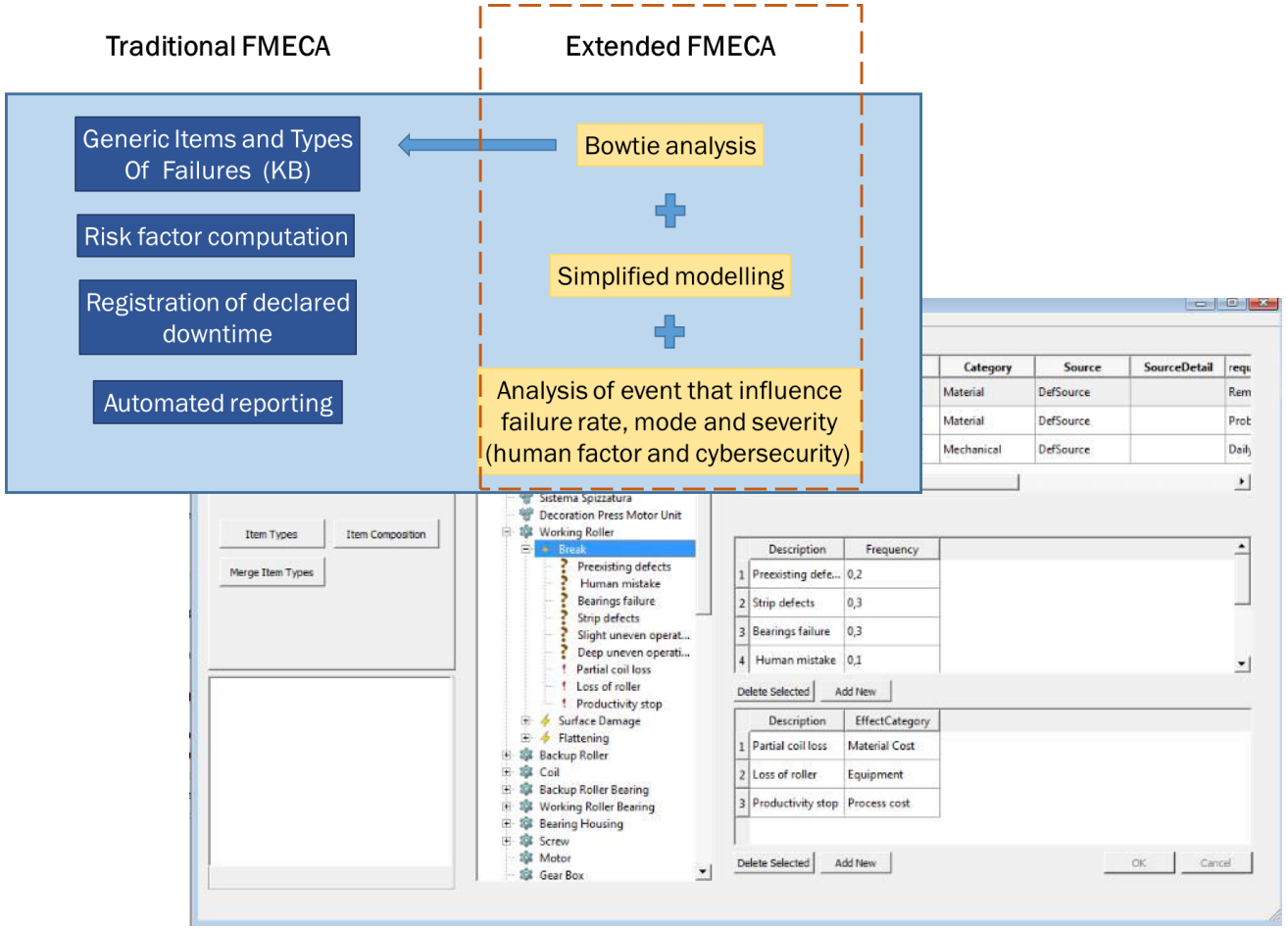


UPTIME_VISUALISE dashboard prototype (M9)

SENSE | DETECT/PREDICT | DECIDE | VISUALISE | FMECA | ANALYSE

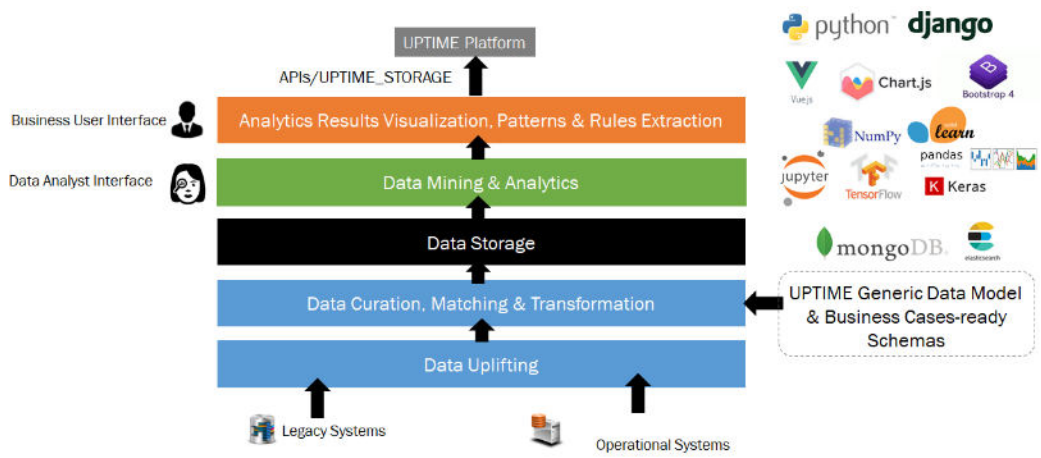
The UPTIME Components

- Dynamic risk monitoring based on bowtie analysis
- Prevention and mitigation measures consider
  - DETECT/PREDICT alerts and prognoses
  - DECIDE prevention measures
- Failure mode probability takes into account
  - Historical data analysis (ANALYSE)
  - DETECT/PREDICT prognoses
- Effect criticality considers
  - Maintenance reports from DECIDE
  - Analysis of historical data from ANALYSE

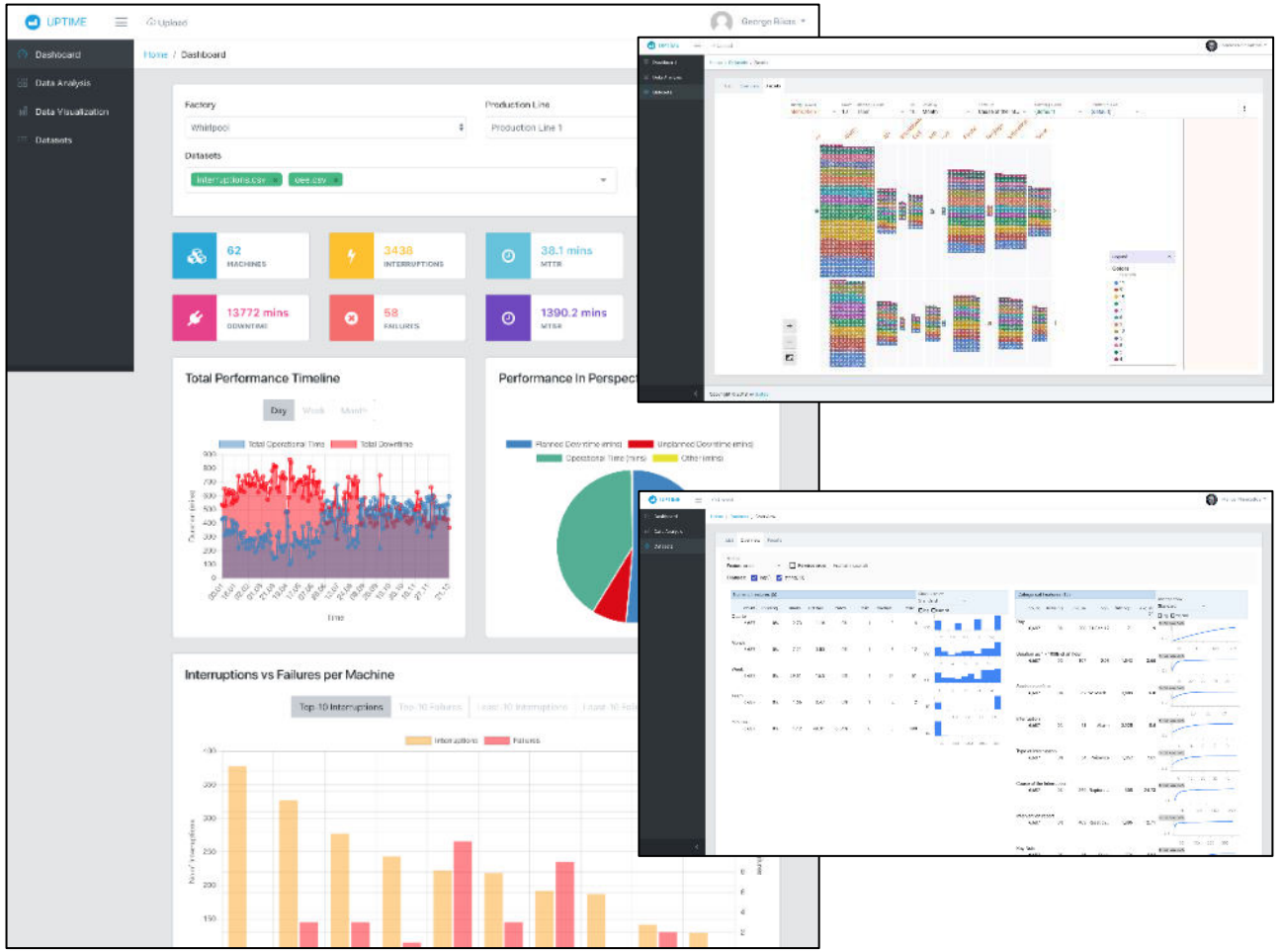


Extended FMECA concept/Prototype UPTIME_FMECA component (M12)

The UPTIME Components



- Interoperability with and analysis of historical maintenance data
- Make historical maintenance data available to other UPTIME components
- Semantic uplift to UPTIME data model
- Data mining and analytics
- Deep and flexible visualisation



UPTIME_ANALYSE dashboard, dataset facets and dataset navigator screens (M9)

SENSE | DETECT/PREDICT | DECIDE | VISUALISE | FMECA | ANALYSE

Industrial Use Cases

Selected Key Characteristics

- Clothes dryer drum production line
- Complex production processes with many datapoints and large volumes of data
- Sensor topology and IT ecosystem in place

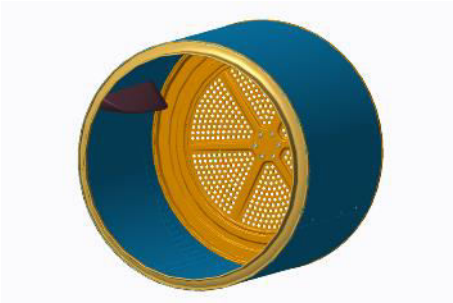
Selected Key Requirements

- Inclusion of historic data and operational data in analysis process.
- Integration with existing sensor topology and IT ecosystem necessary (e.g. SAP-PM)
- Integration with existing FMECA models via UPTIME_FMECA

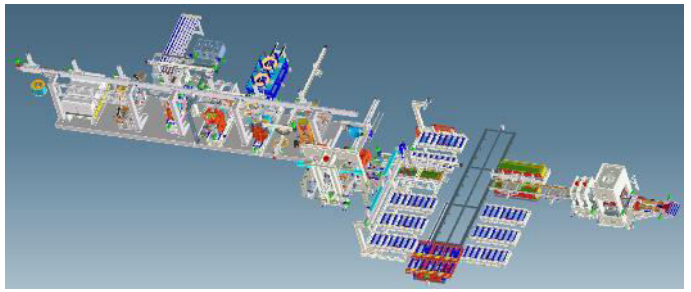
Selected Goals

- Automatically generate warnings, actionable maintenance orders
- OEE average improves from 82% to 87%
- 10% reduction of MTTR
- 30% increase of MTBF
- 25% reduction of Total Cost of Maintenance

Clothes dryer drum production line in Lodz, Poland



Clothes dryer drum



Drum production line model

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Industrial Use Cases

Selected Key Characteristics

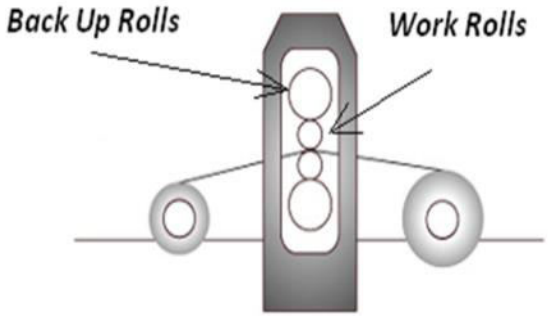
- High-wear work rolls in cold rolling of steel tape
- Rolls need to be replaced regularly
- Product quality loss if rolls not maintained properly
- Downtime in production due to scheduled replacement of rolls

Selected Key Requirements

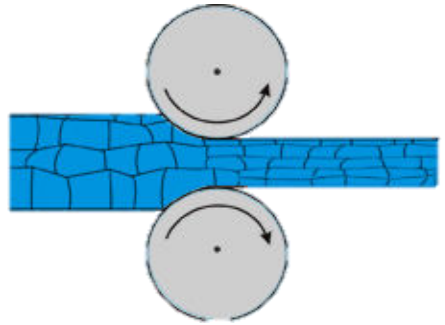
- Maximise operation time of equipment via condition monitoring.
- Improve quality of the product.
- Analyse fault reasons and find effective solutions.
- Maintenance strategy leading to improved production system.
- Reduction of maintenance and thus production costs.

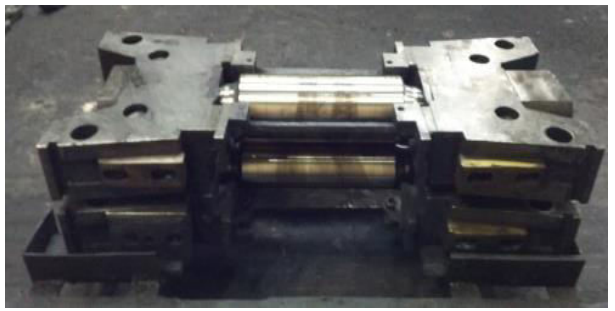
Selected Goals

- Maximization of Utilization Ratio: 10%
- Increase of MTBF (meantime between failure): 20%
- Quality improvement of created products: 10%
- OEE improvement: 20%
- Reduction of total maintenance cost: 15%
- Reduction of production loss: 5%
- Maximization of Rollers' Mean Life: 10%



Roll mill stand


Grain size reduction


Work rolls


Worn work roll

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Industrial Use Cases

Selected Key Characteristics

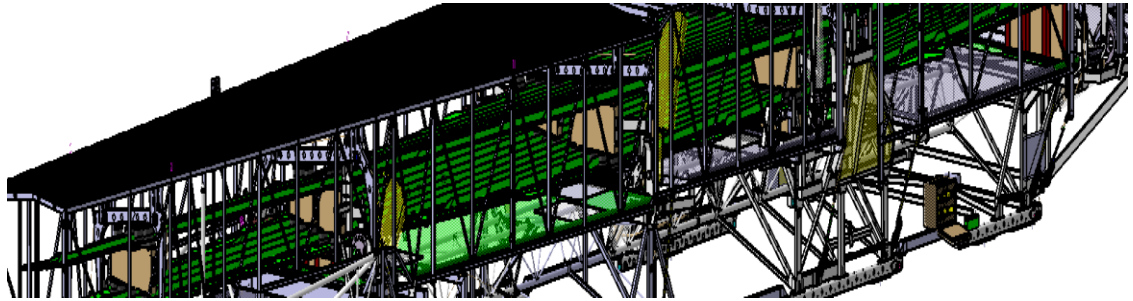
- Wing cover transport jig for aeronautics industry
- 40m aluminium jig used in land, sea and air transport
- Transport and environmental conditions affect asset health

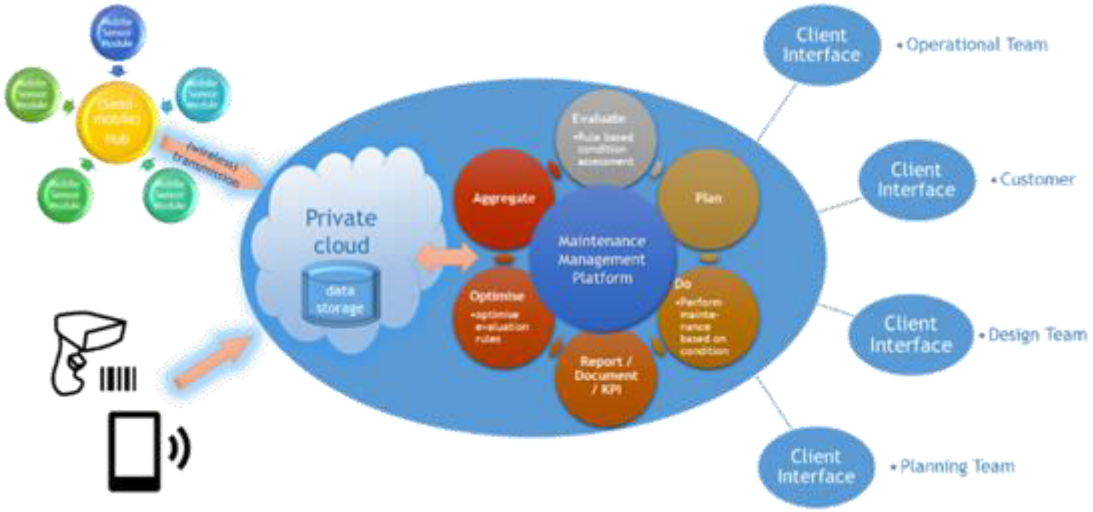
Selected Key Requirements

- Obtain (near-) real-time health-metrics
- Automatic analysis of status for actionable health assessment
- Access and assess historical data for failure cause analysis and design improvements
- Role-based views/access to TJ status for different stakeholders
- Manage data for larger numbers of assets

Selected Goals

- Increase availability of transportation jigs
- Cont. access to operational status and availability prediction
- Scalability to large numbers of assets





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Short Presentation of Maillis Group

MAILLIS

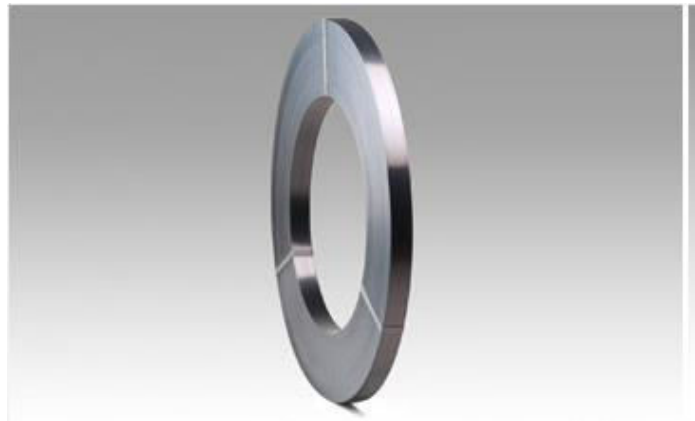
M.J. Maillis was established as a producer of steel tapes in 1968. Nowadays Maillis Group manufactures and provides complete secondary packaging systems, machines and packaging materials in strapping, wrapping and carton sealing industries, including hand strapping tools. The Group operates in 18 countries throughout Europe, North America and Asia.

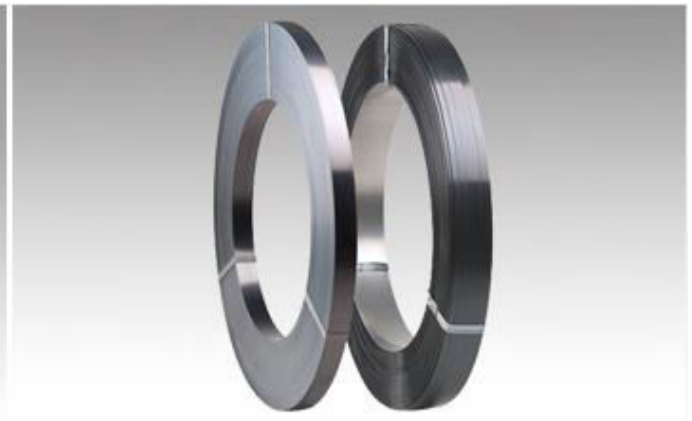
- Over 1.500 employees
- Over 15.000 customers
- 18 subsidiaries
- 6 manufacturing plants

M.J. MAILLIS S.A. Manufacturing Unit in Greece (Inofyta Viotias)

Annual capacity	110.000 TN
Total area	72.000 m^2
Employees	134
Production	91
Maintenance	21

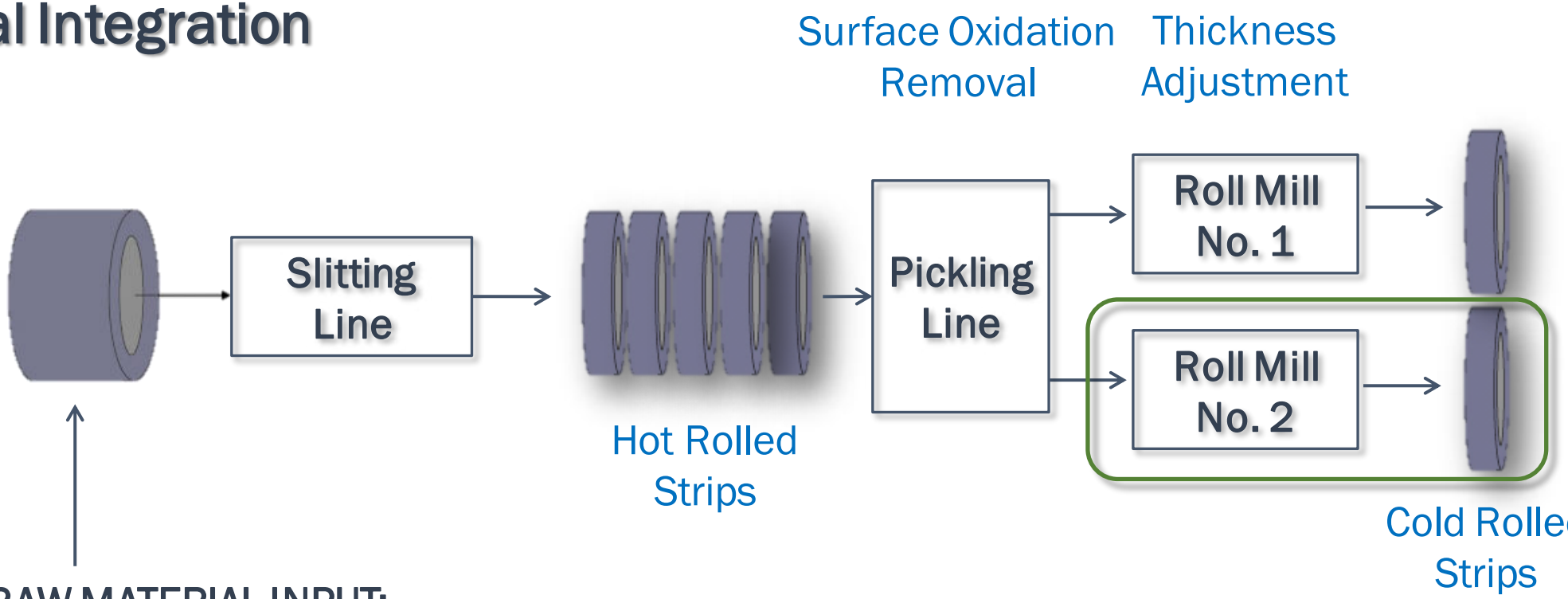
From Raw Material to Final Products





Steel Strap Production Semi Finished

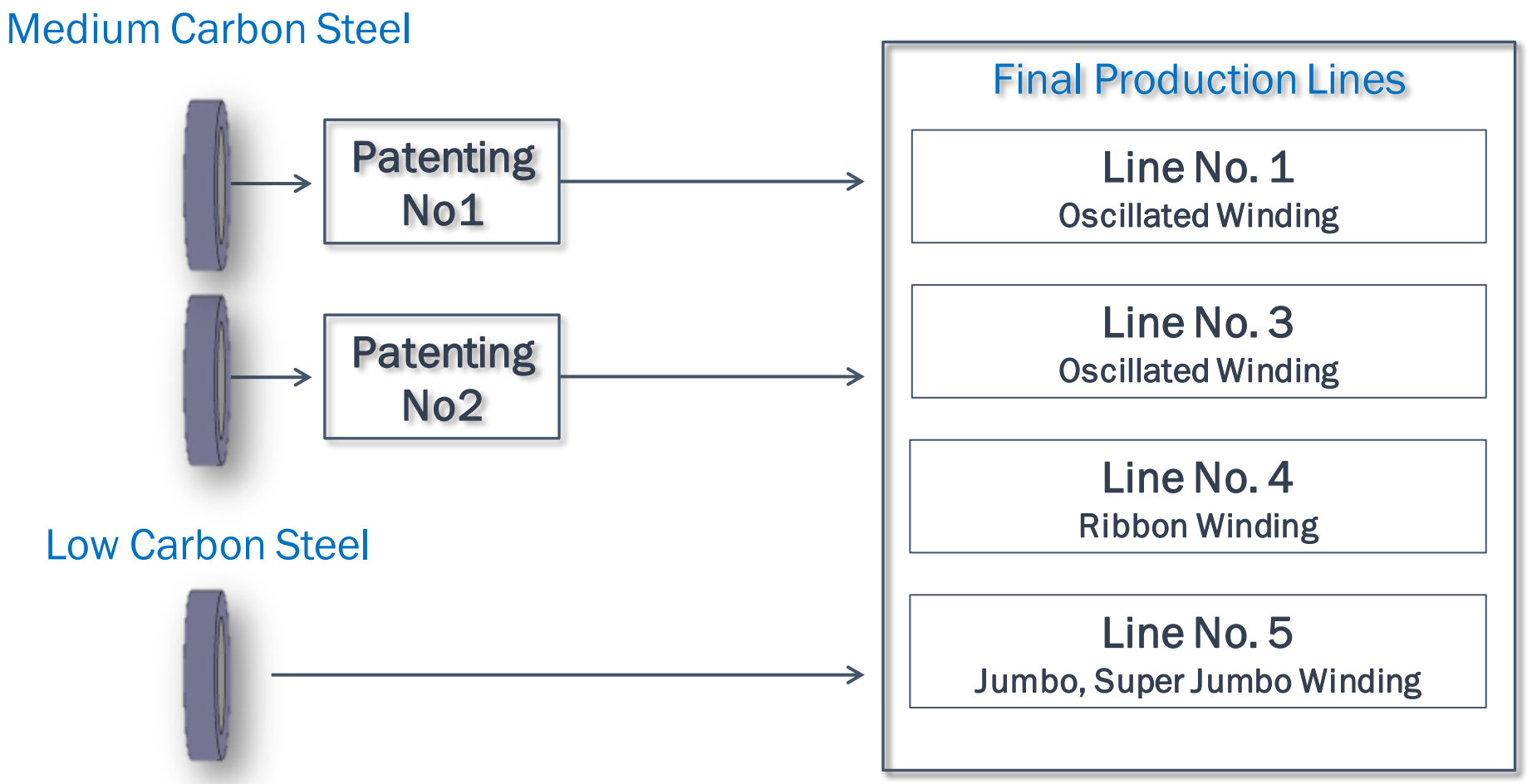
Vertical Integration



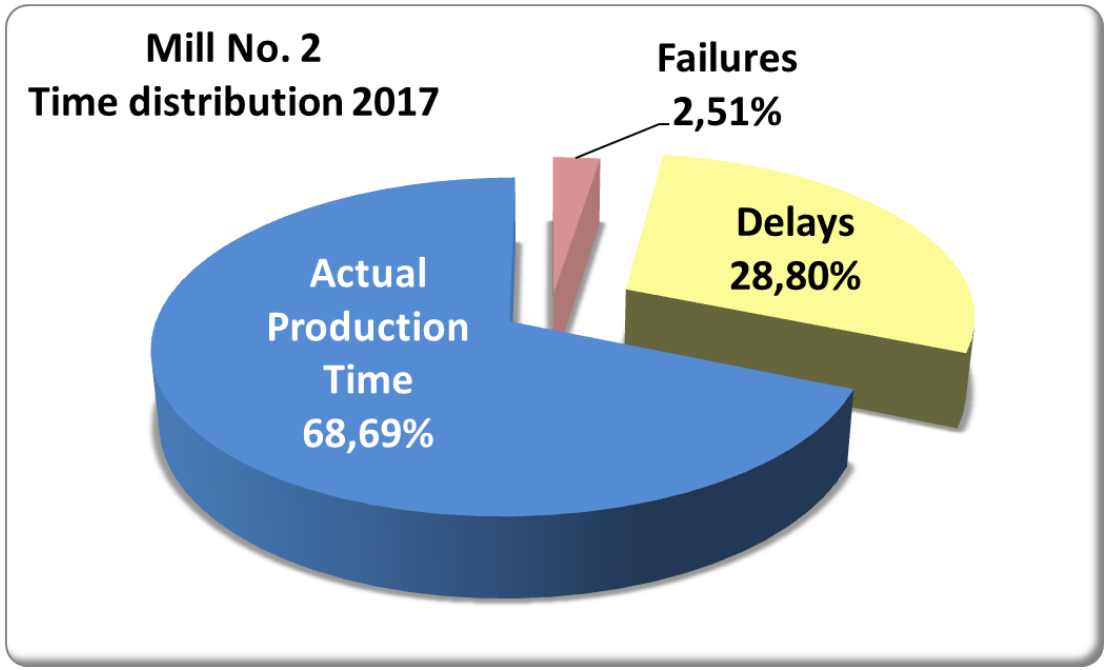
RAW MATERIAL INPUT:

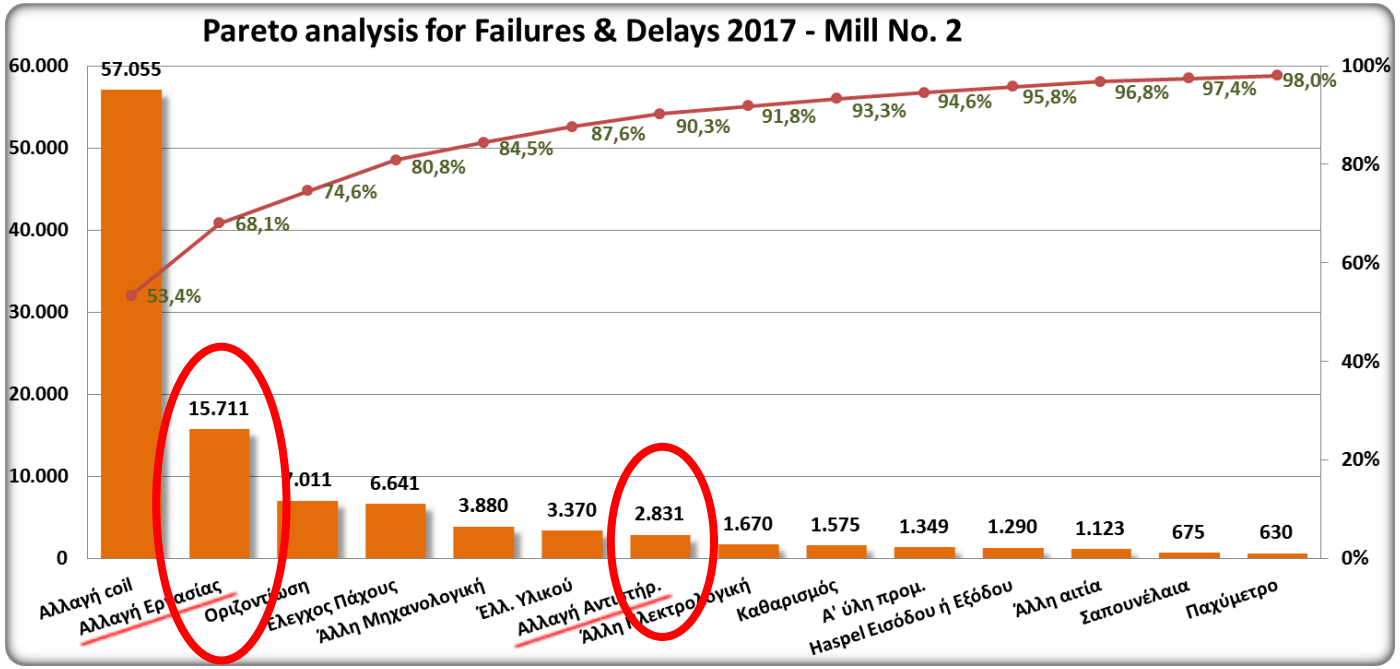
- Hot Rolled / Low Carbon
- Hot Rolled / Medium Carbon
- Cold Rolled / Low Carbon

Steel Strap Production Finished



Mill No. 2 Time Distribution - Time





Purpose and Objectives

MAILLIS Business Case lines to produce rolling products with the closest possible thickness tolerances and an excellent surface finish, this means to:

- Have a machine that reports its current health status along with the appropriate data analytics and metrics to identify the degree to which that status deviates from normal or healthy operational mode.
- Have predictions about equipment's future health as well as recommendations for future actions.
- Enable machines perform self-assessment based on which decision-making can be significantly followed to advance equipment maintenance and facilitate the entire products life cycle.
- Facilitate the development of a predictive maintenance strategy which permits increased productivity through transparency and traceability, lower maintenance and repair costs, higher machine availability and enables for cost efficiencies and better quality of products.

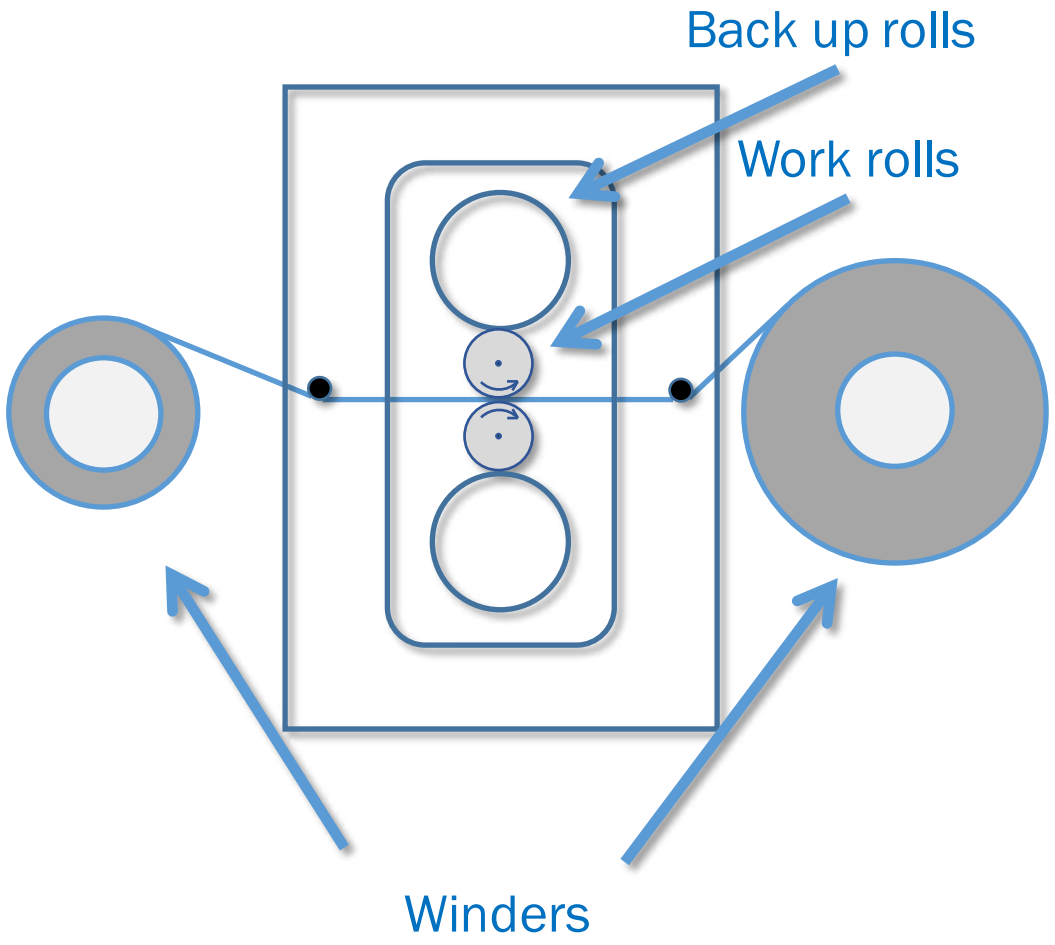
Purpose and Objectives

Key Performance Indicator	TO-BE Value
Maximization of Utilization Ratio	10%
Increase of MTBF	20%
Quality improvement of the created products	10%
OEE improvement	20%
Reduction of total maintenance cost	15%
Reduction of Production Loss	5%
Maximization of Rollers' Mean Life	10%

Cold Rolling Mill No. 2

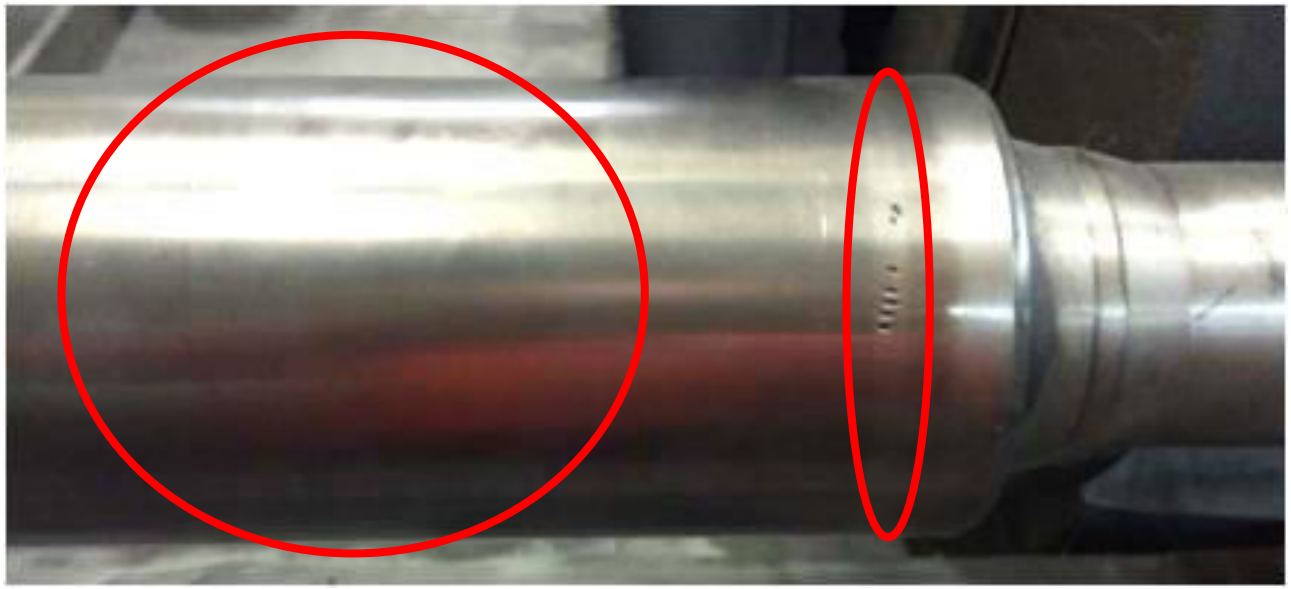
Cold Rolling Mill

Roll Mill Stand



Deforming and Reducing the Grain Size

Wear on Work Roll

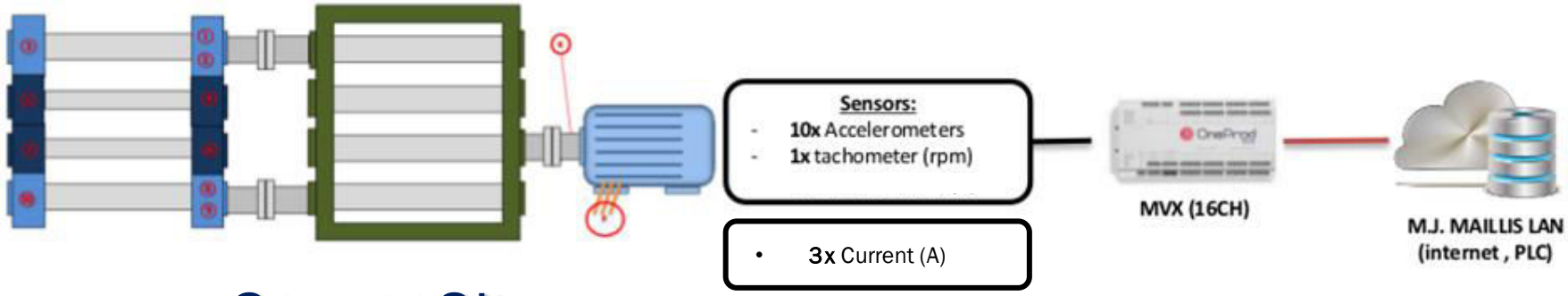


Maintenance Data (Sample Excel File)

UPTIME

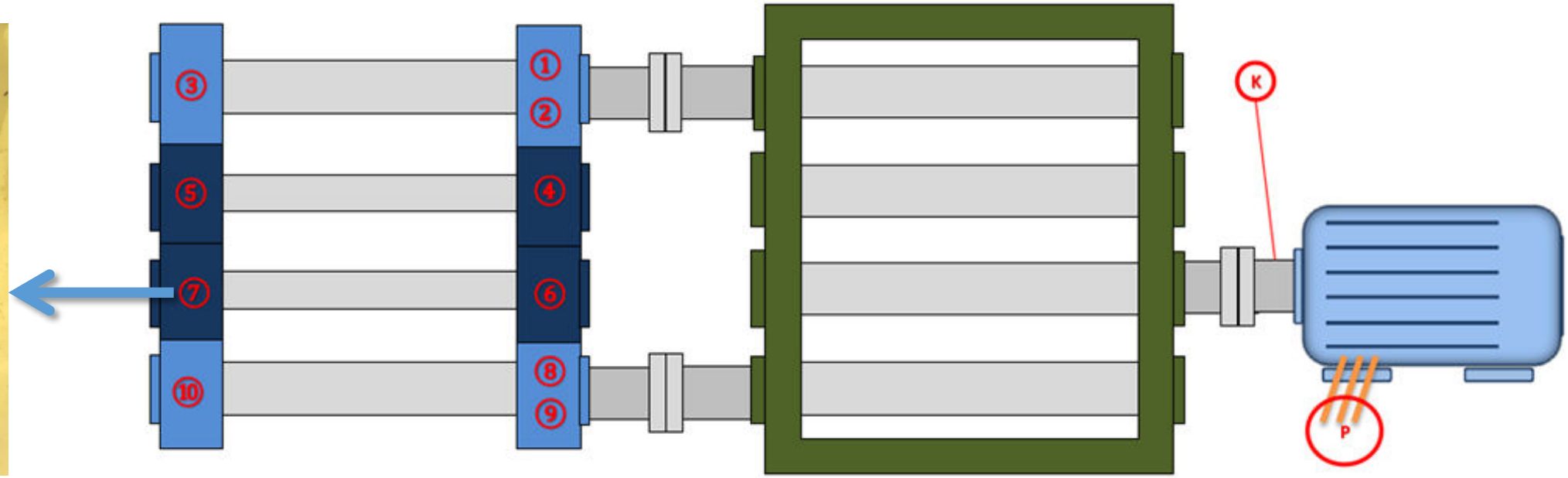
	ΠΑΡΑΚΟΛΟΥΘΗΣΗ ΡΑΟΥΛΩΝ ΕΛΑΣΤΡΟΥ										
	A/A	Ημερομηνία	Διάμετρος (mm)	Αριθμός	Έλαστρο No.	Χειριστής	Περάσματα	Υλικό	Λόγος Αλλαγής	Νέα Διάμετρος (mm)	Προμηθευτής
82	1	30/1/2018	125	70015	2	User1	86	HT	Φυσιολογική Φθορά	124,8	Akers
	2	31/1/2018	125	70015	2	User1	54	HT	Φυσιολογική Φθορά	124,6	Akers
	3	1/2/2018	125	70015	2	User2	69	HT	Φυσιολογική Φθορά	124,2	Akers
	4	2/2/2018	125	70015	2	User1	48	HT	Φυσιολογική Φθορά	124,0	Akers
	5	5/2/2018	125	70015	2	User1	39	HT	Φυσιολογική Φθορά	123,8	Akers
	6	6/2/2018	125	70015	2	User4	45	HT	Φυσιολογική Φθορά	123,6	Akers
	7	8/2/2018	125	70015	2	User2	44	HT	Φυσιολογική Φθορά	123,4	Akers
	8	9/2/2018	125	70015	2	User2	38	HT	Φυσιολογική Φθορά	123,2	Akers
	9	16/2/2018	125	70015	2	User1	51	HT	Φυσιολογική Φθορά	123,0	Akers
	10	21/2/2018	125	70015	2	User2	38	HT	Φυσιολογική Φθορά	122,8	Akers
	11	22/2/2018	125	70015	2	User1	57	HT	Φυσιολογική Φθορά	122,6	Akers
	12	6/3/2018	125	70015	2	User4	42	HT	Φυσιολογική Φθορά	122,4	Akers
	13	27/8/2018	125	70015	2	User1	52	HT	Φυσιολογική Φθορά	122,2	Akers
	14	29/8/2018	125	70015	2	User4	12	HT	Φυσιολογική Φθορά	122,0	Akers
	15	3/9/2018	125	70015	2	User1	60	HT	Φυσιολογική Φθορά	118,7	Akers
	16	10/9/2018	125	70015	2	User1	9	HT	Σκάσιμο	118,5	Akers
	17	24/9/2018	125	70015	2	User1	42	HT	Φυσιολογική Φθορά	118,4	Akers
	18	25/9/2018	125	70015	2	User2	68	HT	Φυσιολογική Φθορά	118,2	Akers
	19	26/9/2018	125	70015	2	User4	20	HT	Φυσιολογική Φθορά	117,9	Akers
	20	2/10/2018	125	70015	2	User4	21	HT	Σκάσιμο	117,9	Akers
							895				
83	1	10/9/2018	125	73620	2	User4	36	HT	Φυσιολογική Φθορά	125,0	Akers
	2	11/9/2018	125	73620	2	User1	27	HT	Φυσιολογική Φθορά	124,4	Akers
	3	12/9/2018	125	73620	2	User1	42	HT	Φυσιολογική Φθορά	124,0	Akers
	4	13/9/2018	125	73620	2	User4	39	HT	Φυσιολογική Φθορά	123,6	Akers

Infrastructure Setup for Sensor Data



Sensor Site

Vibration sensor

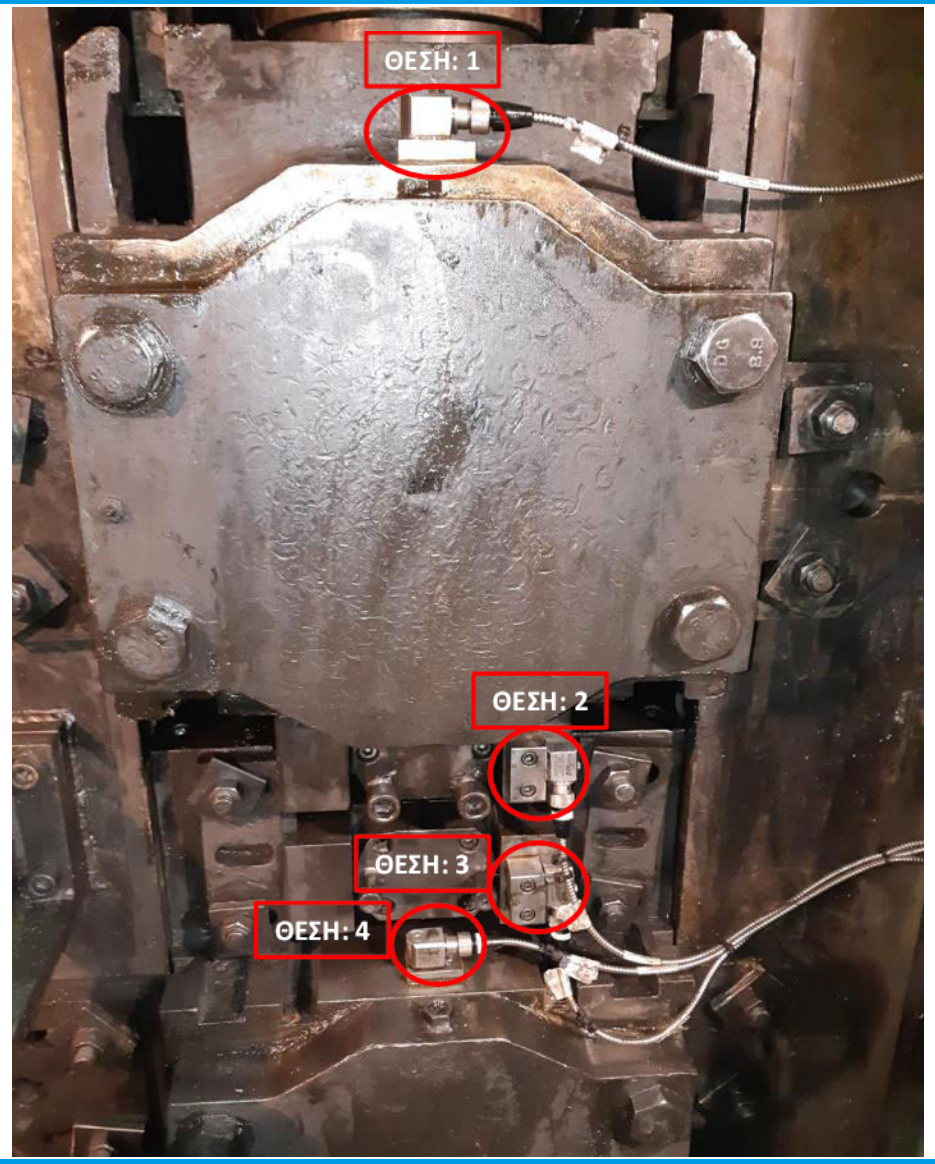


Vibration Sensors Description

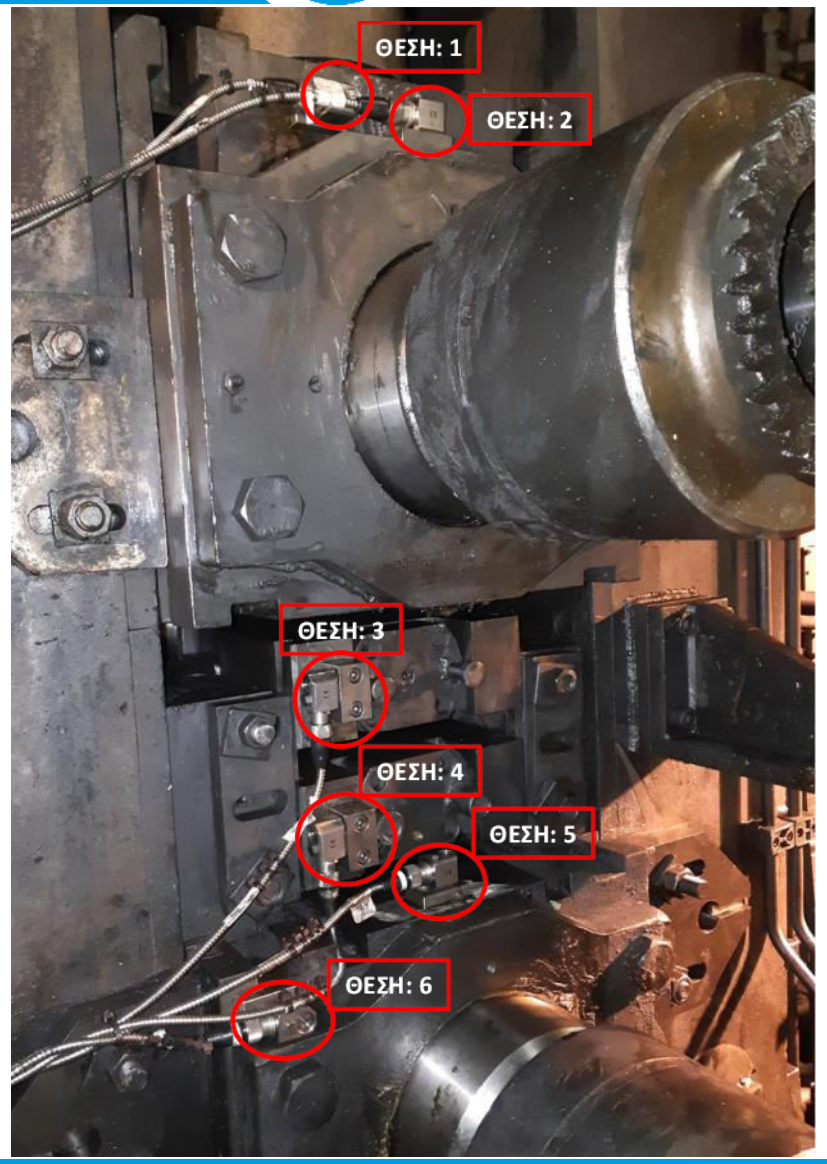
Sensor ID	Measurement point	Sensor direction	Sensor Type
1	Upper backup roll – DE side	Vertical	Accelerometer
2	Upper backup roll – DE side	Axial	Accelerometer
3	Upper backup roll – NDE side	Vertical	Accelerometer
4	Upper working roll – DE side	Reverse horizontal	Accelerometer
5	Upper working roll – NDE side	Horizontal	Accelerometer
6	Down working roll – DE side	Reverse horizontal	Accelerometer
7	Down working roll – NDE side	Horizontal	Accelerometer
8	Down backup roll – DE side	Vertical	Accelerometer
9	Down backup roll – DE side	Axial	Accelerometer
10	Down backup roll – NDE side	Vertical	Accelerometer

Position of Sensors on Rollers

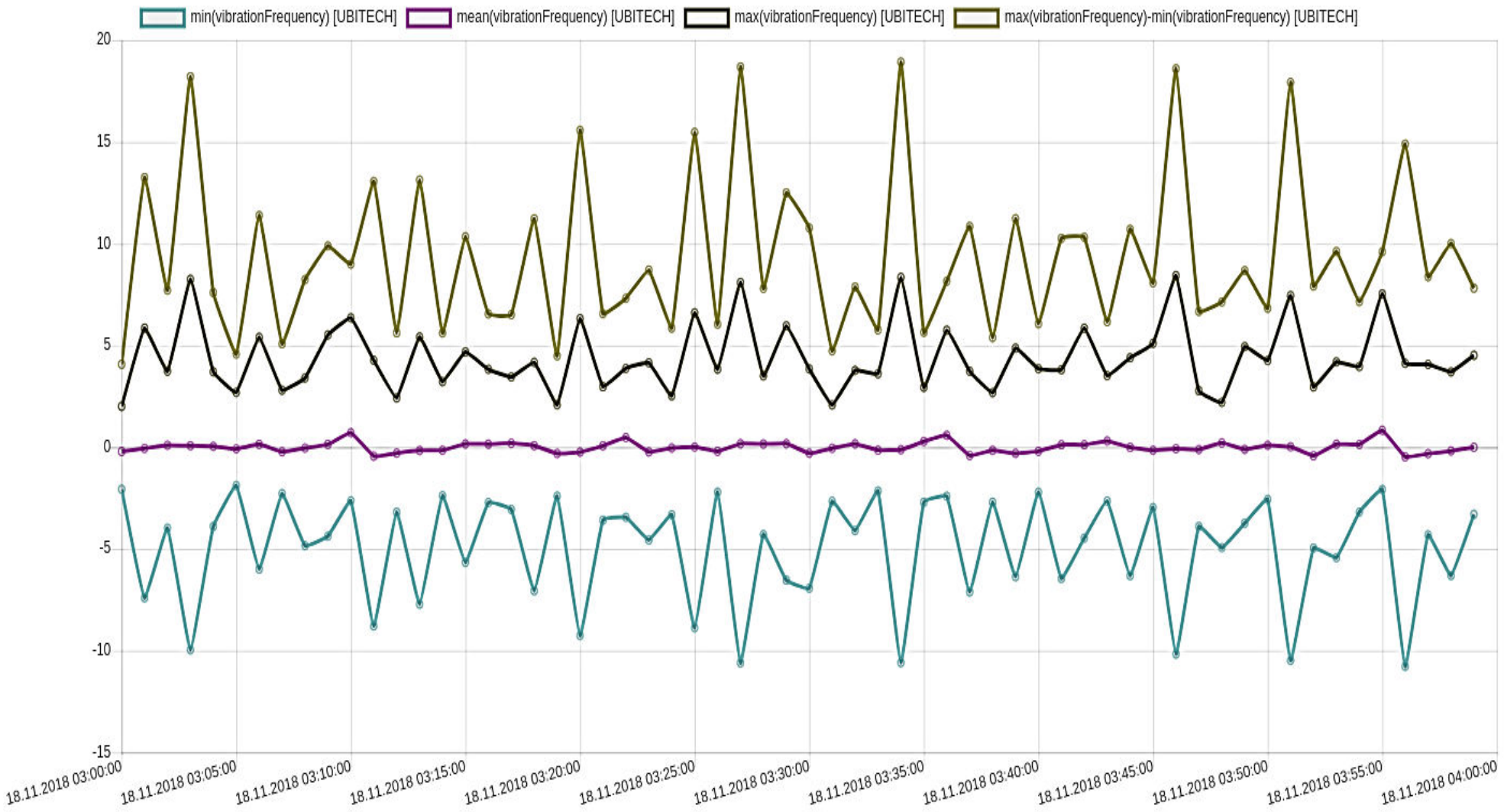
Front view of rollers:



Rear view of rollers:



Roller Vibration Dataset



Next Steps

New data may be introduced, if it is deemed that may boost the fidelity of the results produced for the MAILLIS Case.
All new data will be integrated to the existing infrastructure that can easily be extended to accommodate for new sources of data.

New sensor data can be collected by simply connecting the sensors to the Modbus and by configuring the PLC Data adapter to accommodate for them.

Maintenance and production data are collected through excel files. During course new data may also be integrated to the existing infrastructure.

Next Steps

Next Tasks are following in cooperation with UPTIME partners, within the defined project timetable:

“Data Collection and Infrastructure Setup”

“Deployment of UPTIME and Integration with MAILLIS IT Infrastructure”

“System Evaluation, Learning and Improvement”

Thank You!

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- **Objective:** Novel design and predictive maintenance technologies
- **Topic:** FoF-09-2017
- **Call:** H2020-FOF-2017
- **Lead:** BIBA – Bremer Institut für Produktion und Logistik GmbH
- **Duration:** 36 Months
- **Start:** 2017/09