CONTROL IN STEEL

# AI and Big Data in Control

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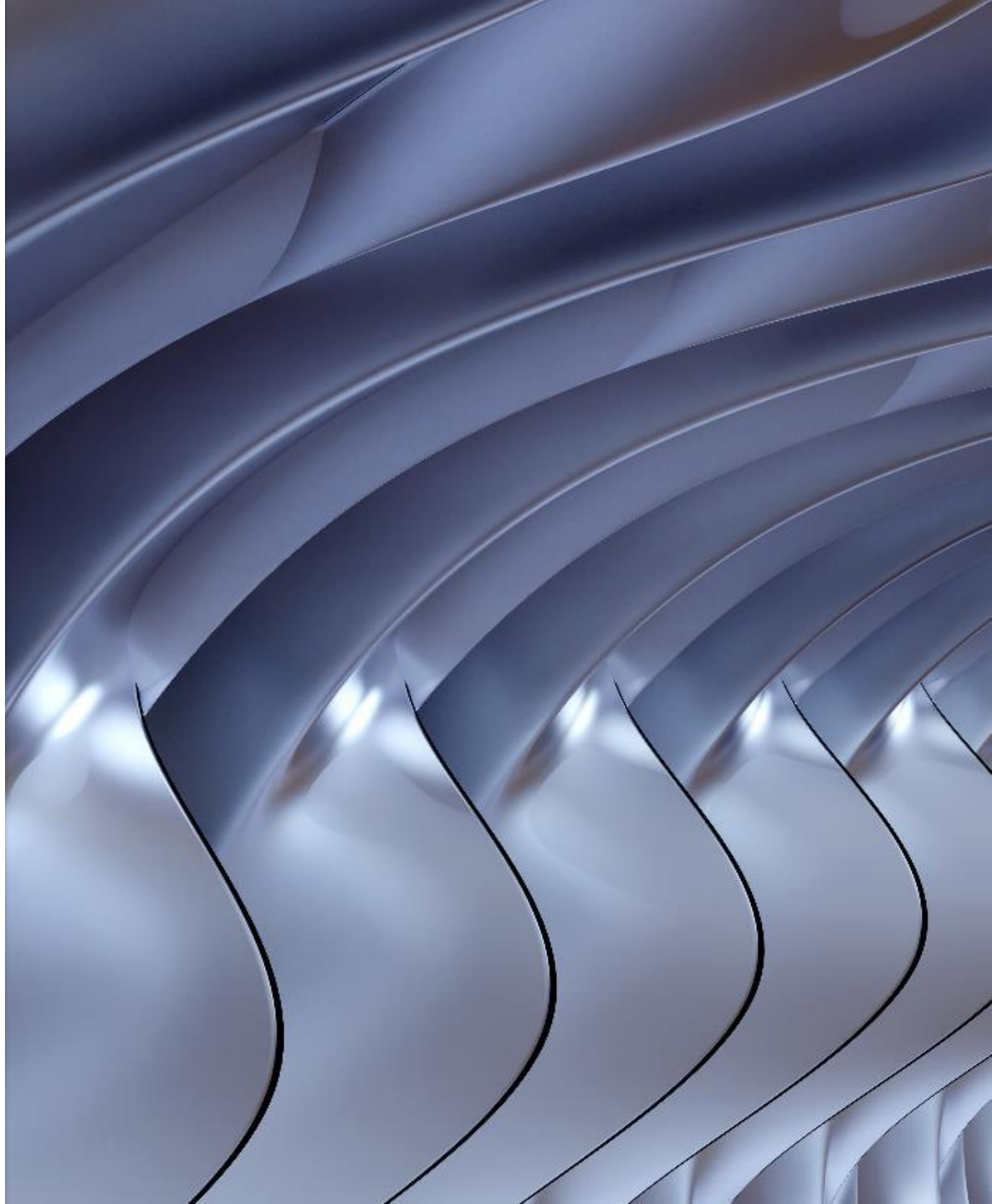

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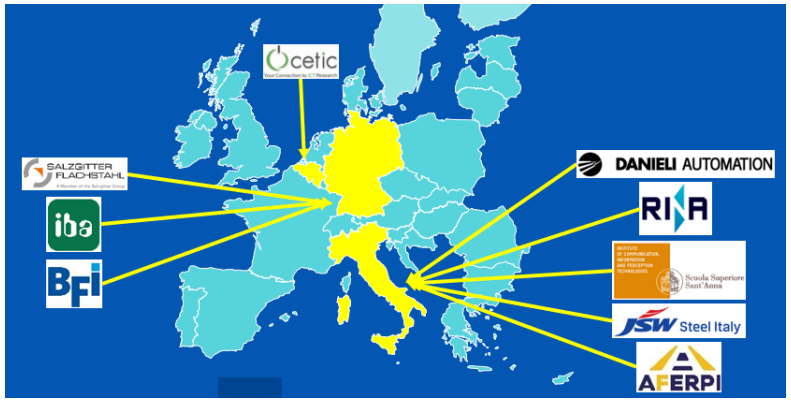
# *NewTech4Steel* European RFCS project




**Cloud** and **Big Data** concepts (approaches, architectures and methods) applied in steel industry in particular at the fast-rolling processes (Lambda Architecture)

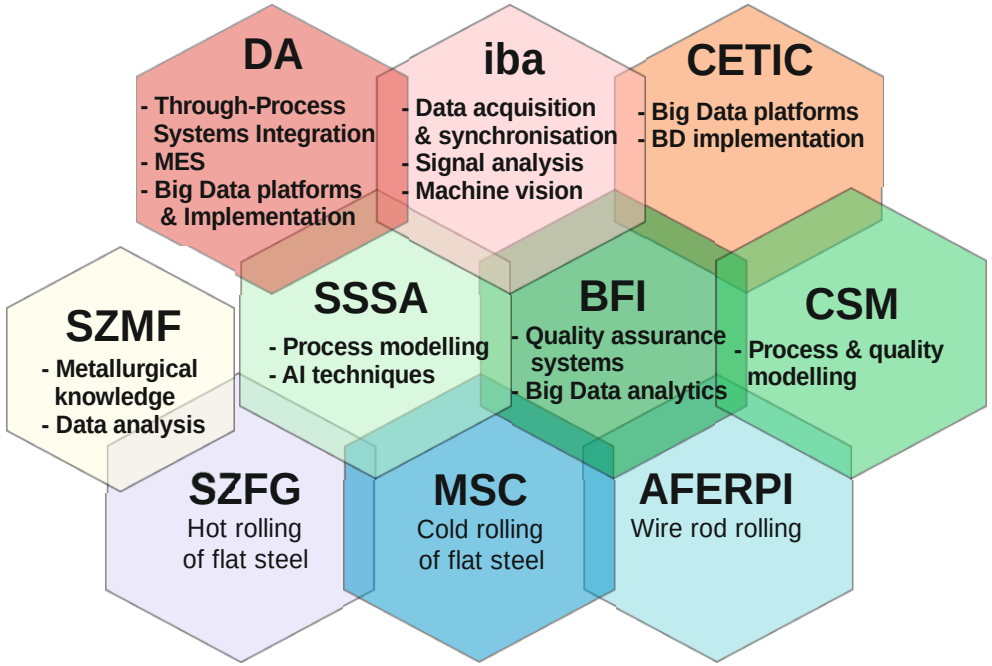
**Project duration**: 01.06.2018 – 31.05.2022

Providing and adapting infrastructures and architectures

Application of knowledge, methodologies and techniques to use cases

Industrial use cases

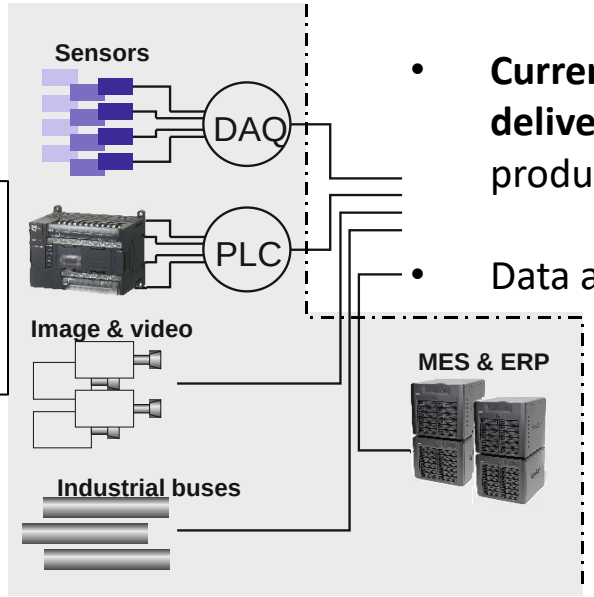
- **Hot-rolled wide strip**
- **Cold rolling area**
- **Wire rod rolling**



# Motivation

There is the demand to **increase the stability of production processes** and **the quality of the products** in the production of rolled steel.

- 1D/2D geometry (sensor, PLC) event – 10Hz
- Surface inspection (image)
- Process data (PLC, sensor, bus) event – 500Hz
- …

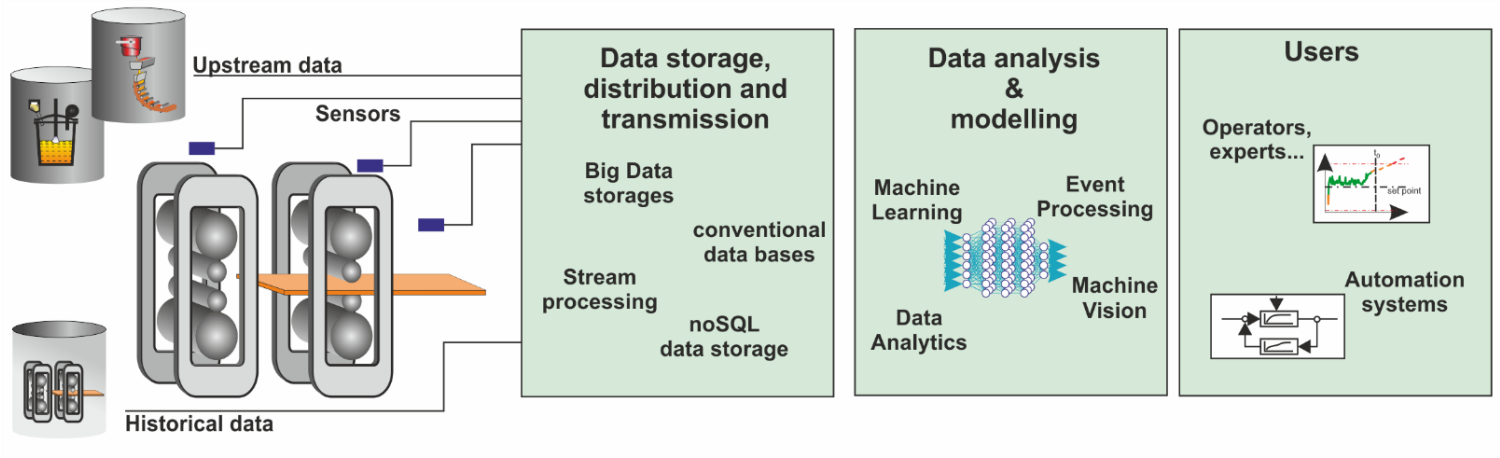



- **Current sensor equipment** at rolling facilities in steel production **delivers masses of data and information** about the process, the product and its quality
- Data are supplied **at high sample rates** and **high spatial resolutions**

**Problem:** process supervision **lacks** an **online or near-online exploitation** of the available data

# Idea and Objective

**Applicable methodologies** to meet the requirements of online/near-online supervision of processes can be found in knowledge domains like **Data Analytics**, **Machine Vision** and in **Big Data techniques.**



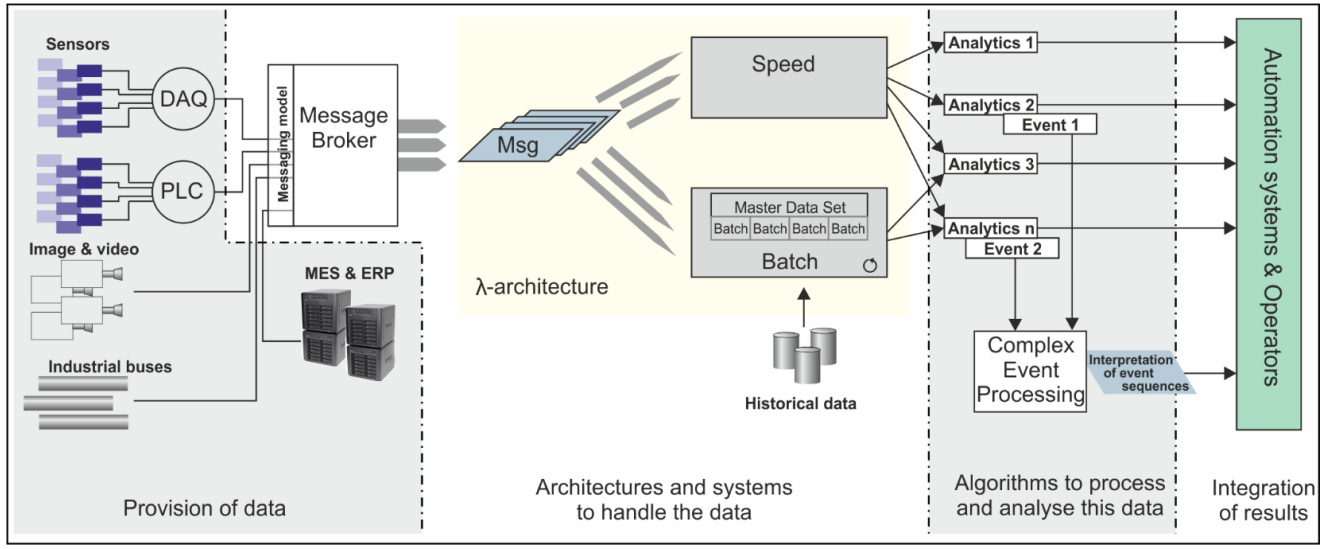

- The implementation of methodologies for data ingestion, storage and transmission to achieve **highest possible data throughput rates**, because this becomes necessary for the aimed **online or near online processing** into operational practice at steel production.

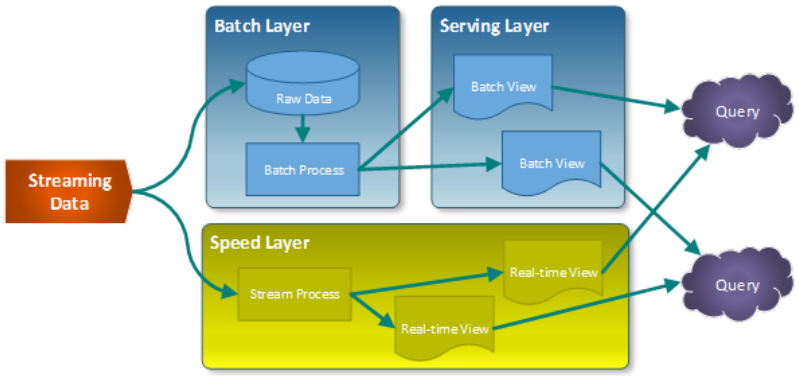
- The application of **newest technologies of Data Analytics** for analysis and modelling, because the existing data acquisition systems supply masses of data of various structures and contents, which have to be **analysed and processed together**.

# Technical approach

The technical solutions based on

- the state-of-the-art equipment of the investigated production facilities (**brown-field implementation**),
- the experts' knowledge about the underlying processes and their physical relations (**model definition**),
- the application of innovative methodologies of modern data processing (**Big Data methodologies**).




[Lambda Architecture – Databricks]

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# Cold Rolling Use Case

## Aim:

Development of a platform software solution based on Lambda Architecture to strengthen and optimize the processes of coils galvanization

a. **Forecast of top defects at HDG line due to flatness problem**
b. **Prediction of specific setup parameters to avoid or limit process problems and product defects during the galvanization**

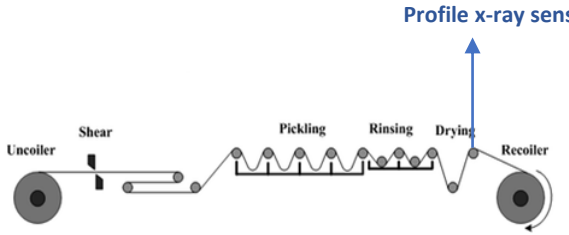
**Platform solution requirement:**

- **Ingestion** and elaboration of high frequency variables (process parameters at Galvanizing line)
- **Storing** of length-based data (coil profile, mechanical charactetistics, stressometer matrix at CRM for each pass, Zinc profile top/bottom), time series and large data per coil (images) in datalake
- Heavy **data processing** for data preparation in the training cycle of ML
- Implementation, deployment and update of **ML models**
- Storage of results on relational-db
- HMI accessible via web

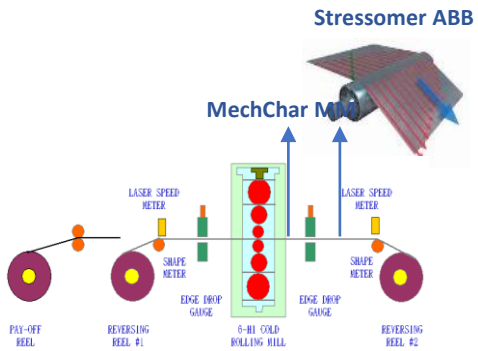
# Methodological approach

Development of a platform to strengthen and optimize the processes of coils galvanization

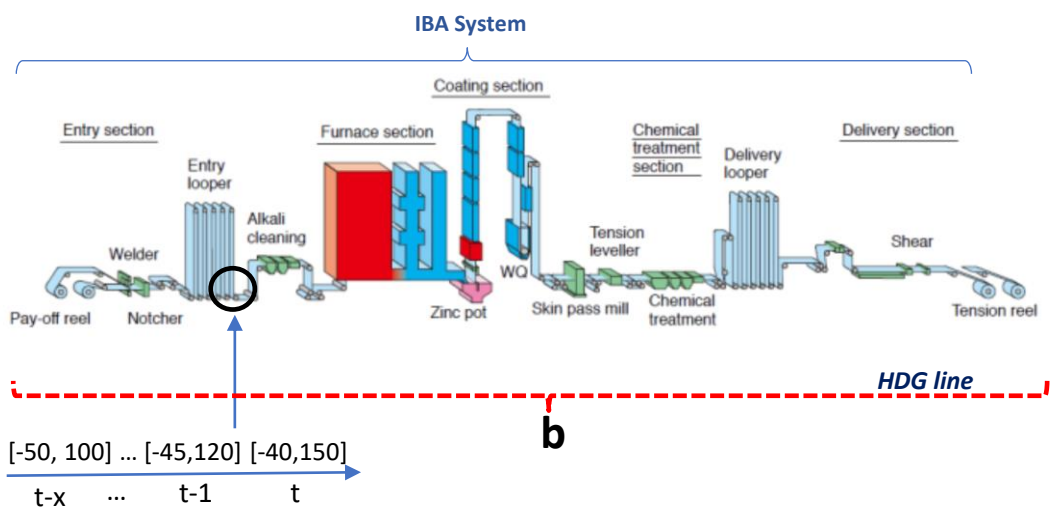
a. **Prediction of top defects at HDG line due to flatness problem**
b. **Prediction of specific parameters setup to avoid or limit problems during the galvanization**

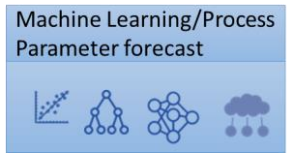



*Pickling line*




*CRM*




✓ **Forecast of specific process parameter**
- **centering device position**
- **guide position**

**Online monitoring of guide/centering device**

Ci
Ci+1
Ci+2
...
Cn

List of next coil to process (Coil Classified by means of feature at point **a** in lambda batch layer)

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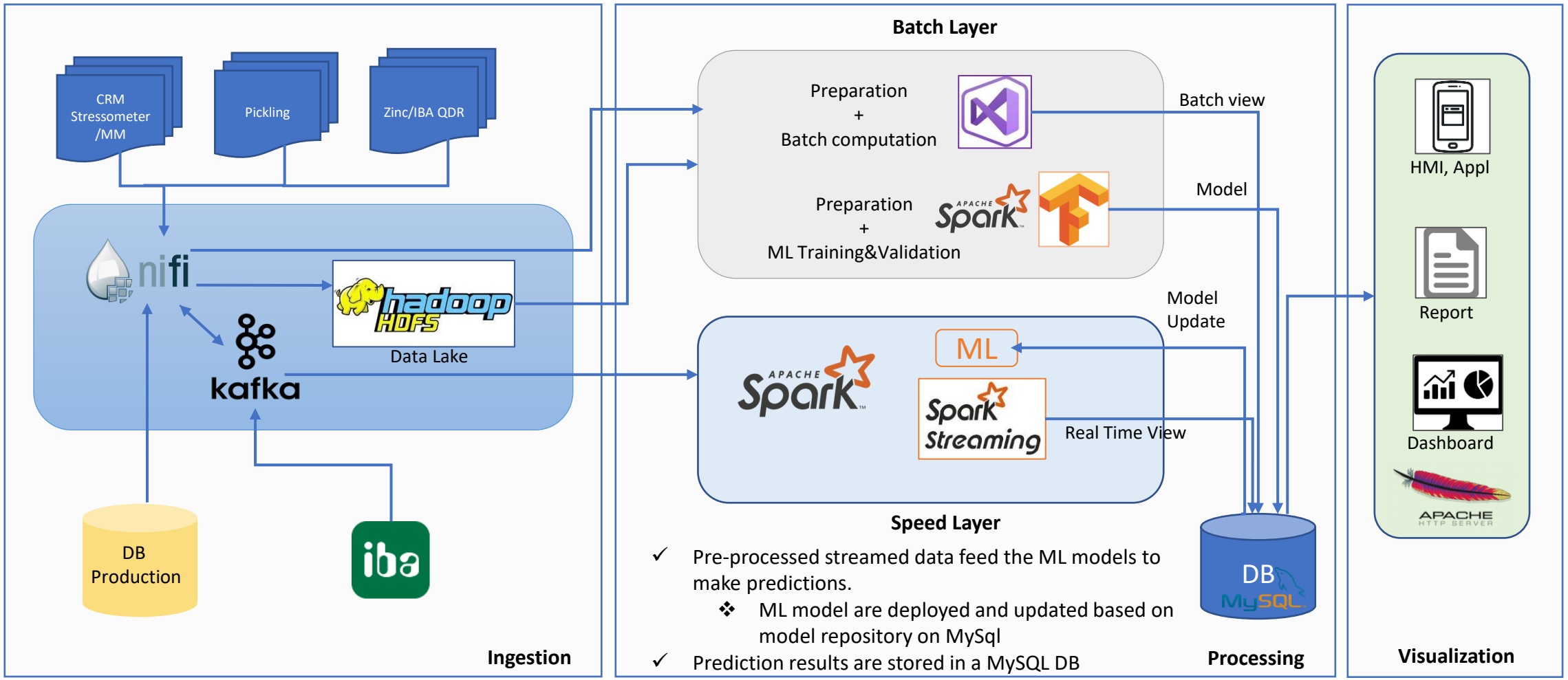
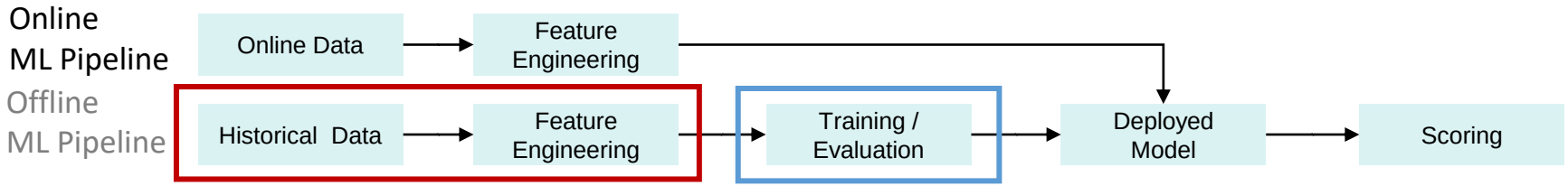
# Project Lambda Architecture Schema

- ✓ Model are created and retrained
  - ❖ The result (as code format or parameters values is stored in the dedicated MySQL server)
- ✓ Batch view on current production are loaded on MySQL server




- ✓ Pre-processed streamed data feed the ML models to make predictions.
  - ❖ ML model are deployed and updated based on model repository on MySql
- ✓ Prediction results are stored in a MySQL DB

# Data preparation, analysis and modelling




CRM Stressometer/ MM

DB Production

**Preparation of dataset based on historical data for the training/test of Machine Learning models involves:**

- Rescale/Transform
  - Stressometer tension to IUnit values
- Data Alignment
  - Interpolation on length/width
  - Realignment to the correct position with the IBA QDR and Zinc profile data based on two reported data:
    - the elongation at pickling line
    - the weight of the cut material at HDG line
- Missing values handling & Filter on noise
- Outliers detection and treatment

**Analysis for feature/variable extraction:**

- Feature engineering & Dimensionality reduction
  Correlations, PCA

**Modelling**

- Data Segregation
  - Split subsets of data to train the model and further validate how it performs against new data
- Training
  - Different schemes of Back Propagation Neural Network

| | R2-Guida | R2-Centr. | INPUT | | | | | | | OUTPUT | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TF-ANN-0 | 0.750 | 0.012 | SM | YS e UTS | Iba | | | | | Guida1 | Centr.1 | | | | |
| TF-ANN-1 | 0.816 | 0.079 | SM | YS e UTS | Iba | Guida1 | Centr.1 | | | | | Guida2 | Centr.2 | | |
| TF-ANN-2 | 0.884 | 0.781 | SM | YS e UTS | Iba | Guida1 | Centr.1 | Guida2 | Centr.2 | | | | | Guida3 | Centr.3 |
| TF-ANN-3 | 0.824 | 0.678 | SM | YS e UTS | Iba | Guida1 | Centr.1 | | | | | | | Guida3 | Centr.3 |
| TF-ANN-3_0 | 0.81 | 0.663 | SM | YS e UTS | Iba | | | | | | | | | Guida3 | Centr.3 |
| ANN-2 Cond-1 | 0.946 | 0.071 | SM | YS e UTS | Iba | Guida1 | Centr.1 | Guida2 | Centr.2 | | | | | Guida3 | Centr.3 |
| ANN-2 Cond-2 | 0.902 | 0.035 | SM | YS e UTS | Iba | Guida1 | Centr.1 | Guida2 | Centr.2 | | | | | Guida3 | Centr.3 |
| ANN-2 Cond-3 | 0.958 | 0.863 | SM | YS e UTS | Iba | Guida1 | Centr.1 | Guida2 | Centr.2 | | | | | Guida3 | Centr.3 |
| ANN-2 Cond-4 | 0.944 | 0.905 | SM | YS e UTS | Iba | Guida1 | Centr.1 | Guida2 | Centr.2 | | | | | Guida3 | Centr.3 |

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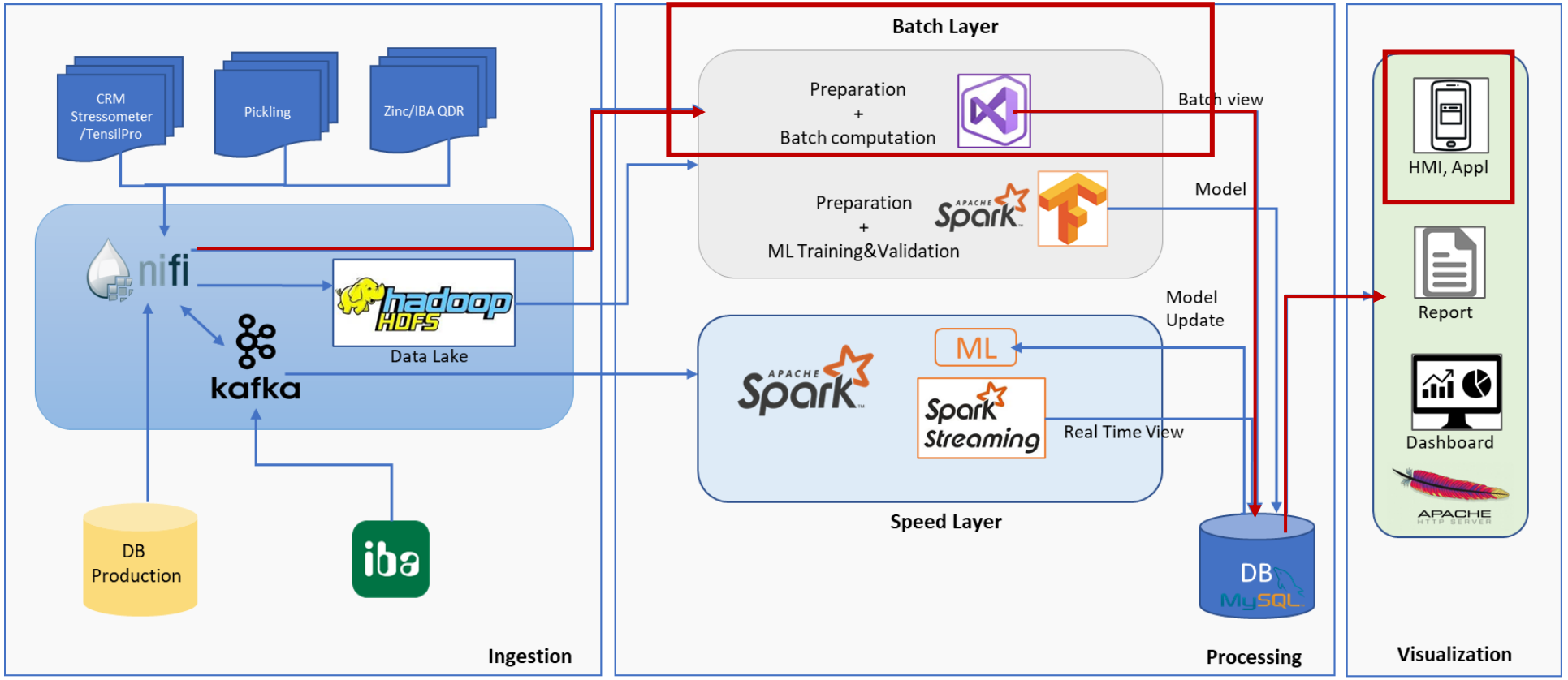
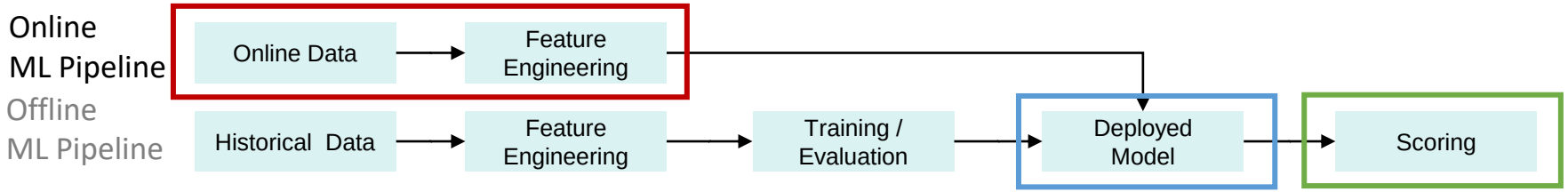
# Batch Layer Deploy



# ML flow of batch process (a)




CRM Stressometer/ MM

- **Rescale/Transform**
  - Stressometer tension to IUnit values
- **Data Alignment**
  - Interpolation on length/width

DB Production

**→Profile**

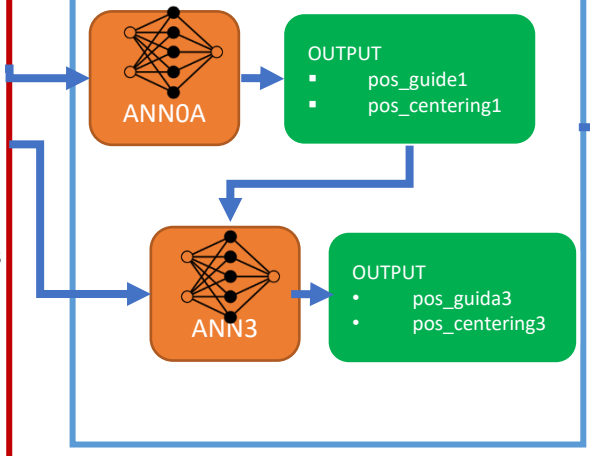
- Crown
- Wedge
- Build_up
- Thickness

**→Line, Coil_Qlt_In, Coil_Supplier**

- Vel_Process_Before_Acc Min/Max
- Vel_Process_HF_After_Acc_Min/Max
- Perc_Acc_Min/Max
- Vel_Process_Before_Acc_SET/Vel_Process_HF_After_Acc_SET/ Perc_Acc_SET

**List of configuration for setup parameters**

50_150_170
63_150_170
77_150_170
90_150_170
80_150_170




❖ Calculation of index on each position of coil length based on the value of guide and centering device predicted by ML model

| Index | Position | Guide | Note |
|---|---|---|---|
| 1 | >=-20 <=20 | >=-80 <=80 | **Position**: Centered **Guide**: Low Correction |
| 2 | >=-20 <=20 | >-200 <-80; >80 <200 | **Position**: Centered **Guide**: Medium Correction |
| 3 | >=-50 <-20; >20 <=50 | <=-80 >=80 | **Position**: Slight Heel **Guide**: Low Correction |
| 4 | >=-50 <-20; >20 <=50 | >-200 <-80; >80 <200 | **Position**: Slight Heel **Guide**: Medium Correction |
| 5 | >=-180 <-50; >50 <=180 | <=-200 >=200 | **Position**: Severe Heel **Guide**: Max Correction |

❖ Calculation of global coil criticality (red, yellow, green) based on the percentages of positional indexes

| Criticality classification logic | | | |
|---|---|---|---|
| Index | % Coil Length | | |
| 1 | 0-100 | | |
| 2 | 0-100 | | |
| 3 | 80 -100 | 50 - 79.9 | 0-49.9 |
| 4 | 15 -100 | 2 -14.9 | 0-1.9 |
| 5 | 5 -100 | 1 - 4.9 | 0-0.9 |
| 0 | 0-100 | | |

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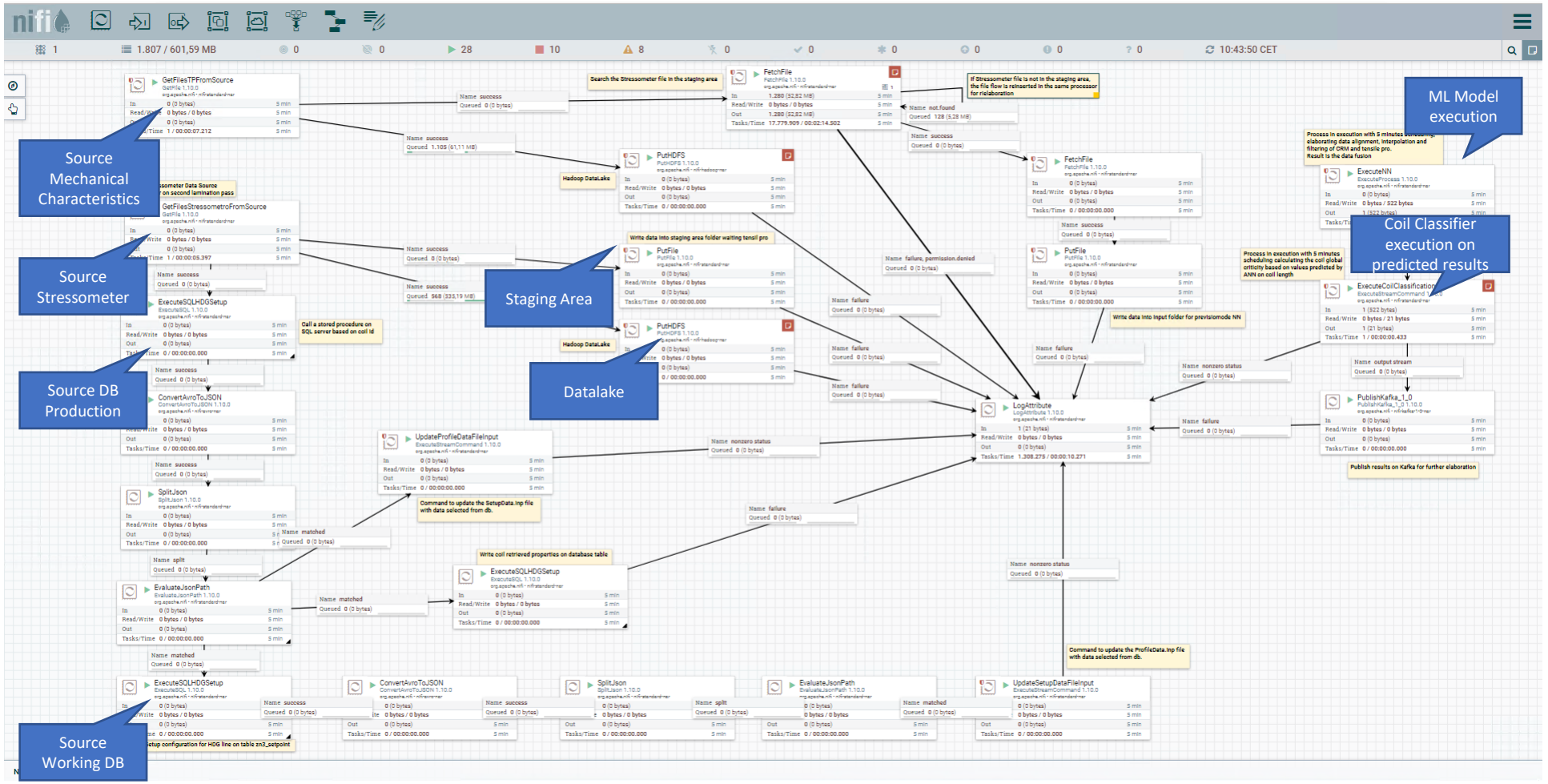
# Flow implementation of batch process (a)

Nifi execution flow with processors interactions starting from data sources until the ML model execution



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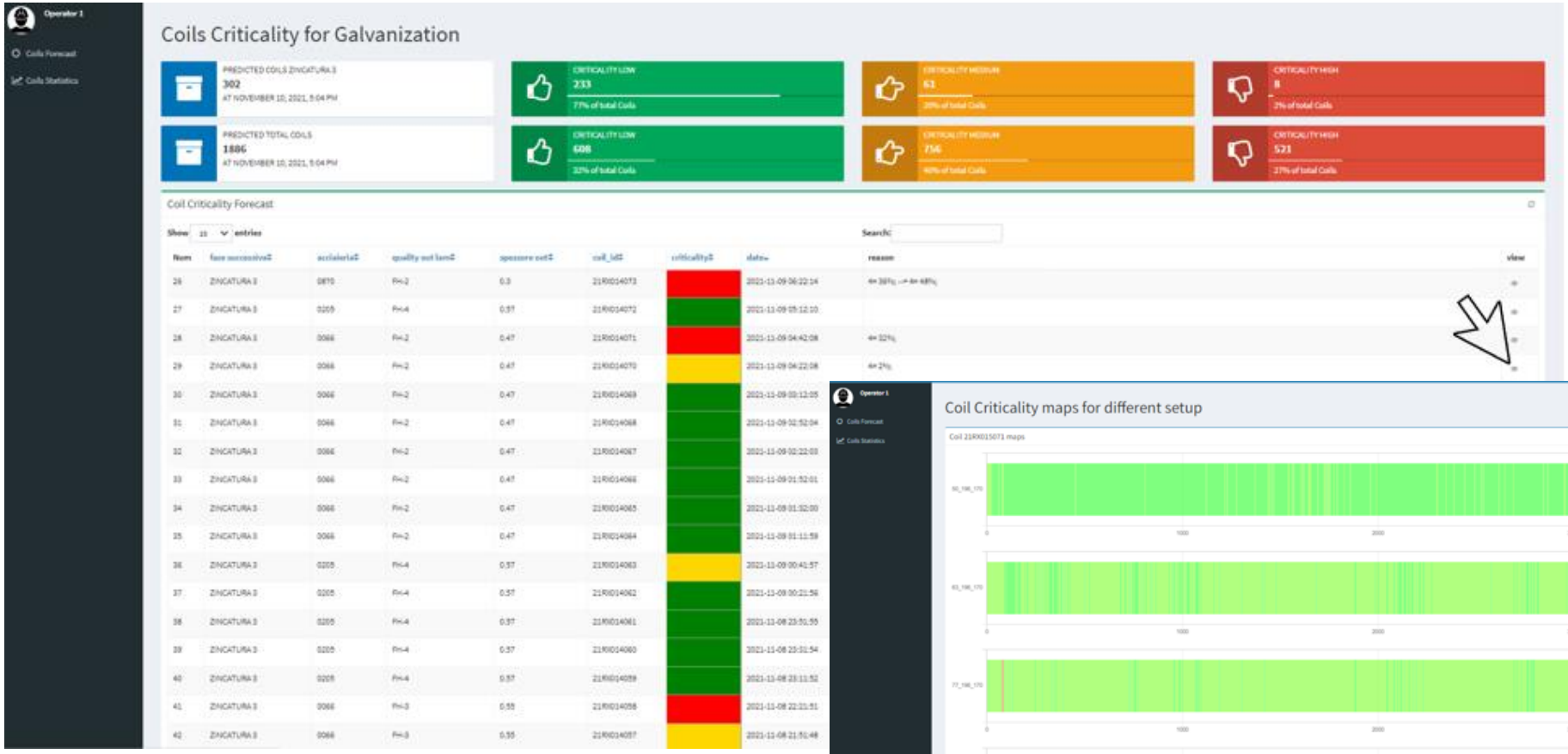
# Visualization of batch process (a)





Web Interface based on Apache Http Server

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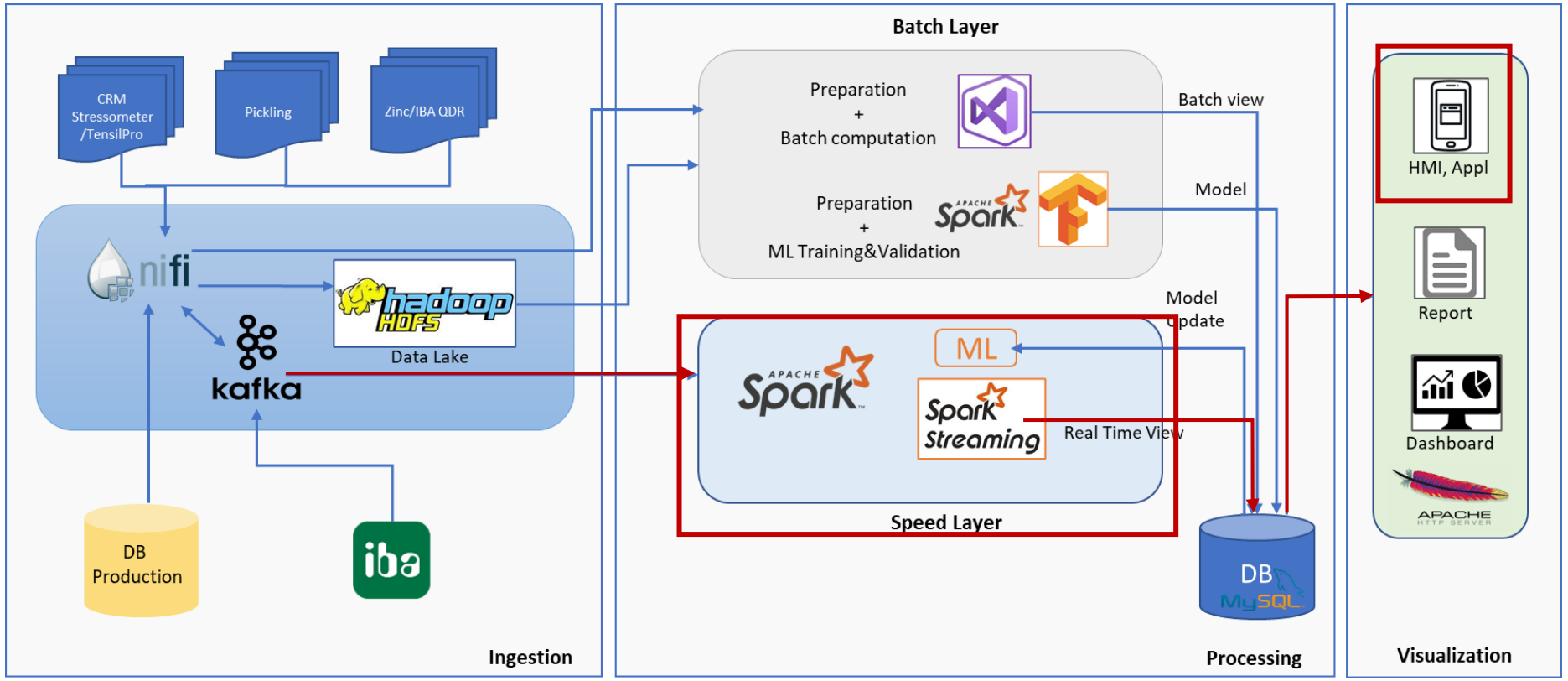
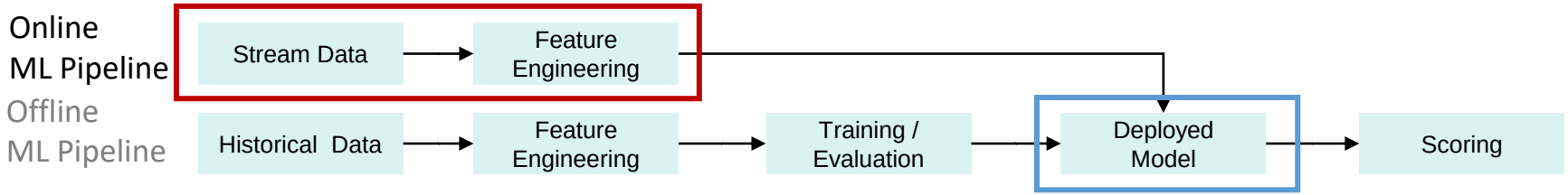
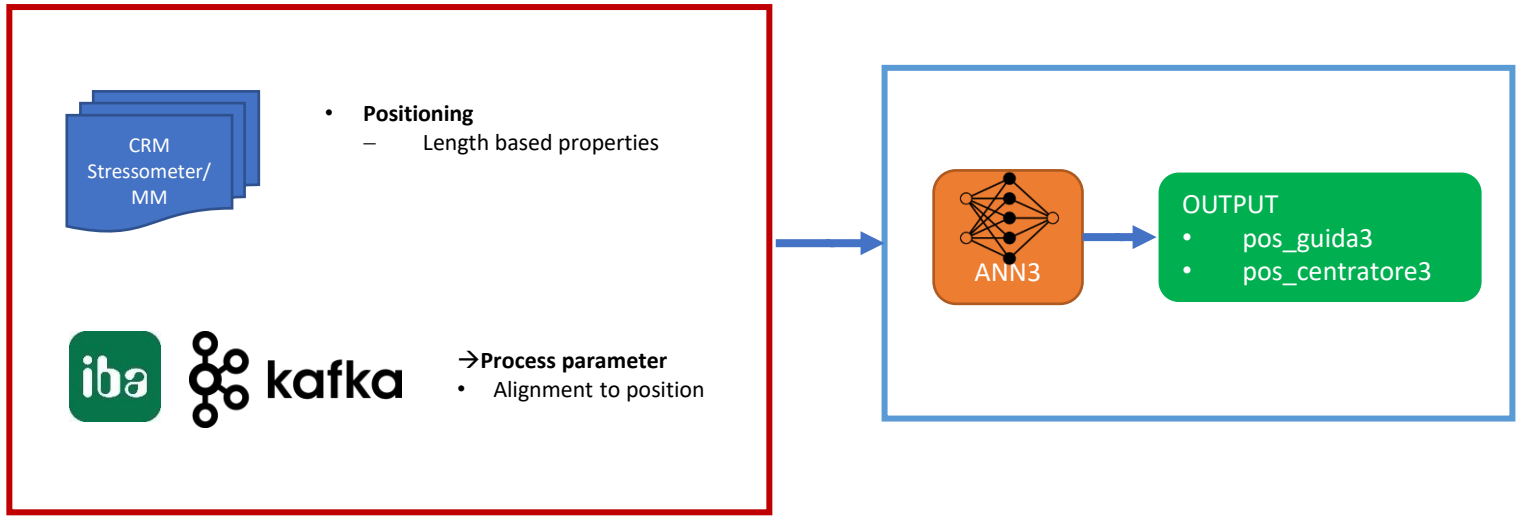
# Speed Layer Deploy



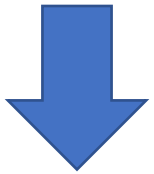
# ML Flow of real time process (b)



# Solutions and main achieved results

- Online data acquisition systems for high resolution process and quality data, by means of innovative tools from Big Data technology.
- Development of models for the monitoring and control of the quality of products depending on process parameters, using advanced Data Analytics and Machine Learning techniques.



✓ A better exploitation of available process and product data through innovative methods and tools for data handling improves the insight into the steel making processes and the enables the early identification of disturbing behaviour.

✓ A better production process supervision and an early detection of anomalies and instabilities corresponds to a reduction of downgraded products, a higher plant availability and a more sustainable production.

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# Thank you for your attention!

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