Machine Learning Applications for Furnace Control and Process Optimization in Steelmaking

Future Steel Forum, Budapest

September 26th, 2019

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Digital Engineering Director

Techint Group

OUR GROUP

At December 31, 2018

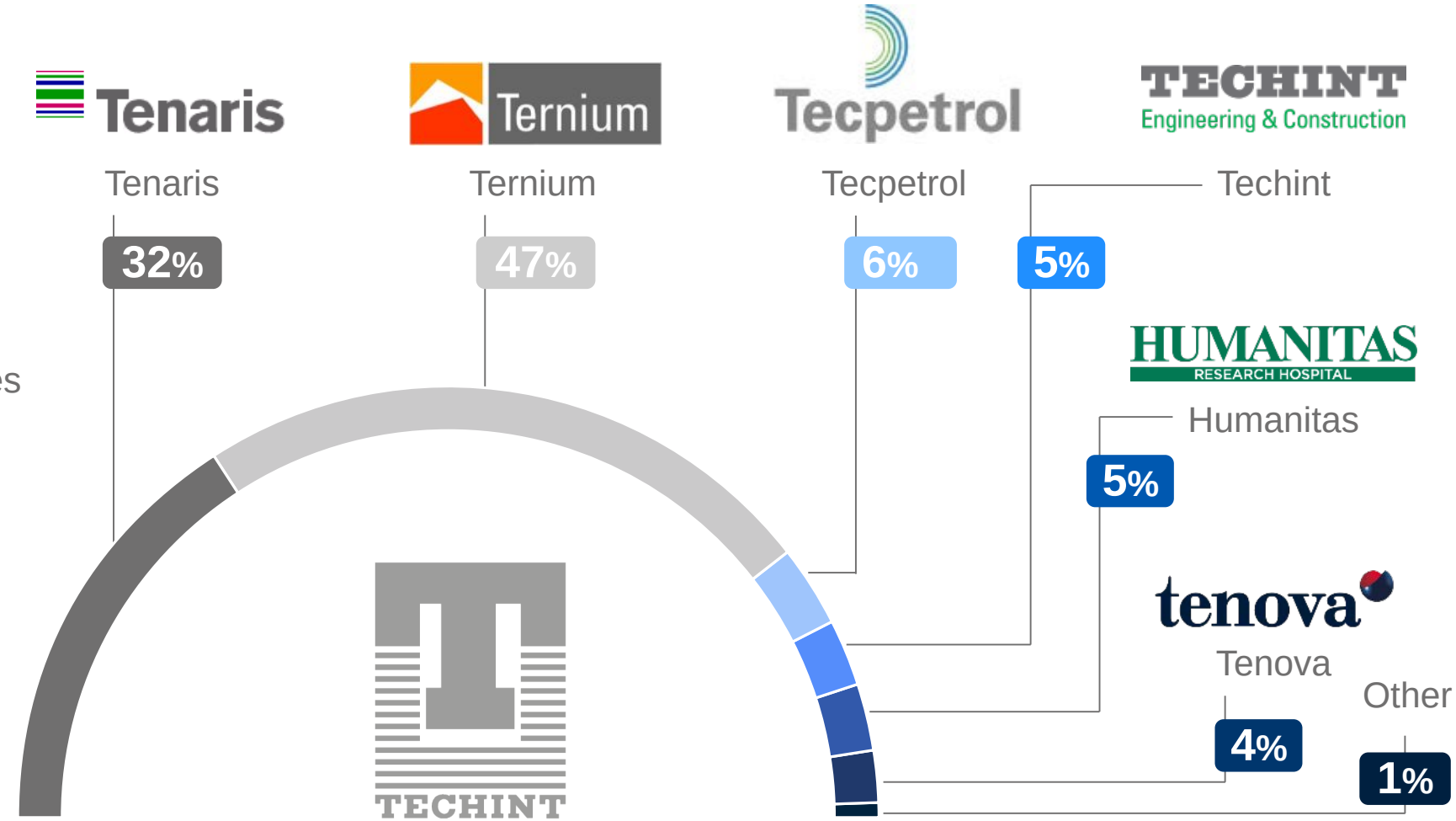
SIX MAIN COMPANIES WITH OPERATIONS WORLDWIDE

US $23.5 billion
Annual Revenues

57,100
Permanent Employees

74,500
Total Employees

5
Continents



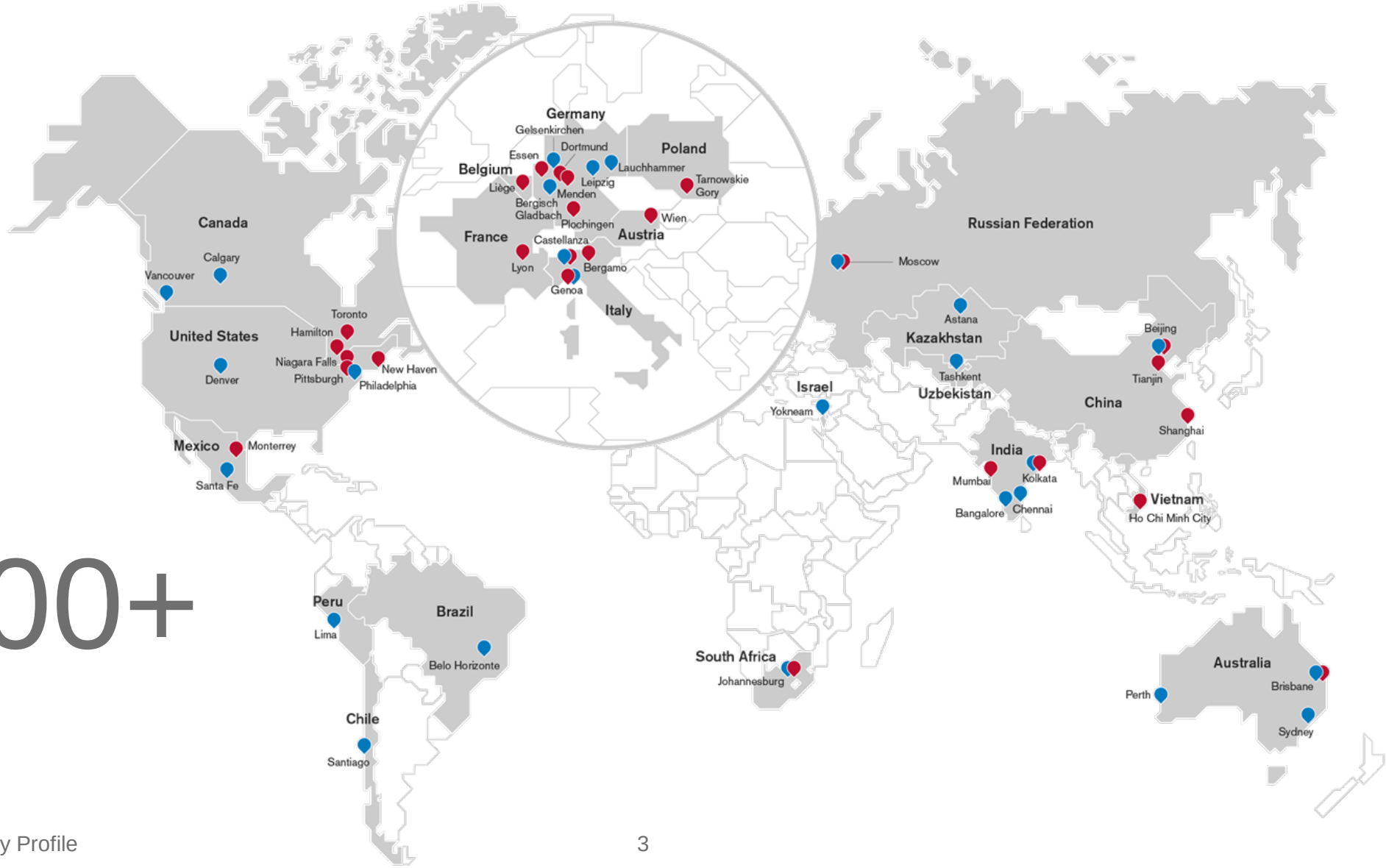
Tenova Company

OUR GLOBAL PRESENCE

19
Countries

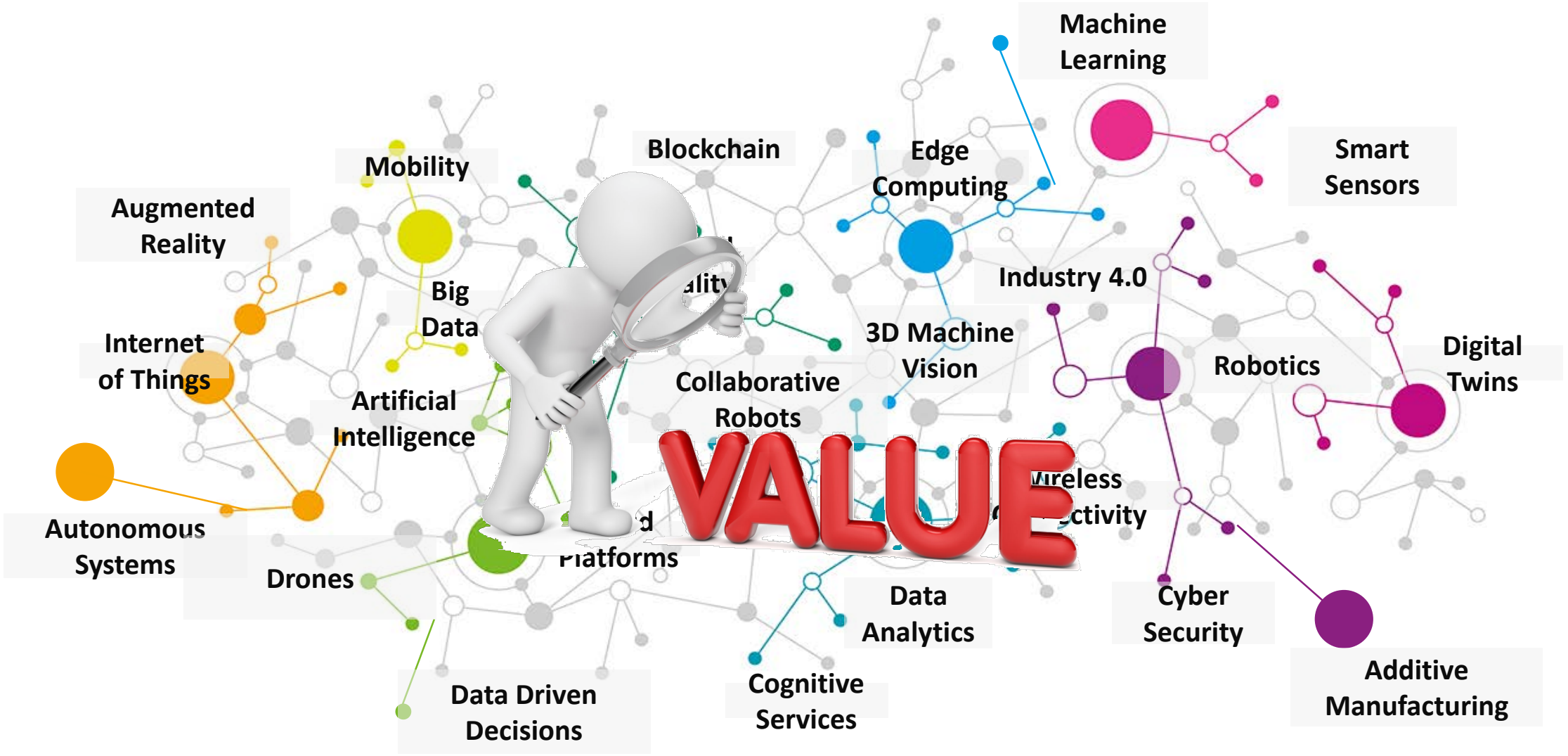
40
Locations

2500+
Employees



Technologies Driving the Digital Era

CHALLENGES OR OPPORTUNITIES?



Tenova Digital

NEW TEAM TO FACE NEW CHALLENGES

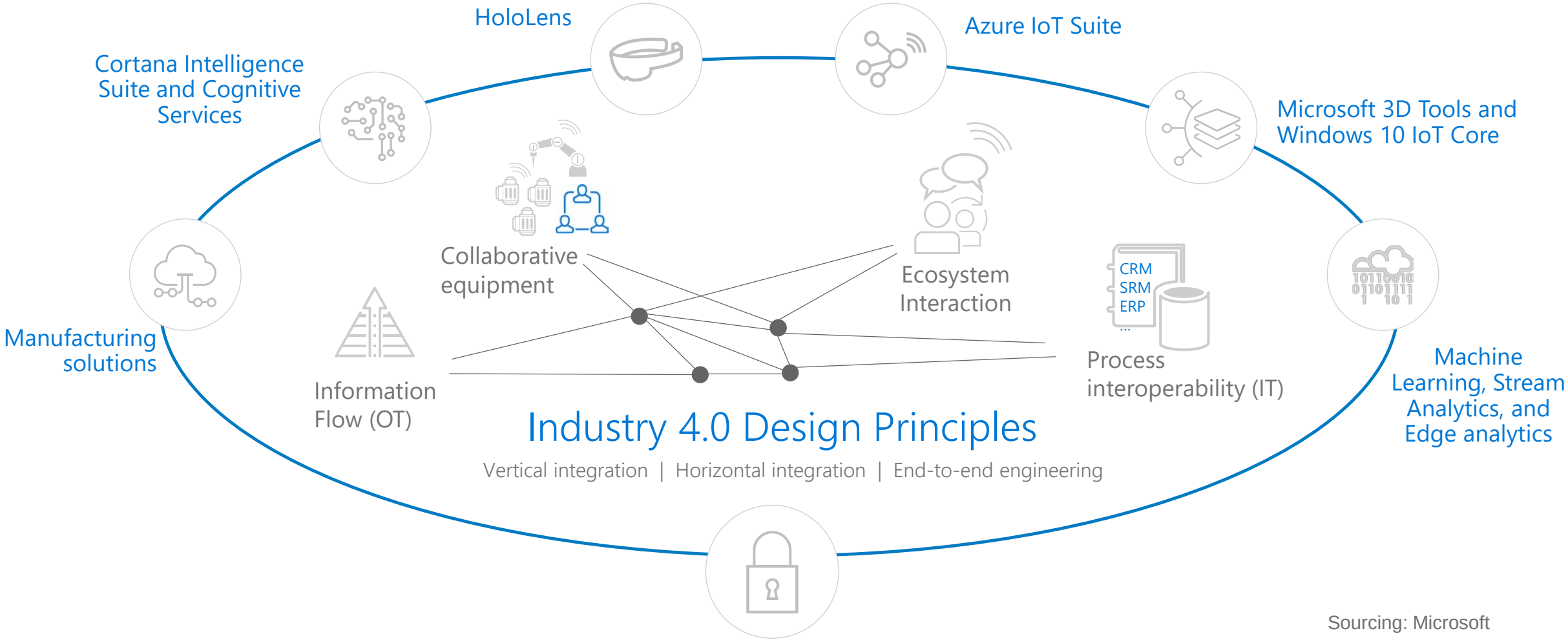
To solidify Tenova's position as the leading provider of products and services in the Metals and Mining Industries, making Tenova the ideal partner in a fast changing technological world

To identify, promote and facilitate a coordinated implementation of new services and business opportunities in Tenova as they are made available by emerging digital technologies

Project → Product → Service → Partnership

Partnership with Microsoft

TECHNOLOGICAL PARTNER WITH STRONG INDUSTRIAL BACKGROUND



Sourcing: Microsoft

Pilot Digital Projects

OUR FIRST STEPS IN DIGITAL TRANSFORMATION

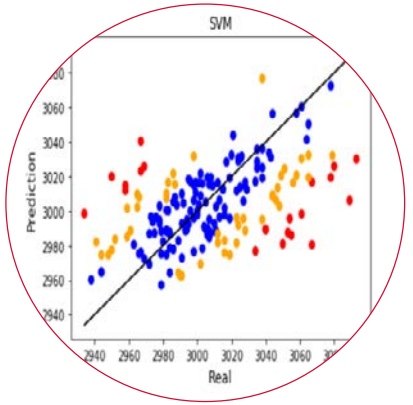
1

PREDICTIVE MAINTENANCE

2

REMOTE ASSISTANCE

3



PLANT OPTIMIZATION

4

DIGITAL CATALOGS

5

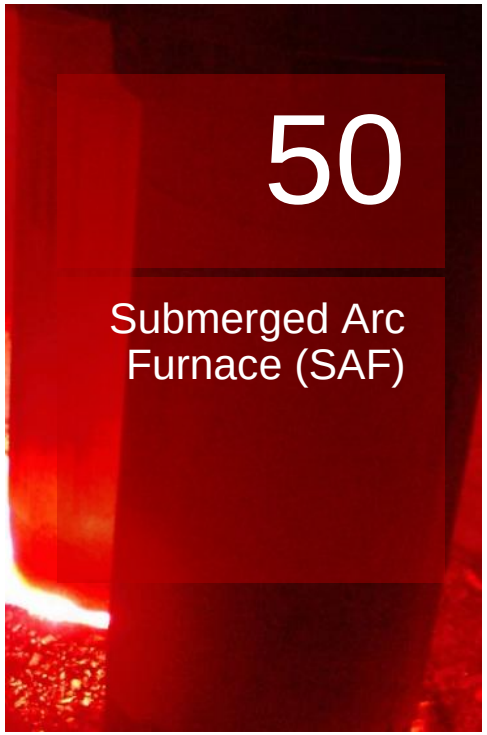
ROBOTICS

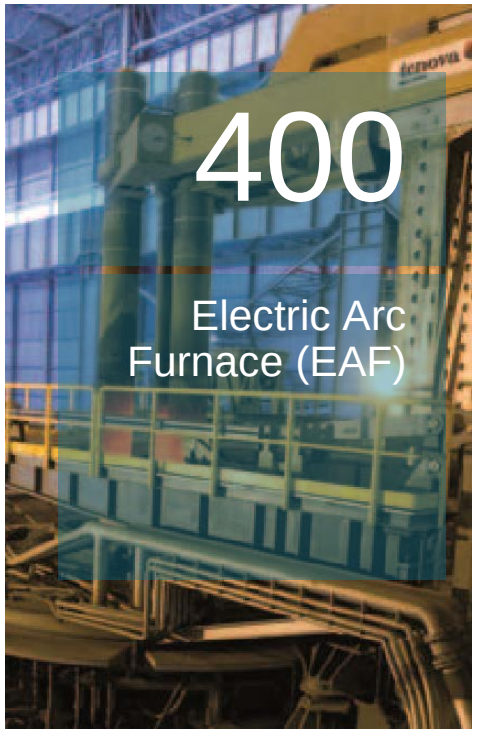
6

ADDITIVE MANUFACTURING

Our Connected Products in the Field

OUR «GOLD MINE»

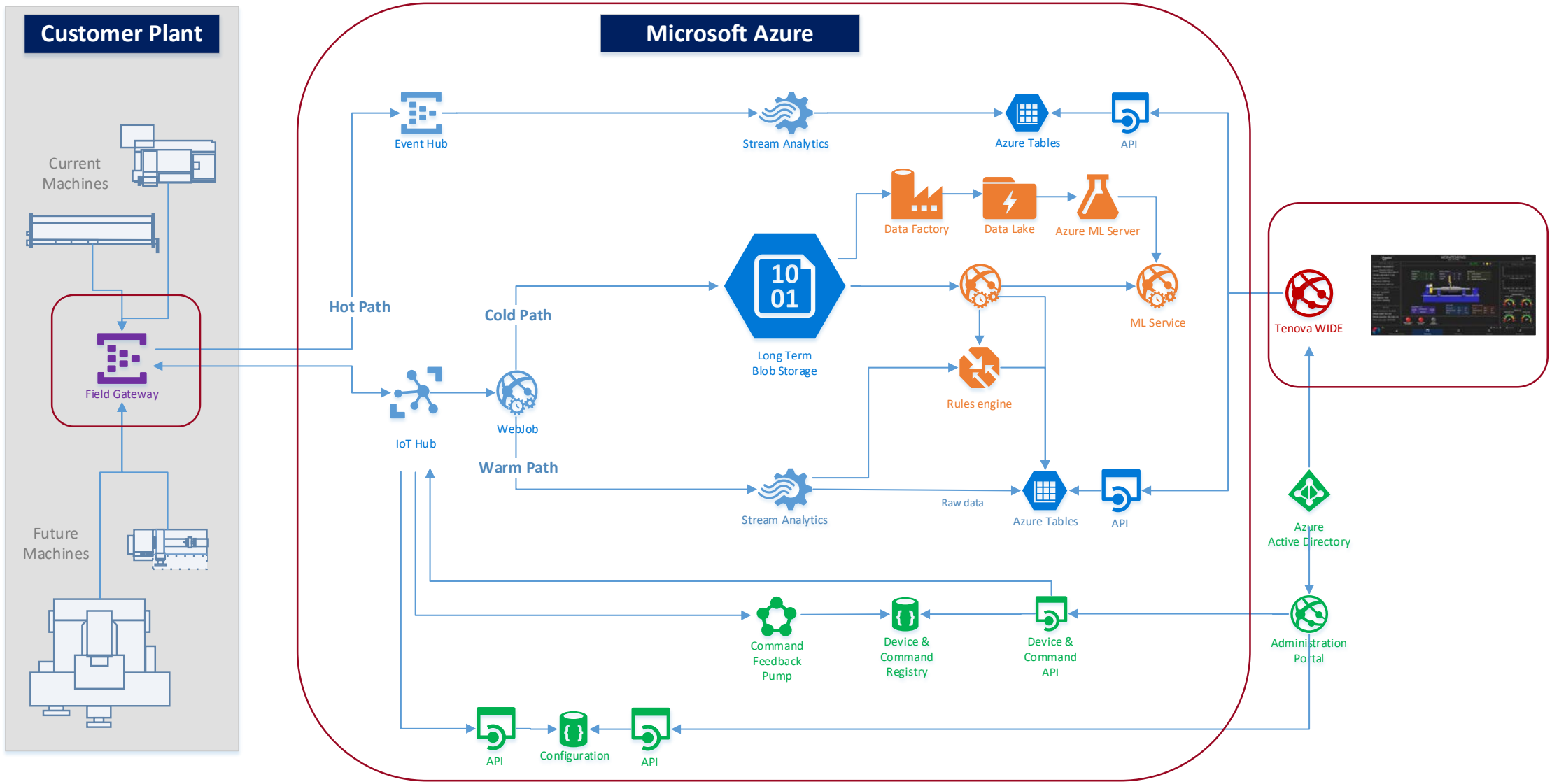





If data is the new oil…
…information is the new energy
…and decisions are the new end goal

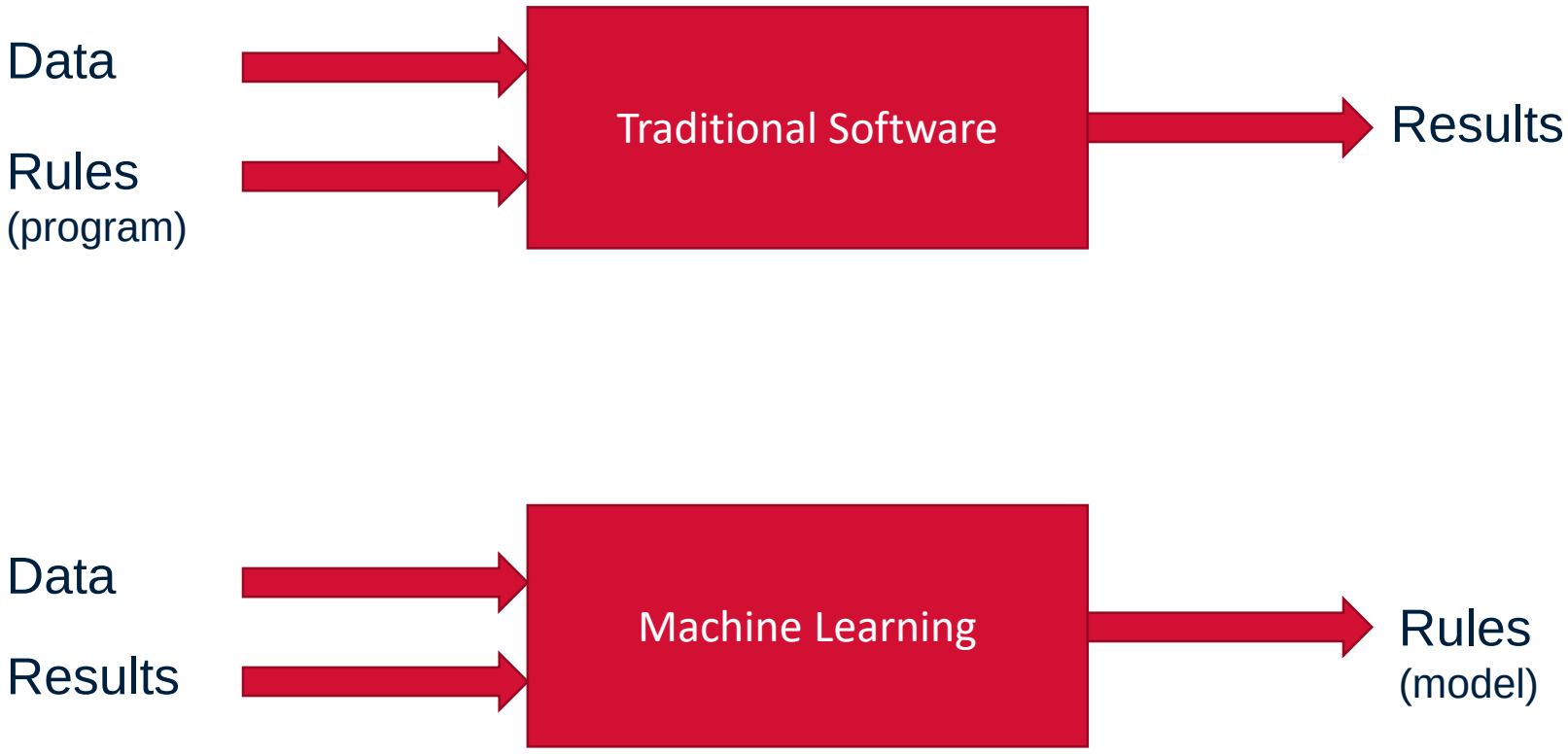
IoT Architecture

CLOUD PLATFORM



Machine Learning Simplified

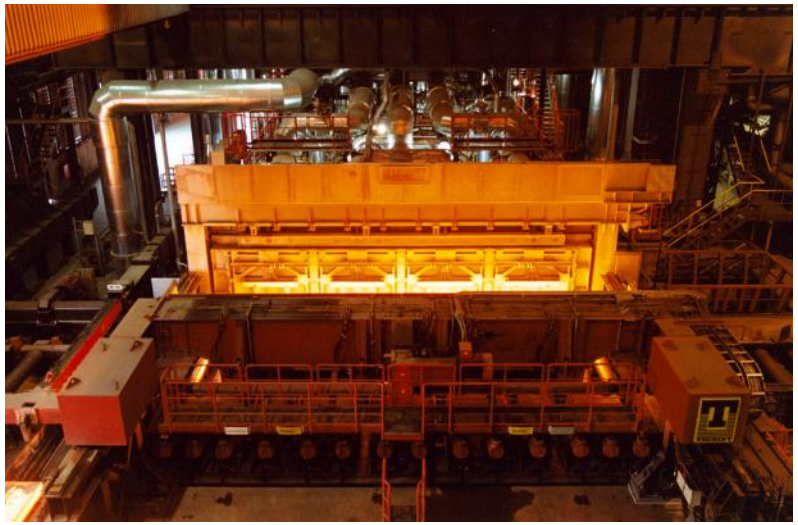
A «NEW» PARADIGM FOR SOFTWARE



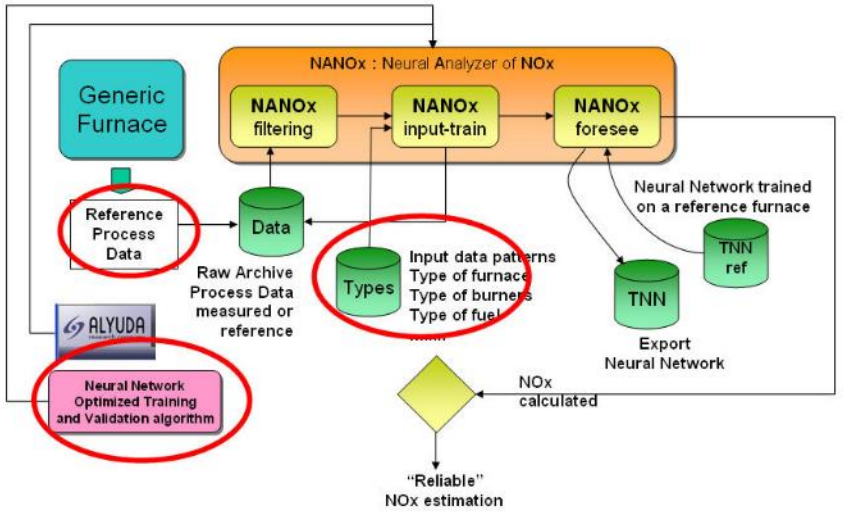
Predicting NOx Emissions with Neural Networks

WALKING BEAM FURNACE, 2008

2008



Walking Beam Furnace
TKS Duisburg



2.2.5 Task 2.5. Generalised model predicting NOx (Techint)

The NOx modelling at Techint is divided into the following sections:

- Predicting large and small scale NOx variations from reheating furnaces
- Overview of the analysis methods for predicting small scale NOx variations
- New model version

The multilayer perceptrons and circular back-propagation (CBP) networks architecture are described. An integrated approach to NOx prediction using Vector Quantization and CBP is described with reports from experimental results carried out on the 380 t/h WBF of TKS at Duisburg Beeckerwerth (Germany). The final version of the neural networks analysis was carried out in cooperation with the DIBE (Dipartimento di Biofisica ed Elettronica) of the University of Genova. A special thanks to the professors Paolo Gastaldo and Rodolfo Zunino. A new release of the NANOx model was implemented including the new theoretical algorithms.

European Commission

Research Fund for Coal and Steel

Minimising NOx emissions from reheating furnaces

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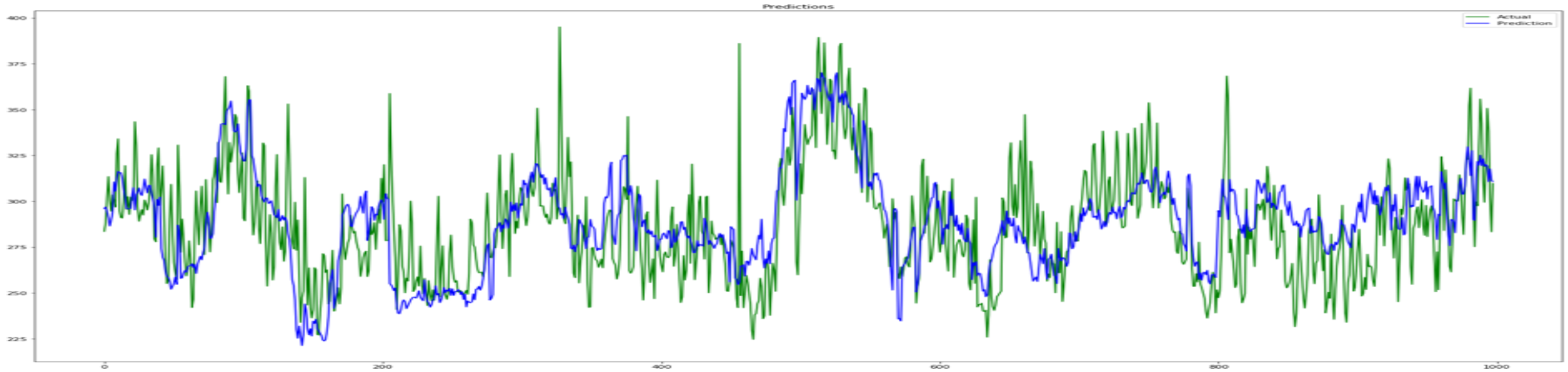
Final report

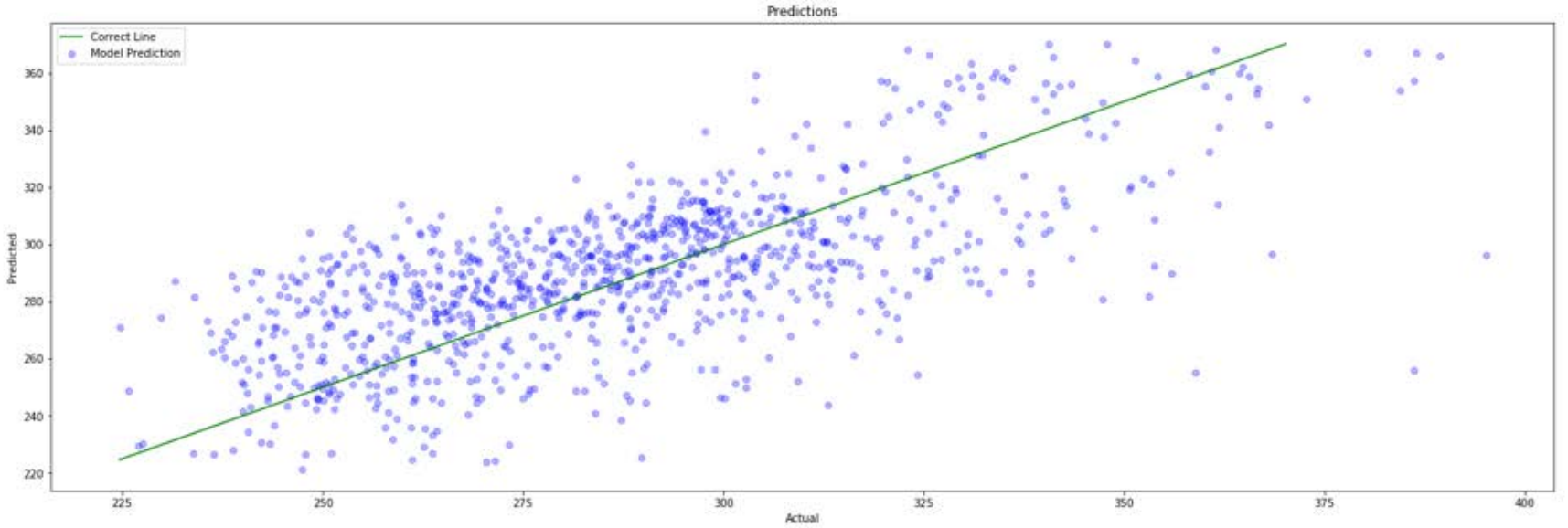
Directorate-General for Research
2008 EUR 23202 EN

Predicting NOx Emissions with Neural Networks

WALKING BEAM FURNACE, 2019



RMSE Train Set	21,6
RMSE Test Set	23,4
RMSE Mean	31,5
RMSE Median	31,0
MAE Train Set	16,0
MAE Test Set	18,3
MAE Mean	25,6
MAE Median	25,1

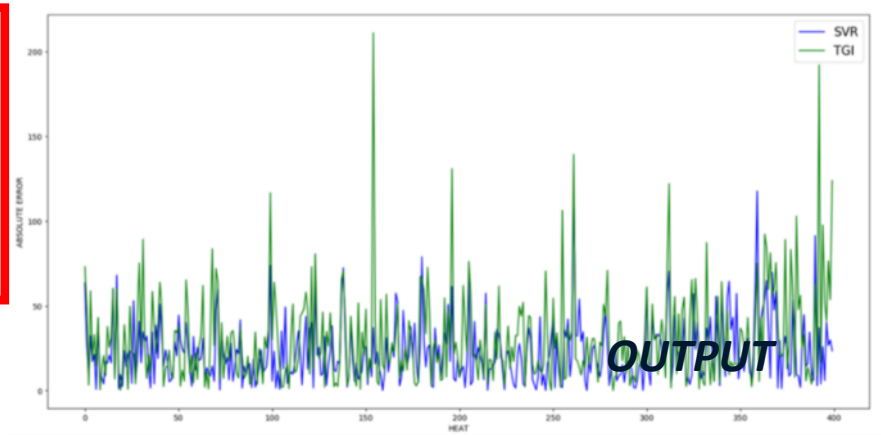


Predicting Steel Temperature in BOF Furnace

BASIC OXYGEN FURNACE

Static Charge Model for BOF developed by Tenova Canada:
Deterministic Mass/Energy Balance model to calculate input materials (HM,SC,..) and blowing Oxygen to reach steel end point
Goal to improve final temperature prediction accuracy for better use of fuel/coolant additions

	HM_WEIGHT	HM_TEMP	HM_C	HM_MN	HM_SI	SCRAP_WEIGHT	AIM_TEMPERATURE	AIM_C	TOTAL_OXYGEN	STEEL_TEMPERATURE
0	398600	2387	3.231382	0.316508	0.618012	159300	3010	0.039	455000	2987
1	403900	2542	3.233148	0.355045	0.546279	155800	3010	0.040	435000	3028
2	392500	2502	3.323361	0.344408	0.656939	173900	3010	0.040	460000	3066
3	412800	2380	3.252486	0.358415	0.540920	150400	3010	0.039	451000	2980
4	401100	2447	3.384791	0.304614	0.329392	149300	3000	0.039	440000	2966



Error on the test set:
RMSE of new predictive model: 30,6 degF
RMSE of deterministic model: 45.5 degF

RMSE Average Improvement: 30%

Data for approximately 4000 heats:
Predictions with error >50 degF reduced by 50% to 10%

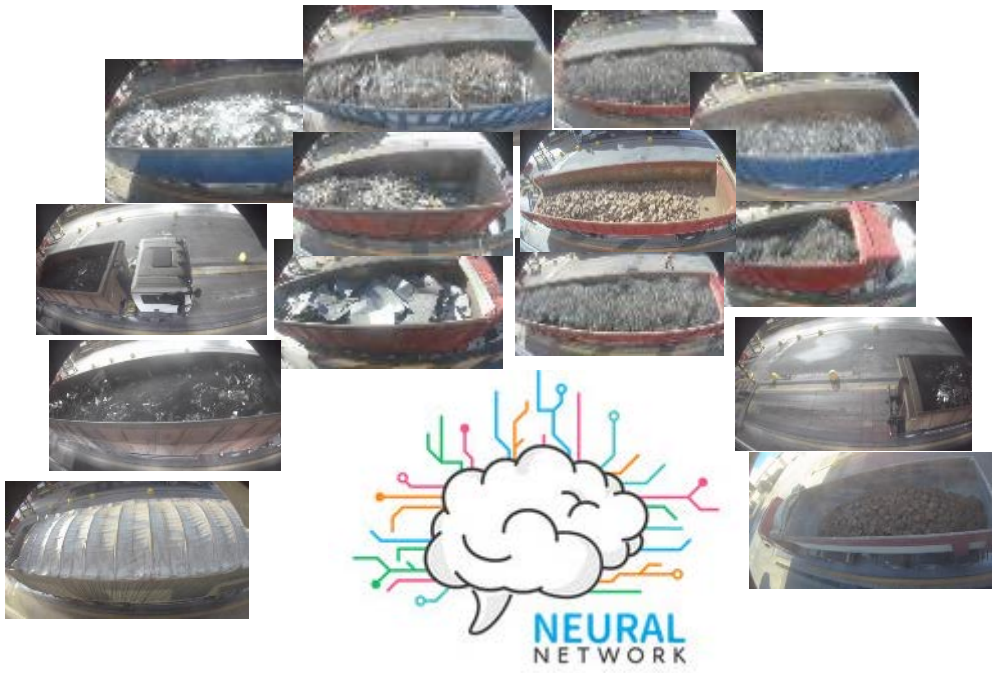
	SVR	Deterministic
MAE (deg F)	19.314	25.600
RMSE (deg F)	30.626	45.530
E < 25° F (% heats)	61.5	49.4
25 < E < 50° F (% heats)	27.7	30.8
E > 50° (% heats)	10.8	19.8

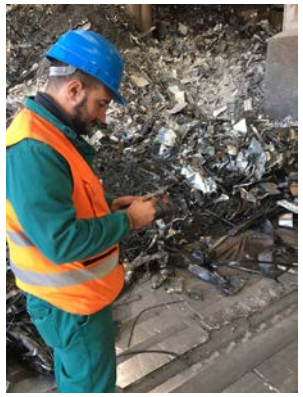
ORI Martin Lighthouse Project

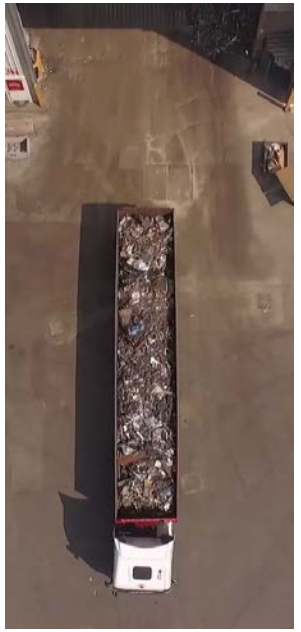
Automatic Classification of Scrap Category from Images

Using Convolutional Neural Networks

Training on 20000 images, 9 categories

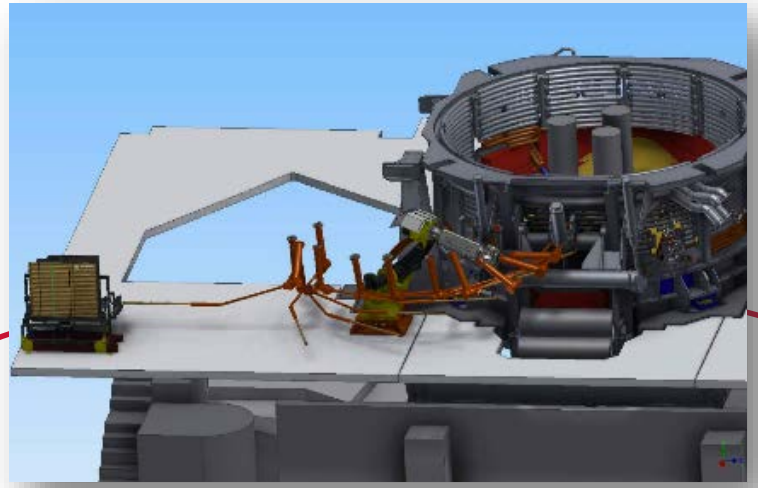






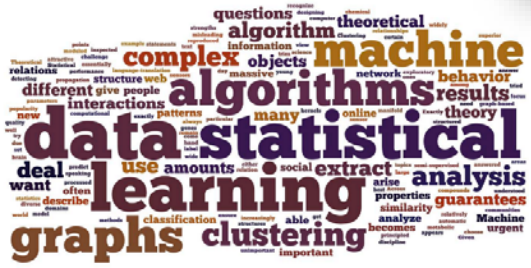
Smart Machine

VISION FOR THE FUTURE



Self-Optimizing Machines

Live data (sensors)



Predictive Maintenance

Cloud

Historical Data (Analytics)

The Future is Digital

VISION FOR THE FUTURE

«Every Business is a Digital Business»
Satya Nadella, CEO Microsoft

«Go Digital or go Home»
Dieter Zetsche, ex CEO Daimler AG

Artificial intelligence is a new form of talent, companies won't be able to compete without it

Digital Transformation Dilemmas

LESSONS LEARNED

Products *versus* Services

IoT & Sensors *versus* Digital Strategy

Exciting Technology *versus* Customer Value

Return on Investment *versus* Leap of Faith

Cost of Investing *versus* Cost of Not Investing

Predict and Control *versus* Learn and Adapt

Internal Digital Team *versus* Outsourcing Digital Projects

Digital Team *versus* Digital Organization

Alone *versus* Partnerships

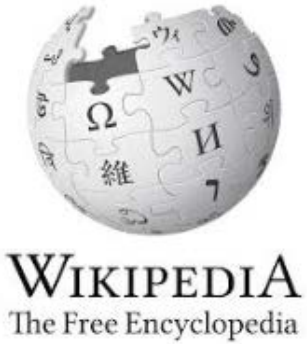
Backlog *versus* Innovation

Share *versus* Hide

https://www.linkedin.com/pulse/30-dilemmas-digital-transformation-giovanni-bavestrelli/

Lifelong learning is here to stay

HUMAN LEARNING



tenova

Thank You!

Giovanni Bavestrelli

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