Artificial Intelligence-enabled Autonomous Plant operations at CEMEX, with Petuum Industrial AI Autopilot

Rodrigo J. Quintero, CEMEX
Prabal Acharyya, Petuum

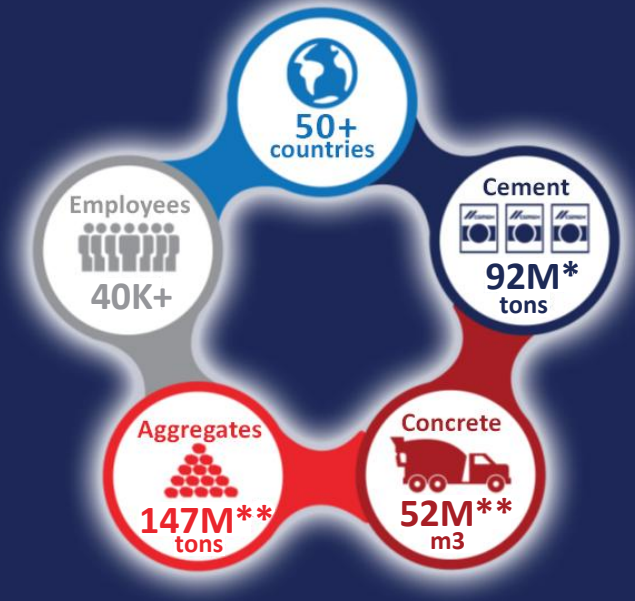
Company overview

Business

CEMEX is a global building materials company that provides high-quality products and reliable service to customers and communities in more than 50 countries throughout the world.

A global industry leader

- Annual sales of US$13.67 billion
- One of the leading cement manufacturers, ready-mix and aggregates in the world
- One of the world's top traders of cement and clinker



* Production Capacity ** Annual Production Levels

2017 Annual Report https://www.cemex.com/about-us/company-profile

Rodrigo Quintero

About the Presenters

- Rodrigo J. Quintero
- Operations Digital Technologies Manager
- CEMEX

- Prabal Acharyya
- Head of Industrial AI
- Petuum

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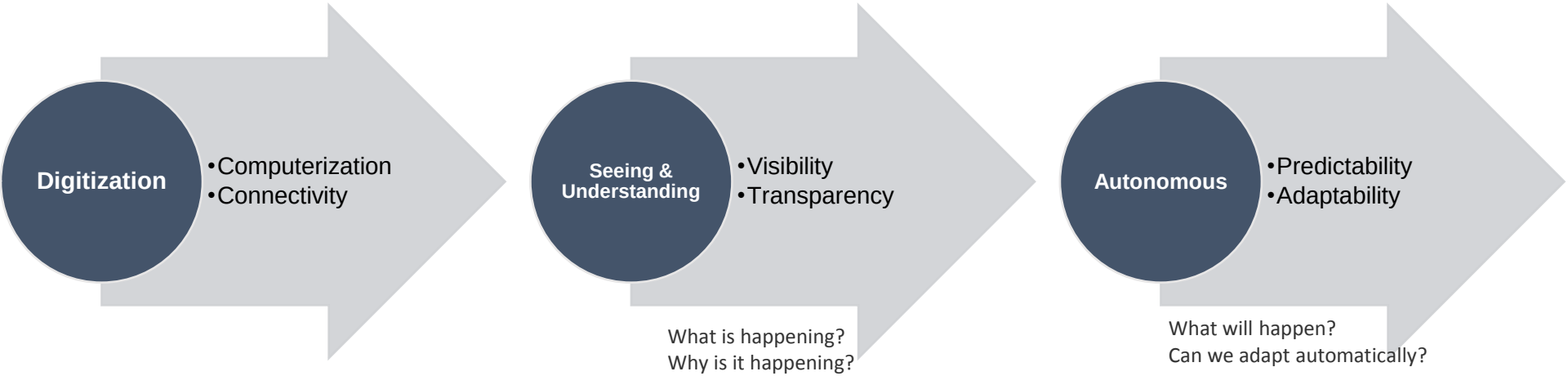
Agenda

- Artificial Intelligence(AI) Potential for Cement Industry
- Cemex : How we got started on the path to AI
- Petuum and Petuum Industrial AI – An Overview
- Autopilot with “Autosteer” for Autonomous Cement Plant Operations at Cemex
  - Cooler, Kiln, Pyro Process , Vertical Mill, Ball Mill examples
  - Fuel Mix (Alternative Fuels), Emissions, Benchmarking, Energy Management
- Petuum Deployment Architecture with OSIsoft PI
- Next Steps

Industry 4.0 : The Digital Transformation Journey

Industry 4.0
What's next?



Connected 1

Prescriptive 2

Autonomous 3

Why Artificial Intelligence?

Artificial intelligence holds the key to future growth and success

In cement operations, artificial intelligence assisted operation can help our plants realize manufacturing process improvements and achieve strategic goals in:

- Safety performance
- Operational Efficiency
- Energy efficiency and alternative fuels substitution
- Quality Assurance and product design

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Artificial Intelligence in Cement Operations

Why is AI so crucial for manufacturing? There are multiple potential applications in

- Failure prediction (operative and corrective failures)
- Production processes optimization
- Predictive Maintenance
- Remote operation & digital twins
- Product design and quality; smart supply chain

*"If you don't have the capability to digitalize the manufacturing processes, your costs are probably going to rise, your products are going to be late to market, and your ability to provide distinctive value-add to customers will decline."**

How can we test the technology, its capabilities, and how to take advantage from it?

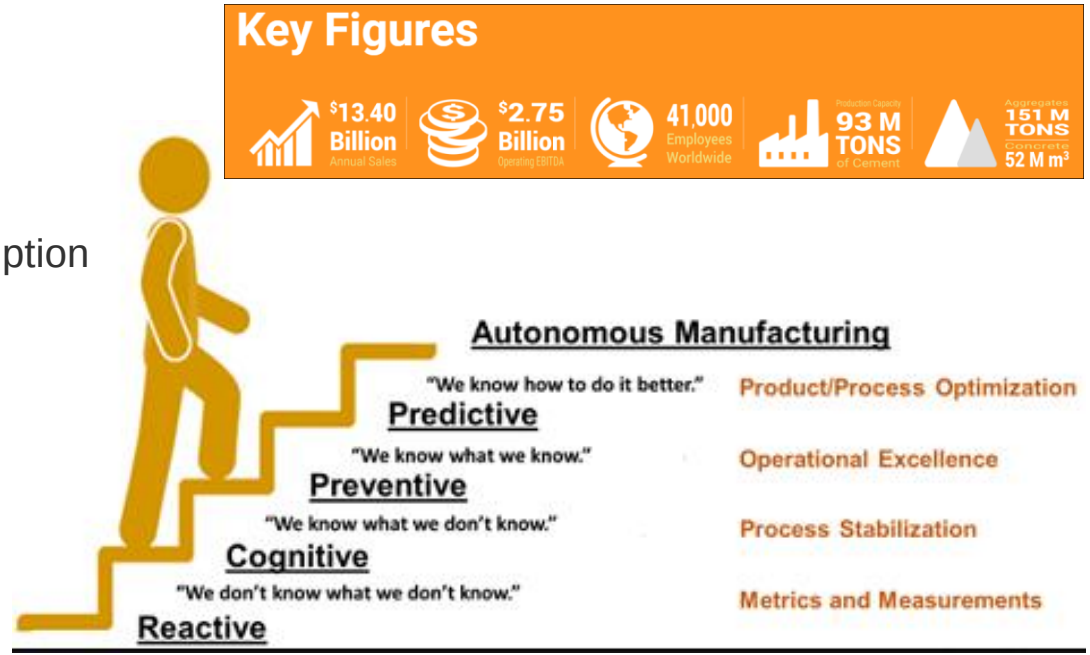
PETUUM and CEMEX pilots

*Source: *"How AI Builds A Better Manufacturing Process"* - Forbes Magazine, Jul 17, 2018

CEMEX AI Pilot: On an Industry 4.0 Journey

CEMEX Autonomous kiln 2022

- Increased Efficiencies
- Reduced fuel & energy consumption
- Better Quality
- Reduced Costs
- Improved Decision Making



Why Petuum AI Autopilot with Autosteer

- Collaborative approach/engagement
- Phased approach:
  - **Predict** : Real time forecasts help boost understanding
  - **Prescribe Only (Autosteer OFF)** : Prescriptions can be validated by operators before updating the setpoints.
  - **Autosteer ON**: Supervised controlled autopilot operation integrated with plant control systems

Use Case: Clinker Cooler Optimization

The cooler transfers the heat from clinker to combustion air to:

- Increase heat recovery
- Obtain clinker at a temperature suitable for grinding
- Maximize clinker potential strength through rapid cooling

Goal

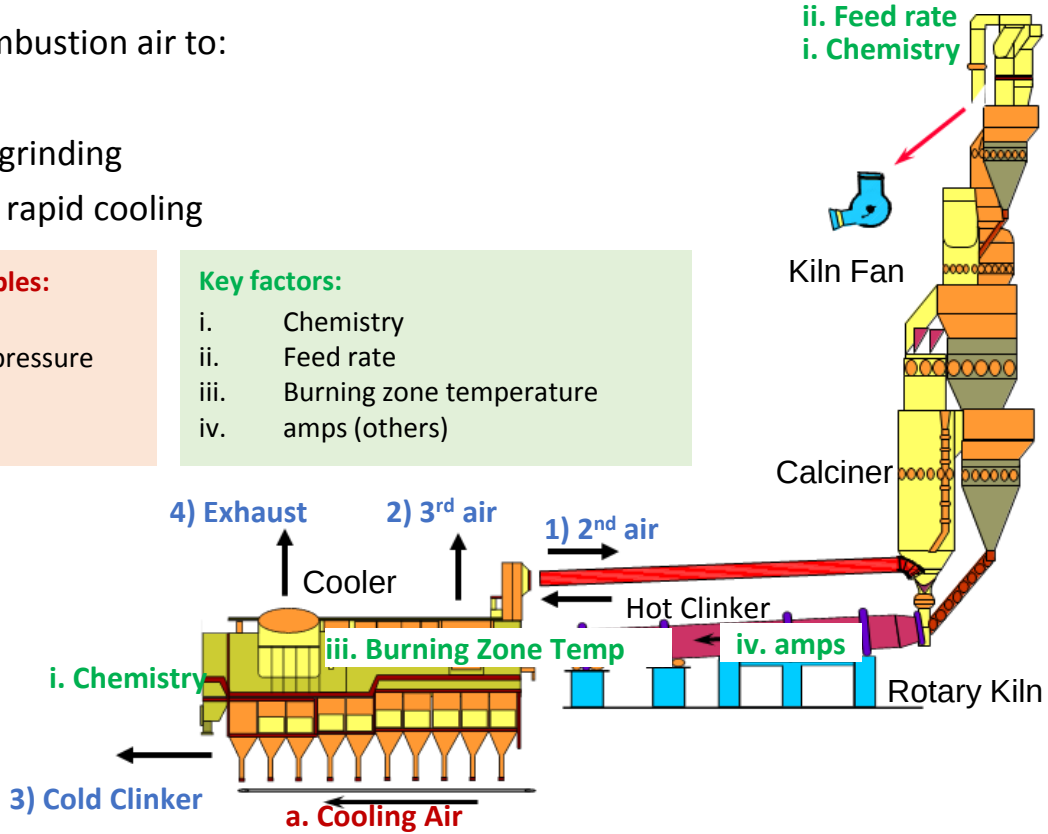
1) Maximize 2nd air heat
2) Maximize 3rd air heat
3) Minimize Cold Clinker heat
4) Minimize exhaust gas heat

Controllable variables:

a. Fan flow
b. Undergrate pressure

Key factors:

i. Chemistry
ii. Feed rate
iii. Burning zone temperature
iv. amps (others)



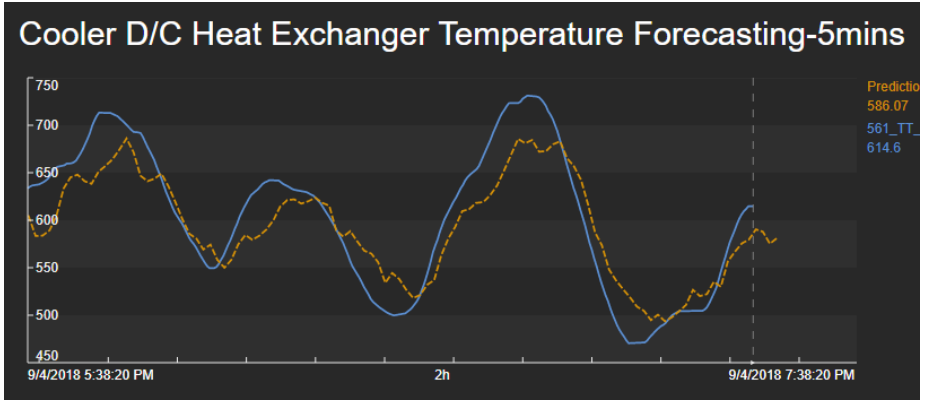
Note: Variables and key factors full list depends on use case complexity; typically contains 40+ variables

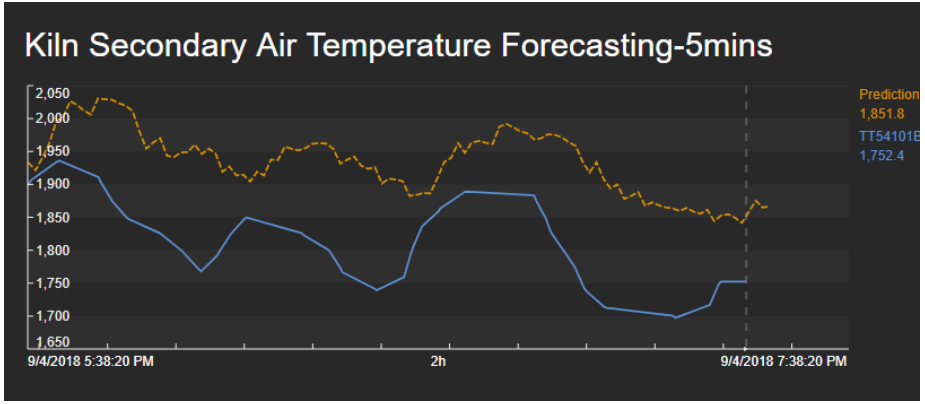
Phased Development

Phase I: Forecast prediction in real-time (Mode: Prediction)

- Identify output variables for AI model to predict behavior 5 to 15 minutes in advance
- Allows kiln operators to take actions if they identify issues before these occur
- Forecast can predict values
- Forecast can predict change in slope

All actionable items rely on kiln operator's knowledge, experience and intuition



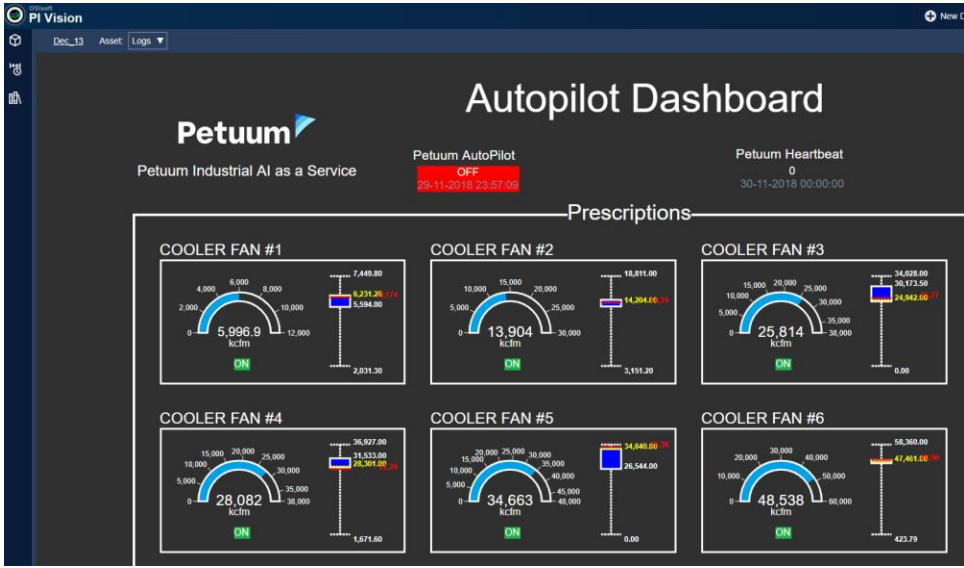


Phased Development

Phase II: Prescriptive Recommendations in real-time (Mode: Prescription)

- The AI model can recommend setpoints for the control variables in real time
- Operators need to validate if recommended setpoints are within operating range before making a decision
- Kiln operator has to accept and input manually the prescriptive recommendation into the control system

All actionable items support kiln operator's knowledge and experience to improve performance

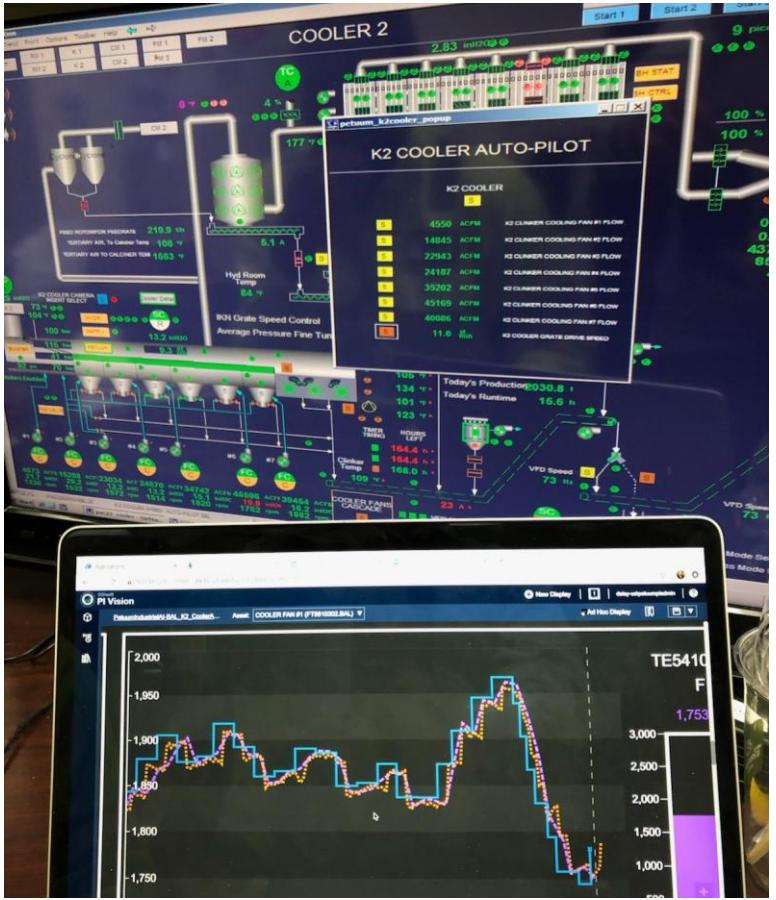


Phased Development

Phase III: Auto-pilot operation of kiln's cooler section (Mode: Autosteer)

- The AI model submits setpoints for the control variables in real time to control system via PI
- Operators can monitor in real-time if auto-pilot operation is aligned to normal operating parameters
- Kiln operator can engage-disengage autopiloting the control system in case of process disruptions (i.e.- power failure, kiln push, blockages, etc.)

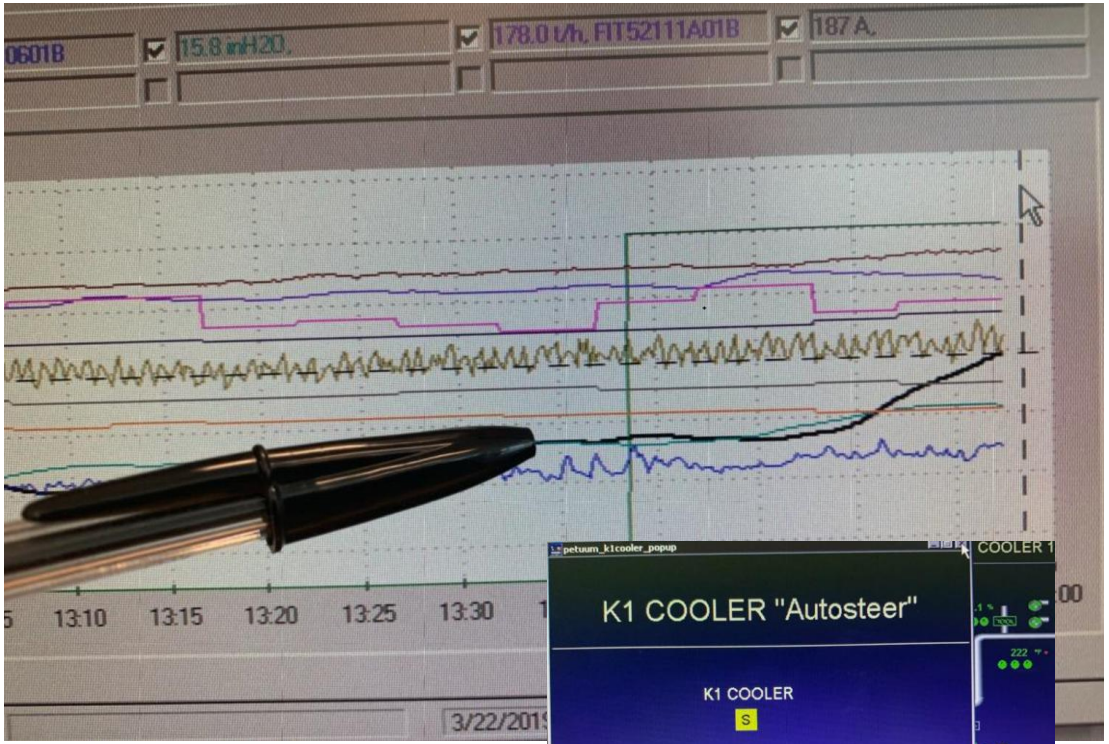
Operators can supervise auto-pilot operation while concentrating on other kiln parameters (similar to a car's cruise control).



Autosteer delivers Immediate Results

As soon as “Autosteer” picks up driving the asset operation, immediate results are achieved.

- Secondary Air Temp for K1 Cooler (black line), resulting in energy savings as soon as the Autosteer is switched ON by the Operator.



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Achievements

Phase I: Forecast prediction in real-time

- ✓ Successfully predicted Clinker and Air temperatures and trend slope changes as outputs of cooler up to 15minutes in advance
- ✓ AI Prediction model showed better results compared to previous POCs using linear modeling to forecast clinker quality (free-lime modeling)

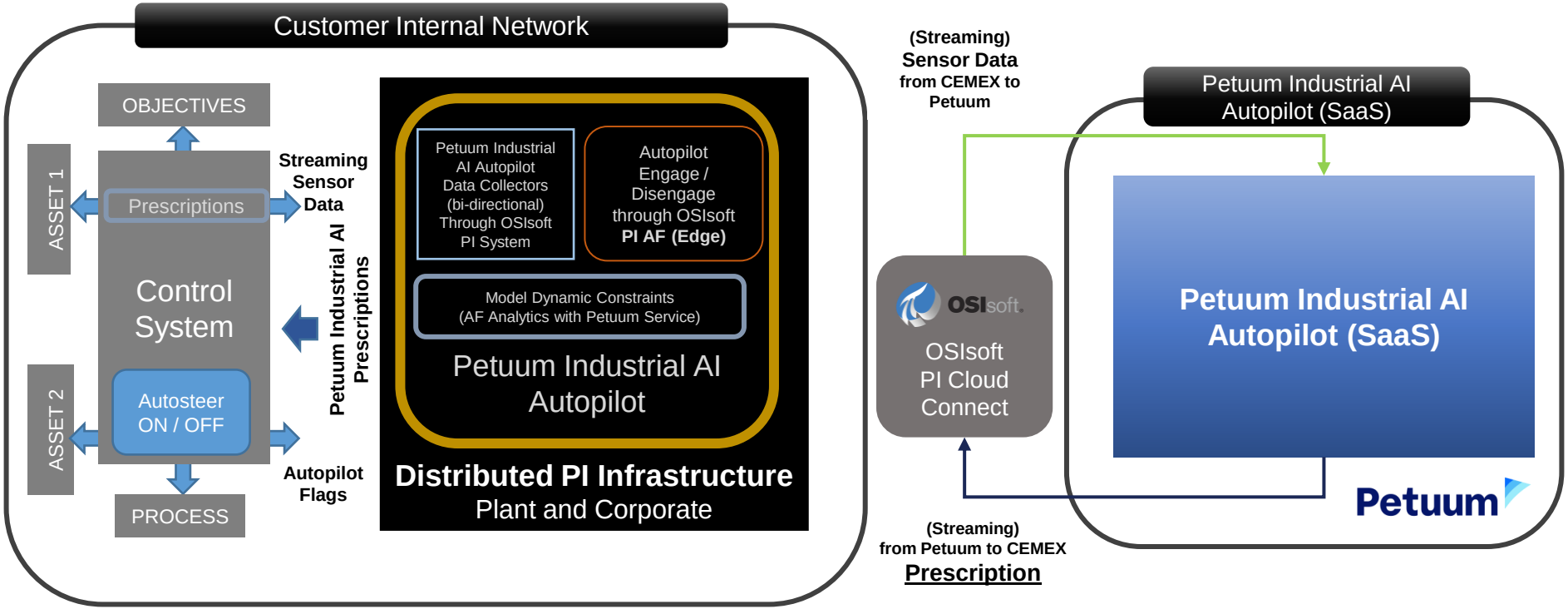
Phase II: Prescriptive Recommendations in real-time

- ✓ Relayed recommendations to kiln operators. Model improvements introduced additional constrains to make recommendations reasonable and actionable

Phase III: Autosteer operation of kiln's cooler section

- ✓ Successfully ran kiln cooler using artificial intelligence
- ✓ AI-supported kiln cooler is obtaining higher exit air temperatures when auto-pilot is engaged

Petuum Industrial AI Autopilot Architecture



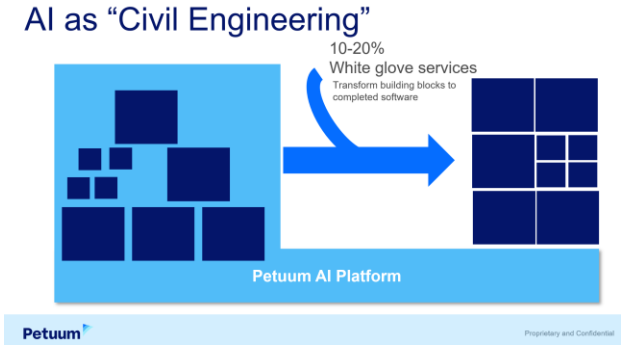
Petuum

Petuum Industrial AI Autopilot

About Petuum

Industrialize AI technology

Turning it from black-box artisanship into standardized engineering process



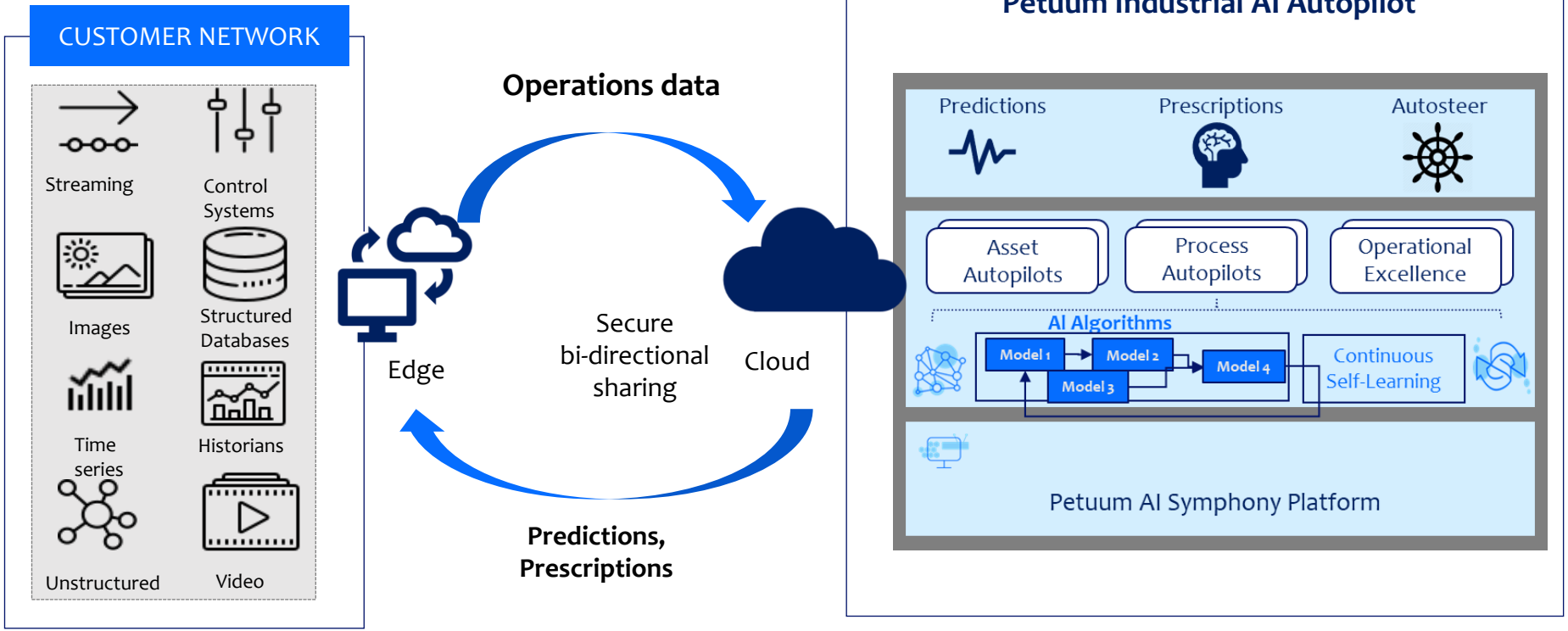
- 150+ employees and growing
- 30+ PhDs, over half from CMU AI research program
- Majority of employees in product, engineering, and AI research. Multiple best publication, PhD dissertation & industrial AI awards

All-Inclusive AI

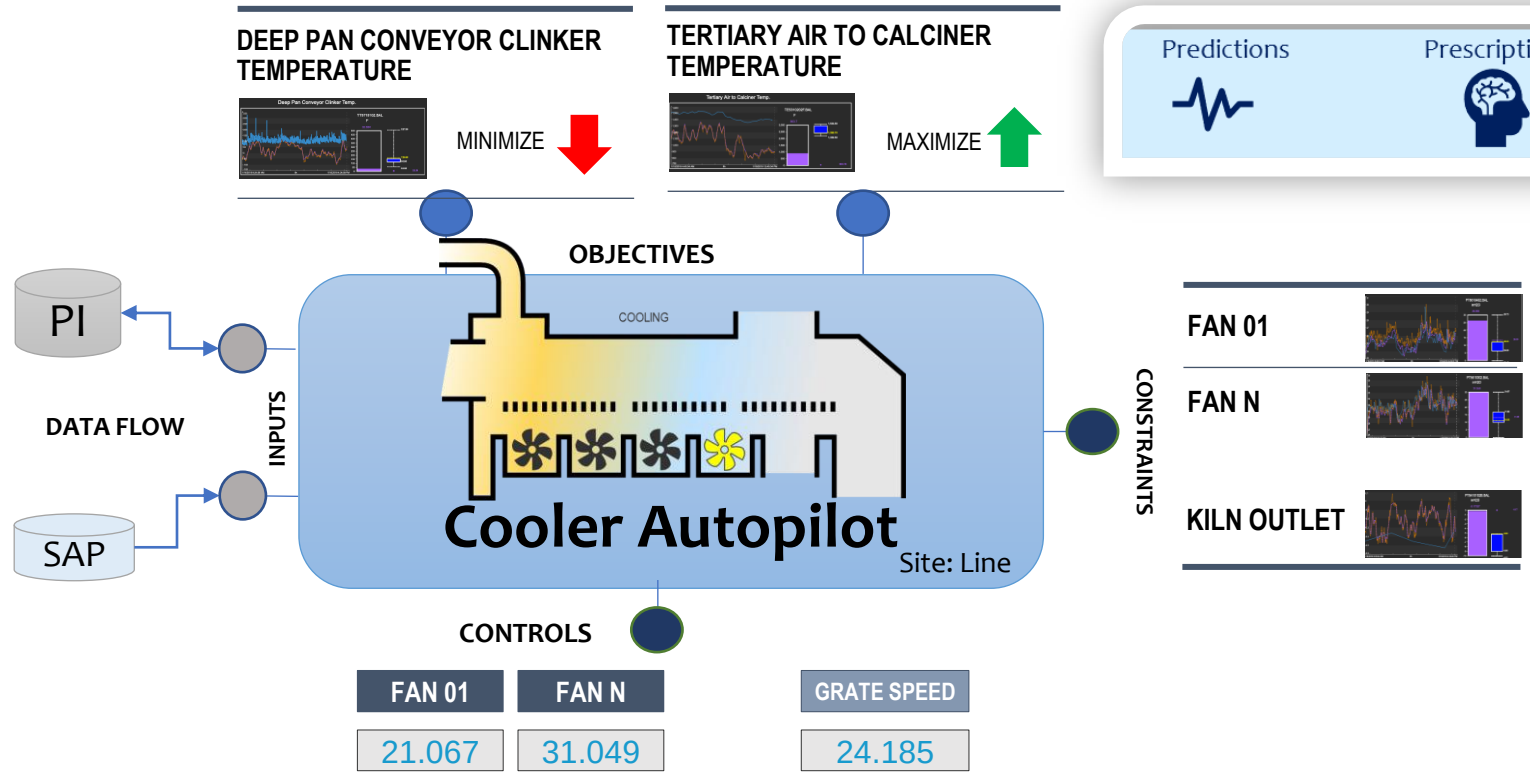
Petuum enables and orchestrates AI for the enterprise with vertical industry solutions. Our solutions deliver ready-to-use AI in numerous verticals, pre-built with the right context and templatized for minimal customization by sub-segments.

Industrial | Financial Services | Healthcare

Petuum Industrial AI Autopilot



Cooler Asset Autopilot - Deployed



Petuum | OSIsoft Integrations

1. PI Web API

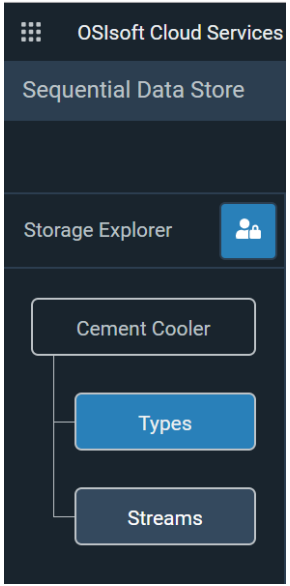
2. PI Connectors and Interfaces
(e.g PI OPC Read-Write)

3. Asset Framework and Asset Analytics

4. PI Vision including custom controls

5. OSIsoft PI Cloud Connect
Next: OCS

COMING SOON



Benefits of Petuum Industrial AI

INCREASED YIELD

Increased operator and equipment productivity through autopilot operation of:

- Cooler
- Rotary kiln
- Pre-heater
- Ball mill
- Vertical mill

REDUCED COSTS

Cut energy costs for pyro process while maintaining high quality through:

- Optimal usage of renewables in the fuel mix
- Minimize energy consumption with access to real-time log data, pyro images, timeseries sensor data

ACHIEVE OPERATIONAL EXCELLENCE

Improve sustainability through reduced emissions

Increase asset utilization through:

- Extended kiln campaigns for benchmarking across lines
- Fleet management of equipment
- Optimized field services for preventive/predictive maintenance

Est 2-5% savings in energy costs and >2% higher overall yield

CEMEX

LEVERAGING THE PI INFRASTRUCTURE & PETUUM INDUSTRIAL AI AUTOPILOT WITH AUTOSTEER TO DRIVE AI-ENABLED AUTONOMOUS OPERATION

CHALLENGE

Predictable, repeatable ”golden day” operations – high yield, high quality at low cost sustainably

- Prove AI / ML capabilities to optimize production processes
- Complex, highly variable operations
- No real time prediction, reactive operator actions

SOLUTION

- Petuum Industrial AI taps into PI system and other sources to deliver real time forecast of process variables, prescriptions for operator actions and a supervised auto-steer
- Integration with OSIsoft suite of products for configuration, data streaming and visualization
  - PI Cloud Connect, PI WebAPI
  - PI AF, PI OPC Read-Write
  - PI Vision incl. Custom Controls

RESULTS

Expected yield and energy improvements in the range of 2-7% from combined use cases

- Reduced process variability
- Increased throughput
- Cost reductions from increased energy recovery:
  - Secondary Air ΔT: +100 °F
  - Tertiary Air ΔT: +15 °F
  - Clinker Temp ΔT: +5 °F (did not decrease; acceptable)

“This is a giant step in digital transformation towards safe, highly standardized operations, that will help us strengthen our high-quality products portfolio while also ensuring we meet our operational and sustainability goals, and minimize costs.” – Rodrigo Quintero, CEMEX

Lessons Learned

- ✓ Company commitment from both corporate and plant leadership is key to successful implementation of new technologies
  - Initial implementation took about 2-3 months, go-Live (27-Nov-2018).
  - Now, we are working with Petuum to deploy Autopilot with Autosteer at multiple sites and use-cases.
  - Subsequent implementations reduced to weeks.
- ✓ AI is not magic: Autosteer mode initially started to run only under stable conditions; it is being expanded to other conditions with different dynamic and static modes.
  - SME input to improve modes of operation
  - Reliable sensors and data are critical
- ✓ Change Management is critical: Autosteer started with engagement only when plant supervision is available (day-shift only).
  - Our goal is to run Autosteer round the clock as plant operators take full ownership of the process.
  - Support is key: CEMEX's C3 / Center of Excellence to provide process support, and Petuum's Live Tracking & Alerting 24x7 to achieve continuous operation.
  - A good change management process can make transition to new technologies faster, easier.

Questions?

Please wait for the **microphone**

State your **name & company**

Please remember