# EUR19_38 - Big data for Operations: from use case to Insights

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# Summary

3 use cases will be presented in this Tutorial:

- SNEF:  IoT design for TOTAL Refinery
- SNEF: Predictive algorithms development for Neste Oil plant
- AIR LIQUIDE: Smart Innovative Operation

# Introduction

1. **SMART INDUSTRY**

APPLIED TO REFINERIES

R&D contract for TOTAL

VICTOR BRISSOT MIOS BY SNEF LAB

2. **PREDICTIVE MAINTENANCE**

for Industry 4.0

Jean Batiste LEGER PREDICT by SNEF Lab

# SMART INDUSTRY

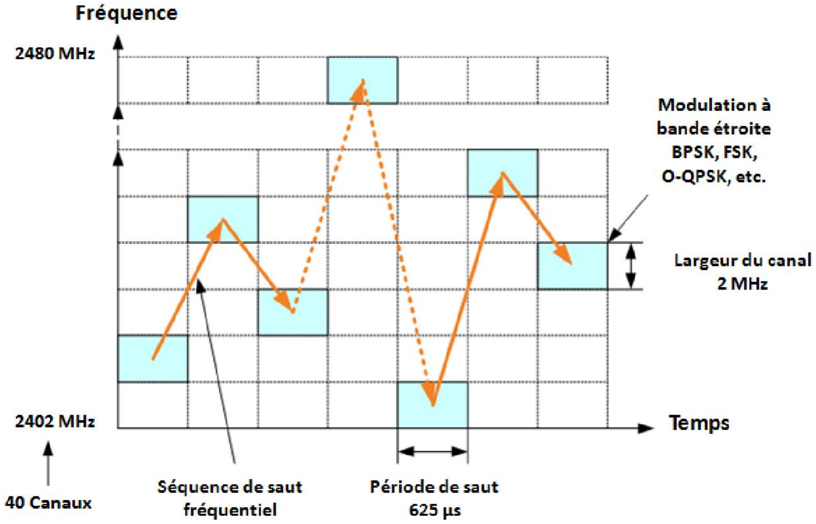
## APPLIED TO REFINERIES

R&D contract for TOTAL

# Our work



R&D CONTRACT FOR TOTAL




## INTERFERENCE STUDY

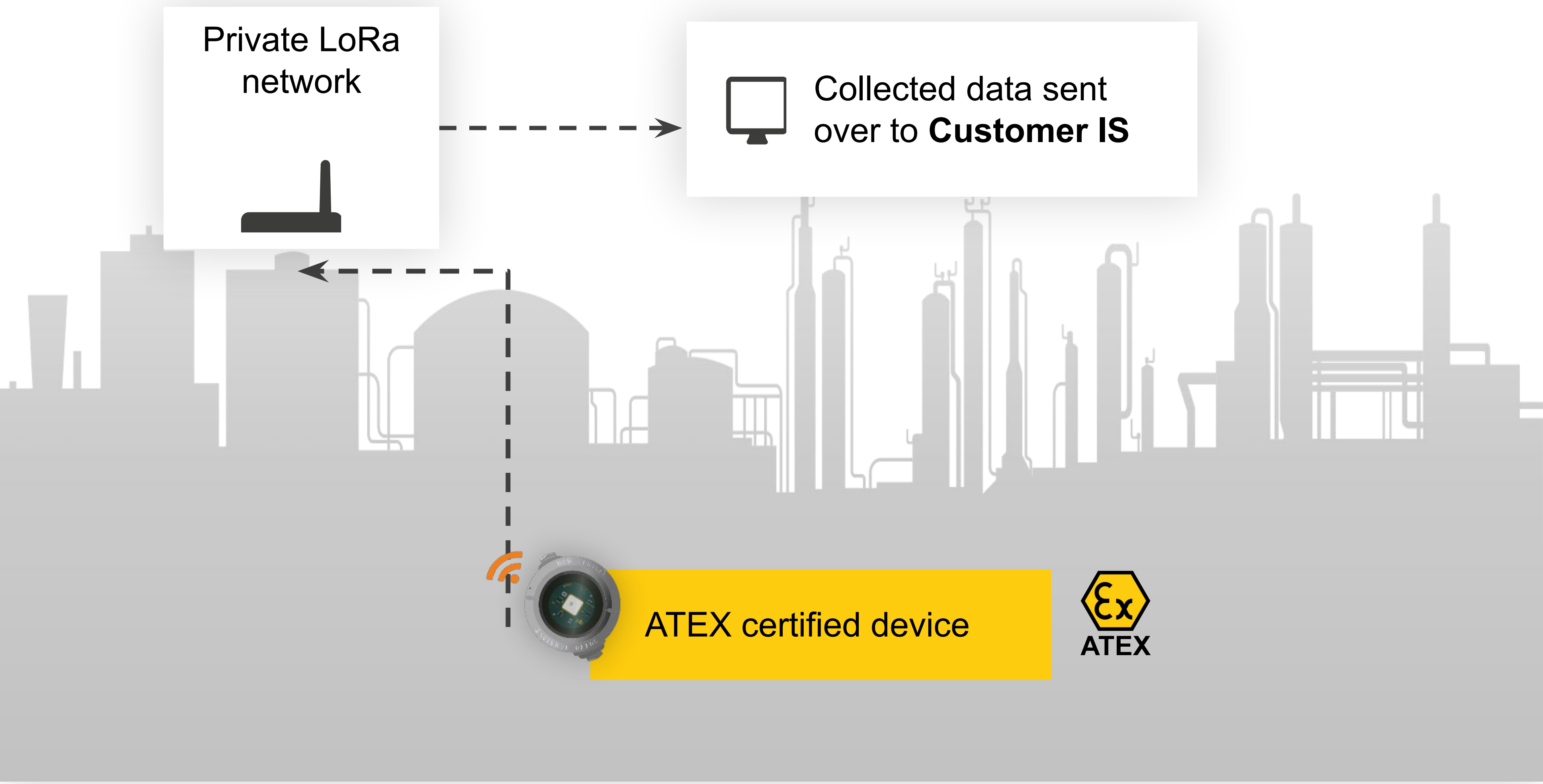
- Radio and weather interference study

## DEVICE DEVELOPMENT & CERTIFICATION

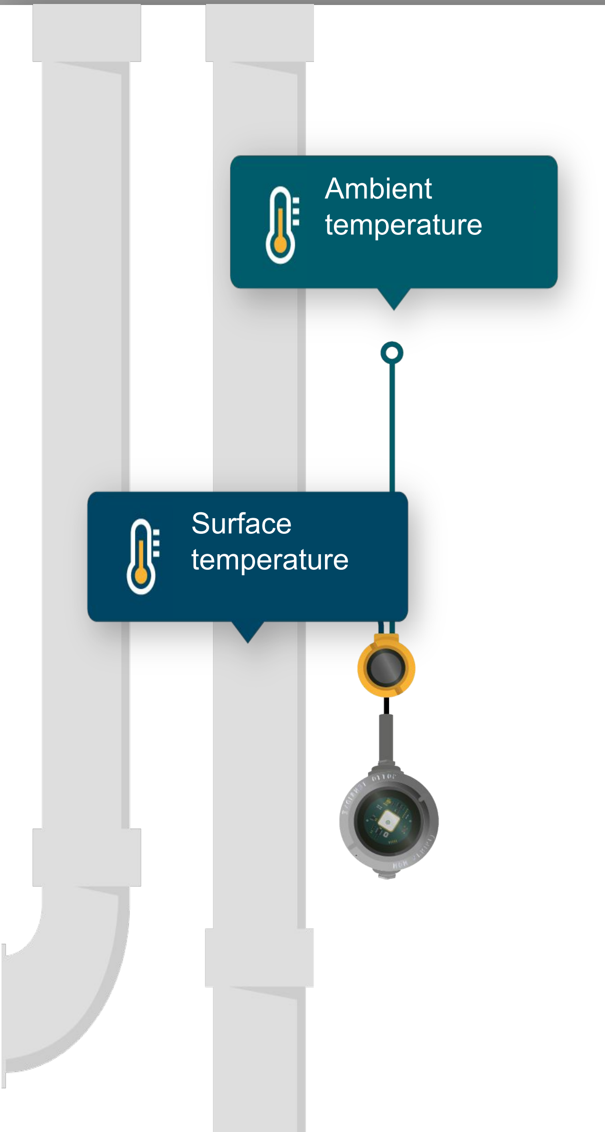
- Specifications from Final Customer
- Results
- Focus on security
  Secure Element, added encryption
- Atex certificate from Ineris

# Architecture

R&D CONTRACT FOR TOTAL



# Gas leak detection focus




Monitoring the differential between pipe's surface and ambient temperature for gas leak detection.

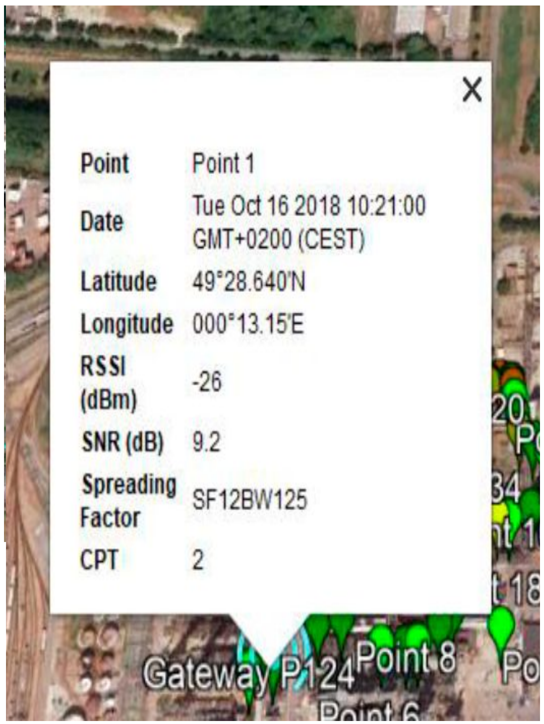
**S.box ATEX**

- Zone 1 certified
- More than 5 years autonomy
- Thermocouple sensors
- Multiple sensors
  on the same device
- Autonomous solution

ATEX

# Our work

R&D CONTRACT FOR TOTAL




## COVERAGE STUDY

- On-site study to determine how many gateway will be needed
- Will be applied to every French refinery within 2 years
- Include captures from deliverable of refinery

## INDUSTRIAL DEPLOYMENT

- 3 refineries already covered by private LoRa Network
- 50 devices deployed

# Keys assets for Total

**SECURITY**

- Dedicated Private IoT network
- Data encryption over LoRaWAN built-in encryption
- Embedded Secure Element

**INTEROPERABILITY**

- LoRaWAN compliant network and devices
- Multiple use cases addressed by an open solution

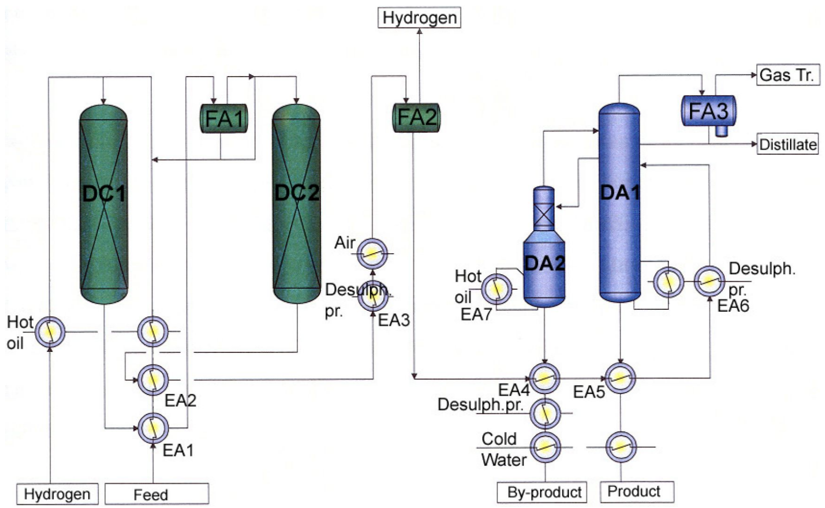
# PREDICTIVE MAINTENANCE

for Industrie 4.0

## FOSSIL FUEL REFINERY

*The refinery concentrates on specialty products, such as solvents and bitumen, and has a capacity of approx. 3 million t/a.*

- **CRUCIAL FACTOR FOR THE OPERATION ECONOMY** Continuous optimisation of the production processes.
- **OBJECTIVE** Increasing the plant availability by improving the equipment fault detection and by more efficient handling of the consequent process disturbances is one way for optimising the production.
- **INNOVATION** Coupling in real time Fault Detection and Isolation (FDI) and Fault Tolerant Control (FTC)



# Innovative approach



**ACQUISITION**

- To acquire data from the Local Application
- To integrate into the Real Time Database

**FAULT DETECTION**

- To detect fault and drift behaviour

**DIAGNOSIS**

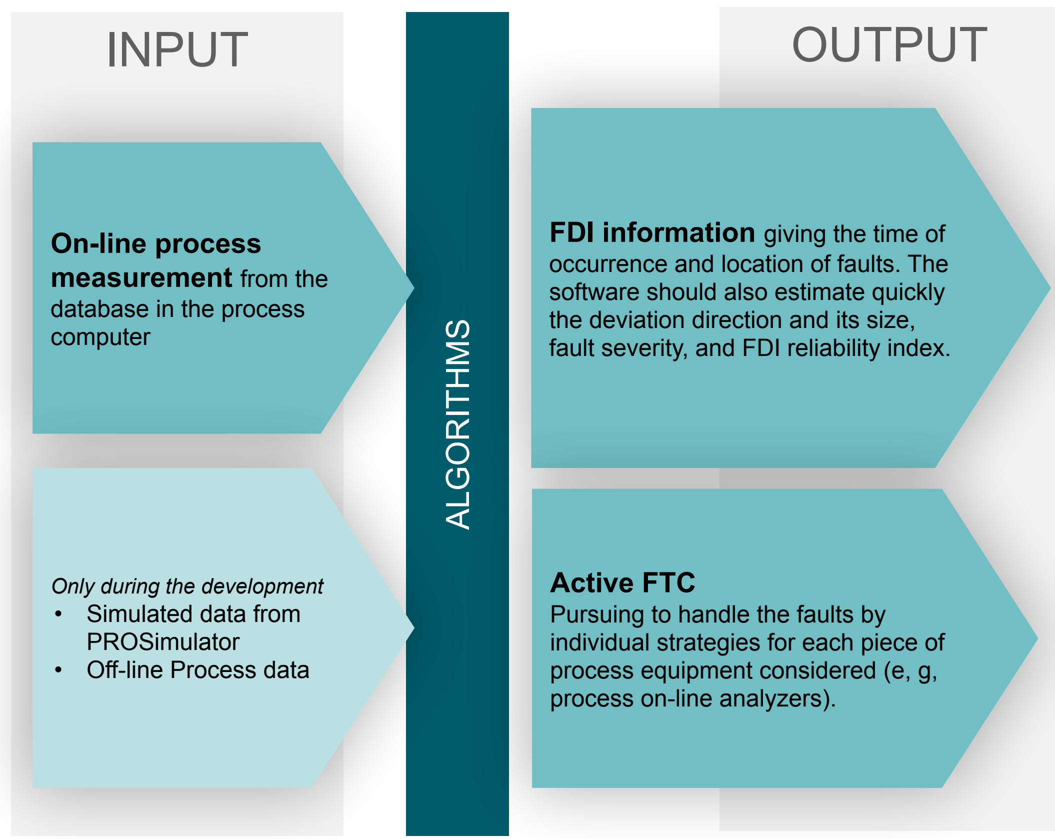
- To identify cause(s) and probability

**PROGNOSIS**

- To determine consequence(s) and risk
- To extrapolate variable value in the future

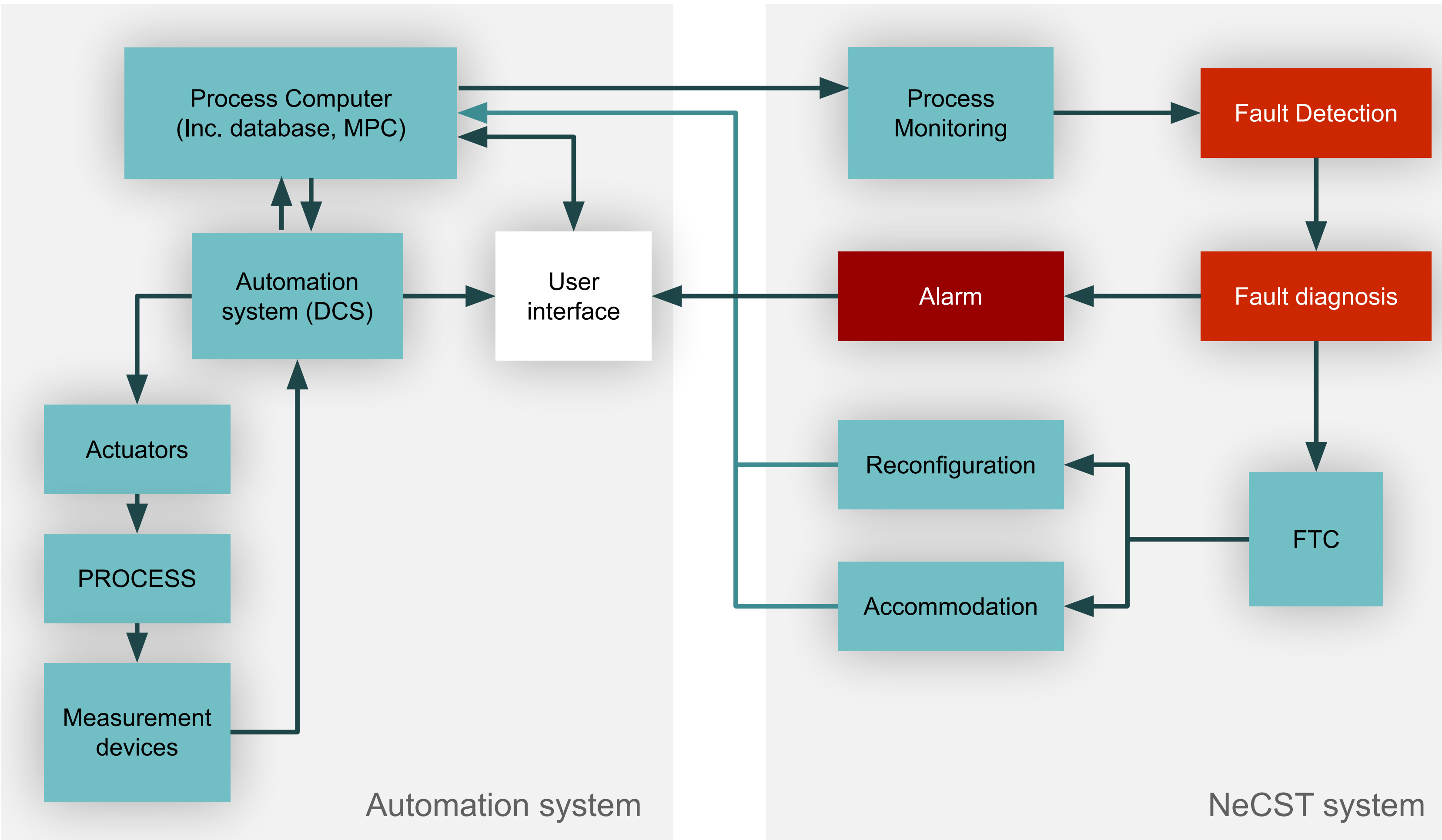
**FAULT TOLERANT CONTROL**

- To calculate accommodation value(s)
- To apply FTC action(s) with a pre-defined ordering sequence

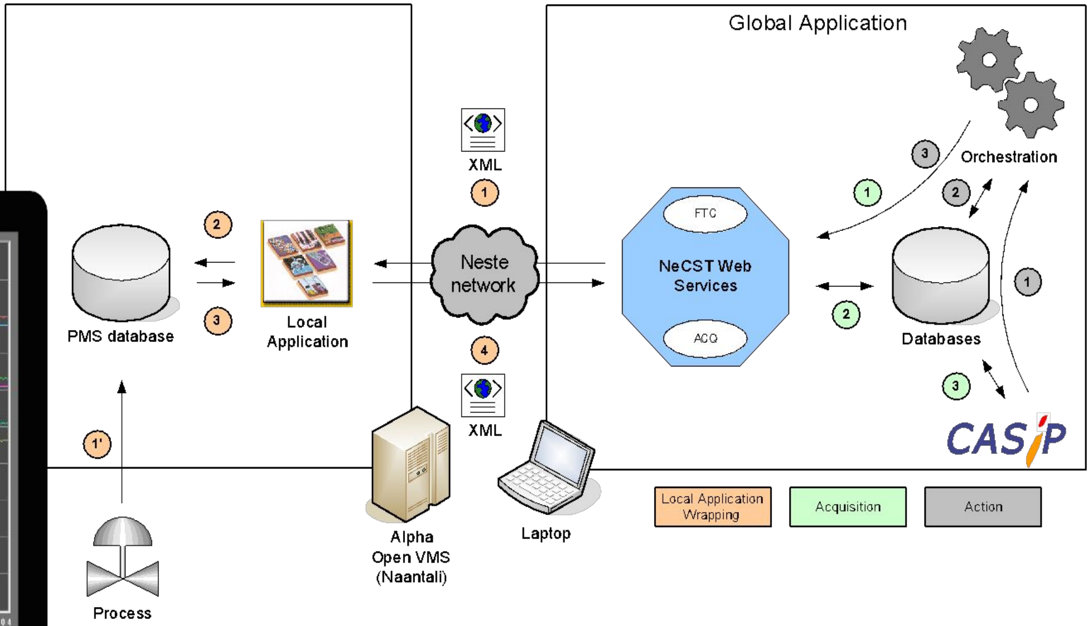


# Innovative approach





# Software interface with DCS



# FTC Strategy Approaches



### FDI / FTC Strategy #1

**FDI m1**
- Fault is detected

FTC m1
- Measurement feedback is turned off
- Calculation of the accommodation target value
- CV target value is increased by 7 °C

### FDI/FTC Strategy #2

**FDI m2**
- Analyser measurement turns healthy

FTC m2
- Measurement feedback is turned back on
- CV target value is returned back to its original value (212 °C)

### FTC Strategy #3

**FDI m3**
- Fault is detected

FTC m3
- Measurement feedback is turned off

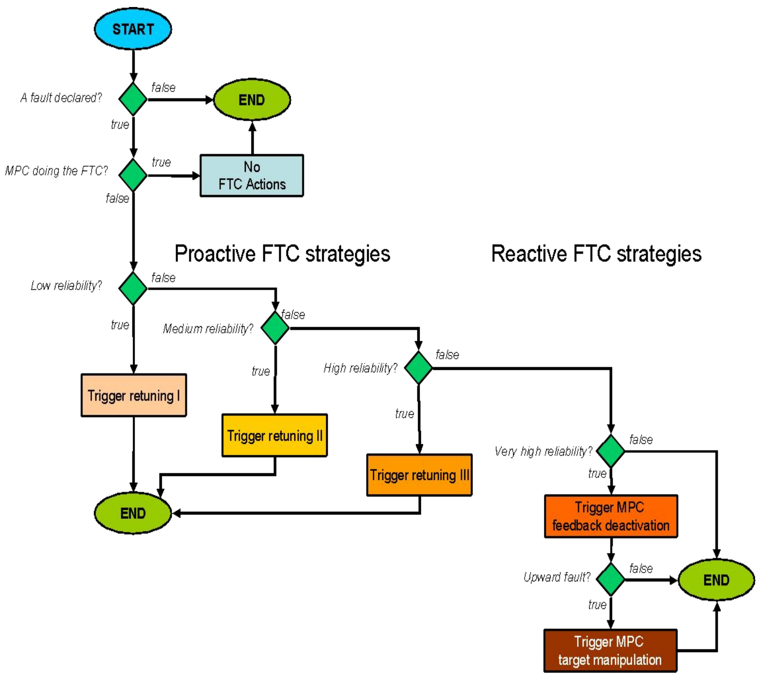
### FTC Strategy #4

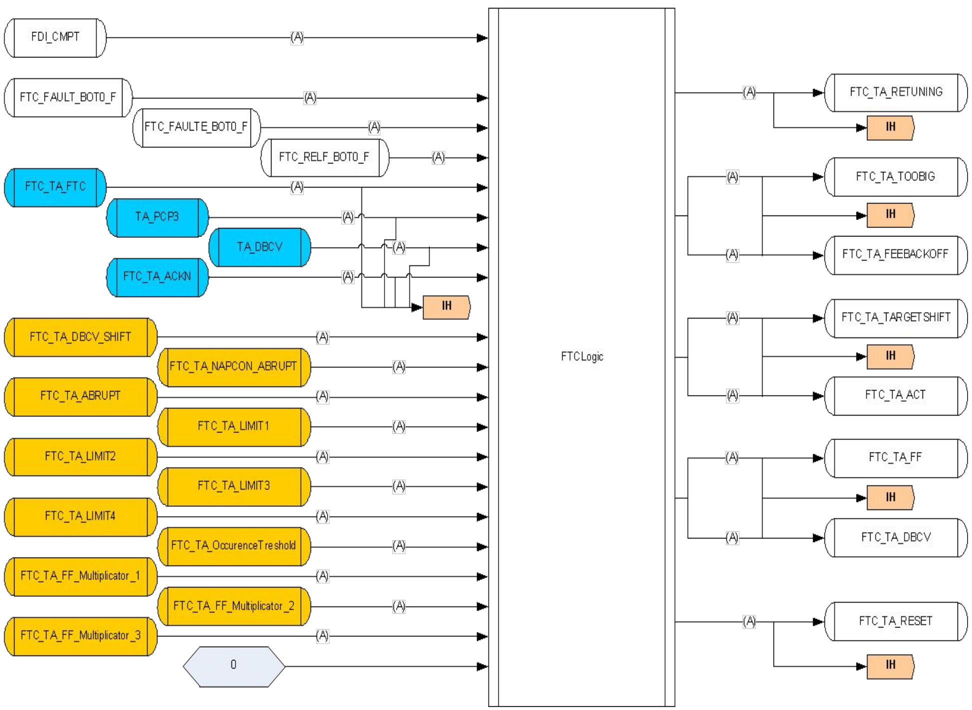
**FTC m4**
- Measurement feedback is turned back on

FDI m4
- Once the analyser measurement becomes healthy

# FTC Algorithm Model





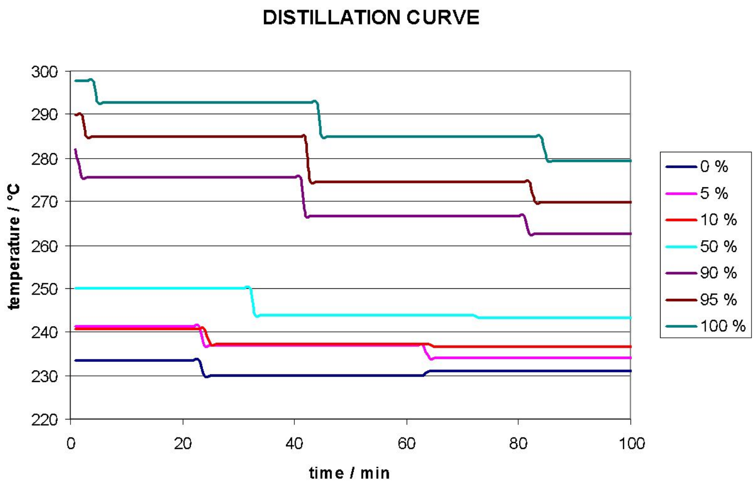



# Early warning visualisation & location



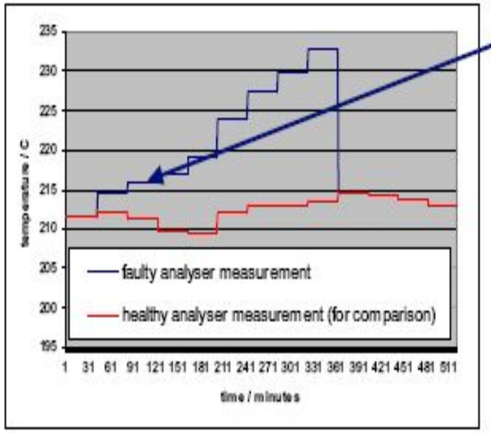
# Application to Analysers



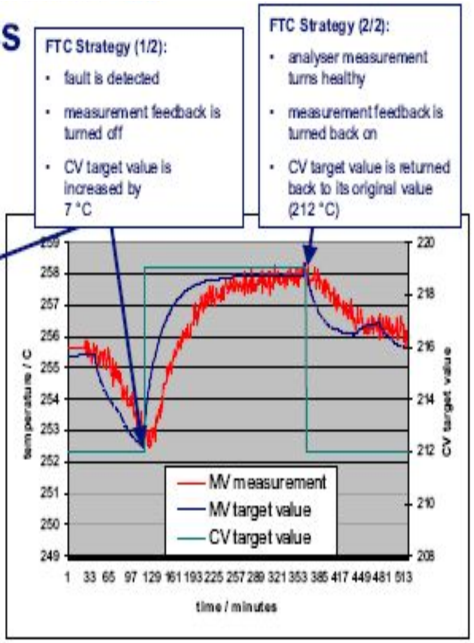



## for the LARPO process

- Upward drift in the analyser measurement:



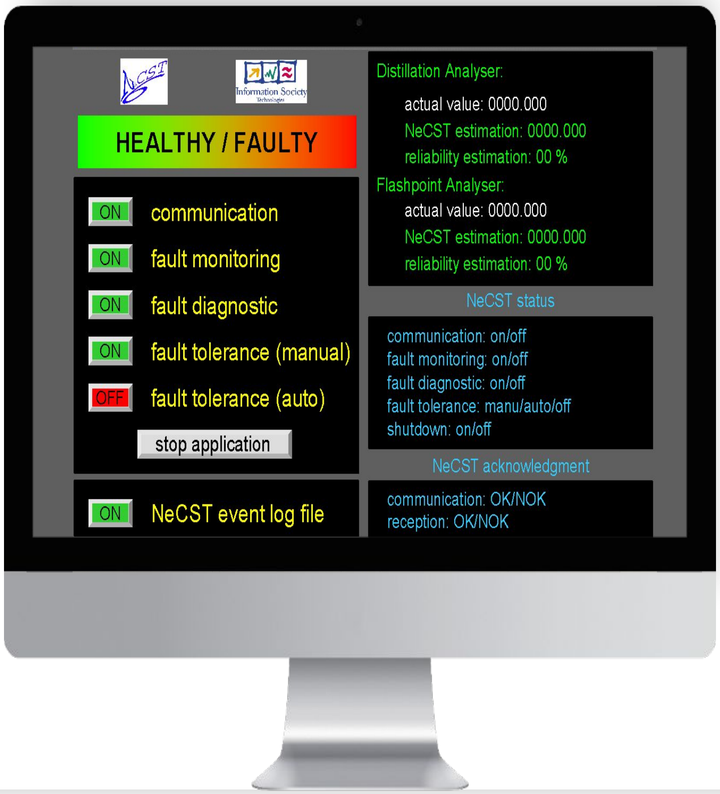

Analyser fault.

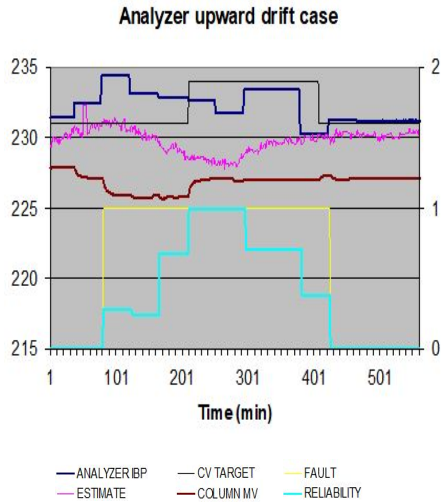


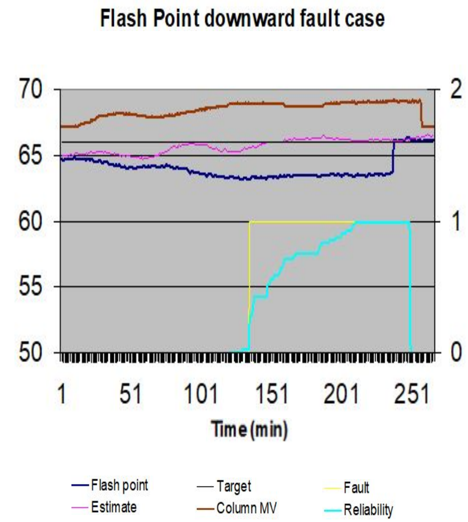

MV (distillation column temperature setpoint) and CV (initial boiling point target value) values.

# Use Cases






## Decision

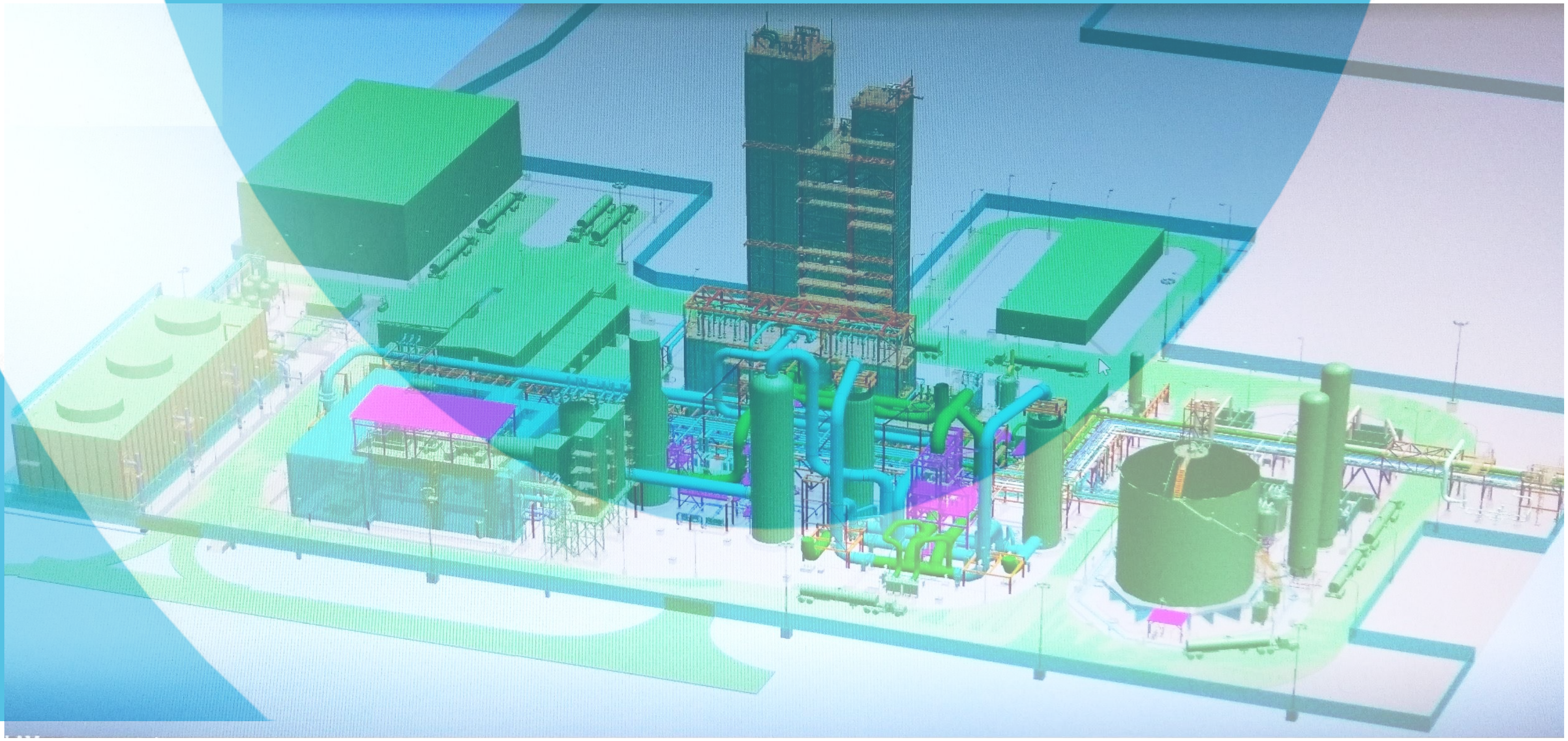
| | Description | Date | Action |
|---|---|---|---|
| More Information | Modify the target value for the control loop LARPO_LP_CVTG to 68 | 15.6.2006 15:38:12 | Validate Reject |
| More Information | Action to get LARPO_TA_CVTG control loop informations | 15.6.2006 15:38:12 | Validate Reject |
| More Information | Set the compensating factor for the control loop LARPO_TA_CVTG to 0 (0=off, 1=on) | 15.6.2006 15:38:12 | Validate Reject |

# CONCLUSIONS

# Introduction - Use case N°3

# SIO @

## Smart & Innovative Operation



# Why Air Liquide is doing SIO?

**Digitalization context**
Global trend towards digitalization represents opportunity for higher performance

**Data available!**
1 M of data points collected, waiting to be leveraged

**Customer expectations**
Customers are looking for continuous improvement and value co-creation

**Competition**
Competitors are realizing efficiencies from similar efforts and using that value to win business

**SIO**

Global **step change** for LI Operations Performance

**Better serve our customers**
Better industrial performance, improved **reliability** and **adaptability.**

**Improved offer**
More competitive offer to win **growth opportunities.**

**Value creation**
Improved profitability of existing operations. Open doors to **value co-creation** and sharing.

French production : Average Consumption 300 MWatt
Average Generation 35 MWatt

**WW Electrical Consumption ≈ 4 GWatt**

# What is **SIO**?

**DIGITAL TECHNOLOGIES TO LEVERAGE DATA**

Data as an Asset
Centralized data driven decision making

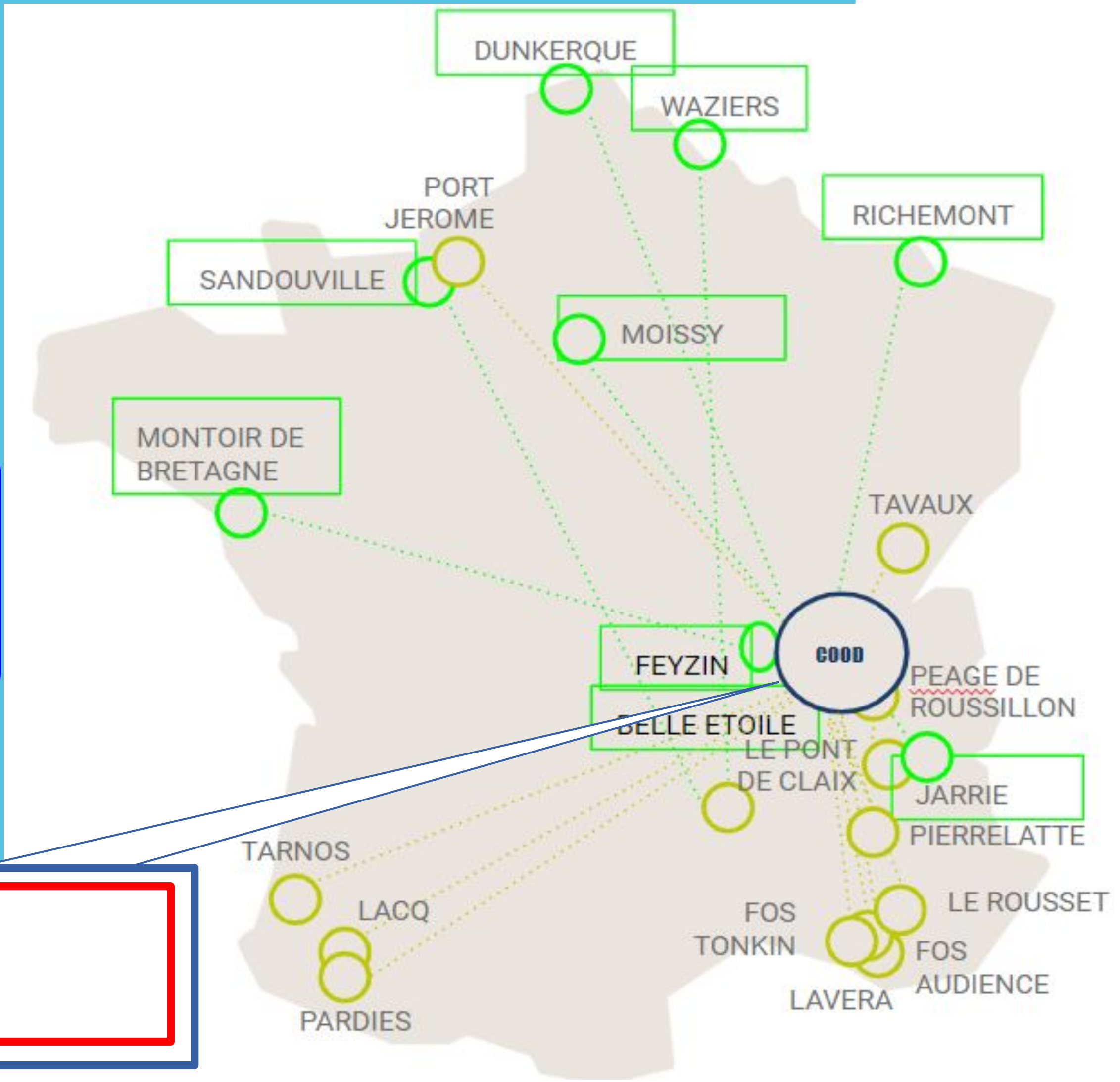
**ORGANIZATIONAL TRANSFORMATION**

New roles, career paths, competencies and new ways of working

**ENHANCE OUR RELATIONSHIP WITH OUR CUSTOMER**

# 1. Focus on SIO.Drive

**France is given as an example but other countries are also connected to a Remote Operating Control Center (ROCC)**




**COOD** Centre d'Opération et d'Optimisation à Distance

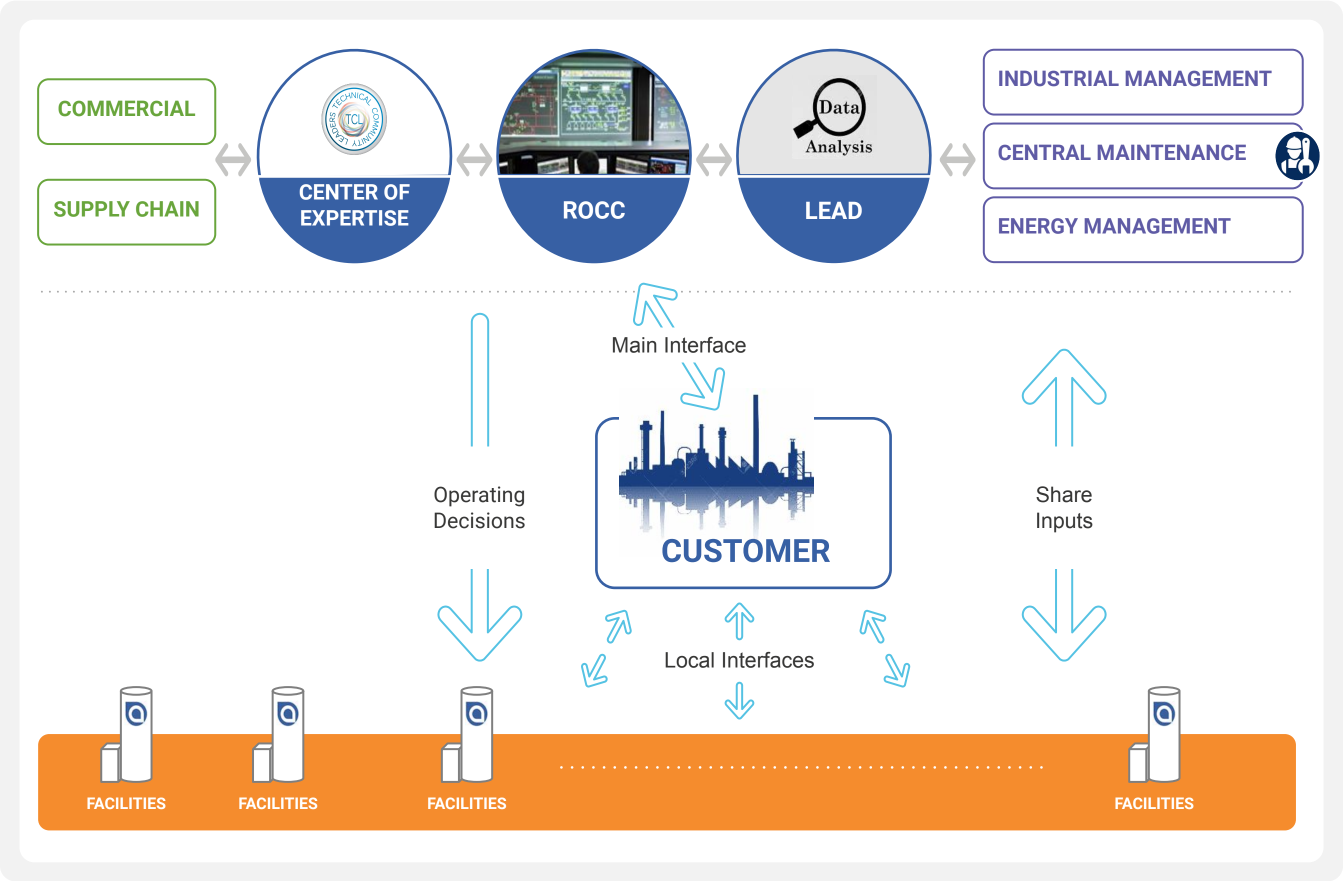
# How to achieve SIO Transformation

## CENTRALIZE

- Operations decision
- Optimization, diagnostic and improvement centers
- Technical expertise

## KEY ENABLERS

- Multi-skilled site personnel
- High level automation of LI facilities
- Digital access to all required information



# New Types of Roles **Through SIO we are able to add new and exciting roles and opportunities for our teams globally**

COOD : 15 PTR (2 / shift)
Analyst (4 ASU, 3 HyCo, 1 IT),
Energy 3,
Supply Chain 2 (Bulk dispatch)

### ROCC PILOTS

Remote Monitoring & Operations through Service Level Agreements (SLA)

- Monitor and respond to alarms
- Equipment List and Process Variables Authorized for RTP response
- Communicates in real time with customers regarding their consumption

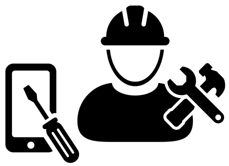
### LEAD CENTER ANALYSTS

Data Analytics & Case Management

- Uses data analytics to monitor for areas for improvement using smart KPIs
- Case managers for issues that are detected
- Optimizes up to 20 plants or more remotely, performing predictive analytics on key equipment
- Supports the preparation of the production & the energy strategy to meet the customer's demand.

### Operator / Technician

- Specific skill set
- Extended working hours and call outs due to operational inefficiencies



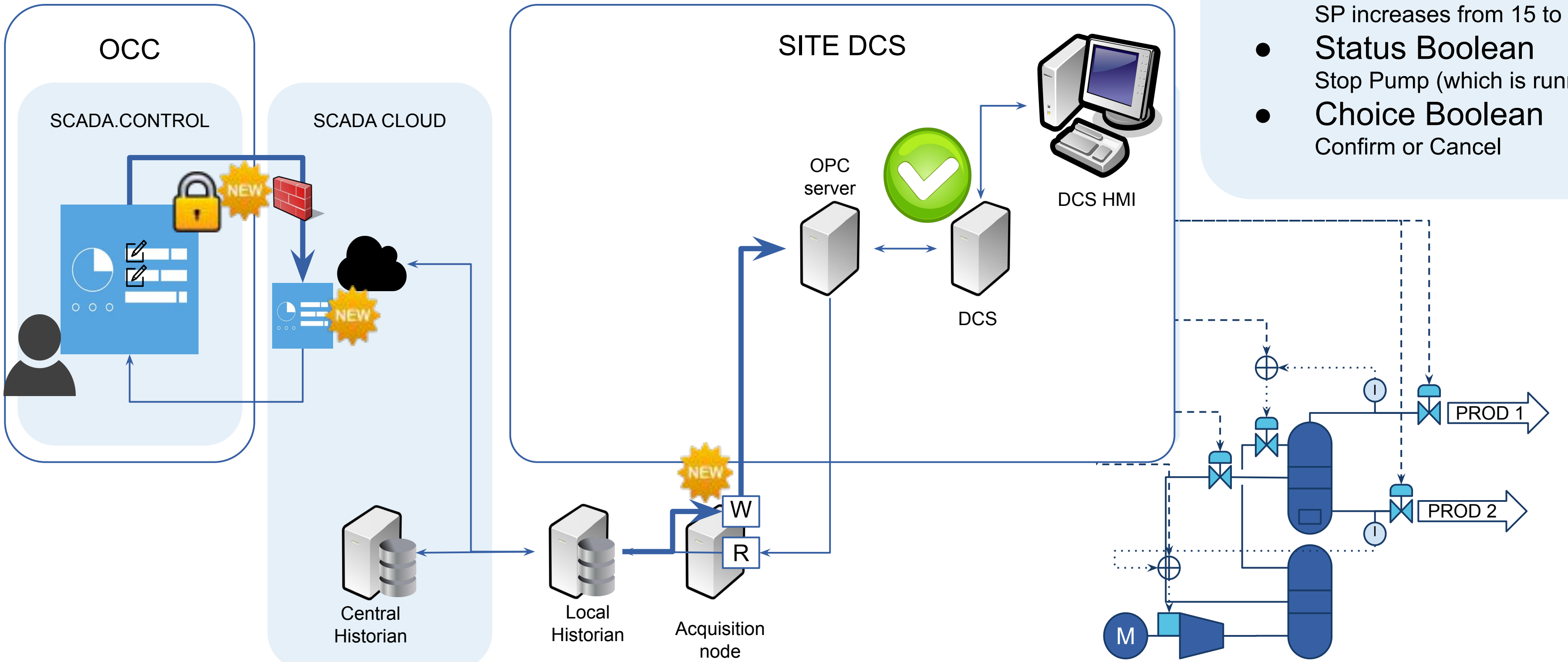
### Multi-Skills Facility Technician

- Analytical and multi-skilled
- Utilizes data for optimized decisions
- Can monitor and control remotely

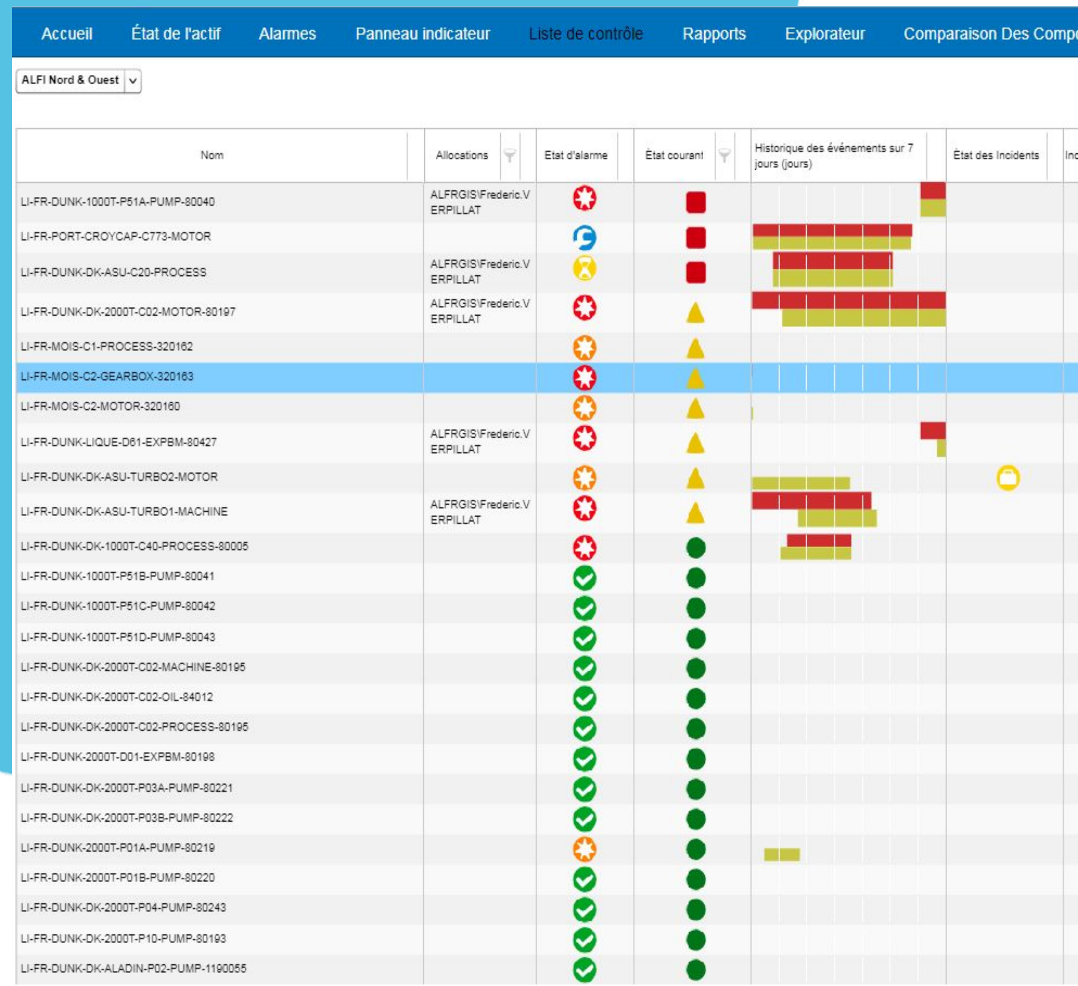
# Remote Control a new flow : write access of the PI system

Three Types of MVS

- Numerical
  SP increases from 15 to 17
- Status Boolean
  Stop Pump (which is running)
- Choice Boolean
  Confirm or Cancel

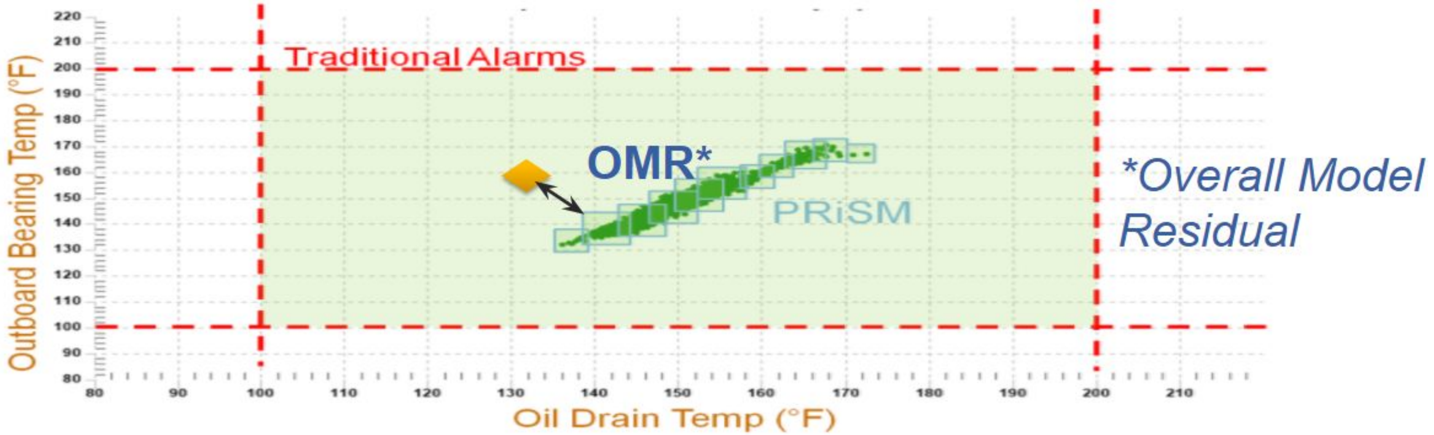


# 2.Focus on SIO.Predict



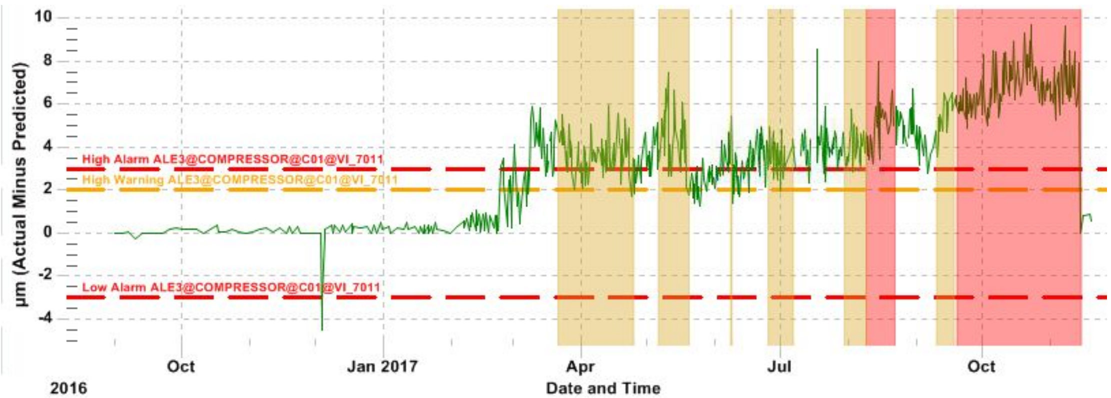
# SIO.Predict - Principle

- Clusters between parameters (Multi-dimensional)
- Historical data (1-2 years) = “normal” behavior

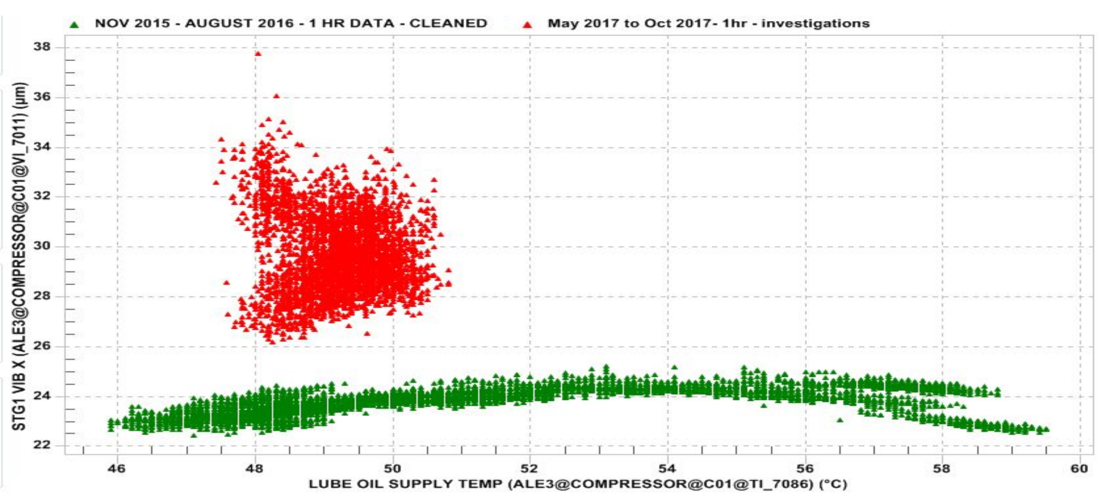



- Deviation to the normal behavior to be analyzed (Weak signal)
- Early Warning = Time to React

# SIO.Predict - Catches - Main Air Compressor

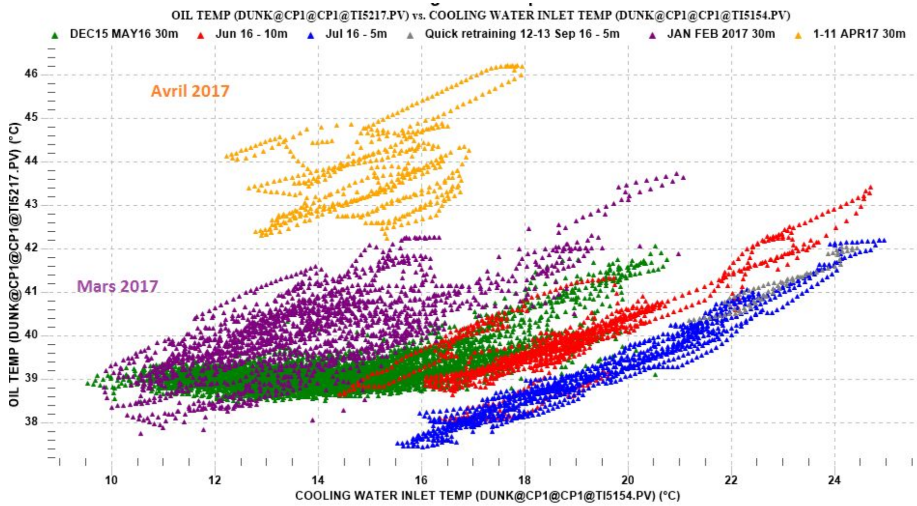



- Correlated parameters used in the model : oil temp, all bearing vibrations and temp and compressor load
- Training of the model : Nov 15 -Aug 16
- No alarm from the DCS




# SIO.Predict in numbers

- **2014 R&D** survey of different products
- **2015** PoC **with a first** software solution (4 plants)
- **2016 second software** 16 licences
- **2017** deployment **the solution** ww
- **Today Global Agreement for 2nd software**




COOD
200 Machines (500 Models)
200 alarms/month
3 Full time + 2 PTR 1 h/shift

- **145 sites** licensed
- **3850** models deployed
- **38** countries
- **130+** people trained
- **280+ actioned catches**

# SIO.Predict Lessons

**Deployment Fast**
Strong Management support
Cloud + PI central server easy to connect
Template (tag, alarm... )

**Indirect Savings**
Reduce Maintenance
(Shorter TAR, reduce OEM supervision)

**Few "Big" Catches**
Instrumentation (50%),
**Mechanical** (Bearing, Oil Cooler),
Efficacity (Approach Temperature)

**Best Practices**
Small projects with high correlated parameters (Compressor Mechanic, Comp Process, Comp Motor, Comp Oil System)

**SIO.Predict**

TOOLS +/-

&

**Organisation**

**Lack of instrumentation**
Auxiliary / Main Oil Pump
Reciprocating Compressor
Fan, Cryo Pump

**Break very fast**
Impossible to anticipate
(-> Maintenance policy is still needed)

**No Alarm or Alarm not treated in time**
Ratio of fake alarm still high (75%)
Discontinue Alarm (Persistence)

Next : Decision Support System for Alarming Automatic Ranking

# 3.Focus on SIO.Perform

BEP
=
Best Economical Point

# SIO.Perform.504

**CAR**

Speed 120 km/h
Benzin consumption 7.2 l / 100 km
Atmospheric Temperature 31°C
Gear 5 / 6
Road slope +2.5/1000
Front wind 12 km/h
Car weight 800 kg
Additional weight 722 kg
Tire Pressure 2.1 bar
Air conditioning ON SP = 21 °C
Windows front Closed
Windows back open 25%
Motor Settings
Oil Filter Plugged

KPI?

Landscape?

Plant / Adjustable Parameters?

# SIO.Perform.504.KPI

**CAR**

Speed 120 km/h
Benzin consumption 7.2 l / 100 km
Atmospheric Temperature 31°C
Gear 5 / 6
Road slope +2.5/1000
Front wind 12 km/h
Car weight 800 kg
Additional weight 722 kg
Tire Pressure 2.1 bar
Air conditioning ON SP = 21 °C
Windows front Closed
Windows back open 25%
Motor Settings
Oil Filter Plugged

**KPI**

Opex : what has been to be paid to achieve the task/duty

KPI = Consumption * Gas_Cost

# SIO.Perform.504.Landscape

**CAR**

Speed 120 km/h ***
Benzin consumption 7.2 l / 100 km
Atmospheric Temperature 31°C
Gear 5 / 6
Road slope +2.5/1000
Front wind 12 km/h
Car weight 800 kg
Additional weight 722 kg ***
Tire Pressure 2.1 bar
Air conditioning ON SP = 21 °C
Windows front Closed
Windows back open 25%
Motor Settings
Oil Filter Plugged

**Landscape**

The duty/task produced

&

The environmental condition that can not be adjusted (but have an impact on the KPI)

*** : data optimized by SIO.Optim
*Output from SIO.Optim (Variables)*
*&*
*Input for SIO.Perform (Landscape)*

# SIO.Perform.504.Plant Parameters

**CAR**

Speed 120 km/h
Benzin consumption 7.2 l / 100 km
Atmospheric Temperature 31°C
Gear 5 / 6 (L1)
Road slope +2.5/1000
Front wind 12 km/h
Car weight 800 kg
Additional weight 722 kg
Tire Pressure 2.1 bar (L2)
Air conditioning ON SP = 21 °C (L1)
Windows front Closed (L1)
Windows back open 25% (L)
Motor Settings (L3)
Oil Filter Plugged (L3)

**Plant / Adjustable Parameters**

The internal parameter that can be adjusted to improve the efficiency

*L1 : ROCC / control room level*
*L2 : “easy/small” maintenance*
*L3 : “big” maintenance*

# SIO.Perform : Air Separation Unit

- KPI : What the plant has to pay to produce
  - Electricity Bill (Electricity Consumption * Electricity Price)

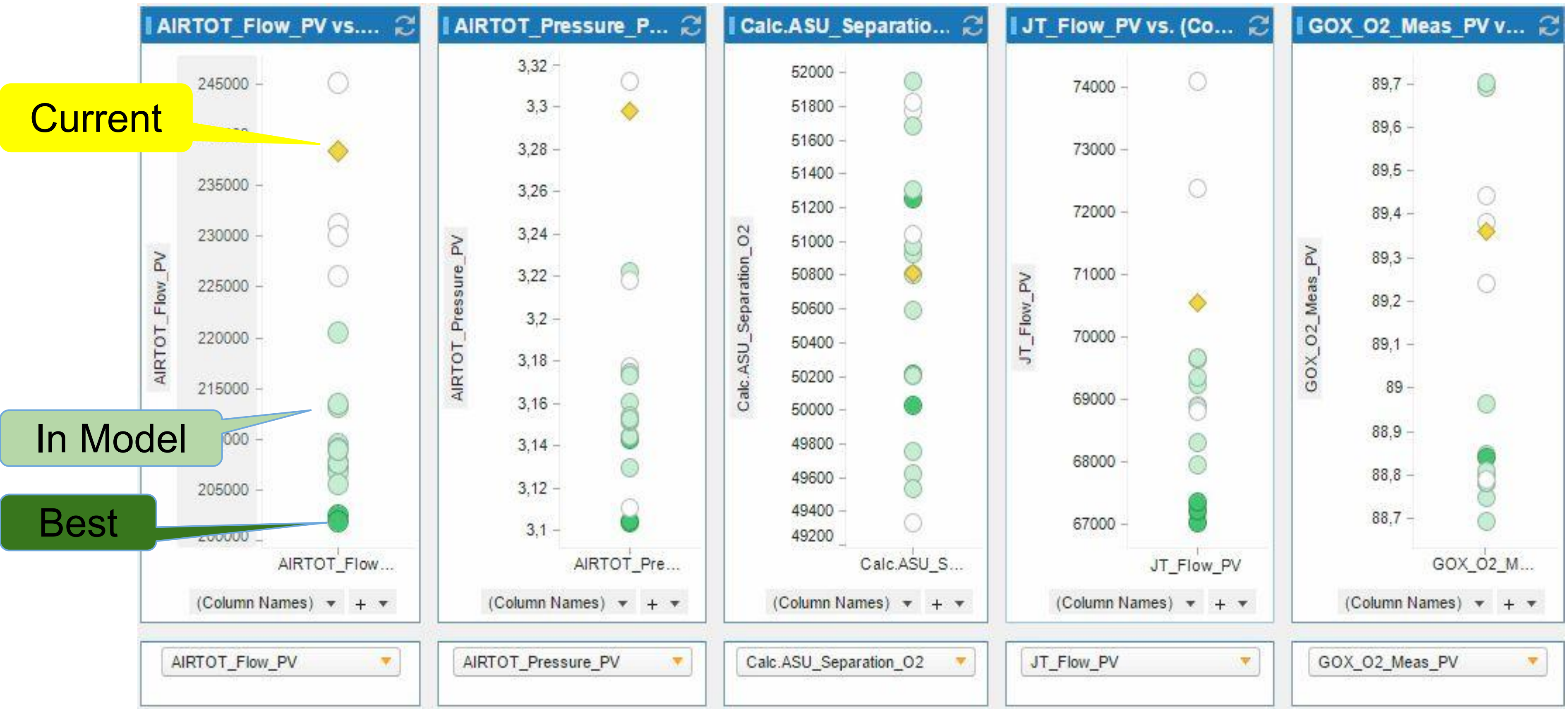
- Landscape : the duty/production of the plant
  - Separation (the distillation part)
    - High_Pressure_GOX_Flow + LOX_Flow

  - Liquefaction (to produce Cryogenic Liquid: LIN, LOX, LAR)
    - LIN_Flow + 1.07 * LOX_Flow + 0.9 * LAR_Flow

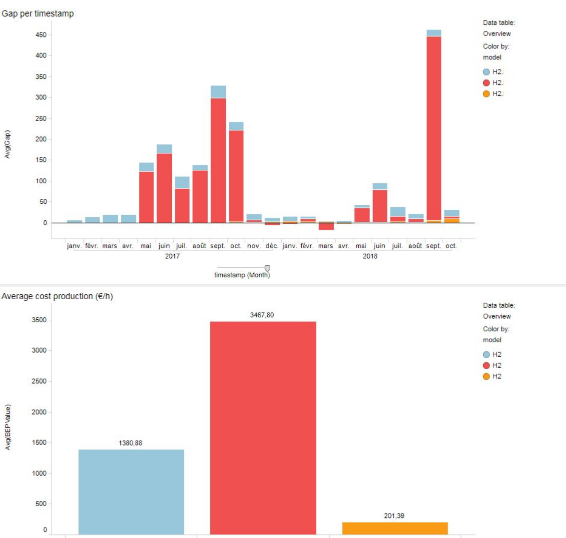
  - Compression (High Pressure Gaseous, Network 40 bars to 120 bars)
    - Theoretical Energy of Compression of all Products

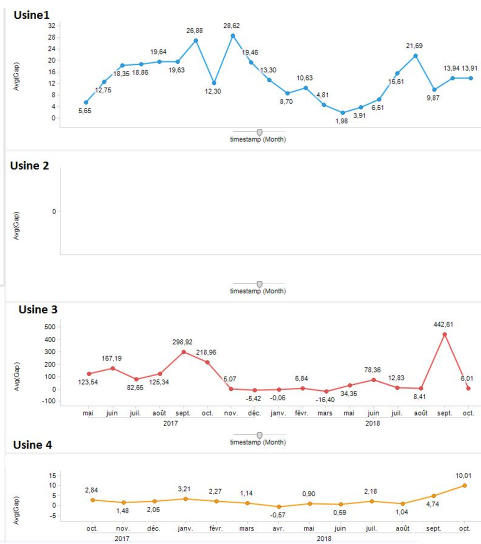
# SIO.Perform : Second principle

- Principle 2 : List of adjustable parameters to reach Historical better Performance (Operator support, OCC analyst)



# SIO.Perform in numbers




- **Catches** reported
  - ➢ Manual Valve (not open, not closed) after TAR
  - ➢ Improper SetPoint (BIAS)
  - ➢ Valve Leaking (Anti-Surge)
  - ➢ Compressor efficiency (Cooler..)
- **Organisation**
  - ➢ Analyst <-> Subject Matter Expert
  - ➢ Analyst <-> Site Local Champion

- **45 plants** deployed
- **25+ countries**
- **100+ people trained** (G+ community)
- **36+ actioned catches**

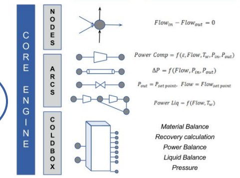
COOD (8 plants):
6 analysts follow weekly all
KPI on Perfom (Hyco + ASU)

# 4.Focus on SIO.Optim

# What is the Core Engine - SIO.Optim ?

It is a mathematical model generator for ASU

using a modular approach




developed internally with tool of the market

for OCC, expert, BD, ...

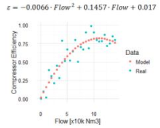
configured by users

configurable and customizable

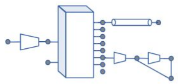
built like a lego

with generic bricks corresponding to ASU equipments

Fit Models to Data




Define Architecture



**Define Application**

Real-Time Optimization

Planning & Scheduling

Simulation / Calculation

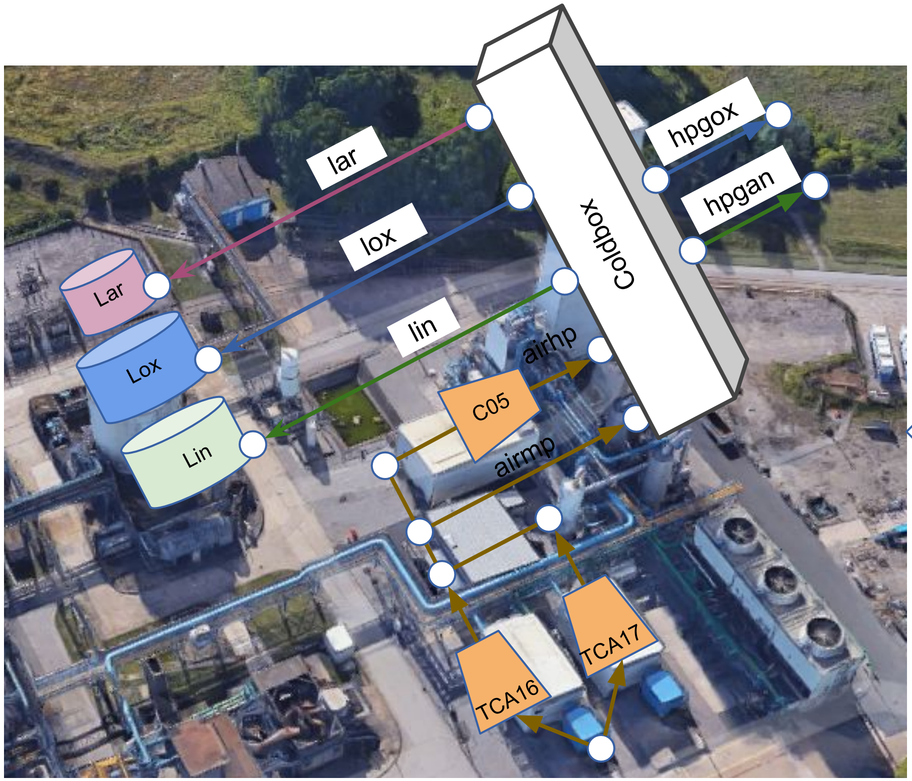
....

**Prepare & Link Database**

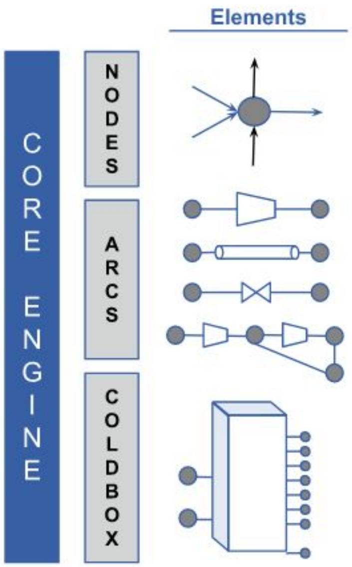

*AIMMS : Mathematical modelization tool using solvers

# Build a model with the Core Engine

1. Select the required bricks

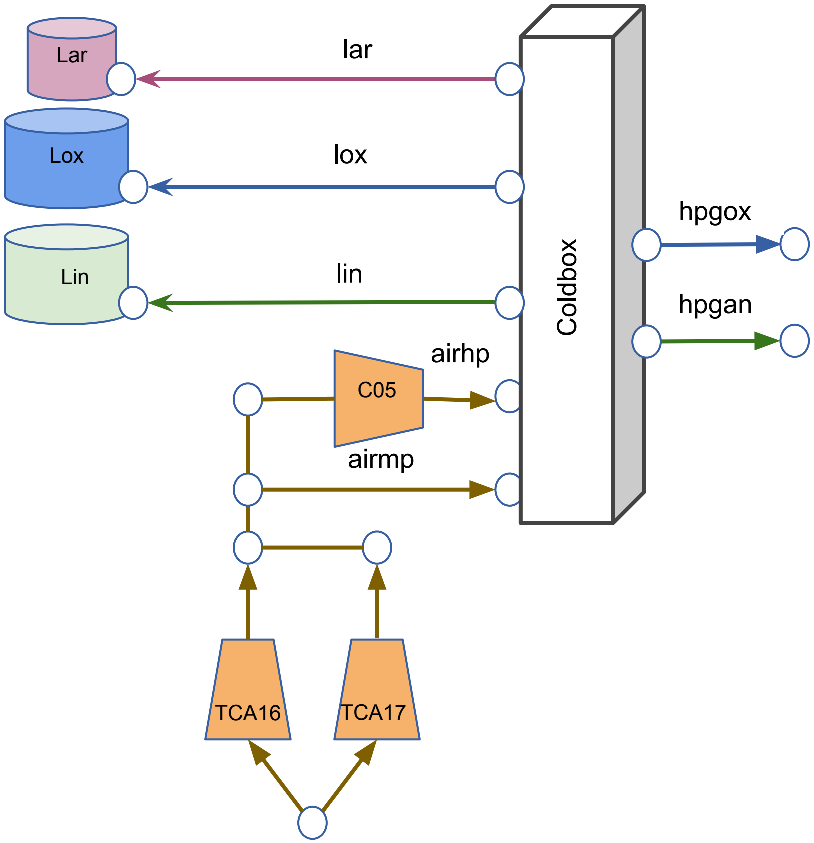



Select the needed elements



# Build a model with the Core Engine

2. Build the schema of the plant (or network ...)



# SIO.Optim in numbers

**Real Time Optimization** (Open loop -> decision support or close loop -> link with DCS) -> OCC, sites operation

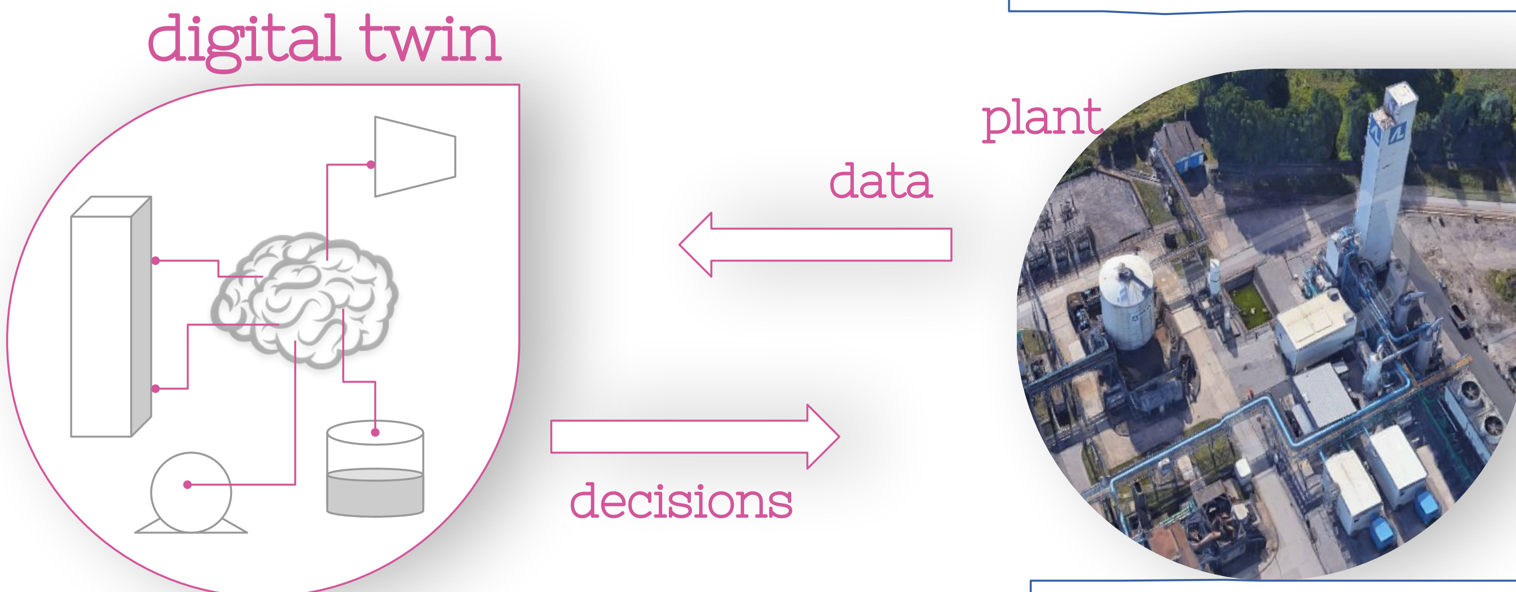
**Liquid production plan** -> OCC

Machine Learning

Modular

Democratized

Competitive advantage



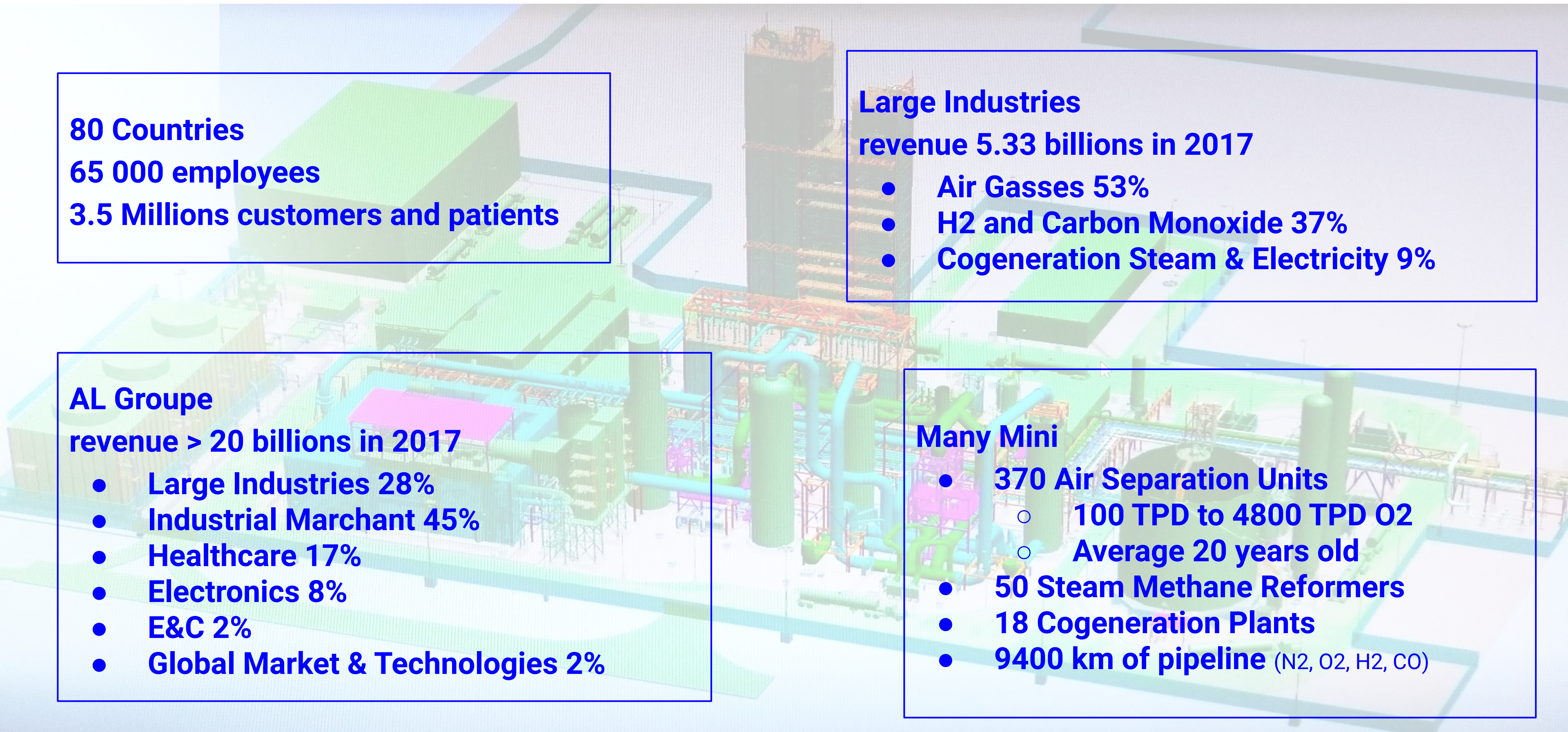

**PDC** (Production and Distribution Coordination)

**Planning** (Maintenance)

- **16 countries**
- **27 applications**
- **121 members in G+ SIO.Optim developers**

# Conclusions and Q&A

# LARGE INDUSTRIES: production numbers



80 Countries
65 000 employees
3.5 Millions customers and patients

Large Industries
revenue 5.33 billions in 2017

- Air Gasses 53%
- H2 and Carbon Monoxide 37%
- Cogeneration Steam & Electricity 9%

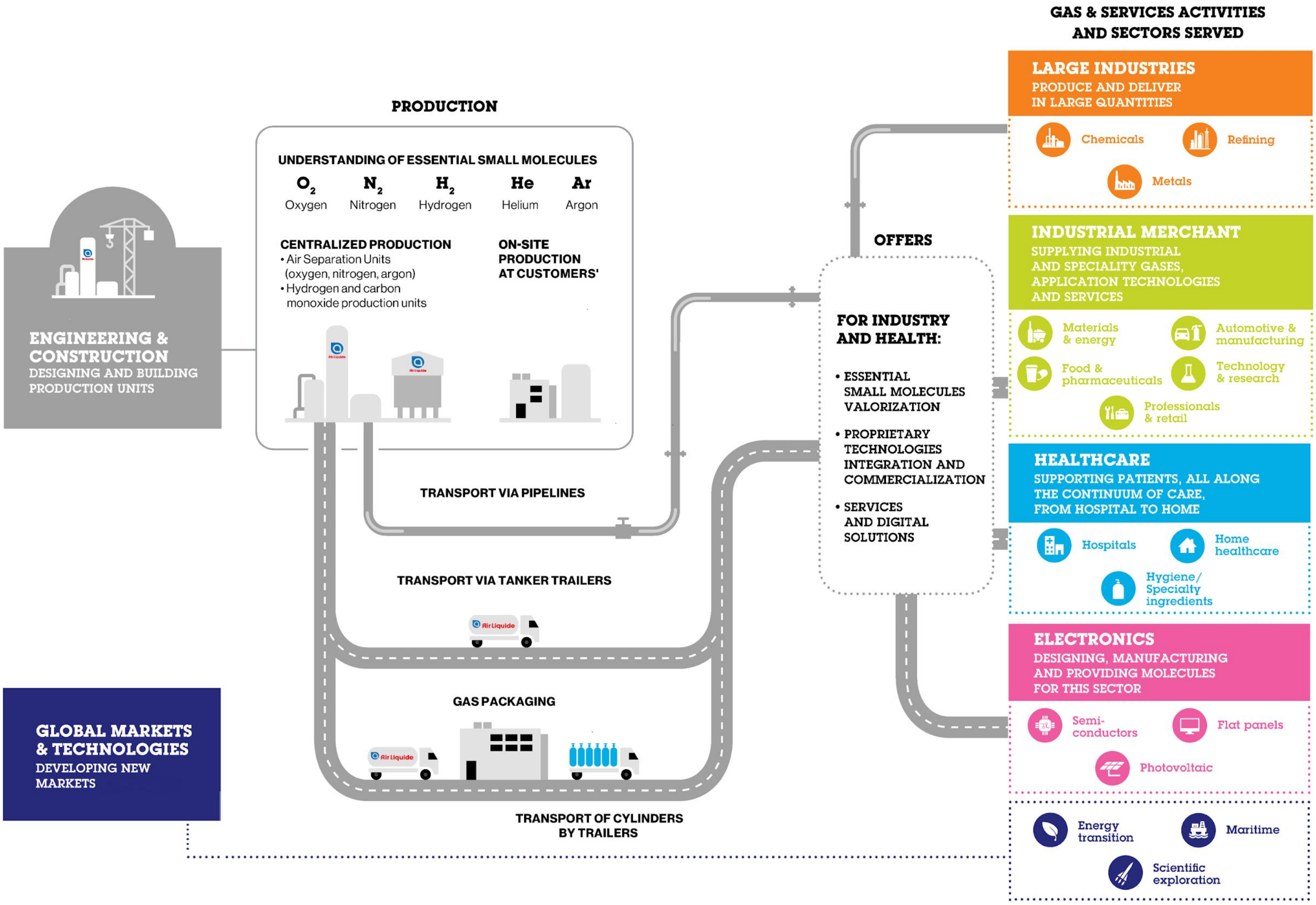
AL Groupe
revenue > 20 billions in 2017

- Large Industries 28%
- Industrial Marchant 45%
- Healthcare 17%
- Electronics 8%
- E&C 2%
- Global Market & Technologies 2%

Many Mini

- 370 Air Separation Units
  - 100 TPD to 4800 TPD O2
  - Average 20 years old
- 50 Steam Methane Reformers
- 18 Cogeneration Plants
- 9400 km of pipeline (N2, O2, H2, CO)

# Activities



GAS & SERVICES ACTIVITIES AND SECTORS SERVED
LARGE INDUSTRIES
PRODUCE AND DELIVER IN LARGE QUANTITIES
Chemicals
Refining
Metals
INDUSTRIAL MERCHANT
SUPPLYING INDUSTRIAL AND SPECIALITY GASES, APPLICATION TECHNOLOGIES AND SERVICES
Materials & energy
Automotive & manufacturing
Food & pharmaceuticals
Technology & research
Professionals & retail
HEALTHCARE
SUPPORTING PATIENTS, ALL ALONG THE CONTINUUM OF CARE, FROM HOSPITAL TO HOME
Hospitals
Home healthcare
Hygiene/ Specialty ingredients
ELECTRONICS
DESIGNING, MANUFACTURING AND PROVIDING MOLECULES FOR THIS SECTOR
Semi-conductors
Flat panels
Photovoltaic
Energy transition
Maritime
Scientific exploration
PRODUCTION
UNDERSTANDING OF ESSENTIAL SMALL MOLECULES
O2 Oxygen
N2 Nitrogen
H2 Hydrogen
He Helium
Ar Argon
CENTRALIZED PRODUCTION
• Air Separation Units (oxygen, nitrogen, argon)
• Hydrogen and carbon monoxide production units
ON-SITE PRODUCTION AT CUSTOMERS'
ENGINEERING & CONSTRUCTION
DESIGNING AND BUILDING PRODUCTION UNITS
OFFERS
FOR INDUSTRY AND HEALTH:
• ESSENTIAL SMALL MOLECULES VALORIZATION
• PROPRIETARY TECHNOLOGIES INTEGRATION AND COMMERCIALIZATION
• SERVICES AND DIGITAL SOLUTIONS
TRANSPORT VIA PIPELINES
TRANSPORT VIA TANKER TRAILERS
GAS PACKAGING
TRANSPORT OF CYLINDERS BY TRAILERS
GLOBAL MARKETS & TECHNOLOGIES
DEVELOPING NEW MARKETS