SMART Manufacturing Journey

Alcoa Smelting and Casting

Presented by Bruno Longchamps
Pierre Boutin

Advancing each generation. ALCOA

SMART Manufacturing Journey

Alcoa, Global Smelting and Casting

Bruno Longchamps, P.Eng
SMART Manufacturing, Program Manager

OSIsoft User's Conference, San Francisco, April 2015

Presentation content

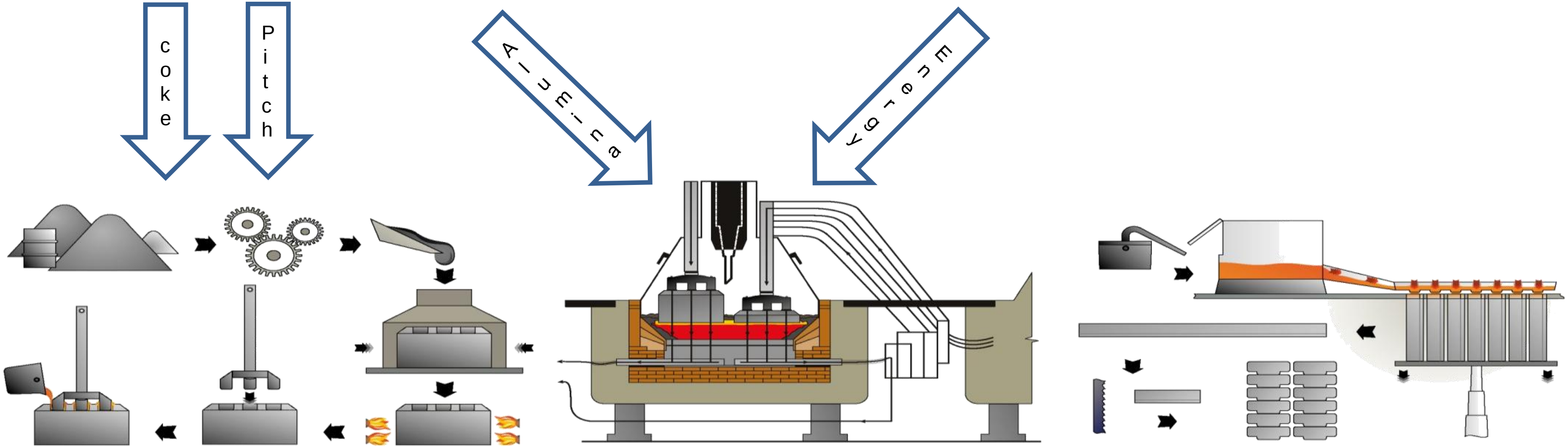
- ❑ Alcoa SMART Manufacturing Journey Overview
- ❑ Users Engagement
- ❑ Anode Tracking
- ❑ Cast Data Collection & Integration
- ❑ Conclusion
- ❑ Questions

Alcoa Inc.

- A global leader in lightweight metals technology, engineering and manufacturing
- Revenues of US$23.9 billion in 2014
- 59,000 employees in 30 countries

At December 31, 2014

Aluminium Production Process

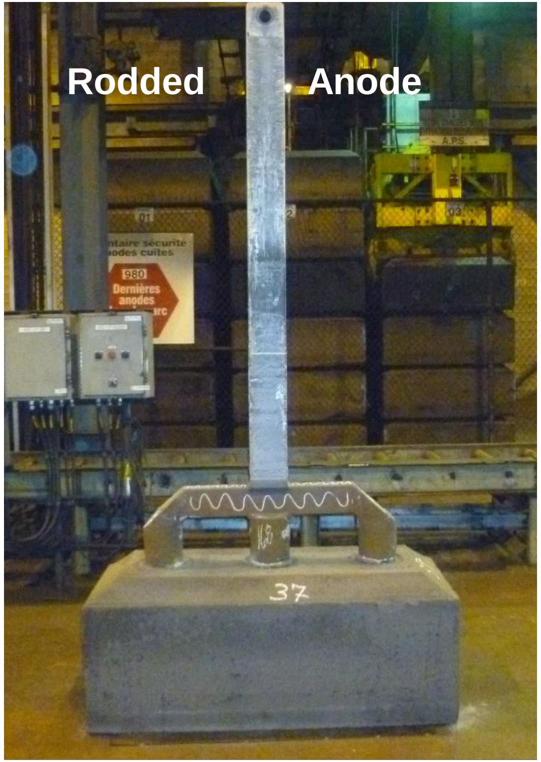


Electrode:
Anode production

Potroom:
Liquid aluminum production

Casthouse
Salable solid aluminium production

Smelting Operation

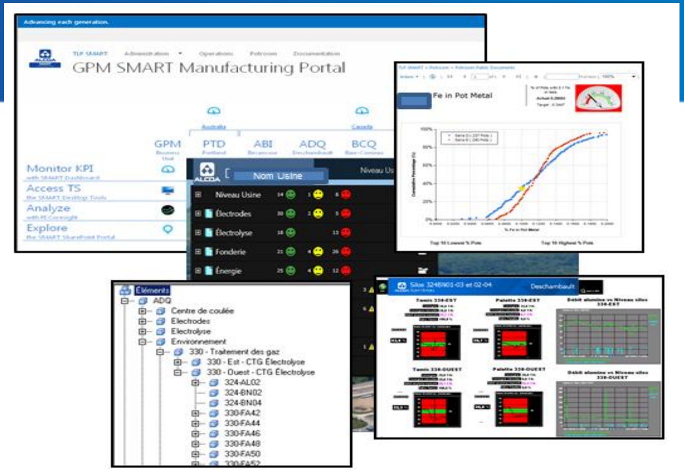


Why Alcoa invested in the SMART Manufacturing Initiative ?

- Aluminum production requires very large manufacturing sites
- With time, the process control and manufacturing systems have **multiplied** and become **heterogeneous**
- Each production system was an isolated data island with limited or no data history
- Common operation best practices and new technology deployment were very difficult to implement

SMART Manufacturing Program

SMART Manufacturing is about integration of data with process expertise to enable proactive and intelligent manufacturing decisions in dynamic environments



Challenges

- Aluminium market has been financially challenged for several years
- Improve competitiveness
- Enhance operational excellence
- High retirement rates, loss of SMEs

Solution

- <u>Establish the SMART Manufacturing program</u>
- OSIsoft *enterprise agreement*
- Deploy a robust infrastructure « cookie cutter » project in all plants
- Mobilize key employees

Results / benefits

- Well integrated, fine granularity, long term production data available
- Increase collaboration and sharing at the plants and between locations
- **<u>Achieve significant savings</u>**

SMART Manufacturing – Main improvement axes

Data Maturity Model

400k to 1200k PI Tags / plant

Standardised « self-service » tools

Hundreds of data sources / plant

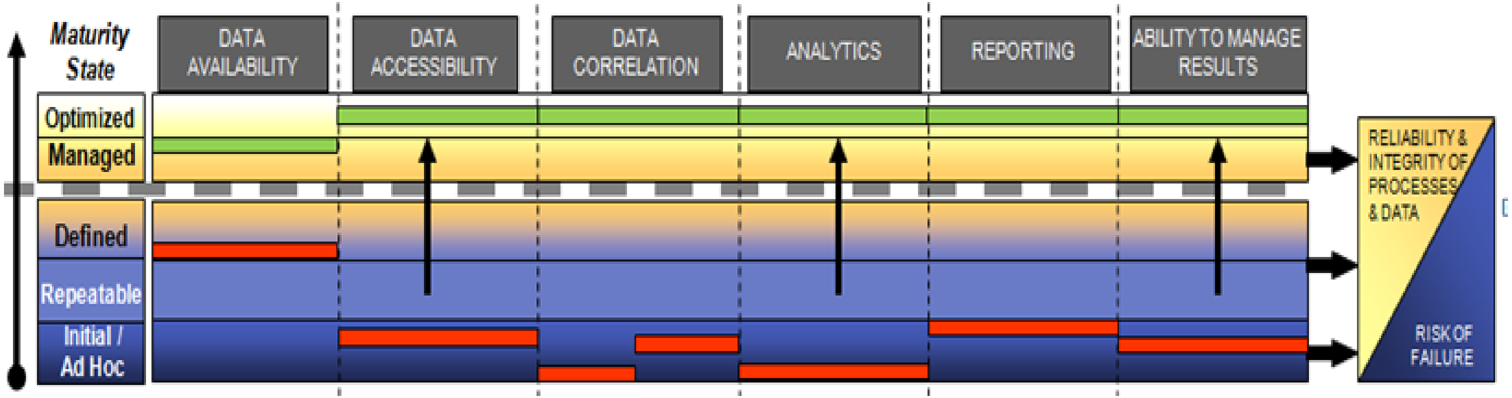
Basic tools in place, foundation to advance initiative

OSIsoft and Microsoft tools

SMART Mfg Dashboard

After :

Before:



SMART Manufacturing – Real plant wide data infrastructure

Site Name	Total
GPM Global BU	1,559,207
GPM Warrick Site	1,246,100
GPM Alumar Site	1,193,900
GPM ABI Site	1,042,900
GPM Baie-Comeau Site	951,450
GPM Portland Site	675,770
GPM Mosjoen Works Site	628,190
GPM Fjardaal Site	554,000
GPM Deschambault Site	501,460
GPM Massena West Site	337,590
GPM Lake Charles Site	30,751
Warrick Power Plant	22,358
GPM Lista Site	6,548
Grand Total	8,750,224

Big Data

Note for Lista: QLC not installed and the initial data collection phase is not completed

The journey to the implementation of the SMART Mfg program

2010	Program Definition (OSIsoft support)
2011	Proof of concept (Deschambault plant, QC)
2011(Q4)	Entered the OSIsoft Enterprise Program
2012-2014	Aggressive Global Deployment (13 plants)
2014	EA extension to other plants
2015	Additional deployments (2 to 5 plants)

SMART Mfg. – Deployment Schedule

Site	2011				2012				2013				2014				2015			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Deschambault																				
Massena West																				
Baie Comeau																				
Mosjoen																				
Fjardaal																				
Lake Charles																				
Warrick																				
Portland																				
ABI																				
Reybec																				
Global BU Instance																				
Sao Luis																				
Lista															ACES					
Intalco																				
San Ciprian																				
Ma'aden																				

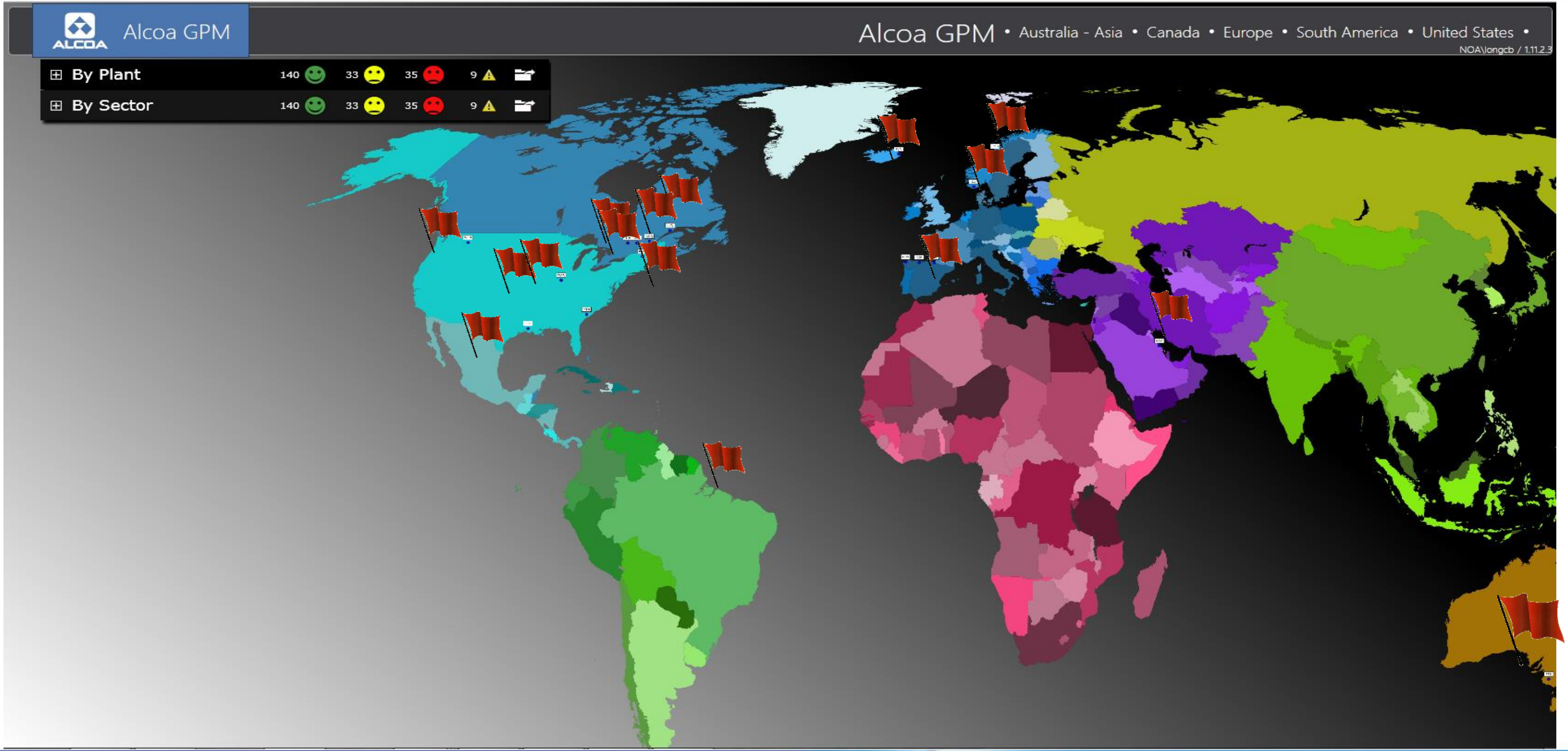
Project Found and Startup
Deployment & Data collection
Value Realization

On Schedule
Schedule at Risk
Behind Schedule

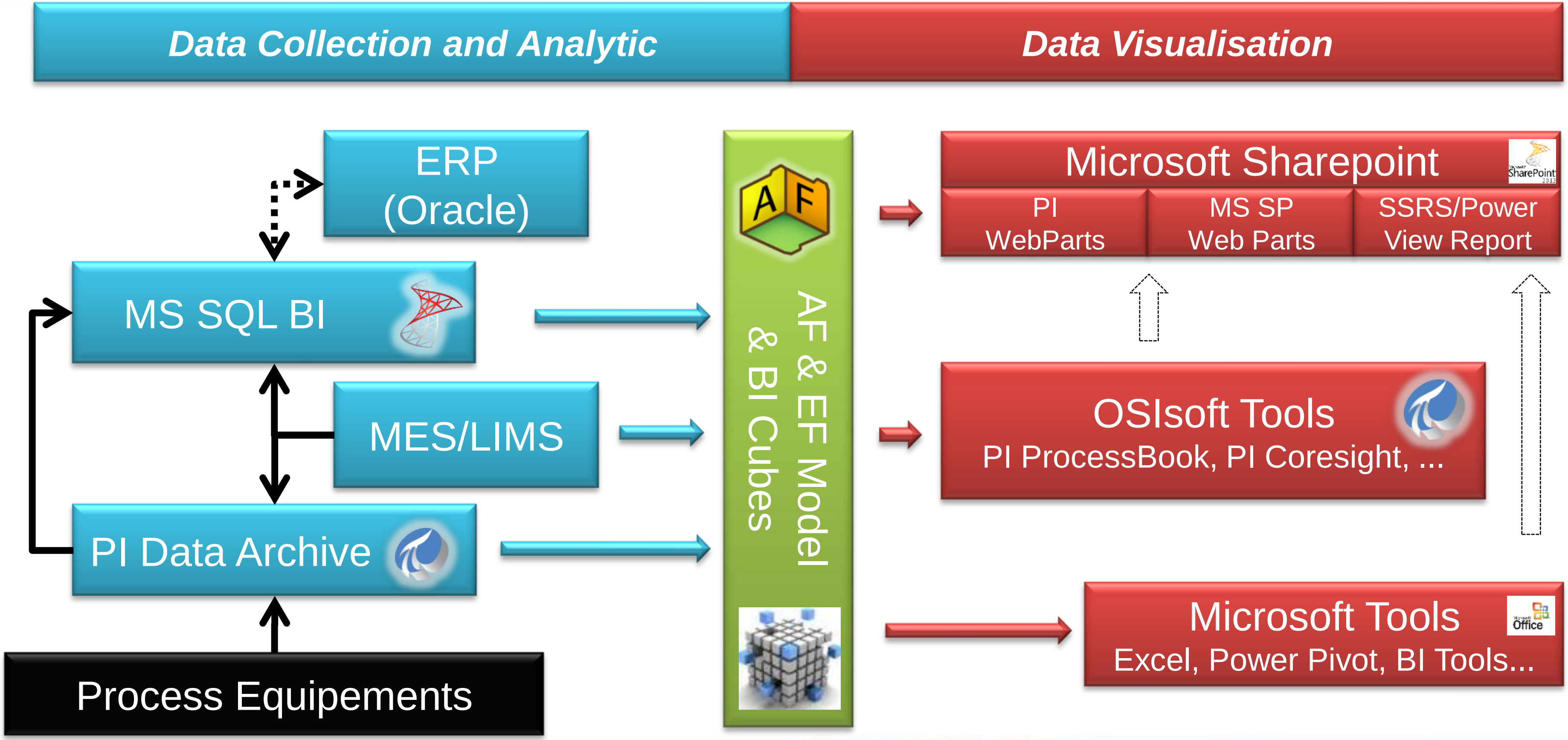
On Hold
Closed

- Approx. one deployment start-up every 2 to 3 months
- Each deployment required a 6 to 9 months effort
- Global BU instance added in 2014

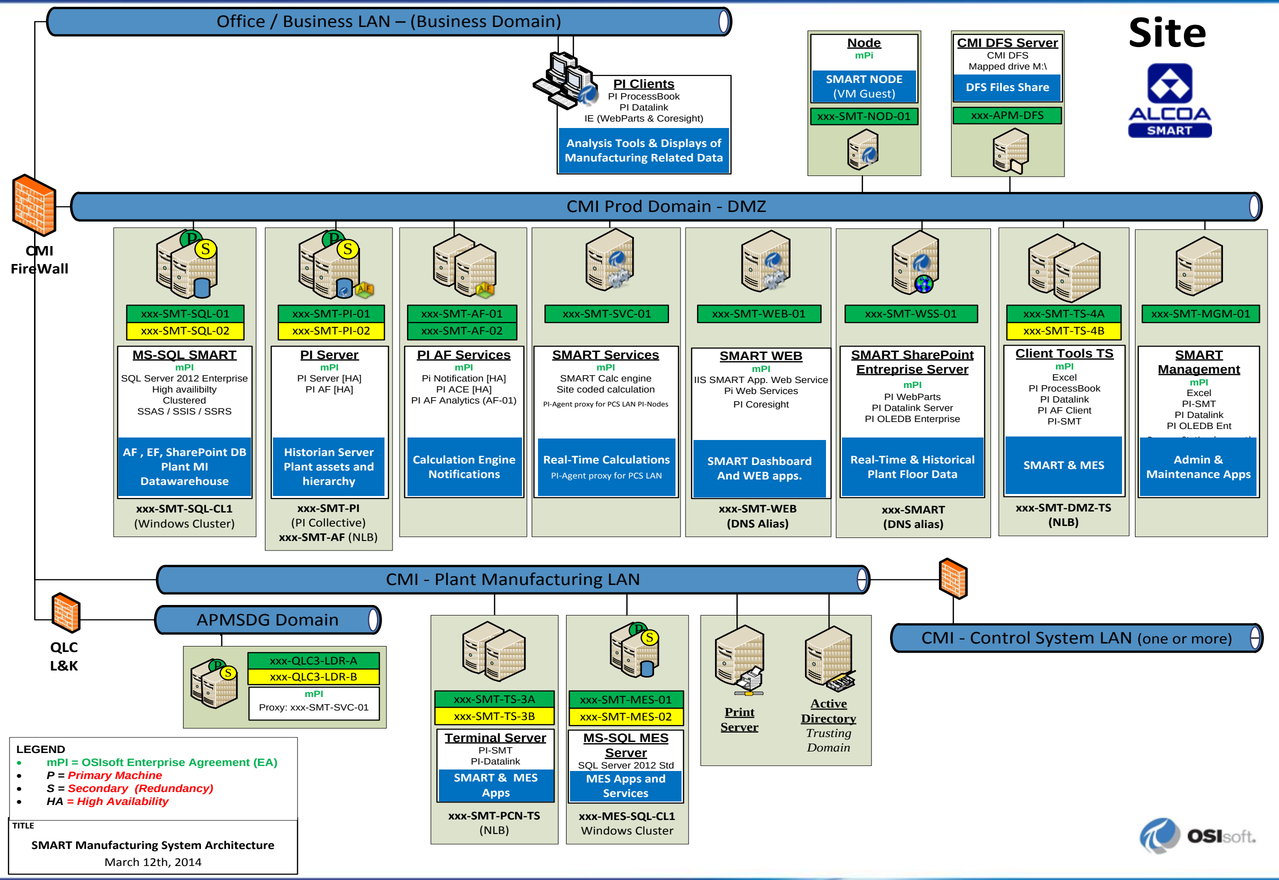
SMART Manufacturing – Geographical localisation



SMART Manufacturing – Functional model



SMART Manufacturing – Implantation diagram



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User Engagement

Pierre Boutin, P.Eng, MPM

Manager, Global Manufacturing Solutions Delivery

OSIsoft User's Conference, San Francisco, April 2015

Organization structure for change management

Global

Sector leaders

Plant

End-users

Plant sector lead/area super-users

Technical lead

Value lead

Global

End-users

Global

Regional leaders

Global

SMART technical team

OSIsoft team

Key success factors

Data visibility

Key success factors

Key success factors

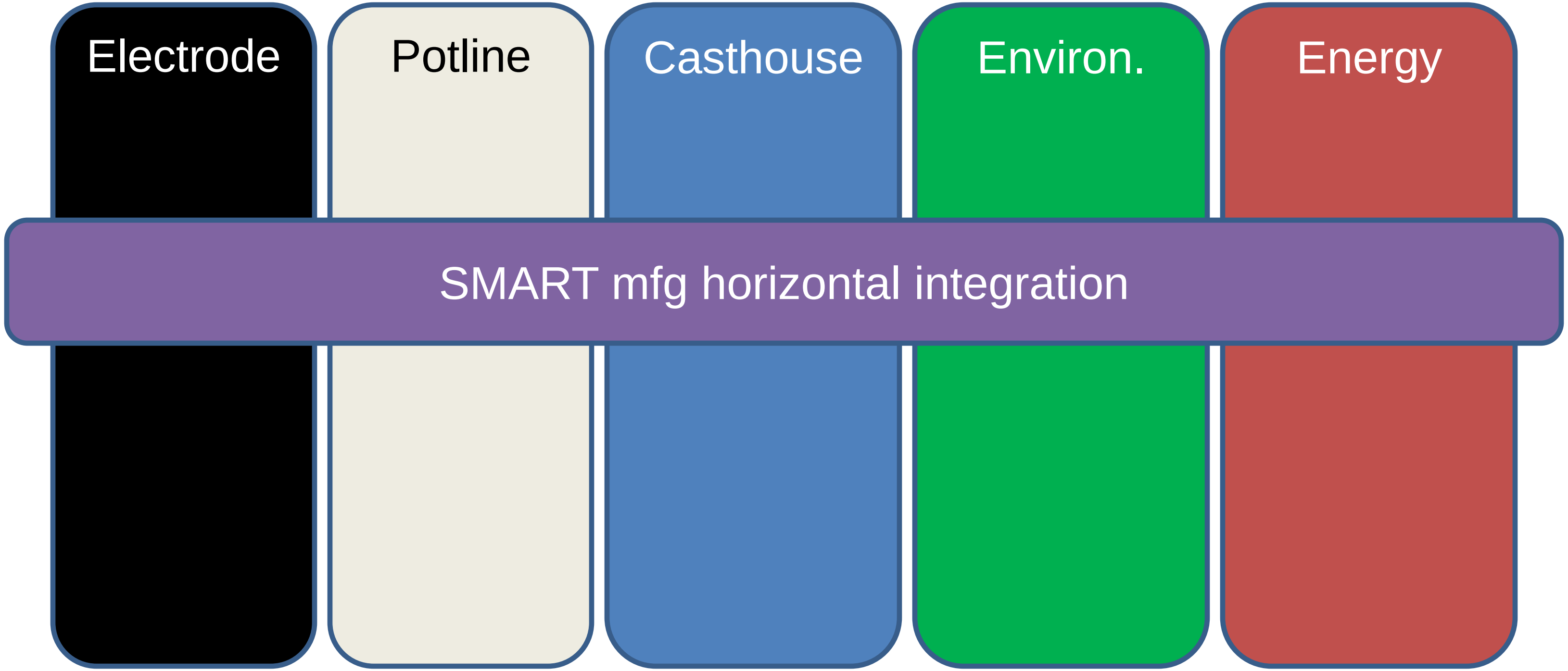
Post installation follow-ups

- Train users
- Answer questions
- Fix issues
- Share best practices from other locations
- Escalate
- Detect lack of engagement before it is too late
- Report value to sponsors

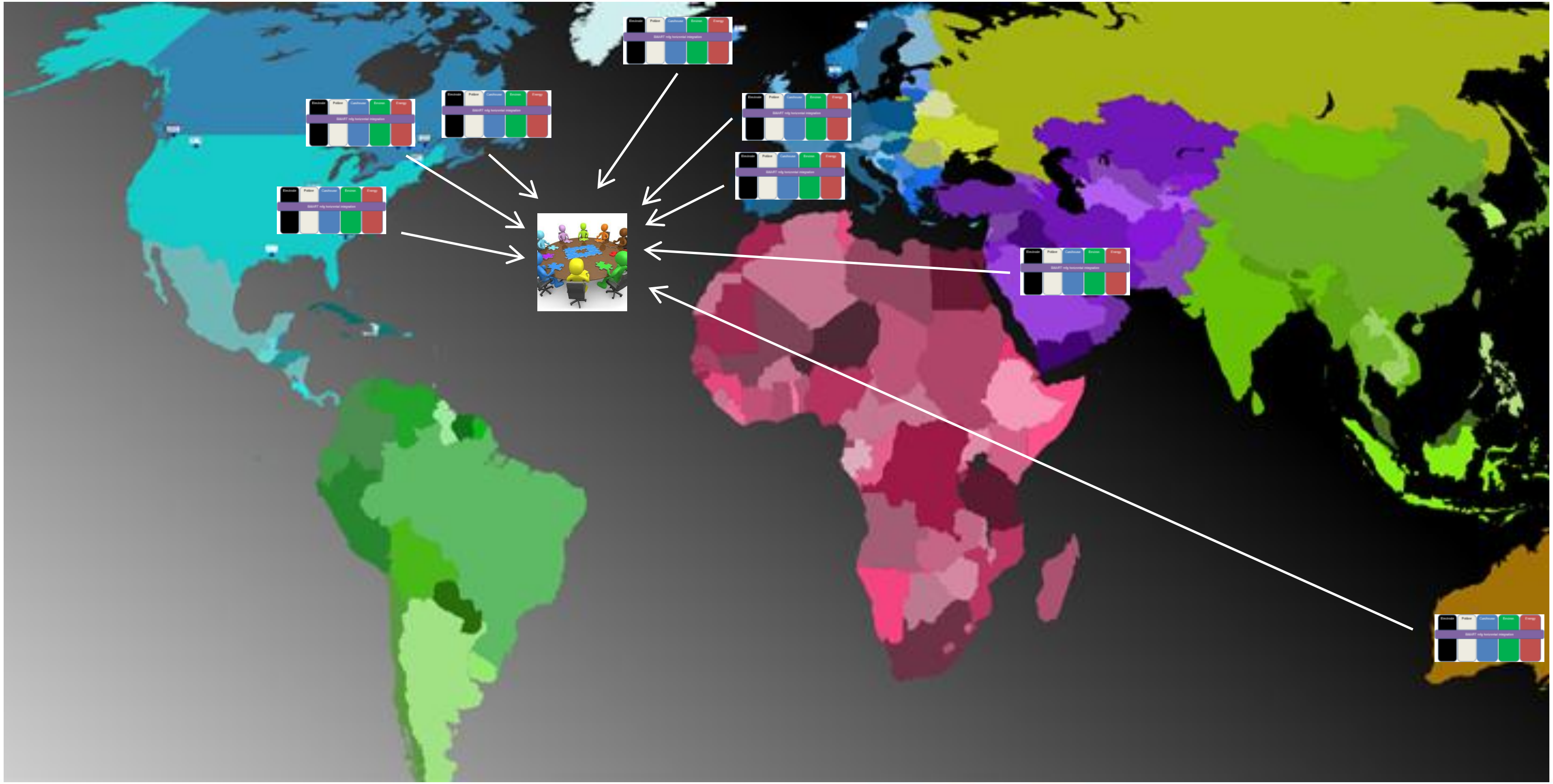
- Keep communication channels open…

Working across silos at the plant level

User engagement at the plant level



Working across silos globally



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Anode tracking

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Anode tracking R&D project

The goal of the anode tracking project is to make anode genealogy data (7 to 8 weeks from start to finish) easily accessible to support process improvements.

Challenges

Technical

- Physical anode identification
- Linking anode data available at different point in time
- Continuous and discrete process involved

Business

- Cost of raw materials
- Establishing anode fabrication best practices

Solution

- Read anode numbers with OCR camera
- Store sampled data in PI Server
- Use Event Frames to organize data in time
- Integrate all data sources with the MS SSAS toolset (BI cube)

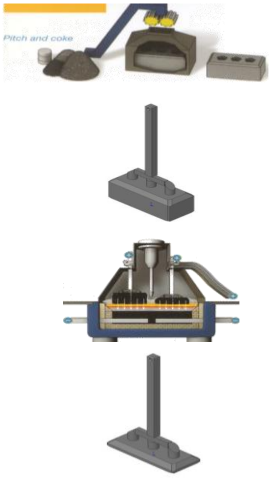
Results / benefits

- Holistic insight over anode life
- Anode performance linked to raw materials and anode fabrication data
- Development of anode manufacturing best practices
- Improved Raw Material selection process

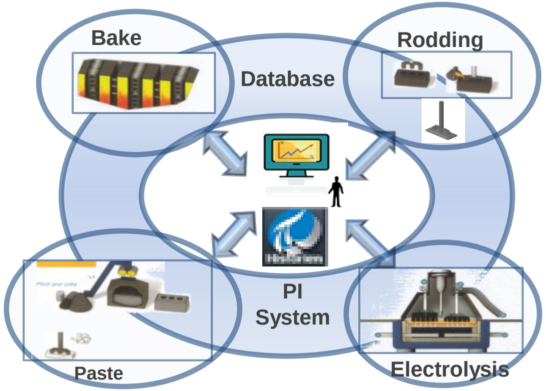
Work breakdown structure

Anode tracking

Physical Tracking

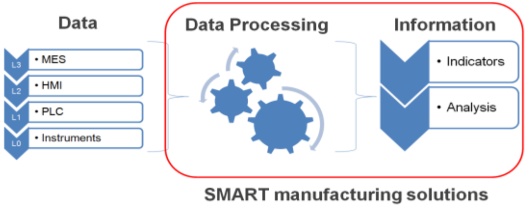


Data Processing



- Data collection
- Structure/organize data
- Manufacturing Intelligence

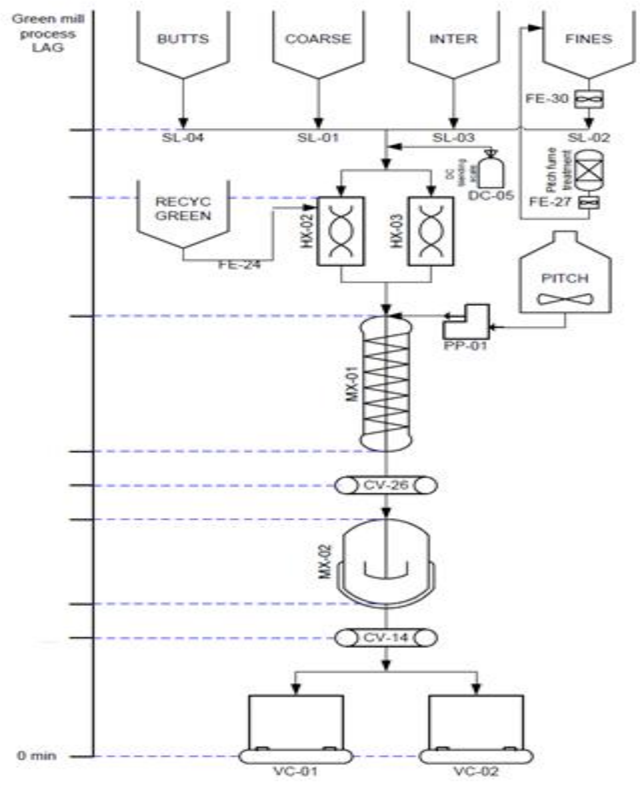
Process optimization



- Process modelization
- Reaction plan
- Preventive/proactive actions
- Predictions
- Process optimization
- Best practices development

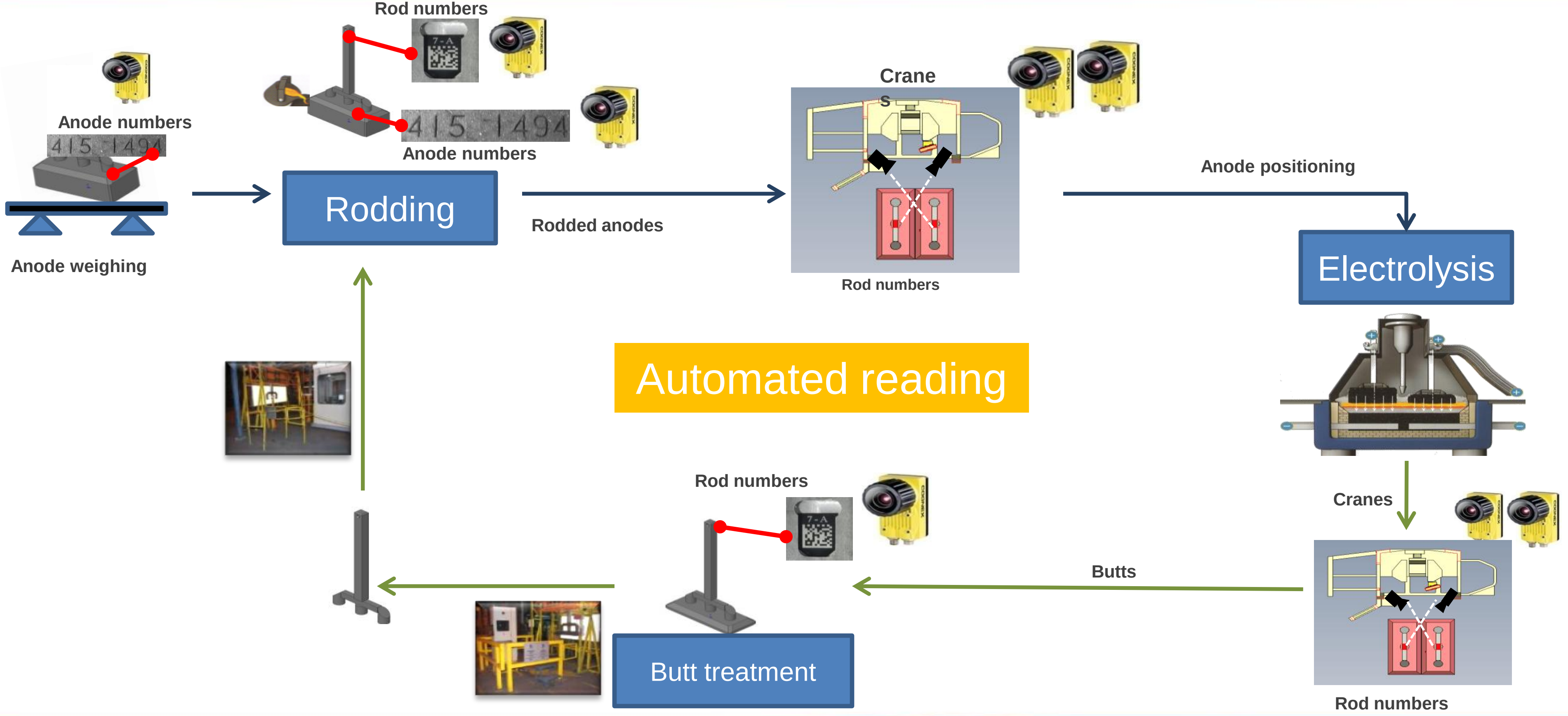
Data – Continuous process

GREEN MILL FLOW SHEET
WITH LAG STRUCTURE AND DATA



Paste plant

Data – Discrete process



Challenges

SMART Manufacturing Anode tracking – Functional specification
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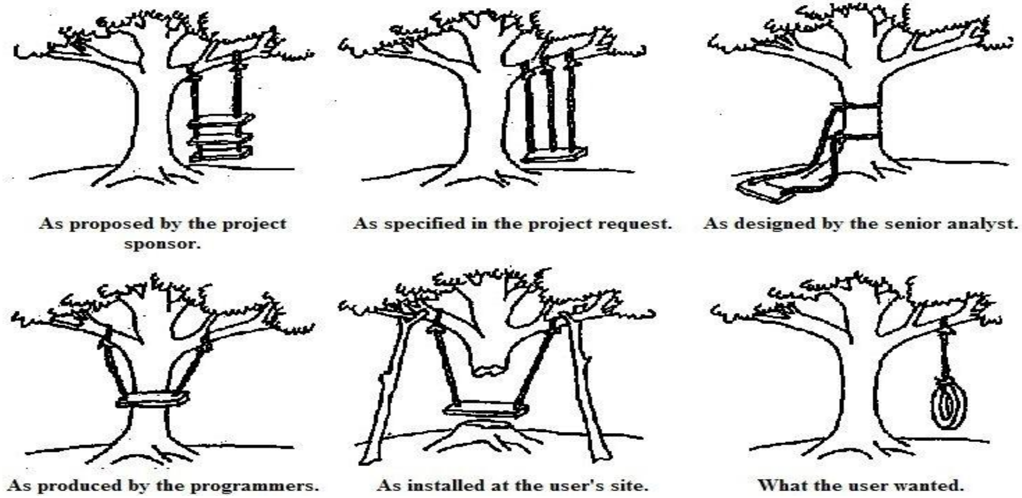
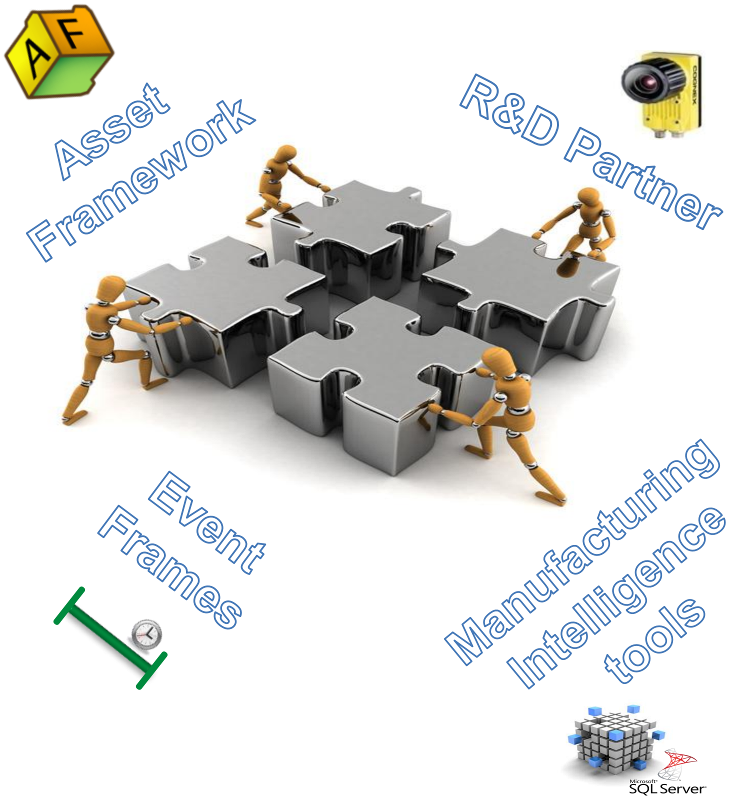


As proposed by the project sponsor.
As specified in the project request.
As designed by the senior analyst.
As produced by the programmers.
As installed at the user's site.
What the user wanted.



AF
Asset Framework
R&D Partner
Event Frames
Manufacturing Intelligence tools
SQL Server

Data processing

OSIsoft.

Raw data

PI Data Server

Lab, MES, other sources

Automation

Asset Framework : equipment hierarchy

- ADQ
  - Centre de coulée
  - Electrodes
    - 01. Tour à pâte
      - Brai - Analyses fournisseur
      - Brai - TK01
      - Brai - TK02
      - Coke - Analyses fournisseur
      - Coke - BN02
      - Coke - BN03
      - Entrepôt des Anodes Crues
      - FPM
      - L1
        - Chaine des Crues
        - Chaine des Fines
        - Chaine des Gros
        - Chaine des Moyen
        - Chaine des recyclés cuits
        - Dépoussièreur

Event Frames : organize data in time

- GA RawMaterial 2014-01-07 10:07
  - GA RawMaterials CokeDetail BN03 2014-01-07 08:57
  - GA RawMaterials PitchDetail TK02 2014-01-07 08:57
  - GA RawMaterials PitchDetail TK01 2014-01-07 10:07
  - GA AggregateSizing L1 2014-01-07 10:07
    - GA Dosing L1 Vibro 2 2020219
      - GA Mixing L1 Vibro 2 2020219
        - Green Anode 2020219

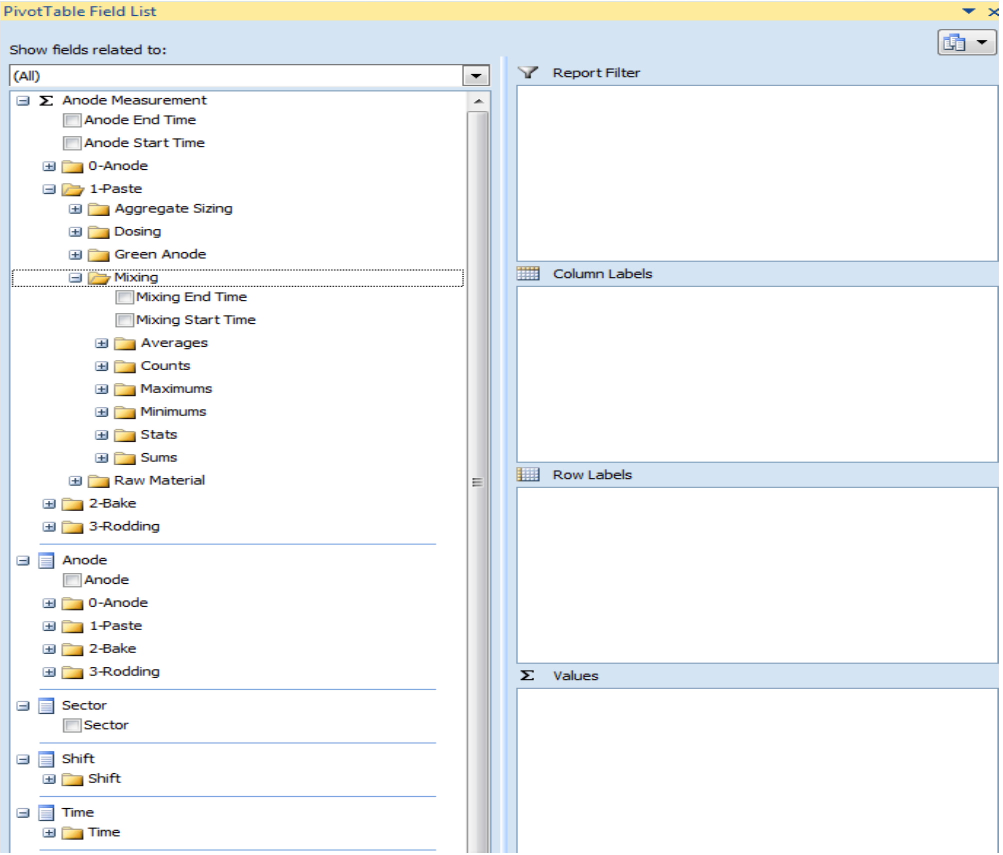
Microsoft SQL Server

Microsoft SharePoint Server 2010

Microsoft Excel

Data extraction / exploitation

- Microsoft SQL-Server Analysis Services (SSAS) dialog



Final result

Data sampled at different points in time are all linked to the same anode

Year - Week - Day	(Multiple Items)
Good	1
BA LIMS Results Accuracy	100

Row Labels	Green Anode Height Avg AVG	Green Anode Weight Avg AVG	Mixing Ton Hour Mixer Avg AVG	Aggregate Sizing Theoretical Sieve8 Avg AVG	Aggregate Sizing Theoretical Sieve48 Avg AVG	BA LIMS Results AirDustReactivity Avg AVG	BA LIMS Res
2170078	623	965	20	14.87732983	13.27331543	3	
1170128	622	968	20	14.87732983	13.27331543		
2170178	622	971	23	15.42470741	12.96173477	3	
1170202	624	969	25	15.42470741	12.96173477	4	
1170280	623	972	30	15.11748695	10.8945713		
1170312	622	971	30	15.11748695	10.8945713		
2170392	623	972	31	15.11748695	10.8945713	4	
2170939	626	968	32	13.9515419	10.53309727		
2170943	624	966	32	13.9515419	10.53309727		
2170979	623	966	33	16.79839325	10.03898811		
1171028	623	967	33	16.79839325	10.03898811	3	

BA LIMS Results AirDustReactivity Avg AVG	BA LIMS Results AirPermeability Avg AVG	BA LIMS Results AirResidueReactivity Avg AVG	BA LIMS Results End Time
3		76	2014-05-09 00:01
	0.95599997		2014-05-10 00:01
3		75.5	2014-05-09 00:00
4	0.280000001	73.09999847	2014-05-11 00:00
	1.578999996		2014-05-08 00:00
			2014-05-08 00:02
4		79.90000153	2014-05-08 00:01
			2014-05-10 00:02
	0.207000002		2014-05-11 00:01
	2.780999899		2014-05-10 00:00
3		76.59999847	2014-05-11 00:02

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Cast data collection and integration

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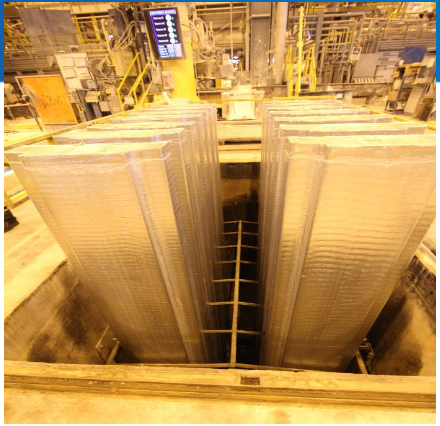
OSIsoft User's Conference, San Francisco, April 2015

Cast data collection & integration



The goal of this initiative was to deliver an efficient and flexible cast equipment's data collection engine and to combine resulting data with other data sources such as elaboration, quality, laboratory and tracking

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Challenges

- Huge volume of data
- Adaptive and generic data capture
- User driven data capture enhancements
- Time series and relational data integration in one spot

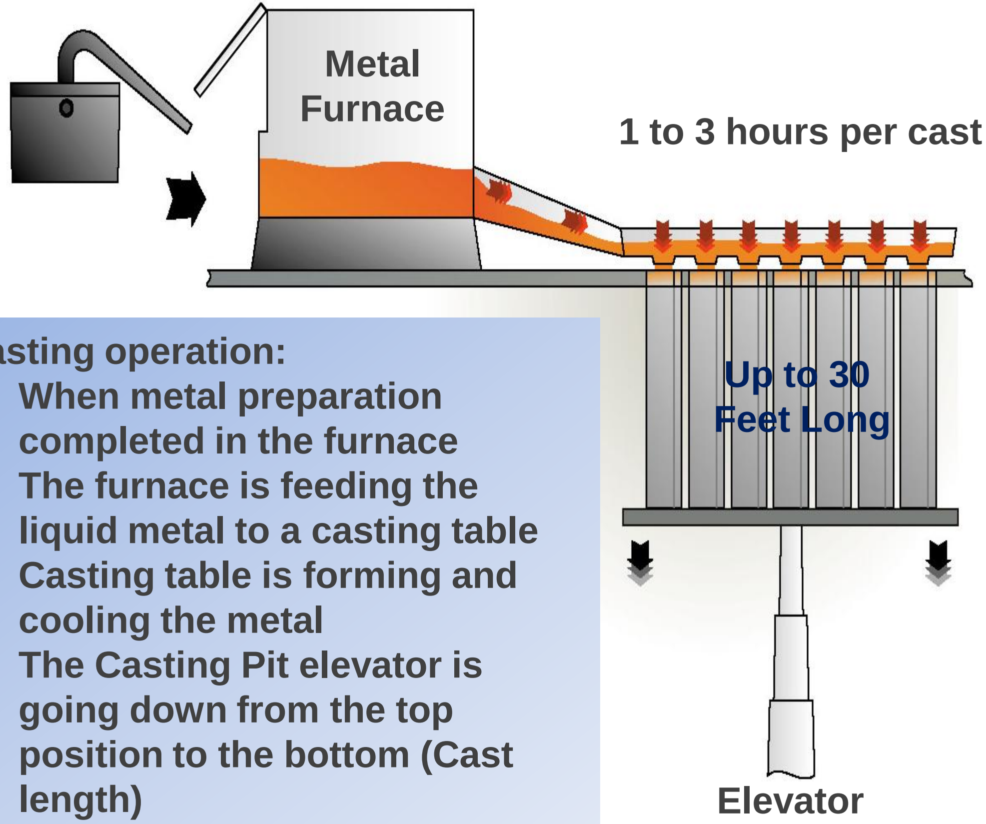
Solution

- Use Event Frames to capture and organize data in time
- Extend EF internal data capability
- Integrate all data sources with the MS SSAS toolset (BI cube)
- Automated EF structure and data transfer to the cube

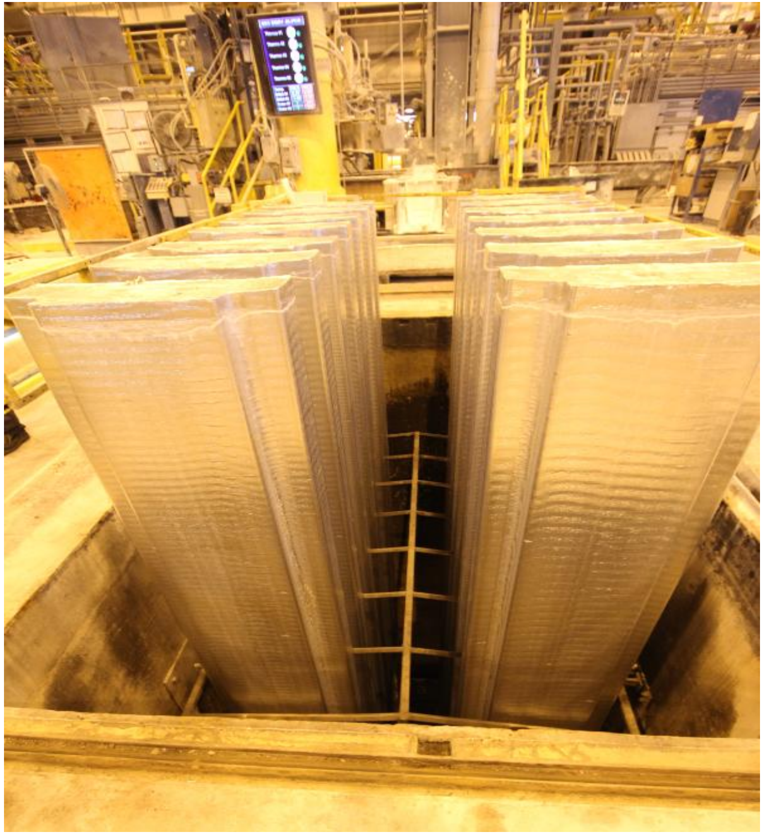
Results / benefits

- Well integrated, right granularity cast data
- Increased monitoring, troubleshooting and analytical capabilities
- **Reduced scrap and improved product quality**

Casting Operation Overview



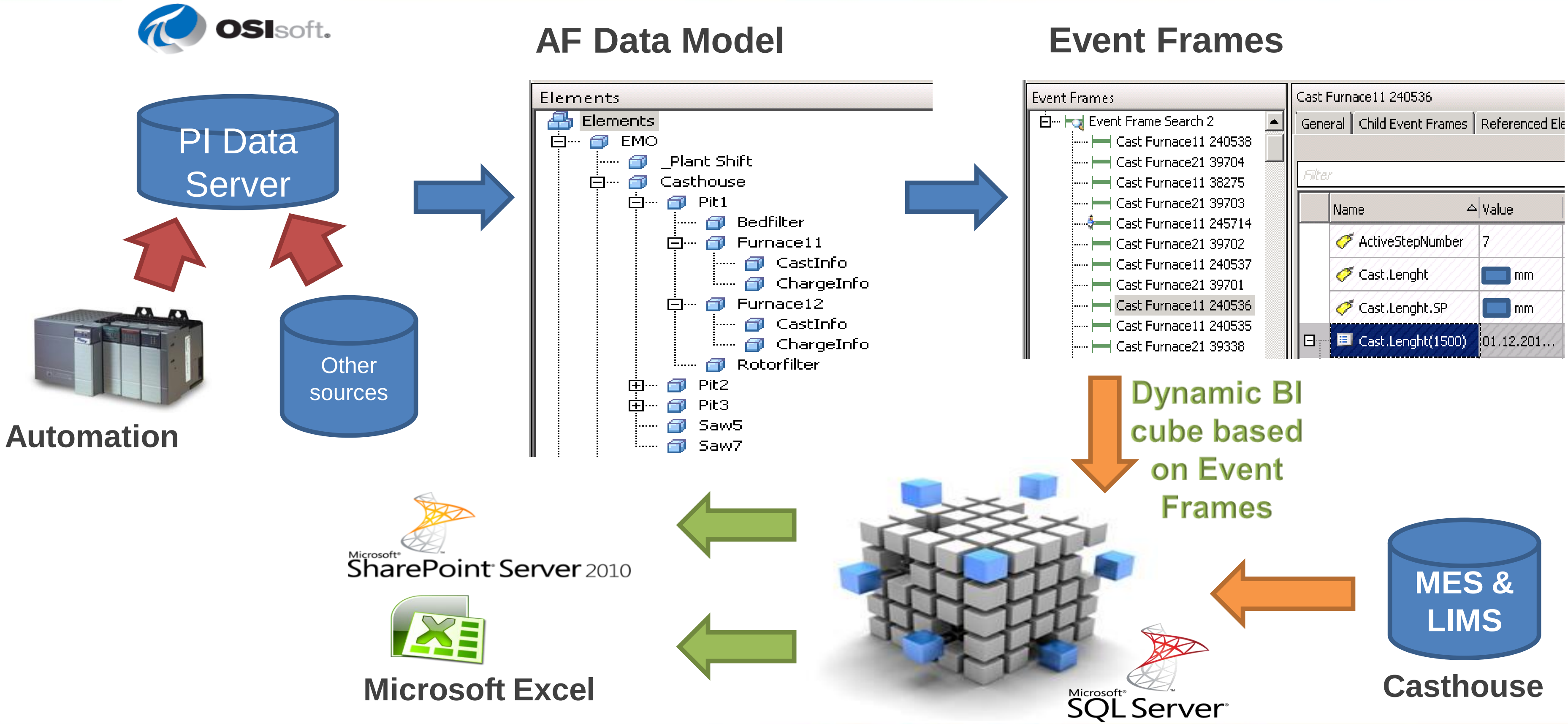
Casting operation:
- When metal preparation completed in the furnace
- The furnace is feeding the liquid metal to a casting table
- Casting table is forming and cooling the metal
- The Casting Pit elevator is going down from the top position to the bottom (Cast length)



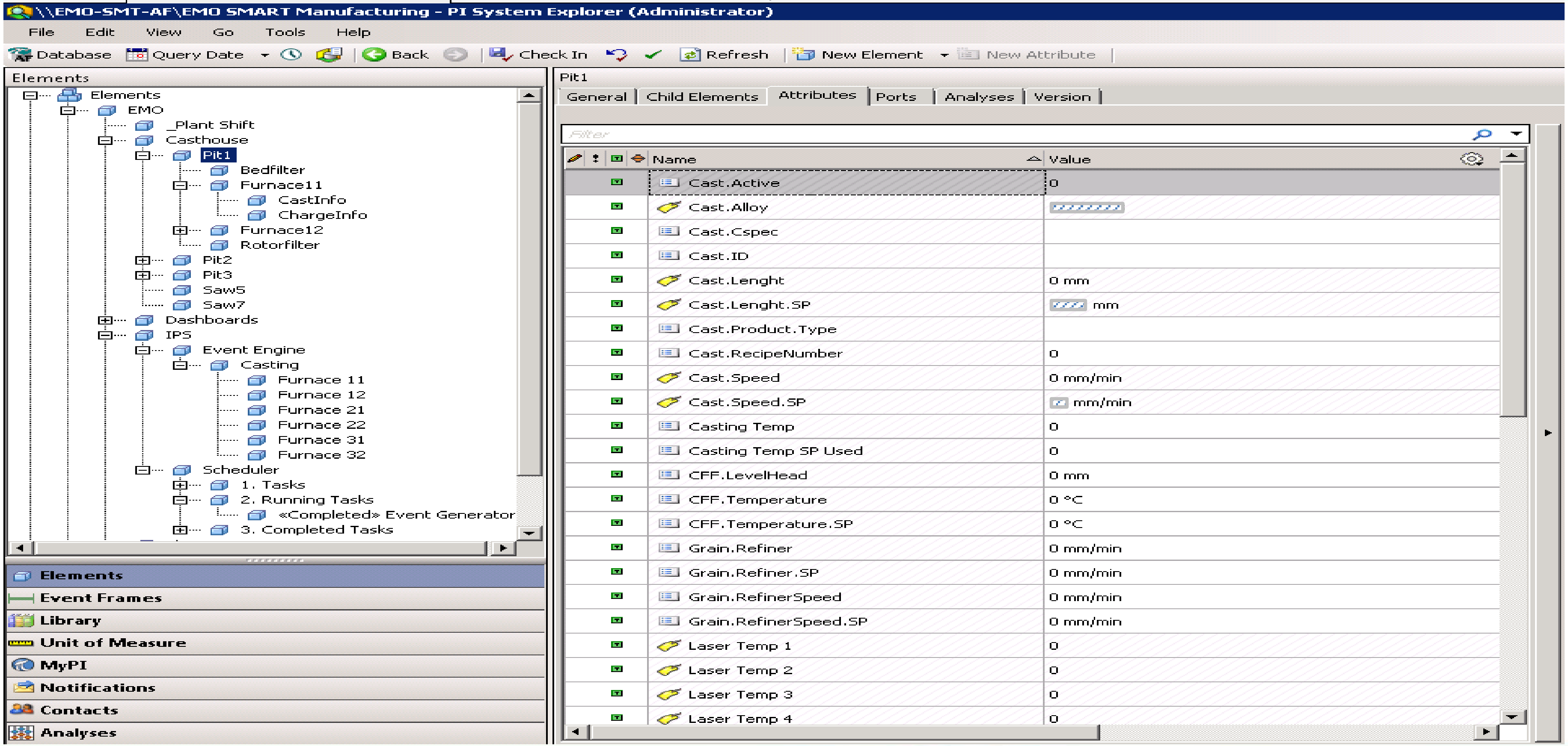
Casting Data Collection & Integration technical challenges

- Summarize the volume of time series data: 50 sensors and set points x 3 hours cast x 1 sec frequency = approx.) 0.5 M values per cast;
- Ability to capture cast data for a specific internal process step like: start-up time, steady state time, stoppage time;
- Ability to capture cast data at a specific time (on critical event);
- Deliver a complete process data integration (from all sources);
- Be able to quickly compare, slice and dice from various angle critical cast data;
- Finally, from the cast summary data, be easily able to go back to the detailed data in one mouse click;

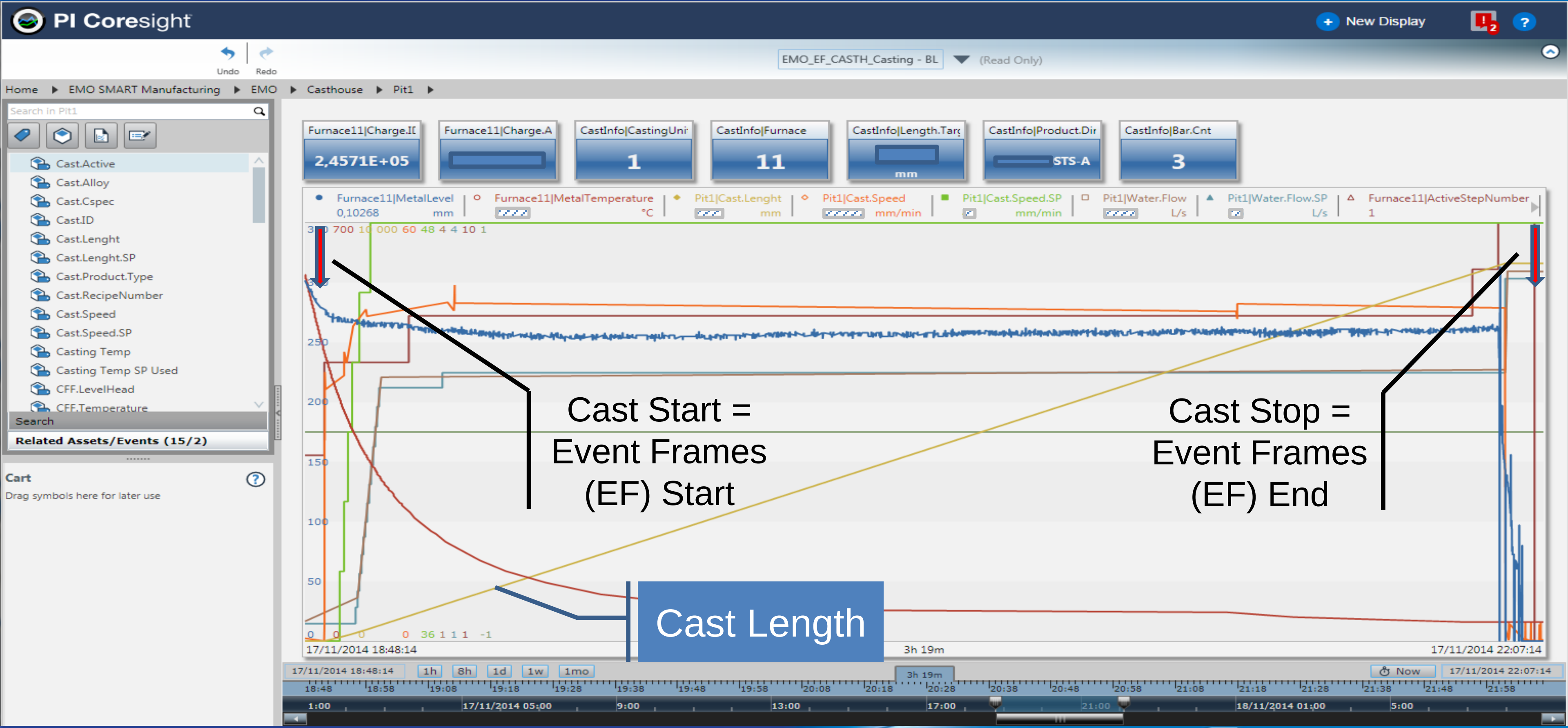
Solution : Casthouse Data Integration Concept



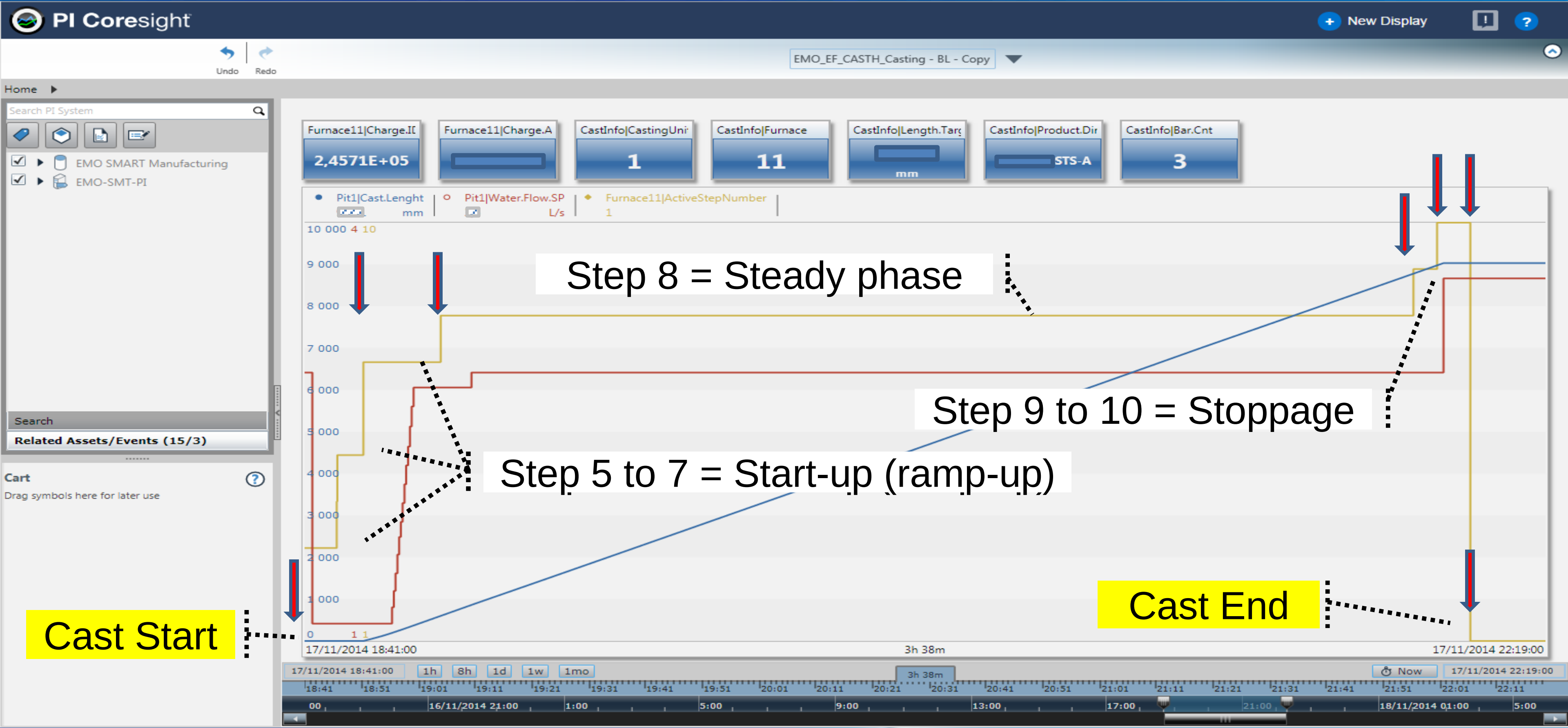
Casthouse AF Data Model



Casting Operation Event Frames Boundaries

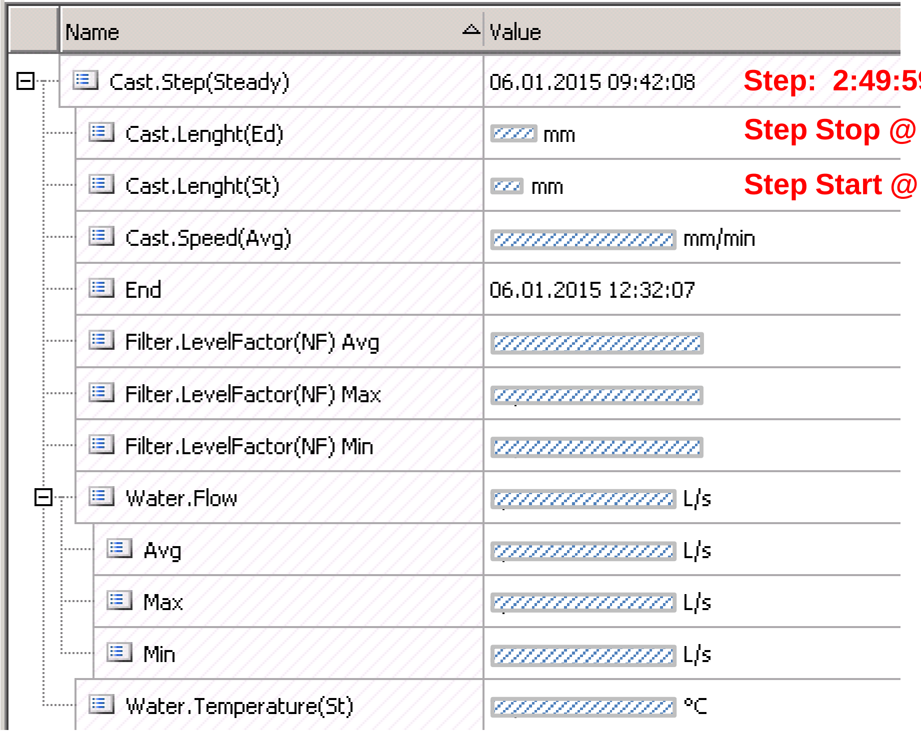


Capture data for specific process phase (time window)



Capture Data during the Steady State phase only

Based on predefined Cast Steps (Steady phase step = 8)

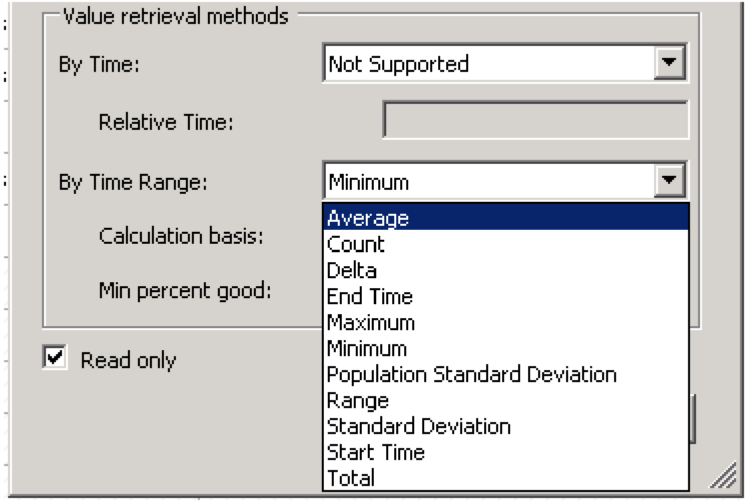


Step: 2:49:59 hours

Step Stop @ mm

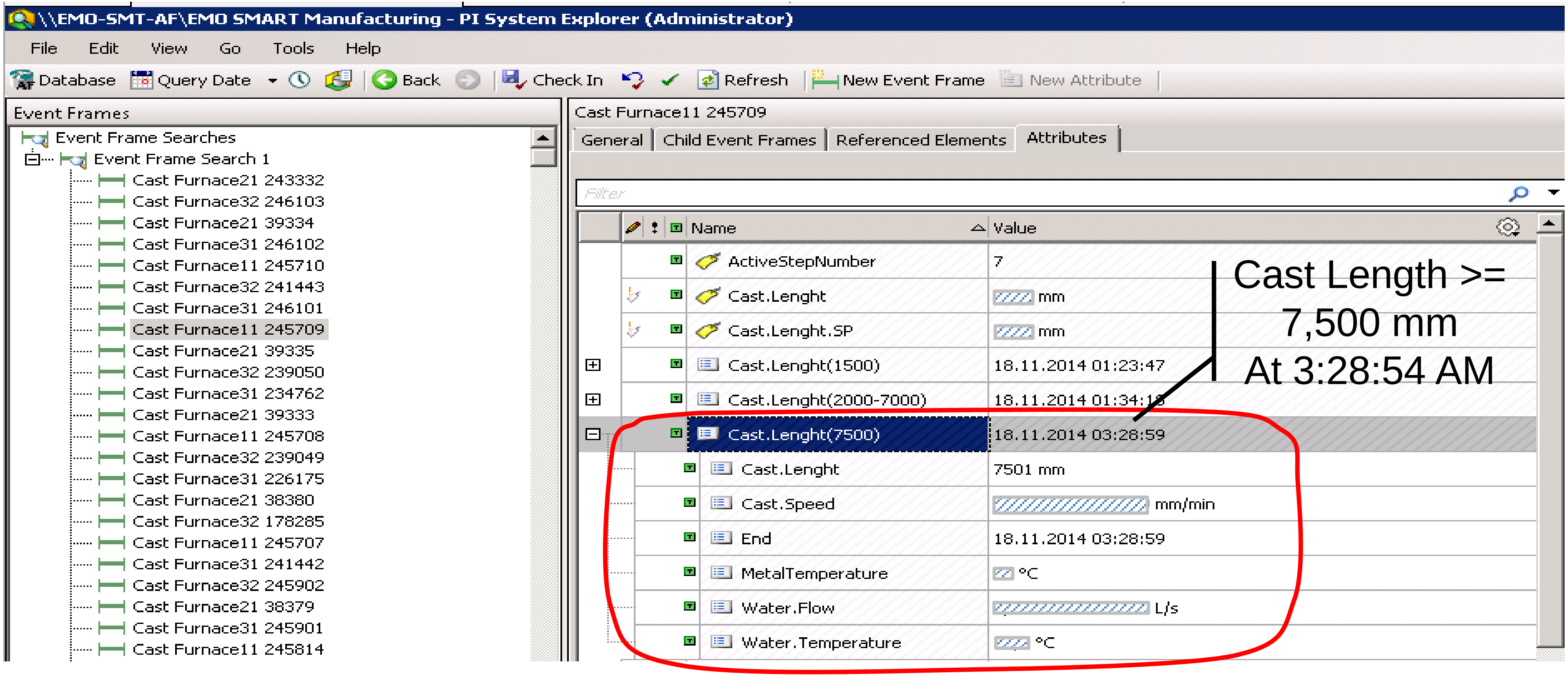
Step Start @ mm

Data is summarized for the cast steady state time window as configured:

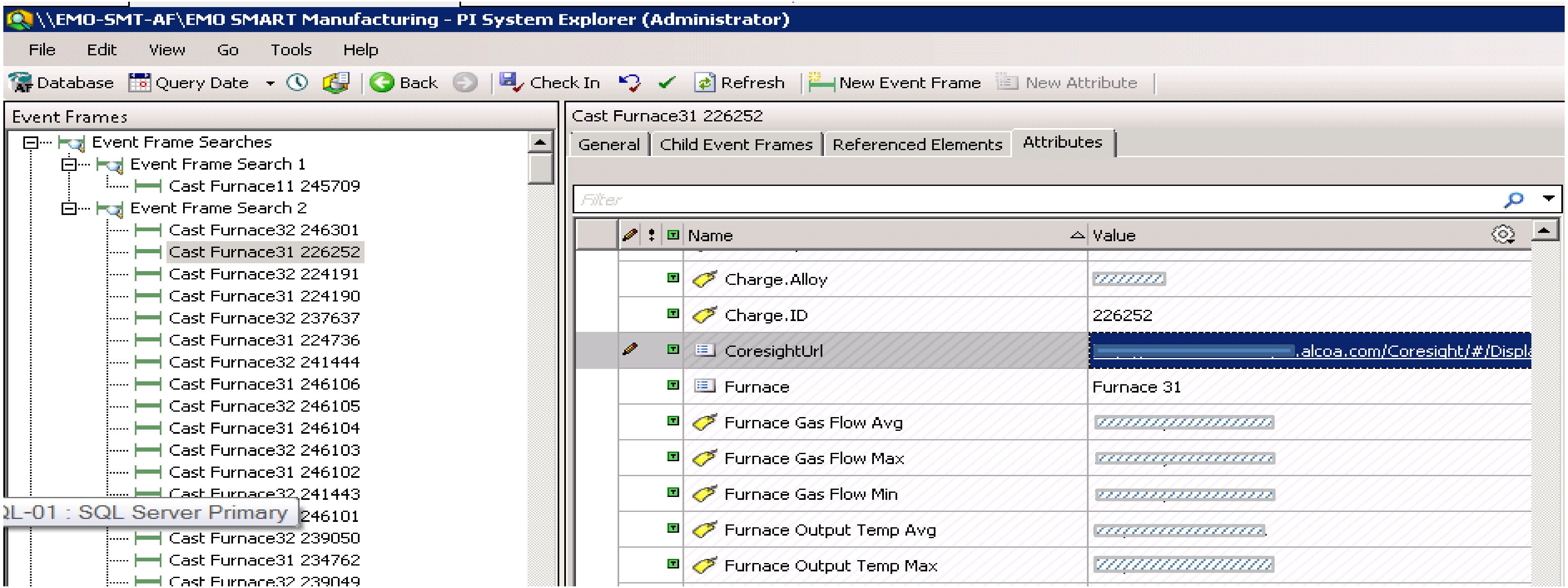


Additional Data capture capability: Data at a specific moment

Capture information at a specific moment (Like a picture)



Can always go back to the detail with imbedded PI Coresight hyperlink



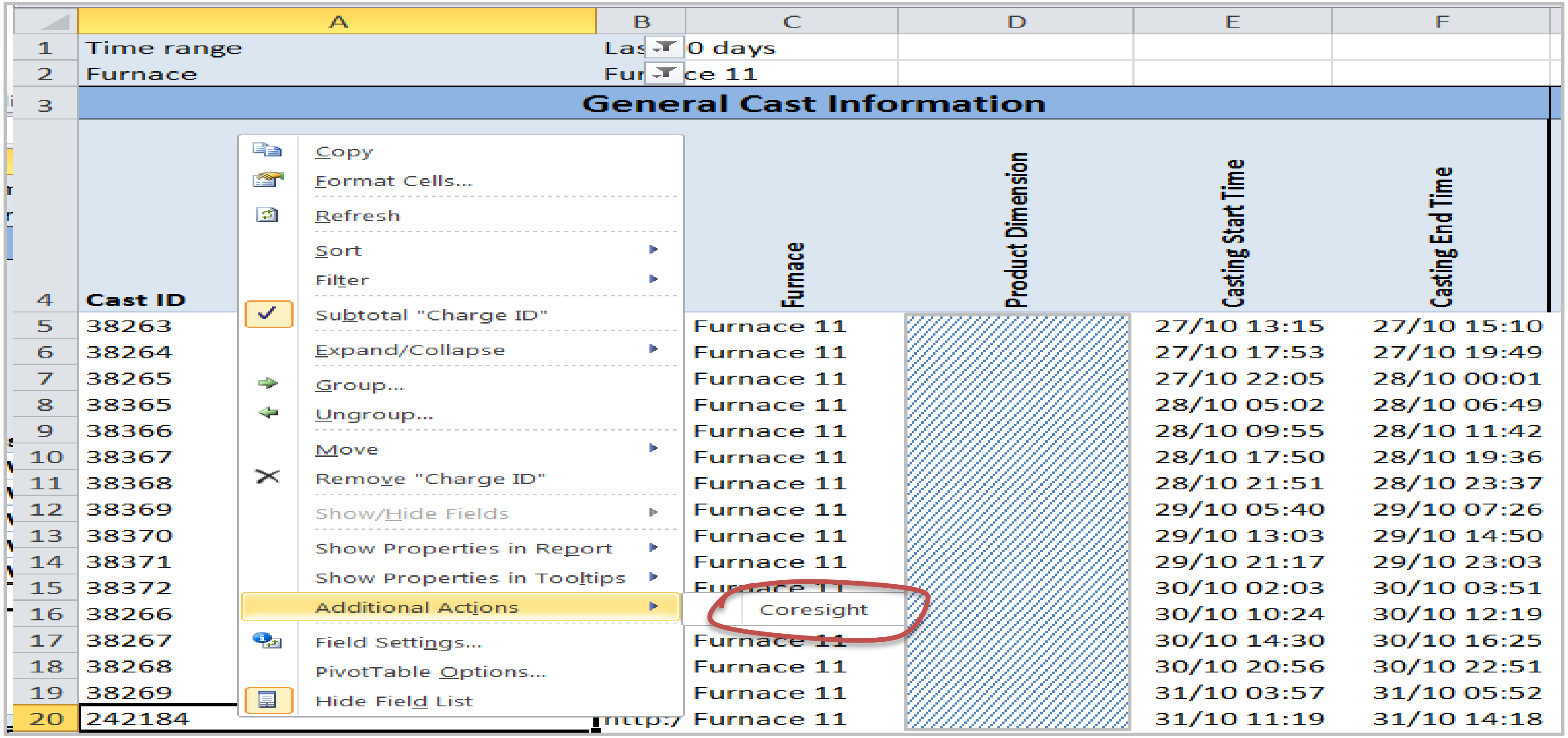
BI Cube needed for the Integration of all data sources (EF and MES)

- Summary of all Cast critical data in one place
- Can look at a large volume of data quickly
- Can do cast to cast comparisons
- Can go back to the detailed data in one click (PI Coresight hyper link)

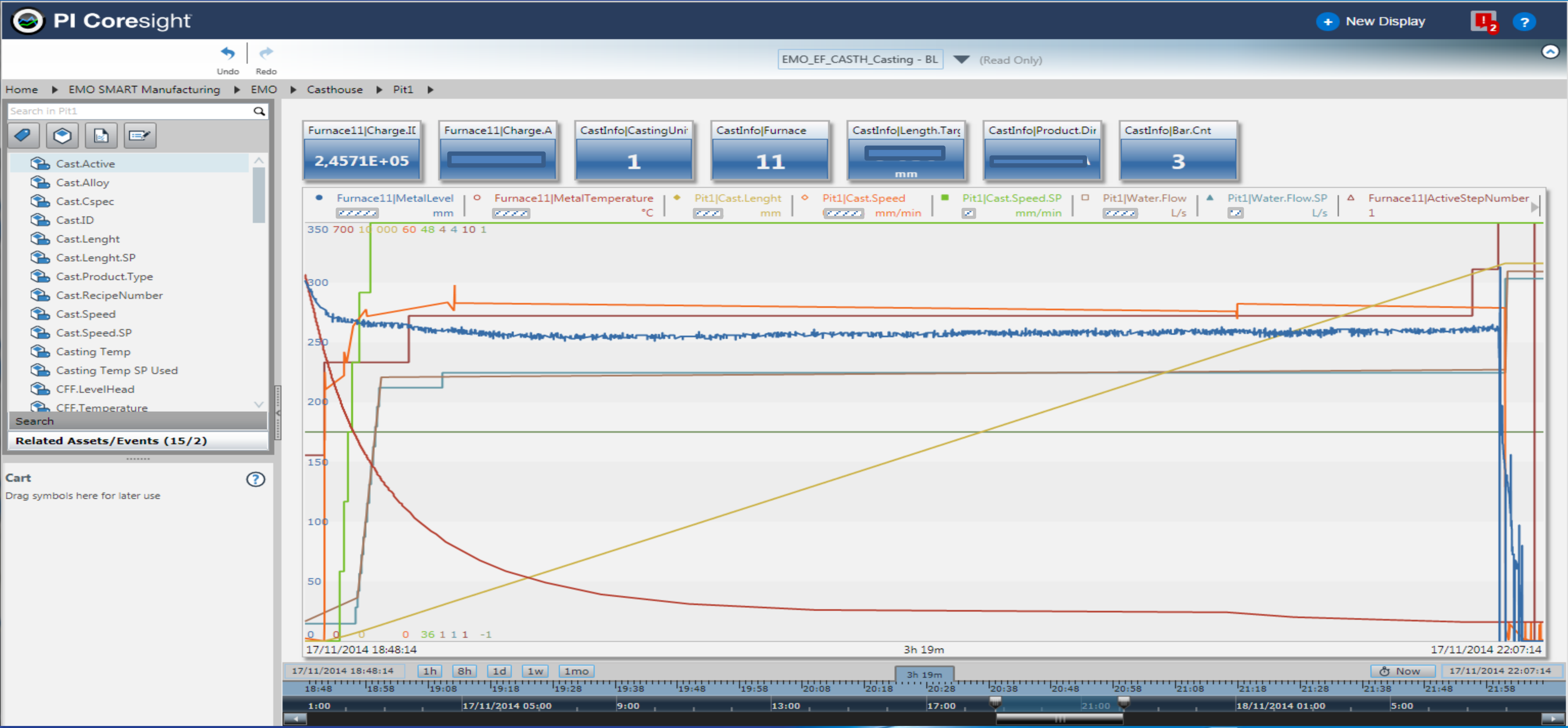
Time range Las 0 days
Furnace Fur ce 11

General Cast Information						@1.5 M		Steady State						@7.5 M	
Cast ID	CoresightUrl	Furnace	Product Dimension	Casting Start Time	Casting End Time	Metal Temp(1.5)	Water Temp(1.5)	Steady Start Time	Speed(avg)	SpeedAvg(SDEV)	Water Flow(Avg)	Water FlowAvg(SDEV)	Steady End Time	Metal Temp(7.5)	Water Temp(7.5)
				16/09 00:52	23/11 05:58			00:52:30		0.31		0.02	05:58:19		
38330	http:/	Furnace 11		16/09 00:52	16/09 02:24			00:52:30					02:24:00		
38331	http:/	Furnace 11		16/09 05:46	16/09 07:18			05:46:56					07:18:38		
38332	http:/	Furnace 11		16/09 11:09	16/09 12:39			11:09:11					12:39:05		
38333	http:/	Furnace 11		16/09 18:51	16/09 20:22			18:51:13					20:22:42		
38334	http:/	Furnace 11		16/09 23:50	17/09 01:20			23:50:32					01:20:57		
38335	http:/	Furnace 11		17/09 08:02	17/09 09:38			08:02:17					09:38:57		
38336	http:/	Furnace 11		17/09 12:48	17/09 14:19			12:48:55					14:19:33		
38337	http:/	Furnace 11		17/09 18:53	17/09 20:23			18:53:05					20:23:41		
38349	http:/	Furnace 11		29/09 16:57	29/09 18:28			16:57:00					18:28:38		
38350	http:/	Furnace 11		18/10 11:23	18/10 13:09			11:36:00					13:05:33		
38351	http:/	Furnace 11		18/10 15:56	18/10 17:42			16:09:03					17:38:49		
38352	http:/	Furnace 11		18/10 21:42	18/10 23:28			21:55:09					23:24:29		
38353	http:/	Furnace 11		19/10 02:26	19/10 04:12			02:38:58					04:09:02		
38354	http:/	Furnace 11		19/10 10:29	19/10 12:16			10:42:17					12:12:15		
38355	http:/	Furnace 11		19/10 15:31	19/10 17:17			15:44:09					17:13:54		
38356	http:/	Furnace 11		19/10 20:02	19/10 21:49			20:15:18					21:45:13		
38357	http:/	Furnace 11		20/10 00:32	20/10 02:19			00:45:15					02:15:34		
38358	http:/	Furnace 11		20/10 06:18	20/10 08:05			06:31:21					08:01:12		
38359	http:/	Furnace 11		20/10 14:04	20/10 15:58			14:17:11					15:54:47		

Can always drill down to the detail with PI Coresight from the CUBE

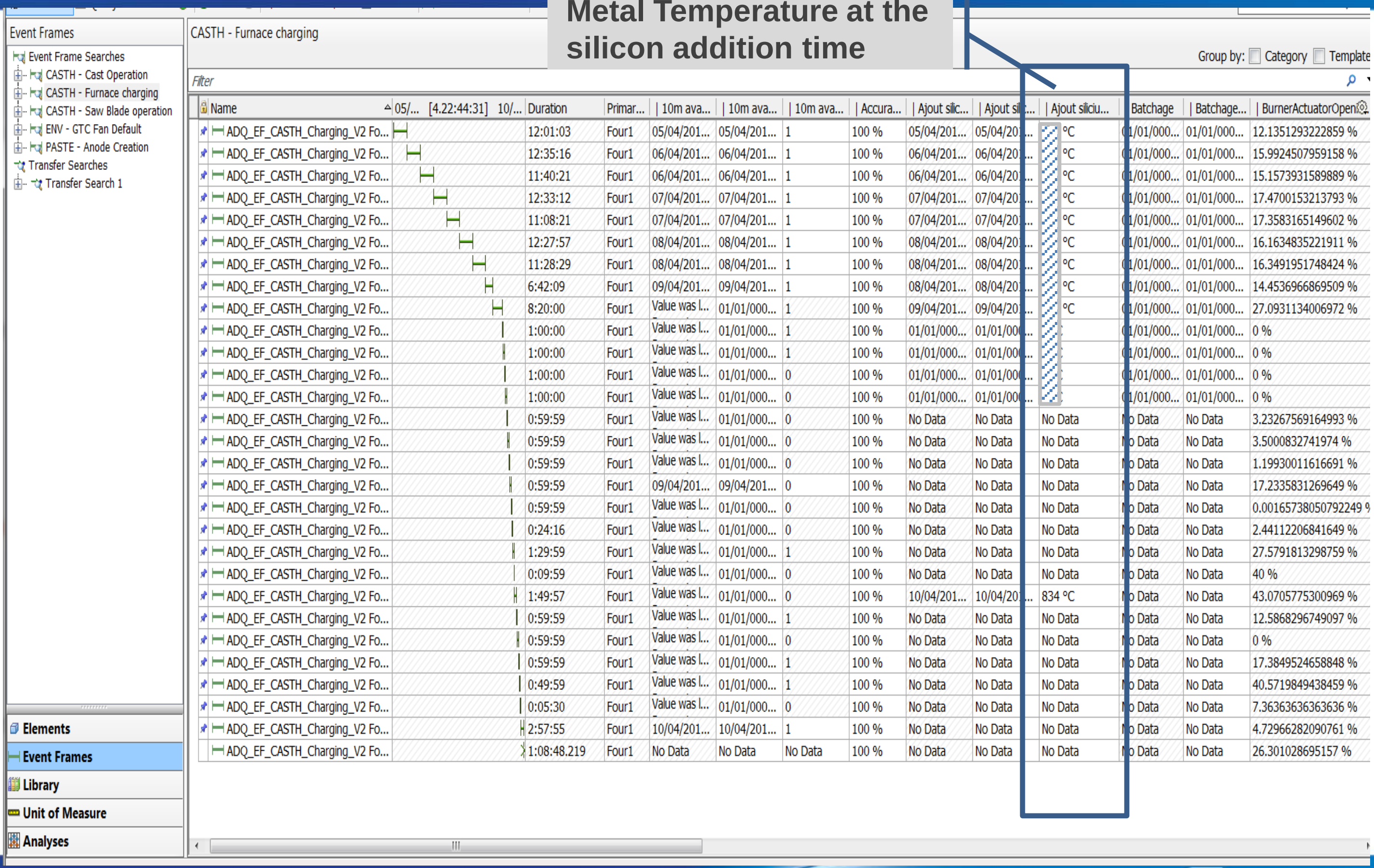


Cast display in PI Coresight – Focus on Start and End



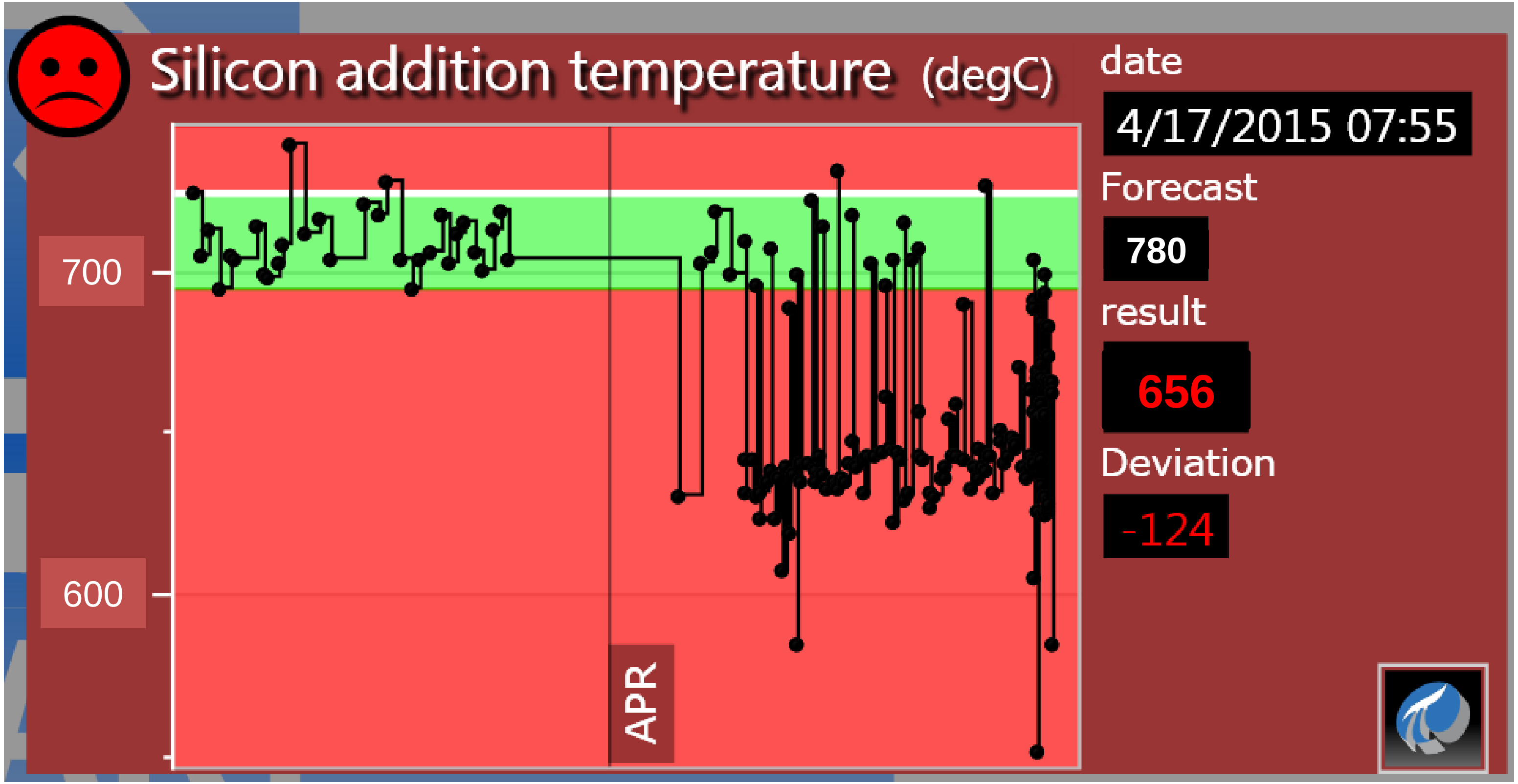
Event Frames – Furnace Preparation EF (if time allows)

Metal Temperature at the silicon addition time



Name	Duration	Primar...	10m ava...	10m ava...	10m ava...	Accura...	Ajout silic...	Ajout si...	Ajout siliciu...	Batchage	Batchage...	BurnerActuatorOpen
ADQ_EF_CASTH_Charging_V2 Fo...	12:01:03	Four1	05/04/201...	05/04/201...	1	100 %	05/04/201...	05/04/20...	°C	1/01/000...	01/01/000...	12.1351293222859 %
ADQ_EF_CASTH_Charging_V2 Fo...	12:35:16	Four1	06/04/201...	06/04/201...	1	100 %	06/04/201...	06/04/20...	°C	1/01/000...	01/01/000...	15.9924507959158 %
ADQ_EF_CASTH_Charging_V2 Fo...	11:40:21	Four1	06/04/201...	06/04/201...	1	100 %	06/04/201...	06/04/20...	°C	1/01/000...	01/01/000...	15.1573931589889 %
ADQ_EF_CASTH_Charging_V2 Fo...	12:33:12	Four1	07/04/201...	07/04/201...	1	100 %	07/04/201...	07/04/20...	°C	1/01/000...	01/01/000...	17.4700153213793 %
ADQ_EF_CASTH_Charging_V2 Fo...	11:08:21	Four1	07/04/201...	07/04/201...	1	100 %	07/04/201...	07/04/20...	°C	1/01/000...	01/01/000...	17.3583165149602 %
ADQ_EF_CASTH_Charging_V2 Fo...	12:27:57	Four1	08/04/201...	08/04/201...	1	100 %	08/04/201...	08/04/20...	°C	1/01/000...	01/01/000...	16.1634835221911 %
ADQ_EF_CASTH_Charging_V2 Fo...	11:28:29	Four1	08/04/201...	08/04/201...	1	100 %	08/04/201...	08/04/20...	°C	1/01/000...	01/01/000...	16.3491951748424 %
ADQ_EF_CASTH_Charging_V2 Fo...	6:42:09	Four1	09/04/201...	09/04/201...	1	100 %	08/04/201...	08/04/20...	°C	1/01/000...	01/01/000...	14.4536966869509 %
ADQ_EF_CASTH_Charging_V2 Fo...	8:20:00	Four1	Value was l...	01/01/000...	1	100 %	09/04/201...	09/04/20...	°C	1/01/000...	01/01/000...	27.0931134006972 %
ADQ_EF_CASTH_Charging_V2 Fo...	1:00:00	Four1	Value was l...	01/01/000...	1	100 %	01/01/000...	01/01/00...		1/01/000...	01/01/000...	0 %
ADQ_EF_CASTH_Charging_V2 Fo...	1:00:00	Four1	Value was l...	01/01/000...	1	100 %	01/01/000...	01/01/00...		1/01/000...	01/01/000...	0 %
ADQ_EF_CASTH_Charging_V2 Fo...	1:00:00	Four1	Value was l...	01/01/000...	0	100 %	01/01/000...	01/01/00...		1/01/000...	01/01/000...	0 %
ADQ_EF_CASTH_Charging_V2 Fo...	1:00:00	Four1	Value was l...	01/01/000...	0	100 %	01/01/000...	01/01/00...		1/01/000...	01/01/000...	0 %
ADQ_EF_CASTH_Charging_V2 Fo...	0:59:59	Four1	Value was l...	01/01/000...	0	100 %	No Data	No Data	No Data	o Data	No Data	3.23267569164993 %
ADQ_EF_CASTH_Charging_V2 Fo...	0:59:59	Four1	Value was l...	01/01/000...	0	100 %	No Data	No Data	No Data	o Data	No Data	3.5000832741974 %
ADQ_EF_CASTH_Charging_V2 Fo...	0:59:59	Four1	Value was l...	01/01/000...	0	100 %	No Data	No Data	No Data	o Data	No Data	1.19930011616691 %
ADQ_EF_CASTH_Charging_V2 Fo...	0:59:59	Four1	09/04/201...	09/04/201...	0	100 %	No Data	No Data	No Data	o Data	No Data	17.2335831269649 %
ADQ_EF_CASTH_Charging_V2 Fo...	0:59:59	Four1	Value was l...	01/01/000...	0	100 %	No Data	No Data	No Data	o Data	No Data	0.00165738050792249 %
ADQ_EF_CASTH_Charging_V2 Fo...	0:24:16	Four1	Value was l...	01/01/000...	0	100 %	No Data	No Data	No Data	o Data	No Data	2.44112206841649 %
ADQ_EF_CASTH_Charging_V2 Fo...	1:29:59	Four1	Value was l...	01/01/000...	1	100 %	No Data	No Data	No Data	o Data	No Data	27.5791813298759 %
ADQ_EF_CASTH_Charging_V2 Fo...	0:09:59	Four1	Value was l...	01/01/000...	0	100 %	No Data	No Data	No Data	o Data	No Data	40 %
ADQ_EF_CASTH_Charging_V2 Fo...	1:49:57	Four1	Value was l...	01/01/000...	0	100 %	10/04/201...	10/04/20...	834 °C	o Data	No Data	43.0705775300969 %
ADQ_EF_CASTH_Charging_V2 Fo...	0:59:59	Four1	Value was l...	01/01/000...	1	100 %	No Data	No Data	No Data	o Data	No Data	12.5868296749097 %
ADQ_EF_CASTH_Charging_V2 Fo...	0:59:59	Four1	Value was l...	01/01/000...	0	100 %	No Data	No Data	No Data	o Data	No Data	0 %
ADQ_EF_CASTH_Charging_V2 Fo...	0:59:59	Four1	Value was l...	01/01/000...	1	100 %	No Data	No Data	No Data	o Data	No Data	17.3849524658848 %
ADQ_EF_CASTH_Charging_V2 Fo...	0:49:59	Four1	Value was l...	01/01/000...	1	100 %	No Data	No Data	No Data	o Data	No Data	40.5719849438459 %
ADQ_EF_CASTH_Charging_V2 Fo...	0:05:30	Four1	Value was l...	01/01/000...	0	100 %	No Data	No Data	No Data	o Data	No Data	7.36363636363636 %
ADQ_EF_CASTH_Charging_V2 Fo...	2:57:55	Four1	10/04/201...	10/04/201...	1	100 %	No Data	No Data	No Data	o Data	No Data	4.72966282090761 %
ADQ_EF_CASTH_Charging_V2 Fo...	1:08:48.219	Four1	No Data	No Data	No Data	100 %	No Data	No Data	No Data	o Data	No Data	26.301028695157 %

Important EF attribute can be displayed in a KPI (if time allows)



Note: Numbers displayed on this slide do not represent real operation data

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Questions

Please wait for the microphone before asking your questions

State your name & company

THANK YOU