SMART Manufacturing Journey

Alcoa Smelting and Casting

Presented by  Bruno Longchamps
              Pierre Boutin
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

Rodded Anode

Potroom

Casthouse Furnace

Finished Products
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
- Establish the SMART Manufacturing program
- 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
- Achieve significant savings
SMART Manufacturing – Main improvement axes

**Data Maturity Model**

**Before:**
- Initial / Ad Hoc
- Repeatable
- Defined
- Managed
- Optimized

**After:**
- SMART Mfg Dashboard
- OSIsoft and Microsoft tools
- OSIs y advance initiative
- Standardised « self-service » tools
- Hundreds of data sources / plant
- 400k to 1200k PI Tags / plant

**Maturity State:**
- DATA AVAILABILITY
- DATA ACCESSIBILITY
- DATA CORRELATION
- ANALYTICS
- REPORTING
- ABILITY TO MANAGE RESULTS

**Reliability & Integrity of Processes & Data**

**Risk of Failure**
SMART Manufacturing – Real plant wide data infrastructure

<table>
<thead>
<tr>
<th>Site Name</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPM Global BU</td>
<td>1,559,207</td>
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<tr>
<td>GPM Warrick Site</td>
<td>1,246,100</td>
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<tr>
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<td>GPM Fjardaal Site</td>
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<td>GPM Massena West Site</td>
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<td>GPM Lista Site</td>
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<td><strong>Grand Total</strong></td>
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Note for Lista: QLC not installed and the initial data collection phase is not completed
<table>
<thead>
<tr>
<th>Year</th>
<th>Event Description</th>
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</thead>
<tbody>
<tr>
<td>2010</td>
<td>Program Definition (OSIsoft support)</td>
</tr>
<tr>
<td>2011</td>
<td>Proof of concept (Deschambault plant, QC)</td>
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<tr>
<td>2011 (Q4)</td>
<td>Entered the OSIsoft Enterprise Program</td>
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<tr>
<td>2012-2014</td>
<td>Aggressive Global Deployment (13 plants)</td>
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<tr>
<td>2014</td>
<td>EA extension to other plants</td>
</tr>
<tr>
<td>2015</td>
<td>Additional deployments (2 to 5 plants)</td>
</tr>
</tbody>
</table>
- 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
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

Electrode | Potline | Casthouse | Environ. | Energy

SMART mfg horizontal integration
Working across silos globally
Anode tracking

Pierre Boutin, P.Eng, MPM
Manager, Global Manufacturing Solutions Delivery

OSIsoft User’s Conference, San Francisco, April 2015
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.

<table>
<thead>
<tr>
<th>Challenges</th>
<th>Solution</th>
<th>Results / benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Physical anode identification</td>
<td>• Read anode numbers with OCR camera</td>
<td>• Holistic insight over anode life</td>
</tr>
<tr>
<td>• Linking anode data available at different point in time</td>
<td>• Store sampled data in PI Server</td>
<td>• Anode performance linked to raw materials and anode fabrication data</td>
</tr>
<tr>
<td>• Continuous and discrete process involved</td>
<td>• Use Event Frames to organize data in time</td>
<td>• Development of anode manufacturing best practices</td>
</tr>
<tr>
<td>Business</td>
<td></td>
<td>• Improved Raw Material selection process</td>
</tr>
<tr>
<td>• Cost of raw materials</td>
<td>• Integrate all data sources with the MS SSAS toolset (BI cube)</td>
<td></td>
</tr>
</tbody>
</table>
Work breakdown structure

Anode tracking

Physical Tracking

Data Processing

- Bake
- Rodding
- Paste
- Electrolysis

- Database
- PI System

- 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

Paste plant
Data – Discrete process

Anode numbers

Rod numbers

Rodding

Rodded anodes

Anode weighing

Anode numbers

Rod numbers

Automated reading

Cranes

Anode positioning

Electrolysis

Rod numbers

Butts

Butt treatment

Anode numbers

Rod numbers
Challenges

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.

Asset Framework
Event Frames
Manufacturing Intelligence Tools
R&D Partner
Data processing

Asset Framework: equipment hierarchy

Event Frames: organize data in time

PI Data Server

Lab, MES, other sources

Automation

微软Excel

SharePoint Server 2010

Microsoft SQL Server

Raw data

Microsoft Excel

Event Frames:
- GA RawMaterial 2014-01-07 10:07
- GA RawMaterials Coke Detail BN03 2014-01-07 08:57
- GA RawMaterials Coke Detail TK02 2014-01-07 08:57
- GA RawMaterials Coke Detail TK01 2014-01-07 10:07
- GA Aggregate Sizing L1 2014-01-07 10:07
- GA Dosing L1 Vibro 2 2020219
- GA Mixing L1 Vibro 2 2020219
- Green Anode 2020219

Event Frames:
- GA RawMaterial 2014-01-07 10:07
- GA RawMaterials Coke Detail BN03 2014-01-07 08:57
- GA RawMaterials Coke Detail TK02 2014-01-07 08:57
- GA RawMaterials Coke Detail TK01 2014-01-07 10:07
- GA Aggregate Sizing L1 2014-01-07 10:07
- GA Dosing L1 Vibro 2 2020219
- GA Mixing L1 Vibro 2 2020219
- Green Anode 2020219
Data extraction / exploitation

- Microsoft SQL-Server Analysis Services (SSAS) dialog

All data is random, fictional data to show functionality only
**Data sampled at different points in time are all linked to the same anode**

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<th>(Multiple Items)</th>
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<th>BA LIMS Results AirDustReactivity Avg AVG</th>
<th>BA LIMS Results AirPermeability Avg AVG</th>
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</tr>
</tbody>
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Cast data collection and integration

Bruno Longchamps, P.Eng
SMART Manufacturing, Program Manager

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.

### 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)

Metal Furnace

1 to 3 hours per cast

Up to 30 Feet Long
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

AF Data Model

Event Frames

Dynamic BI cube based on Event Frames

PI Data Server

Other sources

Automation

Microsoft SharePoint Server

Microsoft Excel

MES & LIMS

Casthouse

AF Data Model Elements:
- EMO
- Plant Shift
- Casthouse
- Pit 1
  - Bedfilter
  - Furnace 1
    - CastInfo
    - ChargeInfo
  - Furnace 2
  - Pit 2
  - Pit 3
    - Saw 5
    - Saw 7

Event Frames:
- Furnace 1
  - Cast Furnace 1 240500
  - Cast Furnace 1 39704
  - Cast Furnace 1 30275
  - Cast Furnace 1 39703
  - Cast Furnace 1 245714
- Furnace 2
  - Cast Furnace 2 39702
  - Cast Furnace 2 240537
  - Cast Furnace 2 39701
  - Cast Furnace 2 245506
  - Cast Furnace 2 240535
  - Cast Furnace 2 39305

Dynamic BI cube based on Event Frames:
- Event Frame Search 2
  - Cast Furnace 1 240500
  - Cast Furnace 2 39704
  - Cast Furnace 1 30275
  - Cast Furnace 1 39703
  - Cast Furnace 1 245714
  - Cast Furnace 2 39702
  - Cast Furnace 2 240537
  - Cast Furnace 2 39701
  - Cast Furnace 2 245506
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  - Cast Furnace 2 245506
  - Cast Furnace 2 240535
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Dynamic BI cube based on Event Frames:
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  - Cast Furnace 1 240500
  - Cast Furnace 2 39704
  - Cast Furnace 1 30275
  - Cast Furnace 1 39703
  - Cast Furnace 1 245714
  - Cast Furnace 2 39702
  - Cast Furnace 2 240537
  - Cast Furnace 2 39701
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Dynamic BI cube based on Event Frames:
- Event Frame Search 2
  - Cast Furnace 1 240500
  - Cast Furnace 2 39704
  - Cast Furnace 1 30275
  - Cast Furnace 1 39703
  - Cast Furnace 1 245714
  - Cast Furnace 2 39702
  - Cast Furnace 2 240537
  - Cast Furnace 2 39701
  - Cast Furnace 2 245506
  - Cast Furnace 2 240535
  - Cast Furnace 2 39305
Casting Operation Event Frames Boundaries

Cast Start = Event Frames (EF) Start

Cast Stop = Event Frames (EF) End

Cast Length
Capture data for specific process phase (time window)

Step 5 to 7 = Start-up (ramp-up)

Step 8 = Steady phase

Step 9 to 10 = Stoppage

Cast Start

Cast End
Capture Data during the Steady State phase only

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

<table>
<thead>
<tr>
<th>Name</th>
<th>Value</th>
<th>Step: 2:49:59 hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cast.Step(Steady)</td>
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<tr>
<td>Cast.Length(Ed)</td>
<td>mm</td>
<td>Step Stop @ mm</td>
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<tr>
<td>Cast.Length(St)</td>
<td>mm</td>
<td>Step Start @ mm</td>
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<tr>
<td>Cast.Speed(Avg)</td>
<td>mm/min</td>
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<tr>
<td>End</td>
<td>06.01.2015 12:32:07</td>
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<tr>
<td>Filter.LevelFactor(NF) Avg</td>
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<tr>
<td>Filter.LevelFactor(NF) Max</td>
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<tr>
<td>Filter.LevelFactor(NF) Min</td>
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<tr>
<td>Water.Flow</td>
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<tr>
<td>Avg</td>
<td>L/s</td>
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<tr>
<td>Max</td>
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<tr>
<td>Min</td>
<td>L/s</td>
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</tbody>
</table>

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

Value retrieval methods
- By Time: Not Supported
- Relative Time: Minimum
- By Time Range: Average
- Calculation basis: Count, Delta, End Time, Maximum, Minimum, Population Standard Deviation, Range, Standard Deviation, Start Time, Total
Cast Length $\geq$ 7,500 mm
At 3:28:54 AM
Capture information at a specific moment (Like a picture)

Cast Length $\geq$ 7,500 mm
At 3:28:54 AM
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)

<table>
<thead>
<tr>
<th>Time range</th>
<th>Less Than 1 day</th>
<th>1.5 M</th>
<th>@1.5 M</th>
<th>Steady State</th>
<th>@7.5 M</th>
<th>Steady End Time</th>
<th>Meta Temp [1.5]</th>
<th>Water Temp [1.5]</th>
<th>Speed [avg]</th>
<th>Water Flow [avg]</th>
<th>Speed [avg] [SDV]</th>
<th>Water Flow [avg] [SDV]</th>
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<tbody>
<tr>
<td>Furnace</td>
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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**

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

Silicon addition temperature (degC)

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

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Please wait for the **microphone** before asking your questions

State your

**name & company**
THANK YOU