From Material Balance to Metallurgical and Operational Accounting

Luis Yacher
Sigmafine Users Conference
San Francisco, April 23, 2012
AGENDA

CONTEXT, the Overall Picture

The Role of Data Reconciliation and Material Balance

Data Reconciliation and Material Balance, AMIRA Reference Model

Data Reconciliation and Material Balance, Execution Fast Tour

The CORE, the Process Model

The CORE, the ENHANCED Process Model

The System Architecture

Met Accounting Implementation

SF in M&M
CONTEXT, Met. & Op. Accounting, the Overall Picture

Business Systems

Total Values  Line/Area Values  Consumables  Production Stats.
Avg, Cummulated  Process Values  Operational KPI  Real vs. Program

What is needed in the gap?

Real time Data
Lab Data
Mine Systems Data
Equipment Data

PROCESS

Inventories
Down Times
Levels
Ore Characteristics
Analysis
Flows
CONTEXT, Met. & Op. Accounting, the Overall Picture

Business Systems

- Total Values
- Line/Area Values
- Consumables
- Production Stats.
- Avg, Cummulated
- Process Values
- Operational KPI
- Real vs. Program

- Data Validation
- Aggregation
- Operational Contexts
- Functional contexts
- Adjustments
- Calculations
- Info. Workflow Mgmt.
- Reconciliation
- KPI’s calcs
- Real time Data
- Lab Data
- Mine Systems Data
- Equipment Data

PROCESS
The Role of Data Reconciliation and Material Balance

...just in one slide

For:

• Material Flows, Inventories and Analysis
• Process Water, Water make-up, Inventories and consumptions
• Effluents

From Mine to Port:

• For every process area and line
• For every critical process

HOW?

Starting from:

• Real time Data
• Lab Data
• Mine Systems Data
• Equipment Data

A formal procedure to get a set of data

To get a single, objective and shared version of the truth

That complies with the following basic principle:

\[ \text{what goes in} - \text{what goes out} + \text{Inventory variation} = 0 \]
DATA IS AN ASSET
DATA IS SHARED AND ACCESSIBLE
DATA QUALITY IS FIT FOR PURPOSE
DATA IS SECURE
DATA IS NOT DUPLICATED (AMIRA P754)
Data Reconciliation and Material Balance, AMIRA Reference Model
Data Reconciliation and Material Balance, AMIRA Reference Model

DATA MANAGEMENT

Data Collection → Data Prefiltering → Data Processing → Data Validation

Errors Identification → Errors Calculation

MET ACCOUNTING MODEL

BALANCE

MET ACCOUNTING MODEL

Reconciliation → Results Analysis → Close and Publish
Data Reconciliation and Material Balance, AMIRA Reference Model

DATA COLLECTION (ENTRY)

DATA COLLECTION FROM VARIOUS SOURCES (SCADA, Plant Historian, LIMS)

PIAF – Data References (PI, SQL Queries, Ad-Hoc queries)

AUDITABLE DATA ENTRY

- Manual Checks
- Range Checking
- Double entry and validation
DATA PREFILTERING

- **NO DATA AVAILABLE** (Instrument maintenance, Interface Error, DCS Error, etc.)
  - Use the last value
  - Use the average for the last x-values
  - Use signal from close meter

PIAF – Analysis Rules
PIAF - Formulas
PI-ACE
DATA PROCESSING

• AGGREGATE DATA
• CALCULATE ESTIMATORS (VIRTUAL SENSORS)

PIAF – Analysis Rules
PIAF - Formulas
PI-ACE

Data Reconciliation and Material Balance, AMIRA Reference Model
Data Reconciliation and Material Balance, AMIRA Reference Model

DATA VALIDATION

• CHECK DATA BEFORE RECONCILIATION
• AUTHORIZED CHANGES

PIAF – Tools
- Excel Add-In
- Ad-Hoc functions
• Define tolerances based on statistical analysis

Variogram Application
MET ACCOUNTING MODEL

• PRIMARY – SECONDARY ACCOUNTING MODELS
• MODELING DIFFERENT PROCESS (Concentrators, Smelters, Refineries, Leaching, SX-EW, etc.)
• HANDLE MODEL CHANGES (Model Versioning)

SIGMAFINE – Templates and Elements

PROCESS BOOK Representation
RECONCILIATION

• SOLVER FOR MASS AND ASSAYS ADJUSTMENTS SOLUTION

SIGMAFINE ALGORITHM

Minimize \[ \sum_{i=1}^{N} \left( \frac{\text{Raw}_i - \text{Reconciled}_i}{\text{Absolute Tolerance}_i} \right)^2 \]
Data Reconciliation and Material Balance, AMIRA Reference Model

RESULTS ANALYSIS

• ADJUSTMENTS REVIEW
• GROSS ERROR DETECTION
• BIAS DETECTION
• IMBALANCE ANALYSIS

SIGMAFINE TOOLS

• Test1, Test2 statistical parameters for variable deviation evaluation
• Test3, Test4 statistical parameters for imbalance evaluation
• Influence determination
Shall be a “MET” user experience
Data Reconciliation and Material Balance, Execution Fast Tour

SELECT (CREATE) A BALANCE CASE
Data Reconciliation and Material Balance, Execution Fast Tour

- **Balance Functions**
- **Analysis Functions**
- **Run and Publish Functions**
Data Reconciliation and Material Balance, Execution Fast Tour

DATA Check and Validation
Data Reconciliation and Material Balance, Execution Fast Tour

QUALITY Balance Index
Data Reconciliation and Material Balance, Execution Fast Tour

**Initial Imbalances**

(Overview)
Initial Imbalances (Detail)
Data Reconciliation and Material Balance, Execution Fast Tour
**Data Reconciliation and Material Balance, Execution Fast Tour**

### Reviewing the Data

#### Table: Values of Entrance

<table>
<thead>
<tr>
<th>N°</th>
<th>FL_0.104_01</th>
<th>FL_0.104_02</th>
<th>FL_0.104_03</th>
<th>FL_0.106_01</th>
<th>FL_0.106_02</th>
<th>FL_0.106_03</th>
<th>FL_0.106_04</th>
<th>FL_0.106_05</th>
<th>FL_0.106_06</th>
<th>FL_0.106_07</th>
<th>FL_0.110_01</th>
<th>FL_0.110_02</th>
<th>FL_0.110_03</th>
<th>FL_0.110_04</th>
<th>FL_0.110_05</th>
<th>FL_0.110_06</th>
<th>FL_0.110_07</th>
<th>FL_0.114_01</th>
<th>FL_0.114_02</th>
<th>FL_0.114_03</th>
<th>FL_0.114_04</th>
<th>FL_0.114_05</th>
<th>FL_0.114_06</th>
<th>FL_0.114_07</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **TMS**: Total Mass Stream
- **% Cu**: Percentage of Copper
- **% Mo**:Percentage of Molybdenum
- **TMO Cu**: Total Mass Stream Copper
- **TMO Mo**: Total Mass Stream Molybdenum
### Data Reconciliation and Material Balance, Execution Fast Tour

#### Reviewing the Tolerances

<table>
<thead>
<tr>
<th>Plant Inventory</th>
<th>Description</th>
<th>Analyzer</th>
<th>Meter</th>
<th>Tot IMSS [S]</th>
<th>Tot Cu [o/r]</th>
<th>Tot Me [o/r]</th>
</tr>
</thead>
<tbody>
<tr>
<td>FL_0_104_01</td>
<td>Fibox</td>
<td>AL_0_104_01</td>
<td>W0_0_104_01</td>
<td>0.00</td>
<td>0.0000000000</td>
<td>0.0000000000</td>
</tr>
<tr>
<td>FL_0_104_02</td>
<td></td>
<td>AL_0_104_02</td>
<td>W0_0_104_02</td>
<td>0.00</td>
<td>0.0000000000</td>
<td>0.0000000000</td>
</tr>
<tr>
<td>FL_0_104_03</td>
<td></td>
<td>AL_0_104_03</td>
<td>W0_0_104_03</td>
<td>0.00</td>
<td>0.0000000000</td>
<td>0.0000000000</td>
</tr>
<tr>
<td>FL_0_106_01</td>
<td></td>
<td>AL_0_106_01</td>
<td>W0_0_106_01</td>
<td>0.00</td>
<td>0.0000000000</td>
<td>0.0000000000</td>
</tr>
<tr>
<td>FL_0_107_01</td>
<td></td>
<td>AL_0_107_01</td>
<td>W0_0_107_01</td>
<td>0.00</td>
<td>0.0000000000</td>
<td>0.0000000000</td>
</tr>
<tr>
<td>FL_0_110_01</td>
<td>Mineral Oil</td>
<td>AL_0_110_01</td>
<td>W0_0_110_01</td>
<td>0.00</td>
<td>0.0000000000</td>
<td>0.0000000000</td>
</tr>
<tr>
<td>FL_0_110_02</td>
<td>Mineral Oil</td>
<td>AL_0_110_02</td>
<td>W0_0_110_02</td>
<td>0.00</td>
<td>0.0000000000</td>
<td>0.0000000000</td>
</tr>
<tr>
<td>FL_0_110_03</td>
<td></td>
<td>AL_0_110_03</td>
<td>W0_0_110_03</td>
<td>0.00</td>
<td>0.0000000000</td>
<td>0.0000000000</td>
</tr>
<tr>
<td>FL_0_110_04</td>
<td></td>
<td>AL_0_110_04</td>
<td>W0_0_110_04</td>
<td>0.00</td>
<td>0.0000000000</td>
<td>0.0000000000</td>
</tr>
<tr>
<td>FL_0_110_05</td>
<td></td>
<td>AL_0_110_05</td>
<td>W0_0_110_05</td>
<td>0.00</td>
<td>0.0000000000</td>
<td>0.0000000000</td>
</tr>
<tr>
<td>FL_0_110_06</td>
<td></td>
<td>AL_0_110_06</td>
<td>W0_0_110_06</td>
<td>0.00</td>
<td>0.0000000000</td>
<td>0.0000000000</td>
</tr>
<tr>
<td>FL_0_110_07</td>
<td></td>
<td>AL_0_110_07</td>
<td>W0_0_110_07</td>
<td>0.00</td>
<td>0.0000000000</td>
<td>0.0000000000</td>
</tr>
<tr>
<td>FL_0_114_01</td>
<td></td>
<td>AL_0_114_01</td>
<td>W0_0_114_01</td>
<td>0.00</td>
<td>0.0000000000</td>
<td>0.0000000000</td>
</tr>
<tr>
<td>FL_0_120_01</td>
<td></td>
<td>AL_0_120_01</td>
<td>W0_0_120_01</td>
<td>0.00</td>
<td>0.0000000000</td>
<td>0.0000000000</td>
</tr>
<tr>
<td>FL_0_201_01</td>
<td></td>
<td>AL_0_201_01</td>
<td>W0_0_201_01</td>
<td>0.00</td>
<td>0.0000000000</td>
<td>0.0000000000</td>
</tr>
<tr>
<td>FL_0_201_02</td>
<td></td>
<td>AL_0_201_02</td>
<td>W0_0_201_02</td>
<td>0.00</td>
<td>0.0000000000</td>
<td>0.0000000000</td>
</tr>
<tr>
<td>FL_0_201_03</td>
<td></td>
<td>AL_0_201_03</td>
<td>W0_0_201_03</td>
<td>0.00</td>
<td>0.0000000000</td>
<td>0.0000000000</td>
</tr>
<tr>
<td>FL_0_201_04</td>
<td></td>
<td>AL_0_201_04</td>
<td>W0_0_201_04</td>
<td>0.00</td>
<td>0.0000000000</td>
<td>0.0000000000</td>
</tr>
<tr>
<td>FL_0_201_05</td>
<td></td>
<td>AL_0_201_05</td>
<td>W0_0_201_05</td>
<td>0.00</td>
<td>0.0000000000</td>
<td>0.0000000000</td>
</tr>
<tr>
<td>FL_0_201_06</td>
<td></td>
<td>AL_0_201_06</td>
<td>W0_0_201_06</td>
<td>0.00</td>
<td>0.0000000000</td>
<td>0.0000000000</td>
</tr>
<tr>
<td>FL_0_201_07</td>
<td></td>
<td>AL_0_201_07</td>
<td>W0_0_201_07</td>
<td>0.00</td>
<td>0.0000000000</td>
<td>0.0000000000</td>
</tr>
</tbody>
</table>

**Note:** The table above demonstrates the process of reviewing tolerances in a data reconciliation and material balance context.
The CORE, the Process Model

A PI-AF(SF) model of:
- Process Flows
- Flows characterizations
- Inventories
- Measurements
- Sources of data
- Data processing methods
- Calculation RULES
- Balance RULES
The CORE, the Process Model
The CORE, the ENHANCED Process Model

Met. Accounting Rules and Processes

Base (SF-AF) Model

Reconciled (balanced) values of:
- Material flows & Composition
- Inventories & Composition
- Water: supply-recovery-use-inventory.

Contextual reference to:
- Real time and history of related measurements and lab data


Context (Model) related values of:
- Program
- Target

Context (Model) related values of:
- Key consumables
  - Steel
  - Energy
  - Reagents
- Key asset KPI
  - Availability
  - Use

Traceability & Data Quality fit for purpose:
- Values from instruments
- Values from inventory variation
- Values from the ERP
The System Architecture

Data Collection
Data Pre Filtering
Data Processing
Data Validation
Error Id and Calculation
Analysis Results
The System Architecture

Business Systems

- Total Values
- Line/Area Values
- Consumables
- Production Stats.
- Avg, Cummulated
- Process Values
- Operational KPI
- Real vs. Program

Data Validation

- Adjustments
- Calculations

Operational Contexts

- Functional contexts

Reconciliation

- KPI’s calcs
- Workflow

Real time Data
Lab Data
Mine Systems Data
Equipment Data

PROCESS
The System Architecture

Business Systems

- Total Values
- Line/Area Values
- Consumables
- Production Stats.
- Avg, Cummulated
- Process Values
- Operational KPI
- Real vs. Program

Real time Data
Lab Data
Mine Systems Data
Equipment Data

PROCESS
Met Accounting Implementation

Process Model Definition
Met Accounting Implementation

Process Model Definition
Met Accounting Implementation

Process Model Definition

<table>
<thead>
<tr>
<th>Stream ID</th>
<th>Description</th>
<th>Stream Flow Type</th>
<th>Units</th>
<th>Laboratory PL Tag</th>
<th>Copper</th>
<th>Gold</th>
<th>Silver</th>
<th>Molybdenum</th>
</tr>
</thead>
<tbody>
<tr>
<td>2960</td>
<td>Soft Float Flow N1 Feed</td>
<td>Dry Tonne</td>
<td>CYL-PFTN</td>
<td>CYL-PFTN</td>
<td>CYL-PFTN</td>
<td>CYL-PFTN</td>
<td>CYL-PFTN</td>
<td></td>
</tr>
<tr>
<td>2962</td>
<td>Soft Float Flow N1 Tail</td>
<td>Dry Tonne</td>
<td>CYL-PFTN</td>
<td>CYL-PFTN</td>
<td>CYL-PFTN</td>
<td>CYL-PFTN</td>
<td>CYL-PFTN</td>
<td></td>
</tr>
<tr>
<td>2964</td>
<td>Soft Float Flow N2 Feed</td>
<td>Dry Tonne</td>
<td>CYL-PFTN</td>
<td>CYL-PFTN</td>
<td>CYL-PFTN</td>
<td>CYL-PFTN</td>
<td>CYL-PFTN</td>
<td></td>
</tr>
<tr>
<td>2966</td>
<td>Soft Float Flow N2 Tail</td>
<td>Dry Tonne</td>
<td>CYL-PFTN</td>
<td>CYL-PFTN</td>
<td>CYL-PFTN</td>
<td>CYL-PFTN</td>
<td>CYL-PFTN</td>
<td></td>
</tr>
<tr>
<td>2968</td>
<td>Soft Float Flow N3 Feed</td>
<td>Dry Tonne</td>
<td>CYL-PFTN</td>
<td>CYL-PFTN</td>
<td>CYL-PFTN</td>
<td>CYL-PFTN</td>
<td>CYL-PFTN</td>
<td></td>
</tr>
<tr>
<td>2970</td>
<td>Soft Float Flow N3 Tail</td>
<td>Dry Tonne</td>
<td>CYL-PFTN</td>
<td>CYL-PFTN</td>
<td>CYL-PFTN</td>
<td>CYL-PFTN</td>
<td>CYL-PFTN</td>
<td></td>
</tr>
<tr>
<td>2972</td>
<td>Soft Float Flow N4 Feed</td>
<td>Dry Tonne</td>
<td>CYL-PFTN</td>
<td>CYL-PFTN</td>
<td>CYL-PFTN</td>
<td>CYL-PFTN</td>
<td>CYL-PFTN</td>
<td></td>
</tr>
<tr>
<td>2974</td>
<td>Soft Float Flow N4 Tail</td>
<td>Dry Tonne</td>
<td>CYL-PFTN</td>
<td>CYL-PFTN</td>
<td>CYL-PFTN</td>
<td>CYL-PFTN</td>
<td>CYL-PFTN</td>
<td></td>
</tr>
<tr>
<td>2976</td>
<td>Soft Float Flow N5 Feed</td>
<td>Dry Tonne</td>
<td>CYL-PFTN</td>
<td>CYL-PFTN</td>
<td>CYL-PFTN</td>
<td>CYL-PFTN</td>
<td>CYL-PFTN</td>
<td></td>
</tr>
<tr>
<td>2978</td>
<td>Soft Float Flow N5 Tail</td>
<td>Dry Tonne</td>
<td>CYL-PFTN</td>
<td>CYL-PFTN</td>
<td>CYL-PFTN</td>
<td>CYL-PFTN</td>
<td>CYL-PFTN</td>
<td></td>
</tr>
<tr>
<td>2980</td>
<td>Combined Head Sample from Float N5</td>
<td>Dry Tonne</td>
<td>CYL-CHD</td>
<td>CYL-CHD</td>
<td>CYL-CHD</td>
<td>CYL-CHD</td>
<td>CYL-CHD</td>
<td></td>
</tr>
<tr>
<td>2982</td>
<td>Combined Tail Sample from Float N5</td>
<td>Dry Tonne</td>
<td>CYL-CTD</td>
<td>CYL-CTD</td>
<td>CYL-CTD</td>
<td>CYL-CTD</td>
<td>CYL-CTD</td>
<td></td>
</tr>
<tr>
<td>2984</td>
<td>Combined Head Sample from Float N6</td>
<td>Dry Tonne</td>
<td>CYL-CHD</td>
<td>CYL-CHD</td>
<td>CYL-CHD</td>
<td>CYL-CHD</td>
<td>CYL-CHD</td>
<td></td>
</tr>
<tr>
<td>2986</td>
<td>Combined Tail Sample from Float N6</td>
<td>Dry Tonne</td>
<td>CYL-CTD</td>
<td>CYL-CTD</td>
<td>CYL-CTD</td>
<td>CYL-CTD</td>
<td>CYL-CTD</td>
<td></td>
</tr>
<tr>
<td>2988</td>
<td>Combined Head Sample from Float N7</td>
<td>Dry Tonne</td>
<td>CYL-CHD</td>
<td>CYL-CHD</td>
<td>CYL-CHD</td>
<td>CYL-CHD</td>
<td>CYL-CHD</td>
<td></td>
</tr>
<tr>
<td>2990</td>
<td>Combined Tail Sample from Float N7</td>
<td>Dry Tonne</td>
<td>CYL-CTD</td>
<td>CYL-CTD</td>
<td>CYL-CTD</td>
<td>CYL-CTD</td>
<td>CYL-CTD</td>
<td></td>
</tr>
<tr>
<td>2992</td>
<td>Combined Head Sample from Float N8</td>
<td>Dry Tonne</td>
<td>CYL-CHD</td>
<td>CYL-CHD</td>
<td>CYL-CHD</td>
<td>CYL-CHD</td>
<td>CYL-CHD</td>
<td></td>
</tr>
<tr>
<td>2994</td>
<td>Combined Tail Sample from Float N8</td>
<td>Dry Tonne</td>
<td>CYL-CTD</td>
<td>CYL-CTD</td>
<td>CYL-CTD</td>
<td>CYL-CTD</td>
<td>CYL-CTD</td>
<td></td>
</tr>
<tr>
<td>2996</td>
<td>Combined Head Sample from Float N9</td>
<td>Dry Tonne</td>
<td>CYL-CHD</td>
<td>CYL-CHD</td>
<td>CYL-CHD</td>
<td>CYL-CHD</td>
<td>CYL-CHD</td>
<td></td>
</tr>
<tr>
<td>2998</td>
<td>Combined Tail Sample from Float N9</td>
<td>Dry Tonne</td>
<td>CYL-CTD</td>
<td>CYL-CTD</td>
<td>CYL-CTD</td>
<td>CYL-CTD</td>
<td>CYL-CTD</td>
<td></td>
</tr>
<tr>
<td>3000</td>
<td>Combined Head Sample from Float N10</td>
<td>Dry Tonne</td>
<td>CYL-CHD</td>
<td>CYL-CHD</td>
<td>CYL-CHD</td>
<td>CYL-CHD</td>
<td>CYL-CHD</td>
<td></td>
</tr>
<tr>
<td>3002</td>
<td>Combined Tail Sample from Float N10</td>
<td>Dry Tonne</td>
<td>CYL-CTD</td>
<td>CYL-CTD</td>
<td>CYL-CTD</td>
<td>CYL-CTD</td>
<td>CYL-CTD</td>
<td></td>
</tr>
</tbody>
</table>
Met Accounting Implementation

Process Model Definition
Met Accounting Implementation

Process Model Definition
Met Accounting Implementation

Process Model Definition

Execution, validation and publishing procedures
Met Accounting Implementation

Process Definitions

Model Definitions

Model Analysis

- Solvability
- Redundancies
- Consistency
<table>
<thead>
<tr>
<th>Activity</th>
<th>Site</th>
<th>Responsible</th>
<th>Deliverables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kickoff Meeting</td>
<td>Customer Site</td>
<td>SF - Customer</td>
<td>- Scope</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Functional Specs.</td>
</tr>
<tr>
<td>System Platform and Infrastructure</td>
<td>Customer</td>
<td>Customer</td>
<td>- Prepared Infrastructure for the System</td>
</tr>
<tr>
<td>Data Gathering Documents</td>
<td>SF</td>
<td>SF</td>
<td>- Flowsheet Diagram</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Data Gathering Spreadsheets</td>
</tr>
<tr>
<td>Data Gathering</td>
<td>Customer</td>
<td>Customer</td>
<td>- Complete Data Gathering Spreadsheets</td>
</tr>
<tr>
<td>Preliminary Model and Redundancy Test</td>
<td>SF- One / two weeks in customer site for Model adjustments</td>
<td>SF</td>
<td>- Preliminary Model</td>
</tr>
<tr>
<td>Prepare Data for Model Validation</td>
<td>Customer</td>
<td>Customer</td>
<td>- Data for Model Validation</td>
</tr>
<tr>
<td>Model Validation</td>
<td>SF- One/two weeks in customer site for final model adjustments</td>
<td>SF</td>
<td>- Model validated</td>
</tr>
<tr>
<td>Model installation</td>
<td>Customer Site</td>
<td>SF - Customer</td>
<td>- Model installed</td>
</tr>
</tbody>
</table>
### SF in M&M

**Copper-Moly**

<table>
<thead>
<tr>
<th></th>
<th>Conc.</th>
<th>Smelter</th>
<th>Refinery</th>
<th>Leaching</th>
<th>SX/EW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Codelco-North</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Codelco-Andina</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Codelco-Teniente</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Antofagasta Minerals-MLP</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Xstrata&amp;Anglo Collahuasi</td>
<td>*</td>
<td></td>
<td></td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>KUCC-Pilot</td>
<td>*</td>
<td></td>
<td></td>
<td>*</td>
<td></td>
</tr>
</tbody>
</table>

**GOLD**

<table>
<thead>
<tr>
<th></th>
<th>Conc.</th>
<th>Leaching</th>
<th>Carbon in Column</th>
<th>Merrill Crowe</th>
<th>Smelter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant XX (project in progress)</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
</tbody>
</table>
Fresh water supply, consumptions, water recovery
Luis Yacher
lyacher@contac.cl