



**COTREM Processing Functional Specification**

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Author: Darren Cohen

Approval

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Definitions

|  |  |
| --- | --- |
| **Abbreviation/Term** | **Description** |
| ACP | Anglo Platinum Converting Process, also known as Waterval Converting Plant |
| AOP | Add On Process |
| Au | Gold (measured in ounces) |
| BMR | Base Metals Refinery |
| Cleanings | Material collected in different parts of the plant as a result of cleaning the floor (spillages), the process equipment, etc. Considered a Recycle in that it most probably contains PGMs therefore it is collected and re-processed to further extract PGMs. |
| Co | Cobalt (measured in Tons) |
| Conc | Concentrate |
| COTREM | Acronym derived from the phrase “from COncentrate To REfined Metal” |
| CPLR | Copper Leaching Residue |
| Cu | Copper (measured in Tons) |
| Dust | Airborne particulate matter generated by the handling activities of ore products, which still may contain valuable content |
| FICO | Final Concentrate (Product of MCL plant) |
| Furnace Matte (FM) | Resulting product of a smelting (furnace) operation containing the PGM’s, base metals (Ni, Cu, Co, Fe) and Sulphur (S) all intermixed. |
| Ir | Iridium (measured in ounces) |
| L/C | Lime Cake |
| MCL | Metallic Concentrator Plant - Leaching |
| MCM | Metallic Concentrator Plant - Milling |
| MFM | Mortimer Furnace Matte |
| MS | Mortimer Smelter |
| NCM | Nickel-Copper Matte |
| Ni | Nickel (measured in Tons) |
| Ounce | An ounce is defined as 32150.7 per ton |
| P/C | Press Cake |
| Pd | Palladium (measured in ounces) |
| PFM | Polokwane Furnace Matte |
| PGM | Platinum Group Metals. Pt, Pd, Rh, Au, Ir, Ru |
| PMR | Precious Metals Refinery |
| PoC | Proof of Concept |
| PS | Polokwane Smelter |
| Pt | Platinum (measured in ounces) |
| PVL | Pressure Vessel Liquor |
| Recycles | Material resulting from different plants often (but not always) with very low PGM content, similar to Cleanings. |
| Residue | Matter remaining after completion of an abstractive chemical or physical process, such as evaporation, combustion, distillation, or filtration |
| Rh | Rhodium (measured in ounces) |
| Ru | Ruthenium (measured in ounces) |
| SCF | Slag Cleaning Furnace |
| SCFM | Slag Cleaning Furnace Matte. Matte resultant from SCF, with similar PGM content as Conc. SCFM is recycled into WS. |
| Slag | Slag is a partially vitreous by-product of smelting ore to separate the metal fraction from the unwanted fraction. It can usually be considered to be a mixture of metal oxides and silicon dioxide. |
| SLR | Secondary Leach Residue. Gets further tolled and treated overseas, but since other most countries ban the import of residues, the name is changed to SLC, or Secondary Leach Concentrate (i.e. it is no more a residue) |
| Tailings | Remaining by-products after ore has been processed |
| tpd | Tons Per Day |
| UI | User Interface |
| WACS | Waterval Converter Slag |
| WCM | Waterval Converter Matte (The Product of the ACP Process) |
| WS | Waterval Smelter |
| WFM | Waterval Furnace Matte |

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# Introduction

*Cyest* has been part of the Proof of Concept (PoC) COTREM model project team since October 2010. This involved building the underlying COTREM model in the Carbon technology based on the ARIS model specification that the project team had developed. This was extended in February 2011 to include the development of a PoC routing engine to apply some of the ‘implicit’ routing rules that Piers Halton has developed to cater for different shut-down and routing scenarios. The next phase of the project is to design, build and implement the full COTREM model in the Carbon technology.

This document represents a functional specification which describes the overall model solution, as well as the interrelationships of the systems to be developed. This includes:

* A detailed description of the integration of the model with existing Excel spread sheets to load data
* The development of necessary user interfaces for the business user to be guided through
  + configuring the model,
  + inputting and validating the data,
  + running scenarios,
  + reporting

The various user interfaces and reporting outputs are described with the aid of screen mock-ups. Additionally, the rules and algorithms used to generate and calculate results are described. Finally, a specification of the hardware requirements relating to client machines and other infrastructure hardware is provided.

# Description of the Overall Solution

COTREM, an acronym derived from the phrase “from COncentrate To REfined Metal”, models material going through the different Anglo Platinum plants and processes, starting with the delivery of concentrate from the various concentrators to the smelters and ending with the calculated refined metal and metal credits after the refining and tolling operations.

The current COTREM model is a well-known and predictable forecasting model, built in Excel, which Piers Halton has been building, upgrading and maintaining since 1999. COTREM outputs are used throughout Anglo Platinum by the plants, head office, finance departments, and management at various levels of the organisation.

The COTREM model’s primary goal is to forecast short, medium and long term production of the different plants. The model presents a combination of forecasted and historical data, allowing the user to compare data between the business plan, monthly production estimates and actual production data. The model is also used to compare future data estimates prepared by the plants against historical actual production achieved. Additionally, it allows for the simulation of extraordinary situations such as extended plant shutdowns, and in general is used to produce “What-If” scenarios by changing different plant efficiencies and inputs and analysing the results.

## Carbon COTREM Solution

The ultimate goal of the Carbon COTREM system is to build a robust replacement for the current Excel implementation of the model, which will encapsulate additional intelligent and streamlined functionality.

The COTREM model is very modular in nature, where each process can be represented as a sub-model simulating the metallurgical behaviour of each plant, providing the prediction of its outputs and inputs to the following stages. This lends itself well to the object-oriented modelling methodology of the Carbon technology, where each instance of the various plants is modelled as a unique object having its own attributes and functionality.

The new solution will calculate and forecast on a daily as well as monthly and annual basis. This capability was demonstrated as part of the PoC. The full project will leverage the model already produced as part of the PoC, and extend the functionality to include the Anglo Platinum Converting Plant (ACP), Slag Cleaning Furnace (SCF), Metallic Concentrator (MC) Plant, Base Metals Refinery (BMR) and Precious Metals Refinery (PMR). In addition to this, functionality to allow for tolling, loaning and redirects of material at various stages of the model will be developed. A block diagram of the model is provided in Figure 1 below.

In addition to modelling the metallurgical processes at each plant, a number of intelligent algorithms will be implemented in order to manipulate the model for certain desired scenarios. These include minimizing transport costs and maximizing platinum output. These are described in detail in Section 8 of this document.



Figure 1: High-level model block diagram

# Solution Architecture

The overall solution, as illustrated in Figure 2, consists of the Carbon Model at its core, with accessory rules based calculation engines and User Interfaces (UI), which allow for the adjustment and customization of model parameters and characteristics.



Figure 2: High-level solution architecture

The Carbon model contains all modelling logic, including all objects, attributes, dimensions and formulae, details of which can be found in the *COTREM Processing Model Specification*.

Input data, in the form of Microsoft Excel spread sheets, will be used to populate the model with forecasted as well as actual production and transfer information. Further details of the required documents and import mechanism to be used can be found in Section 4.

Intuitive UIs, arranged in a clear workflow, will allow the user to customize the process parameters and capacities, as well as schedule any necessary AOP’s and plant shutdowns. A more in-depth analysis of the UI design and workflow can be found in Section 7.

The UIs and Carbon model are interfaced with a number of rules-based calculation engines, which will complement the modelling logic through implementing algorithms which are not captured in the formulae of the Carbon model. These are further discussed in Section 8.

The results of all model calculations will be reported by both native Carbon reporting components, as well as be exported to Microsoft Excel spread sheets, allowing for further analysis outside of the application. Details of the reports to be generated can be found in Section 9.

## Envisioned Usage

For the current implementation only one user will be interacting directly with the COTREM solution. This user is responsible for the following tasks (in order):

* Setup Base Scenario
* Export Templates
* Distribute Templates
* Validate Populated Templates
* Import Populated Templates
* Run Model
* Export Reports
* Distribute Reports

Users responsible for Plant Data are involved indirectly by populating the Templates generated by the COTREM User and returning it for further use.



Figure 3: Envisioned Usage

## Time Dimension

The model will contain both historical and forecasted data, as represented in Figure 4.



Figure 4: Graphical representation of time dimension in model

Due to the differing dynamics of daily, monthly and annual figures, modified formulae will need to be applied when a change in time period occurs (i.e. at the extremes of the time dimension for monthly and annual figures). Aggregation of all values to monthly and annual figures will be performed where applicable.

In order to cater for a changing time dimension (i.e. dependent on the date the model is run), the user will need to select the *Current Date* before running the model, in order for the application to correctly configure the time dimension in the model. As time progresses, historical data falling outside the range of the time dimension will be truncated.

A minimum of 6 months will always be available for a year. E.g. when 2008 is in question, only once July is reached will January until June be truncated. When reaching January 2009, July 2008 until December 2008 will be truncated. This applies to data kept in months and days.

## Add On Process (AOP)

An AOP may represent any one of the following operations of materials: tolling, loaning and redirects. In essence, an AOP represents a generic operation where material exits at a given point in the process, may undergo further external processing, and may be returned again at a different point in the process. For example, the situation may arise where an external company is contracted to smelt concentrate for a certain period of time i.e. the concentrate is *tolled* out. The concentrate would leave the process as concentrate at the concentrators, be processed with a certain recovery, and may re-enter the process as furnace matte product stock at the smelters.

AOPs may occur throughout the model, thus requiring a large amount of flexibility. Therefore, the setting up and scheduling of AOPs will be handled through a UI capable of calculating and generating the required model inputs which is described further in Section 7.

## Actuals Versus Forecast Data Handling

As time continues, the model is required to ‘back-calculate’ actual plant parameters from actual stocks, outputs and transfers for each site and operation that are entered into the model. This allows for the comparison of assumptions made for the parameters in the forecast and actual values for parameters achieved. Actual data will originate from the Excel input sheets, as described in Section 4.

Different logic is needed to calculate the resultant variables for forecast and actual data. In order to minimise the storage requirements of the model, actual and forecast data will be stored as separate attributes within the model, rather than having an *actual* and *forecast* dimensional split. This more clearly separates the two data streams as well as required logic for each.

## Expansion of Model

The Carbon solution will cater for situations where additional concentrators or smelters will need to be added in. For example, should another concentrator come online or a new smelter be built? Functionality will also exist in order to schedule the start-up of these operations at a later stage in the model.

When a new concentrator or smelter is created, a pre-defined template of the appropriate process object will be instantiated in the Carbon model.

# Excel Integration

The current data collection platform are spread sheets based in Microsoft Excel, which originate from various sources. Therefore, in order to interface easily with existing data sources, Microsoft Excel will be used as a platform for data entry. Going forward, data inputs will be organised into standardised input templates which will be used to populate the model, as described below.

## Excel Template Generation

Based on the current date which has been selected within the application, the user will be able to export the required Excel templates to file. These templates will be correct in format and structure required by the application and applicable time dimension.

The excel templates will also be exported with some historical data so that quality checks can be done on the new data that is to be imported. The historical data will be represented as graphs on a ‘data validation’ sheet, allowing the user to manually interrogate the new data against the historical data before approving it for the import.

These graphs will include plots of metal ratios to Pt for Pd, Rh, Au, Ir, Ru as well as Ni/Pt, Ni/Cu, Ni/Co, Pt Grade and % Cr2O3.

## Existing Excel Files

Three specific sources of data used to populate the COTREM model have been identified, namely:

* Concentrator Monthly Forecasts
* Actual Concentrator Outputs and Smelter Allocations
* Actual Stocks and Transfers for Each Site/Operation

### Concentrator Monthly Forecasts

**Document Name: “Total Conc 2011LE05 & BP2011 + 110531.xlsx”**

This document contains the forecasted outputs for each concentrator on a monthly level going forward. These spread sheets are maintained by Johan van Jaarsveld. Within the current COTREM Excel model, the future forecast concentrator outputs are ‘linked’ to this document.

### Actual Concentrator Outputs and Allocation To Smelters

**Document Name: “TPdatabase2011LE05.xls”**

This document contains the actual concentrator outputs and allocation to smelters for the historical months of the model. These numbers are calculated in the same way as the forecast data to determine actual recoveries i.e. forecasted data for the historical time period is replaced by actual data. A user can, outside the model, review actual vs. forecast recoveries and adjust the future model recoveries if need be.

### Actual Stocks and Transfers For Each Site and Operation

**Document Name: Variety of documents sourced from different sites/operations**

These documents contain all actual stocks (opening, closing, in-process etc.) for each site/operation. These documents do not always come in a standard format and will therefore be standardised in a fixed template accepted by the application.

## Required Structure and Content

The Excel input templates will be structured in such a way to ensure:

* The user easily understands how to link data from other spread sheet sources.
* The correct paths to objects and attributes in the model can be ascertained.

This is achieved by structuring the spread sheets in such a way that the *Data Adapter* component within Modeller can be used to populate the model. This component has been designed to facilitate the transfer of data between Carbon Modeller and Microsoft Excel.

All variables that are to be populated from the Excel have (in some form or another) the dimensional structure shown in Table 1, given across time.

Table 1: Dimension Fields for Each Input Variable

|  |  |
| --- | --- |
| Field Name | Unit of Measure |
| Dry Tons | Ton |
| Pt Oz | Ounce |
| Pd Oz | Ounce |
| Rh Oz | Ounce |
| Au Oz | Ounce |
| Ir Oz | Ounce |
| Ru Oz | Ounce |
| Ni Tons | Ton |
| Cu Tons | Ton |
| Co Tons | Ton |
| S Tons | Ton |
| Cr2O3 % | Percentage |

This structure directly correlates with the chosen dimension of the production attributes of the Carbon model. Each variable will have a spread sheet of the structure shown in Figure 5.



Figure 5: Excel Template Example

The object path to the correct attribute, as well as the dimensions, allow for the correct referencing of each cell value to the correct cell within the model.

## Transport Costs

Going forward, transport costs associated with the transfer of concentrate to smelters, as well as furnace matte to the ACP, will also be imported from an Excel template. Transfer costs are supplied as annual figures. This will be of the form shown in Figure 6.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| From Location | To Location | 2011 | 2012 | 2013 |
| AS Mer | **Mortimer Smelter** | 1000 | 1000 | 1000 |

Figure 6: Transport Cost Template Example

## Retrieval Mechanism

The *Data Adapter* component of Carbon Modeller will be used to import data from the abovementioned Excel templates. Data for the model will need to be converted from monthly figures to daily figures where applicable. The Data Adapter component will have modifications to allow for this capability through the incorporation of conversion rules. These will include, for example, the logic of converting the monthly numbers to daily numbers taking into account maintenance days, shutdowns, public holidays etc. at a concentrator.

The user will specify from within the import UI where the files are to be imported from. The user will need to have network access to the path of the files. This access should include both read and write which is to be acquired from the internal network administrator.

## Import Fields

|  |  |  |
| --- | --- | --- |
| Plant | With regards to | Variable |
| Concentrators | Stock Dispatched | * Stock Dispatched |
| Smelters | Stock Balance | * High Priority Bin * Strategic Bin * Low Priority Bin * HG Recycles * LG Recycles * Feed Bin * Slag |
|  | Total FM Available | * In Process FM * FM Product Stock |
| ACP | Stock Balance | * Offline Stock Priority 1 Bin (Priority 1) * PMR Residues Bin (Priority 2) * HG FM Bin (Priority 3) * MG/LG Bin (Priority 4) * Offline Stock Priority 2 Bin (Priority 5) * Acid |
|  | Total WCM Available | * In Process WCM * WCM Product Stock |
| SCF (WACS) | Stock Balance | * Offline WACS Stockpile * WACS Bin * Offline WACS Tails |
|  | Total SCFM Available | * SCFM in Process * SCFM Product Stock |
| SCF (Concentrate) | Total FM Available | * In Process FM * FM Product Stock |
| Slag Mill & Flotation  (SC & EF) | Stock Balance | * SCF Slag (Priority 1) |
| Slag Mill & Flotation  (WACS) | Stock Balance | * WACS Bin, WACS Tails |
| MCM | Stock Balance | * WCM * NCM |
| MCL | Stock Balance | * MEC * FIC |
| BMR | Stock Balance | * NCM Dry * NCM Bagged * Leach & Purification * Tank House * SLR * CPLR * SLC Bagged * SPLR Bagged * NCM Bags |
|  | In Process Stocks | * Residues |
| PMR | Stock Balance | * Metallics Feed Bin |
|  | In Process Stocks | * Stock Balance |
|  | Vault | * Stock Balance |
|  | Residues B | * Rh |
|  | Residues | * A + C |
|  | PGM’s Dispatched | * PGM’s Dispatched |

# The Model

The Carbon Model lies at the core of the COTREM application, and contains all modelling logic and relationships within the model. Utilizing the object-oriented nature of the Carbon modelling technology, each instance of a metallurgical process will be modelled as unique object within the model, having attributes and formulae which describe the interrelationships between each process. An in-depth description of the model and its related logic can be found in the *COTREM Processing Model Specification*.

## Application Interface

Users of the COTREM application will interact with the model through a front-end application containing a series of UI’s (further described in Section 7). The user will not have direct access to the back-end Carbon Model containing the modelling logic, however they will have the ability to configure the model and customize the parameters of all metallurgical processes through the UI. This simplifies the process of running a scenario, and detaches the user from the complexity of the metallurgical formulae contained within the model.

## Base Scenario versus Datasets

In the context of the application, the base or default dataset will contain all necessary input data required to generate a normal calculated output, whilst any additional datasets will be generated for ad-hoc model runs. This is summarised in Figure 7.



Figure 7: Base (Default) dataset versus additional datasets

The input data of the base dataset includes default production data, imported from the Excel spread sheets mentioned in Section 4, as well as the default parameter and capacity values of each process (for example factors, recoveries, bin sizes etc.). Additionally, the user will be able to schedule and configure shutdown profiles and any AOP processes (e.g. tolling, loaning and transfers) through the various user interfaces discussed in Section 7.

The existence of all the information in the base dataset allows for the model to calculate all forecasted results, which shall be kept in a results dataset. If additional scenarios are required, for example if different circumstances are needed to be simulated, the results of these will be stored in additional datasets. This allows for a comparison between different scenarios to be performed (as described further in Section 9).

## External Calculations

The concentrate allocation algorithm encompasses the majority of external calculations that are done outside the model. Further details of this can be found in Section 8. Apart from this, external calculations are down in the application of shutdown profiles and AOPs.

When a shutdown profile is applied to a process, the capacity of that process needs to be adjusted according to the parameters which define the profile, at the correct time within the model. This includes linearly ramping up and ramping down the capacity before and after the scheduled shutdown, as defined in the shutdown parameters.

Additionally, when an AOP is applied, the net movement of the stocks in question are set within the model at the correct instances in time in order to simulate the ‘appearance’ or ‘disappearance’ of stock. This is done using a net stock movement attribute which will be set as positive for inward movement and negative for outward movement.

# File Management & Version Control

The system is not specified to integrate with a file management system, for example Microsoft SharePoint. Any necessary file management will be handled by the user.

## File Repositories

Document management is the responsibility of the user. The system will have no involvement in the managing of files and folders. File access required by the system with regards to the importing of Excel files only require the user to have access to the location of the files. This is internal network access which must be acquired from an internal network administrator.

## Version Control

In order to ensure the integrity of the model structure and prevent corruption of model data, a *scale-out* process will be used in order to construct new instances of the model, derived from scripting instructions. By following this protocol, backward compatibility between newer and older versions of Carbon Modeller can be ensured, should Carbon Modeller be upgraded.

# User Interface

The front-end of the application consists of a number of screens through which the user will be able to configure the model, set-up scenarios to be run and review all data in an intuitive work-flow before actually running the simulation, as shown in Figure 8.

Figure 8: COTREM Application Workflow

See the *COTREM User Interface Mock-ups* document to view the mock-ups of all screens.

## General

### Scenario Selection

The list of available scenarios is accessible from a drop-down list. Changes made in any of the screens will be made in the scope of the selected scenario. By default, the Base scenario will be selected.

### Current Date Selection

The user changes the Current Date of the model by choosing the applicable month and year. The current date will always start at the first day of the selected month.

## Smelter Configuration

### Purpose

The purpose of this UI is to allow the user to create, delete and edit the smelter objects within the model. The user is able to select the activation and deactivation dates of a smelter, should it come online at a future date in the model. Additionally, the user is able to configure the parameters which describe the behaviour of the smelter in the model.

### Usage Pattern

Figure 9: Smelter Configuration Usage Pattern

### Data Requirement

Table 2 and Table 4 below list all editable parameters, factors and metal recoveries which describe the metallurgical behaviour of a smelter process.

Table 2: Editable Smelter Parameters

|  |  |
| --- | --- |
| Smelter Parameter | Unit |
| Maximum Tons Per Day | Tons |
| Maximum Furnace matte Tons Per Day | Tons |
| Maximum Chromite | Percentage |
| Maximum Chromite (Allocation Purposes) | Percentage |
| High Chromite Recovery Adjustment | Percentage |
| Recovery Adjustment Per 1% Excess Chromite | Percentage |
| Product Stock Days | Days |
| Dust Factor | Factor |
| Flux Factor | Factor |
| Concentrate Acid Factor | Factor |
| Feed Bin Days | Days |
| Secondary Smelter Capacity (Use for SCF) | Tons |
| Low Grade Recovery Factor | Factor |

Table 3: Smelter FM Tons Factors

|  |  |
| --- | --- |
| FM Tons Factors | Unit |
| % Chromite Factor | Percentage |
| % Silica | Percentage |
| % Weight Adjustment | Percentage |
| Ni FM Factor | Factor |
| Cu FM Factor | Factor |
| Co FM Factor | Factor |
| S FM Factor | Factor |

Table 4: Smelter Recoveries and FM Factors

|  |  |
| --- | --- |
| Metal | Metal Recovery |
| Pt | Percentage |
| Pd | Percentage |
| Rh | Percentage |
| Au | Percentage |
| Ir | Percentage |
| Ru | Percentage |
| Ni | Percentage |
| Cu | Percentage |
| Co | Percentage |
| S | Percentage |

### Model Interfacing

This UI will interact with the smelter object list existing under the container:

* Model.Smelters.<Selected Smelter>

The *Create* and *Delete* buttons of the UI will instantiate and delete instances of the smelter template at this location in the model, respectively. The *Duplicate* button will create a copy of the selected smelter. Selecting and editing an existing instance of a smelter will change the parameters (attributes) of that smelter object.

## Concentrator Configuration

### Purpose

The purpose of this UI is to allow the user to create, duplicate, delete and edit the concentrator objects within the model. The user is able to select the activation and deactivation dates of a concentrator, should it come online at a future date in the model. Additionally, the user is able to configure the routing rules of concentrate to smelters for each concentrator-smelter combination as well as schedule down-time (e.g. maintenance). The concentrators can be tagged as part of a concentrator group for reporting purposes.

### Usage Pattern

Figure 10: Concentrator Configuration Usage Pattern

### Data Requirement

The user configures the routing for each concentrator by selecting for each smelter:

* Whether routing to that smelter is allowed.
* The corresponding ore type (i.e. destination bin) for the ore that is dispatched.
* The concentrator group (for reporting purposes)

Additionally, the user is able to schedule any downtime for each concentrator. This will be used to determine how the monthly forecast figures are distributed across the days of the month. For this the user must select:

* The start and/or end date of the scheduled downtime.
* The recurrence of the downtime i.e. weekly, monthly or annually.

### Model Interfacing

This UI will interact with the concentrator object list existing under the container:

Model.Concentrators.<Selected Concentrator>

The *Create, Duplicate* and *Delete* buttons of the UI will instantiate, duplicate and delete instances of the concentrator template at this location in the model, respectively. Selecting and editing an existing instance of a concentrator will change the parameters (attributes) of that concentrator object.

## ACP Configuration

### Purpose

This UI allows for the configuration of the recoveries, bin capacities and plant parameters which describe the Anglo Converting Plant (ACP).

### Usage Pattern

Figure 11: ACP Configuration Usage Pattern

### Data Requirement

Table 5: ACP Recoveries

|  |  |
| --- | --- |
| Metal | Metal Recovery |
| Pt | Percentage |
| Pd | Percentage |
| Rh | Percentage |
| Au | Percentage |
| Ir | Percentage |
| Ru | Percentage |
| Ni | Percentage |
| Cu | Percentage |
| Co | Percentage |

Table 6: Editable ACP Plant Parameters

|  |  |
| --- | --- |
| Parameter Name | Unit |
| Maximum Tons Per Day | Tons |
| Flux Factor | Factor |
| WCM Acid Factor | Factor |
| % Fe | Percentage |
| % Sulphur | Percentage |
| In-Process Stock Tons | Tons |
| Product Stock Days | Days |

Table 7: ACP Bin Capacities

|  |  |  |
| --- | --- | --- |
| Bin Name | Limit | Unit |
| Offline Stock Priority 1 Bin (Priority 1) | Min Size | Tons |
|  | Max Size | Tons |
|  | Feed Rate | Tons |
|  | Max Feed Rate | Tons |
| PMR Residues Bin (Priority 2) | Min Size | Tons |
|  | Max Size | Tons |
| HG FM Bin (Priority 3) | Min Size | Tons |
|  | Max Size | Tons |
| MG/LG Bin (Priority 4) | Min Size | Tons |
|  | Max Size | Tons |
| Offline Stock Priority 2 Bin (Priority 5) | Min Size | Tons |
|  | Max Size | Tons |
|  | Feed Rate | Tons |
|  | Max Feed Rate | Tons |

### Model Interfacing

This UI will interact with the ACP object with the address:

Model.ACP

Selecting and editing any parameters of the ACP UI will change the parameters (attributes) of that ACP object.

## SCF (Concentrate) Configuration

### Purpose

This UI allows for the configuration of the recoveries and plant parameters which describe the concentrate part of the Slag Cleaning Furnace (SCF).

### Usage Pattern

Figure 12: SCF (Concentrate) Configuration Usage Pattern

### Data Requirement

Table 8: SCF (Concentrate) Recoveries

|  |  |
| --- | --- |
| Metal | Metal Recovery |
| Pt | Percentage |
| Pd | Percentage |
| Rh | Percentage |
| Au | Percentage |
| Ir | Percentage |
| Ru | Percentage |
| Ni | Percentage |
| Cu | Percentage |
| Co | Percentage |
| S | Percentage |

Table 9: Editable SCF (Concentrate) Plant Parameters

|  |  |
| --- | --- |
| Parameter Name | Unit |
| Maximum tpd | Tons |
| Maximum FM tpd | Tons |
| Max Chromite | Percentage |
| High Chromite Adjustment | Percentage |
| Product Stock Days | Days |
| Dust Factor | Factor |
| Flux Factor | Factor |
| Conc Acid Factor | Factor |
| Feed Bin Days | Days |
| Ni FM Factor | Factor |
| Cu FM Factor | Factor |
| Co FM Factor | Factor |
| S FM Factor | Factor |
| % Chromite Factor | Factor |
| % Silica | Percentage |
| % Weight Adjustment | Percentage |

### Model Interfacing

This UI will interact with the SCF (Concentrate) object with the address:

Model.SCF(Concentrate)

Selecting and editing any parameters of the SCF (Concentrate) UI will change the parameters (attributes) of that SCF (Concentrate) object.

## SCF (WACS) Configuration

### Purpose

This UI allows for the configuration of the recoveries, plant parameters and bin capacity which describe the Waterval Converter Slag (WACS) part of the Slag Cleaning Furnace (SCF).

### Usage Pattern

Figure 13: SCF (WACS) Configuration Usage Pattern

### Data Requirement

Table 10: SCF (WACS) Metal Recoveries

|  |  |
| --- | --- |
| Metal | Recovery |
| Pt | Percentage |
| Pd | Percentage |
| Rh | Percentage |
| Au | Percentage |
| Ir | Percentage |
| Ru | Percentage |
| Ni | Percentage |
| Cu | Percentage |
| Co | Percentage |

Table 11: Editable SCF (WACS) Plant Parameters

|  |  |
| --- | --- |
| Parameter Name | Unit |
| Maximum tpd | Tons |
| Slag variable | Factor |
| Ni Factor | Factor |
| Cu Factor | Factor |
| Co Factor | Factor |
| Fe Factor | Factor |
| Slag recovery | Percentage |
| % FE | Percentage |

Table 12: SCF (WACS) Bin Capacity

|  |  |  |
| --- | --- | --- |
| Bin Name | Limit | Unit |
| WACS Bin | Min Size | Tons |
|  | Max Size | Tons |

### Model Interfacing

This UI will interact with the SCF (WACS) object with the address:

Model.SCF(WACS)

Selecting and editing any parameters of the SCF (WACS) UI will change the parameters (attributes) of that SCF (WACS) object.

## Slag Mill & Flotation (SC & EF) Configuration

### Purpose

This UI allows for the configuration of the recoveries, plant parameters and bin capacity which describe the Slag Cleaning and Electric Furnace (SC & EF) part of the Slag Mill and Flotation Plant.

### Usage Pattern

Figure 14: Slag Mill & Flotation (SC&EF) Configuration Usage Pattern

### Data Requirement

Table 13: Slag Mill & Flotation (SC&EF) Recoveries

|  |  |  |
| --- | --- | --- |
| Metal | SCF Recovery | EF Recovery |
| Pt | Percentage | Percentage |
| Pd | Percentage | Percentage |
| Rh | Percentage | Percentage |
| Au | Percentage | Percentage |
| Ir | Percentage | Percentage |
| Ru | Percentage | Percentage |
| Ni | Percentage | Percentage |
| Cu | Percentage | Percentage |
| Co | Percentage | Percentage |
| Slag recovery | Percentage | Percentage |

Table 14: Editable Slag Mill & Flotation (SC&EF) Plant Parameters

|  |  |
| --- | --- |
| Parameter Name | Unit |
| Capacity | Tons |
| Product Stock Days | Days |

Table 15: Slag Mill & Flotation (SC&EF) Bin Capacity

|  |  |  |
| --- | --- | --- |
| Bin Name | Limit | Unit |
| SCF Slag (Priority 1) | Minimum | Tons |

### Model Interfacing

This UI will interact with the Slag Mill & Flotation (SC&EF) object with the address:

Model.’Slag Mill & Flotation (SC&EF)’

Selecting and editing any parameters of the Slag Mill & Flotation (SC&EF) UI will change the parameters (attributes) of the Slag Mill & Flotation (SC&EF) object.

## Slag Mill & Flotation (WACS) Configuration

### Purpose

This UI allows for the configuration of the recoveries, plant parameters and bin capacity which describe the WACS part of the Slag Mill and Flotation Plant.

### Usage Pattern

Figure 15: Slag Mill & Flotation (WACS) Configuration Usage Pattern

### Data Requirement

Table 16: Slag Mill & Flotation (WACS) Recoveries

|  |  |
| --- | --- |
| Metal | WACS Slag Recovery |
| Pt | Percentage |
| Pd | Percentage |
| Rh | Percentage |
| Au | Percentage |
| Ir | Percentage |
| Ru | Percentage |
| Ni | Percentage |
| Cu | Percentage |
| Co | Percentage |
| Slag recovery | Percentage |

Table 17: Editable Slag Mill & Flotation (WACS) Plant Parameters

|  |  |
| --- | --- |
| Parameter Name | Unit |
| Capacity | Tons |
| Product Stock Days | Days |

Table 18: Slag Mill & Flotation (WACS) Bin Capacity

|  |  |  |
| --- | --- | --- |
| Bin Name | Limit | Unit |
| WACS Bin | Minimum | Tons |

### Model Interfacing

This UI will interact with the Slag Mill & Flotation (WACS) object with the address:

Model.’Slag Mill & Flotation (WACS)’

Selecting and editing any parameters of the Slag Mill & Flotation (WACS) UI will change the parameters (attributes) of the Slag Mill & Flotation (WACS) object.

## MCM Configuration

### Purpose

This UI allows for the configuration of the recoveries, plant parameters and bin capacity which describe the Metallic Concentrator Plant – Milling (MCM).

### Usage Pattern

Figure 16: MCM Configuration Usage Pattern

### Data Requirement

Table 19: MCM Recoveries

|  |  |  |
| --- | --- | --- |
| MEC Recovery | Unit | Type |
| Dry tons | Percentage | Mass Pull |
| Pt oz | Percentage | Recovery |
| Pd oz | Percentage | Recovery |
| Au oz | Percentage | Recovery |
| Rh oz | Percentage | Recovery |
| Ir oz | Percentage | Recovery |
| Ru oz | Percentage | Recovery |
| Ni tons | Percentage | Grade |
| Cu tons | Percentage | Grade |
| Co tons | Percentage | ratio to Ni |

Table 20: Editable MCM Plant Parameters

|  |  |
| --- | --- |
| Parameter Name | Unit |
| WCM grade limit | oz/Ton |
| Recovery adjustment per 10 oz/ton Pd above grade limit | Percentage |
| Max Capacity (tpd) | Tons |
| Max Capacity From 0 min feed stock | Factor |

Table 21: MCM Bin Capacity

|  |  |  |
| --- | --- | --- |
| Bin Name | Limit | Unit |
| WCM Bin | Minimum | Tons |
| NCM Bin | Minimum | Tons |

### Model Interfacing

This UI will interact with the MCM object with the address:

Model.MCM

Selecting and editing any parameters of the MCM UI will change the parameters (attributes) of that MCM object.

## MCL Configuration

### Purpose

This UI allows for the configuration of the recoveries, plant parameters and bin capacity which describe the Metallic Concentrator Plant – Leaching (MCL).

### Usage Pattern

Figure 17: MCL Configuration Usage Pattern

### Data Requirement

Table 22: MCL FIC Recoveries

|  |  |  |
| --- | --- | --- |
| FIC | c.f. MEC input | Type |
| Dry tons | Percentage | % Pt |
| Pt oz | Percentage | Recovery |
| Pd oz | Percentage | Recovery |
| Au oz | Percentage | Recovery |
| Rh oz | Percentage | Recovery |
| Ir oz | Percentage | Recovery |
| Ru oz | Percentage | Recovery |
| Ni tons | Percentage | %Ni |
| Cu tons | Percentage | %Cu |
| Co tons | Percentage | %Co |

Table 23: MCL MCP Press Cake Recoveries

|  |  |
| --- | --- |
| MCP P/C | c.f. MEC input |
| Dry tons | Percentage |
| Pt oz | Percentage |
| Pd oz | Percentage |
| Au oz | Percentage |
| Rh oz | Percentage |
| Ir oz | Percentage |
| Ru oz | Percentage |
| Ni tons | Percentage |
| Cu tons | Percentage |
| Co tons | ratio to Ni |

Table 24: Editable MCL Plant Parameters

|  |  |
| --- | --- |
| Parameter Name | Unit |
| Max PV Runs | Runs |
| Capacity / Run | Tons/Run |
| Max Capacity | Tons |
| FIC Product Stock Days | Days |

Table 25: MCL Bin Capacity

|  |  |  |
| --- | --- | --- |
| Bin Name | Limit | Unit |
| MEC Bin | Minimum Tons | Tons |

### Model Interfacing

This UI will interact with the MCL object with the address:

Model.MCL

Selecting and editing any parameters of the MCL UI will change the parameters (attributes) of that MCL object.

## BMR Configuration

### Purpose

This UI allows for the configuration of the recoveries, plant parameters and bin capacity which describe the Base Metals Refinery (BMR). Additionally, parameters describing the processing of SLR/CPLR, NCM bags and BMR Press Cakes can also be configured.

### Usage Pattern

Figure 18: BMR Configuration Usage Pattern

### Data Requirement

Table 26: General BMR Press Cake Factors (multiplied by Ni Tons)

|  |  |
| --- | --- |
| BMR P/Cs | Factors |
| tons | Factor |
| Pt oz | Factor |
| Pd oz | Factor |
| Au oz | Factor |
| Rh oz | Factor |
| Ir oz | Factor |
| Ru oz | Factor |
| Ni tons | Factor |
| Cu tons | Factor |
| Co tons | Factor |

Table 27: BMR Bin Capacities

|  |  |  |
| --- | --- | --- |
| Bin Name | Limit | Unit |
| NCM Dry Stock (Priority1) | Minimum | Tons |
| Slurry Stock (Priority 2) | Maximum | Tons |
|  | Minimum | Tons |
| Bagged Stock (Priority 3) | Maximum | Tons |
|  | Minimum | Tons |

Table 28: Editable BMR Plant Parameters

|  |  |
| --- | --- |
| Parameter Name | Unit |
| Treated Ni Capacity (tons per annum) | Tons |
| Re-pulp Rate tpm | Tons |
| Sodium Sulphate Factor | Factor |
| Ni - Outside ASTM B39-79 % | Percentage |
| Ni - PQCathode | Percentage |
| Ni - Starter sheets % | Percentage |
| Ni - Sweepings % | Percentage |
| Cu - 'B' grade < 99.9 % | Percentage |
| Cu - PQ cathode | Percentage |
| Cu - Starter sheets/offcuts | Percentage |
| Cu - Sweepings | Percentage |
| Product Stock Days | Days |
| In Process Stock Tonnage | Tons |
| Ni Recovery | Percentage |
| Cu Recovery | Percentage |
| Co Recovery | Percentage |

Table 29: Sodium Sulphate Factors

|  |  |
| --- | --- |
| Description | Unit |
| Acid Input Factor | Factor |
| WCM Treated | Factor |
| Net NCM Ni and Co output | Factor |
| Net NCM Cu output | Factor |
| Other Ni and Co output | Factor |
| Other Cu output | Factor |
| Cobalt Sulphate Co Factor | Factor |

Table 30: CPLR Parameters

|  |  |
| --- | --- |
| Parameter Name | CPLR |
| Bagging rate/day | Tons |
| lot size wet tons | Tons |
| moisture | Percentage |
| SLR/CPLR Product Stock Days | Days |
| SLR/CPLR Product Stock Tons | Tons |
| SLR/CPLR to WS | Percentage |
| BMR Ni Recovery | Percentage |

Table 31: NCM Bagging Parameters

|  |  |
| --- | --- |
| Parameter Name | Unit |
| Bagging rate/day | Tons |
| lot size wet tons | Tons |
| moisture | Percentage |
| Product Stock Days | Days |
| Product Stock Tons | Tons |

Table 32: BMR Press Cake Factors

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Metal | LRPC | EPC | SSPC | IRPC |
| Dry tons | Percentage | Percentage | Percentage | Percentage |
| Pt oz | Percentage | Percentage | Percentage | Percentage |
| Pd oz | Percentage | Percentage | Percentage | Percentage |
| Au oz | Percentage | Percentage | Percentage | Percentage |
| Rh oz | Percentage | Percentage | Percentage | Percentage |
| Ir oz | Percentage | Percentage | Percentage | Percentage |
| Ru oz | Percentage | Percentage | Percentage | Percentage |
| Ni tons | Percentage | Percentage | Percentage | Percentage |
| Cu tons | Percentage | Percentage | Percentage | Percentage |
| Co tons | Percentage | Percentage | Percentage | Percentage |

### Model Interfacing

This UI will interact with the BMR object with the address:

Model.BMR

Selecting and editing any parameters of the BMR UI will change the parameters (attributes) of that BMR object.

## PMR Configuration

### Purpose

This UI allows for the configuration of the recoveries, plant parameters and bin capacity which describe the Precious Metals Refinery (PMR).

### Usage Pattern

Figure 19: PMR Configuration Usage Pattern

### Data Requirement

Table 33: PMR Effluent Losses

|  |  |
| --- | --- |
|  | Effluents losses |
| Dry Tons | Percentage |
| Pt Oz | Percentage |
| Pd Oz | Percentage |
| Rh Oz | Percentage |
| Au Oz | Percentage |
| Ir Oz | Percentage |
| Ru Oz | Percentage |

Table 34: PMR Residue Losses, Recoveries and Factors

|  |  |  |  |
| --- | --- | --- | --- |
| Residues | losses | Ratio Residues | L/C Factors |
| Dry Tons | Grade | Percentage | Factor |
| Pt Oz | Percentage | Percentage | Factor |
| Pd Oz | Percentage | Percentage | Factor |
| Rh Oz | Percentage | Percentage | Factor |
| Au Oz | Percentage | Percentage | Factor |
| Ir Oz | Percentage | Percentage | Factor |
| Ru Oz | Percentage | Percentage | Factor |

Table 35: PMR In-Process Stocks

|  |  |  |
| --- | --- | --- |
| In-Process Stocks | Days to Keep | Oz to Keep |
| Pt Oz | Days | Oz |
| Pd Oz | Days | Oz |
| Rh Oz | Days | Oz |
| Au Oz | Days | Oz |
| Ir Oz | Days | Oz |
| Ru Oz | Days | Oz |

Table 36: Editable PMR Plant Parameters

|  |  |
| --- | --- |
| Parameters | Unit |
| Capacity | Oz per ton per day |
| Month End Variance | Days |

Table 37: PMR Bin Capacities

|  |  |  |
| --- | --- | --- |
| Bin Name | Limit | Unit |
| Metallics Bin | Max Feed Tons | Tons |
|  | Minimum | Tons |
| Feed Bin | Minimum | Tons |

Table 38: PMR By-Product Capacities

|  |  |  |
| --- | --- | --- |
| Product | Limit | Unit |
| Effluent Dam | Feed Rate | Tons |
|  | Minimum Tons | Tons |
| Residues B (Rh) | Minimum Tons | Tons |
|  | Feed Rate | Tons |
| Residues A + C | Minimum Tons | Tons |
|  | Feed Rate | Tons |

### Model Interfacing

This UI will interact with the PMR object with the address:

Model.PMR

Selecting and editing any parameters of the PMR UI will change the parameters (attributes) of that PMR object.

## Import Data Screen

### Purpose

The purpose of this UI is to select the correct Excel input templates and to facilitate the import of the data to the correct attributes in the model through the use of the Data Adapter component in Carbon Modeller.

### Usage Pattern

Figure 20: Import Data Screen Usage Pattern

### Data Requirement

The user must know the path to the populated Excel input templates and should be aware which ones are needed in order to fully populate the model.

### Model Interfacing

Through the use of the Data Adapter component, the data contained in the Excel templates will be mapped to the correct attributes within the model.

### Basic Data Validations

Basic validation of the data will take place before the import process is executed. This is to ensure that all variables within the Excel templates are of the form and data type that the import mechanism will expect. If any validation errors occur, they are reported in the Rejected Imports tab described in Figure 20.

## AOP Configuration Screen

### Purpose

This UI will be able to capture information such as the type of AOP operation and related company names, as well as enable customized scheduling of the operations. The UI will then generate and load the required inputs and outputs at the correct locations in the Carbon model prior to running the model.

### Usage Pattern

Figure 21: AOP Configuration Usage Pattern

### Data Requirement

The user must know the following in order to create a new AOP:

* AOP Type
* External Company
* Entry/Exit Point in Process
* The Product leaving/entering
* Volume of Product
* Scheduling of AOP

Table 39: AOP Recoveries

|  |  |
| --- | --- |
| Metal | Recovery |
| Pt | Percentage |
| Pd | Percentage |
| Rh | Percentage |
| Au | Percentage |
| Ir | Percentage |
| Ru | Percentage |
| Ni | Percentage |
| Cu | Percentage |
| Co | Percentage |
| S | Percentage |

### Model Interfacing

AOP configuration data will be kept external to the model. Each user-created AOP will be applied in the model at the process or processes they were created for. The application of AOPs will only be applied at the dates generated by the scheduling of the AOP activity.

## Scenario Management Screen

### Purpose

This UI allows the user to create and schedule shutdown profiles, as well as choose AOP activities to apply to the base as well as any additional scenarios. Additional scenarios (datasets) are created at this point, in which desired changes can be made to parameters set in the base scenario i.e. to configure what-if scenarios.

### Usage Pattern

Figure 22: Scenario Management Usage Pattern

### Data Requirement

In scheduling and applying shutdown profiles, a validation will be done in order to ensure that consecutive shutdown profiles on a particular plant do not overlap. For shutdown profiles, the user will need to know the following:

* Ramp Down Days
* Shutdown Days
* Ramp Up Days
* Shutdown Capacity

The user will need to select the scheduling of shutdown profiles as well as the scheduling of AOPs for each scenario.

### Model Interfacing

Individual scenarios are stored as datasets within the Carbon model. Therefore, in editing a particular scenario, those changes are made to the corresponding dataset within the Carbon model.

## Data Review Screen

### Purpose

This UI facilitates the viewing of the full model structure and populated attributes so that the user can review any data that has been entered/imported into the model before the model is run.

### Usage Pattern

Figure 23: Data Review Screen Usage Pattern

### Model Interfacing

This UI interfaces directly with the viewable parameters of all objects within the model.

## Run Model

### Purpose

This UI allows the user to initiate the calculation of the model given specific run parameters to take into consideration. The calculation includes only the selected scenarios.

### Usage Pattern

Figure 24: Run Model Screen Usage Pattern

### Data Requirement

All available Scenarios are listed for selection. For each selected scenario the user identifies the type of run to be done: Minimum Transport Costs or Maximum Platinum.

### Model Interfacing

The available list of scenarios is read from the list of datasets contained within the model. Calculation is done within the Carbon model. This is initiated by using the calculate button. Once busy running the calculation can be stopped via the cancel button.

## Reports

### Purpose

The Reports UI allows the user to generate reports in two formats:

* Preconfigured charts viewed on screen
* Custom data in Excel format

The view charts option gives the user a selection of charts to choose from for viewing. Refer to Section 9 for the specific chart content.

Additionally the user can export any data from the model for any timeframe. This data is not formatted and purely exported to an excel file. The user is required to format/pivot the data into the desired report format.

### Usage Pattern

### Data Requirement

In order to view a preconfigured chart the user selects the required one. All parameters have been setup at design time which does not require any interaction from the user.

Exporting data to Excel requires the user to select the desired attributes from the model tree. Once the timeframe is defined the data can be exported to Excel. Data can be exported for the complete timeline or only a sub-section if required.

### Model Interfacing

Preconfigured charts are stored in the model as analysis screens. By accessing one of these screens the chart is viewable.

The complete model is displayed in tree format which allows for the selection of one or more attributes desired in the report. The time dimension is displayed of which the user makes a selection as well. On exporting the selected data within the selected timeframe, data adapters are used to port the data to Excel.

# Algorithms

In order to replicate the procedures performed by the current Excel implementation in improving the outputs of the COTREM model for certain scenarios, rules-based algorithms are implemented. The chosen scenarios include minimizing transport costs of concentrate to smelters as well as maximizing platinum output of the smelters through selective allocation based upon furnace matte output restrictions.

## Minimum Transport Cost

### The Algorithm – Conceptually

The algorithm uses a table, of the form of Table 40, of attributes from within the model which calculates the correct mixture of ore types in order to reach the required chromite level for smelting at the smelter. This table also calculates the associated transport costs for creating one ton of the correct mixture.

Table 40: Concentrate Routing Table

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Destination Smelter** | **Mortimer** | **Mortimer** | **Mortimer** | **Mortimer** | **Mortimer** |
| **Concentrator** | **A** | **A** | **A** | **A** | **B** |
| **Strategic Concentrator** | **W** | **X** | **Y** | **Z** | **W** |
| ***Dilution Factor*** |  |  |  |  |  |
| ***Combined Grade*** |  |  |  |  |  |
| ***Concentrate Portion*** |  |  |  |  |  |
| ***Cost of Concentrate Portion*** |  |  |  |  |  |
| ***Strategic Portion*** |  |  |  |  |  |
| ***Cost of Strategic Portion*** |  |  |  |  |  |
| ***Resulting Furnace Matte Produced*** |  |  |  |  |  |
| ***Cost of Resulting Furnace Matte*** |  |  |  |  |  |
| ***Total Transport Cost per Ton*** |  |  |  |  |  |
| ***Resulting Chromite Level*** |  |  |  |  |  |

In order to minimise transport costs, this table is generated for each smelter and processed in the priority order specified in the UI described in Section 7.2. It is sorted first from minimum to maximum total transport cost per ton, and then by grade. The engine cycles through each possible combination and begins satisfying the smelter capacity requirements through allocating what is available to be dispatched. It begins at the cheapest combination; thereby minimising transport costs associated with dispatching concentrate to the smelters, as well as ensuring that the correct ore mixes (based on chromite level) are available to the smelter.

### The Algorithm – Implemented

Initial Conditions:

All [Stock Dispatched] values for high priority and low priority ore for the day are captured into a Concentrator Stock Table.

All [Stock Dispatched] values for strategic ore for the day are captured into a Strategic Stock Table.

[Smelter outstanding capacity] is set to the [Feed Bin Capacity] (for smelter in model) for that day.

#### First Run (To satisfy minimum requirements of smelter)

From First Concentrator-Strategic Combo

TO

Last Concentrator-Strategic Combo

DO:

1. SET *[Max Available HP]* = Stock Available (FROM Concentrator Stock Table)
2. SET *[MAX Available Strategic]* = Stock Available (FROM Strategic Stock Table)
3. IF *[Dilution Factor]* < 0 OR [Smelter outstanding capacity] = 0 OR ( [Max Available HP] = 0 AND [MAX Available Strategic] = 0 )

THEN SKIP to NEXT COMBO

ELSE CONTINUE

1. CALCULATE *[Chromite Adjust Strategic Need]*:

IF *[Dilution Factor]* = 0

THEN 0

ELSE [*Max Available HP]* / *[Dilution Factor]*

1. CALCULATE *[Adjust for Chromite Available Strategic]*:

IF *[Chromite Adjust Strategic Need]* > *[MAX Available Strategic]*

THEN *[MAX Available Strategic]*

ELSE *[Chromite Adjust Strategic Need]*

1. CALCULATE *[Adjust for Chromite Available HP]:*

* IF *[Chromite Adjust Strategic Need]* = 0

THEN *[Max Available HP]*

ELSE (*[Max Available HP]* \* *[Adjust for Chromite Available Strategic]*) / *[Chromite Adjust Strategic Need]*

1. CALCULATE *[Adjust for Capacity HP]*:

IF (*[Adjust for Chromite Available HP]* + *[Adjust for Chromite Available Strategic]* <= *[Smelter outstanding capacity]*

THEN *[Adjust for Chromite Available HP]*

ELSE (*[Adjust for Chromite Available HP]* \* *[Smelter outstanding capacity]*) / (*[Adjust for Chromite Available HP]* + *[Adjust for Chromite Available Strategic]*)

1. CALCULATE *[Adjust for Capacity Strategic]*:

IF *[Adjust for Chromite Available HP]* = 0

THEN 0

ELSE (*[Adjust for Capacity HP]* \* *[Adjust for Chromite Available Strategic]*) / *[Adjust for Chromite Available HP]*

1. SET

*[Smelter outstanding capacity]* = *[Smelter outstanding capacity]* – (*[Adjust for Capacity Strategic]* + *[Adjust for Capacity HP]*)

1. SET

Concentrator Stock Available (IN Concentrator Stock Table) = *[Max Available HP]* - *[Adjust for Capacity HP]*

1. SET

Strategic Stock Available (IN Strategic Stock Table) = *[Max Available Strategic]* - *[Adjust for Capacity Strategic]*

AFTER LOOP:

* SET per concentrator per smelter the stock to be dispatched (In concentrator Routing object)
* UPDATE Strategic Max Available in Strategic Allocation Object (FROM Strategic Table)

#### Second Run (Allocation of Any Remaining Concentrate)

* SET *[Smelter outstanding capacity]* = *[Smelter max capacity]*

From First Concentrator-Strategic Combo

TO

Last Concentrator-Strategic Combo

DO:

1. SET *[Max Available HP]* = Stock Available (FROM Concentrator Stock Table)
2. SET *[MAX Available Strategic]* = Stock Available (FROM Strategic Stock Table)
3. IF *[Dilution Factor]* < 0 OR [Smelter outstanding capacity] = 0 OR [Max Available HP] = 0 OR [MAX Available Strategic] = 0

THEN SKIP to NEXT COMBO

ELSE CONTINUE

1. CALCULATE *[Chromite Adjust Strategic Need]*:

IF *[Dilution Factor]* = 0

THEN 0

ELSE [*Max Available HP]* / *[Dilution Factor]*

1. CALCULATE *[Adjust for Chromite Available Strategic]*:

IF *[Chromite Adjust Strategic Need]* > *[MAX Available Strategic]*

THEN *[MAX Available Strategic]*

ELSE *[Chromite Adjust Strategic Need]*

1. CALCULATE *[Adjust for Chromite Available HP]:*

IF *[Chromite Adjust Strategic Need]* = 0

THEN *[Max Available HP]*

ELSE (*[Max Available HP]* \* *[Adjust for Chromite Available Strategic]*) / *[Chromite Adjust Strategic Need]*

1. CALCULATE *[Adjust for Capacity HP]*:

IF (*[Adjust for Chromite Available HP]* + *[Adjust for Chromite Available Strategic]* <= *[Smelter outstanding capacity]*

THEN *[Adjust for Chromite Available HP]*

ELSE (*[Adjust for Chromite Available HP]* \* *[Smelter outstanding capacity]*) / (*[Adjust for Chromite Available HP]* + *[Adjust for Chromite Available Strategic]*)

1. CALCULATE *[Adjust for Capacity Strategic]*:

IF *[Adjust for Chromite Available HP]* = 0

THEN 0

ELSE (*[Adjust for Capacity HP]* \* *[Adjust for Chromite Available Strategic]*) / *[Adjust for Chromite Available HP]*

1. SET

*[Smelter outstanding capacity]* = *[Smelter outstanding capacity]* – (*[Adjust for Capacity Strategic]* + *[Adjust for Capacity HP]*)

1. SET

Concentrator Stock Available (IN Concentrator Stock Table) = *[Max Available HP]* - *[Adjust for Capacity HP]*

1. SET

Strategic Stock Available (IN Strategic Stock Table) = *[Max Available Strategic]* - *[Adjust for Capacity Strategic]*

AFTER LOOP:

* SET per concentrator per smelter the stock to be dispatched (In concentrator Routing object)
* UPDATE Strategic Max Available in Strategic Allocation Object (FROM Strategic Table)

After all runs have been completed, any remaining strategic concentrate that was not used in the allocation mixes must be dispatched to the closest smelter.

## Target Date Logic

### The Algorithm – Conceptually

Target date logic is utilized to reduce the spare capacity at a smelter (usually Polokwane in this instance) in order to minimise transport costs associated with dispatching concentrate unnecessarily.

### The Algorithm – Implemented

1. We are required to run the allocation once normally first with no target date (i.e. target date is switched off in the UI)
2. After this, a target date can be selected upon review of the data from within modeller
3. Next, the correct target date will be selected from the UI (i.e. target date is switched on and selected in the UI).
4. When the model is run with target date applied, data from attributes in the dataset that was previously run must be extracted and applied to a new ‘clean for routing’ dataset in order to run the model with the correct adjustments.

OPERATION:

Note: ‘Period’ = All days from 1st day of model till selected target date.

For EACH smelter:

FROM THE PREVIOUSLY RUN DATASET (a new variable is extracted to be applied to the new dataset)

<SmelterName>SpareCapacityAdjustment =

Model.Smelters. <SmelterName>.Smelter\_x20\_Process[Spare\_x20\_Capacity\_x20\_Adjustment] (At the Target Date)

IN THE NEW DATASET:

Now for the entire Period (i.e. each day of the period), [Maximum tpd] is adjusted to the following:

Model.Smelters. <SmelterName>.Smelter\_x20\_Process[Maximum\_x20\_tpd] =

<SmelterName>SpareCapacityAdjustment \*

Model.Smelters.<SmelterName>.Smelter\_x20\_Process[Maximum\_x20\_tpd]

I.e. the SpareCapacityAdjustment is just a single number between 0 and 1, by which we will adjust the smelter capacity for each day of the period in the new dataset.

The allocation for the newly adjusted dataset is then run to ‘optimize’ for transport costs.

## Maximum Platinum Flow

In order to ensure that all concentrate dispatched is smelted and does not sit in a stockpile, the allocation should take into account the furnace matte output restrictions of a smelter. This algorithm still needs to be fully defined.

The basic idea is that a global factor will exist which will be used to reduce the chromite level of other smelters. This is to ensure that all concentrate is smelted and if excess of concentrate exist due to shutdowns, the highest grade concentrates are used.

# Reports

## Simulation Results

After the model has run, the user will be presented with a number of reports in order to review the results of the simulation. Charts to be included in the application for reporting purposes:

* Concentrate
  + Metals Content
* Smelters (across all)
  + Total available Concentrate Smelting Capacity in tons
  + Treated tons
  + Total Concentrate Stocks
* Per Smelter:
  + Treated Chromite Level
  + Tons per day FM produced
  + Tons smelted
  + Available smelting capacity
  + Total site Concentrate Stocks
* Matte Fall
  + For all smelters and ACP
  + Smelters = Tons FM produced / (tons concentrate treated – SCF concentrate)
  + ACP = Tons WCM produced / tons FM treated
* ACP
  + Maximum available converting capacity
  + FM Treated
  + FM Stock
  + WACS Stock
* SCF
  + WACS Capacity
  + WACS Treated
  + Concentrate Treated
* Recoveries (Smelting & Refining)
  + Overall
  + Input Quantity
  + Output Quantity
  + Total Stocks in Process

## Excel Export

To cater for this function, the application will allow the user to export any data within the model whether it is inputs or calculated values. The data can be exported for the complete or a sub-section of the timeline in the model.

The user will be able to select the particular attributes of the model as well as the required time period to export, as described in Section 9.

The data exported will have no format and it will be up to the user to create pivots/charts linking to the raw data. Formatting is applied manually in Excel.

# Conclusion

This document outlines all functionality to be included in the COTREM Processing Model Solution.

The proposed application allows the user to:

* Export templates for importing of data
* Validate data received
* Import data acquired from all the plants
* Configure Smelters & Concentrators
* Set up routing
* Configure each Plant individually by capturing parameter values and recoveries
* Create multiple Scenarios
* Apply relevant Shutdown Profiles and AOPs
* Review data before calculation
* Calculate the model with the required type of allocation to be done
* View Charts for Model validation
* Export any data contained in the Model to Excel for reporting purposes

Combining the functions above provides an application with all the elements for a successful recreation of the current Excel implementation of the COTREM Model.