Reconciliation Explained and Solutions Recommended

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Reconciliation: Definition

- *The process of finding a way to make two different ideas, facts, etc., exist or be true at the same time.* Britannica

- *A process that evaluates a mining operation's capability to meet the projected tonnage and grade specified in the ore reserve. It is an ongoing effort to improve our understanding of the reserve and the quality of the operation.*

Example	Resource models 100,000 Ozs	Mine 97,000 Ozs	Processing plant 96,500 Ozs	Sales 95,000 Ozs

Note: Reconciliation is not an investigation about the operating cost or revenue.

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Introduction

- Benchmarking studies indicate that most mines experience significant discrepancies in tonnages and grades reported at different stages of operation. In our recent observations of six mines, the reported tonnages deviated from the planned figures by -4% to +12%, and the grades varied from -7% to +20%.

- Some of the influencing factors are:
  - The shape of the orebody, the grade distribution, geological impacts (dikes, mineralogy, etc.)
  - The scale and complexity of the operation,
  - The installed instrumentation,
  - The presence of a grade control unit.

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Benefits of Reconciliation Studies

No mine produces exactly what was predicted during the planning phase, yet not every mine is interested in understanding why.

1. Reconciliation enables mining companies to be more confident in their mineral reserve estimates and economic forecasts.

2. Reconciliation studies provide opportunities to improve the economy of the mine by:

   – Improving feed grade – lowering the mining dilution

   – Improving resource recovery – reducing the ore loss

We don't know what we don't know.

We can't do what we don't know.

We won't know until we measure.

We don't measure what we don't value.

We don't value what we don't measure.

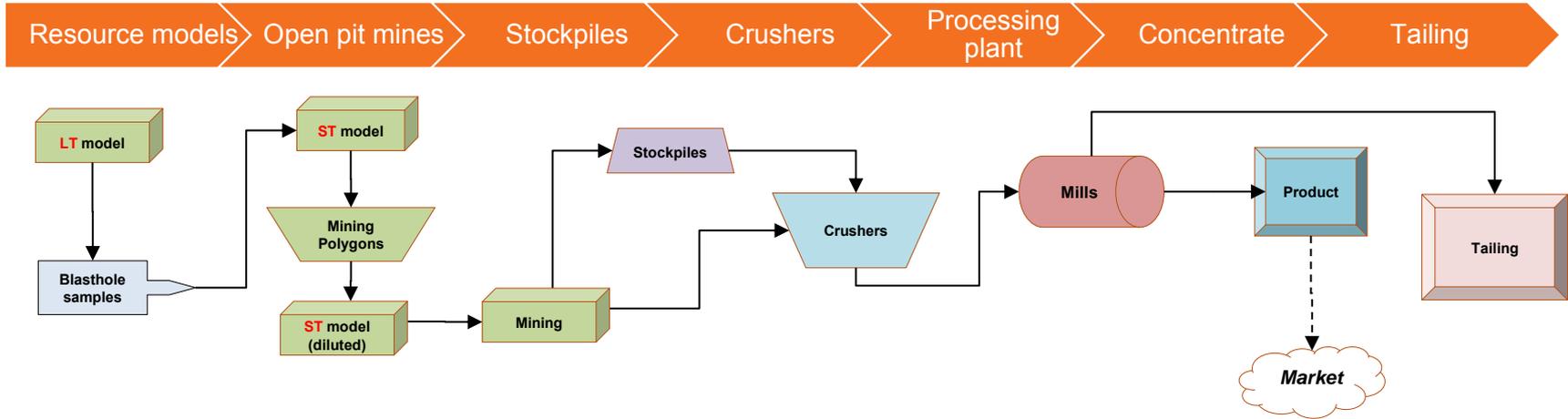Mikel Harry and Richard Schroeder

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The Root Cause of Reconciliation Issues

- The root of the problem lies in the mine's inability to measure tonnages and grades at various stages of production accurately.
  - Insufficient sampling and instrumentation
    - Diamond drill, blast hole sampling, RC sampling, etc.
    - And it is not all about the grade….
    - Density measurement
    - Moisture content
    - ….
  - Error in modeling and calculation
    - Blast movements
    - Dilution factors
    - Stockpiles
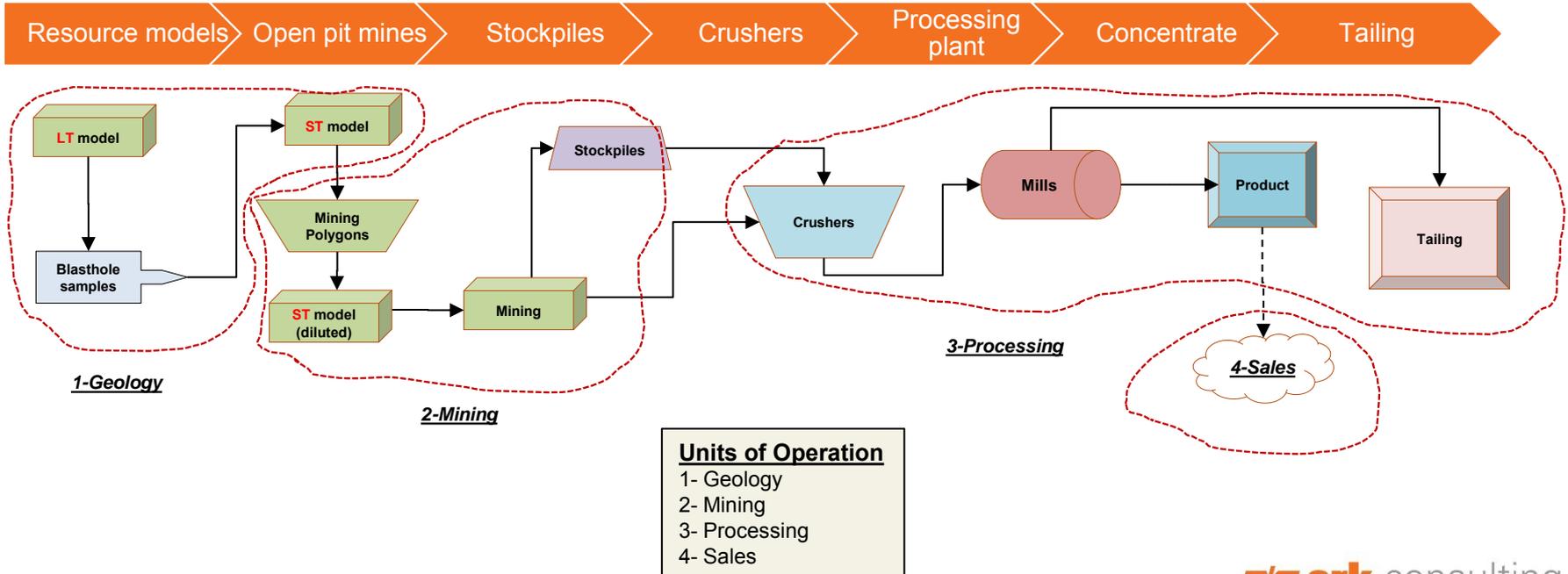   - ….

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Steps in Reconciliation Study

- Define the value chain of the operation
- Form a committee for reconciliation that represent the entire value chain
- Identify "measured" information used in the reports, is it enough?
- Understand the limitations of the instruments installed at the site
- List the gaps for data collection and search for new technologies/instrumentation
- Develop guideline and protocols for:
  - Data collection
  - Reporting
- Define the reconciliation factors that best fit your operation.

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Reconciliation: Define Value Chain, Example

Reconciliation: Identify Units of Operation

Resource models → Open pit mines → Stockpiles → Crushers → Processing plant → Concentrate → Tailing

LT model

ST model

Blasthole samples

Mining Polygons

ST model (diluted)

Mining

Stockpiles

Crushers

Mills

Product

Tailing

1-Geology

2-Mining

3-Processing

4-Sales

Units of Operation
1- Geology
2- Mining
3- Processing
4- Sales

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Production Reports (what, where, when)

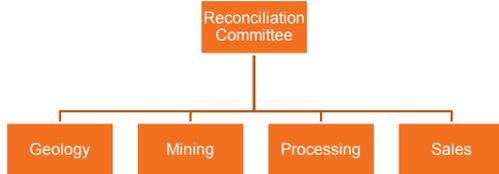*Production reports are the main inputs for reconciliation study.*

- Tonnages
  1. Volumes (surveying)
  2. Densities (resource model, sampling and measurement)
  3. Moisture (assumption, lab work, measurement)
- Quality items
  1. Grades
  2. Mineralogy
  3. Impurities
  4. ….

- Considerations:
  - Measured values
  - Assumptions made
  - Calculated/estimated values
  - Reconciliation period
  - Track the materials in the report
  - Methodologies and techniques used for estimation.

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Reconciliation: Production Reports

Resource models → Open pit mines → Stockpiles → Crushers → Processing plant → Concentrate → Tailing

LT model

R1

Blasthole samples

ST model

R2

Mining Polygons

ST model (diluted)

R3

Mining

R5

Stockpiles

R4

R6

Crushers

R7

Mills

R8

Product

Market

R10

R9

Tailing
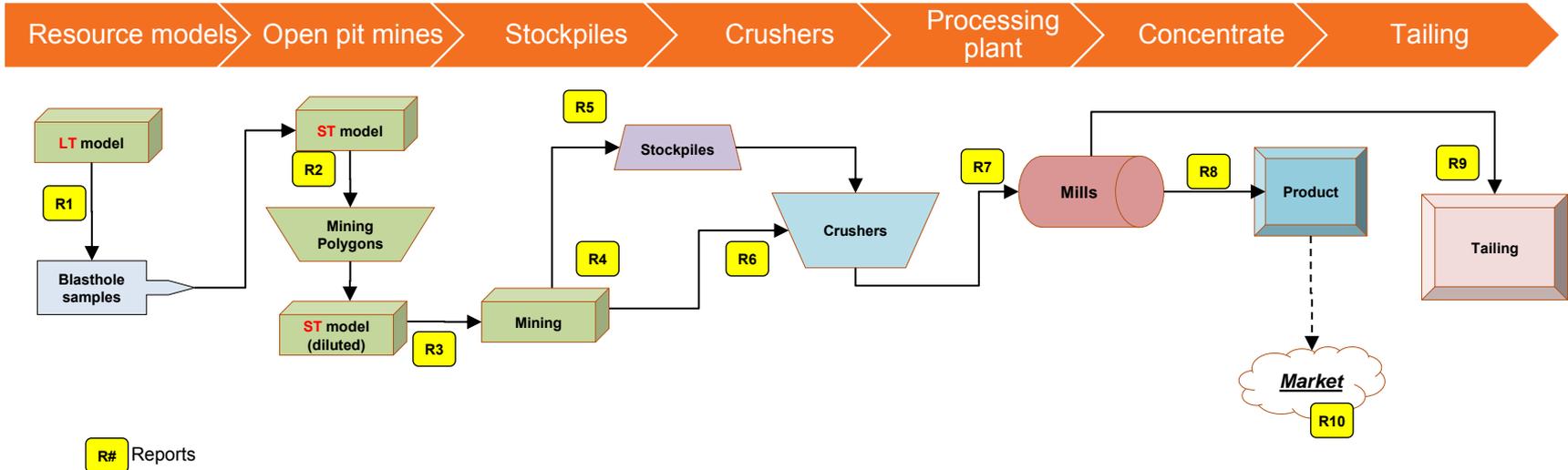
R# Reports

Form Reconciliation Committee
- Responsibility assignment matrix

Reconciliation
Committee

Geology | Mining | Processing | Sales

Reconciliation reporting periods:

- Weekly
- Monthly
- Quarterly
- Yearly

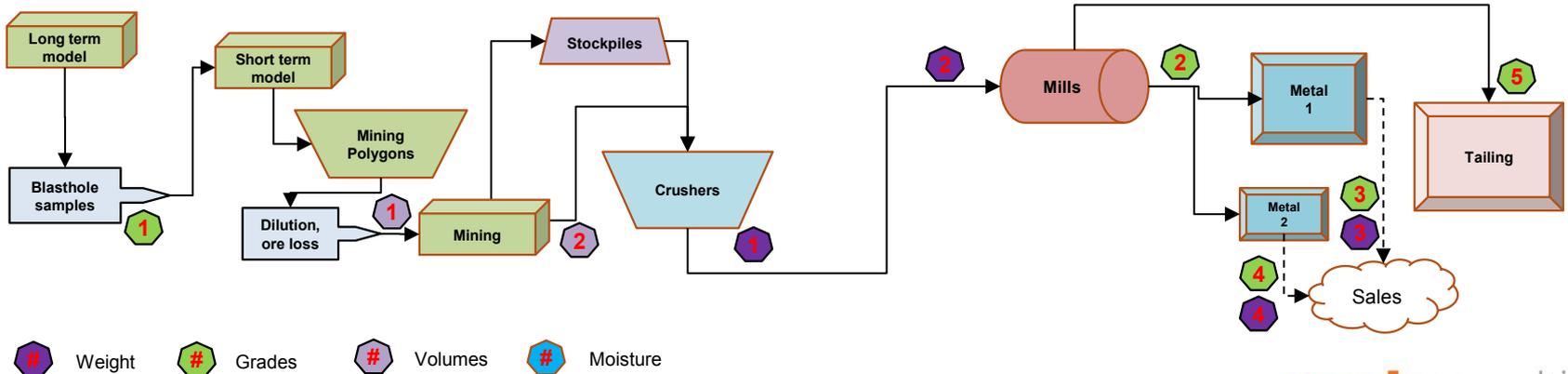| Report	Description	Geology	Mining	Processing
R1- LT model	Reports the tonnages and grades using the LT model developed by exploration for the period of the reconciliation report. This is reported by sources of ore (bench/zone).	✓		
R2- ST model	Reports the tonnages and grades using the ST model developed by geology for the period of the reconciliation report. Considering the mining conditions, the ST model includes two sets of attributes for grades: before and after dilution. This is reported by sources of ore (bench/zone).	✓	✓	
R3- Mining	Tonnages of ore mined and moved out of the pit will be reported by sources and destinations using the ST diluted model.		✓	
R4- Stockpiles	Tonnages and grades of ore moved in and out of the stockpiles will be reported. This will include all the short-term and long-term stockpiles.		✓	
R5- Delivered to the Crushers	Grades and tonnages of ore fed to the crushers will be reported here by the mine.		✓	
R6- Ore crushed	Tonnages of ore received by the crushers will be reported here by the processing. The grades reported will be the same as R5 as there is no sampling in this location.			✓
R7- Coarse ore stockpile	The balance of the month for tonnages and grades of the coarse ore stockpiles inventory will be reported in this R7. R6 and R8 will be used to report the tonnages and grades reported for R7.			✓
R8- Mill feed	Grades and tonnages of ore received by the mills will be reported here by the processing. Both tonnages and grades expected to be well measured at this stage.			✓
R9- Process plant inventory	The balance of the month for tonnages and grades of the mill inventory will be reported in R9.			✓
R10- Concentrates produced	Concentrates produced using the ore for the period that is the subject of the reconciliation report will be determined in this report.			✓
R11- Tailings	Tonnages and grades of the tailings disposed for the same period and same materials will be recorded in this report.			✓

Example

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Considerations: Transient Time (△T)

Dealing with built-in storage capacities.

Resource models → Open pit mines → Stockpiles → Crushers → Processing plant → Concentrate → Tailing

LT model

ST model

Mining Polygons

Blasthole samples

ST model (diluted)

Mining

Stockpiles

Crushers

Mills

Product

Tailing

Market

Mining: 19 hours — Crusher: 4 hours — Plant: 1 hour

ΔT 24 hours
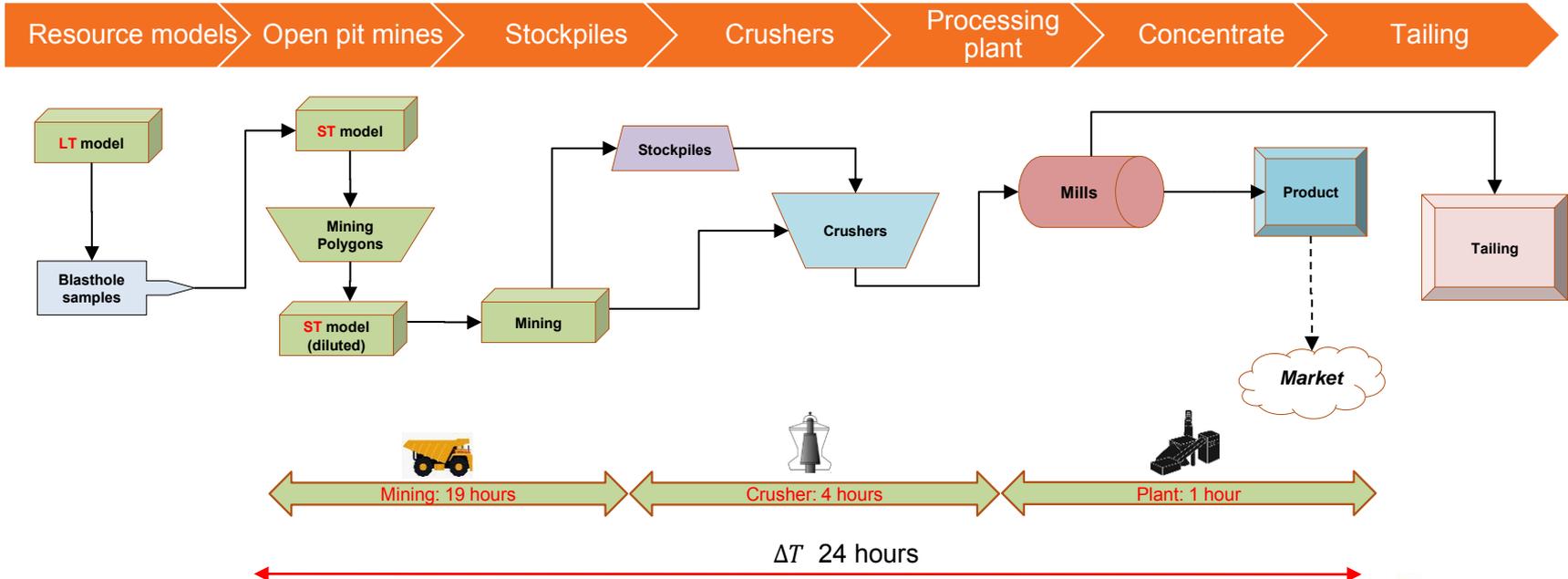
Measurements - Instrumentation

- Densities are often overlooked in both geological models and mining operations.
- Moisture measurement is frequently limited or absent in mining production systems.
- How do we assess mining dilution and blending within the mining operation?

- Consider maximizing measurement points and instrumentation. And note that this is much easier in the construction period than after the mine is built.

Define Customized Reconciliation Factors

F1= R2/R1
F2= R3/R2
F3=R6/R5
F4= R8/(R6,R7)
F5= (R9,R10)/(R7,R8)
F6= (R9,R10)/R3
F7= …….

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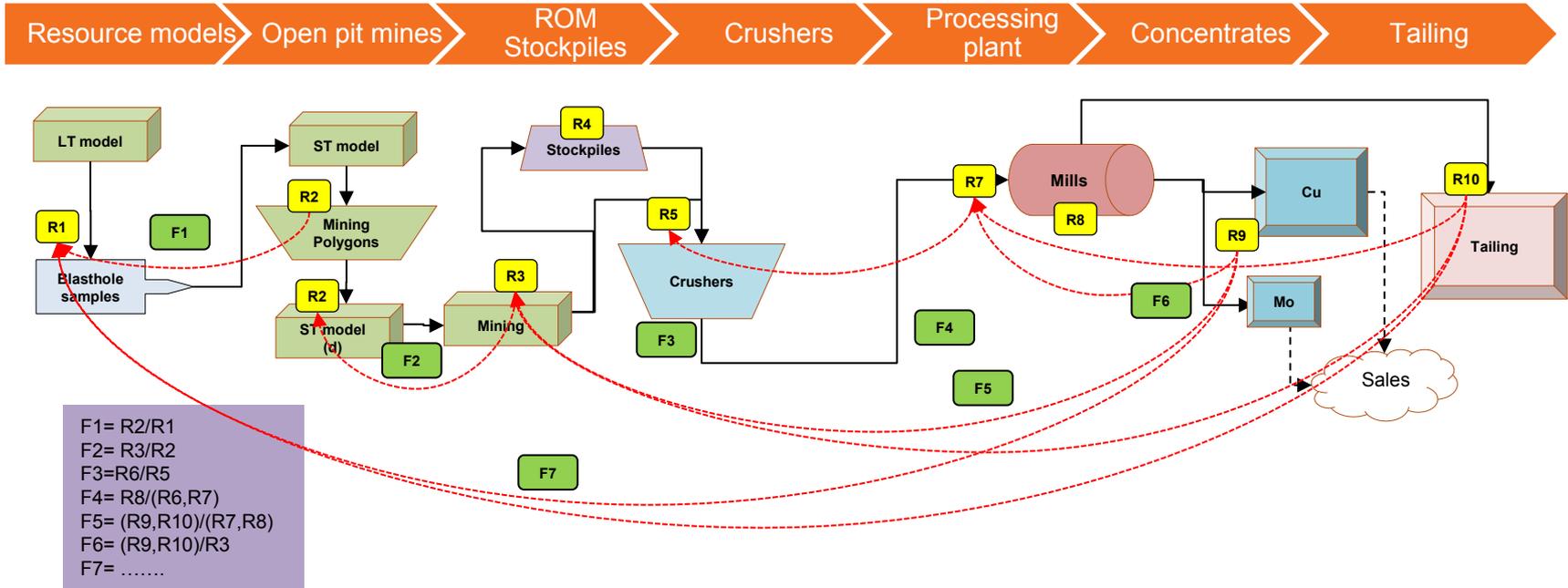
Reconciliation between LT model and ST model

- The ratios between tonnage, grade and metal in the LT and ST models are used to develop reconciliation factors, known as F1.

- Equation F1:

$$F1 = \frac{Short\ term\ model\ depletions}{Long\ term\ model\ depletions}$$

- Where:

  - Short term model is the resource model created using the operational data such as assays from blastholes or grade control RC drill holes. This model is used for short term mine planning and production reporting. This model sometime is called "grade control model" or "hybrid model".

  - Long term model is the resource model created using exploration data for long term mine planning such as for developing mineral reserves.

- Consideration:
  - **Blasthole/RC sampling techniques**

Reconciliation between delivered to mill and received at mill

- The ratios between tonnage, grade and metal received at the mill versus delivered to the mill.

- Equation F2:

$$F2 = \frac{Received\ at\ the\ Crusher\ (reported\ by\ the\ plant)}{Delivered\ to\ the\ crusher\ (reported\ by\ the\ mine)}$$

- Important factors:

  – Ore delivered to the mill often come from different sources, ROM & Stockpiles. This is reported from the mine using different methodologies and techniques such as surveying, truck count/dispatch, and new tools such as ShovelSense.

  – Ore received at the mill is often measured after the primary crusher by the scale on the conveyor.

  – Consideration:

    – Mining dilution
    – Ore loss
    – Moisture factor
    – Trucks carry back factor

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Improve your knowledge about the density variation in your deposit

- <u>Dry metric</u> tonne must be measured and reported in all stages. If any tonnage is reported as wet tonnes, it must be accompanied by its <u>moisture</u> factor.

- Frequent density measurements recommended in bench faces, stockpiles, coarse ore.

- Correction for moisture

| Density	Deviation
2.80	2%
2.75	0%
2.70	-2%

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Cut-off Grades an Important Factor

- It affects the grade reported (mining polygon and dilution):
  - Number of products (concentrates)
  - Value generating elements: a, b, c, etc.
  - Number of pits: Pit 1, Pit 2, etc.
 - Stockpiling policies and cut-off grades

-When dealing with multiple sources of revenues, using NSR for cut-off grade segregates the true ore values more efficiently than using one single element.

-This is particularly recommended for the deposits with low correlation between value generating elements.

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ST model – LT model – Example
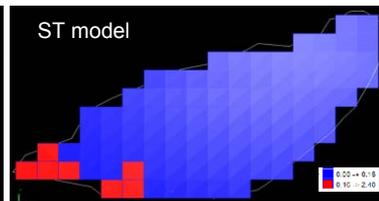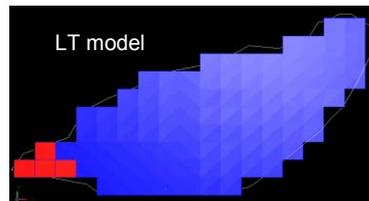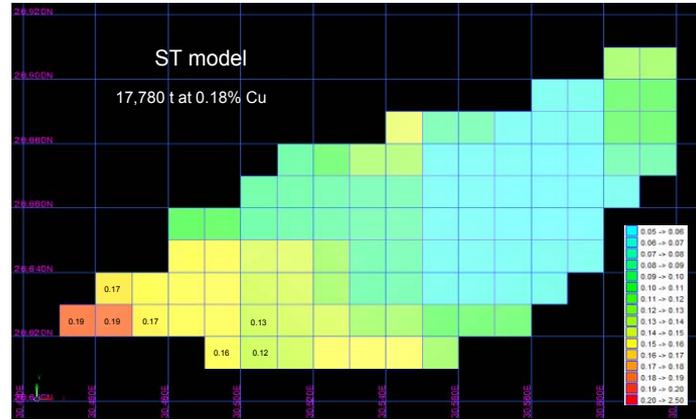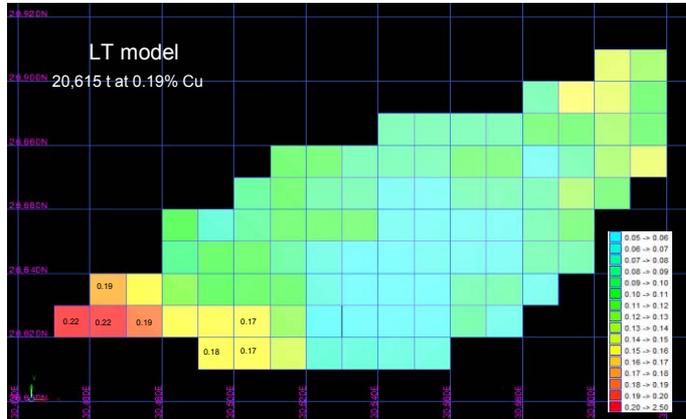
Mining Polygons, Examples (dilution/ore loss)
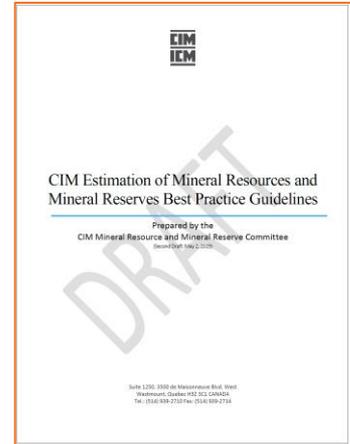

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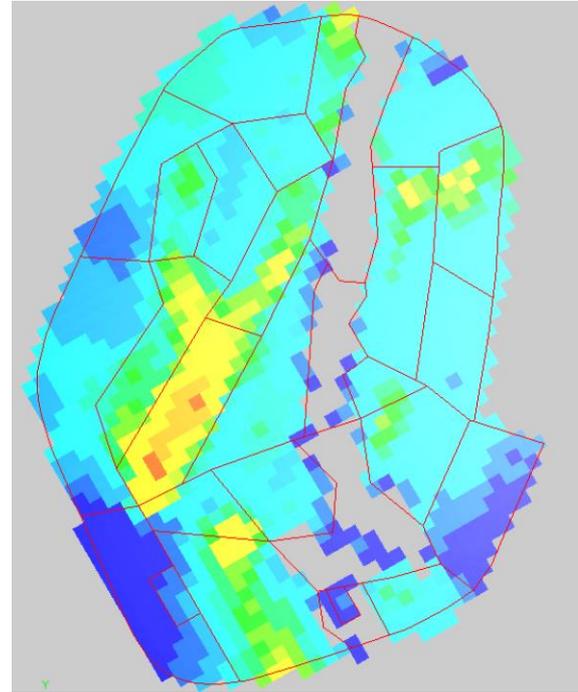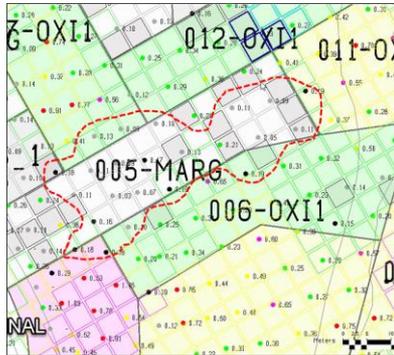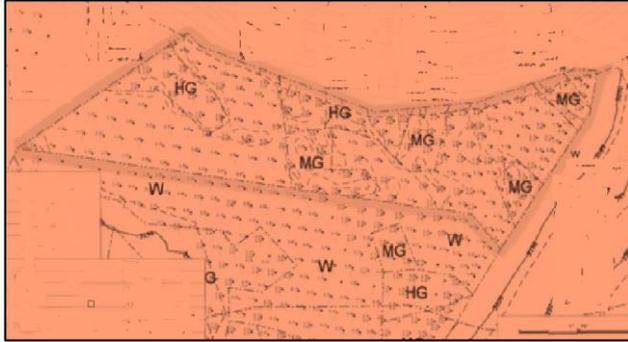
Blast Movements

- Blast movement is important in reconciliation and dilution control.

- Often, the reported ore values may be inaccurate due to the blast movement. In this case, the reported grade is approximately 3.7% higher than it should be. For polygons that include ore-waste boundaries, this discrepancy can be substantial.
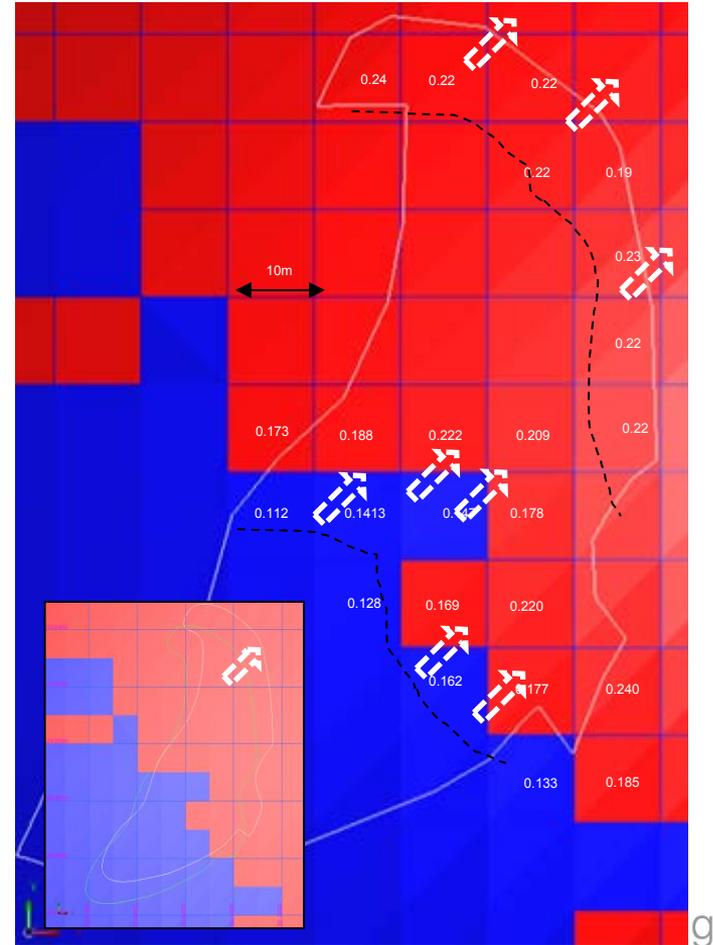
Is there an industry wide reconciliation standard?

- There is no regulation or widely accepted standard,

- CIM guideline Section 6.10.2

- Reconciliation Studies:

  - ….While selection of appropriate reconciliation methods resides with the Practitioner, the method or methods used should be described in detail, along with the results. Two types of principle reconciliation studies may be carried out in the validation of a Mineral Resource block model:

    1. *6.10.2.1. Long Term Model vs. Short Term Model*

    2. *6.10.2.2. Long Term Model vs. Plant Production Data*

CIM Estimation of Mineral Resources and Mineral Reserves Best Practice Guidelines

Prepared by the
CIM Mineral Resource and Mineral Reserve Committee

DRAFT

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Reconciliation - Summary

- Reconciliation studies improves the overall performance of the mining operations
- Have a champion (reconciliation committee)
- Plan in advance for reconciliation when building the mine
  - Maximize installing the measurement points in the system
- Replace correction factors used in the reports by real scientific measurements. (moisture factor, truck's load factor)
- Develop a site-specific reconciliation guideline
- Perform routine audits using third parties

Questions?

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