Applying Modeling & Simulation as part of Business Process Improvement of Complex Mining Logistics

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**Problem Statement** – ‘Setting the scene for complexity’

**Value-Based Business Engineering** – ‘The solution towards decision taking’

- Business Engineering – ‘An introduction to BE’
- Strategic Analysis, Modeling and Simulation – ‘Definitions and concepts’
- Application – ‘Examples of the application of modeling and simulation to mine engineering’

**Closure** – ‘Project success factors, metrics and conclusion’
Value-Based Business Engineering

Problem Statement

Prospecting

Exploration

Development

Exploitation

Reclamation

• Production cycle = drill + blast + load + haul
  • Continuous Miners, Shovel, Dragline, Rail, Conveyors, Truck, Shuttle Cars
  • Auxiliary Operations:
    • Underground – roof support, ventilation and air-conditioning, power supply, pumping, maintenance, lighting, communications, delivery of compressed air, water and supplies to working sections
    • Surface – slope stability, pumping, power supply, maintenance, waste disposal, and supply of material to the production centers

• Complexities
  • Internal (Green-field, brown-field)
    • Mining Method
    • Resources
    • Scheduling
    • Process
  • External
    • Environmental factors
    • Economic factors
    • Legislation

‘Imagine you are VP, Engineering Manager, Mine Manager … you have to decide …’

How will our system react to over or under supply?

What type of stockpile arrangements will be most beneficial?

Is our buffer capacity sufficient for the new customer order?

Should conveyors, rail or road transport be used?

What is the optimal shovel dragline configuration in my open cast mining?

….. ?
Business Engineering – ‘An introduction to BE’

A system is defined as a grouping of parts or functions that operate together for a common purpose, for example a business process.

**BUSINESS PROCESS CHANGE**

Environments in which companies operate change and companies respond by changing their strategies and goals. Those changes drive changes in processes.

- Analysis of processes and their improvements to mining operations is a perennial management responsibility
- Various processes, techniques, tools and methodologies in business process change exist
  - Process measurement and analysis
  - Job redesign
  - Automation (ERP, Workflow)
  - Six Sigma
  - Gaps and disconnects
  - Process simplification
  - Process modeling

Development of Mining Technology

The Mining Industry is a perfect example of the power of business process change in revolutionizing the economics of the industry itself.

- Remote control automated mechanized mining; biological mining
- Continuous mining equipment; tungsten carbide bits
- Dynamite
- Mehanization; improvements in scientific concepts
- Fire setting; use of fabricated metals
- Flint implements; crude methods in ground control, ventilation, haulage, hoisting, lighting, and rock breakage

Adapted from Business Process Change by Paul Harmon (2003); Introductory Mining Engineering by Hartman & Mutmansky (2002)
Strategic Analysis, Modeling and Simulation – ‘Definitions and concepts’

- **Definitions**
  - **mod·el·ing** (mŏd'ĭ·ling) … A simplified representation of a complex entity or process.
  - **sim·u·la·tion** (sim'yə-lā'shən) … A simulation is an imitation of some real device or state of affairs. Simulation attempts to represent certain features of the behavior of a physical or abstract system by the behavior of another system - the process of model “execution”.

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REAL-TIME RULE ENGINE
SMARTER DECISION!
AUTOMATED ACTIONS!

STRATEGY
STRUCTURE
PROCESS
SYSTEM
RESOURCE

BUSINESS ENGINEERING OBJECTS
Value-Based Business Engineering

Strategic Analysis, Modeling and Simulation

- A Knowledge Base (KB) is a collection of related knowledge about a system
  - Generic rules, procedures, formulas and relationships – programming code
  - Models of real-world objects and systems
  - Expert information about process steps and decision strategies
  - Data that represent object properties
- Comprehensive applications may consist of several specific integrated knowledge bases
- Most knowledge concepts can be expressed as a hierarchy
  - Allows application to function at different levels; varying from generic to specific
  - Each element is defined in terms of a set of other more specific elements
**Value-Based Business Engineering**

**Problem Statement**

**Strategic Analysis, Modeling and Simulation** – Underground mine KB composition

**STEP 1. STOPE ACTIVITY**

Includes complete operations from stope to bin to mill and further … also including the supply chain into the client processes.

**STEP 2. U/G TRANSPORT**

**STEP 3. HOISTING**

**STEP 4. SURFACE RAIL**

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Value-Based Business Engineering

Application: Mining operations design rationale

- Provides for graphical and animation features to allow members of the design team to view the performance and operation of their own design
- The use of monitoring points and creating comprehensive simulation reports; errors and inefficiencies in the performance of the mining operation design may be highlighted and quantified
- Employed iteratively to improve the design of the overall mining operation

Case Studies:
- Block-cave production simulation modeling
- Global zinc product distribution simulator
- Iron ore treatment plant model
- Seabed mining and treatment plant model
- Coal wash plant project life cycle and design validation knowledge base
- Underground conveying, underground rail and surface rail dynamic simulation modeling
- Face production modeling (face to feeder)
Application: Control system validation

- Providing a non-destructive environment to validate the correctness of algorithms, coding and parameterization of controllers and supervisory systems
- Reduce time to commission the control systems on the real plant through off-site testing while the construction of the plant is in progress

Case Studies:
- Control systems testing and operator training for a new coal beneficiation plant
- New coal wash plant control system design validation knowledge base
Application: Intelligent control system

- An intelligent control system would provide for management functions such as command and instruction, control and exception reporting, real time communications and the accumulation of intelligence of the dynamics of the operations. This leads to an approach similar to the modern Command, Control, Communications, Coordination and Intelligence (C4I) approach as successfully employed by the US military.
- Intelligence is the top priority for commercial application (IC4), as the key component usually is a clear understanding of the system.
Application: Management through supply-chain modeling

- **EXTRACTION**
  - Ore deposit
  - Surface
  - Underground

- **PROCESSING**
  - Rock
  - Beneficiation
  - Smelting
  - Refining

- **DELIVERY**
  - Product
  - Marketing
  - Delivery

- **MINE**
  - Better responsiveness to unexpected demands
  - Distribution scheduling
  - Improved customer service
  - Orders
  - Shipping scheduling
  - Production plans
  - Demand planning
  - Forecasts
  - Higher product margins
  - Reduced inventory

- **SCOR**
  - Plan
  - Source
  - Make
  - Deliver
  - Return

- The Supply Chain Operations Reference-model (SCOR) has been developed and endorsed as the cross-industry standard for supply-chain management
- Includes benchmarking and best practice analysis
- Supply-chain modeling provides for quick and confident supply chain decisions

- Case Studies:
  - Phosphate product supply chain simulator and scheduler across organizational boundaries of the phosphate producer, rail authority, port authority and the fertilizer producer
  - Coal supply from various mine complexes and stockyards feeding into synthetic fuel plants by conveyor belt
Application: Other

- Production planning & forecasting
  - Detailed activity cost analysis
  - Income/balance sheet estimation as part of budgeting exercise

- Education & training
  - How to react to problems that may arise in day-to-day operation of the plant
  - Online operator training – controlling a simulated section of a plant

- Marketing & client relations
  - Distribution planning
  - Order placement
  - Projected lead times

- Communication
  - Non technical buy-in
  - Presentation to executive management
  - Community relations
  - Offsite

EXAMPLE: Build a mine in 60 seconds.
## Closure

- **Project success factors**
  - Clear scope defined by high level static model
  - Dedicated project champion
  - Understanding of modeling tool capabilities and limits
  - Steepwise approach and categorization
  - Intelligent assumptions to fill the gaps
  - Issues register and classification
  - Data sheet of model inputs – continuous review and approval
  - Unpacking the results to properly address the project requirements
  - Control over-enthusiasm which could lead to complexity

- **Typical project metrics**
  - The investment expense should realize at least ten (10) fold cost benefit to the operation being investigated – experience has proved this value to be closer to 100
  - Minimal percentage increase in throughput provides for significant savings and benefit through the life of the operation
  - Project duration typically range between two (2) weeks and two (2) years, depending on the project scope, complexity and status
  - All types of mining companies or related sub-projects could benefit; from small and midsize commodity companies to large, complex and globally diverse organizations
The VP Engineering, VP Strategic Planning, VP Finances, VP Marketing, Mine Manager and Senior Management need to involve Business Engineering, incorporating Strategic Analysis, Modeling and Simulation, in the early stages of projects (even at project identification and selection) and thereby:

- obtain maximum benefit through the life cycle
- reduce inherent project risk
- maximize Return on Investment (ROI)
QUESTIONS OR FURTHER INFORMATION:

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