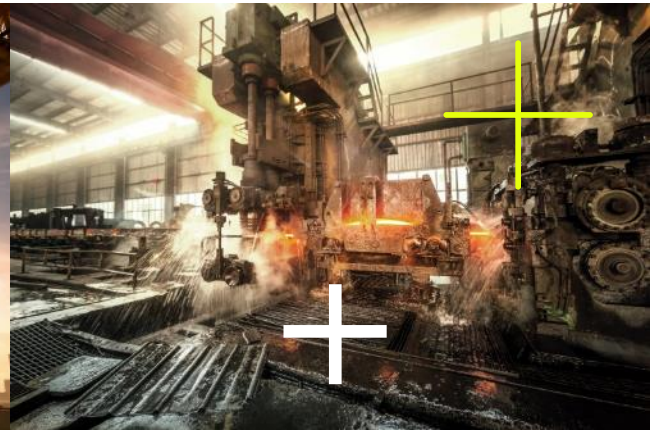


+ From RAM Modelling to Predictive Maintenance



Optimizing Mine Performance Through Digital Innovation Seminar, October 18, 2017

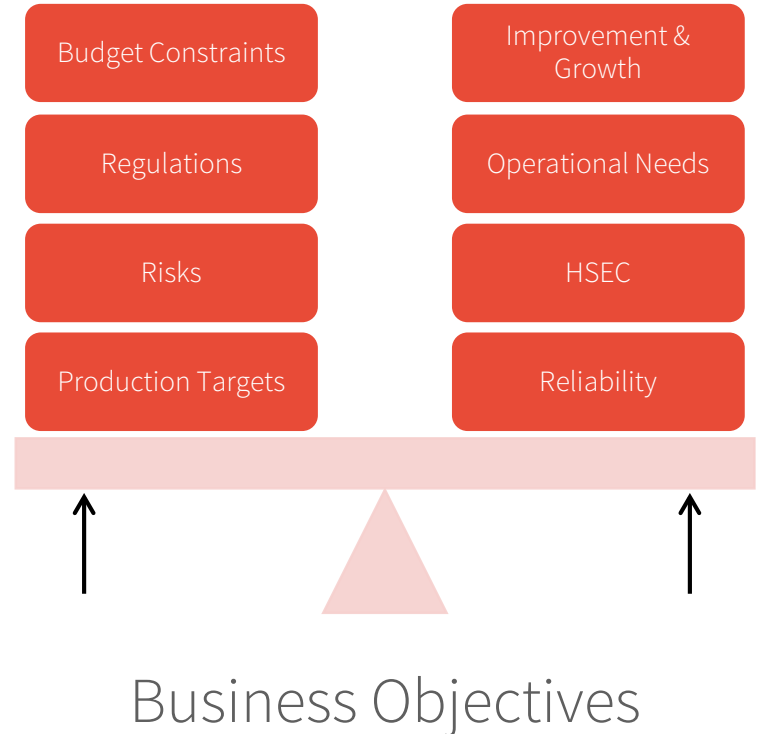
Néstor Deza, Asset Management Lead, Advisory Services

Agenda

- Asset Management
- Asset Management System
- Project & Operations Decision Making
- RAM Modelling
- Enabling Predictive Analytics

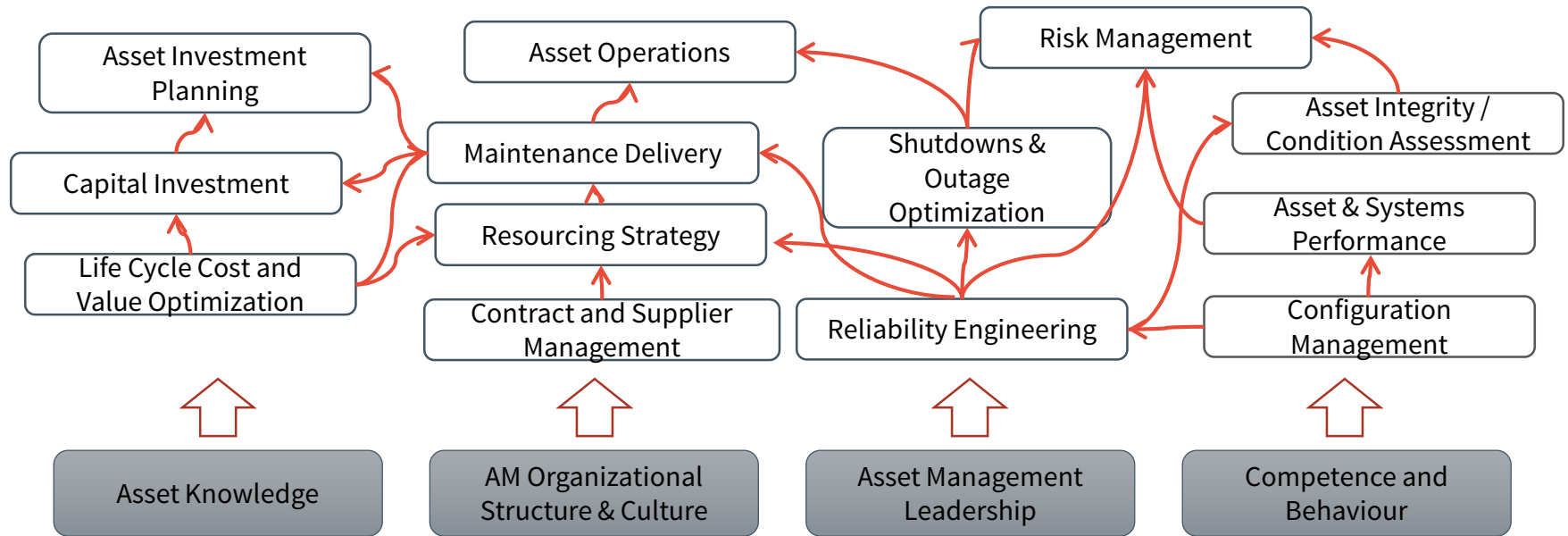
Asset Management

- Co-ordinated set of activities to realize the **full potential** from assets
- From design to construction and beyond – a **lifecycle approach**
- **Balancing business objectives** to ensure **success**



Asset Management System

Stakeholders



Project & Operations Decision Making

How can we answer questions important to project and operations stakeholders?

- How to achieve reliable production targets?
- How to reduce CapEx while keeping OpEx low?
- What is the right maintenance strategy?
- What is the right amount of people required to operate?
- What is the right amount of data to analyze?
- What vendor do I choose?
- Do I need to debottleneck the system?
- How can I improve safety?





RAM Modelling

What is RAM Modelling?

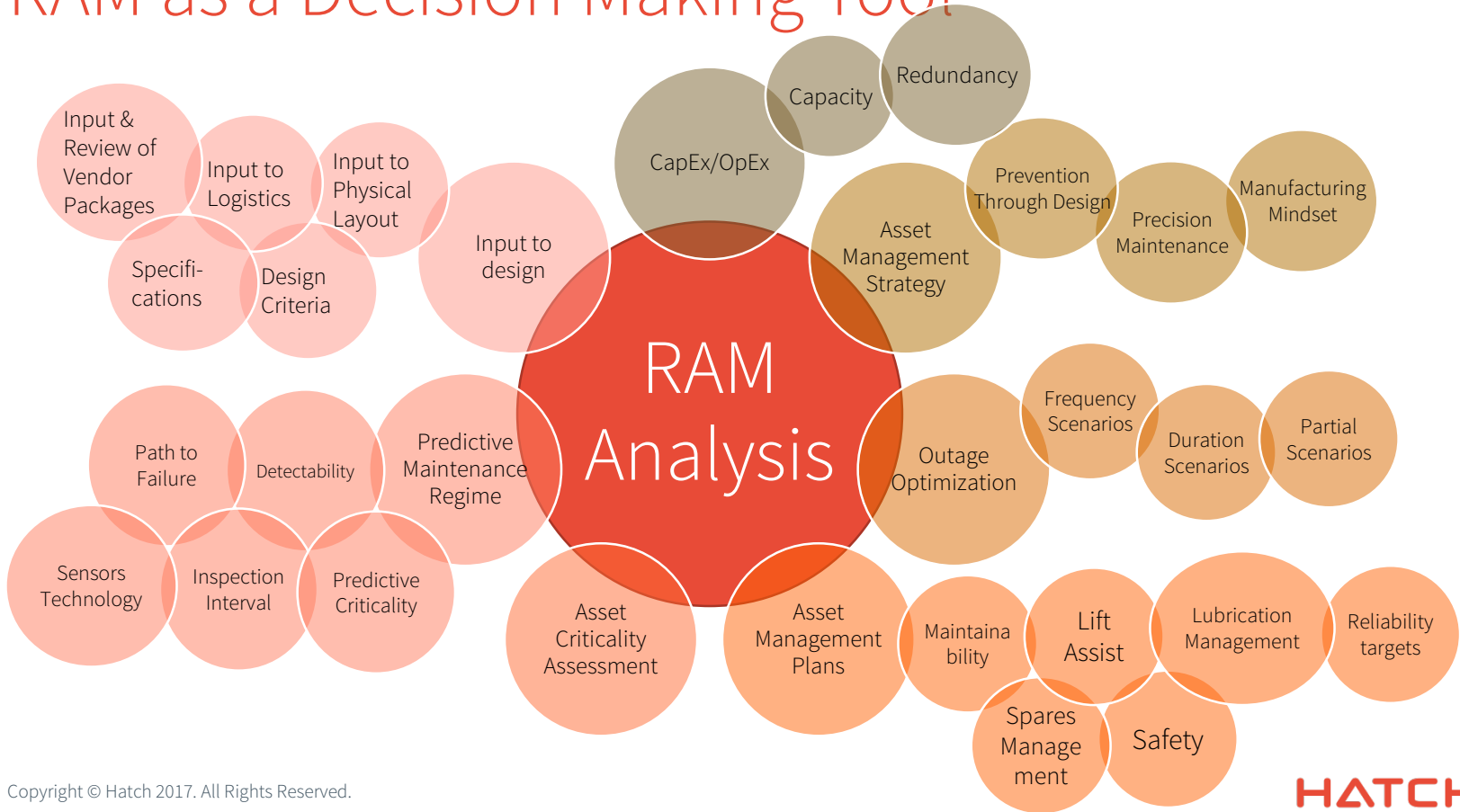
- RAM Modelling is an analytical methodology to:
 - Identify causes of significant losses of operational availability
 - Identify issues that may limit production throughput
 - Uncover improvements to design or maintenance strategy to meet project objectives

Reliability

Availability

Maintainability

RAM as a Decision Making Tool



RAM Model Input & Outputs

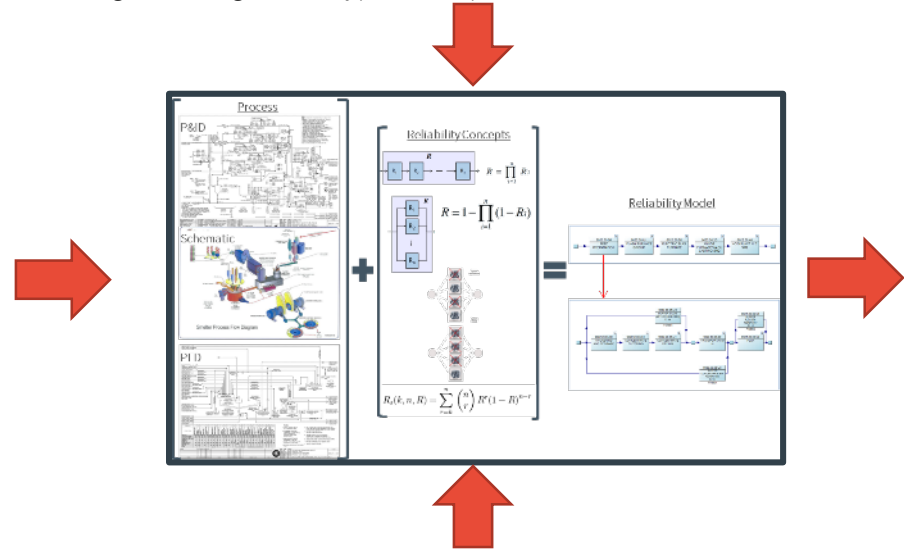
- Failure Modes**
- Unplanned MTTR
 - Planned MTTR
 - MTBF
 - Corrective Tasks
 - Failure pattern

- Inspection Strategy**
- Inspection Interval
 - PF
 - Detectability
 - CM method
 - Plant Shutdowns

- Logic**
- Operational Modes
 - Bypasses
 - Redundancy
 - Minimum capacity

Logics

- Basis of Assumptions, Functionality, Benchmark Information, Rules, Logics, Voting Rules, Bypasses, Operational modes



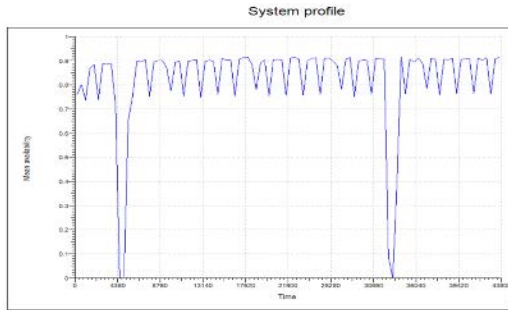
Governance

- RACI, Approval Matrix, Interfaces for data transfer, Team workflow, QA/QC, Simulation parameters

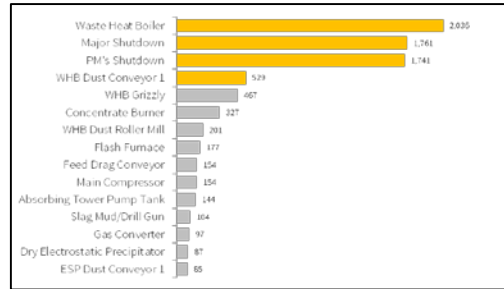
- Reliability**
- System, Area and Equipment MTTR
 - System, Area and Equipment MTBF
 - System, Area and Equipment Availability

- Indicators**
- Total Downtime Importance
 - Total Capacity Importance
 - Single point of failures

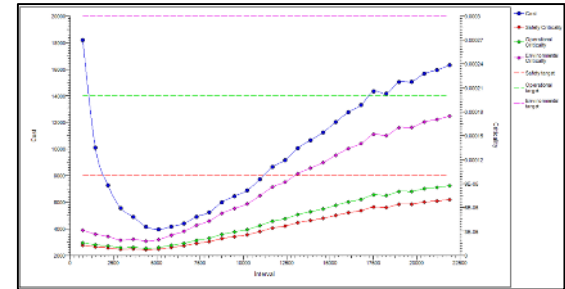
Results Analysis & Interpretations



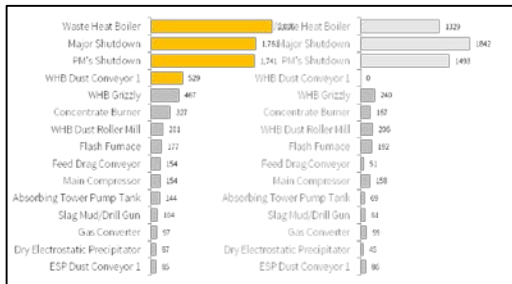
Availability Predictions



TCI & TDI



PM & Outage Optimization

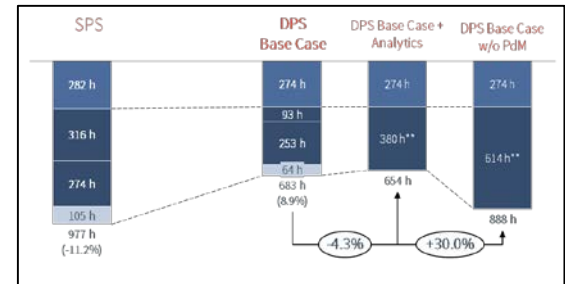


Scenario Comparison

Drill Down & Deep Dive Analysis

Equipment	SPS Model		DPS Results		& Downward SPI vs SPI with radio
	Availability	Downtime Hours / year	Availability	Downtime Hours / year	
Mining Equipment					
191113-MCAM-10001	97.70%	202	97.70%	202	
191122-CV-10003	95.70%	638	95.70%	638	
Underground Material Handling					
191970-CV-10002	99.84%	14	98.81%	184	62
171113-CV-10008	99.73%	27	98.17%	166	123
191112-CV-10006	99.93%	42	99.25%	100	58
191112-CV-10015	99.25%	66	99.28%	63	3
191112-CVTR-10015	99.93%	4	99.81%	17	13
191143-19M-10002	100.00%	0	99.98%	54	54
191179-19D-10003	99.89%	10	99.92%	7	3
191114-CV-10014	99.93%	7	99.87%	30	48
191113-CV-10002	99.28%	63	99.33%	58	-5
191113-19M-10003	100.00%	0	99.98%	2	2
191179-19D-10001	99.97%	1	99.94%	3	2
191163-CV-10011	99.87%	11	99.88%	55	44
Nonconventional Storage					
191144-CV-10028	Bypass Conveyor	99.52%	42		
191144-CV-10029	Delble Conveyor	99.46%	47		
191143-CV-10006	Horizontal Remote Storage Stacking Conveyor	99.91%	60		
191144-CV-10027	Horizontal Storage Reclaim Conveyor	99.32%	60		
191143-CV-10000	Horizontal Storage Supply Conveyor	99.32%	42		
191113-MCAM-10008	Reclaim Drive Motor	98.11%	186		
191123-CV-10006	Reclaim Conveyor Train	98.07%	197		

Drill Down & Deep Dive Analysis



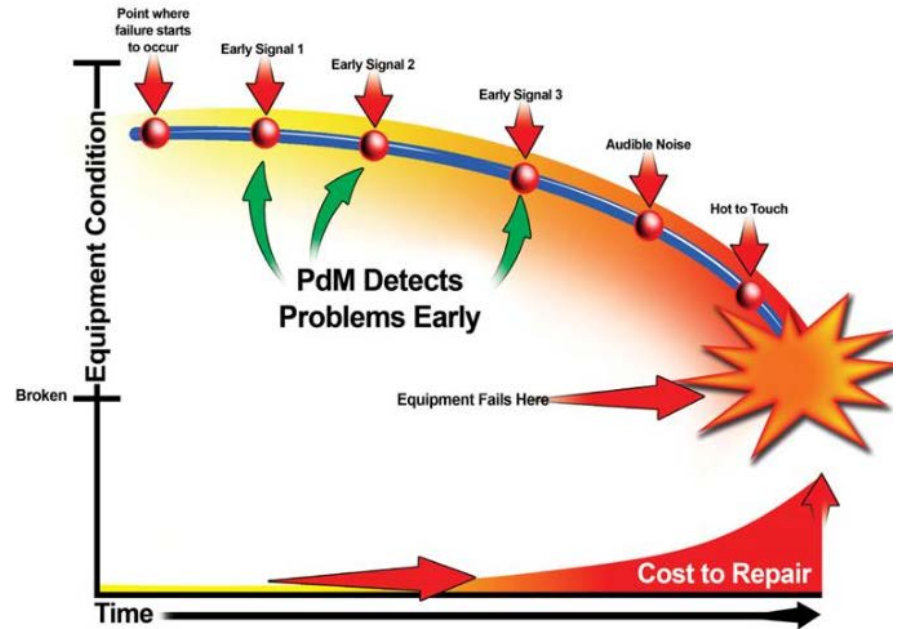
Waterfall along Design Progress



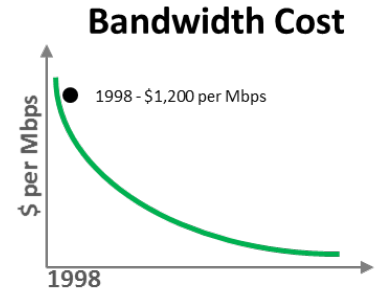
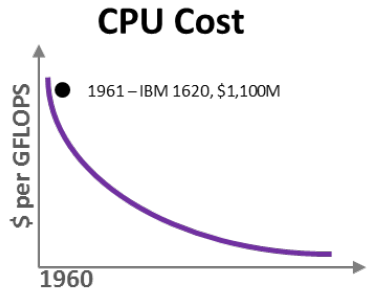
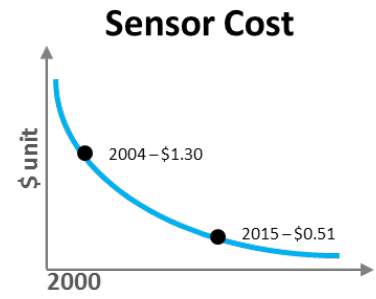
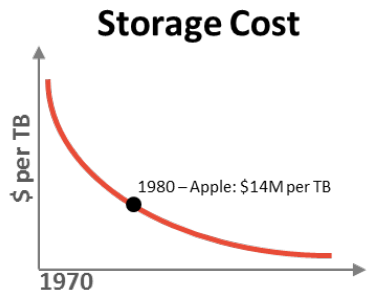
Enabling Predictive Analytics

Value of Predictive Maintenance

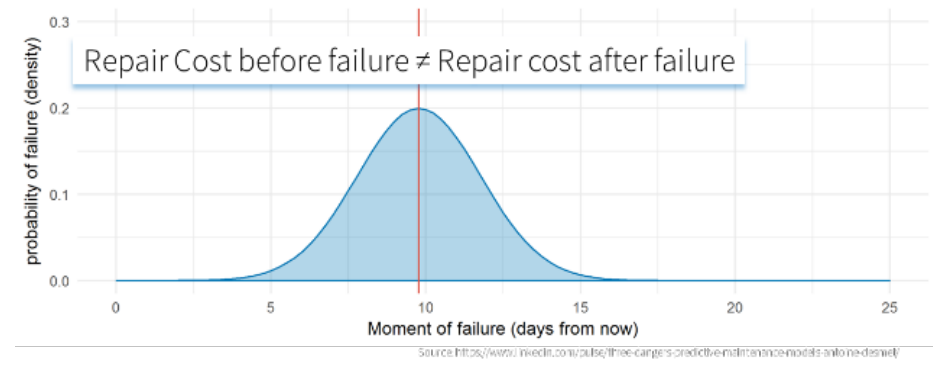
- It is not only about predicting failure
- Detecting for failure elimination before damage is irreversible
- Detecting for life extension until next scheduled shutdown
- Trending for RCA
- For changing operational modes to fulfil operational targets



Why is Predictive Maintenance gaining steam now?



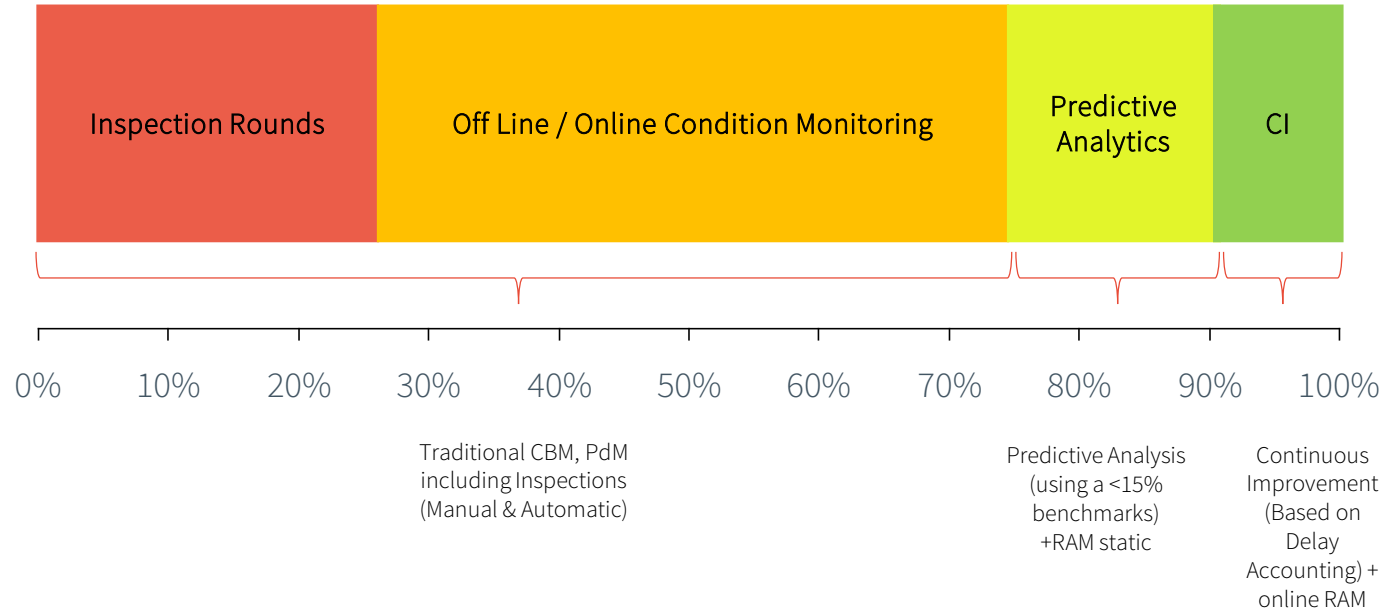
Adapted from: <http://radar.oreilly.com/2011/08/building-data-startups.html/>



Source: <http://www.movus.com.au>

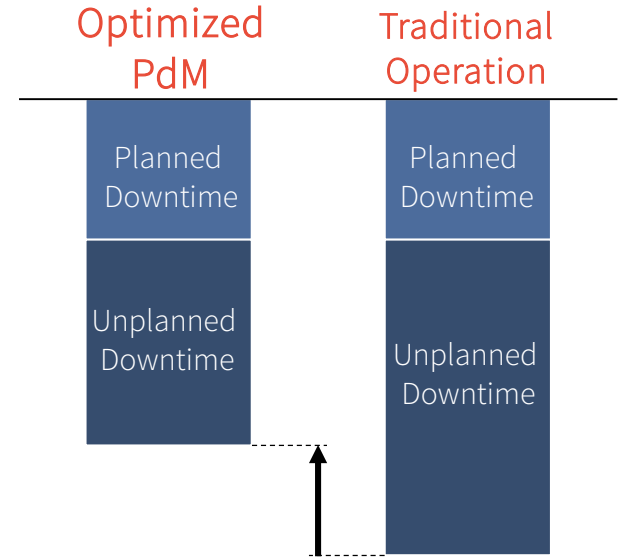


Detectability Opportunity Graph



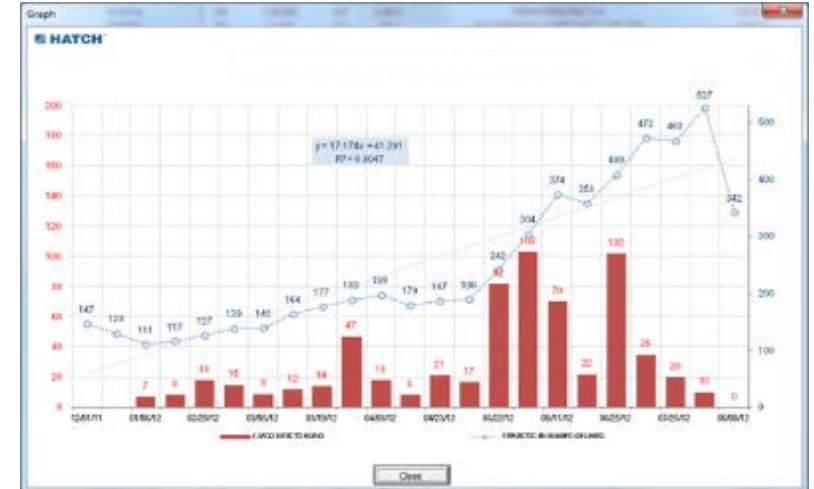
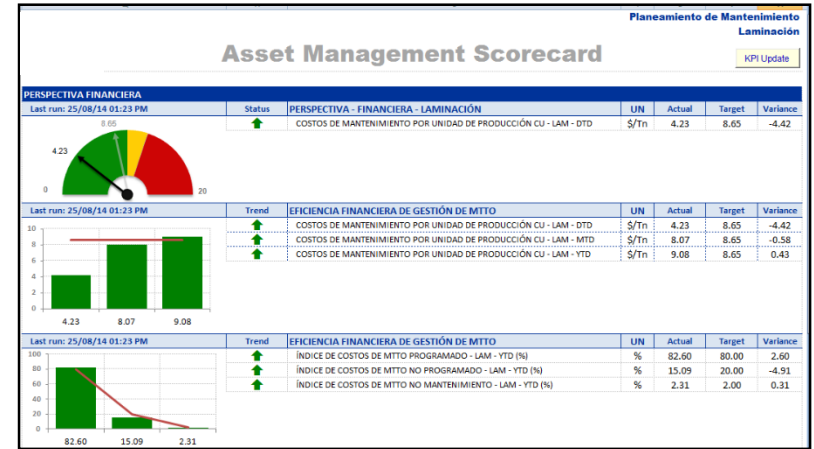
Connecting PdM and RAM

- Optimizing the PdM Regime allows for:
 - Greater detectability of the most critical failure modes in the RAM model
 - Advanced warning of the failures to allow for a planning and scheduling window
 - Decreased unavailability of the plant

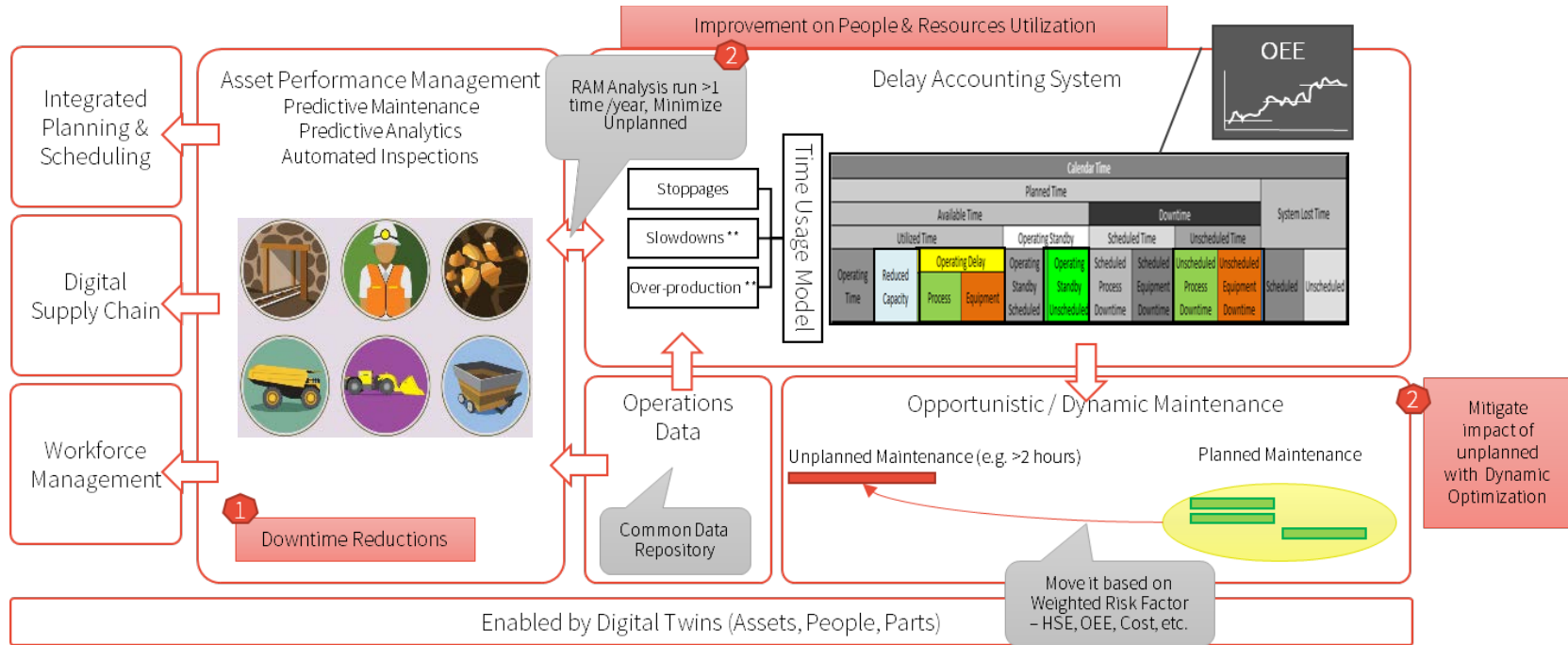


Unlocking Value During Operations

- Digital Twin's Asset Health Index with Specification
- Weighted formula based on PdM Recipe
- Augmented with Predictive Analytics for Estimated Days to Failure
- Online reliability trending



Asset Management becomes Digital Asset Management





Thank you.

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