Simulation & Optimization of a Bulk Material Mine-to-Ocean Supply Chain

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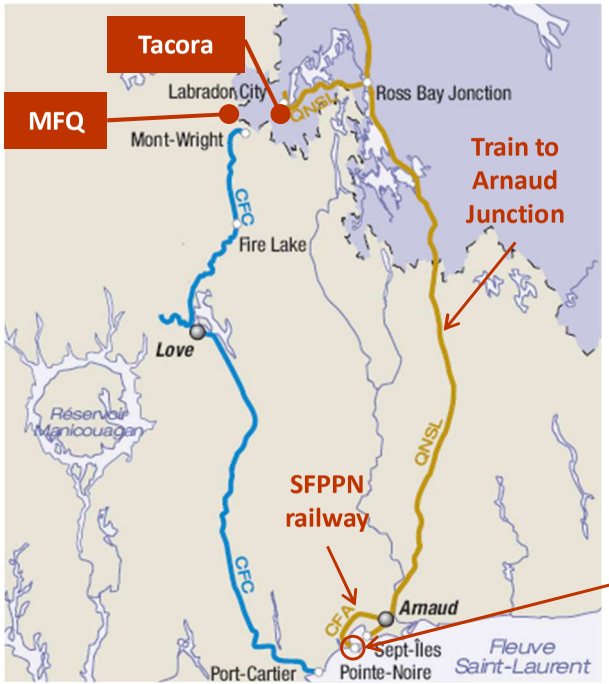
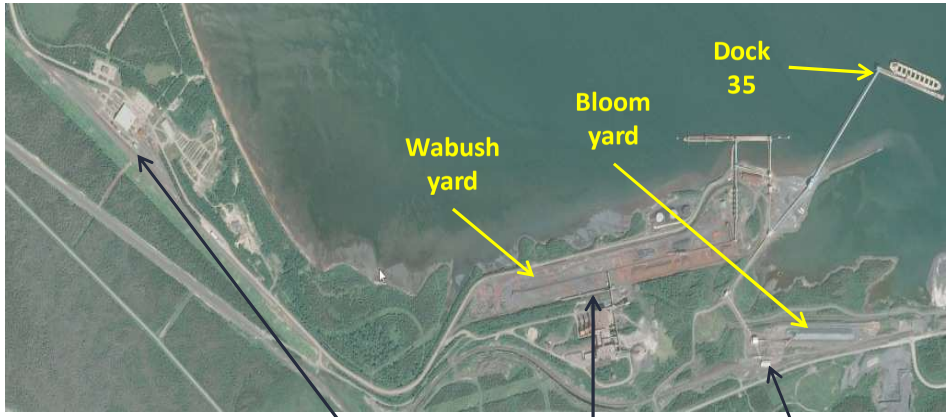
The mine-to-ocean value chain

- Iron ore from northern mines to be exported by ocean





Pointe-Noire Port Terminal (SFPPN)

The value chain stakeholders

- Mining companies
  - Champion Ore (MFQ): **doubling** ore exportations
  - Tacora (formerly Wabush) : stable exportations
- Railways transit
  - QNS&L: from the mines to Arnaud Junction (North of Sept-Iles)
  - SFPPN: from Arnaud Junction to the Pointe-Noire port
- Terminal operator
  - SFPPN: train unloading, yards management, material handling
- Port authority
  - Port of Sept-Iles: shiploading and marine operations

Long history of iron ore mining in Quebec and Labrador…

Between the mines and the Atlantic ocean: a lot of puck passes!

Port expansion plans

Install a new stacker-reclaimer

Use the full Wabush yard capacity
+
Stack and reclaim all products/clients in Wabush yard

Fix mechanical issues on Dock 35 (Port of Sept-Iles)

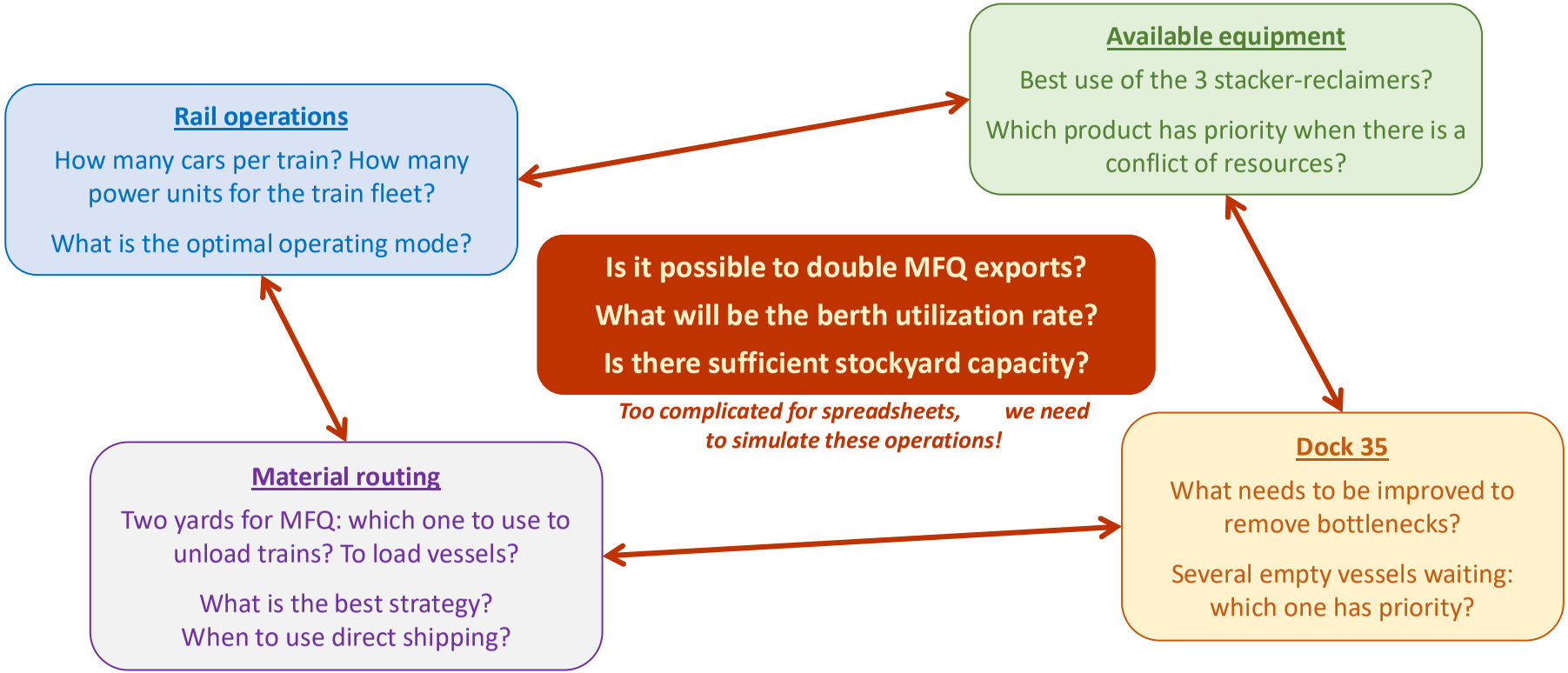
Add a connexion to Wabush yard

Increase Bloom yard capacity

Impacts on marine operations

- Actual Dock 35 yearly clientele
  - Approx. 80 vessels, more than 95% are Cape Size
  - Berth utilization rate around 60%
    - Quick math : overall GLR is around 2,800 tph
- Future Dock 35 yearly clientele
  - Approx. 150 vessels, 80% in Cape Size, 20% in Panamax
  - Berth utilization = ???
    - Assume maximum livable berth utilization of 75%
    - Quick math: GLR will have to be at least 4,200 tph!!!
- Important infrastructure and logistic changes are required

Decision-making challenges



Interlude:
Discrete Event Simulation

Event-based modelling

Model systems which change states at discrete points in time as a result of specific events

Examples of EVENTS

- Order/part arrivals
- Product movement
- Machine process start/finish
- Machine breakdown/repair

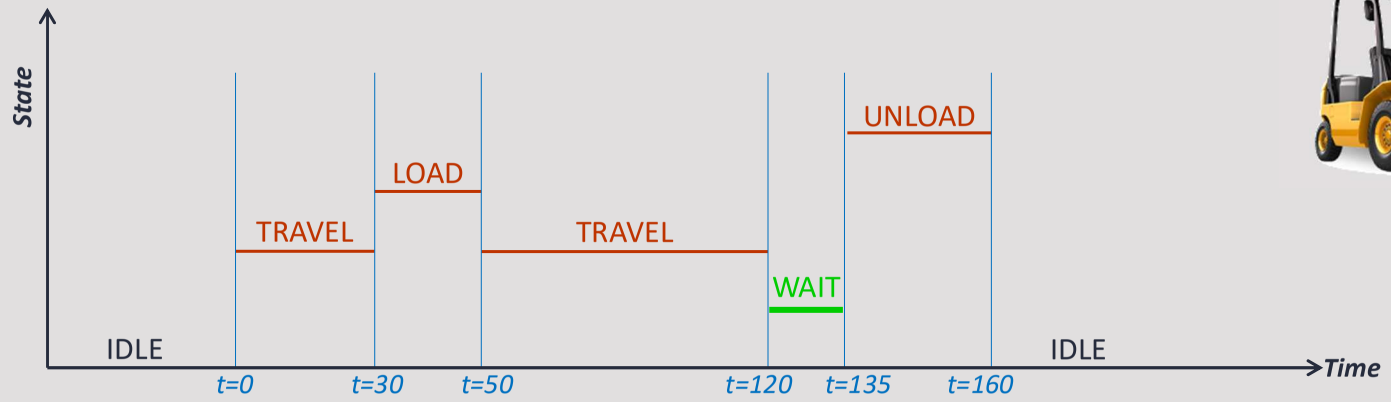
Examples of STATES

- Machines: idle, setup, processing, down
- Queues: empty, full
- Operators: on-shift, off-shift, utilized, idle
- Transports: travelling, loading, unloading

Simulation QUEUE and CLOCK

- Event execution and state updating triggers future events
- All events are put in a time-sorted queue
- The simulator jumps to the next timed event and executes it

Example: moving a box



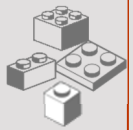
Box to be moved! → Call a forklift → Drop zone is overcrowded → Box delivered + Forklift freed

Model building blocks

Most event-based models are built using these blocks!

VARIABILITY

- ≡ Probability distributions
- ≡ Delays and rates
- ≡ Uncertainty tolerances



MANAGEMENT

- ≡ Scheduler
- ≡ Dispatcher/regulator
- ≡ Assets tracking
- ≡ Performance monitoring

DELAY

- ≡ Cycle time
- ≡ Time to failure
- ≡ Repair time

RATE

- ≡ Vehicle speed
- ≡ Bulk/liquid flow
- ≡ Items arrival

WAIT

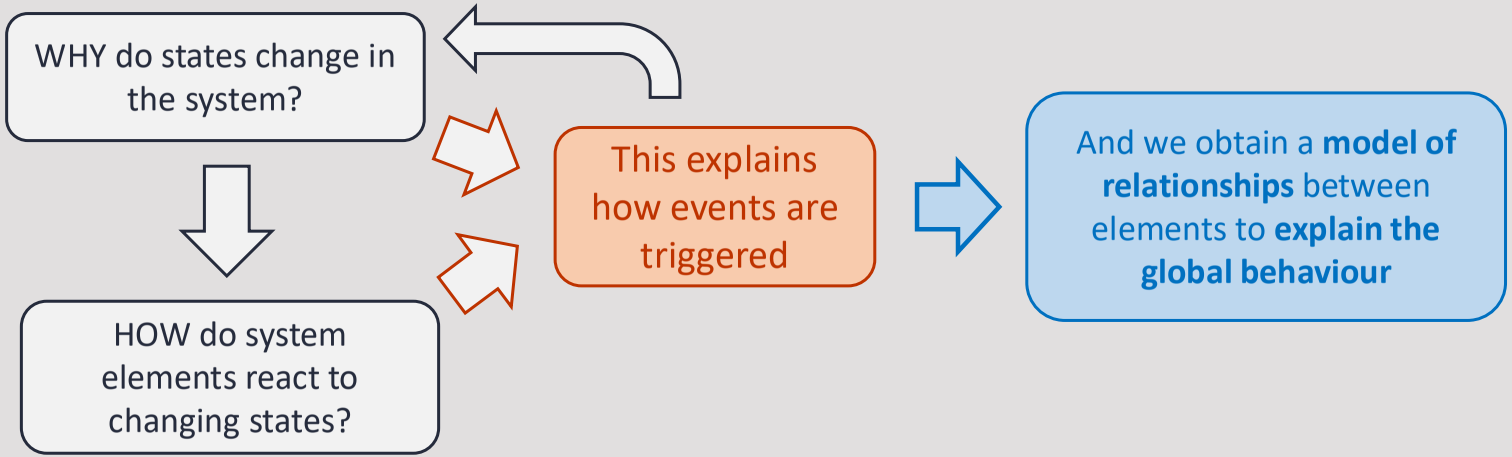
- ≡ Queue (FIFO)
- ≡ Stack (LIFO)
- ≡ Priority pick

INVENTORY

- ≡ Items storage
- ≡ Parts buffer
- ≡ Tank/silo

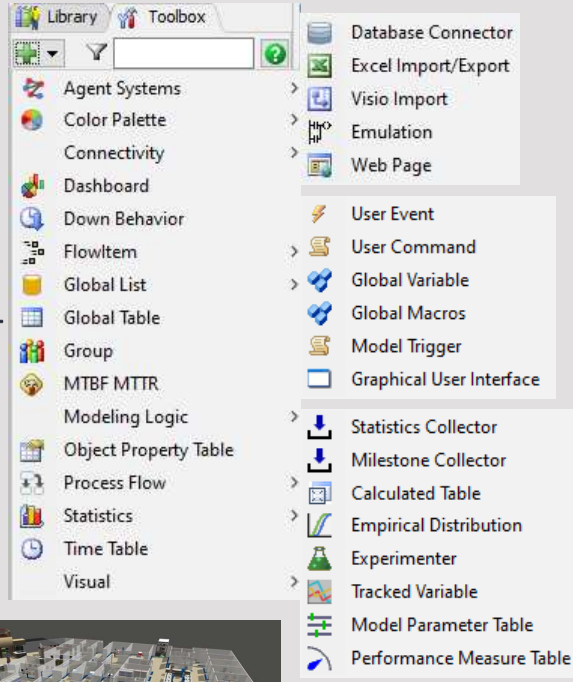
What happens, why and when?

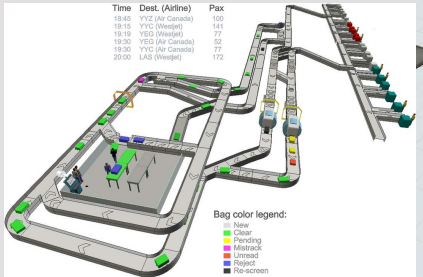
Fundamentally, event-based modelling is about understanding interactions and their root causes

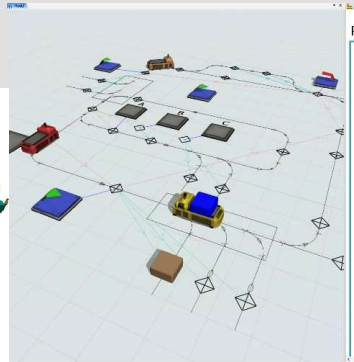


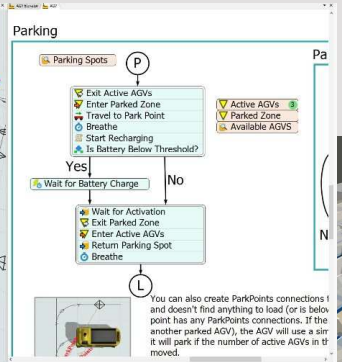
The Flexsim simulation software

- Powerful 3D interactive object-oriented environment
- Several built-in object libraries usable off-the-shelf
- Open architecture and user modules: develop and reuse your own libraries
- Interoperability with known technologies : Excel, local/remote SQL databases, CAD drawings, PLC, etc.
- Comprehensive toolbox to quickly develop models





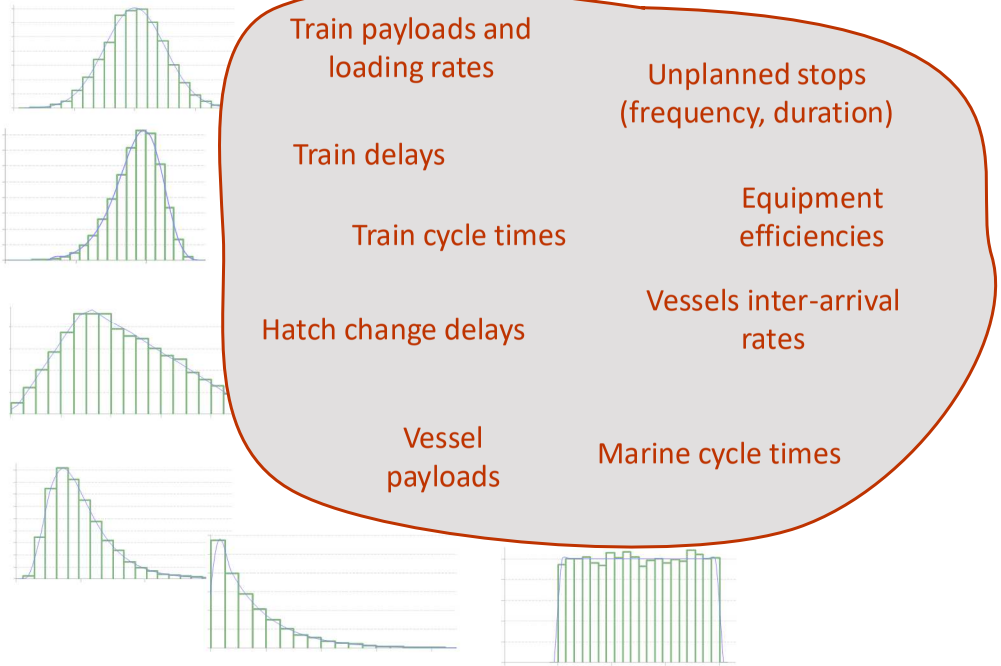




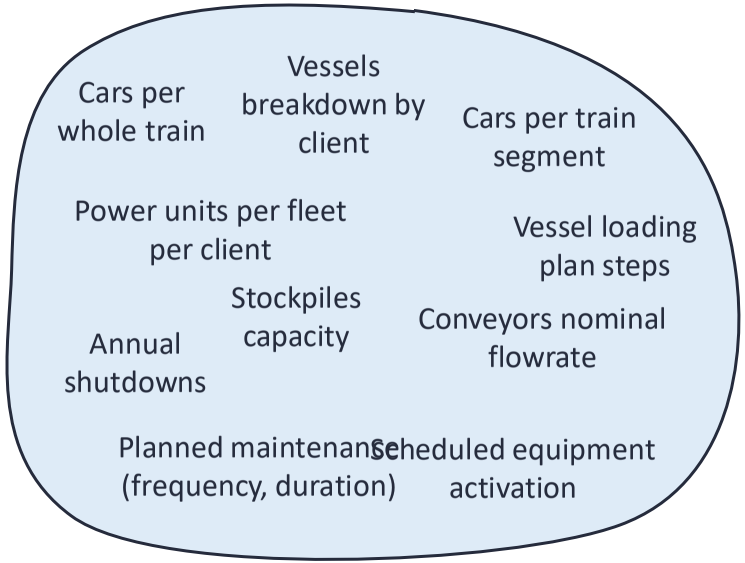
Back to main program: The simulation model

Input parameters (in Excel)

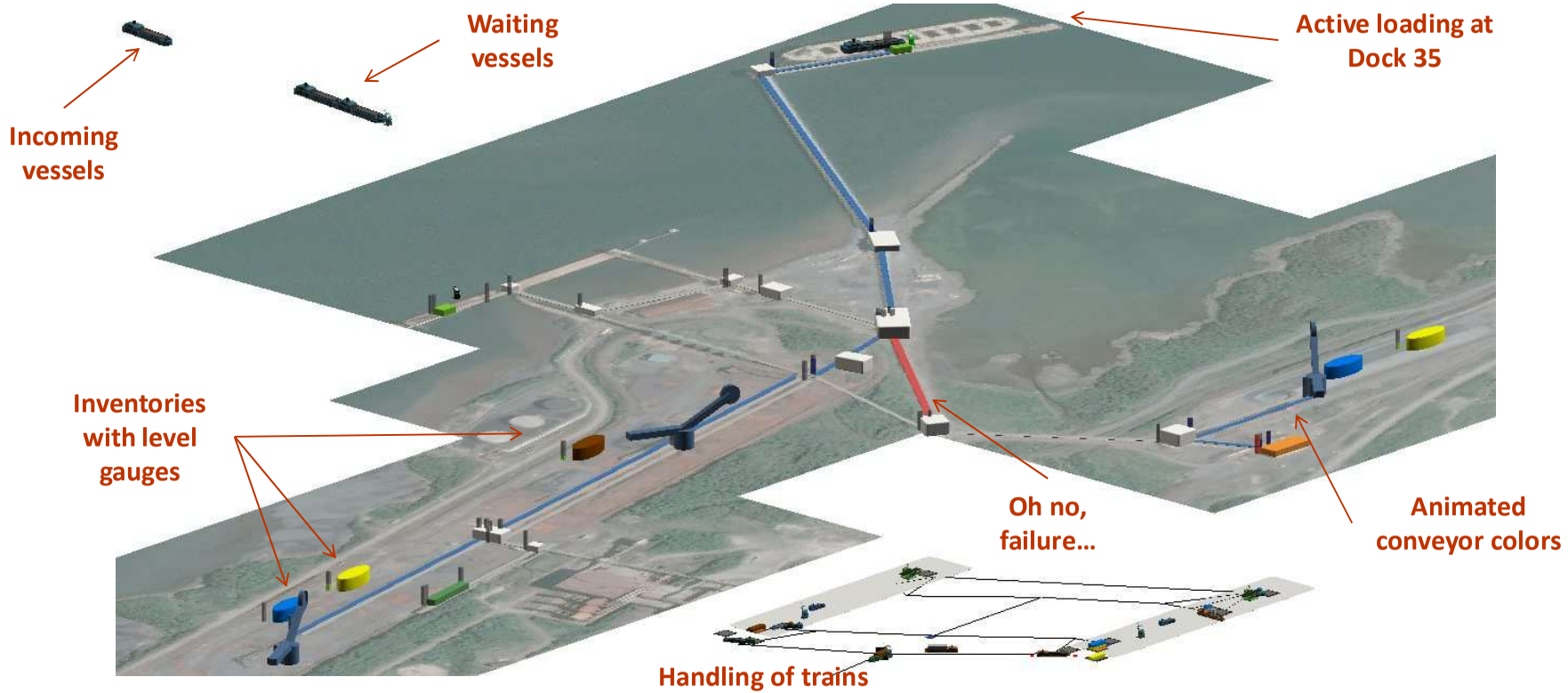
STATISTICAL DISTRIBUTIONS FROM HISTORICAL DATA



CONFIGURABLE PARAMETERS (TO BE OPTIMIZED)



Model implementation



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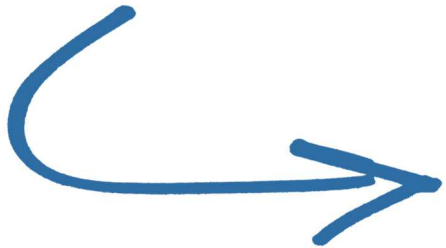


Model outputs (exported to Excel)

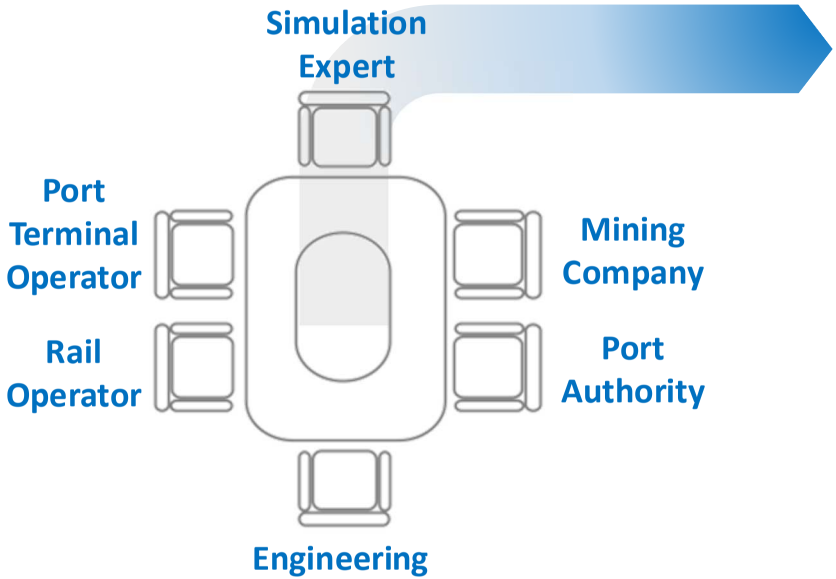
- Utilization rates with breakdowns
  - Idle, operating, full, waiting, etc.
  - For: berths, car dumpers, conveyors, stackers-reclaimers, trains
- Daily trends, end-of-day readings
  - Stockpile levels
  - Processed material (dumpers, shiploaders)
- Summary stats (mean, stdev, etc.) and histograms
  - Gross Loading Rates!
  - Number of vessels waiting in the bay
  - Waiting time in the bay, loading times, etc.
  - Train round trips and unloading durations

Processed outputs for easier interpretation…

Analyzing performance and bottlenecks is made easy!

Decision-making using simulation

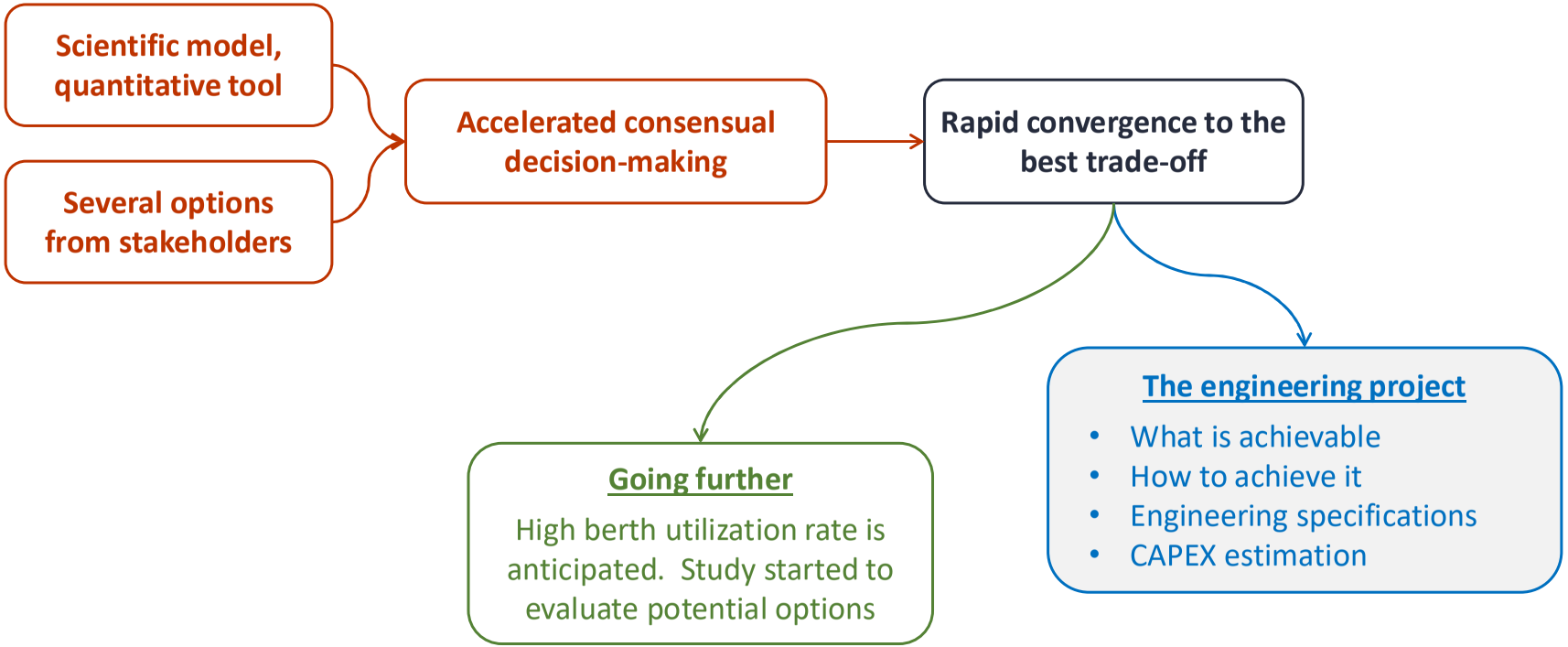
Trade-off study – now it's possible!



- Find the economical stockpiles capacity
- Try and improve routing strategies
- Experiment train configurations
- Test train operating modes
- Verify if conveyor speeds are adequate

- Estimate the berth utilization rate
- Calculate the future GLR
- Obtain the ultimate throughput

Now we have an engineering project!



In conclusion

- Increasing the throughput of a bulk material supply chain:
  - Several stakeholders may have their own agendas and expectations
  - Estimating the throughput of a system that dynamically evolves is far too complex for spreadsheets
    - Selecting the adequate new equipment specs depends on the operating modes and strategies
    - Selecting the best operating modes and strategies depends on the new equipment… egg and chicken!
- Simulation helps on all these aspects!
  - Evaluation and optimization of complex systems
  - Consensual and quantitative team decision-making
  - Everyone's best idea can be tested!

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