



Integrated Logistics Simulation

Determining what is achievable for your system

When 'averages' will not suffice



Our aim is to improve the quality of decisions, identify bottlenecks and assist with investment strategy. We do this by providing quantitative decision support and systems analysis through discrete event simulation. This technology is used to build virtual integrated (operations and logistics) models that consider all physical intermodal processes to measure the actions, effects and responses within a system. This is used to validate design, assess sensitivities, and quantify operational risk to project - not just local risks to each process, but all interconnected risks through the logistics chain. Particular focus is given to ensuring that disruption shock does not impede the ability to deliver target quantities (to market or elsewhere), both in the short term and long-term, ensuring that maximum NPV is realisable.

Our quantified recommendations have positively impacted client operational design to the order of tens of millions of dollars.

Our services have been applied to:

- Supply chain logistics and capacity verification
 - Mining pit to port distribution systems
 - LNG / UCG well to wire supply chains
 - Fuel and material distribution
- Project cost and time risk assessments
 - Construction and modular delivery scheduling
 - Resource development planning
 - FIFO planning
- Detailed processes
 - Detailed mine processing
 - LNG train production
 - Industrial process plants
 - Operational efficiency modelling
- Detailed port assessments
 - Large multi-model port interactions (import, export, container & bulk materials)
- Water networks
 - Storage requirements
 - System capacity/constraints
- Sustainability / EcoNomics™
 - Predictive carbon footprint assessments
 - Inputs for 'physical' components of studies

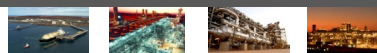
Value is provided through:

- Identification of low cost solutions for saving CAPEX and OPEX while increasing throughput
- Pinpointing precisely which components require upgrading to minimize the cost of improving performance
- Identification and quantification of opportunities to improve the management of available resources, revenue versus expenditure over time, and system flexibility in terms of ramp up and expansion
- Assistance in the formulation of asset management frameworks
- Provision of certainty for developers, owners, operators, users, and financiers, that systems will meet design specification and generate target revenue

Any describable process can be modelled by our team to assess for risk, reliability and capacity.

For further information please contact:

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Project Examples – LNG Logistics Chains

Project: Browse Pre-FEED Supply Chain Studies

Customer: Woodside Petroleum

Phases: IDENTIFY EVALUATE DEFINE EXECUTE OPERATE

WA, Australia

IMPACT:

- Validation / optimisation of engineering, storage and operations
- Quantified and mitigated key risks to throughput and capacity, e.g. cyclone response
- Examples of value impacts:
 - Design storage specifications limiting throughput
 - Cyclone events near site causing 2.3% of production/export loss for 15 Mtpa LNG trains
 - For defined operations and maintenance, end-market impacts throughput by up to 5%
 - 1% difference in Berth operability impact LNG throughput value by \$250m pa

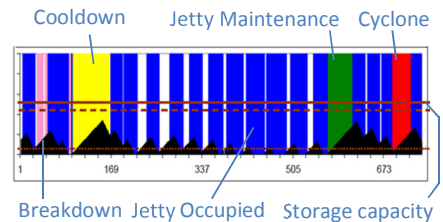
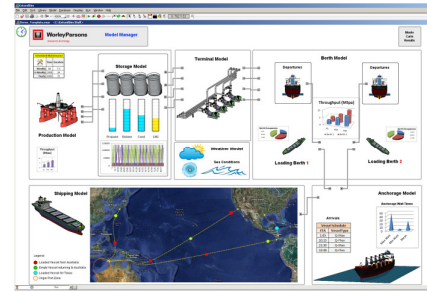
COVERAGE:

WorleyParsons completed a range of supply chain assessments for production, shipping fleet and onshore storage requirements for a new LNG facility. Scope of work extended from submarine pipelines from well-heads to destination ports. To integrate the physical variability that could occur over time the following types of variations were considered:

- Environment – e.g. tides, cyclones, berth operability
- Engineering – e.g. HYSYS process data, fluid dependant flow rates
- Operations – e.g. scheduled maintenance, breakdowns, utilisation targets
- Logistics – e.g. market demand, 3rd party disruption, fleet availability

PREDICTIVE PERFORMANCE EXAMPLE:

The 'shipping steam' plot (right) maps port storage against various operational impacts such as ship loading, LNG train operation, port maintenance, operational downtime, and sea state severity over time. This can be done for any metric, over any defined period (e.g. 10 years) for any number of runs (e.g. 1,000) to obtain confidence on performance, costs, etc.



Project: Singapore Re-Gas Facility – Storage and Shipping

Customer: Singapore Government

Phases: IDENTIFY EVALUATE DEFINE EXECUTE OPERATE

Singapore

IMPACT:

- Validation / optimisation of engineering, storage and operations
- Identified optimal fleet sizes
- Quantified the impact of risks to supply

COVERAGE

A study was undertaken to assess and validate the required LNG storage capacity to ensure adequate supply to domestic power markets. This also required an understanding of the balance between inbound and outbound LNG product to maintain a constant supply to the network. The scenarios examined were 1, 3 and 6 Mtpa supply throughput expansion cases.

The modelling was carried out by developing a representative port, LNG storage and regasification model. A supply fleet of LNG tankers, a supply route from an earmarked gas production hub and the potential impact of severe weather along the route were considered. These factors, in conjunction with operational uncertainties and delays were used to account for unscheduled events.



Background

The resource supply chain is subject to shocks and disruption due to both planned and unplanned impacts, including equipment outages, weather events and shipping constraints. Poor decision making on equipment selection, storage sizes or distribution method can slow the overall throughput and threaten delivery targets and long term contracts.

While traditional discipline-based engineering is generally adequate for the design of individual operations in a supply chain, many whole-project models tend to make overly simplistic assumptions and do not account for the interconnectedness of the systems or the uncertainty around disrupting influences on production, giving a false impression of the supply chain / system capacity. DES models developed by WorleyParsons enable the true capacity and resilience of a supply chain to be assessed. For example, for a development that relies on monsoonal rains to enable module transportation upriver to site, what is the best contingent action to take if those rains do not occur?



Project Examples – Pit to Port Supply Chains

Project: Tonkolili Iron Ore Project DFS

Customer: African Minerals Limited

Phases: IDENTIFY → EVALUATE → DEFINE → EXECUTE → OPERATE

IMPACT:

- Validation / optimisation of engineering, storage and operations
- Quantified and mitigated key risks to throughput and capacity, e.g. processing bottlenecks
- Examples of value impacts:
 - Design storage & maintenance specifications limiting throughput
 - \$37m at mine and rail
 - \$1.5m at port stockyard (reduced footprint)
 - \$100m for dredging in channel (optimized shipping)

COVERAGE:

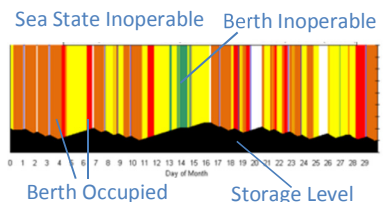
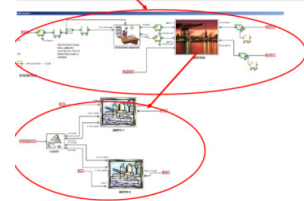
Developed complete pit-to-port model inclusive of mine processing operations and stockpiling, single line rail network (for supply and export), port landside (car dumper, stockpiling, etc), and port marine (shiploading/unloading, inbound/outbound movement to anchorage etc). The model was calibrated to engineering and operational design specifications and real environmental conditions. To integrate the physical variability that could occur over time the following types of variations were considered:

- Environment – e.g. tides, cyclones, berth operability
- Engineering – e.g. METSIM process data, material grade dependant flow rates
- Operations – e.g. scheduled maintenance, breakdowns, utilisation targets
- Logistics – e.g. market demand, 3rd party disruption, fleet availability

PREDICTIVE PERFORMANCE EXAMPLE:

The 'shipping steam' plot (right) to the right maps port storage against various operational impacts, such as ship loading, port maintenance, operational downtime, and sea state severity over time. This can be done for any metric, over any defined period (e.g. 10 years) for any number of runs (e.g. 1,000) to obtain confidence on performance, costs, etc.

Sierra Leone, West Africa



Project: Matthew's Ridge Transportation Scoping Study – Transshipping Options

Customer: Reunion Manganese

Phases: IDENTIFY → EVALUATE → DEFINE → EXECUTE → OPERATE

IMPACT:

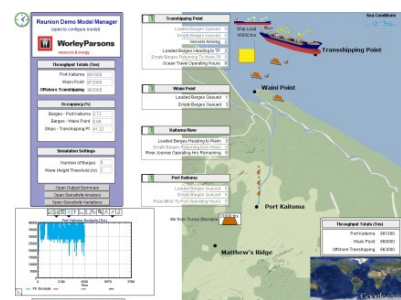
- Validation / optimisation of engineering, storage and operations
- Identified optimal fleet sizes
- Multi-million dollar savings identified for dredging and navigation aid investment requirements

COVERAGE

Following a scoping study which identified a range of transportation options, high level pit-to-port models, involving transshipping options were simulated. The purpose was to address critical strategic questions, such as dredging requirements (both in the transporting river and near shore), the need for navigation aids for night time barging, barge and tug fleet size requirements. In addition to addressing these questions, assessing a range of trade growth scenarios, the simulation identified a range of further questions to address such as potential constraints, mode of ship loading, and type of carrier to be contracted.

Future stages of assessment will consider the land transportation options, mine face logistics and the use of staging ports along the coast.

Guyana, South America



Project: Containerised Transport of Bulk Commodities (Esperance and Fremantle Supply Chains)

Customer: Confidential

Phases: IDENTIFY → EVALUATE → DEFINE → EXECUTE → OPERATE

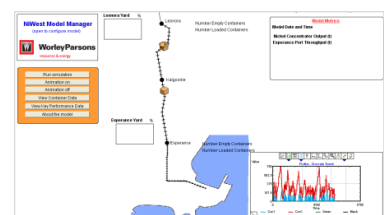
IMPACT:

- De-bottlenecking and expansion solutions tailored for minimal capex
- Full capex and opex costings for proposed solutions

COVERAGE

Assessment of nickel concentrate export through two supply networks including shipping to Xingang, China: 1) ore transported to Esperance using half-height containers for loading into bulk carriers; 2) ore transported in standard 20' containers to Fremantle container terminal, via Kewdale intermodal facility. A runtime interface was produced to allow clients perform their own scenario analysis.

South-West, Australia





Project Examples – Process, Operations & Storage

Project: Weld Range BFS Mine Processing & Materials Transportation

Customer: SinoSteel

Phases: IDENTIFY > EVALUATE > DEFINE > EXECUTE > OPERATE

WA, Australia

IMPACT:

- Validation / optimisation of engineering, storage, crushing and screening operations
- Quantified and mitigated key risks to throughput and capacity, e.g. processing bottlenecks
- Examples of value impacts:
 - Significant potential reductions in train load out stockpile footprints
 - Synchronisation of maintenance to reduce surge requirements & equipment redundancy

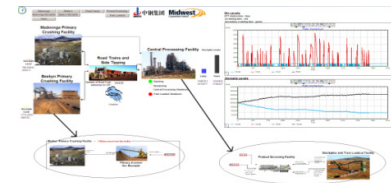
COVERAGE:

The scope encapsulated consideration of the processing of variable grade ore from multiple primary crushing facilities, material transportation ore via road trains to a central processing plant for additional processing inclusive of secondary crushing screening and stockpiling, followed by reclamation to train load out. Included consideration of associated conveyor systems. The model was calibrated to engineering and operational design specifications and environmental conditions. To integrate the physical variability that could occur over time the following types of variations were considered:

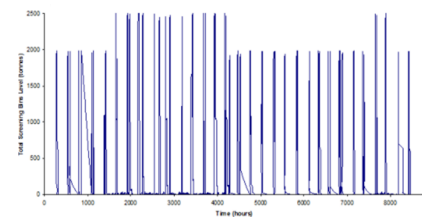
- Environment – e.g. inclement wind & rainfall, cyclones
- Engineering – e.g. METSIM process data, material grade dependant flow rates
- Operations – e.g. scheduled maintenance, breakdowns, utilisation targets
- Logistics – e.g. market demand, 3rd party disruption, fleet availability

STATISTICAL CONFIDENCE:

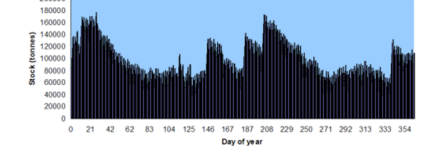
The bin and stockpile plots to the right maps levels, as they vary with operations (e.g. build up in bins due to equipment stoppage), over one year. To obtain statistical confidence over the likely operational levels over the long term this is repeated and measured hundreds of times. This can be done for any metric, over any defined period (e.g. 10 years) for any number of runs (e.g. 1,000) to obtain confidence on performance, costs, etc.



Screening Bin Levels



TLO Stockpile Levels



Project: Shondoni Mine Coal Conveyor Chain

Customer: Sasol Mining (Pty) Limited

Phases: IDENTIFY > EVALUATE > DEFINE > EXECUTE > OPERATE

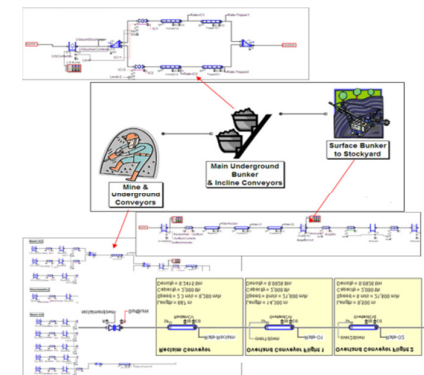
Secunda, South Africa

IMPACT:

- Validated mine production capacity and minimum acceptable underground bunker capacity
- Validation / optimisation of engineering, storage and operations
- Determined optimal shuttle car numbers and utilisation
- Identified smaller permissible incline conveyor rate
- Benchmarked to maximum production loss of 0.5%

COVERAGE

The scope of the analysis was from the mine, where a number of mining sections converged to a main underground bunker, transfer of coal to the surface and along a chain of conveyors (including bunkers and stockpiles) to a stockyard. Feed from the Ithemba Lethu mine was also considered to be combined with Shondoni product. In addition to the above points the study also pinpointed potential bottleneck locations (and provided solutions, such as quantifying post shift run-on allowances), identified the potential to reduce stockpile sizes and demonstrated the impact of marginally increasing stacking and reclaiming rates for improved operational efficiency and reduced bottlenecking.



Project: Christmas Creek Stockyard and Train Load Out – Expansion Study

Customer: Fortescue metals

Phases: IDENTIFY > EVALUATE > DEFINE > EXECUTE > OPERATE

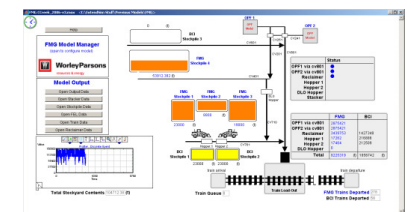
WA, Australia

IMPACT:

- Optimisation of train loading time, stockpile operations and maintenance planning
- Optimized target utilisations of different feed methods and identified the conditions of best use

COVERAGE

Production profiles for ore output from the Ore Processing Facility feeding the stockpiling and train load-out circuits were modelled, with detailed consideration of daily operations and unscheduled interruptions. Additional to the study analysis produced, a runtime model was generated and provided to the client for further sensitivity analysis and asset management planning.





Project Examples – Development Logistics

Project: Coal Seam Gas Well Development Options

Customer: Arrow Energy

Phases: IDENTIFY > EVALUATE > DEFINE > EXECUTE > OPERATE

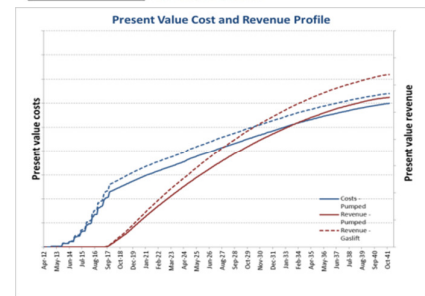
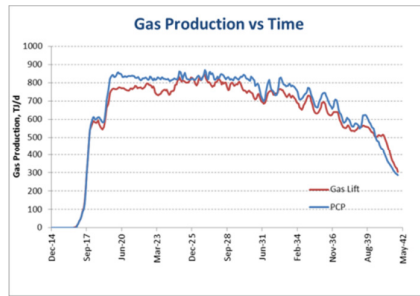
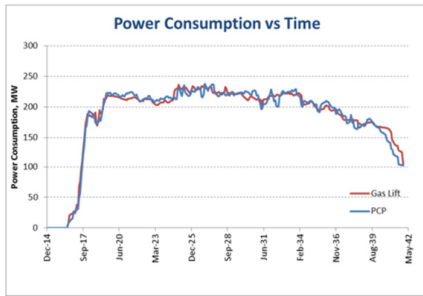
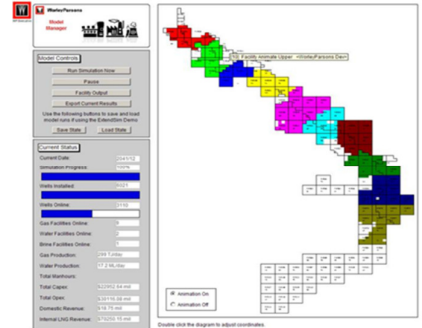
QLD, Australia

IMPACT:

- Identification of lowest cost development routes
- Quantified risks to delivery timeframe and determined contingent actions
- Quantified potential cost over-runs, periods of likely labour shortages and contingencies to mitigate

COVERAGE:

WorleyParsons examined development sequence options for extraction of gas from up to 6,000 well heads in the Bowen and Surat basins. The study considered cumulative supply of gas, material requirements for construction, manhours for construction, coordination between regular surface and subsurface engagement, and timing. Financial models were imbedded in the simulation so that the cost of each development option could also be determined.



Project: Pluto Module Construction and Delivery Risk

Customer: Woodside Petroleum

Phases: IDENTIFY > EVALUATE > DEFINE > EXECUTE > OPERATE

WA, Australia

IMPACT:

- Validation / optimisation of proposed construction & delivery time frame
- Quantified risks to delivery timeframe and determined contingent actions
- Quantified potential cost over-runs and contingencies to mitigate

COVERAGE:

A simulation model was developed to assess risks and validate assumptions pertaining to shipping schedules and modularisation/construction schedules for the Pluto LNG project. The simulation model included relevant aspects of the Heavy Load Out (HLO) operation for the transportation of LNG Train modules from the Port of Laem Chabang in Thailand to the Port of Dampier in Western Australia. Variability, such as shipping availability, construction and transportation time, were considered for every component of the logistics chain. Of particular relevance was seasonal variability and the influence of cyclones.

The model predicted on cost, schedule and associated risks based on the design, fabrication, transportation, installation, commissioning data available, whilst also accounting for unscheduled interruptions.

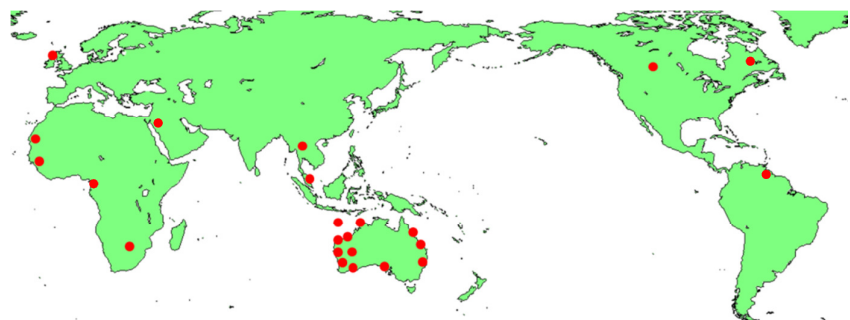


Global Experience

Since 2002 the DS team has worked on over 30 projects around the world, relating to LNG, Petroleum, food commodities, alumina, nickel, coal and iron ore. The team's experience also encompasses third party reviews and project management.

For further information please contact:

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Every Project Lifecycle

Our logistics and systems analysis can be utilized by customers embarking on any or all phases of a project. We understand that project developments involve a myriad of technical and nontechnical challenges. Expansive worksites require innovative resource and logistics planning, and consideration of key yard equipment sourcing is needed to minimise lead-times that can impact schedule outcomes and time to market for commodity sales. WorleyParsons responds to these challenges by deploying our project advisory and engineering consultants to analyse a range of feasible project solutions, and select for development that offering optimum value.

We apply our core engineering expertise in commodity processing, materials handling, transport and ports to define and onward detail the concept. By further augmenting these with project enabling capabilities, such as Integrated Logistics Simulation and approvals management, we provide a foundation for unrivalled delivery assurance and performance.

Below we provide a range of examples pertaining to challenges faced by our customers and the response that Integrated Logistics Simulation can provide.

The challenges

Our response

Challenges through-out project life-cycle

Progressive risk mitigation

