Institution: University College London		
Unit of Assessment: UoA 17, Business & Management Studies		
Title of case study: Improving the Maritime Transshipment Operations of the Noble Group		
Period when the underpinning research was undertaken: 2006- 2012		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s): Bert De Reyck	**Role(s) (e.g. job title):** Professor	**Period(s) employed by submitting HEI:** 01/08/2007 – present
Period when the claimed impact occurred: 2013 – 2020		
Is this case study continued from a case study submitted in 2014? N		

1. Summary of the impact

The Noble Group is a market-leading global supply chain manager of agricultural products, metals, and minerals, operating in more than 140 locations. In 2012, Noble's maritime operations in Indonesia were plagued by constant transportation delays, causing tens of millions of dollars per year in demurrage and detention penalties. As a result, Tim Gazzard, Global Head of Noble's iron ore business, requested Professor De Reyck to lead a research project to reduce or eliminate these delays. Based on his research on optimization for planning and scheduling, Professor De Reyck and his team developed a modelling framework and decision support system to facilitate the planning and management of Noble's transshipment operations, using fast search algorithms that deliver efficient schedules, minimizing the cost of delays and additional resources. After full implementation across Noble's Indonesian operations, savings amounted to between $18-24 million per year.

2. Underpinning research

Professor De Reyck has a track record in the area of scheduling which dates back from 1994, with applications in project management, R&D management, production planning, and logistics. The focus is on generating optimal schedules using optimization techniques such as integer programming, combinatorial optimization and heuristics.

The system developed by Professor De Reyck and his team described in this case study was based on his research on mathematical programming approaches for tackling a core issue in managing operations i.e. having to decide whether to use either company-owned or use bought-in resources in order to meet shipping deadlines and avoid late penalties **([a,b])**. The trade-off between the utilization of spot (immediately accessible) capacity versus the occurrence of penalties from reduced service quality is a fundamental one in the operations management literature. In a maritime transshipment setting, this trade-off is further complicated by an underlying scheduling and allocation component: the timing of the transshipment operations influences the optimal capacity allocation in a non-trivial way. Professor De Reyck's work ([c]) was the first to address the trade-off between spot capacity utilization and penalties for late deliveries in a maritime environment. Professor De Reyck's research tackles the underlying scheduling problem using real-time data, taking into account the time availability of scarce resources. The mathematical complexity of the problem, combined with its sheer scale, puts it beyond the capabilities of standard state-of-the-art solvers. Therefore, Professor De Reyck developed a column generation procedure that provides strong lower bounds, combined with fast local search algorithms that deliver high quality solutions **([c])**.

3. References to the research

[a] Fragkos, I., Degraeve, Z. and De Reyck, B. "A Horizon Decomposition approach for the Capacitated Lot Sizing Problem with Setup Times", *INFORMS Journal on Computing*, 2016, 28, 465 – 482. https://doi.org/10.1287/ijoc.2016.0691

[b] de Araujo, S., De Reyck, B., Degraeve, Z., Fragkos, I. and Jans, R. "Period decompositions for the capacitated lot size problem with setup times", *INFORMS Journal on Computing*, 2016, 28 (4), 431 - 448. https://doi.org/10.1287/ijoc.2014.0636

[c] Fragkos, I. and De Reyck, B. "On improving the maritime transshipment operations at the Noble Group, *INFORMS Journal on Applied Analytics*, 2016, 46 (3), 203-217. https://doi.org/10.1287/inte.2015.0841

The main underpinning research **([c])** was undertaken by Professor De Reyck, Professor at the UCL School of Management since 2007, in collaboration with Ioannis Fragkos, Associate Professor at the Rotterdam School of Management. Professor De Reyck was the principal investigator.

Evidence of the quality of research is provided by publications in key peer-reviewed journals, and award nominations.

4. Details of the impact

The Noble Group specialises in transporting industrial and energy products. When things go wrong – when extra vessels suddenly need to be hired or timetables are not adhered to – it costs Noble money. In 2012, when Professor de Reyck was first approached to help unravel these problems, the group was accustomed to losing tens of millions of dollars every year in what are known as demurrage and detention penalties – the supplementary charges incurred by failing to meet schedules.

Despite globalisation's unrelenting reliance on the shipping industry, many shipping practices are outdated and profligate, with many large maritime businesses continuing to make complex operational decisions manually by using intuition and limited data. This case study shows that advances in optimisation mean we can now address a much broader class of difficulties in this sector and provide a range of tangible benefits **([2])**.

Indonesia is one of the world's leading energy exporters, serving as a supplier to high-growth nations such as China, India, Japan and Korea. Much of its output departs from Borneo's two major trading ports, Taboneo and Muara Kaman, on enormous ocean-going vessels capable of carrying up to 120,000 tonnes of materials. In part due to inaccessibility and in part due to cost and environmental concerns, the journey from mine to port is almost invariably made by barge. Up to 16 barges may be required to load a single ship. Noble owns its own fleet of barges, has long-term contracts for the lease of others and must occasionally hire more on a spot basis. Supplier schedules can turn out to be imprecise, which combined with busy jetties and materials shortages results into delays.

What Noble desperately needed was a procedure that would enable it to strike an economically satisfactory balance between hiring additional barges on a leased or spot basis and avoiding the financial penalties arising from late deliveries. Professor De Reyck reasoned that to achieve this goal, and to realise the savings it would bring, it would be essential to equip managers with the ability to assess with confidence three key considerations, namely (1) how many owned, leased and spot barges to allocate to each vessel, (2) when to dispatch each barge, and (3) whether to hire a floating crane to speed up barges' unloading. The solution was a system developed by Professor De Reyck known as the Barge Rotation System, implemented in AIMMS with Excel as a user interface.

The first step was to arrange all the relevant data in a single system, separating factors on the basis of update frequency. This improved ergonomics and allowed users to complete data entry in a matter of minutes, as opposed to the many hours they previously had to devote to the job, with the added functionality of cross-validating data consistency. Second, the system had to address the large uncertainty that could affect schedules, including vessel arrival dates, loading times and supplier availability. For this purpose, Bert De Reyck's team developed a reactive model, capable of incorporating and reacting to unforeseen changes and new information. The system was made up of two subsystems, the first governing voyage allocation, assigning barges sourced from each supplier to each vessel, while minimising

transportation costs, and the second dealing with voyage scheduling, i.e. scheduling and dispatching the barges to service vessels, while minimising demurrage (lateness) penalties.

The system developed by Professor De Reyck was first tested in two Indonesian ports (Taboneo and Muara Kaman) in 2012 and 2013, where it showed savings exceeding $1.5 million per month. Figure 1 (**[c]**) shows how the system implementation reduced the average cost per tonne in the two ports during the testing phase. This initial test was then followed by a full implementation across Noble's Indonesian operations from September 2013 onwards.

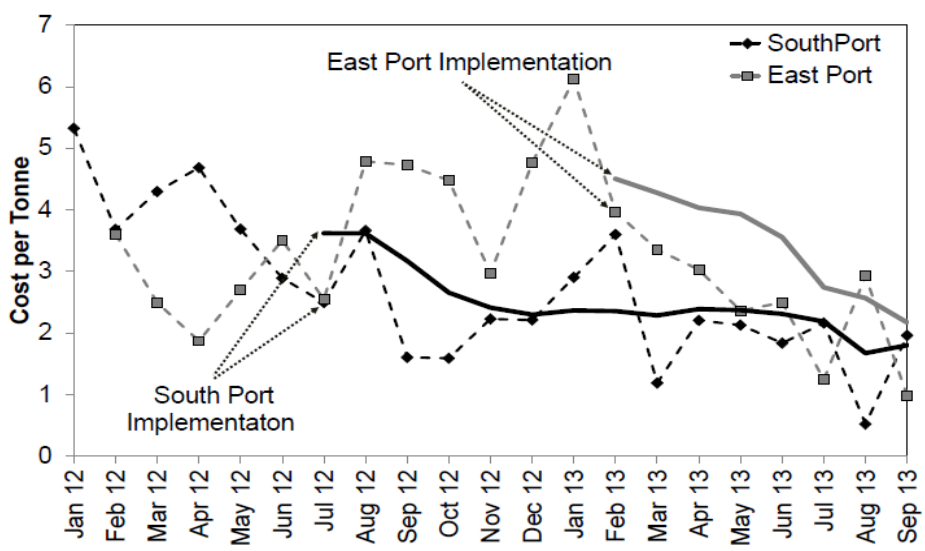

Figure 1. The system implementation reduced the average cost per tonne (dotted lines) in both ports significantly. The bold lines denote six-month moving averages.

The Executive Director with Noble and Global Head of Noble Group's Iron Ore and Special Ore's business, writes that "since implementation, we were able to reduce our logistics costs by approximately $1.0 per tonne. These savings amount to around $18-24 million per year, using our most conservative estimates" **([1])**. He continues, "this tremendous improvement has an unprecedented impact on the financial results of our logistics division." He also adds, "In its totality, the implemented system has not only improved the financial performance of my division, but has also helped the planners improve their understanding of operations, and the other departments to appreciate the complexity of logistics, and understand better how their decisions influence the logistics operations" **([1])**.

The impact of the underpinning research was recognised in the nomination this research received as a finalist for the *INFORMS Daniel H. Wagner Prize for Excellence in Operations Research Practice*. The case study also featured in the *Impact* magazine of the *Operational Research Society*, which features high-impact case studies of operational research in practice **([2])**, and in the *INFORMS Journal on Applied Analytics*, a journal devoted to case studies of management science in practice with demonstrable impact **([3])**.

5. Sources to corroborate the impact

[1] Testimonial from Executive Director with Noble and Global Head of Noble Group's Iron Ore and Special Ore's business.

[2] Robinson, N. "Shipping Forecast", *Impact*, The Operational Research Society, Autumn 2016, 13-16.

[3] Fragkos, I. and De Reyck, B. "On improving the maritime transshipment operations at the Noble Group, *INFORMS Journal on Applied Analytics*, 2016, 46 (3), 203-217. https://doi.org/10.1287/inte.2015.0841