Institution: Robert Gordon University

Unit of Assessment: UoA 11 (Computer Science and Informatics)

Title of case study: Transforming the North Sea Logistics Supply Chain

Period when the underpinning research was undertaken: 2011 - 2020

Details of staff conducting the underpinning research from the submitting unit:

Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
1. Prof. John McCall	1. Professorial Lead in Data Analytics, National Subsea Centre	1. 1992 – present
2. Dr. Ciprian Zavoianu	2. Senior Research Fellow, RGU	2. 2019 – present
3. Dr. Olivier Regnier-Coudert	3. Senior Research Fellow, RGU (now Data Scientist, Airbus AI Research, France)	3. 2010 – 2017
4. Charles Neau	4. KTP Associate at ARR Craib, now Software Engineer at Celerum	4. 2014 - 2016
5. Dr. Mayowa Ayodele	5. PhD student / Research Assistant, RGU (now Senior Researcher, Fujitsu Laboratories of Europe)	5. 2012 – 2017
6. Dr. Lee Christie	6. PhD student / Research Assistant / Research Fellow, RGU	6. 2012 – 2016, 2018 – present
7. Dr. Kate Han	7. Research Fellow, RGU	7. 2019 – present
8. Joan Santos	8. PhD student / Research Assistant, RGU	8. 2018 - present

Period when the claimed impact occurred: 2016 - 2020

Is this case study continued from a case study submitted in 2014? No

1. Summary of the impact (indicative maximum 100 words)

This award-nominated-research focussed on freight logistics optimisation across major players in the Oil & Gas market. Its economic impacts include savings of £6M over a 4-year period for ARR Craib (largest general haulage fleet in Scotland) and savings of £6.5M for Nexen (O&G exploration services provider, now CNOOC) during the same period. The project led to the creation of two spin-out companies and, according to the UK Oil & Gas Technology Centre (OGTC) estimates the applied technology has the potential to unlock £100M annual savings across the whole North Sea Basin.

2. Underpinning research (indicative maximum 500 words)

The North East Scotland freight supply chain, serving the North Sea, is highly fragmented by a complex mixture of industrial activities, making it extremely difficult for operators to plan in an efficient and effective manner. At present, the process is simplified by “fixing” routing and

schedules well in advance, forcing others to work around these fixed points, with limited decision-support tools to drive optimised performance and efficiency.

The RGU team, with experience in operations modelling of the Oil&Gas and marine industries, mathematically formulated optimisation problems representing realistic North Sea freight logistics, identifying previously unstudied and non-standard features. Applying these models to real industry data has helped to identify efficient ways to coordinate logistics resources. Algorithms designed by the team are now enabling optimised decisions to be made automatically and the technology has been embedded in businesses systems realising significant reductions in operational costs, emissions and environmental pollution.

In 2014, an initial study collected operational data from ARR Craib daily truck operations, eliciting objectives and constraints from operators. A new variant of the Vehicle Routing Problem for complex local pick-up and drop operations was identified and published [R1]. The study predicted high savings which were achieved [Source-A, Section 5] through a second stage, (2015-16) when a 140-user AI-driven truck operations control system was implemented by the RGU team, replacing a manual system. The system has been operational since 2016. ARR Craib estimate improved efficiency of 17%, valued at £1.5M per year, or £6M over the case-study period. Further benefits include reduced CO_2 / NOX emissions pro-rata and stress reduction for operators and drivers. In the final stage (2017-18), the partners collaborated to further develop the algorithms [R3], integrating with other parts of the supply chain. A spin-out company, Celerum, was established to commercialise the technology and develop the truck operations module.

A parallel study in 2016 with Nexen (CNOOC), RGU and PlanSea, examined UKCS operations to determine how machine learning and optimisation could reduce Nexen costs. Using RGU scheduling algorithms, the study reviewed 65 weeks of historical operational offshore activities for efficiency savings. The findings enabled Nexen to reduce their fleet of vessels by 50%, saving £6.5M [Source-C, Section 5]. This success was recognised in a nomination for Offshore Achievement Award in the Emerging Technology category (2017) [Source-D, Section 5].

In 2017, ARR Craib, RGU and Celerum combined with BP in an InnovateUK-funded study to evaluate potential savings across the Central North Sea freight logistics supply chain, which attracted participation from the OGTC and six additional operators [R4]. The findings led to a further OGTC-funded project with PlanSea, BP, CNOOC and Equinor (2020-21) to create a software for daily operations, enabling significant cost-savings and environmental benefits estimated by OGTC as worth £100M annually [Source-I, Section 5]. This uses algorithm RK-EDA [R2], developed at RGU, achieving state-of-the-art performance on large scheduling problems with 80% reduction in computational cost compared to leading algorithms. The algorithm and variants are readily applicable to a range of permutation-based optimisation problems with real world application. [R5, R6]

3. References to the research (indicative maximum of six references)

[R1] Regnier-Coudert, Olivier; **McCall, John**; Ayodele, Mayowa; Anderson, Steven; Truck and trailer scheduling in a real world, dynamic and heterogeneous context, **Transportation research part E: logistics and transportation review, 93**, pp389-408, 2016, Pergamon

[R2] Ayodele, Mayowa; **McCall, John**; Regnier-Coudert, Olivier; RK-EDA: A novel random key based estimation of distribution algorithm, International Conference on Parallel Problem Solving from Nature, pp849-858, 2016, Springer, Cham.

[R3] Neau, Charles; Regnier-Coudert, Olivier; **McCall, John**; An Analysis of Indirect Optimisation Strategies for Scheduling, 2018 IEEE Congress on Evolutionary Computation (CEC), IEEE

[R4] Marine Logistics: Summary of feasibility study findings Sept 2017 – May 2018. Final report June 2018. OGTC, 2018. https://www.ogtc.com/media/2369/marine-logistics-project-final-report_june18.pdf Accessed 11 February 2021.

[R5] Ayodele, Mayowa; **McCall, John**; Regnier-Coudert, Olivier; Bowie, Liam, A random key based estimation of distribution algorithm for the permutation flowshop scheduling problem,2017 IEEE Congress on Evolutionary Computation (CEC),,,2364-2371,2017,IEEE

[R6] Ayodele, Mayowa; McCall, John; Regnier-Coudert, Olivier, Estimation of distribution algorithms for the Multi-Mode Resource Constrained Project scheduling problem,2017 IEEE Congress on Evolutionary Computation (CEC),,,1579-1586,2017,IEEE

4. Details of the impact (indicative maximum 750 words)

The underpinning research on freight automatisation and multi-modal supply-chain led to considerable economic impacts across North East Scotland and the North Sea. The work has generated two spinout companies: Celerum and PlanSea Solutions. The findings of this research were widely disseminated across a number of countries, with Professor McCall being invited to several conferences and seminars in Mexico, Sri Lanka, China, Spain, Italy and the UK.

Celerum was established in 2013 as a general optimisation consultancy but has specialised in road freight logistics since taking over the support for the ARR Craib system in 2017 [Source-J]. One fulltime software engineer job was created at Celerum in 2017 and a fulltime CTO has been employed since August 2020 [Source-J]. RGU has transferred the IP to Celerum for truck operations software and it is expanding its customer base. The investment company Frontier IP increased its stake in Celerum with a £100K investment in July 2020 [Source-F]. A pilot study to further deploy the algorithms on a Highlands food and drink open logistics platform, funded by The Data-Lab, Highlands and Islands Enterprise and Celerum, commenced in November 2020.

PlanSea Solutions (established in 2017) focussed on providing fleet optimisation and vessel scheduling software for the offshore Oil&Gas marine support sector. Since its creation, PlanSea has been developing an innovative software based on the research to bring savings and environmental benefits to the Oil&Gas sector. In partnership with OGTC, the study highlighted potential savings of up to 25% on an annual industry spend of over £300M and identified the contribution optimisation software can make to reduce the sector's CO_2 emissions [Source-E].

With ARR Craib, the project resulted in the implementation of a 140-user system that enables the organisation to control their local truck operations using AI algorithms. The project supported their provision of services to ASCO (global operations materials and equipment management company) and realised ~17% improvement in the utilisation of their vehicles. This has allowed substantial financial savings of £1.5M a year throughout the period of 2016-2020 (approximately £6M to date). "Other similar freight businesses are also looking at implementing automated systems but the work we developed, supported by the KTP, has given us a strong lead. Other systems currently do not contain optimisation. The KTP has led directly to a collaboration with BP in their drive to spread optimisation across the logistics chain." (Mike Simpson, COO/ARR, email: mike.simpson@arr-craib.co.uk).

In a study commissioned to PlanSea, Nexen has identified ways for improving the operational efficiencies, i.e. the reduction of 50% of their fleet of vessels, from four to two vessels. This resulted in significant savings of approximately £6.5M [Source-C]. According to Ray Riddoch, managing director UK and senior vice president Europe, Nexen, "In order to live at a low oil price, operators need to make a step change in eliminating waste in the supply chain and this requires a step change in thinking about new modes of operation. Through working with PlanSea, we have been able to enhance vessel utilisation and so reduce our North Sea PSV fleet from four vessels to two, resulting in a 2016 saving of some £6.5 million (US$8.28 million)." The significance of the impact of this research was recognised in a nomination for Offshore Achievement Award in the Emerging Technology category (2017) [Source-D].

In a recent project with OGTC, PlanSea and global operators BP, CNOOC and Equinor have now developed software products for vessel sharing, fleet planning and optimisation that will be available commercially in Q2 2021. OGTC now estimates the savings to be achieved from the software at £100M per annum [Source-I]. From August 2020, PlanSea has employed 2 fulltime staff as well as engaging a fulltime software contractor.

Given the nature and the scale of the operational efficiencies in Oil&Gas sector, by improving the utilisation of trucks and reducing the fleet of vessel required in their daily operations, there is growing confidence that in the longer term, there will be a significant reduction in carbon emissions that will lead to further beneficial impacts to the environment.

Staff involved in this research all continue working on applications of AI in industry: Dr. Ciprian Zavoianu is independently returned in this submission. Dr. Olivier Regnier-Coudert is at Airbus AI Research applying evolutionary algorithms to observation satellite mission planning; Charles Neau is a Software Engineer at Celerum; Dr. Mayowa Ayodele is a Senior Researcher at Fujitsu Laboratories of Europe; Dr. Lee Christie is a Research Fellow at RGU working on transportation systems planning. Joan Santos continues as Research Assistant at RGU.

5. Sources to corroborate the impact (indicative maximum of 10 references)

Source-A). KTP Report on ARR Craib project – supports £6M savings , 17% utilisation gains

Source-B). Oil and Gas UK Case Study – Industry Dissemination
https://oilandgasuk.co.uk/plansea-limited-cost-reduction-of-ukcs-marine-support-operations-through-efficient-fleet-scheduling/

Source-C). Nexen £6.5 Million Saving Press Announcement

https://www.oedigital.com/news/448233-nexen-uses-plansea-software-for-marine-operations

Source-D). OAA 2017 Finalist Nomination for Emerging Technologies
https://www.spe-oaa.org/finalists

Source-E). Report from OGTC on InnovateUK Energy Game Changer project “Transforming the North Sea Oil and Gas Supply Chain” (Celerum, RGU, ARR Craib, BP, OGTC, Chevron, CNOOC, Enquest, Repsol Sinopec, Total, Shell)
https://www.ogtc.com/media/2369/marine-logistics-project-final-report_june18.pdf

Source-F). Celerum attracts investment based on logistics success – report in Financial Times
https://www.proactiveinvestors.co.uk/companies/news/923561/frontier-ip-says-nature-inspired-computing-portfolio-company-celerum-to-support-software-development-for-marine-logistics-firm-923561.html

Source-G). Press coverage of OGTC 2020 project launch
https://www.energyvoice.com/oilandgas/north-sea/244487/bp-cnooc-and-equinor-partner-with-rgu-spin-out-to-save-industry-millions/

Source-H). https://techtransfercentral.com/2020/06/16/rgu-spinout-partners-with-major-oil-and-gas-companies-to-save-industry-millions-using-ai-powered-logistics-software/

Source-I). OGTC Video release announcing impact December 2020 – supports £100M per annum savings and environmental benefits claims https://www.youtube.com/watch?v=9afzHcv8FeY&feature=youtu.be

Source-J). Deryck Brown, Chief Technology Officer, Celerum Ltd. (deryck@celerum.co.uk)