
March 17th — 18th, 2021 | Darmstadt, Germany
Interdisciplinary Conference on Production, Logistics and Traffic
www.icplt.org

An analysis of processes and economic as well as ergonomic improvement potentials at air freight forwarders

Heiko Diefenbach[1], Nathalie Erlemann[2], Alexander Lunin[1], Eric H. Grosse[1,3], Kai-Oliver Schocke[2], Christoph H. Glock[1]

[1] *Technical University of Darmstadt, Department of Law and Economics, Darmstadt, Germany*
[2] *Frankfurt University of Applied Sciences, Department of Business and Law, Frankfurt, Germany*
[3] *Saarland University, Juniorprofessorship of Digital Transformation in Operations Management, Saarbruecken, Germany*

Abstract. The air cargo supply chain consists of several agents. Among them are truckers, who ship freight between customers and airports, and airlines, who transport the freight in-between airports via planes. Freight forwarders are the linking agents between both: they consolidate freight from truckers and forward it to the airlines (and vice versa). Since the unique selling point of air cargo is speed, the freight forwarders' processes need to be organised and executed efficiently, which can be supported by digitalisation and information technologies. Furthermore, the consolidation and disassembly of air freight requires a high amount of physical labour, which makes workers prone to muscular-skeletal diseases and injuries. Based on a case study at two freight forwarders in Frankfurt, Germany, we investigate the freight forwarders' process chain from an economic and an ergonomic perspective. This paper describes and analyses the processes, identifies shortcomings and debates possibilities for improvement with an emphasis on technical and technological measures.

1 Introduction

A growing global trade and demands for decreasing shipping times have led to an ongoing increase of air freight shipments [1]. Already in 2006, air freight was responsible for 36% of the total global trade by value and has since been growing by about 4.7% annually [2, 3]. To benefit from this growth, there is a strong pressure on the agents of the air freight supply chain to increase their capacities and enhance their processes.

One significant bottleneck in the air freight supply chain are the freight forwarders, who link the road transport (between customers and airports) and the air transport (in-between airports) by consolidating and disassembling oncoming freight. Although a large number of publications is concerned with the air freight supply chain as a whole and with individual planning problems that arise in this context [4], extensive descriptions and analyses of the freight forwarders' internal process chains are scarce. For freight forwarders to be competitive, processes need to be planned and executed efficiently [5]. There is, however, a general lack of digitalisation and utilization of information technologies in the air freight industry, which also applies to freight forwarders [6]. This is clearly a missed opportunity for improvement [6]. So far, not even an analysis of suitable technologies exists.

Moreover, the consolidation and disassembly of air freight requires a significant amount of manual materials handling activities. The resulting elevated levels of physical stress are linked to an increasing risk for the workers to develop musculoskeletal diseases [7]. In warehousing, where similar manual labour is required, lost time injuries are about one third above the overall average [8]. Hence, for freight forwarders, there exists a strong incentive to find measures that alleviate the physical strain for workers.

Motivated by these findings, this paper makes the following contributions. Firstly, based on a case study at two freight forwarders at Frankfurt airport, Germany, we give a comprehensive description of a freight forwarder’s process chain. Secondly, we analyse possibilities for process improvements with an emphasis on information technologies and digitalisation. Thirdly, we analyse the workers’ physical strain and evaluate materials handling devices for their potential use. Finally, we summarize our findings in a comprehensive overview.

2 Process description and analysis

There are two main process chains for freight forwarders: freight export and freight import.

The former starts with the acceptance of the freight documents and the transmission of the required information to the internal IT handling system, which is used for all internal and external communication. The employees in the operational sector access it via handheld devices.

Once all documents have passed the security check, the freight is unloaded from trucks, checked for security and transferred to storage using forklifts. Later on, the planning office generates flight manifests, which state how the freight should be consolidated and all associated information.

Given a flight manifest, workers consolidate the freight by loading it onto unit load devices (ULDs), of which there are three distinct types: (1) airfreight palettes, (2) containers and (3) wagons for loose cargo. Forklifts are used to retrieve and handle palletized cargo. Non-palletized freight is handled and built-up on ULDs manually. Once the build-up is complete, the ULD is secured, weighted and, finally, provided for air shipment.

The import process is roughly inverse to the export process. Freight forwarders receive ULDs and freight documents from the airlines. The ULDs are then broken-down, i.e., disassembled into individual shipments, which are stored until transfer to truckers. Both airlines and truckers receive a note once freight is ready for collection. The trucker may then collect the physical freight.

Although there is an IT system to manage all relevant data, internal information management relies heavily on paper, which prolongs processes and lead times. Further inefficiencies arise from the internal communication chain, which partly relies on intermediate coordinators instead of direct communication between the planning office and the operational staff, even though the necessary structures, i.e., the IT system, are already in place. Lastly, imbalanced truck scheduling, partly due to mismanaged information, can lead to shortages in unloading personnel and loading ramps, causing unnecessary waiting times.

3 Analysis of information technologies

The freight forwarders’ physical processes are well structured. However, missing digitalisation causes inefficiencies. The first step for improvement should therefore be the consistent digitalisation of all internal (and where possible external) information flows. For the companies considered in our case study, the infrastructure is already in place, such that paperless communication is quickly achievable.

To improve the bottleneck at the truck dock, integrating a ramp management tool could be a viable option [9]. This could further benefit from digitalized information flows between truckers and freight forwarders.

Finally, augmented reality (AR) holds many opportunities for increasing efficiency such as the visualization of information for hands-free working, indoor navigation, digital process guidance and visual documentation of freight location or damages [10, 11]. In the future, freight forwarders may use AR to support the build-up process by visualizing dimension restrictions or suggesting optimal freight arrangement to the workers [12]; we note, however, that more research is needed on this topic.

4 Analysis of the physical strain

For the ergonomic evaluation, we analysed video recordings of workers building up or breaking down various ULDs in a two-step approach. First, we assessed each process using the “Multiple-Lasten-Tool” [13], which is a screening method based on the “Key Indicator Method” [14]. This provided a first indication of the hazardousness of each build-up and break-down task and allowed for comparisons. Our main findings were that the workers’ physical stains are critical for most tasks. A task was more strenuous the more small-piece freight had to be handled, because larger pieces were moved by forklifts, which required only marginal physical work. In the case study, break-down tasks were generally more stressful, as they often consisted of more small-piece freight. However, this may be a special occurrence at our case companies.

For the second part of the evaluation, we used the software 3DSSPP [15] to analyse two representative tasks, one build-up and one break-down task, in detail. The software allows for the biomechanical modelling of the processes and, i.a., calculates the forces on the lower back joints, allowing us to assess the injury risks associated with each task [16]. The detailed analysis confirmed the high physical strain on the workers, since both maximum and cumulative forces on the lower back joint reach and exceed critical thresholds regularly.

5 Analysis of material handling devices

For the analysis of material handling devices that may be used to reduce the physical strain during the build-up and break-down of air freight, we considered the scientific and practice-oriented literature. Out of all found devices, we selected the most promising for closer evaluation: cranes, exoskeletons, forklifts, lifting platforms and manipulators/cobots.

We found that cranes are comparatively slow to use and, hence, appear less suited for the purpose at hand.

Exoskeletons can reduce physical strains for lifting and lowering significantly [17]. Especially passive exoskeletons, which use springs and dampers to redistribute a worker's own strength, appear well suited. They are, however, a new technology, which may pose some integration challenges and currently unknown long-term health problems [18].

Forklifts are already used. However, they are generally prone to causing accidents. Recent safety developments, such as person detection technologies, may be a reasonable addition.

If lifting platforms are plunged into the shop floor, they can lower and elevate ULDs, such that the workers can handle freight at ergonomically favourable heights. They appear very suitable to reduce physical strains. Installing them at existing terminal is very costly or even impossible, however.

Manipulators/cobots are crane-like robot-arms used for gripping and handling freight. They are operated manually by guiding their movement, which they support with an active force. They can reduce the required physical force to handle objects by 10 times or more [19]. They seem suited for the purpose at hand, but are not completely technologically mature yet.

6 Summary of suggested technologies and devices

For the most part, information technologies and materials handling devices can be implemented independently.

Concerning information technologies, full digitalisation of internal information flows is the basis for increasing efficiency. The implementation of a ramp management system should be pursued, if not already in use. As a long-term goal, the digitalisation of information flows along the air freight supply chain should be emphasized to create transparency and information exchange in real-time between all supply chain agents.

For materials handling devices, we suggest either (passive) exoskeletons or manipulators, which first should be implemented in small-scale trials to test their suitability in practice. Of these two possibilities, we rate exoskeletons as being easier to implement. However, using both devices simultaneously is not advisable, since they mutually reduce their benefits. If terminals are newly constructed, incorporating lifting platform becomes a viable option.

Finally, currently developed technologies, such as augmented reality, may improve process efficiency as well as (cognitive) ergonomics by providing workers with additional information. We see, however, great potential for future research as findings and in particular real-world evidence, is still scarce.

References

1. Ou, J., Hsu, V. N., & Li, C. L. (2010). Scheduling truck arrivals at an air cargo terminal. Production and Operations Management, 19(1), 83-97. (IATA, 2006)
2. Gardiner, J., & Ison, S. (2007). Literature Review on air freight growth. Report for the Sustainable Development Commission, March.
3. Boeing Company (2014). World air cargo forecast 2014–2015. Online: https://www.sec.gov/Archives/edgar/data/1534155/000153415516000068/ex1038boeingwacf.pdf [13.07.2020]
4. Feng, B., Li, Y., & Shen, Z. J. M. (2015). Air cargo operations: Literature review and comparison with practices. Transportation Research Part C: Emerging Technologies, 56, 263-280.
5. Khan, M. R. (2000). Business process reengineering of an air cargo handling process. International Journal of Production Economics, 63(1), 99-108.
6. Bierwirth, B., & Schocke, K. O. (2017). Lead-time optimization potential of digitization in Air Cargo. Proceedings of the Hamburg International Conference of Logistics (HICL), 75-98.
7. Punnett, L. & Wegman, D. H. (2004). Work-related musculoskeletal disorders: the epidemiologic evidence and the debate. Journal of Electromyography and Kinesiology, 14(1):13–23.
8. Meyer, M. & Meschede, M. (2016).: Krankheitsbedingte Fehlzeiten in der deutschen Wirtschaft im Jahr 2015. In: B. Badura, A. Ducki, H. Schröder, J. Klose, M. Meyer : *Fehlzeiten Report 2016: Unternehmenskultur und Gesundheit - Herausforderungen und Chancen*. Berlin/ Heidelberg: Springer, pp. 251-444, (2016)
9. Kahl, B. (2016): Digitale Verabredungen am Frankfurter Flughafen. in: LT Manager (03), 52–56.
10. J. Jost, T. Kirks, B. Mättig, A. Sinsel, T. Trapp: Der Mensch in der Industrie – Innovative Unterstützung durch Augmented Reality. In: B. Vogel-Heuser, T. Bauernhansl, M. ten Hompel (Hg.): *Handbuch Industrie 4.0. Produktion, Automatisierung und Logistik*, Wiesbaden, Springer Vieweg pp. 1-22, (2015)
11. Stoltz, M.-H.; Giannikas, V.; McFarlane, D.; Strachan, J.; Um, J.; Srinivasan, R. (2017): Augmented Reality in Warehouse Operations: Opportunities and Barriers. in: IFAC-PapersOnLine, 50 (1), 12979–12984.
12. Fraunhofer-Institut für Materialfluss und Logistik (IML) (2020): Picture of the Future: AR ULD Build-Up. Online: https://www.iml.fraunhofer.de/de/abteilunge

n/b3/projektzentrum_luftverkehrslogistik/projekte/picture-of-the-future--ar-uld-build-up.html [13.07.2020].

13. Institut für Arbeitswissenschaft (2007): Multiple-Lasten-Tool. Online: https://kobra-projekt.de/download/multiple-lasten-tool [14.07.2020]
14. Federal Institute for Occupational Safety and Health: Risk Assessment with the Key Indicator Method (KIM). Online: https://www.baua.de/EN/Topics/Work-design/Physical-workload/Key-indicator-method/Key-indicator-method_node.html [14.07.2020]
15. Center for Ergonomics (2020): 3DSSPP Software. Online: https://c4e.engin.umich.edu/tools-services/3dsspp-software/ [14.07.2020]
16. Norman, R., Wells, R., Neumann, P., Frank, J., Shannon, H., Kerr, M., & Study, T. O. U. B. P. (1998). A comparison of peak vs cumulative physical work exposure risk factors for the reporting of low back pain in the automotive industry. Clinical biomechanics, 13(8), 561-573.
17. Abdoli-Eramaki, M., Stevenson, J. M., Reid, S. A., & Bryant, T. J. (2007). Mathematical and empirical proof of principle for an on-body personal lift augmentation device (PLAD). Journal of biomechanics, 40(8), 1694-1700.
18. De Looze, M. P., Bosch, T., Krause, F., Stadler, K. S., & O'Sullivan, L. W. (2016). Exoskeletons for industrial application and their potential effects on physical work load. Ergonomics, 59(5), 671-681.
19. Krüger, J., Lien, T. K., & Verl, A. (2009). Cooperation of human and machines in assembly lines. CIRP annals, 58(2), 628-646.