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TRANSPORT 2040

AUTOMATION IN AIRPORTS: AUTOMATIC BAGGAGE HANDLING SYSTEMS

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TRANSPORT 2040

**AUTOMATION
IN AIRPORTS:
AUTOMATIC BAGGAGE
HANDLING SYSTEMS**

TECHNOLOGY AND TRANSFORMATION

ACKNOWLEDGMENTS

This report is part of the study, entitled *Transport 2040: Automation, Technology, Employment – The Future of Work*, a research project undertaken by World Maritime University (WMU) and financially supported by the International Transport Workers' Federation (ITF). The ITF financial support that was provided to carry out the research for this report is gratefully acknowledged.

A team of researchers at WMU, under the coordination of Jens-Uwe Schröder-Hinrichs and Dong-Wook Song (Co-Principal Investigators), worked on this report. The research was carried out by Xiaowen Fu. The initial research was conducted by Adrienne Mannov. The production was done by Khanssa Lagdami and Tiago Fonseca. The study was carried out under the overall guidance of Cleopatra Doumbia-Henry, President, WMU.

The layout of the report and the graphics were provided by Phoenix Design Aid A/S. The report was edited by Alexandra George (through Prime Production Limited).

This study is the result of almost two years of intensive research under the umbrella of the *Transport 2040: Automation, Technology, Employment – The Future of Work* Report. Our special thanks to all interlocutors consulted for this report for their valuable time, interest and openness in sharing their views and knowledge. We are grateful that they were willing to impart their experience and views. All those consulted were under a strict confidentiality policy whereby the Chatham House Rule and non-disclosure agreements were applied.

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INTRODUCTION

INTRODUCTION

As indicated in the Acknowledgments section of this report, the research work forms part of the earlier study, entitled *Transport 2040: Automation, Technology, Employment – The Future of Work*, undertaken by the World Maritime University (WMU) and commissioned by the International Transport Workers' Federation (ITF). The overall trends and a global overview provided in that volume are detailed in a series of Technology and Transformation studies, which provide the reader with an enhanced perspective that focuses on a local context.

An efficient baggage-handling system is of critical importance to the aviation industry, especially for major hub airports that handle large volumes of passengers and connecting flights. Huge investments have been made over the years, and baggage handling has been long recognized as one of the most promising areas for airport automation. However, given the considerable degrees of diversity and dynamic nature of the aviation industry, the levels of automation vary across different airports and regions. Even terminals at the same airport may use very different systems. Institutional factors, such as infrastructure ownership, regulations and airport-airline arrangements, all play important roles in the investment and operation of baggage systems.

For a better understanding of the prospects of baggage system automation, it is important to review the industry

background and analyse these institutional factors. This study highlights the challenges and implications of airport baggage handling automation so as to better describe the trends depicted in the *Transport 2040* Report. This is achieved through a short background review and related case studies. It is hoped that such an investigation will identify the major challenges that the aviation industry needs to address so that stakeholders can better prepare for the future.

This study concludes that baggage automation will be progressively introduced in the aviation industry, especially in newly built terminals, large airports and markets where stakeholders can work jointly. International organizations and government agencies also have important roles to play in such a process. The aviation industry is quite competitive and dynamic. Airlines and airports need to constantly improve their service quality and standards. On the other hand, major aviation markets are often located in high-growth developing countries or high-income developed countries with a shortage in the supply of specialized labour. In the short to medium term, baggage automation is unlikely to bring major destructive shocks to the labour market.

This study is organized as follows: Section A provides a background review of the industry characteristics. Section B summarizes the findings from the interviews and case studies. The last section contains the summary and conclusion.

PROCESS AND BACKGROUND REVIEW

A

A. PROCESS AND BACKGROUND REVIEW

Baggage operation is of critical importance to the aviation industry and involves multiple stakeholders and operators, notably airports and airlines. The process varies across markets and countries, and may involve significantly different types of operations. Generally, the process starts when a passenger checks in baggage at the airport. This is often at the same time as checking in for a flight. With the increasing use of online check-in, more bags are being dropped off separately, or through self-service check-in kiosks or bag drop counters. Baggage labels (tags) are attached upon check-in, which contain information, such as airline, flight number and the destination airport code. A bar code or radio-frequency

identification (RFID) tag can be scanned/read, which allows the tracking of the bag and provides other information such as the weight or priority (e.g. business or first class) of the bag.

Bags need to subsequently go through security checks, after which they are delivered to the sorting and loading areas to be loaded into containers, known as unit loading devices (ULD) – see Figure 1. In airports with automatic cargo/baggage handling systems (or early baggage storage), bags can be temporarily stored until shortly before flight departure.¹ Until this point, most operations are performed within airport terminals, although in many

FIGURE 1 Automated baggage sorting and screening systems

¹ Whereas most airports only allow bag drop-offs two or three hours before flight departure, the Hong Kong international airport allows passengers to check in baggage one day prior to their flights. The airport has an advanced cargo/baggage system which can easily retrieve particular containers or bags. Similar systems have been installed in the Dubai International Airport, London Heathrow Airport, among others.

cases facilities (e.g. check-in counters /kiosks, baggage conveyor and storage, screening systems) may be owned by, or leased to, airlines.² As a result, airports are often the key decision-makers for the design, investment, operation and upgrading of the related facilities.

After being sorted and loaded into ULDs, bags are then delivered and loaded into the aircraft prior to flight departure. These operations are usually performed by ground handling service providers, which may be owned by the airport, the airline, or independent third party companies.

The above process is reversed, albeit in a simpler manner, for arrival flights: baggage ULDs are off-loaded from aircraft and delivered to airport terminals. Bags are then loaded and transported by conveyors to the carousels for baggage claim. In the case of connecting/transfer flights, bags may be temporarily stored until they are re-sorted and loaded onto the next flights.

In summary, baggage handling involves different operators at multiple airports, sometimes across country borders. Security and safety standards need to be followed along the whole process, which calls for close coordination and information-sharing among all stakeholders. Such a need has been well recognized by the aviation industry. For example, the International Air Transport Association (IATA) endorsed resolution 753³. Coming into effect in June 2018, the resolution requires that “*IATA members shall maintain an accurate inventory of baggage by monitoring the acquisition and delivery of baggage.*” A stylized graph of the baggage flow process is depicted in Figure 2, where sections highlighted in red represents the four points at which airlines have to track baggage, namely when passengers handover baggage to the airlines; when baggage are loaded to aircraft; when baggage are delivered to the transfer area; and when the baggage are returned to the passenger. Depending on the baggage system used, airports may also track and monitor baggage at multiple points.

A point to be noted is that the above process is only an outline of the normal baggage handling process. In practice, mishandled bags involve many extra operations and services by airports, airlines and ground handling service providers. The International Aeronautical Telecommunications Association (SITA) 2018 Baggage Report⁴ estimates that a total of 22.7 million bags were mishandled in 2017, at an estimated cost of US\$2.3 billion to the aviation industry.

The aviation industry has been investing heavily in baggage handling systems to improve efficiency, reduce costs, increase reliability and control mishandled baggage

FIGURE 2 Baggage flow and mandatory tracking points

volumes. Automation is one major approach to achieve these objectives. For example, whereas the screening of carry-on bags remains manual, in most airports the screening of check-in baggage has been automated.⁵ Only a very small percentage of bags that failed automatic check will be manually inspected. Bag transportation, storage, retrieval and loading can all be fully automated.

Figure 3 illustrates manual baggage loading with the assistance of lifting tools as against a fully automated baggage loading solution. Figures 4 illustrates the automated transport and sorting systems, and facilities for automated baggage screening. In the aviation industry, there are also proposals to use autonomous vehicles (AVs) to navigate baggage carts between airport terminals and aircraft. However, few systems have been actually implemented so far. A few companies are also designing AV-based baggage distribution systems within airport terminals.⁶

One should highlight that even with the fully automated systems installed, human/manual interventions are frequently needed. For example, the delivery, storage and screening of oversized baggage items are usually handled

² For example, although the Denver International Airport manages and operates baggage-handling systems for most airlines, United Airlines operates its own terminal and baggage facilities at the airport.

³ See: <https://www.iata.org/whatwedo/ops-infra/baggage/Pages/baggage-tracking.aspx> (accessed 8 July 2019).

⁴ SITA, 'Air Transport Industry Insights: The Baggage Report'.

⁵ There are significant differences across markets and countries. In New Zealand, baggage screening is currently not necessary for domestic flights. In the US, technologies are being developed to screen passengers and carry-on bags automatically. For example, the US Department of Homeland Security is considering the Apex Screening at Speed programme. If implemented, this programme will allow passengers to simply walk through a security checkpoint with coat and shoes on, without the need to take out laptop and electronics from their carry-on bags.

⁶ For related reviews and discussions, see for example the analysis of Silven, 'Autonomous Transport Robots in Baggage Handling Systems'.

manually. The processing of specialized items, such as certain medicines, blood samples or even service dogs also requires manual intervention. Although artificial intelligence (AI) applications are being developed, human surveillance

Automated systems also involve a lot of maintenance and upgrading activities. While demand for low-skilled labour may be reduced through automation, there may be an increase in high-skilled jobs.

FIGURE 3 Manual baggage loading with lift solutions vs. automated baggage loading⁷

FIGURE 4 Automated baggage sorting and screening systems⁸

⁷ Photos downloaded from <http://www.vaculex.com/solutions/airports/> and <https://www.airport-technology.com/contractors/baggage/grenzach1/> (accessed 8 July 2019).

⁸ Photos downloaded from <https://www.airport-suppliers.com/supplier/beumer-group/> and <https://airportimprovement.com/article/upgraded-baggage-system-takes-over-commuter-apron-pittsburgh> (accessed 8 July 2019).

CASE STUDIES OF AIRPORT BAGGAGE AUTOMATION SYSTEMS

B

B. CASE STUDIES OF AIRPORT BAGGAGE AUTOMATION SYSTEMS

As air traffic volume increases, airports have been eager to process more passengers and flights, reduce waiting times and increase service quality. Parallel to this, new technologies have begun to mature around the start of the new millennium, offering promising solutions to these challenges and hopes for even greater profits within the industry. On the other hand, due to the tight regulation and safety standards imposed, it appeared that in many aspects the aviation industry has been quite conservative in adopting new technologies and automation systems. For example, although the RFID has been regarded as a very promising technology that could significantly

facilitate baggage automation, only a small number of airports have implemented the technology on a large scale.

To better understand the determinants of automation system adoption in the aviation industry, interviews with technology developers and airport operators, complemented with the reviews of related industry reports, were conducted. This section summarizes the findings of the interviews and report reviews, after which a more detailed case study on the baggage systems used by a mega hub airport is provided.

B.1 CONCLUSIONS FROM INDUSTRY INTERVIEWS AND A LITERATURE REVIEW

Semi-structured and structured interviews were conducted with industry practitioners to identify the technology and automation patterns in the aviation industry. This phase 1 of the research was carried out between May and October 2017 when developers of new technologies were the targets of interviewers. The research devotes particular attention to developers who had products that could automate parts of tasks or tasks in their entirety, although developers who were sceptical of the practical viability of data-driven applications and who did not advocate their use were also interviewed.

The point of entry began with access to a small innovation company in Northern Europe that was developing an application that could automate parts of the baggage handling process at commercial airports. From this point on, contacts were facilitated with other innovation companies that were developing applications that would automate, and to some extent radically change, ground-handling activities in general. These contacts enabled one to conduct interviews and to observe the work at the innovation companies, at on-site demonstrations of a variety of applications and at an international trade fair for airport services and products. The theme of the trade fair was digitalization and “Airport 4.0.” The fair hosted 620 exhibitors from 43 countries. Thus, the findings of this study not only provide valuable insights on airport baggage handling automation in particular, but also the general trends in airport automation.

B.1.1 Character and Structure of the Industry

// This is a very conservative sector. Nothing has changed in how we handle baggage in the past 50 years; we still have people lifting the bags. //

Developers regularly characterized the industry as “conservative”. The above quote is from an investor in an application that automates baggage-handling tasks. His explanation, however, illustrates a general tension observed among developers. For some, the conservativeness, or lack of change referred to above, represents an opportunity. Since so little had changed, they reasoned, there were many areas that could lend themselves to innovation. In the words of one developer, thinking about automation “as a part of the future is to be hopeful about the future.” For others, the “conservative” nature of the industry provided guidance on the fact that new products and services should not *disrupt*, but *adapt* to what existed. Indeed, anyone who thought they could change the conservative nature of the industry was, in the words of one developer, “in for a rude awakening.”

One of the reasons for this conservativeness is the relationship between the cost of equipment and regulations. In fact, many of the developers consulted referred to the industry as being both “highly regulated” and “conservative”. The international regulations for airport

and aircraft equipment are notoriously stringent due to safety standards. This translates into requirements for high quality and expensive materials that can comply with industry certification standards. In an April 2017 article in *Aviation Week*, this relationship is described in regard to the development of new technologies: *“In past years, 75 cents of each dollar for a development program would be spent on engineering and 25 cents on certification (...) We have now swapped over to where it costs more to certify than to develop the system.”*⁹

Because of these high costs, one developer explained that this meant that the success of a new product in the aviation market depended on trust, rather than low cost. He explained that the investment is so huge that it is more important to have a long-term relationship that one can depend upon than it is to get a new product that is slightly cheaper from someone without long-term ties. He explained that because certifications require high quality and expensive materials, the price tag for production is very high, thus making the financial stakes high for the buyer. Given such conditions, the conservativeness that many developers pointed to can be equated to being risk-averse in terms of investing in new applications, particularly innovations that would impact safety requirements.

B.1.2 Infrastructure ownership and institutional factors

Airport infrastructure and equipment are potential sites for innovation and automation. An example of that is shown in Figure 5 with a current trial of an autonomous baggage handling vehicle at Rotterdam The Hague Airport in the Netherlands. The developers that were consulted explained that equipment could be owned by a ground-handling company, an airline or an airport.¹⁰ If ground-handling equipment, such as luggage carts, are owned by a ground handling company, they may not be interested in sharing their equipment with a competing ground handling company. If the equipment is owned by an airline, this may only apply in a specific terminal (this is a common practice in the United States), which means that there may be other ownership structures at play in other terminals at the same airport and other equipment strategies.

Larger airports may own the equipment, but they will make contracts with ground-handling companies for several years at a time, perhaps switching to another company later. These various ownership infrastructures add a layer of complexity to a system that is already quite complex, considering the various and connected

FIGURE 5 Autonomous baggage handling vehicles being trialed in Rotterdam The Hague Airport (Netherlands)

Source: Vanderlande.

⁹ Source: *Aviation Week*, 'What Is The Certification Tipping Point?'. This article addresses innovation in aviation and not specifically airport innovation. Airports, however, also require to be certified through the International Civil Aviation Organization. See: Airports Council International, 'Airport Planning, Design, Operation and Safety'. Further investigation into the certification requirements for airport applications and how this influences investment should be pursued.

¹⁰ As explained in previous sections, a ground handling company may be completely or partly owned by the airport and/or the airlines. There may be more than one ground handling company in an airport providing baggage services to airlines.

tasks carried out within their premises. Many baggage-handling systems depend upon permanent and physical infrastructures in an airport. Replacing or removing them altogether would imply a major change in the airport's physical infrastructure.

This imposes limits – or at least challenges – to how developers may envisage the innovation process and product design. The ownership structures discussed above are not standardized around the world and, with static physical infrastructures to contend with, new innovations need either to be able to *adapt* to existing infrastructures, including their various levels of modernity and their ability of absorbing new technologies, or such innovations can completely disrupt the status quo thereby requiring a rethinking of how infrastructure can serve new ways of operation.

As described above, ownership structures at airports are complicated and can vary from airport to airport. In the words of one developer, “If you’ve seen one airport, you’ve seen one airport.” One of the challenges of automating complicated and heterogeneous tasks is managing to bring all of the details and potential outcomes together in one system.

B.1.3 Autonomous vehicles and data applications

Autonomous vehicles have been identified as one promising application for baggage handling automation. For example, they may be used for the transportation of baggage within the terminals, replacing conveyors to connect bag drop facilities (see Figure 5). AVs may also be used to deliver baggage carts between terminals and aircraft, and other apron activities that involve vehicles, such as aircraft guidance vehicles, passenger buses, catering vehicles and waste and water vehicles. One developer interviewed had devised tracking devices for these various vehicles.

The tracking devices translated the vehicles’ paths and the timing of their movement into digital information. This might fall into the category of “big data”. By using the Internet of Things technologies, these processes could be optimized and carried out more efficiently. Significantly, this could also lay the groundwork for automation because as data is gathered on the movement of the vehicles, their movement is understood in relation to one another and not as single activities. Their movement can be seen as a system and programmes that can be written to optimize and control the movement.

This developer explained that providing the data infrastructure for such processes represented the future. Because airport management companies, such as “Fraport”,¹¹ want to be able to monitor all airport activities and they are powerful, standardization is the way forward for them. Those who do not cooperate will be left behind. It is, however, important to remember that, although companies like Fraport are powerful, this mode of structuring airport activities is far from the norm.

Another developer explained that apron activities, including some baggage handling activities, would be difficult to automate because everything would have to be standardized. He asked, “Have you ever taken off from Frankfurt? It’s like all hell broke loose. How do you want to standardize that?” But in the words of another developer, “As soon as there are sensors on these machines they will be automated.” Here, he specified the pushback tractor, the dolly and the high loader. Apron vehicles, he explained, “were the most vulnerable.”

The sensors the developer referred to are the same ones being used on autonomous vehicles for road transportation. Sensors are able to gather and interpret unstructured data (images) and, together with GPS technology, the movement of these vehicles can be controlled and automated. Despite the scepticism of the first developer noted here, he suggested that apron activities could be fully automated within five to ten years.

B.2 CASE STUDY OF BAGGAGE HANDLING IN A MEGA-HUB AIRPORT

To obtain better insight into airport baggage systems and the potential for automation, in November 2018 the research team visited one major hub airport, which was consistently ranked among the top 10 airports in the world by traffic volume. Seven airport managers, and senior- and mid-level managerial staff from the aviation business department, international affairs department, research and air cargo business department all attended the meeting. Most of them held titles of supervisor, business manager and general manager. The general manager had supervised the airport’s baggage handling operations for about 15 years, and is currently in charge of the airport’s research and strategy development activities. Therefore, participants of the meeting formed an excellent panel that provided us both facts and insights related to the airport’s baggage systems.

B.2.1 Background of the airport’s baggage handling systems

The airports have multiple terminals that were constructed during different periods. Among them, the baggage handling system in Terminal X basically remains the same since the last construction/upgrading in the 1980s. It relies extensively on manual operations, but is, nevertheless, simple and reliable, meeting the expectations of the managers.

The baggage system in Terminal Y was constructed in the late 1990s by a US company, which no longer exists. As a result, little external support on maintenance, operation and systems upgrade is available. Although the airport’s internal team has been providing technical and operational support,

¹¹ “Fraport” is the airport managing company at Frankfurt airport at Frankfurt am Main, Germany. For more information see: <http://www.fraport.com/en/our-company/fraport/about-us.html> (accessed 5 July 2019).

overall, the baggage system causes a lot of problems. The system is partly automated.

A leading company in the industry installed the current baggage system in Terminal Z in the mid-2000s. The baggage system was designed in line with the terminal building and passenger flows. Advanced technologies and automation systems were implemented to improve efficiency, increase service quality and reduce manual work. The equipment company provided the following information concerning the baggage system:

- The baggage system in Terminal Z is one of the world's biggest baggage handling systems, utilizing state-of-the-art design and the most advanced technology.
- The baggage handling system can sort and transport close to 20,000 baggage items per hour from more than 300 check-in counters/facilities. This helps the hub airlines using the terminal to grow its network continuously and successfully.
- The system utilizes a combination of belt conveyor, high-speed tray system and tilt-tray sorters, occupying a total land area over 100,000 square meters. It offers more than 3000 Early Baggage Storage places.
- The IT information system can incorporate and analyse the real-time data such as flight information, baggage bar code and Radio Frequency Identification Devices. The system can thus track, monitor and sort baggage items with accuracy of 99.9 per cent.

B.2.2 Issues for operation and automation – focusing on baggage system in Terminal Z

Overall, the airport is satisfied with the performance of the baggage system in Terminal Z, which has been able to keep up with the increasing passenger and baggage volumes. The airport, nevertheless, is concerned about its high costs. To begin with, the baggage system was quite expensive to build. More importantly, maintenance costs have been quite high, in the range of “tens of millions dollars a year”. These costs include mostly “parts and labour” for the existing system. System upgrades would have involved extra costs.

In an effort to control such costs, the airports once sought alternative service providers. However, system reliability was reduced and the airport has since relied exclusively on the original manufacturer for maintenance. The airport has a feeling that it is “locked-in” and has limited options to upgrade and further automate the baggage system.

The airport has considered further automation. For example, to use AVs to transport baggage carts between terminals and aircraft. However, limited progress has been made so far due to the following considerations:

- Currently, many baggage-handling activities are performed by independent ground handling companies. Further automation is likely to benefit these firms most, yet the investment costs are borne largely by the airport. Unless there is a clear mechanism that allows the airport to make a good return on the investments, it will be reluctant to commit further investments.
- Baggage automation also involves other stakeholders, notably airlines that lease airport space and facilities for their own check-in and baggage operations. It is not easy to streamline the benefits/revenues/costs allocation among airlines, ground handling companies and the airport. This issue is further complicated by regulations on airport pricing, and safety and security operations. Automation requires coordinated operations among all operators. However, the airport is often the first to be blamed when incidents and/or service disruptions occur.
- Full automation involves the adoption of new technologies, common standards of data and operation protocols. Yet the company that built the current baggage system has significant control over the operation and maintenance of the system. It is not easy to coordinate all stakeholders' actions and interests.

For the aforementioned reasons, limited progress has been made in introducing further automation. However, where coordinated efforts can be made, it is possible to improve the current baggage system. For example, the airport is working closely with another major hub airport in the region, in order to set common standards of RFID tags and the exchange of baggage information. These actions are expected to significantly reduce baggage-mishandling rates for aviation services between the two airports.

SUMMARY AND CONCLUSIONS

SUMMARY AND CONCLUSIONS

Efficient baggage systems are of critical importance to airports and airlines. Over the years, more advanced systems have been designed and implemented, particularly in newly built terminals at hub airports. Nevertheless, despite the claimed benefits of automation, in many aspects the aviation industry has been conservative in upgrading/adopting innovative baggage automation systems. The background review and case studies undertaken suggest that in addition to technology challenges, institutional factors also play important roles in the development and implementation of automation systems.

The benefits, costs and responsibilities associated with further automation need to be fairly allocated among stakeholders. Common industry standards need to be established to promote the cooperation among airlines, airports and application developers, sometimes in different countries. The providers/manufacturers of existing baggage systems have significant control and influences over the implementation of new systems. These firms need to be motivated to support the automation projects at reasonable costs. Stakeholders including airports, airlines, regulators, and technology companies need to work together for the aviation industry's long-term growth.

LESSONS LEARNED

LESSONS LEARNED

- Baggage systems are of critical importance to airports and airlines. Such systems have to be efficient, reliable and meet the high safety and security standards imposed on the aviation industry. As a result, automation systems often involve major investments and complex infrastructures.
- Information sharing is one important requirement for baggage automation and tracking. However, the operation and investments of baggage systems involve many stakeholders, such as airports, airlines, ground service providers and government regulators, sometimes in different countries. It is not always easy to fairly allocate the benefits, costs and responsibilities. In addition, many globally accepted standards and protocols are yet to be agreed upon to guide the aviation industry.
- Baggage handling systems are sophisticated and expensive. Maintenance costs also tend to be high. Airports prefer to adopt automation systems with proven reliability at reasonable costs. Whereas airports may choose advanced technology for newly built terminals, they may be conservative in upgrading existing infrastructures.
- Institutional factors play important roles in airports' and airlines' automation decisions. If airlines and airports cannot fully benefit from automation, they will be reluctant to make the needed investments. Therefore, government policy and regulation will play important roles in the related decision-making.

REFERENCES

REFERENCES

Airports Council International. 'Airport Planning, Design, Operation and Safety'. ACI Policy and Recommended Practices Handbook. Airports Council International, 2009.

Aviation Week. 'What Is The Certification Tipping Point?', 2017. <http://aviationweek.com/commercial-aviation/what-certification-tipping-point>.

Silven, Alisa A. E. 'Autonomous Transport Robots in Baggage Handling Systems'. Master Thesis, Delft University of Technology, 2018.

SITA. 'Air Transport Industry Insights: The Baggage Report', 2018.

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