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Enterprise Architecture for Enterprise Innovation

Autonomous Check-In Luggage System

Chiara Zandomeneghi - 132881

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1 Introduction

The aviation industry is undergoing a profound transformation, driven by rapid technological innovation and increasing passenger expectations for seamless travel experiences. In response to these evolving demands, our airline is introducing an Autonomous Luggage Check-In System, designed to revolutionize the luggage check-in process and significantly enhance operational efficiency at airports. This system leverages advanced technologies like RFID tracking and self-service kiosks to automate the entire check-in process, reducing the need for human intervention. By optimizing workflows, minimizing wait times, and improving the overall passenger experience, this innovation sets a new benchmark for efficiency and convenience in the aviation sector. We believe this system represents a pivotal step forward, and we invite other industry players to explore how it can redefine luggage handling and operational excellence across the board.

1.1 Case Description

The Autonomous Luggage Check-In System is designed to transform the traditional luggage check-in experience through the integration of self-service kiosks, RFID technology, and centralized data management. By automating the check-in process, the system minimizes the need for human intervention, thereby streamlining operations and enhancing passenger convenience.
Upon arrival at the airport, passengers are greeted by user-friendly self-service kiosks that enable them to check in their luggage with ease. The kiosks allow for real-time verification of flight details and passenger identity, either through manual entry or by scanning boarding passes. This immediate verification process reduces delays and empowers passengers to take control of their check-in experience.
The system includes advanced weighing mechanisms that accurately assess luggage weight while notifying passengers of any excess luggage fees. Once the luggage is validated, the kiosks print out securely embedded luggage tags, which are affixed to the luggage. These tags contain vital flight information and are automatically scanned as the bags enter the airport's sophisticated luggage handling system.
This seamless process not only minimizes the risk of human error but also enhances security through better tracking capabilities. Passengers can enjoy real-time visibility of their luggage's status throughout their journey, fostering a greater sense of confidence in the airline's operational integrity.

1.2 Case Processes

The Autonomous Luggage Check-In System implements a range of efficient, automated processes that greatly enhance the airport experience for both passengers and airline staff. This system streamlines operations by automating key steps in the check-in process, resulting in faster service, reduced wait times, and smoother workflows, ultimately improving overall efficiency and customer satisfaction.

Passenger Check-In Initiation

The process begins when a passenger approaches the self-service kiosk, greeted by an intuitive interface. Passengers can either manually enter their flight details or scan their boarding pass for instant validation. This quick verification helps reduce congestion during peak hours, allowing passengers to check in swiftly and without hassle.

Luggage Weighing and Fee Calculation

After flight verification, passengers are instructed to place their luggage on the integrated weighing scale. The system automatically checks the weight against the airline's luggage allowance. If the luggage exceeds the permitted weight, passengers are immediately notified of any excess luggage fees. This upfront transparency allows passengers to make informed decisions, helping to streamline the check-in process and reduce surprises during boarding.

luggage Tagging

Once the luggage is weighed and any fees settled, the kiosk prints a uniquely encoded luggage tag. Passengers are guided through a simple step-by-step process to securely attach the tag to their luggage. This step is essential for ensuring accurate tracking and identification as the bags move through the airport's system, reducing the chance of errors or misplaced luggage.

Automated Luggage Routing

After tagging, the system scans the luggage and seamlessly integrates it into the airport's automated conveyor network. Using advanced RFID and barcode scanning technologies, the luggage is directed to the correct luggage handling area according to its flight details. This automation ensures efficient and accurate routing, minimizing delays and greatly reducing the risk of lost luggage.

Real-Time Luggage Tracking

The system offers real-time tracking capabilities, allowing both passengers and airline staff to monitor the status of the luggage throughout its journey. This feature provides transparency and peace of mind, enabling passengers to stay informed about their luggage's location. The enhanced visibility improves customer confidence in airline operations, contributing to a smoother and more reassuring travel experience.

1.3 Purpose

The primary purpose of this report is to provide an in-depth analysis of the Autonomous Luggage Check-In System from the perspective of a Norwegian airline. By utilizing enterprise modeling frameworks such as 4EM and ArchiMate, the report seeks to elucidate the system's objectives, processes, and technological components in detail.
The report aims to demonstrate how the implementation of this system can yield significant benefits, including reduced waiting times, enhanced operational efficiency, and increased passenger satisfaction. By adopting these frameworks, we will explore how the system aligns with the airline's strategic goals, fostering a culture of innovation and efficiency in the face of evolving industry demands.
Moreover, this report will advocate for the broader adoption of the Autonomous Luggage Check-In System across airports, showcasing its potential to modernize and enhance airport operations in a fast-paced aviation landscape. By highlighting both the practical implications and strategic advantages of the system, this analysis serves as a compelling case for investing in automation technologies that prioritize passenger experience while ensuring operational excellence.

2 Enterprise Modeling

2.1 Design of the Model

The design and analysis of the Autonomous Luggage Check-In System rely on two established frameworks: 4EM (For Enterprise Modeling) and ArchiMate. These frameworks provide complementary perspectives that enable a thorough understanding of the system's goals, processes, and technological components while ensuring alignment with the broader operational objectives of the airport and airline. By using 4EM for detailed goal modeling and process analysis, and ArchiMate for architectural visualization, the model presents a holistic representation of the system's integration within the airport's infrastructure. This dual-framework approach ensures that every aspect of the system is geared toward operational efficiency and passenger satisfaction.

2.2 4EM

2.2.1 Goal Sub-Model

The goal sub-model identifies the primary objectives of the system, which include automating the luggage check-in process, reducing passenger wait times, and improving operational security and accuracy. Central to these goals is the aim to streamline operations while enhancing passenger satisfaction. However, the implementation faces several challenges, such as ensuring system uptime during peak travel hours and mitigating cybersecurity risks that could compromise passenger data or operational integrity. Space constraints for installing kiosks and conveyor systems also pose logistical challenges.
Despite these risks, the system offers significant opportunities for innovation. For instance, integrating mobile applications could enhance passenger engagement by allowing users to track their luggage in real time or pre-check their luggage before arriving at the airport. While the system prioritizes automation, it also ensures that on-site assistance remains available to cater to less tech-savvy passengers, creating a balanced approach to adoption.

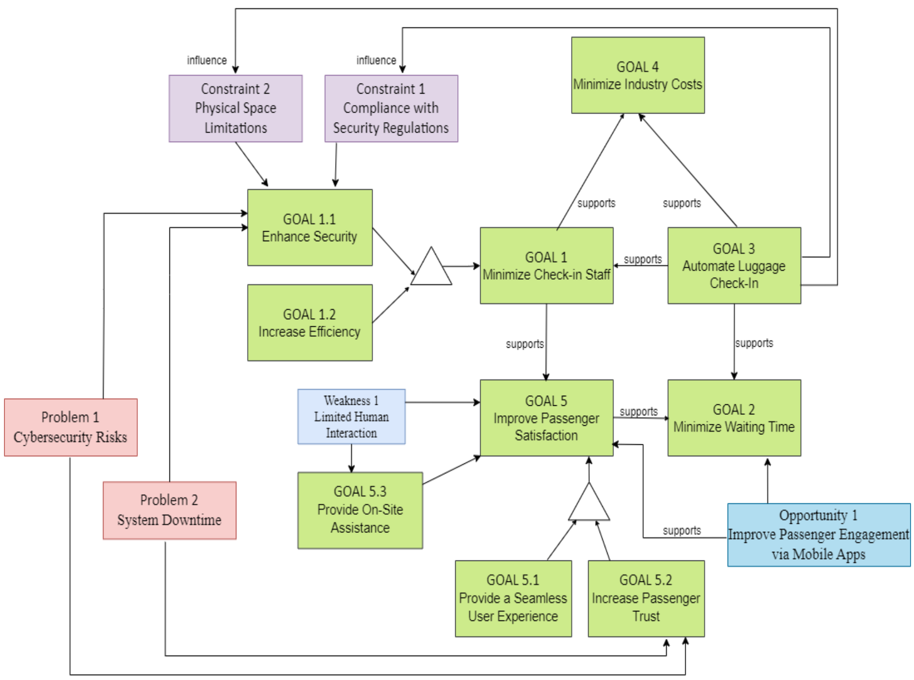

Figure 1: 4EM - Sub-Model Goal

2.2.2 Business Process Sub-Model

The check-in process begins when a passenger approaches the kiosk and selects the check-in option. The kiosk prompts the passenger to input their flight details or scan their boarding pass. Upon verification of the flight information, the kiosk guides the passenger through the luggage check-in process. This involves weighing each piece of luggage, comparing the weight to the allowed limit, and printing luggage tags. Finally, the luggage is scanned and transferred to the conveyor belt for automatic routing to the correct flight.

Passenger Interaction and Information Verification: Initially, the passenger approaches the kiosk and initiates the check-in procedure. The kiosk requests the passenger's flight details, which are verified against an external system. If verification fails, the kiosk displays an error message, prompting the passenger to retry or seek assistance.

Luggage Check-in and Tagging: Once the passenger's flight information is confirmed, the kiosk guides them through the luggage check-in process. The passenger places their luggage on the weighing scale, and the kiosk compares the weight to the allowed limit. If the luggage exceeds this limit, the passenger is notified and given the option to pay for excess luggage. The kiosk then prints luggage tags and instructs the passenger to attach them to their luggage.

Luggage Handling and Routing: After tagging, the luggage is scanned and transferred to the conveyor belt. The conveyor system automatically directs the luggage to the appropriate flight's luggage handling area. Any discrepancies or issues are flagged for manual inspection by a luggage handler or security personnel.

External Processes: The diagram also highlights the involvement of external systems in the process. An external system is utilized to verify the passenger's flight information, while the luggage conveyor system routes the luggage to the appropriate flight based on the tagging information.

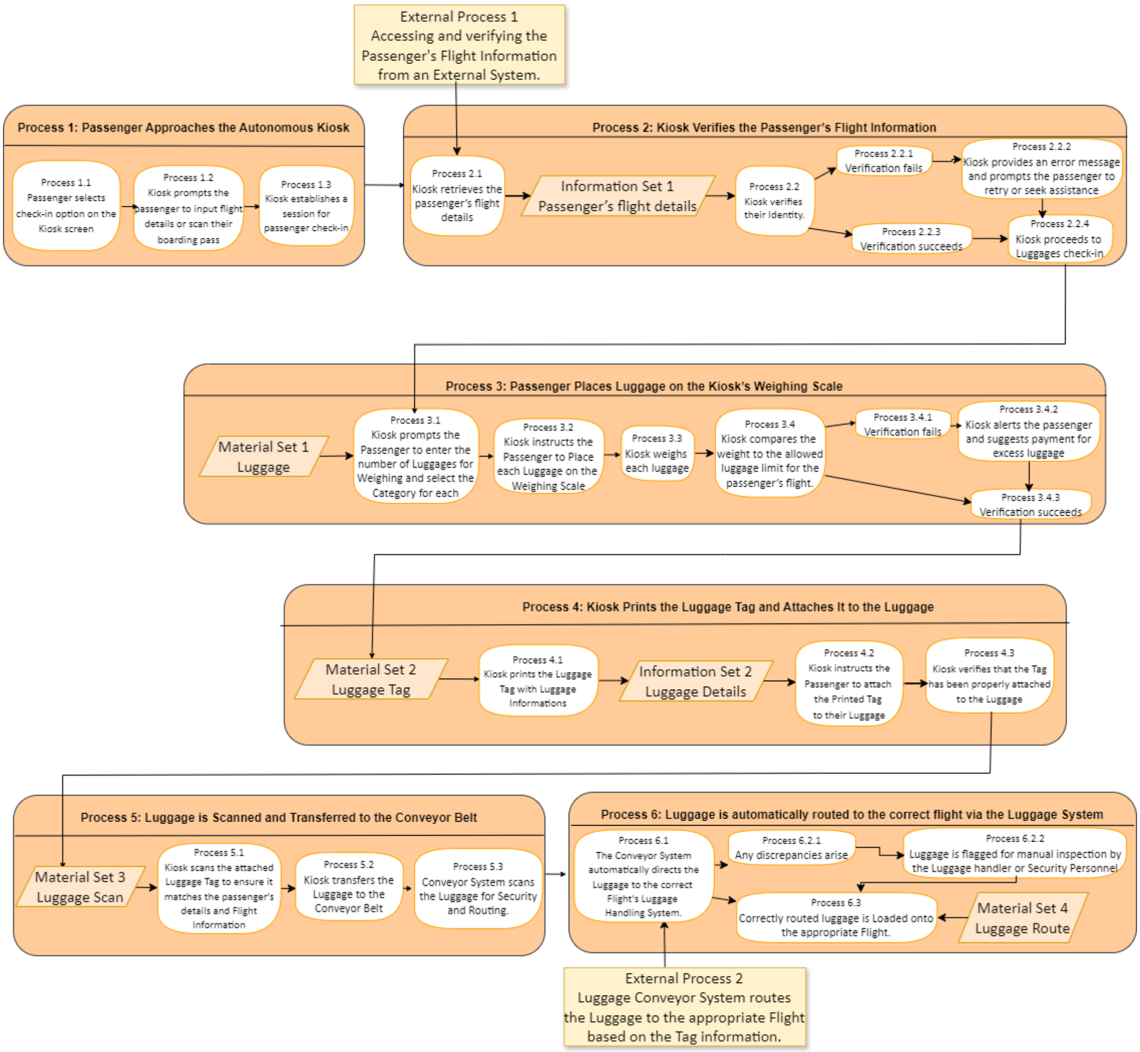

Figure 2: 4EM - Sub-Model Process

2.2.3 Technological Components Sub-Model

This section illustrates an autonomous check-in and luggage handling system designed to streamline airport operations. It comprises four main technical components, each contributing to overall system efficiency.

Autonomous Kiosk System: Serves as the primary user interface, allowing passengers to interact through a touchscreen interface, QR/barcode scanners, and integration with airline databases. This enables real-time retrieval of flight and passenger information, and real-time data processing after complete the procedure that notify the passenger.

Weighing Mechanism: Automates luggage weighing and integrates with payment systems to handle excess luggage fees seamlessly. This component ensures accurate luggage weight recording, allowing passengers to pay for excess fees directly through the system, minimizing the need for manual interventions.

Luggage Handling System: Manages luggage once checked in, featuring a tag printer for labeling, a conveyor belt system for transporting bags, and RFID/barcode scanners to ensure error-free tracking and routing. This system reduces manual handling and improves luggage routing accuracy.
These components are designed to meet key requirements such as real-time information management, automated weighing and payment processing, error-free luggage routing, and high system availability during peak hours. The integration of these systems ensures a seamless, automated experience for both passengers and airport staff, minimizing errors and improving efficiency throughout the check-in and luggage handling process.

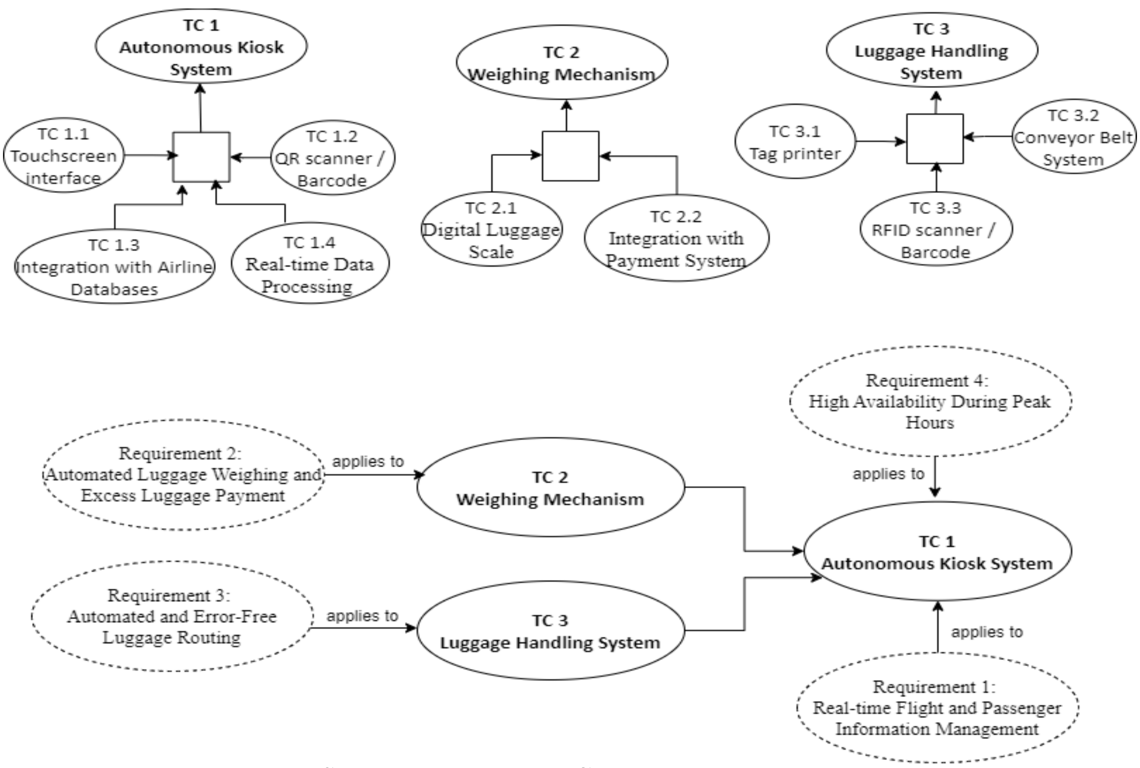

Figure 3: 4EM - Sub-Model Technical Components and Requirements Model

2.2.4 4EM - Enterprise Model

This enterprise model outlines goals, processes, and technical components for an autonomous check-in and luggage handling system. Key objectives include enhanced security, reduced staff involvement, improved efficiency, and shorter wait times. It links these goals to processes like kiosk-based passenger check-ins, luggage weighing, and automatic routing, ensuring regulatory compliance and addressing downtime and cybersecurity risks. Mobile app integration is also explored to boost passenger engagement.

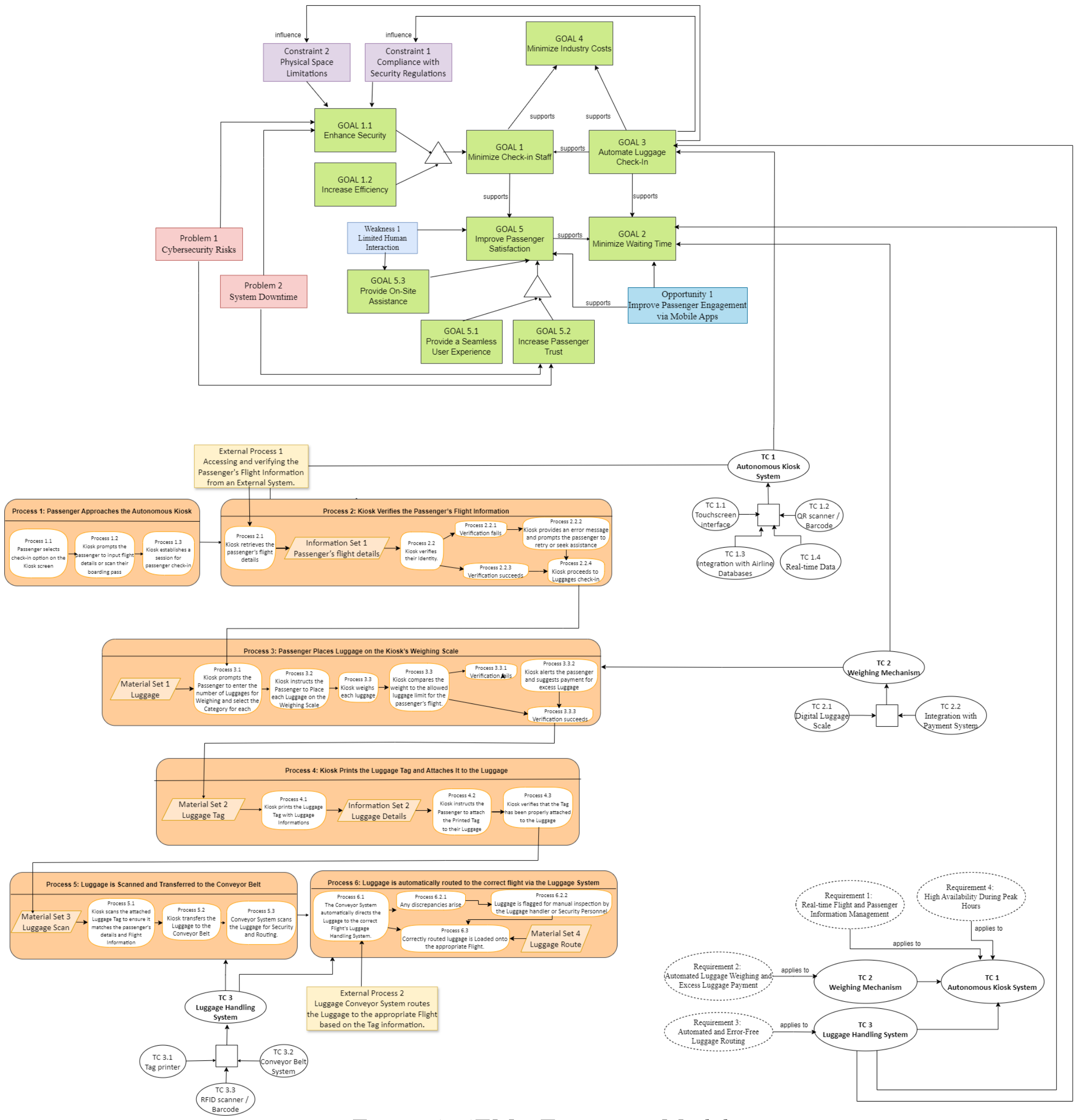

Figure 4: 4EM - Enterprise Model

2.3 ArchiMate

ArchiMate provides a standardized language for describing the structure and functioning of business processes, organizational setups, information flows, IT systems, and technical infrastructures, organized into distinct layers. One of the core principles of ArchiMate is that model structures across these layers are designed to be similar (Lankhorst 2017, p.77). This allows for easy alignment between models from different layers. Like the 4EM framework, the key perspectives in this approach include the motivation view, business process view, and organizational view, which can later be integrated to form a comprehensive enterprise view.

2.3.1 Motivation Layer

The motivation layer emphasizes the driving forces behind the system's development and deployment. The primary motivation lies in automating luggage check-in to enhance operational efficiency, minimize staffing requirements, and reduce passenger waiting times. These goals align with the broader objectives of improving passenger satisfaction and reducing operational costs, both of which are essential in today's competitive aviation industry.
The layer also incorporates strategies to address challenges like physical space constraints and stringent security regulations. Additionally, it underscores the importance of engaging passengers through mobile applications. This innovation fosters real-time interaction, allowing passengers to track their luggage, receive updates, and reduce their perceived waiting time, contributing to an enhanced overall travel experience.

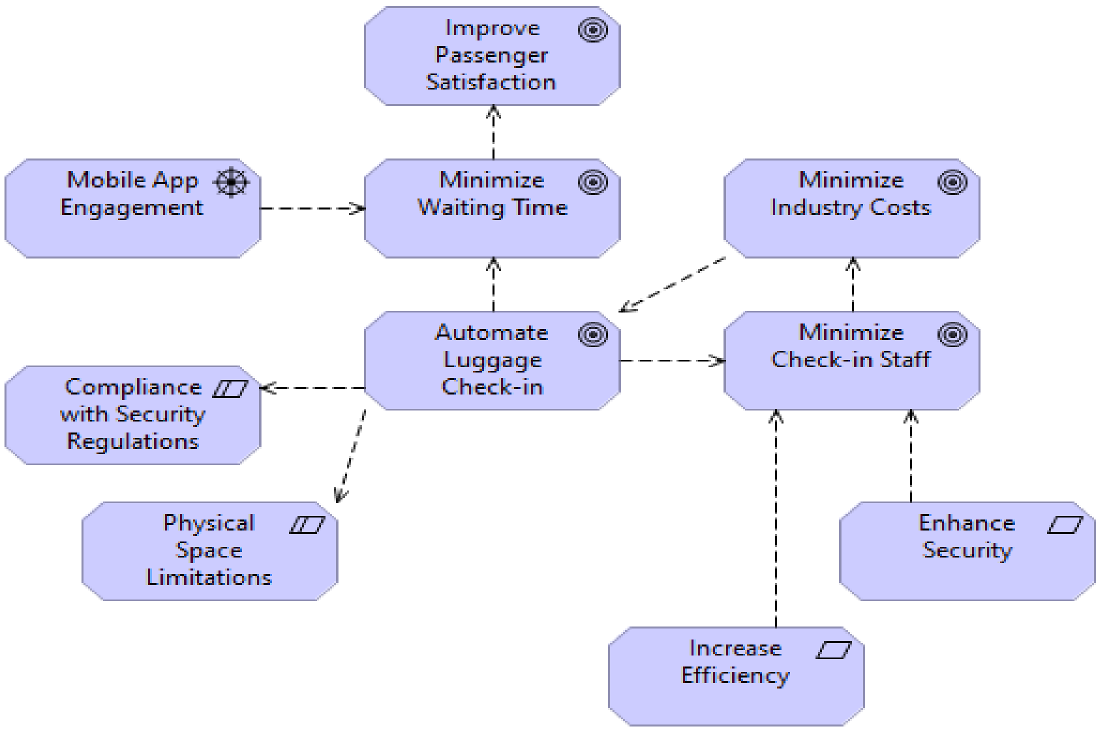

Figure 5: ArchiMate - Sub-Model Motivation Layer

2.3.2 Business Process Layer

The business process layer for the luggage check-in process demonstrates how automation enhances traditional workflows, streamlining efficiency and accuracy.
The process begins with passengers using self-service kiosks to verify their flight details. Passengers can either scan their boarding passes or manually input their flight information. Once the details are validated, the kiosk instructs passengers to place their luggage on an integrated weighing scale. The system calculates the luggage weight and compares it with the airline's allowance, immediately notifying passengers of any excess fees and facilitating payment directly through the kiosk.
After weight verification, the system generates luggage tags equipped with RFID or barcode technology. Passengers attach these tags to their luggage, which is then scanned and directed to the airport's conveyor system. The automated system ensures accurate routing of the luggage to the appropriate flight handling area. If any irregularities are detected, the system flags the luggage for manual inspection by security personnel.
This process showcases the transformative role of automation in reducing manual intervention, minimizing errors, and optimizing the overall check-in experience for passengers and airport staff alike.

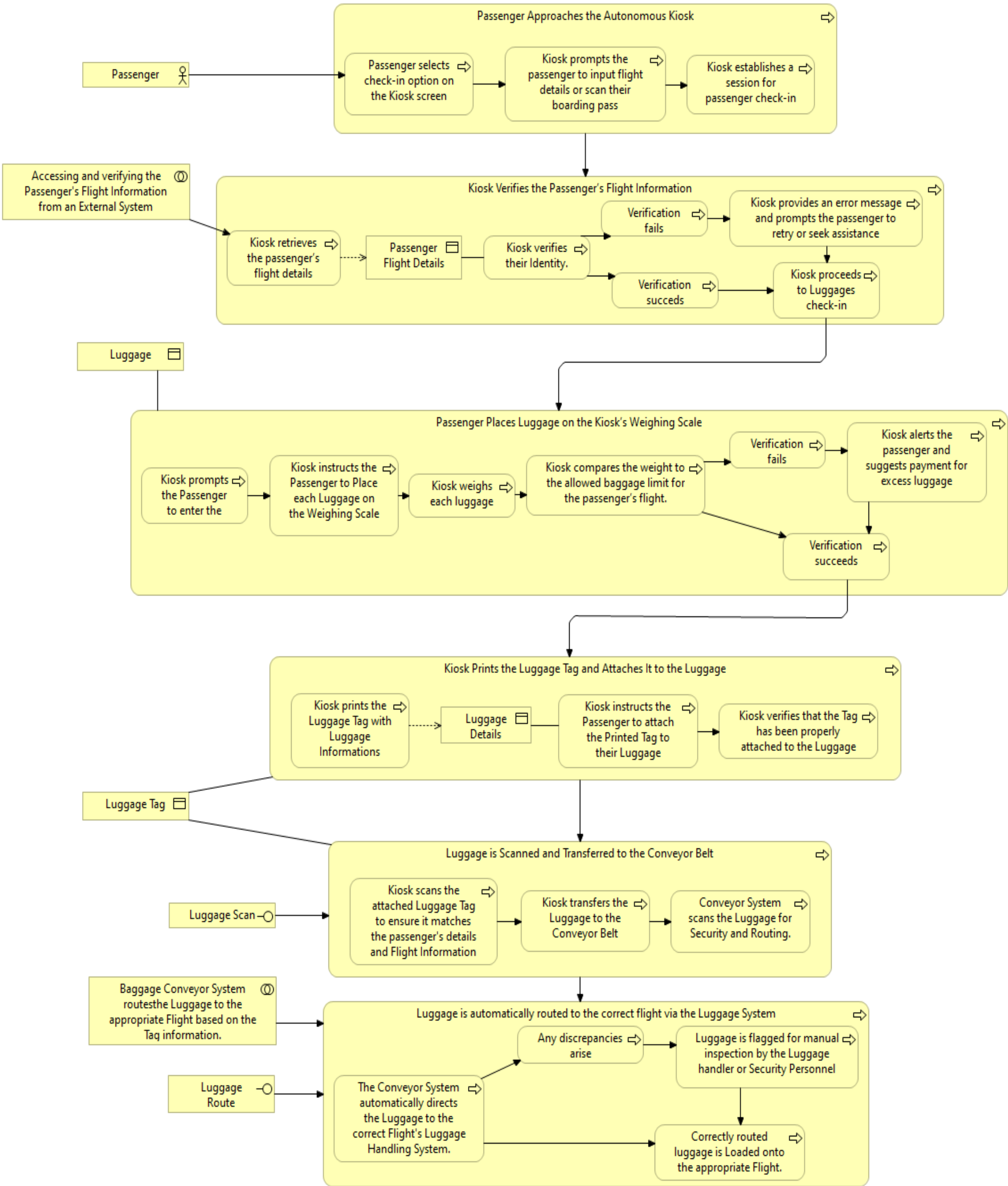

Figure 6: ArchiMate - Sub-Model Business Process Layer

2.3.3 Technology Layer

The technology layer illustrates the architectural foundation of the Autonomous Luggage Check-In System. It details the interconnected components that enable seamless luggage processing, ensuring real-time communication and efficient operations.
At the heart of the system is the Autonomous Kiosk System, which serves as the interface between passengers and the luggage handling infrastructure. The kiosk retrieves passenger and flight data by connecting to airline databases and verification services. It interacts with the Weighing Mechanism, which automates luggage weight assessment, and the RFID/QR Code Scanner, which scans and tracks luggage tags.
Once the luggage is tagged, the Luggage Tagging Service ensures that each tag is encoded with accurate routing data. The tagged luggage is then routed through the Luggage Handling System, which uses advanced conveyor belts and scanning technologies to direct luggage to the correct flight. This process is governed by the Luggage Route Service, which coordinates the movement of luggage in real time.
The system's decentralized architecture ensures robust and efficient operations, minimizing reliance on a central server. This approach not only enhances scalability and fault tolerance but also supports data-driven decision-making across all components.

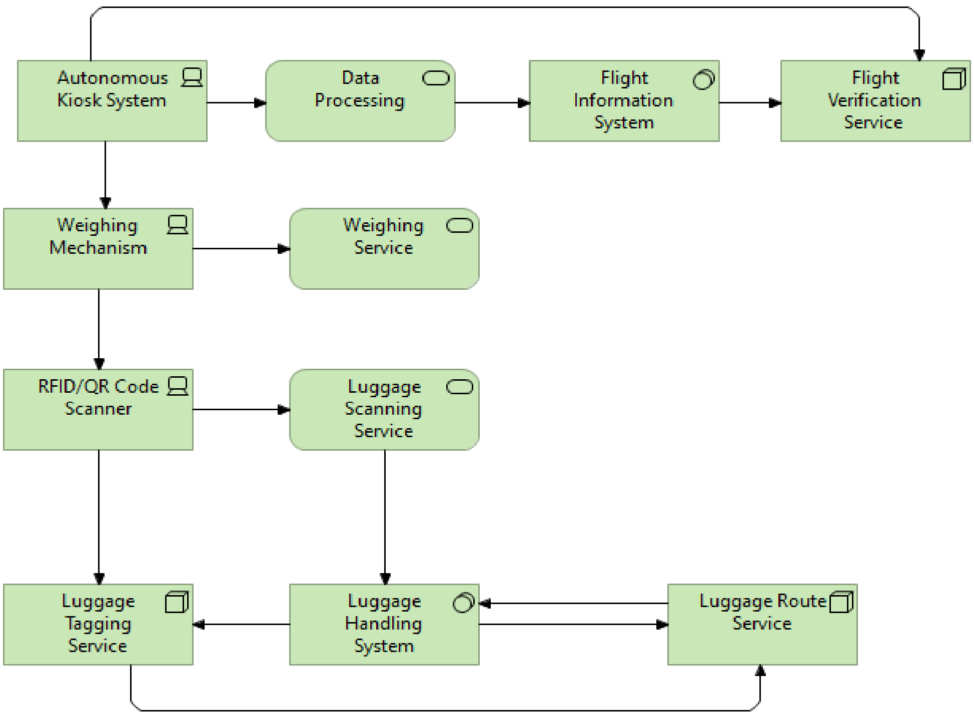

Figure 7: ArchiMate - Sub-Model Technology Layer

2.3.4 ArchiMate - Enterprise Model Layer

The ArchiMate enterprise model provides a layered representation of the Autonomous Luggage Check-In System, encompassing its business, application, technology, and data aspects. Each layer is meticulously crafted to highlight the integration of automated processes, cutting-edge technologies, and passenger-focused solutions.

In the business layer, key processes like check-in, weighing, tagging, and routing are visualized, demonstrating how automation reduces staff involvement while maintaining compliance with security protocols. The application layer emphasizes the role of software systems in facilitating real-time data exchange and decision-making. In the technology layer, the model showcases the infrastructure components, such as kiosks, conveyor belts, and scanning devices, that ensure smooth operations.
The data layer integrates all components by visualizing the flow of information across the system, from passenger inputs at the kiosk to the final routing of luggage. This interconnected structure highlights the system's reliance on data-driven automation, ensuring accuracy and efficiency without the need for centralized control.
By combining these layers, the ArchiMate enterprise model demonstrates the Autonomous Luggage Check-In System's potential to revolutionize luggage handling in the aviation industry. It provides a clear roadmap for integrating automation and IoT technologies, ensuring scalability, resilience, and passenger satisfaction.

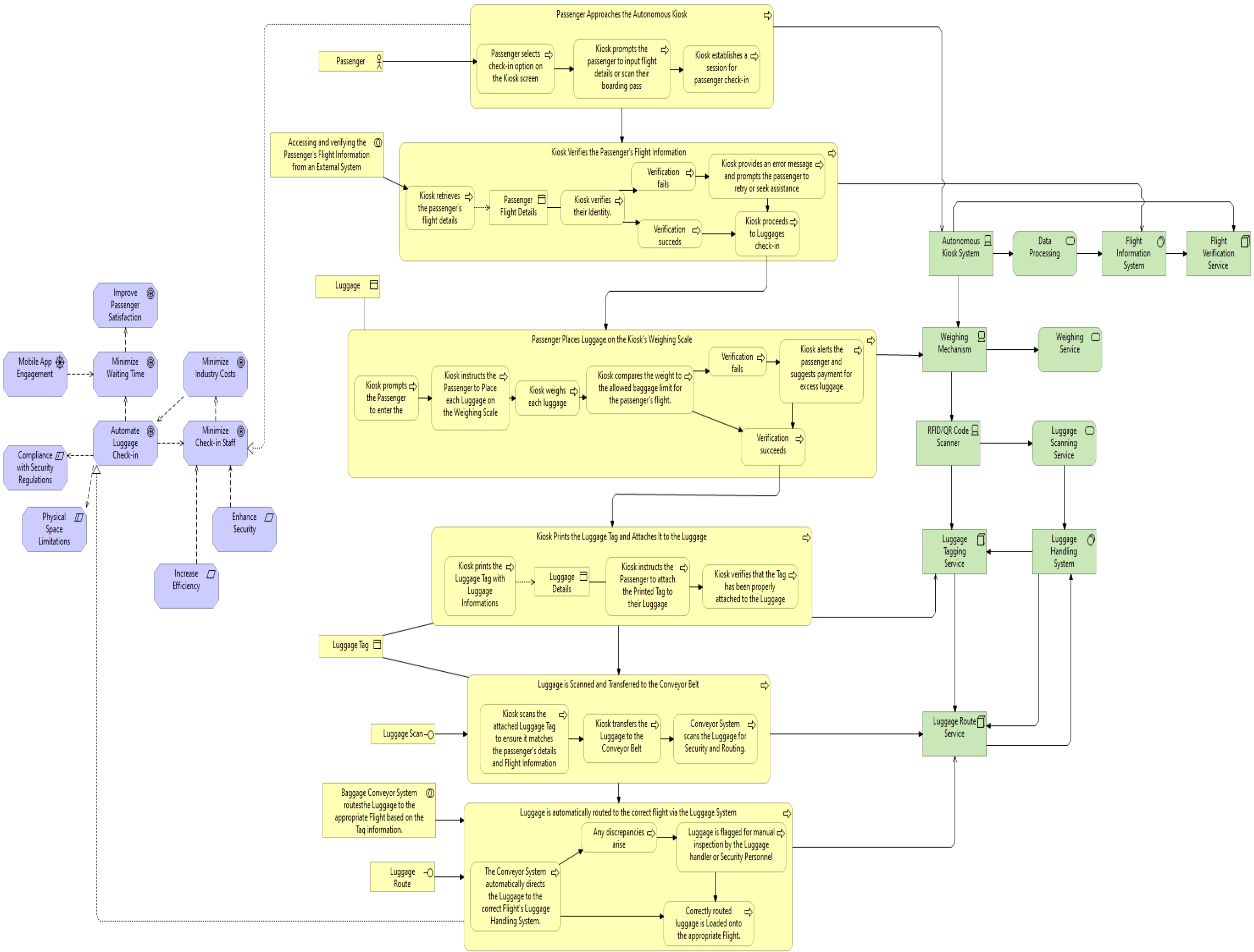

Figure 8: ArchiMate - Model

2.4 Choose of Modeling Tool

For the Autonomous Luggage Check-In System, the 4EM framework emerges as a more appropriate choice due to its ability to align strategic objectives with operational processes and technological elements. Unlike ArchiMate, which focuses heavily on IT infrastructure and its interdependencies, 4EM takes a broader view, integrating both high-level business goals and detailed system functionalities.

4EM excels in linking strategic objectives, processes, and technology through its Goal Sub-Model, which directly aligns with the airline's aims of improving efficiency, reducing wait times, and enhancing customer satisfaction. Its Business Process and Technological Components Sub-Models provide deep insights into how specific operations, like luggage weighing and RFID tracking, interact with the system's underlying technology. This enables a comprehensive understanding of how the system supports both operational efficiency and sustainability goals, such as reducing energy consumption and minimizing waste.

On the other hand, ArchiMate is highly effective at visualizing the technical architecture and the integration of IT components, like kiosks and RFID systems, within the enterprise. However, its layer-based structure can make it difficult to directly link strategic business goals with technology. While ArchiMate excels at managing technical complexity, it lacks the flexibility needed to integrate broader objectives such as innovation and sustainability into the business processes.

In contrast, 4EM offers the flexibility to seamlessly model both business strategy and technology integration, making it the ideal framework for innovations like the Autonomous Luggage Check-In System. In this case, operational efficiency, customer experience, and sustainability are key drivers. Although 4EM may lack some standardization in IT modeling, its comprehensive approach ensures that both the enterprise's strategic goals and technological infrastructure are well-aligned, making it the better choice for driving innovation and sustainability.

2.5 Using the model

The successful operation and expansion of the Autonomous Luggage Check-In System rely on the coordinated efforts of several key stakeholders. Customers, as primary users, require clear and accessible instructions to guide them through the process, ensuring that each step of the check-in procedure is intuitive and minimizes confusion. This ease of use not only improves the passenger experience but also enhances overall efficiency. Airline employees play a vital role by being adequately trained to assist customers, addressing issues with the kiosks or providing guidance during the check-in process. Their expertise ensures a seamless experience for passengers, particularly during unexpected technical difficulties or first-time use of the system.

Kiosk staff serve as a bridge between the technology and the users, offering real-time assistance to passengers who encounter difficulties. Their familiarity with the system allows them to troubleshoot issues efficiently and maintain smooth operations, which is crucial during peak travel times. Aviation companies, meanwhile, are pivotal in scaling the system. By promoting its adoption among airlines and airport operators worldwide, they drive the broader implementation of the innovation. This global expansion not only streamlines operations across multiple airports but also enhances the passenger experience by reducing waiting times, improving system efficiency, and easing congestion.

To support its scalability and adaptability, the goal model must identify and address the system's strengths, weaknesses, and challenges. This includes pinpointing areas for improvement, such as integrating the system into existing airport infrastructures or mitigating potential technical issues during large-scale implementations. Such proactive identification can guide strategic enhancements and encourage collaboration with IT companies to refine the system's performance.

The process model is equally critical, capturing every stage of the passenger's journey within the system. It must highlight areas where airport staff add value, especially at points where customers might encounter obstacles. External contributions, such as robust IT database management and efficient system updates, are also essential to ensure the kiosks operate seamlessly. Identifying and managing potential bottlenecks or disruptions in the process further strengthens the system's reliability and consistency.

From a technological perspective, the components model must address the infrastructure necessary to implement the system across airports. This includes an evaluation of costs, maintenance requirements, and dependencies on external systems. For instance, reliance on a central server to manage data across airports introduces risks such as potential server downtime, which must be mitigated through redundancy and robust design. The model must also incorporate critical components like RFID tags, kiosks, weighing mechanisms, and conveyor belts, ensuring their integration supports smooth operations. Additionally, effective management of mobile apps and tracking systems is vital to provide real-time updates to passengers and maintain the system's overall functionality.

In summary, the Autonomous Luggage Check-In System's success hinges on a collaborative and comprehensive approach. Clear and customer-friendly instructions, well-trained airline and kiosk staff, a strategic vision for global expansion, and a robust understanding of the system's technological and operational requirements are all essential. By addressing these factors cohesively, the system can deliver on its promise of enhancing efficiency, reducing congestion, and elevating the passenger experience in airports worldwide.

2.6 Evaluate the model

G: The Goals of the Modeling

The primary goals of the modeling process for the Autonomous Luggage Check-In System are to enhance operational efficiency, improve security, reduce staffing needs, enhance customer satisfaction, and achieve global scalability. The system aims to automate the check-in and luggage handling process, thereby reducing passenger waiting times and minimizing the reliance on airport staff. It also seeks to adhere to necessary airport security protocols, minimizing human error, and ensuring compliance. By automating routine tasks, the system will allow airport employees to focus on more critical tasks such as handling exceptions and preparing flights. Ultimately, the goal is to provide passengers with a smoother, quicker, and more intuitive experience, making their time at the airport more pleasant. Additionally, the system is designed to be scalable, supporting deployment across multiple airports globally with consistent and efficient operations.

L: What Can Be Expressed in the Modeling Language

The modeling language, specifically 4EM and ArchiMate, is capable of expressing several aspects of the Autonomous Luggage Check-In System. It can represent the strategic goals and objectives of the system, such as enhancing operational efficiency, improving security, and ensuring customer satisfaction. These goals are captured through the Goal Sub-Model in 4EM and the Motivation Layer in ArchiMate. The language can also represent the business processes involved in the check-in process, detailing how passengers interact with kiosks, input flight information, weigh luggage, print tags, and route luggage to the appropriate conveyor belt. Furthermore, it can describe the technological infrastructure of the system, including kiosks, RFID scanners, weighing mechanisms, and conveyor belts, as well as how these components work together to automate the process. Additionally, the modeling language captures the interactions between various actors such as passengers, airline employees, and IT professionals, outlining their roles and responsibilities within the system.

M: What Is Expressed in the Model

The model expresses the alignment between the system's operational processes and its strategic business goals. It shows how objectives like improved efficiency and customer satisfaction are supported by the design of the system. The model visualizes the operational workflow, detailing the sequence of events in the check-in process, including passenger interactions with kiosks, luggage weighing and tagging, and the automatic routing of luggage for security and flight handling. It also demonstrates the integration of technological components like kiosks, weighing systems, and conveyor belts, which work together to ensure smooth luggage handling and minimize errors. Moreover, the model expresses the roles and responsibilities of stakeholders, from passengers using kiosks to airline staff assisting with troubleshooting and IT professionals maintaining the system.

A: What Actors That Develop or Have to Relate to the Model Have Access to

Different actors involved in the system's development and operation have access to various aspects of the model. Airport authorities use the model to ensure compliance with local regulations and to manage system deployment across different airport locations. Airline employees interact with the model primarily in terms of assisting passengers, troubleshooting issues, and ensuring the system runs smoothly during check-in. IT professionals focus on the system's technical components, ensuring its integration with existing infrastructure and operational efficiency. Passengers access the system's user interface, such as kiosks, to check in, input flight details, weigh luggage, print tags, and complete the check-in process.

D: What Can Be Expressed About the Domain (Area of Interest) Which Is Relevant to Achieve G (The Goals of Modeling)

The domain of airport and airline operations is expressed in the model through various elements relevant to achieving the goals. The operational workflow of the system is central, optimizing the check-in process from passenger interaction with kiosks to the automated handling of luggage, directly supporting goals like efficiency and reduced wait times. The system also addresses security protocols, ensuring that luggage is tagged, scanned, and routed correctly, which aligns with the goal of improved security. The integration of technologies such as RFID for tracking luggage and automated weighing mechanisms also plays a key role in achieving operational efficiency. Finally, the model addresses the customer experience, improving passenger satisfaction by minimizing confusion, reducing waiting times, and offering clear instructions throughout the process.

K: The Explicit Knowledge of the Participating Persons About the Domain D

The participating individuals in the development and operation of the system possess a range of relevant knowledge. Airport operations professionals understand the flow of passengers, luggage, and cargo, including the necessary security protocols and handling procedures. IT professionals and system integrators have technical expertise in how components like RFID systems, kiosks, and conveyor belts function and can be integrated into existing airport infrastructures. Stakeholders, including airline management, are knowledgeable about the strategic business objectives, such as improving customer experience, reducing operational costs, and enhancing service delivery. Additionally, the team involved in developing the system is familiar with the technical specifications, system integration requirements, and performance criteria necessary for the system's success.

I: What the Participating Persons Interpret the Model to Express

The participants interpret the model as a representation of the alignment between strategic objectives and operational processes. They understand that the system's design supports overarching business goals, such as improving efficiency, security, and customer satisfaction. The model is also seen as a detailed depiction of the steps involved in the check-in and luggage handling process, highlighting how luggage is processed safely and efficiently. Additionally, the model is interpreted as demonstrating how technological components work together to automate the check-in process, improving accuracy and speed. The model also clarifies the roles of both staff and passengers, illustrating how staff assist passengers and how passengers are expected to use the system.

T: What Relevant Tools Interpret the Model to Express

Several tools are used to interpret and implement the model. Modeling tools like ArchiMate and 4EM are used to create, visualize, and modify the model, enabling stakeholders to express the structure of goals, processes, and technology within the system. Simulation tools help test how the system performs under various scenarios, ensuring its robustness and reliability, especially during peak passenger times or technical failures. Data analysis tools interpret the data produced by the system, such as check-in times and luggage handling performance, providing insights for system optimization. Finally, project management tools are essential for managing the deployment, maintenance, and scaling of the system, ensuring alignment with project timelines, resources, and budgets.

3 Open Service Innovation and Service Design

3.1 Customer Journey

The customer journey for check-in and luggage handling at airports can differ significantly based on whether a traditional check-in system or an autonomous check-in system is in place. This section examines the distinctions between these two approaches, beginning with the conventional check-in process and transitioning to the more efficient and technology-driven autonomous system. The accompanying diagram provides a comprehensive overview of the customer journey under both systems, detailing key stages from flight booking to luggage collection at the destination airport.

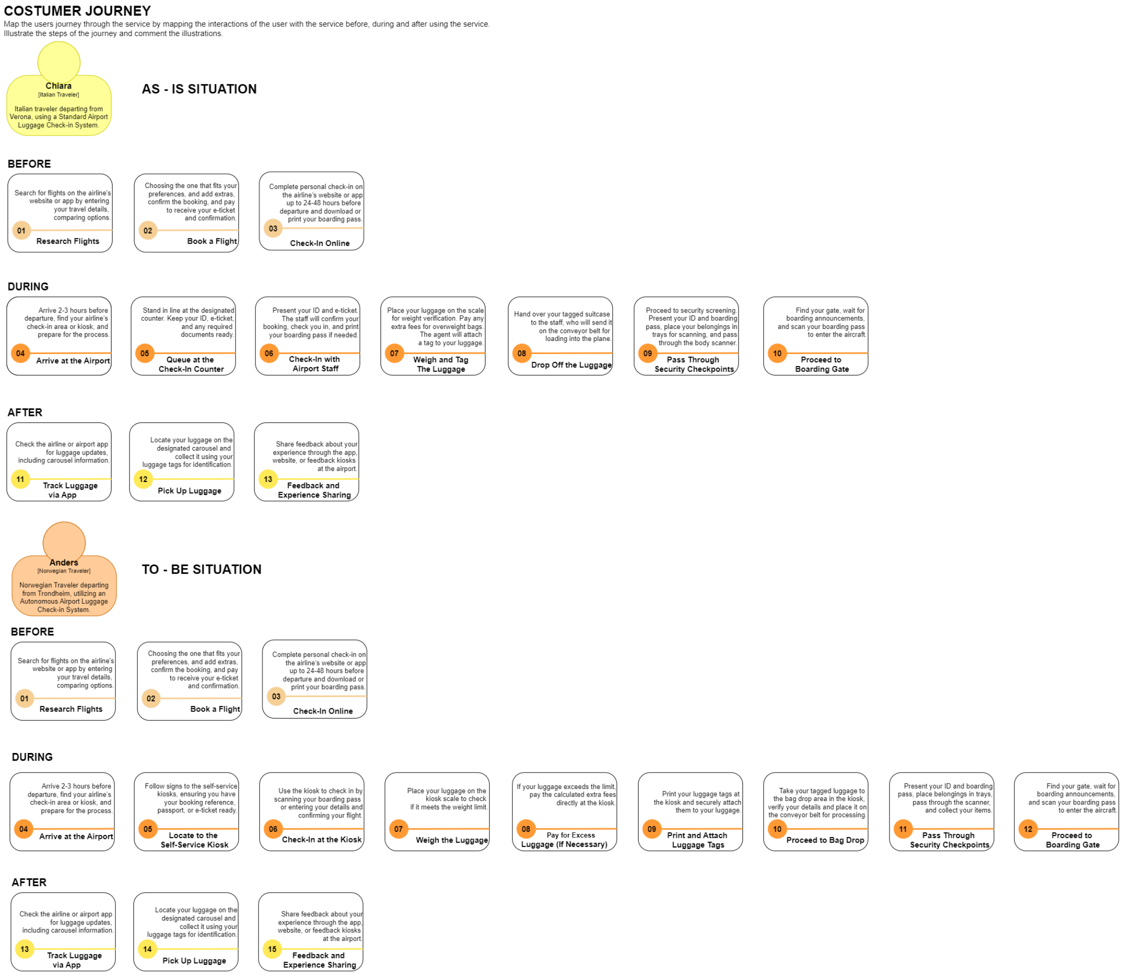

Figure 9: Customer Journey

3.1.1 AS - IS Situation: Traditional Check-in Luggage System

Before the Flight

Search for Flights Online: Passengers start their journey by researching flight options online. They look for flights based on various criteria like price, flight schedule, and airline. They often use websites, apps, or third-party aggregators to compare flight offers across multiple airlines and platforms. This step generally takes place in the comfort of the customer's home or office.
Compare Prices and Airlines: Customers compare the different airlines, flight schedules, and prices. Many travelers may also check for promotions or discounts that can influence their decision. The goal is to find the best deal within their preferred travel time frame and budget.
Book the Flight: After selecting the flight, customers proceed to book the tickets. Booking can be done directly through the airline's website, a travel agent, or a third-party booking service. Once booked, the customer receives a confirmation email, which includes essential travel information, a booking reference, and sometimes a digital or physical ticket.

During the Flight

Arrive at the Airport: On the day of travel, passengers arrive at the airport with adequate time to go through the check-in process. Depending on the airport's size, passenger volume, and the time of day, this can involve navigating through various terminals or security areas.
Queue at the Check-in Counter: In the traditional check-in process, passengers must stand in line at the airline's check-in counter. These counters are typically staffed by airline personnel who assist passengers with ticketing, luggage handling, and checking identification. This part of the process can be time-consuming, especially during peak travel seasons or at busy airports.
Check-in with Airport Staff: When it's the passenger's turn at the counter, they present their identification (e.g., passport or ID) and their flight details. The airline staff checks the travel documents, verifies the flight reservation, and confirms seat preferences. If the passenger has checked luggage, it is weighed, tagged, and processed by the airline personnel.
Weigh and Tag the Luggage: The staff manually weighs each checked piece of luggage to ensure it complies with the airline's weight restrictions. If the luggage exceeds the allowed weight, the passenger is charged for excess luggage. The staff then attaches a luggage tag that includes important information like the destination airport and flight number. This process involves handling the luggage directly.
Drop Off the Luggage: Once tagged, the checked luggage is handed over to the airline personnel. The staff then sends the luggage to be scanned and transported to the correct aircraft for loading. This step involves significant staff interaction and takes time for each passenger.
Pass Through Security Checkpoints: After completing check-in, passengers move to the security checkpoint. This involves presenting travel documents and passing through metal detectors, as well as having their carry-on luggage scanned by an X-ray machine. Security processes may involve waiting in line, and the time spent here depends on the airport and time of day.
Proceed to the Boarding Gate: Once through security, passengers can proceed to the designated boarding gate. Depending on the size of the airport and the availability of seating, this part of the journey may involve additional walking, waiting, and sometimes more checks before being allowed to board the flight.

After the Flight

Board the Flight: Once at the gate, passengers present their boarding pass for scanning and pass through the boarding process. Flight attendants assist passengers in locating their seats on the plane.

Arrive at the Destination Airport: Upon landing, passengers disembark the aircraft and head to luggage claim. In international airports, this may include going through customs and passport control before heading to the luggage area.
Collect Luggage from the luggage Carousel: After passing through customs (if applicable), passengers collect their checked luggage from the luggage carousel. This process can sometimes take a while, as bags are unloaded and transported to the carousel in batches. Passengers must identify their bags among the many others on the carousel.
Exit the Airport: Finally, once their bags are collected, passengers exit the airport. This marks the end of the check-in process. At this point, travelers can either continue their journey or head home.

3.1.2 TO - BE Situation: Autonomous Check-in Luggage System

Before the Flight

Search for Flights Online: The initial steps of searching for flights, comparing airlines, and booking remain largely the same. Customers continue to make their decisions based on similar criteria like price, schedule, and personal preferences.
Compare Prices and Airlines: Passengers still compare available flights across multiple platforms to find the best option before booking.
Book the Flight: Customers proceed to book their flight through the airline's website or a third-party service, just like in the traditional process. After booking, they receive an e-ticket or confirmation with the booking details.

During the Flight

Arrive at the Airport: Passengers arrive at the airport and are ready to check in. While the process is largely the same, passengers will now have additional options for self-service check-in.
Locate the Self-Service Kiosk: Instead of proceeding to a staffed counter, passengers locate a self-service kiosk. These kiosks are strategically placed in airports to ensure that travelers can quickly find them. Some airports offer kiosks throughout the terminal, reducing congestion at check-in counters.
Check-in at the Kiosk: At the kiosk, passengers input their details (e.g., booking reference, passport number) to verify their identity. The system confirms seat availability, processes the check-in, and updates the passenger's flight status. This eliminates the need for a customer service agent in most cases.
Weigh the Luggage: The kiosk includes a built-in luggage scale. The passenger places their checked luggage on the scale to determine if it meets the airline's weight allowance. If the luggage exceeds the limit, the kiosk will prompt the passenger to pay for excess luggage directly through the system.
Pay for Excess Luggage (if Necessary): If the luggage exceeds the weight limit, the passenger is prompted to pay the additional charges via the kiosk's payment system. This step is handled autonomously, meaning no interaction with airline staff is required.
Print and Attach Luggage Tags: Once the luggage is weighed and excess fees are paid (if applicable), the kiosk prints luggage tags. Passengers must attach these tags to their checked luggage themselves, reducing reliance on staff assistance. The tag includes crucial information such as the destination airport and flight number.
Proceed to Bag Drop: After tagging the luggage, passengers proceed to the automated bag drop area. These self-service stations automatically verify the luggage tag, scan the bag, and confirm that it is ready for transport. The luggage is then sent to be screened and transferred to the correct aircraft, all without requiring staff assistance.

Pass Through Security Checkpoints: After completing the autonomous check-in process, passengers proceed through security, just like in the traditional process. Depending on the airport, security may be more streamlined, as more passengers may have already completed their check-in through kiosks, reducing wait times.
Proceed to the Boarding Gate: Once cleared through security, passengers head to the boarding gate. With the self-check-in process having sped up their earlier steps, they may have more time to relax before boarding.

After the Flight

Board the Flight: After presenting their boarding pass at the gate, passengers board the flight in the usual manner.
Arrive at the Destination Airport: Upon arrival, passengers head to luggage claim as usual. There is no major change here, as the autonomous check-in process only affects the pre-flight and boarding phases.
Collect Luggage from the luggage Carousel: Passengers collect their checked luggage from the carousel in the same way as with the traditional process. However, the luggage handling on the airline's side may be more automated and efficient, allowing for quicker delivery to the carousel.
Exit the Airport: After retrieving their luggage, passengers exit the airport, having experienced a more efficient check-in and luggage drop process than with traditional methods.

Future Innovation: Internal Central System Server

The airline industry can significantly benefit from creating an internal central system server that integrates key functions like check-in, baggage handling, and security into one platform. This system would streamline operations, enhance communication across departments, and improve the passenger experience.
Cost Reduction: By automating processes and reducing manual tasks, airlines can lower labor costs and optimize resource allocation, making operations more cost-efficient.
Improved Customer Satisfaction: The system would provide real-time updates, faster check-ins, and smoother baggage handling, reducing wait times and offering personalized services, improving the overall travel experience.
Optimized Staff Operations: The system can automate routine tasks and dynamically adjust staffing based on real-time data, ensuring optimal coverage during peak travel times.
Data Security: A centralized system allows airlines to quickly adopt the latest security measures, protecting customer data from cyber threats and ensuring compliance with regulations, maintaining trust in a digital world.

3.2 Blueprint

Lines of Differentiation

The service blueprint employs key lines of differentiation to distinguish between various components and interactions in the service process. These lines provide clarity on the roles of customers, frontstage operations, backstage processes, and support systems, ensuring a seamless and efficient service delivery. Below is an explanation of the three primary lines of differentiation:

Line of Interaction

The Line of Interaction separates the actions taken by customers from visible service interactions. This line highlights the points where passengers engage directly with the service, such as interacting with self-service kiosks. While passengers may experience the outcomes of certain processes (e.g., paying excess luggage fees), they do not directly engage with backend systems or algorithms handling these operations.

Line of Visibility

The Line of Visibility differentiates visible, customer-facing operations from the backstage processes that support them. For example, passengers can observe and interact with the self-service kiosks and assistance counters but remain unaware of invisible systems like weight-check algorithms or tag-printing mechanisms that enable these interactions.

Line of Internal Interaction

The Line of Internal Interaction delineates backstage interactions from support processes that ensure the service's operational reliability. While backstage interactions involve processes such as RFID tracking and luggage tagging, support processes include system monitoring, kiosk maintenance, and error resolution, which remain entirely hidden from passengers.
This are divided into 5 lanes as below:

Physical/Online Evidence

This lane represents all visible elements of the system that passengers interact with or observe during their journey. These touchpoints guide passengers through the service process, such as the airline website/app, boarding passes, airport signage, self-service kiosks, real-time luggage tracking apps, and feedback portals.

Customer Actions

This lane maps every step passengers take throughout their journey, from researching flights and booking tickets to providing post-experience feedback. These actions are central to the passenger's experience, including locating kiosks, checking in, weighing luggage, and boarding the flight.

Frontstage Interactions

This lane highlights visible interactions passengers have with service personnel or technology. It includes interactions with self-service kiosks, assistance counters, and security scanning procedures.

Backstage Interactions

This lane focuses on the essential processes and systems that passengers do not see but which are crucial to service delivery. These include weight check algorithms, kiosk fee systems, RFID/barcode systems, and tag printing mechanisms.

Support Processes and Systems

This lane ensures the smooth operation of all other components. It includes system monitoring, maintenance of kiosks and scales, error handling, real-time data integration, and lost/delayed luggage processes that keep the service running efficiently and seamlessly.
The service process involves multiple steps that guide passengers from pre-travel preparations to post-experience feedback. Each stage is designed to enhance efficiency, minimize effort, and ensure a seamless travel experience. The process is divided into various lanes, each representing a specific category of actions, interactions, and systems that contribute to the overall experience. Below is a detailed explanation of each step and how it relates to the lanes.

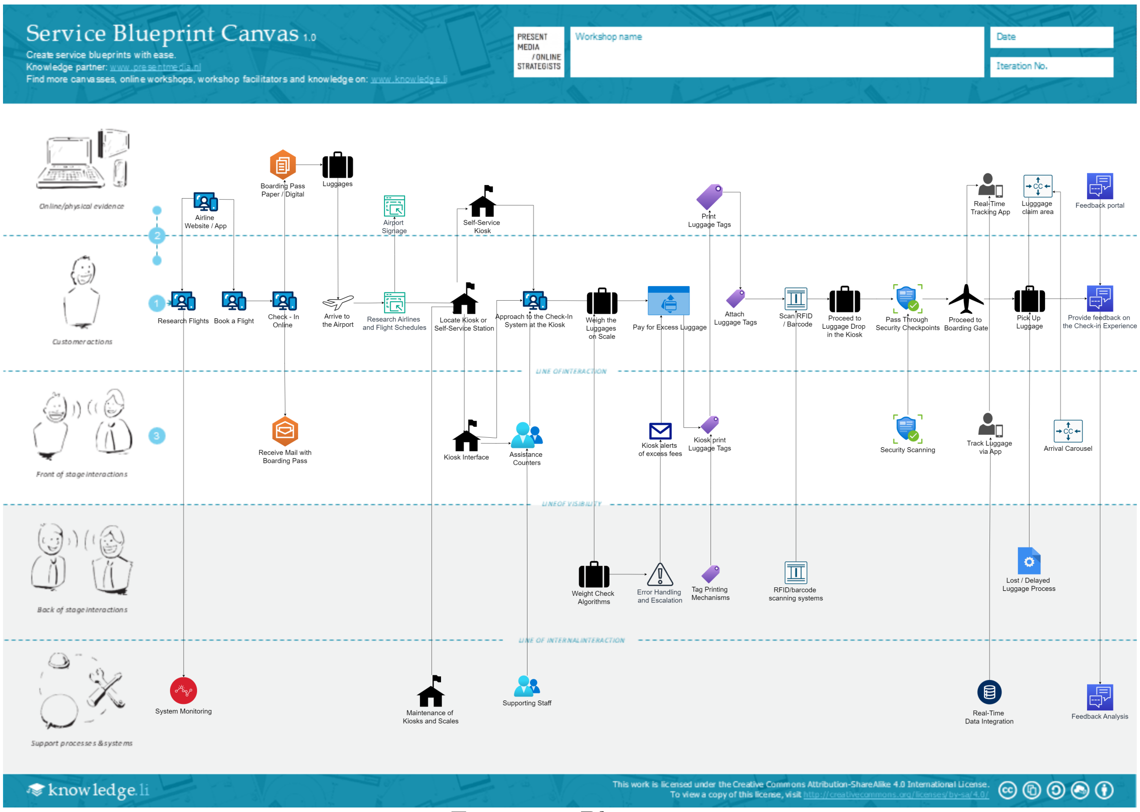

Figure 10: Blueprint

3.2.1 Pre-Travel Activities

Research Flights

Customer Actions: Passengers compare airlines, routes, and pricing on airline websites or apps, helping them make informed decisions.
Physical/Online Evidence: Passengers interact with the airline website or app to gather information about flight options. This platform serves as the starting point for research, offering digital resources for comparisons.

Book Flights

Customer Actions: Once a flight is chosen, passengers confirm their bookings and receive tickets electronically. This may include adding optional services like additional luggage or preferred seating.
Physical/Online Evidence: The airline website/app generates the booking confirmation and electronic tickets, which are delivered via email or within the app.

Check-In Online

Customer Actions: If available, passengers complete online check-in, providing their travel details and receiving a digital boarding pass via email or app.
Physical/Online Evidence: The digital boarding pass sent through the airline's website or app serves as the key evidence of the passenger's check-in, which they carry with them to the airport.

3.2.2 Airport Arrival and Check-In

Arrival at Airport

Customer Actions: Upon arrival at the airport, passengers use signage or digital tools to locate the check-in area or self-service kiosks.
Physical/Online Evidence: Airport signage, both physical and digital, directs passengers to check-in areas, kiosks, or customer service desks.

Locate Kiosk

Customer Actions: Passengers find the self-service kiosks, which help them complete the check-in process.
Physical/Online Evidence: Self-service kiosks are clearly visible and are located near the entrance or check-in zones, allowing passengers to independently manage their check-in.

Use Kiosk

Customer Actions: Passengers interact with the self-service kiosk interface to check-in, verify personal details, and make any additional selections.
Frontstage Interactions: Passengers interact with the kiosk's digital screens to complete their check-in, print luggage tags, and pay for excess luggage.
Backstage Interactions: The kiosk system verifies the passenger's information, integrates with flight databases, and ensures the details are accurate.

Weigh Luggage and Pay Fees

Customer Actions: Passengers place their luggage on the connected scales for automated weight measurement. If the luggage exceeds the allowed weight, they make an excess luggage payment.
Frontstage Interactions: The kiosk displays luggage weight and prompts the passenger to pay any excess luggage fees.
Backstage Interactions: Weight check algorithms calculate the excess luggage fees based on the weight of the luggage and integrate with payment systems to facilitate payment.

Tag Luggage

Customer Actions: After paying any necessary fees, passengers print luggage tags, which they then attach to their bags.
Frontstage Interactions: Passengers use the kiosk to print tags with their flight details, which they then attach to their checked luggage.
Backstage Interactions: The tag printing mechanism retrieves flight and luggage data, ensuring that the correct tags are printed with accurate information.

3.2.3 Luggage Processing and Security

RFID/Barcode Registration

Customer Actions: Tagged luggage is scanned at drop-off points, allowing the system to register the luggage and initiate tracking.
Frontstage Interactions: Passengers observe as their tagged luggage is scanned by the system at the drop-off area.
Backstage Interactions: RFID and barcode systems track the luggage as it moves through the airport, allowing the system to update its location in real-time.

Security Clearance

Customer Actions: Passengers proceed through security while the system tracks their luggage.
Frontstage Interactions: Security personnel scan carry-on luggage for safety checks, while passengers clear security.
Backstage Interactions: The luggage's movement is continuously tracked by the system through security checkpoints to ensure it complies with safety regulations.

3.2.4 Boarding and Arrival

Board Flight

Customer Actions: After clearing security, passengers proceed to the boarding gate, where they present their boarding passes for scanning before boarding the aircraft.
Physical/Online Evidence: Passengers present their digital or paper boarding passes for scanning at the boarding gate.

Track Luggage

Customer Actions: Passengers can track the status of their checked luggage via a real-time tracking app, reducing anxiety about their luggage during the flight.
Physical/Online Evidence: The real-time luggage tracking app provides passengers with continuous updates about their luggage's location.

Retrieve Luggage

Customer Actions: Upon arrival at their destination, passengers go to the luggage claim area to retrieve their checked luggage.
Physical/Online Evidence: luggage carousels and signage at the destination airport help passengers locate their luggage.

Issue Resolution

Customer Actions: If there are issues such as lost, delayed, or damaged luggage, passengers can report these problems to the airline's support services.
Frontstage Interactions: Assistance counters or customer service personnel are available to assist passengers in locating or resolving issues with their luggage.
Backstage Interactions: The system helps locate and track delayed or lost luggage, ensuring real-time updates are sent to both passengers and airport staff.

3.2.5 Post-Experience Feedback

Provide Feedback

Customer Actions: After completing their journey, passengers are encouraged to provide feedback on their overall experience using digital feedback portals.
Physical/Online Evidence: The feedback portal, available through the airline's website or app, collects data from passengers to assess service quality.
Support Processes and Systems: Airlines analyze the collected feedback to identify areas for improvement and enhance future customer experiences.

3.3 Reflections

The transition to autonomous check-in and luggage handling systems represents a transformative leap in the airline industry, with notable benefits in customer experience, operational efficiency, and technological innovation. This section reflects on the impact and implications of these changes, offering insights into their advantages and challenges.

Enhanced Customer Experience and Empowerment

Autonomous systems empower passengers by introducing self-service kiosks for tasks such as check-in, luggage tagging, and payment for excess baggage. These systems significantly reduce waiting times and provide travelers with greater control over their journey, fostering a sense of independence and convenience. The integration of real-time luggage tracking further enhances the passenger experience by offering peace of mind and transparency about the status of their belongings. These advancements collectively create a smoother, faster, and more satisfying travel experience, especially during peak travel periods.

Improved Operational Efficiency

From an operational perspective, automation streamlines key processes, such as luggage weighing, tag printing, and baggage drop-off, reducing reliance on manual interventions. This allows staff to focus on complex or high-touch tasks, such as assisting travelers with special needs or resolving issues. Additionally, automated systems minimize errors in luggage handling and accelerate passenger processing, resulting in reduced labor costs and improved resource allocation. Technologies such as RFID tracking and automated bag drop systems further enhance speed, accuracy, and overall efficiency in baggage logistics.

Seamless Technology Integration and Scalability

The autonomous system exemplifies the successful integration of various technologies, including self-service kiosks, real-time data analytics, and automated baggage handling. This interconnected approach ensures smooth operations and scalability, enabling airlines and airports to adapt to increased passenger volumes or accommodate future innovations. The system's modular design allows it to be expanded or upgraded with minimal disruption, making it a sustainable solution for the evolving needs of the airline industry.

Challenges and Human-Centered Considerations

While the benefits of automation are clear, certain challenges must be addressed. System malfunctions or technical failures could lead to delays, creating potential bottlenecks during high-traffic periods. Additionally, some passengers—such as those unfamiliar with the technology, elderly travelers, or those with disabilities—may prefer or require human assistance. Striking the right balance between automation and human support is crucial to ensuring inclusivity and maintaining service quality. Providing adequate on-site assistance and clear instructions can help bridge the gap for passengers who may struggle with autonomous processes.

Strengthened Security and Data Protection

As digital systems handle sensitive passenger information, robust cybersecurity measures are paramount. Protecting data through advanced encryption, secure server infrastructure, and compliance with global data protection regulations is essential to maintaining trust. A focus on proactive security measures not only safeguards personal and financial information but also ensures the long-term viability of these systems in an increasingly connected world.

4 Business Model

The autonomous luggage check-in system marks a transformative step toward enhancing airport efficiency and improving passenger convenience. By automating the check-in process, it allows travelers to bypass traditional counter queues, streamlining their journey while minimizing human errors. This report outlines the business model for implementing such a solution, emphasizing its strategic partnerships, resources, activities, and revenue streams. The following sections explore the essential components that enable the system to provide value to travelers and airport stakeholders while ensuring sustainable growth.

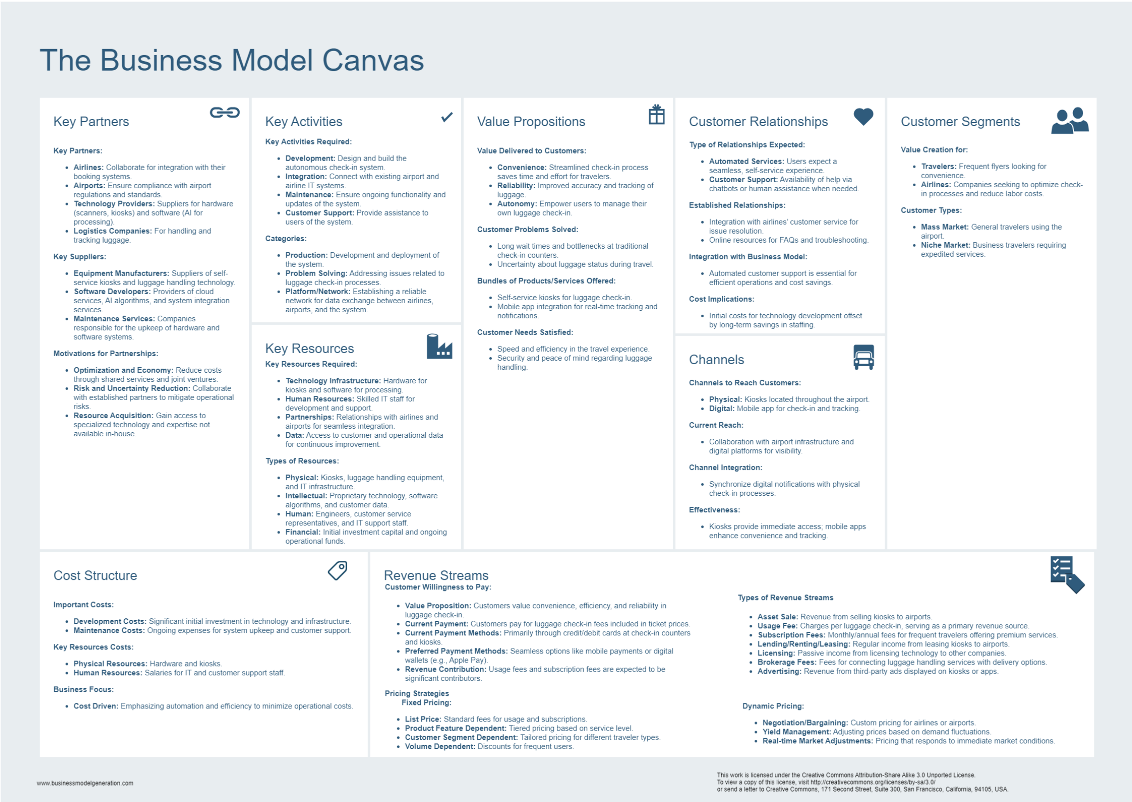

Figure 11: Business Model Canva

4.1 Key Activities

To operate the autonomous check-in system successfully, several critical activities must be undertaken:
System Development: This involves the design and development of the autonomous luggage check-in technology, encompassing both hardware (kiosks, scanning devices) and software (user interfaces, AI-driven processing systems). Continuous improvement and innovation in this area are necessary to enhance user experience.

Integration: A key activity is ensuring seamless connectivity between the autonomous check-in system and existing IT frameworks at airports and airlines. This integration facilitates data exchange and operational efficiency, allowing for real-time monitoring and updates.

Ongoing Maintenance: Regular maintenance and updates of the system are vital for ensuring its functionality and reliability. This includes software updates, hardware checks, and troubleshooting issues that may arise, thus minimizing downtime and ensuring a smooth user experience.

Customer Support: Providing robust customer support is essential for assisting users and addressing any issues during the check-in process. This includes training staff to help passengers, as well as offering online resources such as FAQs and troubleshooting guides to enhance user satisfaction.

4.2 Key Resources

The operation of the autonomous check-in system relies on various critical resources:
Technological Infrastructure: This includes all hardware and software components necessary for processing check-ins and managing luggage. High-quality kiosks, scanning devices, and a reliable software platform are essential for system functionality.

Human Capital: Skilled personnel are necessary for IT development, system maintenance, and customer support. Having a team of qualified engineers and customer service representatives ensures that the system operates smoothly and that users receive timely assistance.

Strategic Partnerships: Collaborations with airlines and airports are crucial for successful system integration. These partnerships enhance operational capabilities and ensure compliance with industry standards.

Data Assets: Access to customer data and operational insights is vital for continuous improvement of the service. Analyzing this data allows the company to identify areas for enhancement and adapt services to meet customer needs more effectively.

4.3 Value Propositions

The autonomous luggage check-in system delivers several key benefits to users, which are critical for attracting and retaining customers:
Enhanced Convenience: By enabling quick and efficient luggage check-in without the need for lengthy queues, the system significantly improves the overall travel experience for passengers. This convenience is particularly appealing to frequent travelers who prioritize speed and efficiency.

Increased Reliability: The system reduces the potential for human error in the check-in process, offering travelers accurate luggage tracking. This reliability builds trust among users, as they can monitor the status of their luggage throughout their journey.

User Autonomy: Passengers gain more control over their luggage check-in process, allowing them to manage it independently and reducing their reliance on airport staff. This autonomy enhances the overall experience by empowering travelers to take charge of their check-in activities.

4.4 Customer Relationships

Building and maintaining positive customer relationships is crucial for the system's success:
Automated Self-Service: Users expect a smooth, self-service experience that minimizes friction and enables independent check-in. The design of the system should facilitate this by providing intuitive interfaces and clear instructions.

Accessible Support Services: Offering multiple support channels, including chatbots and live agents, ensures that travelers can receive help whenever needed. Responsive customer support can significantly enhance user satisfaction and loyalty.

4.5 Channels

The system utilizes a mix of physical and digital channels to effectively reach customers:
Physical Kiosks: These kiosks are strategically placed throughout airports, providing travelers with immediate access to check-in services. The physical presence of these kiosks is essential for maximizing user interaction and convenience.

Digital Platforms: A complementary mobile app enhances the user experience by offering real-time luggage tracking and notifications. This digital channel allows users to stay informed and engaged throughout their travel experience.

4.6 Customer Segments

The autonomous luggage check-in system targets various customer segments, including:
General Travelers: This segment includes individuals utilizing airport services who seek efficient and convenient check-in options. These customers value time-saving solutions and ease of use.

Business Travelers: Frequent travelers, such as business travelers, require expedited services and premium handling for their luggage. Catering to this segment can result in higher revenue through tailored service offerings and subscription models.

4.7 Cost Structure

Understanding the cost structure is crucial for sustainable operations:
Development Costs: Significant initial investments are necessary for technology development, infrastructure, and deployment. Budgeting for these costs is essential to ensure the project is adequately financed.

Maintenance Costs: Ongoing expenses related to system upkeep, software updates, and customer support must be carefully managed to ensure long-term sustainability. Establishing a budget for maintenance helps to avoid unexpected costs and ensures consistent service quality.

4.8 Revenue Streams

The autonomous luggage check-in system has multiple potential revenue streams, which can enhance its financial viability:
User Fees: Revenue generated from charges per luggage check-in represents a primary source of income. This fee structure can be designed to incentivize users while covering operational costs.

Subscription Services: Offering monthly or annual subscription plans for frequent travelers seeking premium services can generate consistent revenue. This model appeals to business travelers who prioritize efficiency and convenience.

Leasing Agreements: Regular income from leasing kiosks to airports adds a steady revenue stream. This arrangement can provide airports with modern technology while generating revenue for the system operator.

Licensing Revenue: Passive income through licensing technology to other entities interested in implementing similar systems can expand revenue without significant additional investment.

Brokerage Fees: Revenue derived from connecting luggage handling services with delivery options for travelers creates additional income streams. This service can enhance the travel experience by offering convenience in luggage transport.

Advertising Revenue: Income from third-party advertisements displayed on kiosks and within mobile applications can supplement earnings. By partnering with relevant brands, the system can monetize user engagement effectively.

5 Flourishing Business Model

In the fast-paced travel landscape, the integration of advanced technology within airport operations is vital to meeting evolving passenger expectations. This business model canvas presents a comprehensive framework for an autonomous luggage check-in system aimed at simplifying the check-in process, increasing operational efficiency, and elevating passenger satisfaction. By focusing on sustainability, effective resource utilization, and user-centric solutions, this model caters to the varied needs of travelers, airlines, and airport authorities. The accompanying diagram encapsulates the core components of this innovative approach, illustrating its strategic alignment with industry objectives.

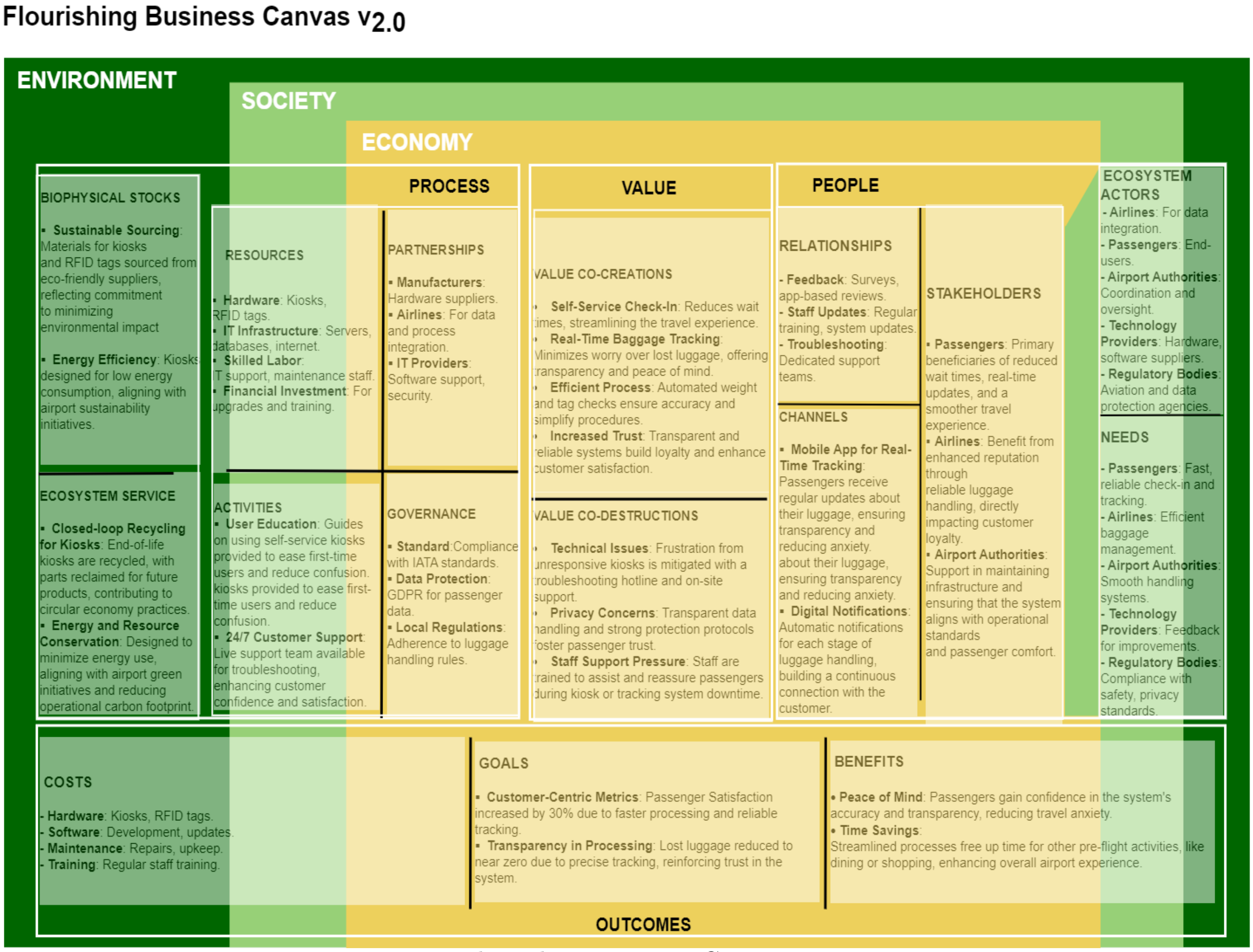

Figure 12: Flourishing Business Canva

5.1 Environment Layer

5.1.1 Biophysical Stocks

The environmental sustainability of the autonomous check-in luggage system is supported through various initiatives:
Sustainable Sourcing: Materials used for kiosks and RFID tags are sourced from environmentally responsible suppliers. This practice not only aims to minimize environmental impact but also ensures that the materials are sustainable and ethically produced.

Energy Efficiency: The kiosks are engineered for low energy consumption, aligning with broader airport sustainability initiatives. This not only reduces operational costs but also contributes to the airport's commitment to minimizing its carbon footprint.

Closed-Loop Recycling: At the end of their life cycle, kiosks will be recycled, allowing for the reclamation of parts for future products. This closed-loop recycling approach supports a circular economy by reducing waste and encouraging the reuse of materials.

Energy and Resource Conservation: The entire system is designed to minimize energy use, further supporting green airport initiatives and contributing to an overall reduction in the airport's carbon footprint.

5.1.2 Costs

A comprehensive understanding of the costs associated with the autonomous check-in luggage system is critical for its viability:

Hardware Costs: These include the procurement and installation of kiosks and RFID tags, which are essential for the functioning of the self-service check-in process.

Software Costs: Ongoing expenses will be incurred for system development, updates, and necessary security enhancements to ensure the system remains robust and secure against potential threats.

Maintenance Costs: Periodic repairs and upgrades will be required to maintain system reliability and performance, ensuring a consistent user experience.

Training Costs: Regular training sessions will be necessary for staff members to effectively operate and troubleshoot the system, ensuring that they are well-equipped to assist passengers.

5.2 Society Layer

5.2.1 Resources

The successful implementation of the autonomous check-in luggage system relies on several key resources:

Hardware: The system's infrastructure consists of kiosks and RFID tags that facilitate passenger check-in and luggage tracking, enhancing operational efficiency.

IT Infrastructure: A robust IT infrastructure, including servers, databases, and internet resources, is necessary for real-time tracking and data management, ensuring that the system operates seamlessly.

Skilled Labor: Qualified personnel will be essential for system support, maintenance, and training, providing the expertise needed to keep the system functioning optimally.

Financial Investment: Adequate funds must be allocated for infrastructure development, ongoing updates, and continuous staff training, ensuring the system's long-term sustainability and effectiveness.

5.2.2 Activities

Key activities are vital for the successful operation and acceptance of the system:

User Education: Providing clear guides and instructions will help passengers navigate self-service kiosks more effectively, reducing confusion and enhancing their overall experience.

24/7 Customer Support: A dedicated support team will be available around the clock to troubleshoot and assist passengers with any issues they may encounter, ensuring prompt resolution of concerns.

5.2.3 Governance

Effective governance is essential for maintaining the integrity and functionality of the system:

Standard Compliance: The system will adhere to IATA standards to ensure safety and reliability in operations, fostering trust among users.

Data Protection: Implementing robust protocols to protect passenger data is critical. These measures will ensure privacy and build confidence in the system's handling of sensitive information.

Local Regulations: The system will comply with local luggage handling regulations, ensuring that all operational practices are aligned with existing legal frameworks.

5.3 Economy Layer

5.3.1 Process

Successful partnerships are crucial for the operation of the autonomous check-in luggage system:
Manufacturers: Hardware suppliers play a vital role in providing the essential equipment necessary for the system's deployment.

Airlines: Partner airlines will contribute to data integration efforts, enabling seamless operational processes and enhancing the overall travel experience for passengers.

IT Providers: Technology partners will support software development, security enhancements, and ongoing maintenance, ensuring that the system remains up-to-date and secure.

5.3.2 Value

Creating value through the system involves co-creating positive experiences while addressing potential challenges:

Value Co-creations:
Self-Service Check-In: This feature significantly reduces wait times, streamlining the passenger experience and allowing for more efficient airport operations.

Real-Time luggage Tracking: Passengers benefit from transparency regarding their luggage, which minimizes stress and anxiety about lost items.

Efficient Processes: Automated weight and tag checks ensure accuracy and reliability during the check-in process, enhancing operational efficiency.

Increased Trust: A dependable system fosters customer loyalty and enhances the reputation of both airlines and airports.

Value Co-destructions: **Technical Issues**: Frustration from unresponsive kiosks can be mitigated through a dedicated troubleshooting hotline and on-site support to assist passengers promptly.

Privacy Concerns: By adopting transparent data handling practices, the system builds passenger trust and alleviates privacy worries.

Staff Support Pressure: Staff will receive comprehensive training to assist passengers effectively, particularly in cases of kiosk or system downtime.

5.3.3 People

Understanding the perspectives of various stakeholders is essential for continuous improvement:
Feedback: Collecting insights through surveys and app-based reviews will provide valuable information for ongoing enhancements to the system.

5.3.4 Relationships

Building strong relationships among stakeholders is key to achieving operational success:
Passengers: Travelers benefit from a more efficient and streamlined travel experience characterized by reduced wait times and timely real-time updates on their luggage.

Airlines: Partner airlines gain customer loyalty and enhanced reputation due to reliable and efficient luggage handling, leading to positive passenger experiences.

Airport Authorities: Authorities maintain critical infrastructure to ensure the system meets operational standards and supports passenger comfort, ultimately leading to increased airport efficiency.

5.3.5 Channels

Effective communication channels are essential for engaging with passengers:
Mobile App for Real-Time Tracking: Passengers can receive regular updates about their lug-

gage status, helping to alleviate anxiety during their travel experience.

Digital Notifications: Automatic notifications throughout the luggage handling process enhance passenger connection and keep them informed every step of the way.

5.3.6 Stakeholders

Identifying and engaging with key stakeholders is vital for the system's success:
Passengers: They are the primary beneficiaries of the enhanced travel convenience and reduced stress that the system provides.

Airlines: Airlines benefit from improved reputations due to efficient luggage handling and increased customer satisfaction.

Airport Authorities: Authorities ensure that the infrastructure aligns with operational standards and meets passenger needs effectively.

5.4 Ecosystem Actors

5.4.1 Actors

Several key actors play integral roles within the ecosystem of the autonomous check-in luggage system:
Airlines: These are key players in data integration and operational processes, facilitating seamless interactions within the system.

Passengers: As end-users, passengers directly benefit from the system, enjoying improved convenience and efficiency during their travels.

Airport Authorities: These authorities oversee the infrastructure and ensure compliance with relevant standards and regulations.

Technology Providers: They supply the necessary hardware and software, playing a critical role in the system's functionality.

Regulatory Bodies: These organizations ensure compliance with aviation and data protection standards, safeguarding passenger interests.

5.4.2 Needs

Understanding the needs of each actor is crucial for the system's success:
Passengers: They demand fast, reliable check-in and tracking services to enhance their travel experience.

Airlines: Airlines seek efficient luggage management solutions to improve customer satisfaction and streamline operations.

Airport Authorities: These authorities require smooth handling systems to ensure operational efficiency and passenger comfort.

Technology Providers: Feedback from users is essential for ongoing system improvements and refinements.

Regulatory Bodies: These entities ensure compliance with safety and privacy standards, reinforcing trust in the system.

5.5 Outcomes

5.5.1 Goals

The implementation of the autonomous check-in luggage system aims to achieve the following key goals:
Customer-Centric Metrics: Increase passenger satisfaction by 30% as a result of faster processing times and reliable tracking of luggage.

Transparency in Processing: Strive to reduce lost luggage incidents to near zero, reinforcing passenger trust in the system's efficiency and reliability.

5.5.2 Benefits

The benefits of the autonomous check-in luggage system are numerous and impactful:
Peace of Mind: Passengers will gain confidence in the system's accuracy and transparency, significantly reducing travel-related anxiety.

Time Savings: A streamlined process will free up valuable time for passengers, allowing them to engage in other activities and enhancing their overall travel experience.

6 Redesigned Enterprise model

The evolution of airport operations depends on adopting technologies that improve processes, enhance security, and offer better passenger experiences. As airports face increasing passenger numbers, there is a clear need for solutions that balance efficiency, security, and cost-effectiveness. An important innovation is the **Internal Central System Server**, which integrates all technological components into a unified infrastructure. This approach eliminates the reliance on external companies for storing and processing sensitive passenger data, reducing costs and enhancing privacy. By keeping data within the airport's control, the server ensures compliance with privacy standards while minimizing operational expenses related to outsourcing.
The server enables real-time synchronization of passenger and luggage data, reduces errors, and maintains availability even during peak periods. It is designed to scale with demand, support automated decision-making, and integrate with airline and regulatory systems. This innovation reduces costs and enhances privacy, making it a key component of efficient and secure airport operations.

6.1 4EM - Models

6.1.1 4EM - Technological Components Sub-Model

This sub-model illustrates an autonomous check-in and luggage handling system built on innovation-driven technological components, each playing a critical role in enhancing system performance and user experience:

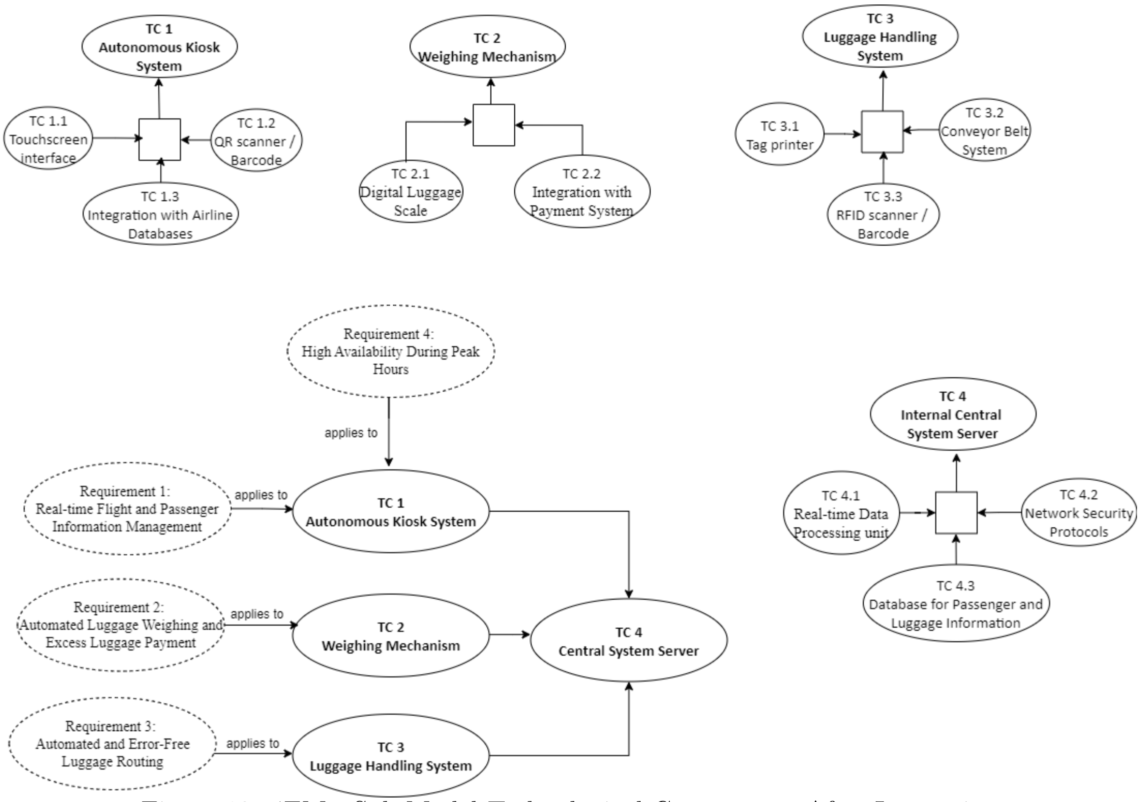

Figure 13: 4EM - Sub-Model Technological Components After Innovation

Autonomous Kiosk System The autonomous kiosks serve as the primary interface for passengers, offering intuitive, user-friendly features such as touchscreen displays, QR and barcode scanners, and real-time integration with airline databases. By streamlining the check-in process and minimizing the need for manual assistance, these kiosks provide passengers with a fully automated and efficient experience.

Weighing Mechanism This automated system precisely measures luggage weight and integrates directly with secure payment platforms for processing excess baggage fees. Its seamless functionality ensures accurate weight recording and enables on-the-spot fee transactions, significantly reducing delays and improving passenger satisfaction.

Luggage Handling System The advanced luggage handling system includes automated conveyor systems equipped with RFID and barcode technologies for tagging, routing, and tracking baggage. This minimizes errors, boosts efficiency, and ensures that every piece of luggage is reliably routed to its intended destination.

Internal Central System Server The Internal Central System Server is the backbone of the model, orchestrating the integration and management of all components. It offers robust real-time data processing, scalable storage, and advanced network security, ensuring seamless operations even during peak traffic periods. By safeguarding sensitive passenger information and optimizing workflows, the server delivers unmatched efficiency and security.
The combined functionality of these components addresses key operational requirements such as real-time data synchronization, automated decision-making, high system reliability, and error-free processes. The central server ensures a fully connected and secure ecosystem, driving efficiency for both passengers and airport staff.

6.1.2 4EM - Enterprise Model

This enterprise model highlights the strategic alignment of objectives, processes, and technological advancements to achieve a fully autonomous and streamlined system. At the core of this approach is the Internal Central System Server, which serves as a unifying hub for various system components, driving overall efficiency and seamless integration.
The model aims to enhance security by implementing centralized data management and encrypted information flows, ensuring robust protection of sensitive passenger data. By automating key operations such as check-in, luggage handling, and payment processing, it significantly reduces the need for staff involvement, lowering operational costs while improving reliability.
Efficiency is further improved through cutting-edge automation and real-time system coordination. These innovations eliminate manual bottlenecks, enabling smoother operations and reducing the likelihood of errors. A critical outcome of this approach is the significant reduction in passenger wait times, providing a frictionless experience from check-in to luggage drop-off.
Central to this system are core processes such as kiosk-based check-ins, automated luggage weighing, and intelligent routing, all seamlessly powered by the Internal Central System Server. The server's scalable design not only supports these foundational operations but also allows for future enhancements, such as mobile app integration. This added functionality enables passengers to receive real-time updates and access self-service options, fostering a more engaging and convenient travel experience.

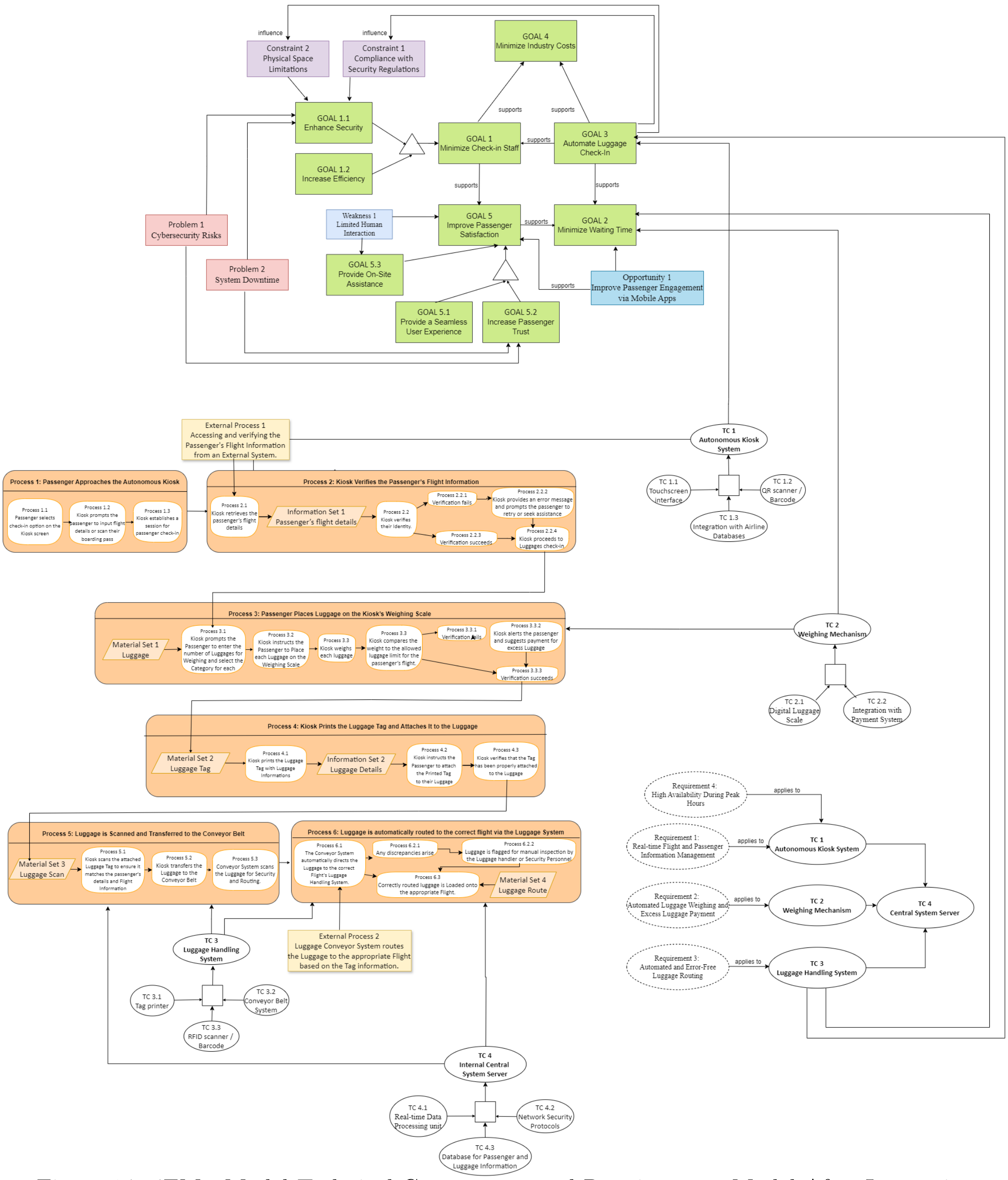

Figure 14: 4EM - Model Technical Components and Requirements Model After Innovation

6.2 ArchiMate - Models

ArchiMate - Technology Layer

This model illustrates the architecture of the autonomous luggage check-in system. The Autonomous Kiosk System collects passenger data, connects to flight information and verification services, and interacts directly with other components of the system. Luggage details are sent to the Weighing Mechanism and RFID/QR Code Scanner. Luggage is then tagged via the Luggage Tagging Service and routed to the appropriate flight through the Luggage Handling System and Luggage Route Service. Each component communicates with others in a decentralized manner to ensure efficient luggage processing without relying on a central server.

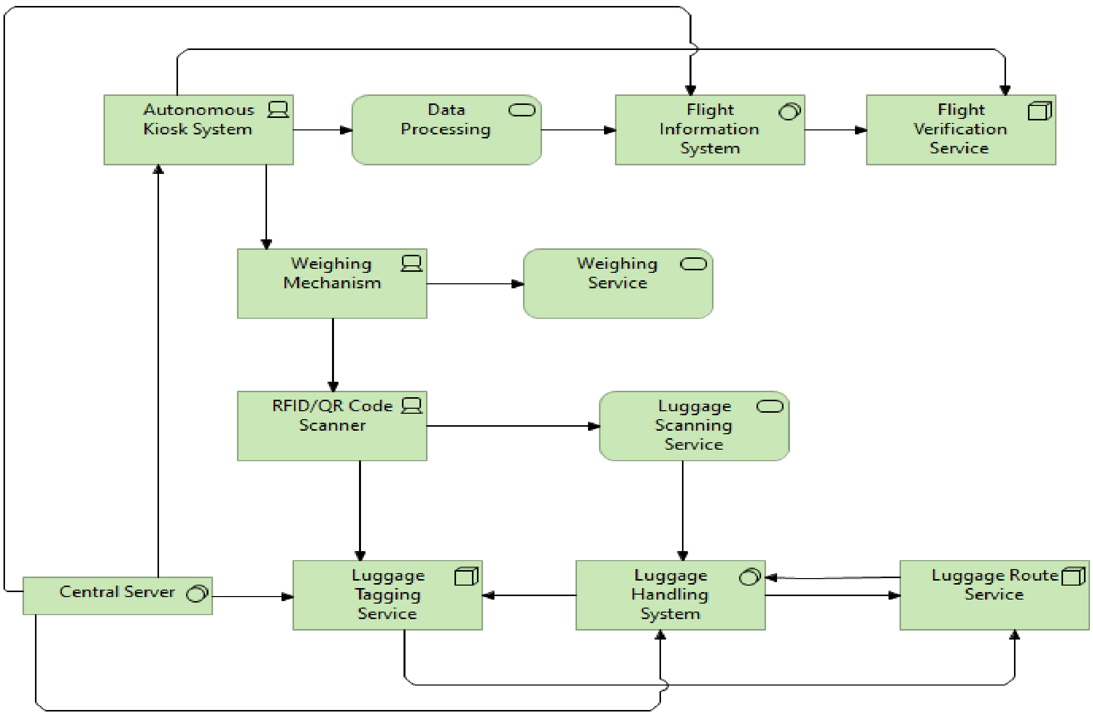

Figure 15: ArchiMate - Sub-Model Technology Layer After Innovation

6.2.1 ArchiMate - Enterprise Model Layer

The ArchiMate model represents a sophisticated system in manufacturing or logistics, organized into business, application, technology, and data layers. It emphasizes critical processes such as production and quality control, along with key roles and physical assets. Applications facilitate these processes, and data flows illustrate the exchange of information. The technology layer showcases vital infrastructure and devices, highlighting the integration of automation and IoT. Without a central server, the model relies on decentralized interactions between components, emphasizing data-driven operations and seamless integration. The forthcoming report will encompass an overview, key components, interactions, data flow, technology infrastructure, and an analysis of potential benefits and challenges.

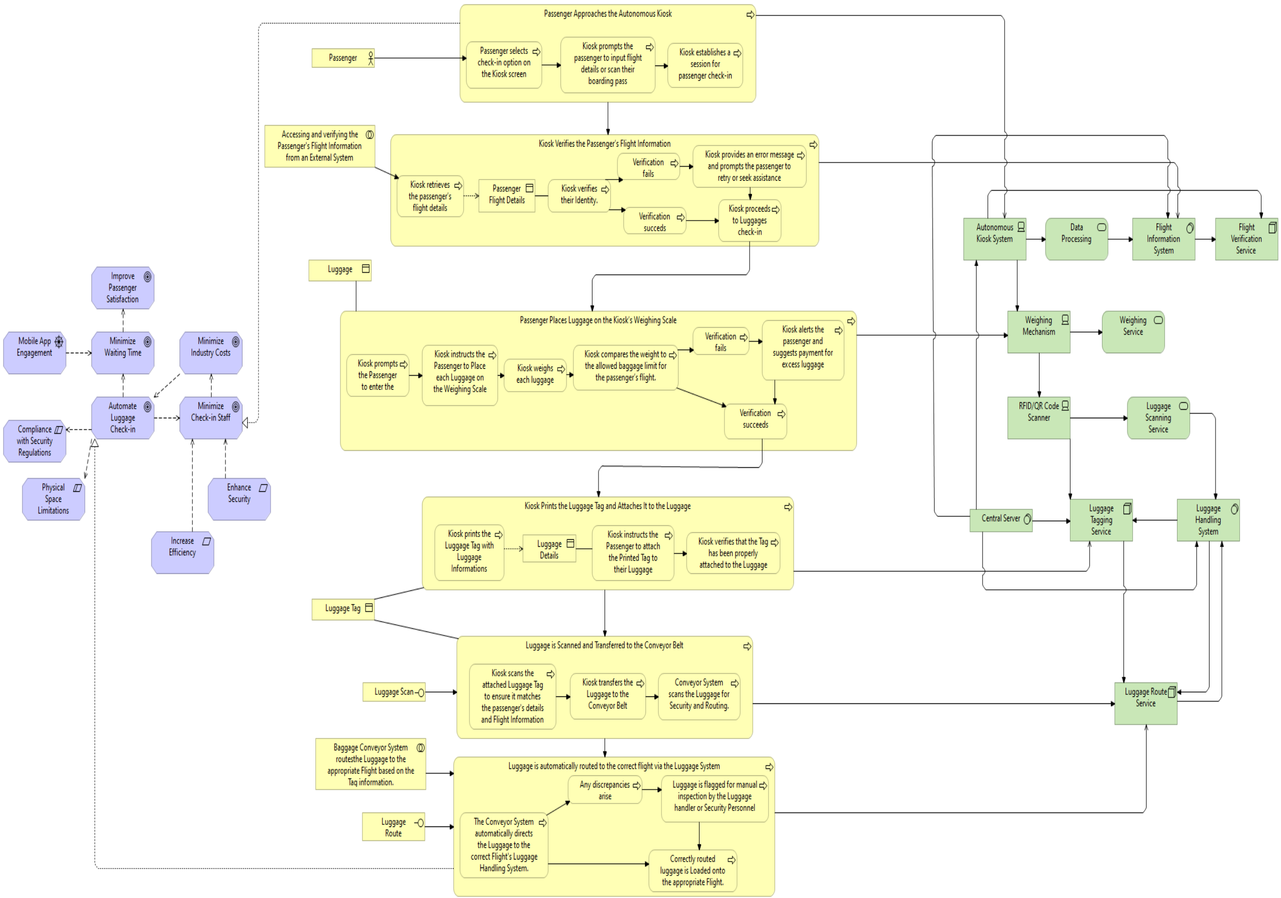

Figure 16: ArchiMate - Model After Innovation

6.3 Relate the Enterprise Model to Enterprise Architecture

Integrating **Enterprise Architecture (EA)** with the Autonomous Airport Operations model helps ensure that all parts of the system—business processes, technology, and infrastructure—work together efficiently and effectively. EA provides a framework to organize and align business goals with the technology used to achieve them.

Key Parts of the Model in Enterprise Architecture

Business Layer: The business layer in EA focuses on the organization's goals and processes. In our model, processes like automated check-in, baggage handling, and payment all fit into this layer. These processes aim to improve efficiency, reduce costs, and provide a better experience for passengers. For example, automating check-in and baggage handling aligns with the airport's goal of reducing operational costs and improving passenger satisfaction.
Application Layer: This layer includes all the software and systems that help carry out the business processes. In our model, components like the Autonomous Kiosk System, Weighing Mechanism, and Luggage Handling System belong to this layer. These applications work together to automate tasks and improve coordination. The Internal Central System Server is the core of the application layer, handling real-time data exchange and ensuring everything runs smoothly.
Technology Layer: The technology layer in EA focuses on the physical infrastructure, like hardware, networks, and servers that support the applications. In this model, it includes the devices such as kiosks, RFID scanners, and servers that store and manage data. This layer also ensures that data is processed efficiently and can scale during busy times. For example, edge computing helps handle large amounts of data close to the source, improving system speed and reliability.
Data Layer: This layer handles how data is stored, shared, and managed. For the airport model, it involves managing sensitive passenger information, luggage details, and operational data. Security and privacy are key, so data is encrypted and stored safely. Real-time data tracking through RFID ensures smooth operations and reduces errors in luggage handling.

Connection Between Enterprise Modeling and Enterprise Architecture

While **Enterprise Modeling (EM)** shows how business processes and technology fit together, **Enterprise Architecture (EA)** offers a blueprint to organize and structure those processes and technologies. In this case, the Internal Central System Server acts as the link between the business and technology layers. It ensures real-time coordination and smooth data flow, which is a key principle in EA.
The model uses modern EA ideas, like decentralized data processing and cloud computing, which make the system more flexible and able to scale when needed. By automating processes, it aligns with the goal of EA to make systems more efficient, secure, and adaptable.

6.4 Re-evaluate the model

G: The goals of the modelling
The modeling goals should focus on improving efficiency, security, and passenger experience, with future innovations like scalability and real-time data handling. Misalignment with long-term goals, such as Internal Central System Server improvements, can render the model ineffective over time.
L: What can be expressed in the modelling language
The modeling language must express both current processes and future innovations, such as enhanced data synchronization and system scalability. A restrictive language limits the model's long-term utility.

M: What is expressed in the model
The model should reflect the current system and future innovations. If it neglects future technological advancements, it will become outdated and fail to meet evolving needs.
A: What actors have access to the model
Access should be limited to actors involved in both current operations and future innovations, such as technical staff and decision-makers. Mismanagement of access can lead to poor implementation or misunderstandings.
D: What can be expressed about the domain
Domain knowledge must include current operations and future technological advancements. Failing to consider future innovations can make the model less effective.
K: The explicit knowledge of the participating persons about the domain
Participants must have knowledge of both the existing system and upcoming innovations. Lack of understanding can result in incomplete or inaccurate models.
I: What the participating persons interpret the model to express
Participants must interpret the model accurately, including both current processes and future innovations. Misinterpretation can lead to poor decision-making and implementation issues.
T: What relevant tools interpret the model to express
Tools should be able to handle both current and future system requirements. Tools that can't accommodate innovations like system scalability will limit the model's effectiveness.

7 Reflections

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