SkyLink Airlines

Enterprise Systems Architecture

Project Report

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November, 2025

Table of Contents

Table of Figures

1. Introduction

We are a software consultant company engaged by SkyLink Airlines to develop layered reference architecture. Airline systems can have many different parts to them. We will start by doing research into the context of airline systems to helps us gain a deeper understanding into the workings of how airline systems operate.

2. Architecture Vision

2.1. Arline Context

2.1.1. Global airlines

Skylink Airline operate flights for people and goods over many countries with different routes around the world making them a global business and needing to comply with laws and regulations for the corresponding countries in which they operate.

2.1.2. Mixed aircrafts

Skylink operates with a diverse range of different aircrafts used for both passenger and cargo flights to be able to serve different demands across the globe. The airline has flexibility and can choose the right aircraft for the demand of the flight which will result in saving costs.

2.1.3. Airport ground services

Grounds services deal with loading and unloading and then transport to the necessary party. E.g. suitcases back to conveyor belts where passengers can get them after disembarking. This can be automated with the help of conveyor belts to reduce human handling and increase efficiency. Handled in cooperation between the airline and the airport.

Besides dealing with just cargo, ground services also help with , handling passengers getting on and off alongside cleaning up the plane before take-off. They handle these steps as efficiently as possible so we can take off again as soon as possible.

2.1.4. Partner codeshares

Airlines can work with other companies and use code shares to sell tickets for flights with different companies. There could be different rates depending on which airline you book with even if it is for the same flight.

2.1.5. Real time flight tracking & status updates

Flight tracking is important both for keeping your customers informed of when the plane is arriving and making sure things are staying on schedule. Also, the information is shared from the airline to the airports flight control towers to tell them if it is safe to land.

2.1.6. Passenger reservations & loyalty management

Skylink provides flight booking system for passengers to book flights, check in online or at the airport. A loyalty program is included which allows passengers to earn points which they can receive by traveling with Skylink airline and redeeming points by how much kilometres they travel.

2.1.7. Aircraft maintenance & operational analytics

Maintenance will be carried out on the plane on a regular basis to make sure the plane is fit and in good shape so that it can fly without any potential dangers from parts malfunctioning. There will be different types of maintenance conducted on it such as scheduled maintenance, preventative maintenance, and corrective Maintenance. Scheduled is done at planned time interval such as after a specific number of flight hours. Preventative is for stopping issues before they happen and dealing with smaller defects before things get worse. Corrective maintenance is unscheduled and for dealing with a defect that has been found., e.g. fixing a faulty component. It is super important to catch these potential issues before they happen as it could lead to loss of life if the plane was not working properly. Analysis can be done during maintenance to see how much fuel got used and optimize to make sure we always have enough when refuelling to reach our next destination. Besides maintenance just to make sure the plane flies, maintenance also needs to be done to conform to certain national and international aviation regulations. As a global airline maintenance done at the plane must meet the standards for all regions that the plane flies in. Some different regulators include FAA (Federal Aviation Administration) for the USA, EASA (European Union Aviation Safety Agency) for the EU and the ICAO (International Civil Aviation Organization) for global aviation.

2.1.8. Monitoring & incident-response

Monitoring the data of how well the plane is flying is vital as flight controllers can now what is going on and if there is any danger. Live response using the data is important since urgency would be needed in case of an emergency. The data that was collected can be stored in the cloud and can be used for analysis later to see trends overall such as most common times that planes are landing or how many flights can a plane do a day on average. These can be analysed and used to assist in future business decisions for the company.

2.1.9. Crew scheduling & airport resource coordination

The cockpit crew flies the plane consisting of the pilot and copilot, other crew members are in the cabin crew and help deal with the services on the plane including interacting with passengers and pre and post flight clean up. There is a maximum number of hours that a pilot can work on a given day so there needs to be schedules for when another pilot is taking over, to maximise how often flights can take place. The crew also deal with maintenance and checking that the plane is flightworthy and capable of flying without issue and if there is anything that needs to be checked out or dealt with about the plane itself.

2.2. Strategic Drivers

2.2.1. Safety

There are strategic important drivers that are important to airline systems. Safety should be maximised as there are lots of people about and large moving vehicles, there is a desire to avoid lots of life or harm as it would lead to lawsuits and bad public reception. Make sure that customers are safe and that planes are safe to land.

2.2.2. Punctuality

Punctuality wise the planes should arrive on times as listed. Any potential changes should be reflected real time in the app and on the public display flight schedule. Customers should be able to board as soon as possible after the plane has been cleaned from its previous flight and is ready for take-off.

2.2.3. Customer experience

As there are lots of customers it is important to deal with handling them. We are trusted to safely handle people's items. Issues like lost luggage can deeply upset customers. We try to have good customer service to encourage repeat customers by helping them solve their issues if they arise.

2.2.4. Cost efficiency

There is a wide variety of different people who go on flights. As a global airline we are prepared to handle a variety of customer Bases. Different customers want different things, some want short flights to nearby places, while some are travelling far on long flights . There is also different classes of passengers such as economy, super economy, business class and first class. Economy is the basic standard and has limited leg room, super economy has more leg room and can have priority boarding, business class is higher and offers more comfort for travelling professionals or people willing to pay for the extra comfort. First class is the highest end and offers even more benefits such as high end seats with lots of comfort options and lots of space and expansive entertainment systems. As a global airline Skylink offer flight from to many countries. Some of these flights can be long , some are shorter. Depending on the flights there are different options for passenger classes and within those there are also bonus optional add on benefits to improve the passengers comfort so they can feel relaxed and happy at a higher price, which includes bonuses such as seats with more leg room, or being allowed to bring along more baggage. These allow the airline to meet the needs for the various types of passengers.

The price of the flight can be influenced by a variety of factors, shorter flights have less fuel cost, but there are also other costs such as landing charge. Different airports can have different prices for being allowed to land there, busier airports closer to cities can be more expensive. Airlines must constantly optimize fuel consumption, crew scheduling, and airport fees to reduce operational costs and to be ready for take-off as soon as possible, as the airplane only makes money when it is in the air. There are also maintenance costs and storage costs when the plane is not in use. Technology and automation also play a role in lowering expenses, allowing SkyLink to remain competitive while still offering a quality service to customers.

2.2.5. Driver KPI Metrics

There are 4 main drivers that we are considering: Safety, punctuality, customer experience and cost efficiency.

Safety: measured by number of incidents, maintenance reports and incident reports. Keep track of most common types of maintenance and improve efficiency for how often the maintenance needs to happen and host fast to make sure everything works properly. We process the most common maintenance reasons into graphs to show how often they are done compared to other types of maintenance.

Punctuality: measured by scheduled vs actual departure and arrival times. (e.g. gotten from US department transport.) Why did the delay happen, to process split it into categories and then ways of improvement. Ryan Air keeps good records.

Customer Experience: measured by reviews, surveys and number of complaints received. We take this data and transform the data into useful information that we can extract. Close ended questions are easier to display in graphs and obtain information from, while open ended answers and reviews can be processed by large language models to compile all the different data and find out the most complaints from customers and areas for improvement.

Cost Efficiency: Measured by Fuel consumption per flight and maintenance costs. We compare our costs to profits for particular flights and flight routes. We display these in graphs and tables for the comparison of flight routes against each other.

As the airline is global, our strategic drivers are stored in regions and not all on one system. The raw sensor data is stored in edge devices for quick access and reacting to potential critical issues such as warning lights. While things like maintenance logs and reviews are stored and processed in the regional databases, the data is aggregated, and trends are found and predictive analysis is done for the future based on these trends. All the data logs, surveys and reports are brought together eventually in the cloud to give a global view, and graphs made out of the suitable information to present and display the information gathered for our KPIs in an easy-to-read way so that issues can be clearly seen and improvements made if necessary.

2.3. Scope

With all this context in mind we can set an achievable scope for what we aim to accomplish from keeping track of flights, making sure planes are maintained properly on scheduling and that we treat our customers well and give them a good experience making sure our flights arrive on time and that customers are aware of when they will be able to board.

This scope also ensures that both customer-facing systems and backend operational systems are considered, so improvements benefit both passengers and staff. It will help the airline focus on the most critical aspects first while leaving room for future scalability and integration with new services.

Our scope will incorporate the functional areas of the airline. We handle the tickets for our different flights and different prices for different seats. Up to date information on available seating. We need to keep track of what seats are booked and empty, how many passengers each plane can hold. Do we have enough staff for handling maintenance and handling passengers boarding and their luggage. Do we have legal permissions for the routes we are flying and agreements in place with airports for landing.

2.4. Guiding Principles

We will do our best to satisfy our stake holders by increasing profits with process optimization while at the same time providing customers with a cost-effective flights and positive experience.

These guiding principles will act as a foundation for decision-making whenever trade-offs arise between cost, safety, and customer experience. They will ensure the architecture remains adaptable to change while still aligning with the long-term strategy of the airline.

3. Information Architecture Package

3.1. Data Models

3.1.1. Conceptual Data Model

The Conceptual Data Model provides a high-level business view of our Airline Operations System, focusing on the core business entities and their relationships without technical implementation details. This model serves as a communication bridge between business stakeholders and technical teams, capturing the essential concepts of flight operations, passenger services, crew management, and aircraft maintenance that define our airline's operational ecosystem.

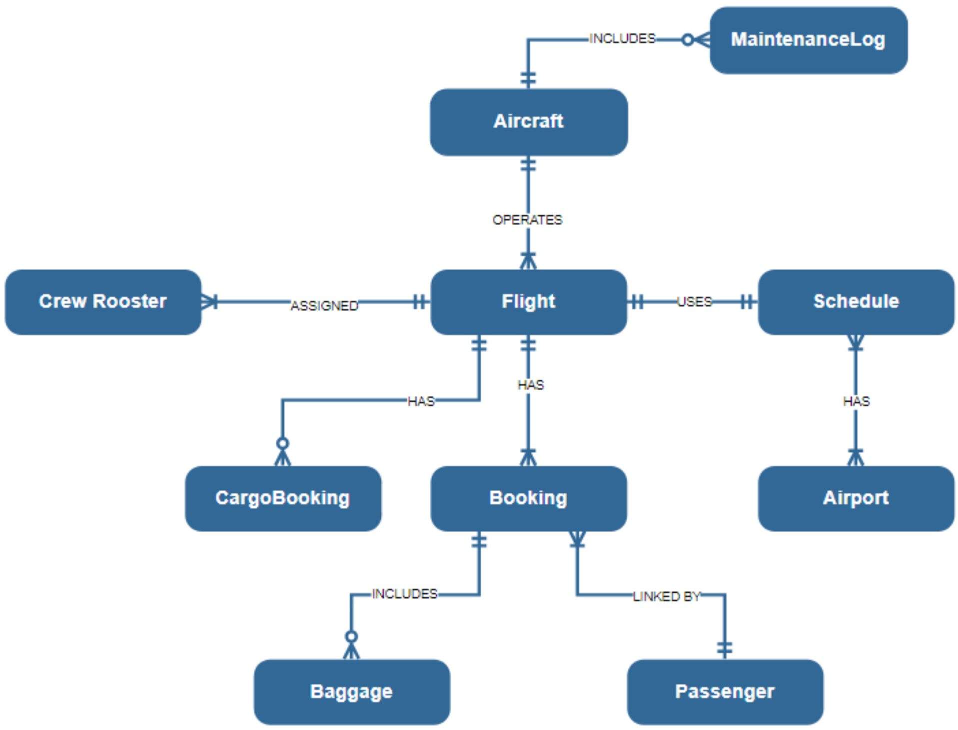

Figure 1. Conceptual Data Model

Key Entities:

Flight	Central entity representing a scheduled journey between two airports.
Aircraft	Represents each airplane in operation by SkyLink.
Booking	Records the details of a passenger's reservation on a specific flight.
CargoBooking	Represents cargo or freight reservations linked to a flight.
Baggage	Linked to passenger bookings to represent checked-in luggage
Passenger	Represents individuals who make reservations and travel on flights.
Schedule	Defines the operational timing of flights (departure, arrival, duration).
Airport	Represents the location from which flights depart and arrive.
MaintenanceLog	Records maintenance activities related to flights.
CrewRoster	Represents crew assignments for a flight.

Key Relationships

Aircraft – Flight	Each aircraft can operate many flights. Each flight is assigned to one aircraft.	1:N
Flight - CrewRoster	Each flight must have multiple crew members Each roster must belong to one flight	1:N
Flight - Booking	A flight must have one or more bookings Every booking must refer to one flight	1:N
Flight – CargoBooking	A flight can include multiple cargo bookings. Each cargo booking belongs to one flight.	1:N
Booking – Baggage	Each passenger booking can include multiple baggage items. Each baggage item can be linked to one booking	1:N
Flight - Schedule	Every flight must use exactly one schedule Each schedule must be used by exactly one flight	1:1
Aircraft - MaintenanceLog	Each aircraft can have multiple maintenance logs over time. Each maintenance log must refer to one aircraft	1:N
Booking - Passenger	Each booking must be linked to one passenger Each passenger must make one or more bookings	1:N
Schedule - Airport	Schedule must have exactly one departure and one arrival airport Each airport must be used in one or more schedules	1:N

3.1.2. Logical Data Model

The Logical Data Model serves as the business foundation for our Airline Operations System, defining how core aviation entities interact and ensuring data integrity across flight operations, passenger services, and maintenance tracking. This conceptual blueprint aligns with airline industry standards and regulatory requirements, establishing clear relationships between flights, schedules, aircraft maintenance, and passenger bookings that reflect real-world aviation workflows.

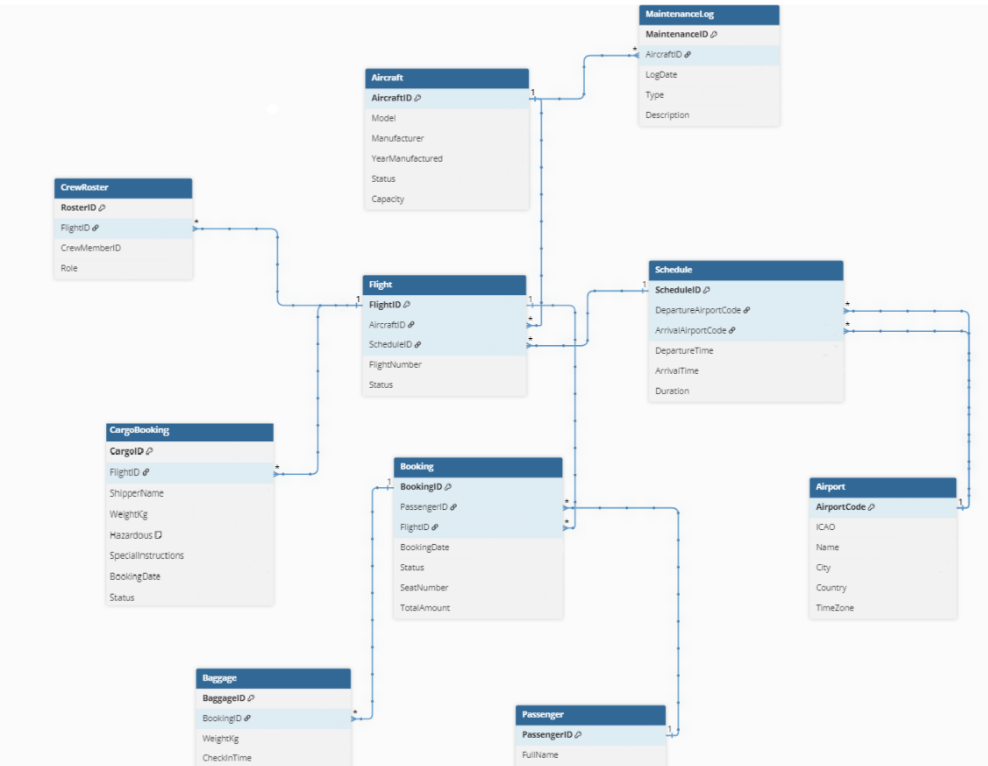

Figure 2. Logical Data Model

Normalization Notes

Flight	3NF	ScheduledID FK enforces 1:1 with Schedule
Aircraft	3NF	Each aircraft identified by unique registration
Booking	2NF	Stored directly for performance and audit purposes
CargoBooking	3NF	Distinct from passenger bookings
Baggage	2NF	Denormalized for operational speed
Passenger	3NF	No transitive dependencies
Schedule	2NF	Stored for query performance and operational efficiency
Airport	3NF	No redundancy
MaintenanceLog	2NF	Denormalized for quick access and reporting
CrewRoster	3NF	Role is specific to each flight assignment

3.1.3. Physical Data Model

The Physical Data Model implements our airline system with performance-optimized structures designed to handle high-volume booking transactions, real-time flight operations, and mandatory maintenance tracking. This implementation includes strategic partitioning for time-sensitive data and comprehensive indexing to support critical airline workflows like passenger bookings, crew scheduling, and aircraft maintenance compliance.

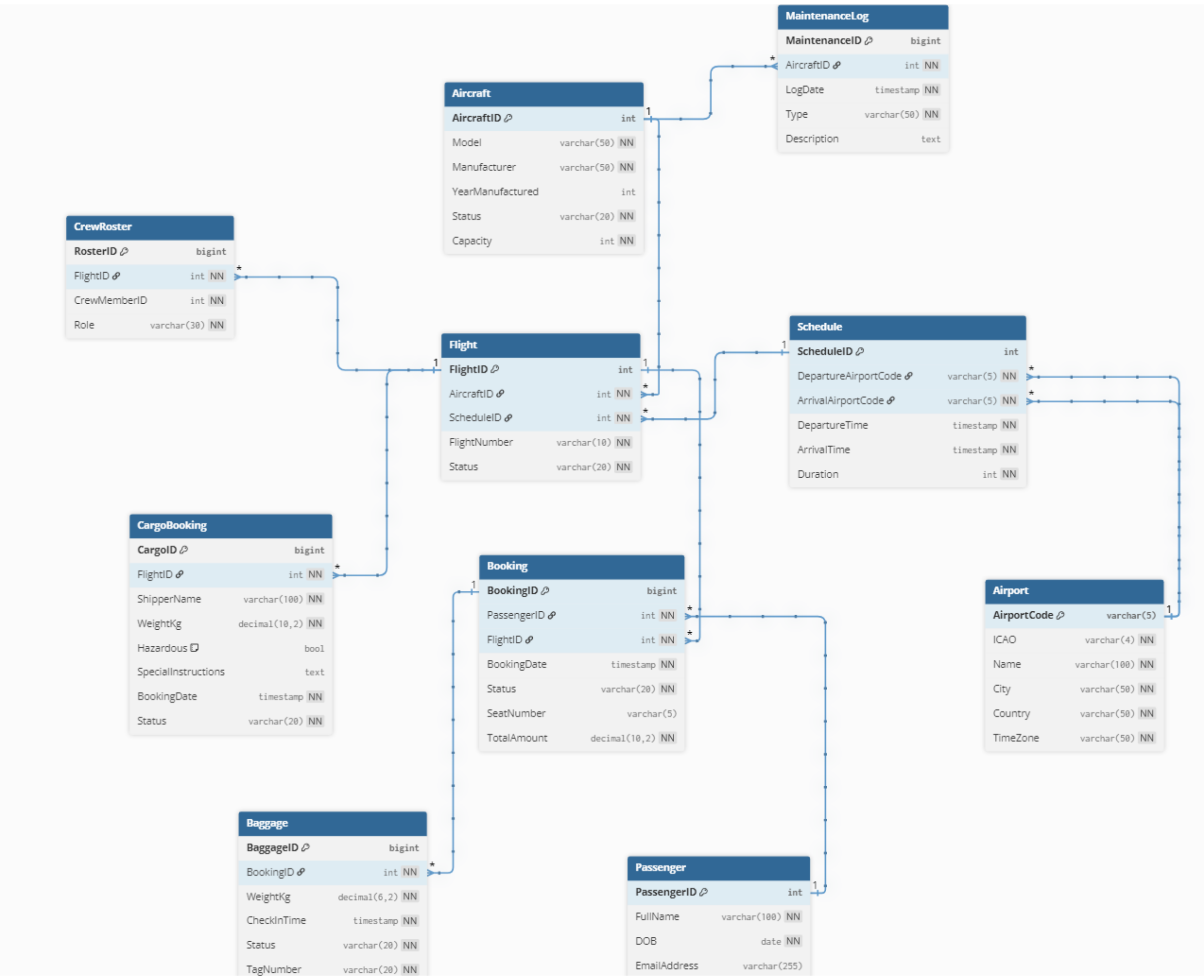

Figure 3. Physical Data Model

Table Schemas:

Airport

```sql
-- Stores static location and timezone information for all airports in the system.
CREATE TABLE Airport (
  AirportCode VARCHAR(5) PRIMARY KEY,
  ICAO VARCHAR(4) NOT NULL UNIQUE,
  Name VARCHAR(100) NOT NULL,
  City VARCHAR(50) NOT NULL,
  Country VARCHAR(50) NOT NULL,
  TimeZone VARCHAR(50) NOT NULL
);
```

Schedule

```sql
-- Defines the planned timetable for a flight, including departure/arrival times and airports.
CREATE TABLE Schedule (
  ScheduleID INT PRIMARY KEY,
  DepartureAirportCode VARCHAR(5) NOT NULL,
  ArrivalAirportCode VARCHAR(5) NOT NULL,
  DepartureTime TIMESTAMP NOT NULL,
  ArrivalTime TIMESTAMP NOT NULL,
  Duration INT NOT NULL,

  FOREIGN KEY (DepartureAirportCode) REFERENCES Airport(AirportCode),
  FOREIGN KEY (ArrivalAirportCode) REFERENCES Airport(AirportCode)
);
```

Aircraft

```sql
-- Stores information about physical aircraft in the fleet.
CREATE TABLE Aircraft (
  AircraftID INT PRIMARY KEY,
  Model VARCHAR(50) NOT NULL,
  Manufacturer VARCHAR(50) NOT NULL,
  YearManufactured INT,
  Status VARCHAR(20) NOT NULL,
  Capacity INT NOT NULL
);
```

Flight

```sql
-- Represents a specific, operational instance of a scheduled journey.
CREATE TABLE Flight (
  FlightID INT PRIMARY KEY,
  AircraftID INT NOT NULL,
  ScheduleID INT NOT NULL UNIQUE,
  FlightNumber VARCHAR(10) NOT NULL,
  Status VARCHAR(20) NOT NULL,

  FOREIGN KEY (ScheduleID) REFERENCES Schedule(ScheduleID),
  FOREIGN KEY (AircraftID) REFERENCES Aircraft(AircraftID)
);
```

Passenger

```sql
-- Holds the personal and contact details for all individuals who can make bookings.
CREATE TABLE Passenger (
    PassengerID INT PRIMARY KEY,
    FullName VARCHAR(100) NOT NULL,
    DOB DATE NOT NULL,
    EmailAddress VARCHAR(255),
    PhoneNumber VARCHAR(20)
);
```

Booking

```sql
-- Records a passenger's reservation and payment for a seat on a specific flight.
CREATE TABLE Booking (
    BookingID BIGINT PRIMARY KEY,
    PassengerID INT NOT NULL,
    FlightID INT NOT NULL,
    BookingDate TIMESTAMP NOT NULL,
    Status VARCHAR(20) NOT NULL,
    SeatNumber VARCHAR(5),
    TotalAmount DECIMAL(10, 2) NOT NULL,

    FOREIGN KEY (PassengerID) REFERENCES Passenger(PassengerID),
    FOREIGN KEY (FlightID) REFERENCES Flight(FlightID)

) PARTITION BY RANGE (BookingDate);
```

CrewRoster

```sql
-- Assigns crew members and their roles to a specific flight.
CREATE TABLE CrewRoster (
    RosterID BIGINT PRIMARY KEY,
    FlightID INT NOT NULL,
    CrewMemberID INT NOT NULL,
    Role VARCHAR(30) NOT NULL,

    FOREIGN KEY (FlightID) REFERENCES Flight(FlightID)
);
```

MaintenanceLog

```sql
-- Tracks all mandatory maintenance events performed on an aircraft, linked to the flight that necessitated it.
CREATE TABLE MaintenanceLog (
    MaintenanceID BIGINT PRIMARY KEY,
    AircraftID INT NOT NULL,
    LogDate TIMESTAMP NOT NULL,
    Type VARCHAR(50) NOT NULL,
    Description TEXT,

    FOREIGN KEY (AircraftID) REFERENCES Aircraft(AircraftID)
);
PARTITION BY RANGE (LogDate);
```

Baggage

```sql
-- Tracks luggage associated with passenger bookings.
CREATE TABLE Baggage (
   BaggageID BIGINT PRIMARY KEY,
   BookingID INT NOT NULL,
   WeightKg DECIMAL(6,2) NOT NULL,
   CheckInTime TIMESTAMP NOT NULL,
   Status VARCHAR(20) NOT NULL,
   TagNumber VARCHAR(20) NOT NULL UNIQUE,

   FOREIGN KEY (BookingID) REFERENCES Booking(BookingID)
);
```

Cargo Booking

```sql
-- Records freight and cargo shipments on flights.
CREATE TABLE CargoBooking (
   CargoID BIGINT PRIMARY KEY,
   FlightID INT NOT NULL,
   ShipperName VARCHAR(100) NOT NULL,
   WeightKg DECIMAL(10,2) NOT NULL,
   Hazardous BOOLEAN DEFAULT FALSE,
   SpecialInstructions TEXT,
   BookingDate TIMESTAMP NOT NULL,
   Status VARCHAR(20) NOT NULL,

   FOREIGN KEY (FlightID) REFERENCES Flight(FlightID)
);
```

Partitioning

Partitioning is a database technique that splits a large table into smaller, more manageable pieces called partitions, while still treating it as a single table. This dramatically improves performance for queries that access a recent subset of data and simplifies data management operations like archiving old data.

Partition Key: BookingDate / LogDate

Method: Monthly Range Partitioning. This is ideal for time-series telemetry data, making it cheap to drop old records and fast to query recent maintenance history.

Example Partitions: maintenance_2024_01, maintenance_2024_02, etc.

```sql
-- Booking table partitions
CREATE TABLE booking_2024_01 PARTITION OF Booking
  FOR VALUES FROM ('2024-01-01') TO ('2024-02-01');
CREATE TABLE booking_2024_02 PARTITION OF Booking
  FOR VALUES FROM ('2024-02-01') TO ('2024-03-01');

-- MaintenanceLog table partitions
CREATE TABLE maintenance_2024_01 PARTITION OF MaintenanceLog
  FOR VALUES FROM ('2024-01-01') TO ('2024-02-01');
CREATE TABLE maintenance_2024_02 PARTITION OF MaintenanceLog
  FOR VALUES FROM ('2024-02-01') TO ('2024-03-01');
```

Indexing

An indexing strategy involves creating optimized data structures (indexes) that allow the database to find data without scanning the entire table. A good strategy is crucial for performance but adds overhead on writes; it should be tailored to common query patterns.

Example Indexes:

```sql
CREATE INDEX idx_booking_passenger_date ON Booking(PassengerID, BookingDate DESC);
CREATE INDEX idx_booking_flightid ON Booking(FlightID);
CREATE INDEX idx_maintenancelog_tail_date ON MaintenanceLog(TailNumber, LogDate DESC);
CREATE INDEX idx_maintenancelog_flightid ON MaintenanceLog(FlightID);
CREATE INDEX idx_schedule_departure_search ON Schedule(DepartureAirportCode, DepartureTime);
CREATE INDEX idx_crewroster_crew_flight ON CrewRoster(CrewMemberID, FlightID);
CREATE INDEX idx_passenger_email ON Passenger(EmailAddress);
```

3.2. Master Data Management Strategy

Skylink uses MDM system to create and maintain golden records for their most important business entities: Aircraft, Airports and loyalty.

A golden record is a single, authoritative version of truth and most accurate version of a data entity within and organisation system to ensure accuracy, consistency and reliability across multiple source systems to have the most trusted version of each record used across airline operations.

Aircraft: The golden record combines data from maintenance systems, flight operations, manufacturer specs to track each aircrafts maintenance status, registration and configurations.

Airports: airport data uses IATA/ICAO registries integrated with Skylinks operational database to standardize names, codes and locations for flight planning and scheduling systems

Loyalty members: Customer master database consolidates data from reservations, transactional history and CRM systems combined into one, to ensure accurate point tracking, identity management and personalised experiences.

3.3. Metadata Catalog Sample

The metadata catalog stores key information about the datasets within skylink systems to ensure data transparency and traceability of data across the airline so users can understand and trust the data they use for operations and analytics.

3.3.1. Data lineage for flight telemetry

Data lineage for flight telemetry describes how telemetry data is generated, transmitted, processed, stored and consumed across Skylinks ecosystem. This data is collected from aircraft sensors ADS-B transponder which is essential for ensuring accurate and traceable information is available for flight monitoring, maintenance and performance analytics

3.3.2. Business Glossary for IATA codes

Each airport around the world is assigned with a unique code which is used for its quick and accurate identification in flight documentation, crew scheduling and everything related to the air operation.

The business glossary defines the key IATA terms Skylink uses across its airline systems to ensure consistent understanding of these aviation data.

Term	Definition	Example
IATA Airport Code	An IATA code is three-character code assigned by the international air transport association (IATA) to identify an airline or location such as an airport.	DUB - Dublin
ICAO	A four-letter code assigned by the international civil aviation organisation used in flight operations and air traffic control	EIDW - Dublin
IATA Airline Code	A two-character code assigned by IATA to identify airlines for commercial purposes such as reservations, timetables, telecommunications, cargo documentation and other stuff	SL – Skylink Airline
PNR	A passenger name record is a digital document containing the itinerary, passenger details, payment details and contact details for passengers	1LUV67
AWB (Air Waybill)	A unique IATA document and tracking number issued for cargo shipments used to identify and track for air freight	911 - 12345678
Load factor	Percentage of available seats on a flight that are filled with passengers.	Flight SL123- 67% load factor
Baggage Tag number	This is unique barcode number that is attached to each checked bag used to track through airline baggage system	123w67

IATA Aiport Code: Skylink operates global passenger and cargo flights, so every reservation, flight plan and ticket uses IATA's 3 letter airport code

ICAO Airport Code: Skylink's operations, crew and maintenance systems rely on the more technical ICAO codes for air traffic control.

IATA airline designator: As skylink is a global carries they need an IATA 2 letter airline code SL which identifies the airline on flight numbers like SL001

PNR: Skylink's reservation, check-in and loyalty program uses PNR to link passenger bookings and service information.

AWB: Skylink's cargo systems use Air Waybill number to track and manage air freight shipments ensuring accurate handling, custom documentation and visibility of cargo movement.

Load Factor: Skylink's operation teams use load factor to measure how efficiently each aircraft seating capacity is being used. This helps the airline choose which aircraft if better on different routes which allows to adjust pricing and improving profitability.

Baggage tag number: Skylink's baggage handling system uses baggage tag number to track each passengers checked luggage to ensure accurate transfers and reducing the risk of lost bags.

These codes are essential for Skylinks global passenger and cargo operations. They will ensure consistency and accuracy across all systems used for flight planning, cargo tracking, reservations and regulatory compliance. IATA and ICAO codes allows seamless communication between Skylink, airports and logistics providers.

3.4. Business Operating Model

We use our operating model to show how we create and deliver value to our customers, it incorporates our people, processes and infrastructure. We provide customers with flights to places on our airplanes along with delivering their luggage.. They book seats and other services They book a particular flight and seat via the app. We allow them to book or just be assigned a random seat. Some seats have more leg room than others. Customers can also buy food, drink or other items while on the flight, or they can also book more luggage to bring with them.

As we are a global airline and can travel further distances, food on the flight, helps make sure people don't get hungry. More legroom and comfort are nice for longer flights to help make customers feel more relaxed. We keep our processes as efficient as possible, in order to maximise time, we are flying. Customers check in at the airport and then we help them onto the plane and store their luggage onto the plane. Depending on the flight we might employ a shuttle bus depending on how far away the plane is from the airport to help customers get on. After the plane lands we help them off and transfer their luggage to the airports onto conveyor belts.

3.5. Information System Architecture

Our information system tracks how information moves between our organization, it can be made up of our hardware, software, processes we use, people we employ and data we gather. Our main hardware is the planes themselves which keep track of lots of data. We also have servers for handling the backend servers and software and managing the ticket prices and bookings. Database for our customers and their information. This data is shared with the airport for when people are checking in.

Customers book a flight, we take their information and money and update our systems so that their booking information is stored, when they are at the airport they can check in at the counter or using the app. Flight attendants let people onto the plane and they sit down, when all are seated the plane takes off. Flight to destination, then landing, passengers disembark and the seats are cleaned and maintenance done to the plane.

We can keep track of load factor (seat occupancy rate), what flights are most popular, fuel usage and weight per flight. Passengers and airports can stay updated with our flight data. Can also see how much weight is on board with luggage and how much more we could potentially fit. Our system keeps track of what crew we have on each flight, and how long it takes them to clean.

Our information systems keep our flight schedule updated, along with any delays from unexpected maintenance or other unforeseen issues. We make sure we have planes available for the times on the flight schedule and that we have crew available. We can see each crew members pay and qualifications and reallocate them as necessary. We keep track of metrics such as how much the plane and crew have flown in the last 24 hours. There is a maximum flight time to keep track of and not exceed.

4. Application Architecture Package

4.1. Component Diagram

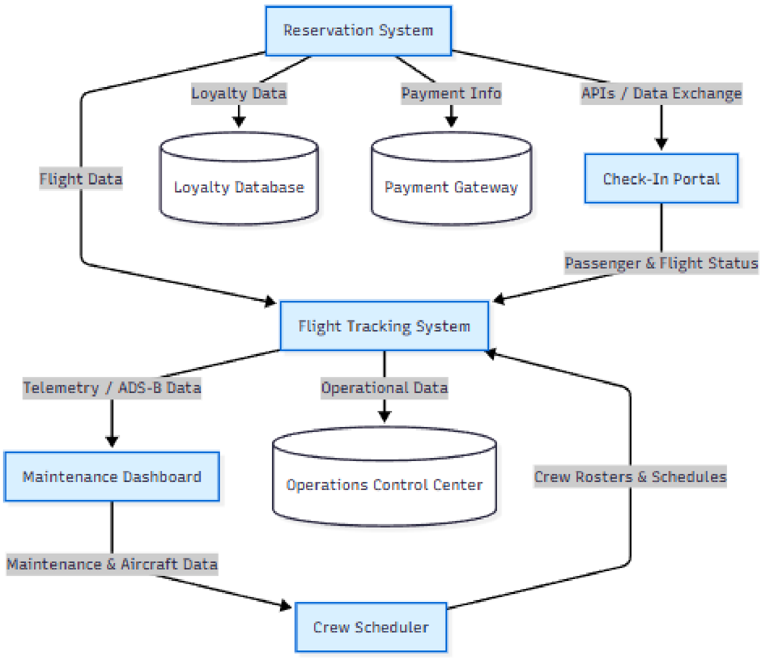

Figure 4. Component Diagram

This component diagram shows the main applications systems and data interactions within SkyLink Airlines. Each box represent key application component (Reservation, Check-in, Flight tracking, Maintenance and Crew). The arrows show how the data flows between components

Reservation System: this is the core for Skylink passenger services. It manages bookings, payments and loyalty programms.

Check-in Portal: the portal interacts with the reservation system via APIs to retrieve booking details and issue boarding pass.

Flight tracking system: receives real time flight and telemetry data which provides live updates to passengers and operations control center.

Maintenance Dashboard: processes ADS-B data for predictive maintenance and safety checks.

Crew Scheduler: responsible for creating and managing flight schedule for pilots and flight attendants to ensure every flight has the right crew and in the right place and time.

4.2. Service Boundaries

SkyLink's application design is built around the bounded context principle from domain-driven design, where each microservice models a specific business area of the airline. Each service includes all the logic, data, and components it needs to operate independently, reducing dependencies and avoiding tight coupling between systems. This approach allows SkyLink to evolve, scale, and deploy services separately while maintaining overall system stability. SkyLink defines its key service boundaries as follows:

Reservation Service – Manages flight search, ticket booking, payment, and loyalty point updates. It acts as the entry point for customers through the mobile app or web portal.

Check-in Service – Operates within its own context to issue boarding passes, verify identity, and assign seats, interacting with the Reservation Service through REST APIs only when required.

Flight Tracking Service – Processes live telemetry from aircraft via MQTT and provides real-time updates to the operations dashboard and passenger applications.

Maintenance Service – Handles aircraft diagnostics, logs, and predictive maintenance analytics. It is data-isolated and retrieves only necessary flight details through API calls.

Crew Scheduling Service – Manages pilot and cabin crew assignments, availability, and compliance with flight time regulations, coordinating schedules with flight operations but maintaining its own data store.

Service granularity is guided by business functionality rather than technical layers. Each service performs a complete workflow within its domain without requiring complex distributed transactions. For instance, reservation and payment logic stay within the Reservation Service, while maintenance events and telemetry analysis are contained in the Maintenance Service. This avoids unnecessary inter-service communication and improves reliability.

A key design rule is data isolation. Each service manages its own database and schema, preventing conflicts and enabling independent scaling. The Reservation Service may use a relational database for transactional consistency, while the Flight Tracking Service might use a time-series database for telemetry. This autonomy also allows teams to choose the best technology for their domain's data needs.

Finding the right boundaries is an evolving process. As SkyLink's systems grow, some services may be merged or split to reduce communication overhead or improve domain clarity. This iterative refinement ensures that microservice boundaries continue to align with real airline workflows, maintaining both efficiency and domain integrity.

4.3 API Contracts

API Contracts Information

The APIs serve as the connection point for transferring data between the front end website or app to the backend booking systems.

For our API endpoints we have GET /flights, POST /bookings, Post /check-in

GET /flights, POST /bookings

- These APIs allow customers to search for flights that are available. They can then choose from the available flights and create a booking that is sent off. They help out the customers and support the business goals that we have set. Customers can search for available flights and then make bookings. Being able to book flights allows them to book ahead of them giving the customer a better experience and improves cost efficiency for us the airline as we know how many people will be on the flight and the booking is automated.

Post /check-in

- These give a better user experience for when the passenger is at the airport and going onto the plane. You can check in on the app which helps reduce waiting time for customers not having to go in as many lines and also for the airline as they can have customers book in earlier to confirm that they will be on the flight.

Also have ADS-B (Automatic Dependent Surveillance - Broadcast)

- We have decided on MQTT and use it to receive the real time position of the aircraft along with the movement data from ADS-B transponders. It helps to improve safety though being able to monitor aircraft data in real time. These conveys important safety information that the plane is flying correctly and it won't end up crashing into anything else. It helps to track the plane and know when the plane will be arriving in its destination which helps to keep the next passengers that will be using the plane informed with accurate information.
  We decided on the using **REST** schema with JSON for the Booking Management and the passenger Check In.

The base URL for the endpoints is: https://api.skylink.com/v1

4.3.1. REST Schema

Flight Search

```
GET /flights?origin=JFK&destination=LAX&date=2023-12-15{
 "flights": [
  {
   "flightId": "SL101",
   "origin": "JFK",
   "destination": "LAX",
   "departureTime": "2023-12-15T08:00:00Z",
   "price": 299.99
  }
 ]
}
```

Create Booking

```
POST /bookings

{
 "flightId": "SL101",
 "passengers": [
  {
   "firstName": "John",
   "lastName": "Doe",
   "email": "john@email.com"
  }
 ]
}
```

Check In

```
POST /check-in
{
 "bookingId": "BK789XYZ",
 "seat": "14C"
}
```

4.3.2. Streaming Definitions for ADS-B with MQTT

Data Flow

Aircraft → ADS-B (Flight Position, Velocity, flight number) → MQTT → Airline Systems QOS (Quality of Service), will deliver at least once

MQTT Configuration:

```yaml
broker: "mqtt://adsb-broker:1883"
topic_structure: "skylink/telemetry/{aircraft_id}"
qos: 1
```

Telemetry Message Format:


```json
{
 "aircraft_id": "ABC123",
 "timestamp": "2024-01-15T10:30:00Z",
 "position": {
  "latitude": 40.7128,
  "longitude": -74.0060,
  "altitude": 35000
 },
 "movement": {
  "ground_speed": 450,
  "heading": 123.5
 },
 "flight": {
  "callsign": "SKY101",
  "squawk_code": "1234"
 }
}
```


Topic Structure:

- skylink/telemetry/all - All aircraft
- skylink/telemetry/{aircraft_id} -Specific aircraft
- skylink/telemetry/airport/{code} - Airport area

4.4. User Workflow

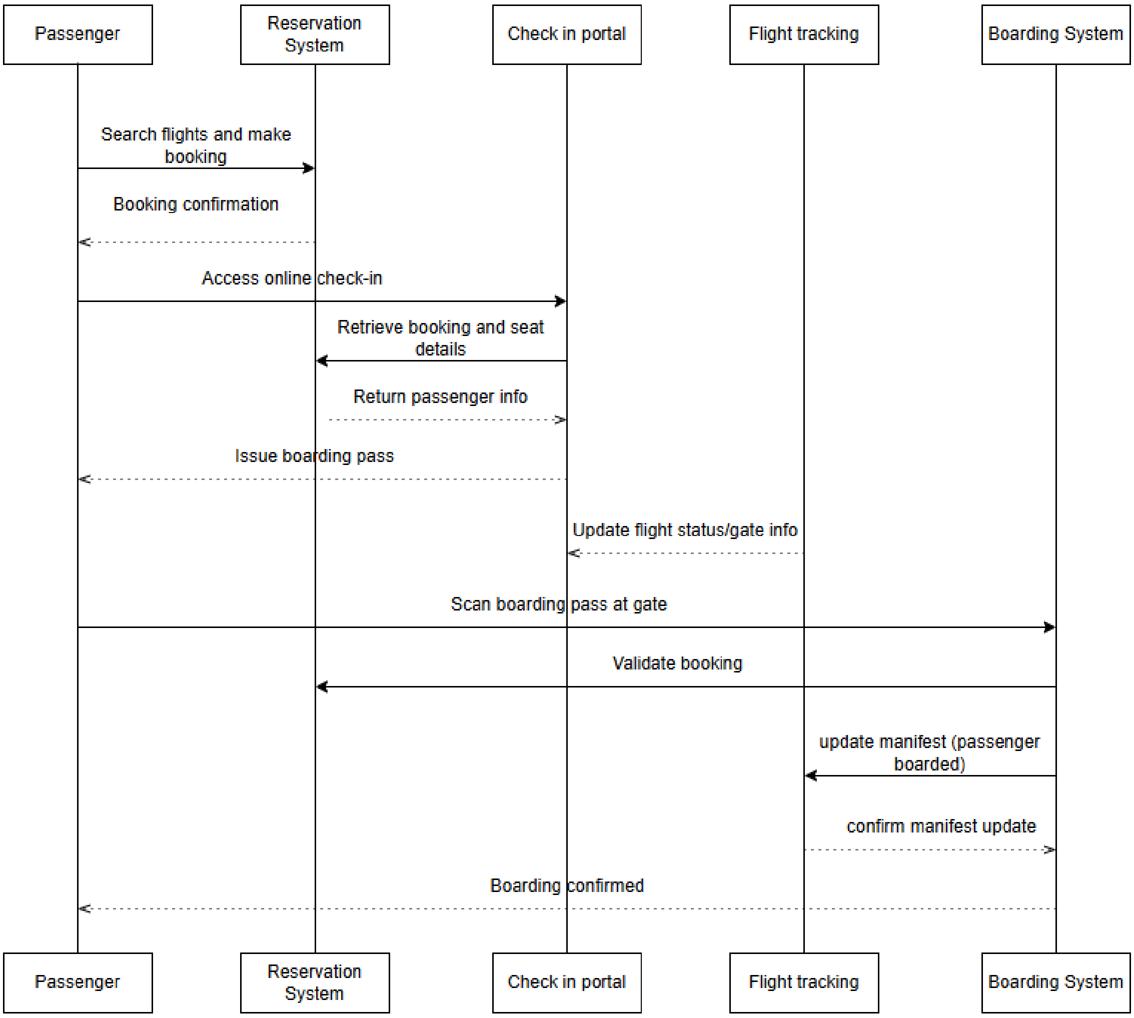

Figure 5. User Workflow Diagram

This sequence diagram shows how Skylink's system interacts during a passenger's journey. It shows how the booking, check-in and boarding information flow between the Reservation system, Check-in Portal, Flight tracking and Boarding system. This ensures that data for passengers, flight status and boarding get updated and remain synchronized across all Skylinks platforms.

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