Frd

**Title -Functional Requirement Document**

**Client: Airport Authority of India**

Implementing Baggage Tracking System at International Airport

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**VERSION CONTROL**

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| --- | --- |
| FRD Version | Date |
| 1.1 | 15-3-2025 |
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**APPROVALS**

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| FRD Version | Date | Approved By |
| 1.1 | 15-3-2025 | XYZ |
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1. **Introduction**

Define the functionality to create an advanced baggage tracking system that seamlessly integrates with airport security, airline check‑in, and baggage handling systems for real‑time monitoring and enhanced operational efficiency.

1. **Objectives:**

* **Enhance Real-Time Monitoring:**  
  Implement a system that provides continuous, up‑to‑date tracking of baggage across all checkpoints to reduce delays and improve accuracy.
* **Improve Passenger Satisfaction:**  
  Enable live updates for passengers—via mobile apps or web portals—so they can track their baggage in real time, reducing anxiety and complaints.
* **Increase Operational Efficiency and Reduce Mishandling:**  
  Streamline and automate baggage processes to cut down on manual errors and mishandling incidents, thereby speeding up overall operations.
* **Ensure Security and Regulatory Compliance:**  
  Incorporate robust security protocols and adhere to international standards (e.g., IATA guidelines) and data protection regulations to safeguard both operational integrity and passenger data.

1. **Project Scope**
   1. **In Scope:**
2. **Real-Time Tracking Using RFID/Barcode Technology**

* **RFID Technology:**
  + **How It Works:** Each piece of baggage is tagged with an RFID chip that emits a unique identifier. RFID readers placed at strategic checkpoints (check-in, security, loading, unloading, and claim areas) pick up these signals continuously.
  + **Benefits:** Enables continuous, automated tracking without manual intervention. It provides high accuracy and speed in capturing real-time data on baggage location.
  + **Implementation Considerations:**
    - Ensure sufficient coverage of RFID readers throughout the airport.
    - Calibrate the system to handle interference from metallic structures and other electronic devices.
    - Integrate with middleware to process and relay data in real time.
* **Barcode Technology:**
  + **How It Works:** Baggage is also tagged with a barcode (or QR code) which can be scanned at various points in the process.
  + **Benefits:**
    - Serves as a reliable backup to RFID.
    - Useful for manual verification or in environments where RFID signals might be weak.
  + **Implementation Considerations:**
    - Deploy handheld or fixed barcode scanners at key areas.
    - Ensure the barcode printing process is integrated with check-in systems.

1. **Integration with Security Systems, Airline Check-In, and Central Baggage Handling**

* **Integration with Airport Security Systems:**
  + **Purpose:** To ensure that baggage movements are continuously monitored in the context of overall airport security.
  + **How It Works:**
    - The tracking system exchanges data with existing surveillance and access control systems.
    - Helps verify that baggage is handled only by authorized personnel and is stored in secure areas.
  + **Implementation Considerations:**
    - Utilize secure APIs to integrate with existing security systems.
    - Ensure data encryption and access controls to protect sensitive information.
* **Integration with Airline Check-In Systems:**
  + **Purpose:** To link each piece of baggage to passenger information and flight details.
  + **How It Works:**
    - When a passenger checks in, their baggage tag is generated and associated with their flight itinerary.
    - Real-time updates are shared between the airline’s system and the baggage tracking system.
  + **Implementation Considerations:**
    - Synchronize data using RESTful APIs or middleware solutions.
    - Validate data integrity and consistency between systems.
* **Integration with Central Baggage Handling Systems:**
  + **Purpose:** To automate the routing and processing of baggage from check-in to the baggage claim area.
  + **How It Works:**
    - The system interacts with conveyor belt controls and sorting systems to direct baggage efficiently.
    - Ensures that baggage is routed correctly based on real-time tracking data.
  + **Implementation Considerations:**
    - Establish real-time data exchange protocols.
    - Monitor system performance to quickly resolve routing issues.

1. **. Automated Alerts and Notifications for Delayed or Misplaced Baggage**

* **Automated Alerts:**
  + **How It Works:**
    - The system continuously monitors baggage movement. If a bag deviates from its expected path or is delayed beyond a set threshold, an alert is automatically triggered.
    - Alerts are sent to airport operations and security personnel for immediate action.
  + **Notification Channels:**
    - SMS, email, or push notifications via a dedicated mobile app.
    - Dashboard alerts for real-time monitoring by control room staff.
  + **Implementation Considerations:**
    - Define threshold levels for delay or misrouting.
    - Integrate an alert management module with escalation protocols.
* **Passenger Notifications:**
  + **How It Works:**
    - Passengers receive real-time updates about their baggage status, including notifications if their bag is delayed or misrouted.
  + **Implementation Considerations:**
    - Develop an interface for passengers that connects to the alert system.
    - Ensure that notifications are clear and actionable.

1. **Passenger Interfaces (Mobile/Web) for Baggage Status**

* **Mobile Application & Web Portal:**
  + **Purpose:** To empower passengers with the ability to track their baggage in real time.
  + **Key Features:**
    - Real-time status updates, including current location and estimated arrival time.
    - A user-friendly interface with clear navigation and visual cues.
    - Integration with customer service for inquiries or support.
  + **Implementation Considerations:**
    - Use responsive design to ensure compatibility across devices.
    - Incorporate secure authentication methods to protect user data.
    - Provide multilingual support if needed.

1. **Reporting and Analytics for Management**

* **Operational Dashboards:**
  + **Purpose:** To offer management a real-time overview of baggage handling performance.
  + **Key Metrics:**
    - Tracking accuracy (e.g., percentage of baggage tracked correctly).
    - Incident rates for delays, misrouting’s, or mishandling.
    - Average processing times at various checkpoints.
  + **Implementation Considerations:**
    - Develop customizable dashboards using BI tools (e.g., Power BI or Tableau).
    - Enable data filtering and drill-down capabilities for detailed analysis.
    - Schedule automated reports to support strategic decision-making.
* **Data Analytics:**
  + **Purpose:** To provide insights that help optimize operations and improve efficiency.
  + **Key Features:**
    - Historical data analysis to identify trends and recurring issues.
    - Predictive analytics to anticipate bottlenecks or peak periods.
  + **Implementation Considerations:**
    - Integrate with the central database to aggregate tracking data.
    - Use data visualization tools to present insights in an easily digestible format.
  1. **Out of Scope:**
* Hardware procurement (e.g., RFID tags/readers) unless specified.
* External systems not related to baggage handling.

**4. Functional Requirements**

**4.1 Baggage Tagging & Identification**

**Requirement:** Each bag will receive a unique identifier using RFID/barcode technology.

**Details:**

* + **Tag Generation and Printing at Check-In:**
    - **Process:** During passenger check-in, the system will generate a unique RFID tag or barcode for each piece of baggage. This tag will be printed and attached to the bag, enabling automated tracking throughout its journey.
    - **Implementation Example:** XYZ Airlines implemented RFID technology across 344 stations, deploying 3,800 RFID bag tag printers to facilitate this process.
  + **Data Recording in Central Database:**
    - **Process:** The unique identifier encoded in each tag will be recorded in a central database, along with relevant information such as the passenger's details, flight number, and destination. This centralized data management ensures accurate tracking and quick retrieval of baggage information when needed.
    - **Industry Standard:** According to IATA Resolution 753, airlines are required to track baggage at various points, including check-in, to improve baggage handling processes and reduce mishandling.

**Analysis Summary:**

Implementing RFID technology for baggage tagging and identification enhances the efficiency and accuracy of baggage handling systems. Airlines like XYZ have demonstrated the benefits of such systems, including real-time tracking and reduced mishandling rates. Adhering to industry standards, such as IATA Resolution 753, further ensures that baggage is accurately tracked at all critical points, leading to improved passenger satisfaction and operational efficiency.

By integrating RFID technology and maintaining a centralized database, airports and airlines can achieve a more streamlined and reliable baggage handling process, minimizing errors and enhancing the overall travel experience for passengers.

**4.2 Real-Time Tracking**

**Requirement:** Track baggage movement across predefined checkpoints, including check-in, security, loading, unloading, and claim.

**Details:**

* + **Capture Location Data in Real-Time:**
    - **Process:** Implement RFID technology to automatically capture and record the location of each bag as it passes through various checkpoints. RFID readers installed at strategic points will detect the unique identifiers on baggage tags, enabling continuous monitoring without manual intervention.
    - **Benefits:** This automation reduces the risk of human error, enhances tracking accuracy, and ensures timely updates on baggage location, thereby minimizing incidents of lost or mishandled luggage.
  + **Update Status on Both Staff Dashboards and Passenger Interfaces:**
    - **Staff Dashboards:** Develop an integrated dashboard for airline and airport staff that displays real-time baggage status. This platform will allow staff to monitor baggage flow, quickly identify and address any issues, and optimize handling processes.
    - **Passenger Interfaces:** Provide passengers with real-time updates on their baggage status through mobile applications or web portals. Notifications can inform passengers when their bags are loaded onto the aircraft, unloaded, or ready for pickup at the claim area.
    - **Case Study:** XYZ Airlines utilizes RFID technology to offer real-time baggage tracking. Customers receive push notifications via the Fly XYZ app, updating them on their luggage status from check-in to the arrivals carousel. This system has achieved a 99.9% tracking success rate, ensuring proper routing and loading.

**Analysis Summary:**

Implementing real-time baggage tracking using RFID technology significantly enhances the efficiency and reliability of baggage handling systems. Automated data capture at critical checkpoints reduces mishandling incidents and improves operational workflows. Providing real-time updates to both staff and passengers enhances transparency and satisfaction, aligning with industry trends toward improved baggage management.

By adopting such technologies, airlines and airports can streamline operations, reduce costs associated with lost luggage, and enhance the overall travel experience for passengers.

**4.3 Integration**

**Requirement:** Seamlessly integrate with:

* + **Airport Security Systems:** For monitoring and validation.
  + **Airline Check-In Systems:** To sync flight and passenger data.
  + **Baggage Handling Systems:** To route and manage baggage flow.

**Details:** Use RESTful APIs for data exchange between systems.

**4.4 Automated Alerts & Notifications**

**Requirement:** Automatically notify airport staff and passengers in case of baggage delays, misrouting, or mishandling.

**Details:**

**Set Thresholds for Triggering Alerts:**

* + - **Process:** Define specific criteria and thresholds that, when met, will trigger automated alerts. For example, if a bag does not reach a designated checkpoint within a predetermined time frame, an alert is generated.
    - **Implementation:** Utilize advanced tracking technologies, such as RFID, to monitor baggage movement in real-time. The system can be configured to recognize deviations from expected transit times or routes, prompting immediate notifications to relevant personnel.

**Integrate with SMS/Email and Mobile App Notifications:**

**For Airport Staff:**

* + - * **Integration:** Connect the alert system to internal communication platforms, enabling instant notifications via SMS or email to baggage handling teams. This ensures prompt action to rectify issues like delays or misrouting.
      * **Case Study:** XYZ Airlines implemented a system where passengers receive notifications as their baggage is detected by RFID readers, enhancing engagement and involvement in the travel process.

**For Passengers:**

* + - * **Mobile App Integration:** Develop features within the airline's mobile application that provide real-time updates on baggage status. Passengers can receive push notifications about their luggage's location, delays, or mishandling incidents.
      * **SMS/Email Notifications:** Offer options for passengers to receive updates through SMS or email, catering to those who may not use the mobile app.
      * **Industry Example:** United Airlines integrated Apple's Share Item Location feature for AirTag tracking devices into its mobile application, allowing passengers to monitor their luggage in real-time and receive timely updates.

**Analysis Summary:**

Implementing automated alerts and notifications in baggage handling systems enhances operational efficiency and passenger satisfaction. By setting precise thresholds for alerts and integrating communication channels like SMS, email, and mobile apps, airlines can promptly address baggage issues, reducing mishandling rates and improving the overall travel experience. Adopting advanced tracking technologies and seamless communication strategies aligns with industry trends towards automation and enhanced customer service.

**4.5 Reporting & Analytics**

**Requirement:** Provide dashboards and reports for operational insights.

**Details:**

* + **Generate Daily/Weekly Reports on Baggage Handling Performance:**
    - **Process:** Implement a reporting system that automatically compiles data on baggage handling operations to produce daily and weekly performance reports. These reports should be accessible through web-based platforms, allowing stakeholders to monitor system performance remotely.
    - **Benefits:** Regular reporting enables proactive identification of trends, potential issues, and areas for improvement, facilitating data-driven decision-making to enhance operational efficiency.
  + **Include Metrics Such as Processing Times, Error Rates, and Incident Logs:**
    - **Processing Times:** Measure the time taken for baggage to move through various stages of handling, from check-in to loading, unloading, and claim. Monitoring these times helps in identifying bottlenecks and optimizing processes.
    - **Error Rates:** Track the frequency of mishandled bags, including misrouting and delays. Analyzing error rates assists in pinpointing problem areas and implementing corrective actions to reduce mishandling incidents.
    - **Incident Logs:** Maintain detailed records of any irregularities or issues encountered during baggage handling operations. Incident logs provide valuable insights for root cause analysis and help in developing strategies to prevent future occurrences.

**Analysis Summary:**

Implementing comprehensive reporting and analytics within baggage handling systems is crucial for maintaining operational excellence. By generating regular reports and monitoring key performance indicators such as processing times, error rates, and incident logs, airports can identify inefficiencies and implement targeted improvements. Utilizing web-based dashboards enhances accessibility and real-time monitoring capabilities, aligning with industry trends towards data-driven operations.

Adopting such reporting mechanisms not only enhances operational efficiency but also contributes to improved passenger satisfaction by reducing baggage mishandling and delays. Investing in robust analytics tools is essential for airports aiming to optimize their baggage handling processes and overall service quality.

* + 1. **Business Rules**

**Compliance:**

* **Adherence to IATA Guidelines and Security Protocols:**
  + **Implementation:** Ensure that all baggage handling processes align with the International Air Transport Association (IATA) standards, including Resolution 753, which mandates baggage tracking at four key points: check-in, loading onto the aircraft, transfer, and arrival at the claim area.
  + **Benefits:** Compliance with these guidelines enhances operational efficiency, reduces mishandling incidents, and improves passenger satisfaction.

**5.2 Data Integrity:**

* **Ensuring Real-Time Data Accuracy and Secure Storage:**
  + **Implementation:** Utilize robust data management systems that provide real-time updates on baggage status, ensuring accuracy and reliability. Implement encryption protocols and multi-factor authentication to protect data integrity and prevent unauthorized access.
  + **Benefits:** Maintaining accurate and secure data fosters trust among stakeholders and supports efficient baggage handling operations.

**5.3 User Roles:**

* **Defining Permissions for Airport Staff, Security Personnel, and Passengers:**
  + **Implementation:** Establish a role-based access control system that assigns specific permissions based on user roles. For instance, airport staff may have access to operational data, security personnel to security-related information, and passengers to their individual baggage status.
  + **Benefits:** Clearly defined user roles enhance data security, ensure compliance with privacy regulations, and streamline operations by providing users with relevant information tailored to their responsibilities.

**5.4 Operational Protocols:**

* **Outlining Standard Procedures for Handling Alerts and Exceptions:**
  + **Implementation:** Develop comprehensive standard operating procedures (SOPs) that detail the steps to be taken when alerts are triggered or exceptions occur, such as delayed or misplaced baggage. These protocols should include communication strategies, escalation paths, and resolution timelines.
  + **Benefits:** Having clear protocols ensures swift and effective responses to issues, minimizing disruptions and enhancing the passenger experience.
    1. **User Interface Requirements**

**6.1 Staff Dashboard:**

* **Real-Time Data Visualization:**
  + **Functionality:** The staff dashboard should present live data on baggage status, movements, and system performance through intuitive visual elements like charts, graphs, and maps.
  + **Benefits:** Real-time visualization enables staff to monitor operations efficiently, quickly identify issues, and make informed decisions to maintain smooth baggage handling processes.
* **Alert Management and Detailed Baggage Status:**
  + **Functionality:** Incorporate an alert system within the dashboard to notify staff of delays, misrouting, or equipment malfunctions. Provide detailed information on each bag's status, including location history and handling records.
  + **Benefits:** Effective alert management allows for prompt responses to irregularities, reducing mishandling incidents. Detailed baggage information aids in tracking and resolving specific issues efficiently.

**6.2 Passenger Interface:**

* **Mobile App/Web Portal to Track Baggage:**
  + **Functionality:** Develop user-friendly mobile applications and web portals that allow passengers to monitor their baggage in real-time, from check-in to arrival at the destination.
  + **Benefits:** Providing passengers with access to their baggage status enhances transparency and reduces anxiety related to baggage handling, improving overall travel satisfaction.
* **Simple, Intuitive Design with Real-Time Updates:**
  + **Functionality:** Ensure the passenger interface features a clean and straightforward design, offering real-time notifications about baggage location, delays, or issues.
  + **Benefits:** An intuitive design ensures passengers can easily access and understand baggage information, leading to a more pleasant user experience.

**6.3 Accessibility:**

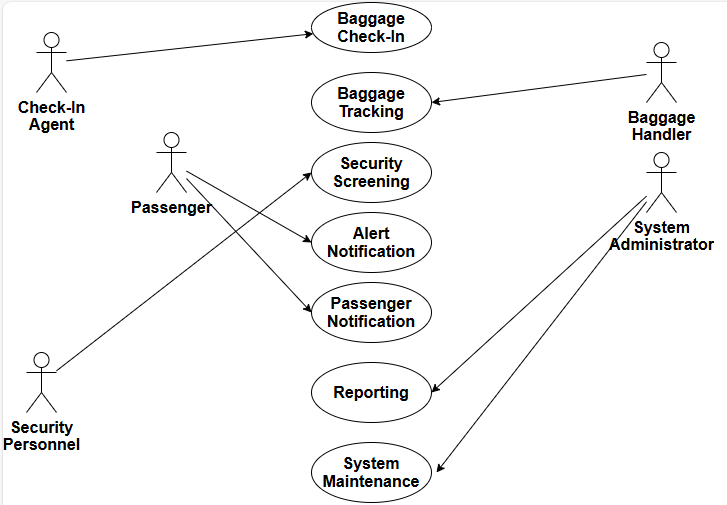
* **Ensure Compliance with Accessibility Standards for Diverse Users:**
  + **Functionality:** Design both staff and passenger interfaces to comply with international accessibility standards, such as the Americans with Disabilities Act (ADA), to accommodate users with disabilities.
  + **Benefits:** Adhering to accessibility standards ensures that all users, regardless of physical or cognitive abilities, can effectively interact with the system, promoting inclusivity and equal access.
    1. **Use Case Diagram**

**Actors:**

1. **Passenger:** Interacts with the system to check in baggage and receive status updates.
2. **Check-In Agent:** Handles baggage tagging and initiates tracking processes.
3. **Baggage Handler:** Manages the physical movement of baggage within the airport and updates the system accordingly.
4. **Security Personnel:** Conducts security screenings and updates the system with clearance statuses.
5. **System Administrator:** Oversees system maintenance, manages user roles, and ensures data integrity.

**Use Cases:**

1. **Baggage Check-In:**
   * Passengers check in baggage, which is tagged with a unique identifier (RFID/barcode) by the check-in agent.
2. **Baggage Tracking:**
   * The system monitors baggage movement through various checkpoints (e.g., check-in, security, loading, unloading, claim) in real-time.
3. **Security Screening:**
   * Security personnel perform screenings and update the system with the baggage's security status.
4. **Alert Notification:**
   * The system generates automated alerts for delays, misrouting, or mishandling, notifying both staff and passengers.
5. **Passenger Notification:**
   * Passengers receive real-time updates on baggage status via mobile app or web portal.
6. **Reporting:**
   * The system compiles data to generate reports on baggage handling performance for management review.
7. **System Maintenance:**
   * Administrators perform regular maintenance, manage user roles, and ensure data integrity.



* + 1. **Assumptions & Constraints**

**Assumptions:**

**Airport Infrastructure:**

* **RFID Technology Implementation:** The airport has deployed RFID systems, including tags and readers, to facilitate accurate and efficient baggage tracking. RFID technology offers higher read rates compared to traditional barcode systems, enhancing tracking accuracy.
* **Network Connectivity:** A robust network infrastructure is in place to support real-time data transmission between RFID readers and central baggage tracking systems, ensuring seamless monitoring and management.

**Stakeholder Cooperation:**

* **Access to System Documentation:** All relevant stakeholders, including airlines, airport authorities, and security agencies, will provide timely access to existing system documentation. This access is crucial for integrating the new baggage tracking system with current operations and ensuring compliance with industry standards.
* **Collaboration:** Stakeholders are committed to active participation and collaboration throughout the integration process, facilitating smooth implementation and operation of the baggage tracking system.

**Constraints:**

* + **Fixed Budget and Six-Month Timeline:** The project must be completed within a six-month timeframe and adhere to a predetermined budget, necessitating efficient planning and resource allocation.
  + **Environmental Factors Affecting RFID Performance:** Elements such as metal surfaces, liquids, and other radio-frequency (RF) emitting devices can interfere with RFID signals, potentially impacting system performance
    1. **Acceptance Criteria**
* **Performance:**
  + System must track at least 99% of baggage movements accurately.
* **User Acceptance:**
  + Achieve 90% satisfaction rate in UAT.
* **Compliance:**
  + Full adherence to IATA and local security standards.
    1. **Technical Approach**
* **System Architecture:**
  + Cloud-based centralized system with modular design.
* **Database Management:**
  + Secure SQL/NoSQL database ensuring redundancy and disaster recovery.
* **Security Measures:**
  + Data encryption (in transit and at rest), user authentication, and role-based access control.
* **Integration:**
  + Use RESTful APIs and, where necessary, middleware for seamless data exchange.
    1. **Testing & Quality Assurance**
* **Functional Testing:** Validate each module’s functionality.
* **Integration Testing:** Ensure all systems (check-in, security, baggage handling) work seamlessly.
* **Performance & Load Testing:** Confirm system performance under peak loads.
* **Security Testing:** Conduct audits and compliance checks.
* **User Acceptance Testing (UAT):** Validate system usability and accuracy with end-users.
  + 1. **Deployment & Training**
* **Phased Rollout Starting with a Pilot Phase:**
  + **Pilot Phase:**
    - **Objective:** Implement the advanced baggage tracking system in a controlled environment, such as a specific terminal or a limited number of flights, to evaluate its performance and identify potential issues before a full-scale deployment.
    - **Benefits:** This approach allows for the assessment of system functionality, user interaction, and operational impact on a smaller scale, reducing risks associated with immediate widespread implementation.
  + **Transition to Full Production After Successful Pilot Testing:**
    - **Process:** Based on insights gained during the pilot phase, make necessary adjustments to the system. Upon successful testing and validation, gradually expand the deployment to additional terminals or flights, eventually achieving full-scale implementation.
    - **Advantages:** A phased rollout minimizes disruptions to airport operations and allows for continuous improvement based on real-time feedback.

**Training:**

* **Develop User Manuals and Training Sessions for Airport Staff:**
  + **User Manuals:** Create comprehensive, role-specific manuals detailing system functionalities, standard operating procedures, and troubleshooting guidelines. These manuals should be easily accessible and regularly updated to reflect system enhancements.
  + **Training Sessions:** Conduct interactive training programs, including workshops and hands-on sessions, to ensure staff are proficient in using the new system. Tailor training content to address the specific needs and responsibilities of different user groups within the airport staff.
* **Provide Technical Documentation and Support for Ongoing Maintenance:**
  + **Technical Documentation:** Develop detailed technical manuals covering system architecture, integration points, maintenance procedures, and troubleshooting protocols. This documentation should serve as a reference for IT personnel responsible for system upkeep.
  + **Ongoing Support:** Establish a dedicated support team to provide continuous assistance, address technical issues, and implement system updates. Regular refresher training sessions and knowledge-sharing platforms can help maintain staff competency and adapt to system advancements.
    1. **Post-Implementation Support**
* **Maintenance:**
  + 24/7 technical support and regular system updates.
* **Monitoring:**
  + Continuous monitoring of system performance and incident management.
* **Feedback Loop:**
  + Implement a process for collecting user feedback and making improvements.