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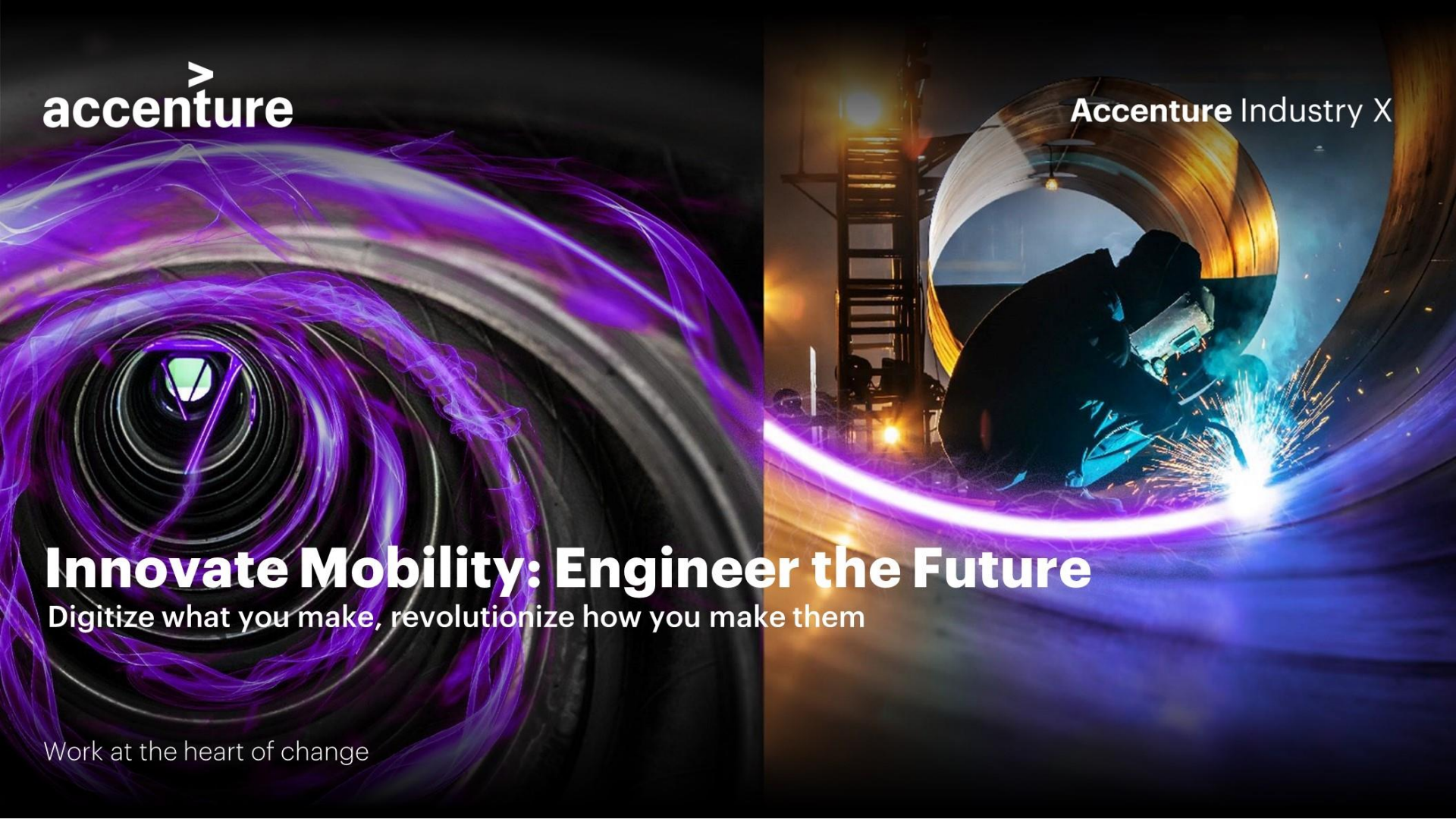

Innovate Mobility: Engineer the Future

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Guidelines

The template should consist of the following and it is mandated to be used by your teams for submitting your innovative ideas/solutions.

Note - Make a copy of this template & share with the teams on the Team Dashboard.

Team Name : **Strategic Engineer**

Team Leader Name : **Tarun Kurakula**

Problem Statement : Accelerating Engineering Clearance for AOG Scenarios with Innovative Solutions

Problem statement you are trying to address

Challenge 6: Accelerating Engineering Clearance for AOG Scenarios with Innovative Solutions

In the current challenging and competitive aviation industry, aircraft on the ground due to damage to aircraft need immediate attention in resolving the engineering clearance before they fly back. In this scenario the engineering clearance needs to be given for the specific repairs' occurrence, Lead time in resolving the issues is especially important as it adds burden to the airliner. Can you propose innovative solutions that resolve minimum lead time with maximum quality output?

Understanding the Problem

- Aircraft on Ground (AOG) is a term used in the aviation industry to describe situations where an aircraft is unable to fly due to technical, mechanical, or logistical issues, resulting in it being grounded. This status indicates a serious problem that necessitates immediate attention to return the aircraft to operational status. AOG situations are critical because they disrupt flight schedules, potentially causing significant financial losses and operational challenges for airlines.
- Handling AOG effectively requires a coordinated effort from various teams and stakeholders, encompassing maintenance, logistics, supply chain management, and communication.

CONSEQUENCES

Aircraft Maintenance Cost

- **Precision** – From the smallest details to larger components, every part must be carefully addressed.
- **Urgency** – Repairs must be conducted swiftly to minimize downtime.
- **Costs** – Significant expenses are involved in both flying teams and conducting the necessary repairs.

Revenue Loss

- **Revenue Loss** – Grounded aircraft can't generate income through passenger or cargo transport.
- **Fixed Costs** – Airlines continue to incur expenses such as insurance, parking, and leasing, even when the aircraft isn't flying.
- **Operational Efficiency** – Keeping aircraft operational is crucial for minimizing financial strain and maintaining business viability.

Passenger Compensation

- **Compensation** – Airlines must provide vouchers, refunds, or accommodation to affected passengers.
- **Delays** – Passengers face inconvenience while waiting on the tarmac or for the next available flight.
- **Costs** – The airline incurs additional expenses due to passenger compensation and disrupted schedules.

Delayed Air Cargo

- **Disruptions** – Delayed shipments disrupt supply chains, causing cascading delays and logistical issues.
- **Liability** – Delays can result in liability disputes between shippers and consignees.
- **High Stakes** – The risks are greater when handling perishable goods or live animals, where timing is critical.

Key issues foreseen

Let us Look into Some key issues that may cause delay and how we can tackle them

- **Engine Malfunctions** – Critical issues with the engine, such as turbine failure, can ground the aircraft.
- **Hydraulic Failures** – Problems in systems controlling landing gear and flight surface which may cause Oil Leaks.
- **Avionics Failures** – Malfunctions in navigation, communication, or electronic systems.
- **Structural Damage** – Damage to fuselage, wings, or landing gear can cause grounding caused either by foreign object or lack of durability.
- **Spare Parts Shortage** – Lack of available spare parts delays repairs and maintenance.
- **Unexpected Repairs** – Sudden, unforeseen repairs requiring non-stocked parts can cause delays.
- **Delayed Maintenance** – Maintenance schedules running longer than planned due to complications.
- **Staffing Shortages** – Insufficient qualified personnel, especially in remote locations, can delay operations.

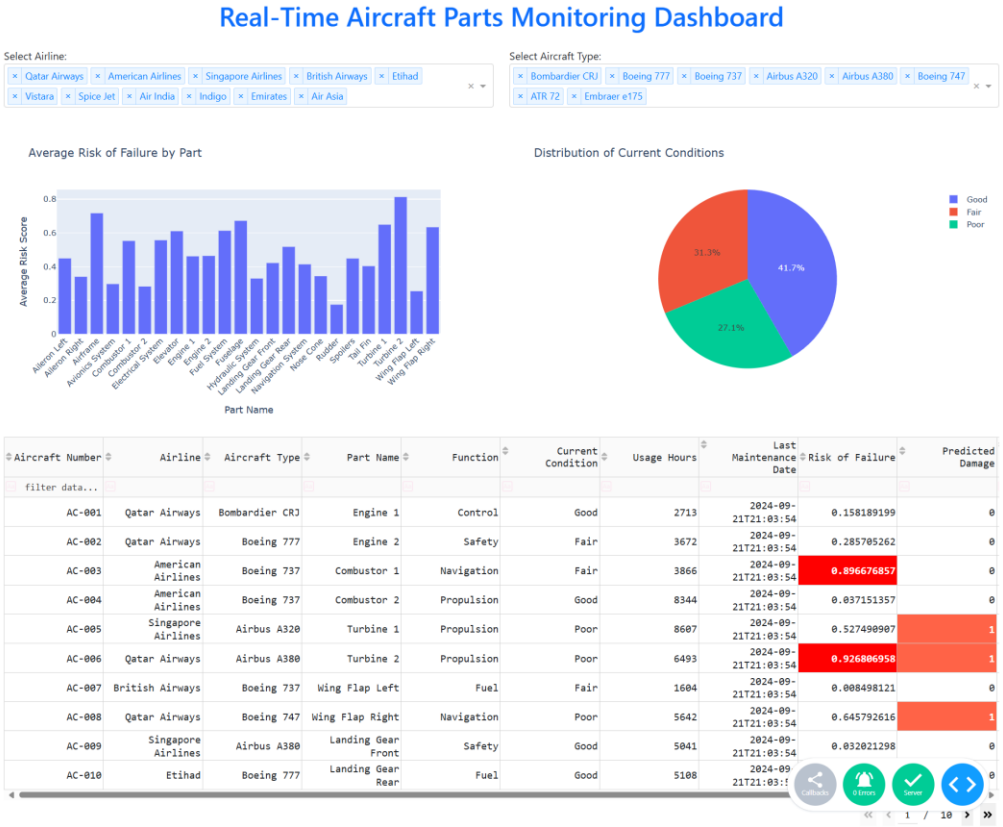
Handling This Scenarios

Managing this situation requires strategic and tactical actions to minimize downtime and ensure safety.

- **Immediate Response and Assessment**
  Quick assessment of the issue by maintenance crew, followed by notifying relevant teams to coordinate a response.
- **Resource Allocation**
  Deploying specialized maintenance teams and rapidly sourcing spare parts through local inventories or expedited shipping.
- **Logistics Coordination**
  Managing supply chains for fast part delivery, with OEM technical support and remote diagnostics if needed.
- **On-Site Repairs and Testing**
  Repairs are performed on-site, followed by testing and certification to ensure airworthiness.
- **Communication and Coordination**
  Continuous updates to operations teams and passengers on delays, cancellations, and alternatives.
- **Predictive Maintenance**
  Data analytics and real-time monitoring are used to predict and prevent potential failures.
- **Advanced Logistics Solutions**
  Global inventory systems and logistics partnerships ensure rapid part availability and delivery.
- **Enhanced Training and Staffing**
  Cross-training staff and using remote support for better flexibility and faster response times.

Solution Overview

Step 1: Risk Analysis and Early Prediction of Part Failure



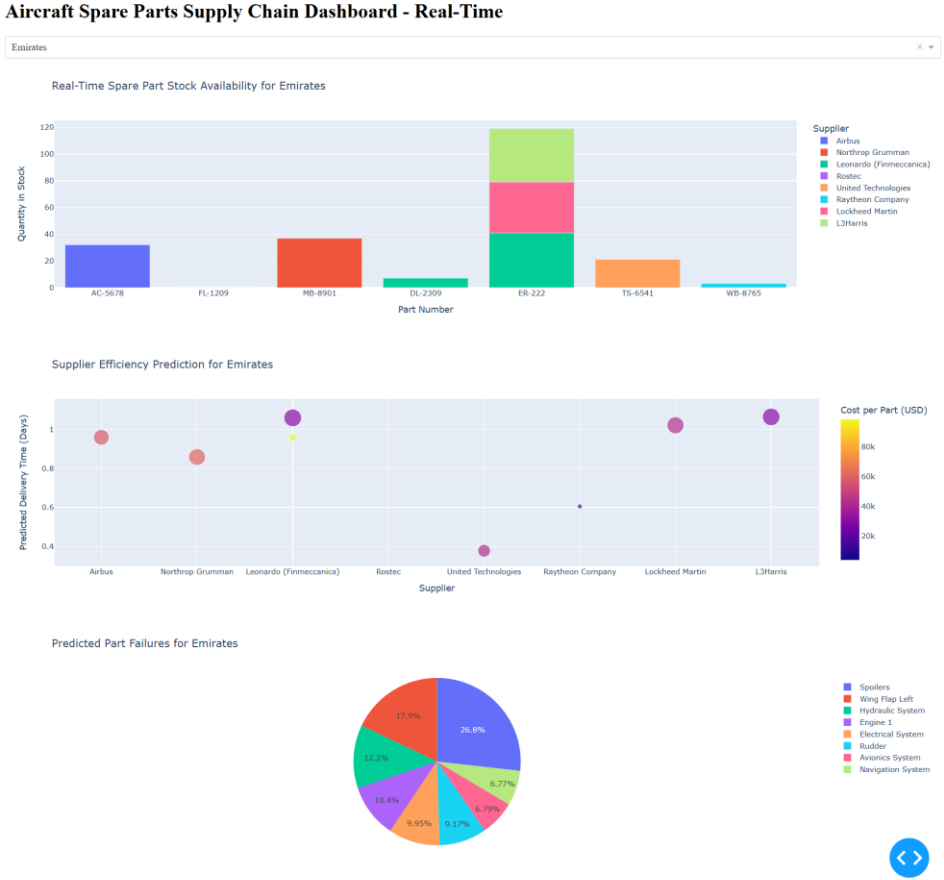
Aircraft Number	Airline	Aircraft Type	Part Name	Function	Current Condition	Usage Hours	Last Maintenance Date	Risk of Failure	Predicted Damage
filter data...									
AC-001	Qatar Airways	Bombardier CRJ	Engine 1	Control	Good	2713	2024-09-21T21:03:54	0.158189199	0
AC-002	Qatar Airways	Boeing 777	Engine 2	Safety	Fair	3672	2024-09-21T21:03:54	0.285705262	0
AC-003	American Airlines	Boeing 737	Combustor 1	Navigation	Fair	3866	2024-09-21T21:03:54	0.896676857	0
AC-004	American Airlines	Boeing 737	Combustor 2	Propulsion	Good	8344	2024-09-21T21:03:54	0.037151357	0
AC-005	Singapore Airlines	Airbus A320	Turbine 1	Propulsion	Poor	8607	2024-09-21T21:03:54	0.527490907	1
AC-006	Qatar Airways	Airbus A380	Turbine 2	Propulsion	Poor	6493	2024-09-21T21:03:54	0.926806958	1
AC-007	British Airways	Boeing 737	Wing Flap Left	Fuel	Fair	1604	2024-09-21T21:03:54	0.008498121	0
AC-008	Qatar Airways	Boeing 747	Wing Flap Right	Navigation	Poor	5642	2024-09-21T21:03:54	0.645792616	1
AC-009	Singapore Airlines	Airbus A380	Landing Gear Front	Safety	Good	5041	2024-09-21T21:03:54	0.032021298	0
AC-010	Etihad	Boeing 777	Landing Gear Rear	Fuel	Good	5108	2024-09-21T21:03:5		0

This approach uses real-time monitoring and risk prediction for aircraft parts to help engineers make quick and accurate decisions. Key aspects include:

- **Real-Time Data Dashboard**: A system that shows aircraft health in real-time, allowing engineers to spot critical issues right away.
- **Predictive Maintenance**: Machine learning predicts potential damage and part failures, helping to avoid unexpected breakdowns.
- **Informed Decisions**: Engineers get valuable insights about part risks and when they might fail, allowing for better planning.
- **Risk Prioritization**: Parts with higher failure risks are flagged, so they can be repaired faster.
- **Automation**: The process is streamlined by automatically gathering and displaying data, reducing the need for manual work.

Note: For detailed data analysis, procedures, python codes, and custom datasets, please visit the following link: https://github.com/TarunK45/Aircraft-on-Ground-/.

Step 2: Supply Chain Management and Logistics Dashboard



This approach aims for efficient management of spare parts availability, cost, and delivery time is crucial to minimizing AOG durations while integrating predictive maintenance with a robust logistics and supply chain management dashboard to ensure rapid identification, procurement, and deployment of necessary spare parts.

- **Predict Part Failures:** Utilize machine learning models to forecast potential part failures, enabling proactive maintenance.
- **Manage Spare Parts Logistics:** Maintain an up-to-date inventory of spare parts, their suppliers, costs, and delivery times.
- **Real-Time Dashboard:** Provide an interactive interface for stakeholders to monitor, analyze, and respond to AOG scenarios swiftly.
- **Optimize Decision-Making:** Facilitate informed decisions on part procurement and maintenance scheduling to reduce AOG durations and costs.

Note: For detailed data analysis, procedures, python codes, and custom datasets, please visit the following link: https://github.com/TarunK45/Aircraft-on-Ground-/.

Step 3: Augmented Reality Model for Aircraft Maintenance

This approach aims to create an Augmented Reality (AR) model to help aircraft maintenance technicians and engineers deal with situations where an aircraft is grounded (AOG). The main goals are to speed up repairs, improve decision-making using predictive data, and enhance efficiency with AR visual guides.

The AR model will combine various data sources, including real-time supply chain information, forecasts of part failures, and detailed maintenance manuals. It will act like a virtual assistant for technicians, offering:

- **Access to Repair Manuals**: The AR model will show relevant repair instructions.
- **Predicted Failure Analysis**: The model will identify parts that are likely to fail based on past data, helping technicians take preventive action.
- **Real-Time Stock Availability**: Technicians can see if needed parts are available or on their way through the AR interface.

Note: For detailed data analysis, procedures, python codes, and custom datasets, please visit the following link: https://github.com/TarunK45/Aircraft-on-Ground-/.

Technologies Used

- Python (data analysis and dashboard creation)
- Pandas & NumPy (data manipulation and risk predictions)
- Scikit-learn (machine learning models for part failure prediction)
- Dash (real-time dashboard development)
- Plotly (interactive visualizations)
- Seaborn & Matplotlib (exploratory data analysis)
- Microsoft HoloLens(AR Visuals):
- Unity (AR Foundation Software)

Other Tools and Technologies For more better results:

- IBM Maximo – IoT monitoring, predictive analytics
- Siemens MindSphere – IoT integration, real-time analytics
- Azure IoT Hub – Real-time data collection
- IBM Blockchain – Supply chain tracking
- Hyperledger – Secure part authentication
- VeChain – Supply chain transparency
- Google Cloud AutoML – Advanced predictive modeling
- Amazon SageMaker – AI/ML model training
- H2O.ai – Predictive maintenance AI
- PTC Vuforia – Augmented reality visualization
- UiPath – Automated logistics processes
- Automation Anywhere – Robotic process automation(RPA)
- SAP S/4HANA – Real-time ERP integration
- Oracle Cloud SCM – Supply chain management
- GE Digital Twin – Virtual aircraft modeling
- Dassault 3DEXPERIENCE – Digital twin simulations
- Slack – Real-time team communication
- Microsoft Teams – Collaboration with integrations
- TRAX – Aviation fleet management
- AMOS – Aircraft maintenance system

High level Architecture Diagram

Data refreshes every 5 seconds showing real time analysis

Dataset Creation and Data Integration
Created a comprehensive dataset that integrates airline names, aircraft types, and detailed parts data to enable effective risk analysis.

Risk Analysis
Conduct an analysis of the dataset to identify high-risk aircraft parts based on their current condition and usage, facilitating proactive maintenance decisions.

Aircraft Part Damage Dashboard
Developed an interactive dashboard that visually represents the damage status and risk levels of aircraft parts, aiding quick decision-making for maintenance teams.

Real-Time Monitoring
Implemented a real-time monitoring system to track aircraft part conditions continuously, ensuring timely responses to potential issues and minimizing downtime.

Prediction of Aircraft Part Damage
Utilize predictive modeling techniques to forecast the likelihood of aircraft part failures, enabling preventative maintenance to enhance overall aircraft reliability and safety.

Aircraft data

Data refreshes every 5 seconds showing real time analysis

If Prediction shows part will be damaged

Data Ingestion and Integration
Collect data from maintenance logs, spare parts inventory, and suppliers. Integrate the datasets using ETL pipelines to create a comprehensive dataset for analysis.

Predictive Maintenance Modeling
Use machine learning models to predict part failures based on historical and condition data. Deploy models to schedule maintenance and minimize AOG incidents.

Logistics and Supply Chain Management
Monitor inventory levels, supplier performance, and part delivery times. Ensure optimal stock and quick procurement during AOG events.

Interactive Real-Time Logistics Dashboard
Provide a centralized platform for monitoring AOG scenarios with real-time data and visualizations. Enhance decision-making and operational responsiveness.

Monitoring and Continuous Improvement
Track system performance and refine models based on feedback. Implement ongoing updates to improve predictive accuracy and supply chain efficiency.

Accelerated Engineering Clearance
AR acts as a virtual engineer, providing technicians with immediate access to real-time data from maintenance manuals and supply chain analytics, thereby streamlining the engineering clearance process for quicker approvals and reduced aircraft downtime.

Enhanced Maintenance Efficiency
Leverage AR technology to expedite maintenance tasks, reducing the likelihood of errors and improving overall workflow efficiency.

AR Hardware and Software
Utilize Unity Augmented Reality modeling software to integrate all data from previous analyses, including aircraft manuals and supply chain logistics, into a cohesive AR platform.

Aircraft Maintenance Manuals and Techniques
Store comprehensive maintenance manuals and techniques within the AR software to provide technicians with easy access to critical information during repairs.

Future Improvements

1. Risk Analysis and Damage Prediction

- AI-Powered Models: More accurate failure predictions using deep learning.
- Real-Time Sensor Data: Enhance models with real-time part data.
- Self-Learning Systems: Models that improve with continuous data analysis.

2. Improving Logistics and Supply Chain

- Blockchain Tracking: Ensure transparency and faster part delivery.
- Autonomous Drones: Rapid delivery of parts during emergencies.
- AI Inventory Management: Predict demand and optimize part availability.

3. Augmented Reality Modeling

- AI-Powered Diagnostics: Use AI to suggest optimal parts and repairs via AR.
- Voice and Gesture Enhancements: Improve user interaction via enhanced voice commands or gesture-based navigation.
- IoT Integration: Real-time IoT sensors on parts could automatically update AR overlays with real-time wear-and-tear data.

Conclusion

- **Accelerating Engineering Clearance:** By using predictive tools and real-time data, the solution quickly identifies which parts may fail and helps airlines get the necessary parts fast, reducing the time it takes to approve and complete repairs in Aircraft on Ground (AOG) situations.

- **Optimized Supply Chain and Repair Workflow**: The dashboard gives clear, real-time updates on part availability, supplier delivery times, and repair progress, helping airlines fix aircraft more quickly and efficiently, minimizing delays.

- **Augmented Reality for Quicker Repairs**: Augmented reality (AR) helps engineers by displaying real-time information directly on the parts being repaired, making it easier to locate and fix issues faster while ensuring high-quality work and reducing aircraft downtime.

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Thank You