Cargo Technology Trends Survey

Shape the future of operations

IATA calls air cargo experts to provide insights into the industry's upcoming technological disruptors. By helping us identify the most impactful trends, you will help the industry prepare for the future. The technologies outlined in this survey are divided into six thematic blocks.

Click on the sections below for more information about the different blocks and technologies.

BLOCK ONE – Artificial Intelligence

Classified as an enabler for the rest of the technologies in this survey, Artificial Intelligence (AI) in air cargo involves using advanced algorithms to optimize operations, enhance forecasting, and improve decision-making. Machine Learning (ML), a subset of AI, processes vast amounts of structured data to identify patterns and predict outcomes, such as pricing ad hoc shipments and managing resources efficiently. Large Language Models (LLMs), another AI subset, analyze unstructured data like text and speech to provide customer support, sentiment analysis, and operational insights. Together, these technologies streamline processes, reduce errors, and enhance overall efficiency in the air cargo industry.

Artificial intelligence

Artificial Intelligence is the simulation of human intelligence in machines that can learn, reason, and self-correct and perform tasks such as visual perception, speech recognition, decision-making, and translation between languages.

Possible applications within air cargo

- Predictive maintenance of cargo handling equipment.
- AI-powered robotics and automated equipment
- Optimization of cargo space utilization and loading operations.
- Dynamic scheduling of workforce and equipment.
- Automated anomaly detection in cargo security screening.
- AI-driven inventory management and demand forecasting.
- Route planning with facility and trucking services
- Load planning, ULD build-up automation, and improvement
- Real-time tracking and monitoring of cargo conditions (temperature, humidity, etc.).
- Natural language processing (NLP) for customer service chatbots
- Facilitate application of industry standards, SOPs, carrier, and state variations in operations

API Technology

APIs (Application Programming Interfaces) enable seamless communication between software systems by acting as intermediaries that enable different applications and systems to communicate. In air cargo, APIs streamline real-time data sharing, collaboration, integration, and interoperability between platforms, facilitating seamless operations across the supply chain.

Possible applications within air cargo

- Booking and scheduling, connecting freight forwarders, airlines, and cargo management systems
- Real-time tracking through the integration of tracking platforms with customer-facing interfaces
- Improved customs and compliance data exchange with authorities
- Capacity management by linking airlines and freight forwarders to manage and allocate capacity dynamically
- IoT integration, enabling real-time data sharing between devices and monitoring systems for cargo condition tracking.

Cloud computing

Cloud computing provides on-demand access to computing resources over the Internet, such as storage, processing power, and applications. In air cargo, cloud computing enables scalable, cost-effective, and real-time data and systems management, facilitating seamless collaboration and operational efficiency.

Possible applications within air cargo

- Centralized data storage securely in the cloud
- Storage of large volumes of cargo data, enabling advanced analytics and reporting.
- Real-time visibility by supporting tracking platforms providing live updates about shipments
- Collaboration among stakeholders through data sharing and communication tools
- Capacity planning and demand forecasting by enabling the processing of large datasets to optimize routes, schedules, and resource allocation
- Disaster recovery and backup creation
- Integration hub of APIs, IoT devices, and legacy systems

Computer vision

Computer Vision (CV) uses AI to interpret and process visual data from images or video streams. CV automates inspection, cargo identification, and workflow monitoring in air cargo by analyzing visual inputs with high accuracy.

Possible applications within air cargo

- Cargo identification in ramp and facility by scanning barcodes, QR codes, and labels
- Damage detection during loading, transit, or unloading.
- Enhanced threat detection by analyzing X-ray images of shipments.
- Workflow monitoring: Tracks operations in warehouses to identify inefficiencies or bottlenecks.
- Real-time tracking: Uses cameras to monitor cargo movement within facilities.
- Automated quality control: Verifies packaging integrity and compliance with regulations.
- Enhances employee safety, automatically detecting potential risks and unsafe practices

Predictive / Advanced Analytics

Advanced and predictive analytics leverage AI, machine learning (ML), and statistical algorithms to analyze historical and real-time data, enabling proactive decision-making and forecasting. In air cargo, these analytics optimize operations, improve efficiency, facilitate decision-making, and mitigate risks by identifying patterns and trends.

Possible applications within air cargo

- Routing & warehousing optimization and automation, operations streamlining, transparency & data-driven decision-making, quality improvements
- Demand forecasting, predicting cargo volume trends for optimal resource allocation.
- Route optimization
- Dynamic pricing based on demand, capacity, and market trends.
- Predictive equipment maintenance using performance data to predict failures before they occur.
- Optimization of processes such as cargo handling, workforce scheduling, and space utilization.
- Customer analytics to analyze behavior and preferences

BLOCK TWO – Wearables

Extended Reality

Extended Reality (XR) is the umbrella term encompassing Augmented Reality (AR), Virtual Reality (VR), and Mixed Reality (MX). It blends virtual and real-world environments to enhance interactions, simulations, and data visualization.

Possible applications within air cargo

- AR or VR-based training enables immersive employee training for cargo handling, equipment operation, and safety procedures.
- Facility planning and design by using AR or MR to visualize warehouse layouts and optimize workflows
- Cargo space visualization to optimize cargo loading configurations and maximize space utilization.
- Maintenance and repair support with AR-guided instructions for troubleshooting and maintaining equipment.
- Real-time inventory management through AR glasses or devices that can display cargo details and handling instructions directly to workers.
- AR-based navigation systems guide workers to the exact location of cargo items.
- Customs inspection support by overlaying inspection data onto cargo to streamline verification.

Wearable devices

Wearables are devices worn on the body that enhance worker efficiency, productivity, and safety by providing real-time information or assistance.

Possible applications within air cargo

- Enhanced communication by displaying real-time instructions, shipment details, or navigation for cargo handling and warehouse operations.
- Hands-free scanning of barcodes or RFID for cargo tracking and inventory management
- Employee health monitoring, tracking worker vitals and fatigue levels to ensure safety and optimize workload distribution

Exoskeletons

Exoskeletons are a subset of wearable devices that augment workers' physical capabilities by providing mechanical support to reduce physical strain, particularly for manual cargo handling.

Possible applications within air cargo

- Lifting assistance for workers during the loading and unloading of heavy goods
- Reduction of strain for repetitive movements
- Ergonomic support during prolonged standing
- Production and efficiency improvement for physically demanding tasks

BLOCK THREE – Robotics

Unmanned Aerial Vehicles

Commonly known as "drones", Unmanned Aerial Vehicles (UAVs) are aircraft operated without a human pilot onboard. In air cargo, UAVS enables fast, flexible, and cost-effective transportation of lightweight and time-sensitive shipments and operational support in other ways.

Possible applications within air cargo

- Last-mile delivery for small, urgent, or high-value shipments directly to customers
- Inter-hub transportation of cargo
- Inspection of cargo, facilities, and other infrastructure using drones equipped with cameras and sensors
- Inventory management, scanning and tracking cargo within the warehouse
- Emergency logistics in remote or disaster-stricken areas
- Cargo facility security and surveillance

Automated Guided Vehicles

Automated Guided Vehicles (AGVs) are self-driving vehicles that transport goods and materials within a facility or across specific routes and fixed paths. In air cargo, AGVs enhance efficiency by automating repetitive tasks such as moving cargo pallets, containers, and inventory, reducing reliance on manual labor.

Possible applications within air cargo

- Transport ULDs, pallets, or containers between loading docks, storage areas, and cargo aircraft.
- Warehouse automation by streamlining material handling and inventory management within extensive cargo facilities.
- Automates cargo sorting and stacking for optimized space utilization.
- Move cargo efficiently between terminals within large airport hubs.
- Ensure temperature-sensitive cargo is transported within the warehouse and ramp under controlled conditions
- Dock-to-aircraft delivery, moving cargo directly to aircraft with minimal human intervention.

Autonomous Mobile Robots

Autonomous Mobile Robots (AMRs) are self-navigating robots that move dynamically through environments without fixed paths. Unlike AGVs, AMRs use advanced sensors, AI, and real-time data to adapt to changing surroundings, making them highly versatile for air cargo operations.

Possible applications within air cargo

- Dynamic cargo transportation across facilities without requiring fixed infrastructure like tracks or predefined routes
- Optimize picking, sorting, and inventory management by dynamically navigating between storage locations.
- Ensure safe and efficient handling of temperature-sensitive shipments by integrating with IoT monitoring systems.
- Real-time inventory tracking uses barcodes and/or RFID scanners to manage cargo locations accurately.
- Seamless movement of cargo across airport terminals or between adjacent warehouses.

Stationary robotics

Robotics encompasses automated machines that execute tasks that humans typically perform from a fixed, stationary position or designated workspace. These machines improve efficiency, safety, and accuracy in handling cargo and managing facilities in air cargo. They are used for repetitive, high-precision tasks such as loading, stacking, sorting, and ULD and skid build-up and break-down, among other activities.

Possible applications within air cargo

- Automates the scanning and sorting of parcels, containers, and packages based on size, weight, destination, and other parameters
- Handle palletizing and depalletizing of cargo, optimizing space utilization, stability of the loads, and reducing manual labor
- Assist with loading and unloading of goods from conveyor belts to storage or transport units
- Improve e-commerce and mail services by performing repetitive tasks such as weighting, labeling, or inspecting parcels

Collaborative Robots

Collaborative robots, or cobots, are designed to work alongside humans in shared environments, unlike traditional industrial robots operating in isolated areas. Cobots are equipped with advanced safety features, sensors, and AI, allowing them to perform repetitive or physically demanding tasks while enabling human-robot collaboration in operations.

Possible applications within air cargo

- Assist humans during repetitive tasks, reducing strain on workers
- Works with employees to sort packages and stack cargo efficiently
- Performs quality checks, scans barcodes, or applies labels on shipments
- Helps in securely packaging delicate or irregularly shaped items
- Assist with training and onboarding, demonstrating tasks to new workers

BLOCK FOUR – Sustainable operations

Bio-based materials

Bio-based materials are derived from renewable biological resources, such as plants, biological resources, agricultural waste, biopolymers, etc. They serve as sustainable alternatives to conventional materials used for packaging, skid and ULD build-up, facility infrastructure, and so on. Examples of this are insulated packaging made of plant fibers or bio-based concrete and wood used in warehouse construction.

Possible applications within air cargo

- Plastic waste reduction through the replacement of items such as wrapping, packaging, straps, etc., for biobased alternatives
- Reduced infrastructure environmental impacts during the construction and utilization phases
- Minimization of non-recyclable packaging waste, including advanced solutions for special cargo.

Energy-efficient infrastructure

Energy-efficient building design incorporates materials, technologies, and practices to minimize facility energy consumption. This includes insulation, optimized layouts, energy-efficient HVAC systems, and the use of natural light.

Possible applications within air cargo

- Optimized warehouse insulation to maintain internal temperatures and reduce HVAC load.
- Passive solar design to use natural light and heat to lower energy consumption.
- Smart building controls that integrate IoT sensors to monitor and adjust energy usage.
- High-efficiency HVAC systems to reduce energy use in cargo storage and handling areas.

Energy generation on site

On-site energy generation refers to the local power production at air cargo facilities, mainly utilizing renewable sources like solar panels, wind turbines, or combined heat and power (CHP) systems. This practice decreases reliance on external energy grids and enhances sustainability.

Possible applications within air cargo

- Solar panel installations: Generates electricity for lighting, HVAC, and other facility operations.
- Wind turbines: Provides supplementary energy in regions with consistent wind patterns.
- Energy storage systems: Stores excess energy generated on-site for later use.
- Electric vehicle charging stations: Powers GSE and delivery vehicles.
- Backup power systems: Provides a renewable alternative for emergency energy needs.

Advanced packaging solutions

Next-generation packaging uses innovative materials, designs, and technologies to improve cargo protection, sustainability, and efficiency. These include reusable, biodegradable, and smart packaging solutions.

Possible applications within air cargo

- Reusable containers that reduce costs and waste
- Use of biodegradable and compostable materials
- Smart packaging containing sensors for condition monitoring (e.g., temperature, humidity), particularly for time and temperature-sensitive cargo
- Packaging made of lightweight materials reduces costs and energy use.

Zero Emission Vehicles

Zero-emission vehicles (ZEVs) generate no tailpipe emissions, lessening transportation's environmental impact. Usually, these vehicles run on electric batteries or hydrogen fuel cells. In the air cargo sector, ZEVs have the potential to transform ground operations by reducing carbon footprints.

Possible applications within air cargo

- Ground support equipment (GSE) electrification (electric tugs, loaders, etc.) for cargo handling on the tarmac.
- Last-mile delivery through electric vans or hydrogen-powered trucks for cargo delivery to final destinations.
- Electrification of forklifts and pallet movers within cargo facilities.
- Sustainable cold chain operations using electric or hydrogen-powered refrigerated vehicles to transport temperature-sensitive goods.

BLOCK FIVE – Visibility & Transparency

Connected devices

The Internet of Things (IoT) involves connecting physical devices (or groups of devices) to the Internet, enabling them to collect and share data. These devices are embedded with sensors, processing ability, software, and other technologies that connect and exchange data with other devices and systems over the Internet or other communications networks. In air cargo, they are broadly used to track and monitor shipments and other assets.

Possible applications within air cargo

- Cargo tracking via IoT sensors that monitor cargo conditions such as temperature, humidity, and location in real time.
- Predictive maintenance as they collect performance data to predict and prevent breakdowns.
- Fleet management, tracking vehicles and assets within cargo facilities and during transportation.
- Security monitoring, including detection of tampering or unauthorized access to shipments.
- Warehouse optimization and automated workflows

Radio Frequency Identification (RFID)

RFID-enabled tags have been used for decades to manage inventory and prevent theft, especially in retail. These inexpensive labels function effectively in controlled environments with the necessary infrastructure, such as readers and routers, but they are no longer detectable once they leave these environments. RFID labels are particularly useful for inventory management, tracking, and process automation by embedding them in cargo, containers, and equipment.

Possible applications within air cargo

- Monitoring of movement of assets as they move throughout the facility
- Inventory management by automating the scanning and recording of cargo at acceptance/release phases or loading/unloading
- Security monitoring, including detection of unauthorized movement of cargo
- ULD and asset management to optimize their utilization

Real-Time Transportation Visibility Platforms

Real-time transportation visibility platforms (RTTVPs) provide tools to track and monitor shipments in real-time. They are also used to gain near-real-time status, determine the location of transit shipments, and predict estimated arrival times. These platforms leverage GPS, IoT sensors, RFID artificial intelligence, and cloud-based systems to give stakeholders actionable insights into shipment status, location, and condition, enabling them to respond to disruptions and optimize operations within and outside the facility.

Possible applications within air cargo

- Real-time cargo tracking and movement mapping within facilities
- Condition monitoring, tracking temperature, humidity, and vibration for special cargo
- Management of potential disruptions caused by factors such as traffic, weather conditions, etc.
- Proactive issue resolution, alerting stakeholders to real-time delays, deviations, or risks, enabling quick responses.
- Ensures compliance and adherence to regulations for temperature-sensitive and hazardous goods.
- Customer transparency by enabling live shipment updates and enhancing service satisfaction.

Smart Labels

Smart labels are advanced, technology-enabled tags that combine traditional labeling (text, images, barcodes, QR codes) with embedded sensors, RFID, or IoT features. The most sophisticated variations include intelligent inlay technology, such as printable batteries and microchips, transforming them from simple labels into active tracking devices. In air cargo, these labels could become a more affordable solution to enhance real-time tracking and monitoring for all packages, commodities, or assets.

Possible applications within air cargo

- Real-time tracking throughout the supply chain thanks to actively connected labels
- Affordable condition monitoring through embedded sensors, ensuring cargo integrity
- Security monitoring, including detection of tampering or unauthorized access to shipments.

BLOCK SIX – Digital Processes

Advanced Self-Service Technologies

Advanced self-service technologies are automated systems and tools that allow users to independently perform tasks with minimal or no assistance. This trend includes automated kiosks, online portals, and self-service equipment designed to streamline cargo handling and administrative processes.

Possible applications within air cargo

- Self-service kiosks for cargo drop-off and pickup, enabling faster processing for shippers.
- Online booking platforms that enable customers to book cargo space and track shipments independently.
- Self-service document scanning for validating and submitting shipping documents.
- Automated payment systems for cargo services
- Mobile apps for drivers to help with check-in, navigation, and real-time status updates during cargo handling stages.

Robotic Process Automation

Robotic Process Automation (RPA) is an application of technology governed by business logic and structured inputs to automate business processes. Using RPA tools, a company can configure software, or a "robot," to capture and interpret applications for processing a transaction, manipulating data, triggering responses, and communicating with other digital systems. RPA streamlines documentation, data entry, and communication processes in air cargo, reducing errors and improving efficiency.

Possible applications within air cargo

- Automate data entry for air waybills, customs declarations, and compliance documents
- Booking management handles repetitive booking confirmations and schedule updates
- Automatically update inventory records based on cargo movements
- Invoice processing automates billing and payment reconciliation tasks
- Customer service responds to routine queries, such as shipment tracking, through chatbots or email bots
- Exception handling flags anomalies in cargo data or workflows for human intervention