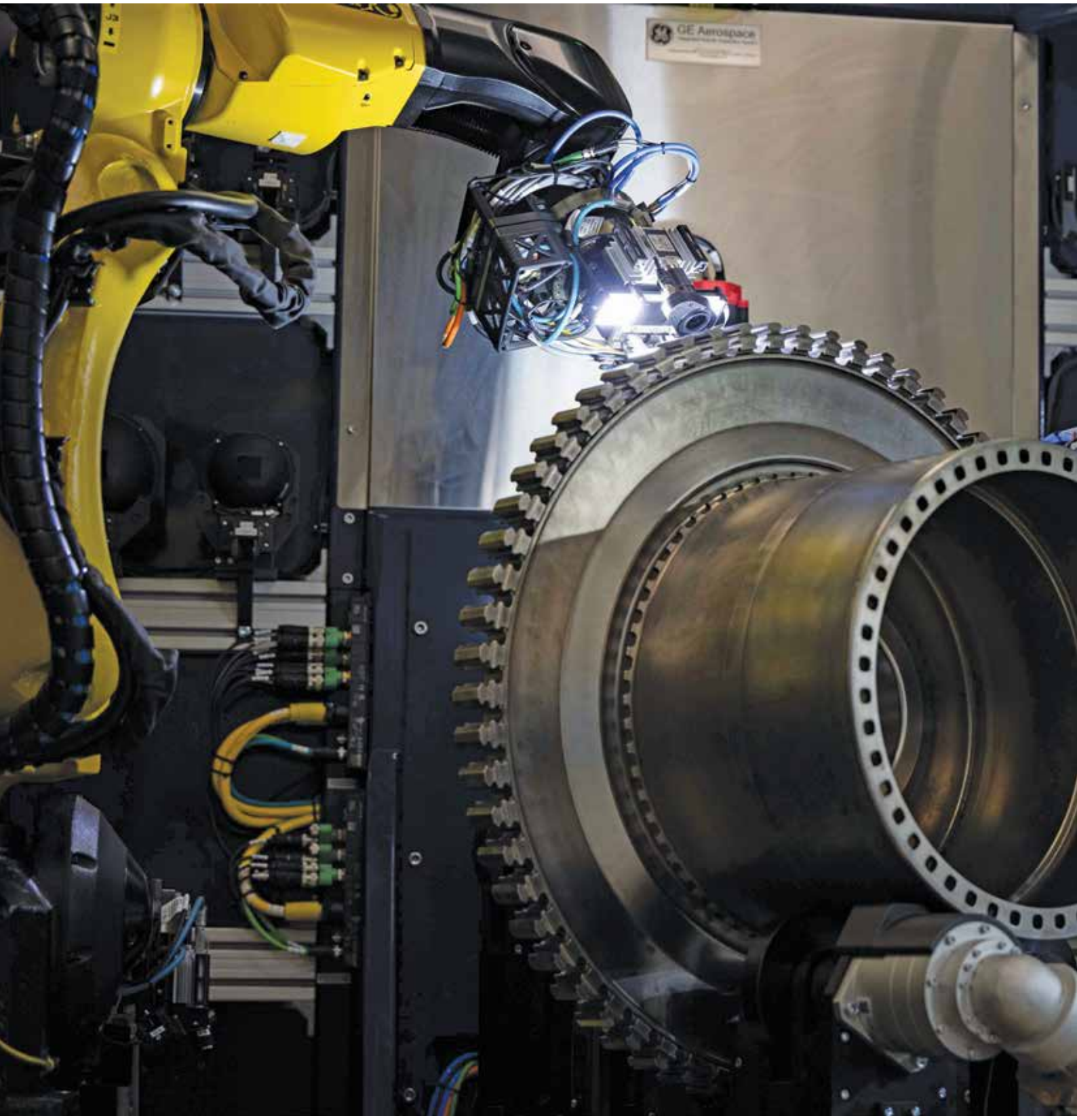

All About Aircraft Smart Tools

Embedded intelligence is smartly revolutionizing aviation maintenance tools

By Mark Robins

Standing in a universal workstation, two articulated industrial robots outfitted with white light optical scanners move closely over the entire surface of the high-precision part — in this case, a turbine disk for a GE90 engine. Like two ballroom dancers, the robots' movements are carefully choreographed by human operators and use AI to capture and analyze data with optimal accuracy, speed, and consistency, simultaneously creating a digital record of each part's condition. GE Aerospace image.

Aviation tools — the guardians of the sky — are fundamental to maintaining the high safety standards and operational efficiency demanded by the aviation industry. It's advanced technology integration that's been the driving force behind the innovation and evolution of these aviation tools. The emergence of smart tools powered by Internet of Things (IoT), artificial intelligence (AI) and automation is at the forefront of this. Smart tools open up new opportunities for data-driven decision-making and optimization in aircraft maintenance enhancing efficiency, productivity and overall performance.

Work Smarter, Not Harder

Smart tools combine traditional functions with sensors, processors and connectivity to automate data collection. Smart tools give greater control over data and reduce mistakes by taking human error largely out of the equation. Data entered by hand increases the risk of mistakes, especially when inputting long identification codes.

Gathering massive amounts of data that can be used for quality control and quality assurance, smart tools can communicate this data to other systems, such as a mobile app or software, where team members can access it. This data can be recorded in real time, then processed using advanced algorithms and analytics tools, which can identify patterns, trends and insights. By sending data directly to a software program, physical manuals and logs can be eliminated. The integration and connectivity of multiple devices and systems enable seamless communication, which significantly improves overall efficiency.

With traditional tools, users may not know when they need maintenance, leading to them breaking down unexpectedly. This breakdown often causes downtime, as a replacement tool needs to be found and tool repair needs to be scheduled. Smart tools reduce downtime by keeping track of when they need maintenance and providing alerts. Remaining tool life can be predicted based on machine signals correlated with wear. Repairs can be scheduled more efficiently so they don't affect downtime and productivity.

Smart tools can warn users if they're using them improperly, thus preventing mistakes. Their accuracy facilitates better quality results, leading to greater client and customer satisfaction. Smart tools can identify required maintenance tasks and verify a tool is needed for a particular job.

A Growing Market

According to a research report titled, "Smart Tools Market" (2025 - 2035) by the research firm Future Market Insights, the global smart tools market is projected to grow from USD 1.29 billion in 2025 to approximately USD 2.18 billion by 2035, marking an absolute increase of USD 890 million over the decade. This growth reflects a total expansion of 68.9%, with the market forecast to advance at a compound annual growth rate (CAGR) of 5.4% during the 2025 to 2035 period. The total market size is expected to grow by nearly 1.7 times its current size by the end of the forecast window, supported by the integration of sensor-based diagnostics, predictive analytics and IoT connectivity.

The report goes on to say that growth in the smart tools

Smart inspection tools such as digital dent-mapping systems allow technicians to quickly measure damage on complex surfaces like wing leading edges, delivering accurate results through intuitive, easy-to-use workflows. 8tree image.

market is being supported by the convergence of Industry 4.0 deployment, demand for operator safety and the rising importance of traceable maintenance operations. Labor shortages in skilled trades are also encouraging adoption of programmable tools that reduce operator error and simplify complex procedures.

Smartly Reducing Downtime

Smart inspection tools reduce downtime by shortening the time required to inspect, document and communicate findings. Aishah Yahya, marketing coordinator at 8tree, Rancho Cucamonga, California, says traditional dent-mapping or fastener-checking methods often involve multiple manual steps, repeated measurements, and handwritten or separately entered documentation, all of which slow the workflow and introduce variability.

"Digital tools replace those steps with automated measurement, instant visualization and standardized outputs," Yahya explains. "For example, dentCHECK allows technicians to capture dent measurements in seconds and immediately generate digital, SRM-compliant reports that can be shared with engineering teams for rapid assessment. Industry case studies have shown that digital dent-mapping tools can dramatically reduce inspection time. For example, data collected during Aerospace Maintenance Council (AMC) maintenance competitions demonstrated that technicians using dentCHECK completed dent-mapping tasks up to 90% faster than with traditional manual measurement methods. In addition, studies have shown that dentCHECK can reduce false-positive detections by up to 32%, helping maintenance teams avoid unnecessary repairs and the associated downtime. Similarly, fastCHECK helps operators evaluate large numbers of fasteners in a single click, delivering immediate go/no-go feedback directly on the surface and reducing the time spent on repetitive, manual checks."

Another area where smart tools have seen significant advancements in recent years are digital non-destructive inspection tools that help aviation teams work faster, more consistently and with greater traceability. Yahya cites common examples of this as digital borescopes for internal visual inspections, ultrasonic and eddy-current equipment for subsurface defect detection and optical scanning systems for surface damage assessment.

"These technologies reduce subjectivity and help replace manual methods that can vary depending on the technician's skill and interpretation," Yahya says. "Two examples from 8tree that are relevant to this trend are dentCHECK and fastCHECK. dentCHECK is an augmented reality (AR)-enabled handheld 3D inspection tool used to measure dents and other surface defects on aircraft surfaces and generate instant, SRM-compliant digital reports. fastCHECK is an all-in-one fastener-flushness measurement solution that enables operators to inspect 100 fasteners or more in a single click, providing instant go/no-go results for quality control in aircraft assembly and maintenance environments. Together, these tools support faster and more standardized airframe inspection workflows."

Technology in the Tool

According to the Smart Tools Market Research Report, other smart tools aiding aviation maintenance include drills and drivers, saws, sanders and grinders, and measuring tools. Smart measuring tools process surroundings with vision algorithms and can retrieve acceptable measurement values from a database. Digital calipers allow users to determine the exact size of small objects. They display measurements on a screen rather than having the user look at the ruler. Electric torque wrenches can be programmed to properly tighten nuts and bolts at the best number of turns. Smart drills typically come with a touchscreen and sensors to help guide users as they drill holes and sense the angle the user is holding it at. Many can update cutting conditions at each material layer and even monitor the drilling depth. Smart screwdrivers use tightening configurations to improve a screwdriver's performance and reduce its torque reaction. Ingersoll Rand's IQi Series, transducerized low-torque electric screwdriver uses real-time torque feedback and advanced error-proofing. The IQi Series measures actual torque applied, ensuring every fastener is secured correctly.

Digital inclinometers can use electronic sensors to measure the angle of an object relative to the earth's surface. Unlike traditional analog inclinometers, which rely on mechanical components and gravity, digital versions offer enhanced accuracy, ease of use and additional functionalities. Operating with up to 0.1° of repeatable accuracy, they provide digital readouts of angular reading instantly with no interpretation or guesswork needed. They can measure and display any angle through 360° and readings can be relative to any angle. These qualities make them ideal for many aviation maintenance applications.

Image Recognition and Classification

AI-enabled smart tools for image recognition and classification in avionics repair, testing and inspection are becoming an important part of modern aviation maintenance, repair and overhaul (MRO). Tom Heiser, CEO of Orama.AOI, Lilburn, Georgia, says they help technicians inspect aircraft surfaces, avionics hardware, and structural components more efficiently and consistently.

AI inspection tools are called smart because they have capabilities beyond simple imaging systems. AI-enabled avionics inspection tools combine computer vision, machine

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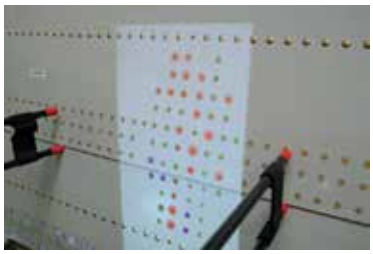
learning and automated diagnostics to detect and classify defects on aircraft surfaces and electronic systems. They are considered smart because they learn from data, recognize complex patterns, provide automated decisions and continuously improve over time, making aircraft maintenance safer, faster and more reliable.

"AI vision systems analyze images of aircraft surfaces (fuselage, wings, radomes, avionics housings) to detect defects such as cracks, corrosion, dents, paint degradation and lightning strike damage," Heiser adds. "Often these systems are mounted on handheld inspection devices, drones, robotic crawlers and hangar scanning systems. Image analysis can detect hidden defects in composite materials, internal delamination and structural fatigue. This supports predictive maintenance, reducing unexpected failures."

Orama.AOI's recent initiative in drone-based aircraft inspection used in aircraft MRO significantly reduces both inspection time and operational cost compared with traditional manual inspections. The main savings come from automation, faster data collection and reduced labor requirements. Traditional aircraft inspection requires technicians to move scaffolding or lifts, visually inspect large surfaces manually and take photos and document findings. "This process can take several hours or even days," Heiser says. "However, smart drone systems fly around the aircraft automatically, capture thousands of high-resolution images, and can scan the entire fuselage, wings and tail. This typically reduces inspection from 6-to-12 manual hours, to 1-to-2 drone inspection hours. This dramatically reduces aircraft ground time."

The IQi Series Transducerized Screwdriver is an intelligent fastening solution that combines advanced technology, precision engineering and intuitive design providing real-time torque feedback and advanced error-proofing. Ingersoll Rand image.



An augmented reality-enabled fastener inspection tool highlights fastener flushness conditions in real time, instantly identifying which fasteners are within tolerance and which require attention. 8tree image.

The future of smart power tool use in aircraft maintenance looks promising. As technology continues to evolve, smart power tools will become even more sophisticated, offering advanced features. AVM

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Key examples include:

- Creating a multimodal AI "Engineering Assistant" trained on 30+ years of parts non-conformance dispositioning data. This eliminates thousands of hours of work while accelerating the work of our engineering teams to assess whether these parts can be used, repaired or scrapped.
- Deploying AI-guided Blade Inspection Tools (BIT) to improve inspection consistency for the workhorse blades of narrow-body and wide-body aircraft engines, while also cutting inspection times in half to 1.5 hours. Technicians use the tool to take images of turbine blades and AI then guides them on the selection of which images to review, providing more consistency to spot issues sooner.
- Jointly developing and deploying an AI-assisted commercial engine borescope solution with Waygate Technologies to GE Aerospace's MRO network to be used for High Pressure Compressor (HPC) inspections for its GEnx and CFM LEAP engines. The integration of cutting-edge AI techniques has been shown to reduce overall inspection times while helping to increase detection rates by ~34%, while reducing false alerts by >13% vs. previous Gas Power-assist model version 4.1. Additional details can be found in the following press release here.

Along with deploying advanced tools to reduce inspection times, we're integrating AI to bolster our predictive maintenance capabilities to identify issues sooner and tailor maintenance work scopes to further prevent instances of unplanned downtime in our MRO shops. For example, we have deployed an AI-Material Assistant that accurately assesses workscope needs and replacement components required for CFM LEAP engines weeks ahead of their induction date for service to avoid unnecessary delays. As a result, our Celma and Malaysia facilities are seeing a 5- to 7-day turnaround time improvement with the service of these engines. Overall, we continue to improve our predictive maintenance capabilities to gain earlier visibility to engine service needs that allow for more optimal maintenance planning with our airline customers to further minimize unplanned downtime.

An inspection engineer performs an inspection using Waygate Technologies' Mentor Visual iQ+ borescope. Waygate Technologies and GE Aerospace have jointly developed a new AI-enhanced version that will be made available to customers through an upcoming software update for the Mentor Visual iQ+ video borescope later this year. GE Aerospace image.

Information provided by Nicole Jenkins, chief MRO engineer, GE Aerospace, Evendale, Ohio.

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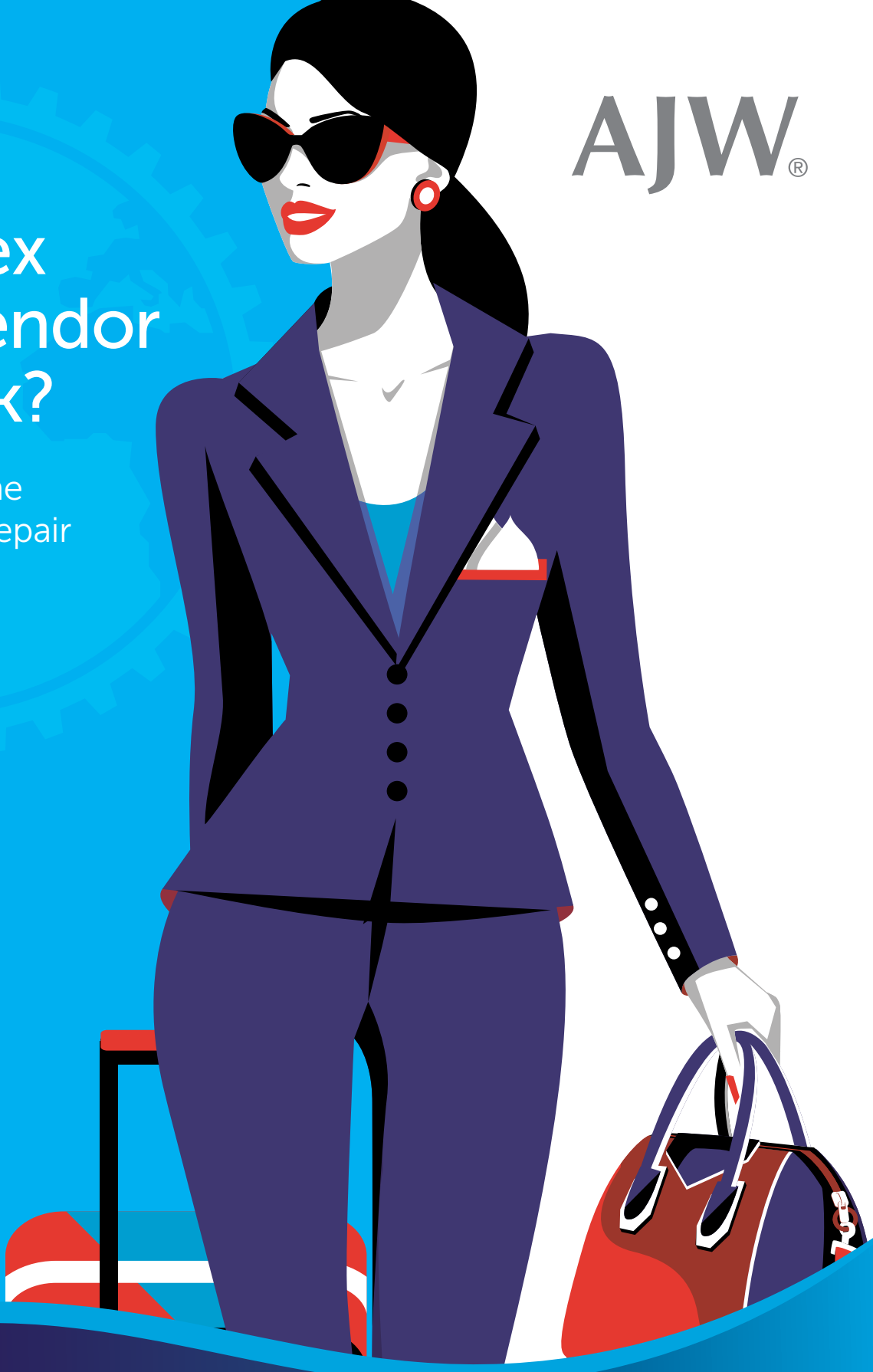

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