X-ray inspection of aviation electronic components

How fully inspected, quality electronic components ensures safer aircraft and protects profits

Executive summary

"Aviation is proof that given the will, we have the capacity to achieve the impossible."
Edward Vernon Richenbacher

One foundational principle is true: Innovation is the nexus of the aviation industry. Across commercial airlines, military aircraft and aerospace industries, aviation advancements continue to challenge what is possible. Powering these advancements are the sophisticated electronics, or avionic components—such as semiconductors, printed circuit board assemblies (pcba's) and lithium-ion batteries – which are being developed to do more and more via increasingly denser and smaller componentry. Successful flight now relies heavily on the micro-level quality of electronic components, often determined by the integrity of non-visible electronic elements. Avionics, it seems, are increasingly "in the pilot's seat."

In 2018, an **estimated 4.5 billion passengers** flew on 45 million scheduled civilian flights globally. Clearly, aviation safety is of paramount importance to our wellbeing. Thus, aviation companies—airlines, aerospace and military—alongside governing agencies around the world, have mandated a "zero defects" standard for all mission critical parts for 30 years strong. This standard aptly regulates the manufacture of avionic components.

Zero defects is the utmost quality mandate, requiring every single electronics part, in every instance, to be fully inspected at ultra-high levels of resolution. There is one type of technology able to meet these stringent requirements: 2D and 3D Computed Tomography (CT) X-ray solutions. Specifically, X-ray inspection enables ultra-high (micro and nano levels) resolution of visible and non-visible areas without altering or compromising the integrity of the part.

Manufacturers of avionic components must employ high resolution 2D and 3D X-ray inspection to ensure fully tested, defect-free parts. As the use and role of electronics in aviation intensifies, proper, reliable aircraft operation is increasingly reliant on zero defects electronic components.

Today, progressive X-ray inspection solutions are enabling a new frontier of "what's possible" by further catalyzing aviation innovations. For avionic component manufacturers, X-ray inspection helps to deliver steadfast, mandated, zero defects protection that, in turn, safeguards people and sustains manufacturing viability and profitability.

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The current state of aviation and avionics

Avionics utilize components such as semiconductors, printed circuit board assemblies (pcba's) and lithium-ion batteries that help provide extraordinary innovation and functionality in small, refined packaging. **Projections** forecast strong avionics market growth from US $68.5 billion in 2019 to US $86.9 billion by 2024. Growth is due to avionics sophistication fueling new designs, capabilities and connectivity that improve aircraft operations while simultaneously enhancing safety, such as collision avoidance systems and satellite navigation. These benefits come with a steep responsibility as avionics play a vital role in proper aircraft operation. As a result, successful flight today is greatly dependent on avionic component quality, often at a micro-level on non-visible elements. Across the entire aviation industry, avionics' impact is significant and pervasive.

The aviation industry is comprised of commercial airlines (passenger, business and cargo), military and aerospace sectors. They share common principles and trends such as:

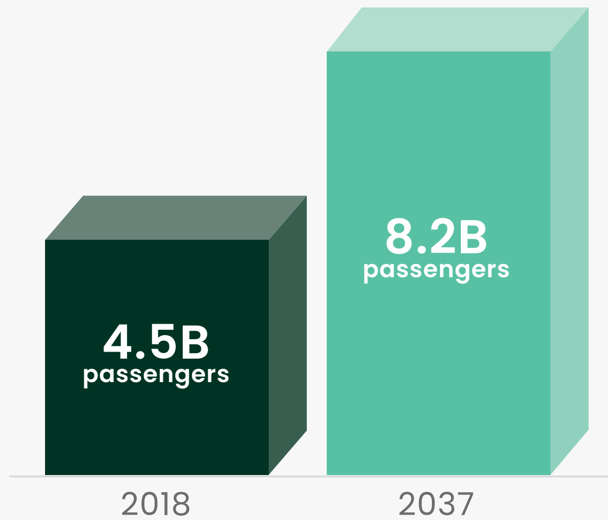
- A hyper-focus on safety
- A strict demand for zero-defects on all mission critical parts—mandated by industry and government regulatory requirements for the past 30 years
- An increasing use of, and reliance on, avionics
- A healthy forecast for future growth

Commercial aviation is the largest of the three aviation sectors and, in many ways, acts as a leading indicator for the aviation market as a whole. The **estimated** 4.5 billion passengers who flew on 45 million scheduled civilian flights globally in 2018, not including business and cargo flights operated by companies such as FedEx, Emirates, UPS, Cathay Group, Lufthansa, etc., is a staggering statistic. And, according to the sources below, there is no growth slowdown in sight:

- IATA **forecasts** 8.2 billion passengers will be traveling per year by 2037
- According to airliners.net, there were about 39,000 planes in the world in 2017, including all commercial (passenger and cargo) and military planes. A Boeing estimate puts the number of aircraft worldwide at 63,220 by 2037 (not including older planes no longer in service at that time).

Alongside of market growth, today's aircraft have complex electrical systems, requiring the increased use of avionic components and subsequently creating stringent zero-defects requirements for quality inspection and testing of mission critical electronics parts. Zero defects means 100% of parts fully inspected at high-resolution for all visible and non-visible areas. The aviation industry strives for zero incidents therefore parts must be zero defects compliant. In-flight aircraft repairs of defects are, of course, not possible and the consequences of failure are extraordinarily high, most notably due to tragic fatalities.

Growth in airline passenger travel



Source: IATA and USA Today

Does the strictly regulated, zero-defects avionics requirement translate into aircraft safety?

In commercial aviation, zero fatal incidents is the goal. In fact, fatal incidents have continually declined over the last decade, excepting 2018 that spiked to 500 fatalities following 2017's record of 13 fatal incidents. The **leading causes** of fatal airplane crashes are: pilot error, weather and mechanical failures. Electronic component failure is notably absent from this list, even with the rise in avionics' usage. It appears the zero-defects-in-avionics standard is working. Thus, the stringent and rigorous avionic component mandates are warranted as they refuse to compromise our safety. However, we cannot rest on our laurels. With new technology and novel designs that employ more and more electronics, the standards and compliance to those standards must keep up to sustain this important avionics safety record.

Contrarily, during the last decade, U.S. military aviation **accidents** are **on the rise**, attributed primarily to mechanical/maintenance failures and pilot error.

Achieving zero incidents is both a lofty and earnest goal, and avionic components must contribute their part to aviation safety by maintaining the zero defects regulatory requirements. However, as electronic componentry evolves and usage increases, attaining zero defects becomes a moving target, raising the bar on the requirements to achieve it.

Electronic componentry creates new requirements

Zero defects is the utmost quality mandate. In electronic components it requires thorough inspection of each and every part at ultra-high resolution, including all visible and non-visible areas. This is an elevated challenge as micro-sized parts increase in density as more sophistication is engineered into smaller and fewer, more-highly integrated parts. Further intensifying this challenge is the increasing use of sophisticated electrical systems in aircraft and connectivity interfaces, which employ more avionic components and, in turn, create ever-evolving stringent quality requirements.

LAND-BASED (CARS, TRAINS) CAPABILITIES	*MIRROR*	AIRCRAFT CAPABILITIES
• Assured clear distance ahead (ACDA) • Obstacle detection sensor (ODS)	⟷	• Traffic alert and collision avoidance system (TCAS) • Terrain Awareness and Warning Systems (TAWS)

Advanced avionics will help further improve both aviation performance and safety by providing real-time, in-use data. For example, consider automatic dependent surveillance-broadcast (ADS-B) technology, now **FAA-mandated** (Federal Aviation Administration) for adoption by January 1, 2020. ADS-B leverages satellite navigation, enabling an aircraft to determine its position and reduce strain and reliance on air traffic control, thus aiding in-flight efficiency while safely increasing airspace capacity. Avionics capabilities also mirror technology developments in land-based vehicles which improves the safety profile of air travel, such as the examples above.

Space travel is heavily dependent on avionics as the command and control "brains" of aircraft. **According to NASA**, several avionic "brains" direct the power, trajectory and control for NASA's deep space rocket to launch over 8 million pounds of thrust and reach 25,000 miles per hour while navigating accurately in real-time.

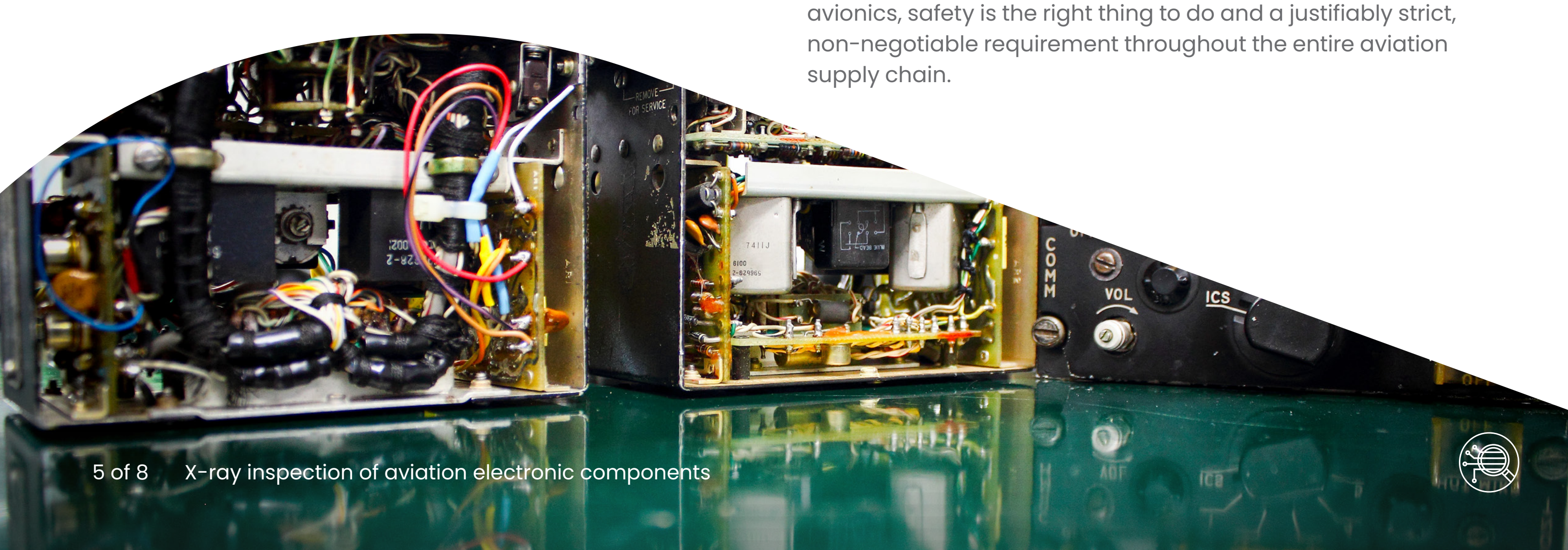
As avionics increase in sophistication, more innovative breakthroughs become possible. Both inspection technologies and regulatory standards must evolve concurrently to sustain this innovation and on-going safety.

The sole capability equipped to meet the demanding inspection and testing challenge in avionics is state-of-the-art 2D and 3D X-ray technology. By providing ultra-high resolution of visible and non-visible areas without destroying the part, X-ray inspection helps to validate avionics integrity on each component. Because aviation regulation demands that each part must be inspected prior to aircraft installation and use, non-destructive testing is the only viable approach. The actual part used must be the part that is comprehensively inspected and tested.

Safety necessitates investment. In avionics, governed by the most stringent regulations, additional manufacturing costs are required to produce, inspect, test and maintain compliant electronic components. Consider these areas of investment:

- **Governing standards.** To navigate, understand and meet regulatory requirements while sustaining on-going compliance requires time, expertise and capital manufacturing investments.
- **Inspection processes.** To fully inspect each part requires X-ray scanning equipment or X-ray scanning services (outsourced inspection). This translates into relatively lower speed, off-line 2D and 3D inspection and testing.
- **Avionics manufacturing.** To ensure quality while producing advanced avionics, manufacturing is often constrained to low speed, low volume production. As such, it entails a different business model relative to other electronic component industries such as those serving the automotive or consumer sectors.

As the saying goes, "safety isn't expensive, it's priceless." In avionics, safety is the right thing to do and a justifiably strict, non-negotiable requirement throughout the entire aviation supply chain.



How do avionics increase aircraft safety?

Avionics are providing **innovations** that are making aircraft operations safer. With a goal of reducing pilot workload and improving operations, automation, powered by avionics, is advancing in-flight safety. In addition to the collision avoidance and obstacle detection examples mentioned earlier, other avionics advancements to expand a pilot's situational awareness are emerging.

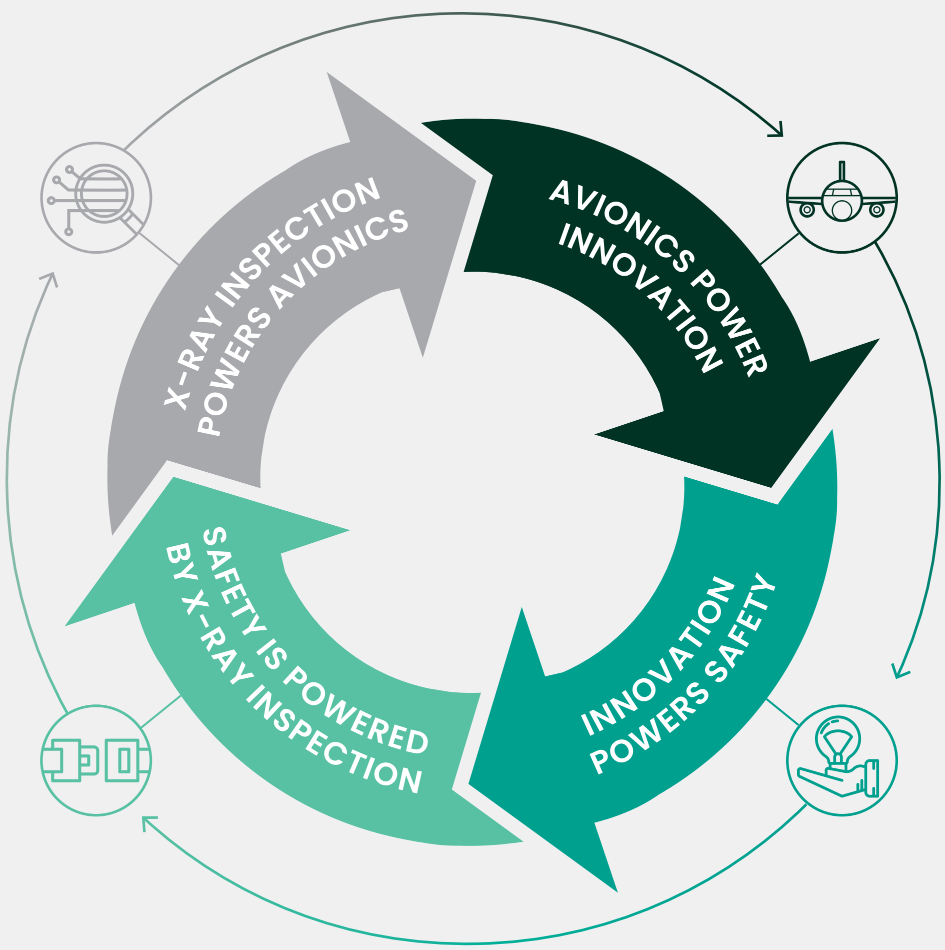
Consider intuitive touch-screen technology, now moving from consumer electronics into aviation. One emerging solution, enhanced vision systems (EVS) utilizes interactive touch screens (versus traditional display screens) to help pilots gain improved clarity and navigate difficult in-flight situations, such as low-visibility or challenging weather conditions.

Another technological innovation is visual, high-resolution airport mapping to assist pilots in proper runway and taxiway selection and increased awareness of ground equipment, other planes and signage, with the goal of mitigating the risk of on-ground collisions.

In military environments, the progression of **unmanned combat aircraft** in threatening situations helps protect lives. Speaking of unmanned, there have also been tests proving the efficacy of robot co-pilots successfully landing commercial aircraft.

Avionics power innovation. State-of-the-art X-ray inspection catalyzes avionics usage by ensuring quality electronic components.

The virtuous cycle of avionics



What matters to the aviation industry?

Aviation standards are justifiably high and the regulations ironclad. Compliance at 100% aids in-flight safety, because proper aircraft operation is highly reliant on zero defects in mission critical electronic components. Beyond safety, avionics compliance has financial and legal implications. Standards issued by IPC (The Association Connecting Electronics Industries)* regulate requirements along with government-mandated avionics standards.

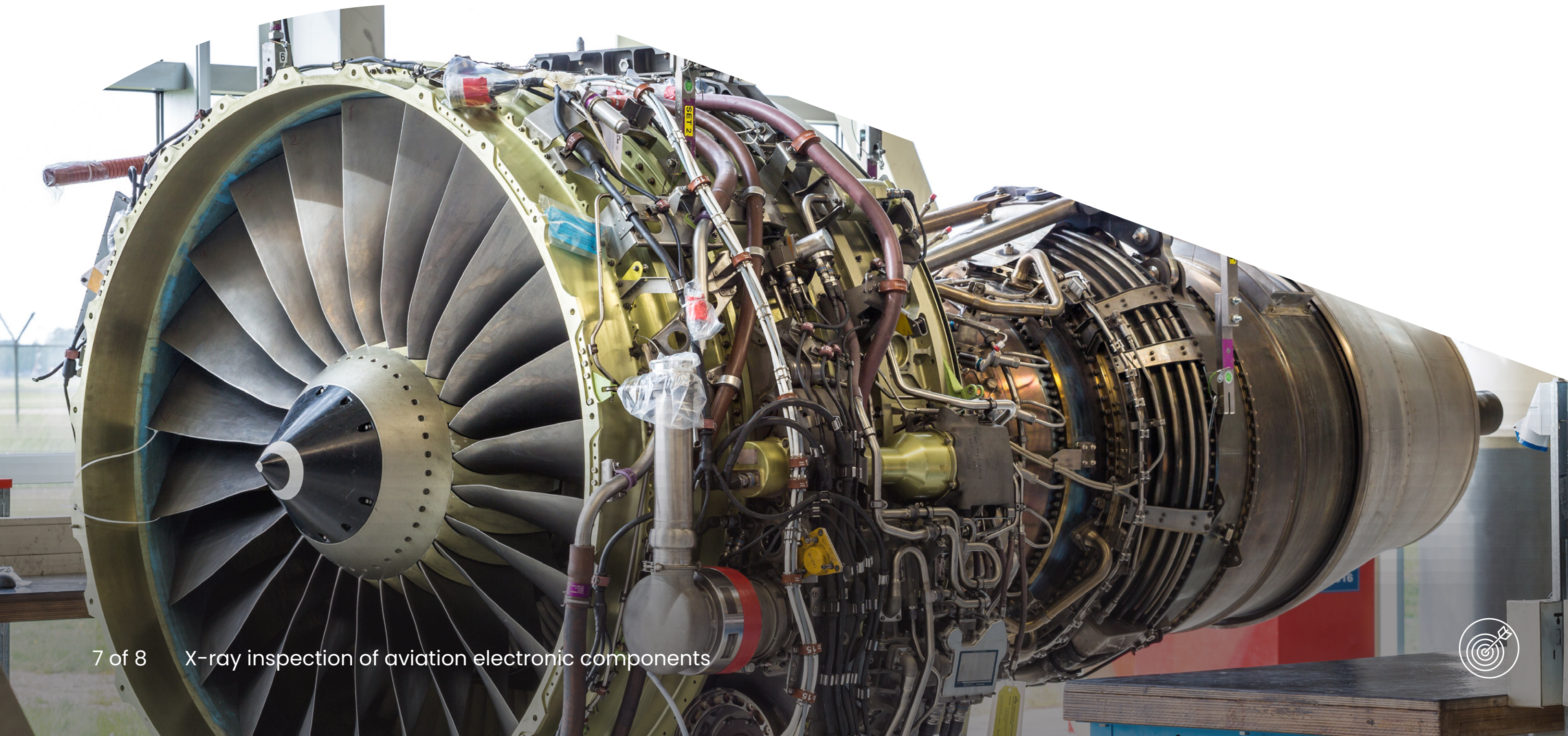
IPC has published Class 3/A, written specifically as supplemental requirements for aerospace and military applications. It is the most stringent class of regulations across the IPC family. Within IPC Class 3/A are two key standards to ensure parts withstand the vibration and thermal cycles of space and military environments without the option of doing in-use repairs:

IPC-6012DS
For rigid printed boards used in space and military avionics.

IPC Standards
For soldered electrical and electronic assemblies operating in space and military applications.

The aviation industry is also regulated by other agencies, both government and non-government, such as **FAA** (Federal Aviation Administration), **EASA** (European Union Aviation Safety Agency), NAS (National Airspace System), **ASTM** International and ISO (International Organization for Standardization). The dominant standard for avionics adopted by the FAA and EASA is DO-254, developed by the Radio Technical Commission for Aeronautics.

As technology progresses, the multitude of governing agencies and regulating standards strive to keep up. This is not easily achieved since technology advancements are a few years ahead of standards and the pace of change is increasing while industry adaptation, approval and adoption take time. This divide puts electronic component designers and manufacturers in a challenging position. To keep avionics safe and businesses viable, manufacturers must navigate standards, achieve and sustain component compliance, stay current on technology and standards all while managing costs and return on investment. Safety, while challenging and mandated, is always a worthy, regret-free journey.



Summary

As avionics usage expands throughout the aviation industry in commercial, military and aerospace sectors, many innovative benefits are realized. Simultaneously, the micro nature of avionic components, semiconductors, pcba's and lithium-ion batteries, inherently introduce risks that must be mitigated to ensure zero defects. High resolution 2D and 3D X-ray inspection of visible and non-visible areas provides that assurance and regulatory compliance for avionic components. Innovation, the lifeblood of aviation, can progress, unbridled, with solutions such as advanced X-ray inspection, which catalyze avionic developments while concurrently safeguarding people and profits.

For more information, feel free to contact us here: industrial.ai/contact

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