AS5678: Progress in SPEC 2000 for RFID use in Aerospace and Defense

ABSTRACT

ATA (Air Transport Association) Spec 2000 Chapter 9, Automated Identification and Data Capture (AIDC), outlines industry guidelines for traceability and includes standards such as linear and bar-coding, 2D Data Matrix bar coding and Radio Frequency Identification (RFID), which are used to mark and identify products and/or store information which can be read in an automated manner. In recent years, the benefits of using RFID have become more attractive to the industry. Much of RFID, which had its origins in Aerospace and Defense (A&D), has been expanded and developed in more consumer and commercial marketplaces. As the aerospace industry moves to adopt this technology as an integral aspect of component tracking and maintenance, a need to specify for testing and qualification standards has arisen. This has been the driver for the creation of SAE AS5678. AS5678 is a requirements specification created by SAE International for the production and test of passive RFID tags for the Aerospace industry. This whitepaper discusses AS5678 and its context for tag manufacturers, integrators, and end users of the technology. The background of RFID in the A&D industry is briefly covered for appropriate context.

Overview

The intention of this paper is to provide brief context of RFID in A&D, the specifics of SPEC2000, and provide more details about the requirements and tests unique to A&D usage. A central theme presented is to gain an understanding of the layering of specifications, prior art, and practice that puts the emphasis on test and qualification of passive RFID tags for parts tracking in the aerospace supply chain, manufacturing cycle, and the implications of life-limited parts. For the extent of this article “RFID” and “RFID tags” will refer to EPCglobal UHF Class 1 Generation 2 passive tags. There is current work underway to qualify active tags. That work is out of the scope of this article.

Brief History

RFID technology has been used extensively in electronic article surveillance applications within the retail industry, as well as employee identification badging and access control. Now, the commercial aviation industry is eager to take advantage of RFID technology to increase productivity and reduce costs.

Boeing and Airbus have agreed to collaborate on developing commercial aviation industry standard requirements for RFID by joining forces on the Air Transport Association’s (ATA) Automated Identification and Data Capture Task Force. This industry-wide task force is made up of representatives from airlines, suppliers, and airframe manufacturers with the goal to establish and maintain an industry-wide common format for RFID on parts. By working together on these non-competitive standards initiatives, both Boeing and Airbus benefit by avoiding conflicting requirements with mutual suppliers and customers.

The guidelines defined by this wide task force are contained in Chapter 9 of ATA SPEC 2000, "Integrated Data Processing Materials Management." ATA SPEC 2000 is an international specification that establishes comprehensive standards to support the exchange of information between airlines and suppliers in aircraft parts industry-related processes. These processes include provisioning, invoices, repair orders, warranty claims, and automated identification and data capture.

Boeing and FedEx have jointly concluded three “proof of concepts” by introducing both passive and active RFID “smart labels” on significant airplane parts of a converted FedEx MD-10 freighter in 2003 and 2004. “The tests identified no electromagnetic interference or detrimental environmental effects,” said Kenneth Porad, program manager of the in-service evaluation for Boeing Commercial Airplanes.

Boeing announced future plans to introduce RFID smart labels on maintenance significant parts of the 787 Dreamliner. Boeing plans for the tags to contain unique identification as well as maintenance and inspection data in accordance with industry standards developed for commercial aviation by the ATA. That unique identifier is also used as a pointer to a database that contains much more extensive information on the overall lifecycle of the part. Boeing says that “information stored on the RFID tag will enhance parts traceability and reduce the cycle time to solve in-service problems by improving the accuracy of information exchanged between customers and suppliers.”[1]

Airframe manufacturers such as Boeing and Airbus have concluded that RFID technology will improve configuration control and help airlines reduce ownership costs by managing the histories of part maintenance and repair. Using RFID smart labels on airplane parts can improve the accuracy of reliability and maintenance information exchanged between the airline industry and manufacturers. RFID technology provides an accurate, easy, and inexpensive method of data storage and data entry for computerized information management systems. RFID supports an efficient system of tracking key aircraft components during their entire life cycle.

These benefits include:

- Reduced cycle time to correct service-related problems.
- The ability to identify and remove rogue parts.
- Reduced risk of counterfeit parts.
- The ability to maintain repair history, including upgrades.
- Spare parts pooling.
- Reduced inventory and warranty claim-processing costs.

RFID devices do not adversely affect the simultaneous operation of any aircraft systems or interfere with continued safety of flight. The FAA published RFID policy in May 2005 stating that passive RFID poses no safety risk and is acceptable for use on civil aircraft under specified conditions.

Airlines, manufacturers, and suppliers all can take advantage of RFID technology to provide automatic, error-free data entry and so help reduce costs. By introducing a program for RFID enabled parts identification, Boeing can help reduce the cycle time required to solve customers’ in-service problems. In addition, standardized RFID is a precursor to future steps the aviation industry can take to share databases of product history information. The industry will profit from shared in-service data by using it for troubleshooting, provisioning, and early identification of problems.

The usage of RFID and Edge technologies within the industry is already underway in other closed systems for internal inventory tracking, tool tracking, and maintenance. These less formal usages are improving the efficiencies within their given organizations, but a more significant transformation will occur when this technology is used in deep JIT (Just in Time manufacturing) methods for integrated inter-corporate manufacturing as well as parts tracking and maintenance in the client domain.

Testing Context

Aerospace and Defense Testing

Aerospace and Defense testing is well defined and well documented. Practices are tied to rigorous specifications (e.g. RTCA DO-160). Testing requirements cover the gamut from temperature extremes, humidity, pressure, shock, vibration, explosion, crash safety, waterproof, dust, fungus, fluid susceptibility, etc. These tests are applied per client request, but are specific to the system or component’s expected usage, exposure, and range of operation. Aging tests are also conducted to characterize product performance over its life cycle. During execution of these particular tests, functional tests are performed to evaluate any performance degradation or any failures.

[1] FAA Advisory Circular updates this. 20-162

Testing is part of the design and planning stages of a product life cycle and is not conducted as an afterthought or generally, reactively. As with all good experiments and tests, reproducibility and repeatability are essential characteristics.

RFID Testing

We can begin this discussion by regarding current practice in RFID testing. Ad hoc and improvisational testing performed by individuals who do not have a test engineering discipline has been a pervasive problem. As a result, testing can be well intentioned, but non-significant and provide results that can be misleading for an intended application. This has been a pervasive problem in the RFID field since its early adoption by some of the commercial pioneers. It is typical of emerging technology that is crossing over from other disciplines such as IT-- that the engineering disciplines suffer. This has fed into a lot of the FUD (Fear, Uncertainty, Doubt) around the use of RFID as a viable and reliable technology.

In early deployments, read rates – measured as the number of successful tag interrogations divided by the number of interrogation opportunities – varied widely with even subtle differences in tag placement and orientation, tag manufacturer, reader portal configuration, and distance. Variances in read rates from 0.60 to 0.99 were common. Traditional difficult to tag materials such as metal or liquid-filled bodies only added to the variance and rarely achieved read rates better than 0.90. Recent advances, particularly in tag design and tag/portal technique and testing, routinely result in read rates above 0.99.

RFID Testing and Engineering Discipline: It should go without saying to any test engineer on how to proceed, but often this discipline is not hired or invoked to assist with these projects in general commercial RFID projects. In the hands of experienced test engineers, standalone RFID testing per se, is not particularly difficult in practice, but it is also not particularly meaningful within a vertical application. It is the testing performed within a usage and environmental context that adds value and provides useful information to the testing client. This context assists with selection and utilization of the appropriate tags/reader/printer technologies as well as advises on boundary conditions of operation. This is an essential part of the design and engineering cycle. It is the combination of RF skills, vertical industry expertise, and test engineering skills that make for valuable testing for RFID and Edge technologies. Care must also be taken in the selection of samples for test evaluation with regard to the particular subject being examined. Testing for design validation would differ from testing to evaluate production process. Read range and read rate testing of a random sampling of tags would be appropriate both for the tag manufacturer before delivery, and for the tag consumer before introduction into their process. This is a simple application of standard quality practices but is often overlooked in the case of passive RFID tags. This type of sampling and testing should be ongoing. Testing of tag use in production processes differs in that it is an intensive, all-encompassing trial which attempts to incorporate all likely process variables and may deliberately introduce detrimental conditions to measure process strain and induce failures. This type of test is typically performed during the process design/start-up phase, or as a trouble-shooting tool. Further variables are thrown in when considering the target system and variations on the construction of that system.

AS5678 Philosophy

Fact: if it is on a plane, it must be tested and qualified for safety and reliability. Specifications already exist for A&D testing of electrical and mechanical components. General testing specifications for RFID tags, by and large, do not exist. There exist some recommendations for specific usage, but *repeatability* and *reproducibility* are not there. Part of the foundation of AS5678 is to apply the correct tests with the same rigor expected from any other aircraft component.

The philosophy for the development of AS5678 was to meet the criteria provided in the FAA document: "AIR-100/AFS-200/AFS-300 joint memorandum, Policy for Passive-Only Radio Frequency IDentification (RFID) Devices, dated May 13, 2005." At all points during the development we were provided FAA recommendations and clarification by key FAA personal.

AS5678 - Audience

The AS5678 specification is relevant to several audiences in many different ways.

The first audience includes chip, tag, and inlay manufacturers, also known as tag converters. This audience will need to understand and comply with the standard and have their products undergo qualification testing by properly equipped and trained labs. An extended set of this group are the airframe component designers and manufacturers who will be specifying particular tags and are responsible for the test and qualification of overall aircraft subassemblies. These organizations will need to make sure that they are using certified parts and understand how those components work in conjunction with their overall systems.

The second audience is the test engineers and test labs that will want to conduct this manner of testing . The pilot lab for this work and assisting with the creation of the specification is the Sun Microsystems Advanced Product Test Lab in Longmont, Colorado. Their extensive background in test engineering, A&D testing as well as their long history as a founding RFID test lab makes them an ideal candidate for this work. Also included in this audience are the reader and device manufacturers who will be interested in the performance metrics of the devices tested and how that can help influence their designs for best operation.

The third level audience is the users of this technology beyond the manufacturing supply chain and includes airlines, Maintenance Repair Overhaul organizations (MRO's) as well as other operational roles.

A fourth and final group include industry standards organizations and regulatory agencies that will be interested in the usage, interoperability, proliferation, and education surrounding RFID in A&D i.e. EPCglobal, ATA, FAA, etc.

Test Suite Overview

Items that are to be tested can and will include tags that are to be used on Line Replaceable units and time controlled and life limited parts. These fall into different domains that do not require the particular rigor of A&D testing and would in most cases not be identifiable for prescriptive testing. The overall test suite may not be applicable to every device since it is selected by the particular use case.

This is divided by environmental requirements as well as applicable categories such as Internal, External, or Power Plant. The particular environmental requirement is tied to performance tests such as data integrity. To perform these tests requires not only the tag as a DUT (Device Under Test) and reader for data testing, but also a comprehensive suite of environmental test systems that are unlikely to be found at an RFID shop as well as trained and experienced test engineers. The following 2 tables summarize the AS5678 test suite. The original table is also provided as an appendix to this document.

AS5678 RFID Tag Testing Reference (1 of 2)

Specification	Section/Test	Interior	Exterior	Power Plant	Required?	Comments
AS5678	6.3.5, Tag Range Measurement	860-960 MHz in 1 Mhz steps; test measures lowest activation energy; results in Performance Grade (A to F) for tag mounted to conductive or non-conductive material			Yes	Defined Radio Regions 1-3 use only 862-870, 902-928, and 950-956 MHz; testing of 860-861, 871-901, 929-949, and 957-960 MHz may not be necessary
AS5678	6.3.5, Environmental Performance	**Table 3, RTCA DO-160/14 CFR 25**			Yes	
RTCA DO-160 Rev E	4.5.1, Ground Survival Low Temperature	-40 deg C	-55 deg C	-55 deg C	Yes	
RTCA DO-160 Rev E	4.5.2, Operating Low Temperature	-15 deg C	-55 deg C	-55 deg C	No	
RTCA DO-160 Rev E	4.5.3, Ground Survival High Temperature	+70 deg C	+70 deg C	To be declared by equipment manufacturer relative to temperature extremes	Yes	
RTCA DO-160 Rev E	4.5.4, Operating High Temperature	+55 deg C	+70 deg C	To be declared by equipment manufacturer relative to temperature extremes	No	
RTCA DO-160 Rev E	4.5.5, In-Flight Loss of Cooling	+30 deg C	+40 deg C	To be declared by equipment manufacturer relative to temperature extremes	No	
RTCA DO-160 Rev E	4.6.1, Altitude	15,000 feet or 4,600 meters	50,000 feet or 15,200 meters	50,000 feet or 15,200 meters	Yes	

AS5678 RFID Tag Testing Reference (2 of 2)

Specification	Section/Test	Interior	Exterior	Power Plant	Required?	Comments
RTCA DO-160 Rev E	4.6.2, Decompression	8,000 feet to Maximum operating altitude for aircraft	Not Applicable		Yes	Typically 8,000 feet to 50,000 feet
RTCA DO-160 Rev E	4.6.3, Over Pressure	-15,000 feet or -4,600 meters	Not Applicable		Yes	
RTCA DO-160 Rev E	6.3, Humidity	Cycle: +30 deg C 85% Relative Humidity (RH), 2 hours to +50 deg C 95% RH, hold 6 hours, 16 hours to +38 deg C 85% RH; 2 Cycles total	Cycle: +30 deg C 85% RH, 2 hours to +55 deg C 95% RH, hold 6 hours, 16 hours to +38 deg C 85% RH; 6 Cycles Total		Yes	48 hours total for Interior, 144 hours total for Exterior/Power Plant
RTCA DO-160 Rev E	7.2, Operational Shock	3 Shock Inputs of 6g/11ms Terminal Saw-tooth Wave Shape applied to each pole of each axis (six faces)			Yes	18 shock inputs total
RTCA DO-160 Rev E	8.5, Standard Vibration - Fixed Wing	1) 0.5g Sine Sweep 10-2000hz, 1.0 oct/min, 1 sweep each axis; 2) 1 hour per axis 1.48 gRMS Random Vibration, Curve "B"; 3) 0.5g Sine Sweep 10-2000hz, 1.0 oct/min, 1 sweep each axis			Yes	"B" Curve: 10hz - 0.012, 40hz - 0.012, 100hz - 0.002, 500hz - 0.002, 2000hz - 0.00013
RTCA DO-160 Rev E	11.4, Fluid Susceptibility	Item is wetted with appropriate fluid for 24hrs, then operated for 10 minutes. Item is then subjected to +65 deg C for 160 hours, then operated for 2 hours			Customer Defined	Customer determines which fluid categories/test fluids to use, from RTCA DO-160 Rev E, Section 11, Table 11-1 (see Tab 2).
RTCA DO-160 Rev E	15.3, Magnetic Effect	Tag must deflect uncompensated compass less than 1.0 degree at 0.3 meters or less		Not Applicable	Cockpit Installation Only	
14 CFR 25	Section 25.853(a) and Appendix F, Part 1 paragraph (a)(1)(ii), Flammability	Vertical Burn Test: A Minimum of 3 samples must be tested and results averaged; samples must be at least 8 inches by 8 inches in size; minimum flame temperature of +1550 deg F applied for 12 seconds and removed			Yes	Average burn length may not exceed 8 inches, average flame time after flame source removal may not exceed 15 seconds, drippings from test specimen may not continue to flame for more than 5 seconds.

Specific Test Area Discussions

Data Integrity

These specific notes apply to testing in an RF quiet environment. Although the RFID tags, in practice, will be used in somewhat indeterminate RF environments, the actual testing for qualification and performance must begin in a controlled, low RF environment. This eliminates any interaction, interference and secondary effects that may arise and is critical to ensuring repeatability. Even if a testing area is evaluated using a spectrum analyzer and deemed currently quiet or stable, there is the opportunity for that environment to be corrupted by changes in machinery, introduction of portable communications equipment (phone, radio, laptop, etc.) or the operation or failure of existing systems. High induction systems such as motors and arc welders, or damaged grounding and shielding may alter that environment severely without presenting other outward effects. RF anechoic chambers are recommended to create a low noise isolated environment that will allow for reliable and repeatable testing. It is more accurate to say that the RF anechoic chamber is housed inside of a Faraday cage. This combination of technology attenuates incoming signals as well as absorbing RF radiation emanating from the devices under test (e.g. RFID tags) as well as the test equipment (e.g. RFID reader/exciter). Core testing includes read distance calculations by specific, rigorous, and repeatable processes. The first test set goes through this process to characterize tag sensitivity over frequency and power. In order to identify product consistency, multiple instances of a given tag are put through the test procedure to identify the operational performance distribution of the tag set. The below diagrams illustrate the test setup as well as representative frequency response of a tag.

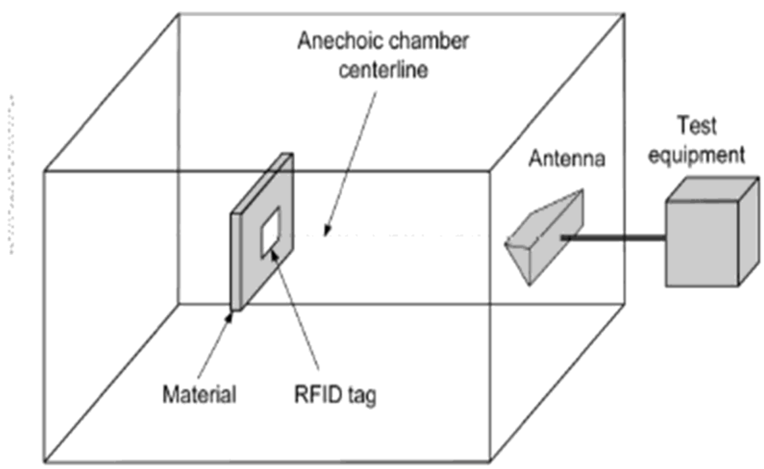

Figure 1 : RFID Range Measurement Setup per SAE AS5678

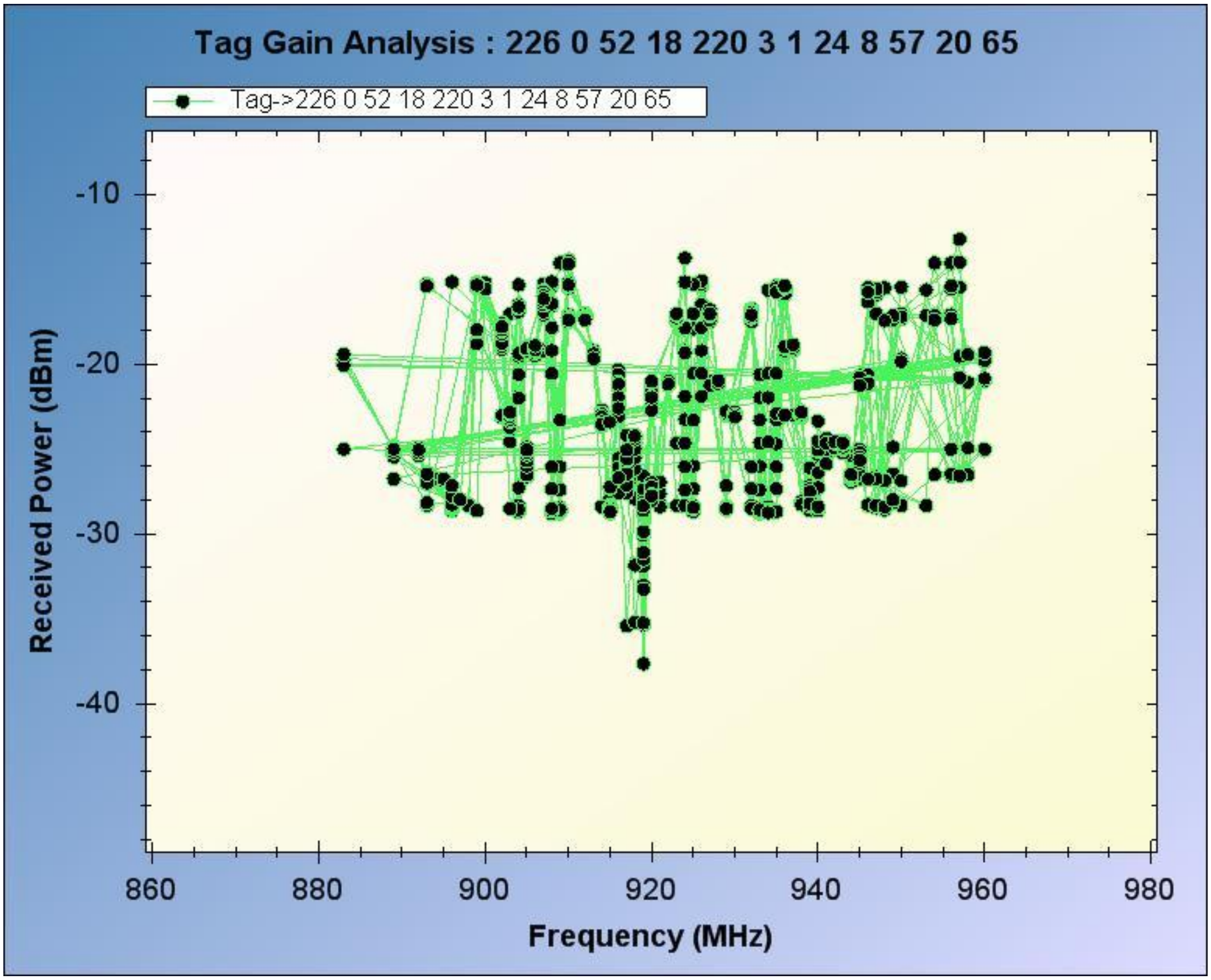

Figure 2: Typical frequency response graph for a North American-tuned passive UHF tag using the AS5678 measurement method.

Breadth of Testing

The nature of these tests for environmental and survivability will mean that some test labs may not be able to cover all of the tests in house. The vendor then faces the choice of managing more than one lab or using a single lab as the testing contractor to oversee all of the aspects of testing. The choice of how to proceed has much to do with the vendor's own internal staff and their ability to assure that the test work is performed in a method consistent, complete and sufficient across the test labs.

There are fourteen tests outlined in AS5678 covering Temperature, Altitude, Humidity, Shock, Vibration, Fluid Susceptibility, and Magnetic Field. These particular tests reference back to existing standards for aerospace testing such as *RTCA DO-160 Environmental Conditions and Test Procedures for Airborne Equipment*. The selection and execution of these tests are outlined in the AS5678 specification as specifically apply to internal, external or power plant equipment for the aircraft.

Preparing for AS5678 Testing

Process design and testing will dictate the requirements for tag selection. For process refinement, it may make sense to take a single run of tags with fixed conditions. For overall QC (quality control), it is best to perform random sampling for the test set. Ultimately, these tags will then be programmed with unique serializations (USER ID, etc.) for better identification in testing as well as improvement of operational distribution. There should be a statistically significant number of tags submitted for testing, ideally in a single batch.

For process, it is expected that either the tags will pass and report information, will be relayed to the requestor, or fail (in part or whole) with the reflecting report returned for evaluation. If there is a failure, integration with the testing team is essential to identify the mode of failure and possible cause/recommendations. Given that many of these tests require equipment and testing skills that may be outside of the normal capabilities of a tag facility, it is recommended to find a good testing partner to work with through the process.

Larger samples of tags will improve the quality of information as well as accelerate the testing process. The testing does not require that each single tag is put through the tests sequentially, so parallel tests can be conducted more readily with large samples. Nevertheless, this range of testing can be expected to last between 1-4 weeks, so plan your testing accordingly.

It is recommended to integrate the tested tag with a functional unit and perform the testing as part of the overall design cycle of the functional unit. It is a component in regular design and should be integrated into normal engineering disciplines. One of the challenges of RFID adoption has been the unnecessary isolation of the RFID device from the actual product design cycle. This separation may just be an artifact of RFID common usage as a part of shipping label and packaging, but that has created a false mind-set with too many engineers. An RFID tags is part of the design, will be on the BOM (Bill of Materials) for assembly, and should be treated like any other component. That RFID tag will be a permanent part of aircraft subassembly and should be treated as such.

Each of the organizations throughout the supply chain should consider how that RFID device is used and tested in the other organizations within that supply chain. The chip manufacturer needs to consider, for the conditions required in the final airframe, what stresses will the tag (chip, antenna and substrate) undergo and how that chip will need to accommodate those conditions. The tag manufacturer (converter) should consider tag operation within the scope of a final airframe assembly. This sort of forward thinking is essential in the early adoption phases to improve the overall performance of the devices and reduce the number of trials to pass testing.

Finally, make sure that test planning is an early part of the design cycle. SPEC 2000 A&D RFID is still in adoption phase. Use your testing partners to help identify requirements and possible pitfalls to smooth the design and process.

Looking Forward

One of the themes alluded to in this paper is a rigorous approach to design and implementation of systems. This requires the cooperation and longer term vision of the partners working in this space. The challenges facing forward are the creation of appropriate specifications and art to allow for easier adoption and usage of the technology. Next phases will include trial, additional specs, vertical trial, on to full implementation. Work is also being done in parallel for active tags and other technologies. The RFID chip, tag, and subassembly manufacturers should be looking to AS5678 test completion as a significant achievement for their entry into the A&D supply chain.

In other industries, the practices exercised in this space will also stand as an example for new vertical usage of RFID outside of A&D and will show the appropriate design and test disciplines for successful integration of this new technology.

Appendix

The original "Environmental Performance Requirement Table" from SAE AS5678 is included here for completeness. For the entire AS5678 specification, contact SAE.

TABLE 3 - ENVIRONMENTAL PERFORMANCE REQUIREMENTS

Environmental Requirement	Environmental Test Reference Document	Applicable Category or Guidelines				Applicable Performance Standard	Comments
		Interior	Exterior	Power Plant	*		
Temperature Altitude							
4.5.1 - Ground survival low temperature and short time operating temperature test	RTCA DO-160 Rev. E or latest, Section 4	Category A1	Category D2	Category D3		Data Integrity (5.3.3)	After the RFID device has been subjected to the short-time low operating temperature for at least 30 minutes it should be returned to room temperature and tested to determine compliance with applicable equipment performance standards.
4.5.2 - Operating low temperature test (N/A)	RTCA DO-160 Rev. E or latest, Section 4	N/A	N/A	N/A		Data Integrity	Optional
4.5.3 - Ground survival high temperature and short time operating high temperature	RTCA DO-160 Rev. E or latest, Section 4	Category A1	Category D2	Category D3		Data Integrity	After the RFID device has been subjected to the short-time operating high temperature for at least 30 minutes it should be returned to room temperature and tested to determine compliance with applicable equipment performance standards.
4.5.4 - Operating high temperature test (N/A)	RTCA DO-160 Rev. E or latest, Section 4	N/A	N/A	N/A		Data Integrity	Optional
4.5.5 - In-flight loss of cooling test (N/A)	RTCA DO-160 Rev. E or latest, Section 4	N/A	N/A	N/A		Data Integrity	Optional
4.6.1 - Altitude test	RTCA DO-160 Rev. E or latest, Section 4	Category A1	Category D2	Category D3		Data Integrity	RFID device is not activated for the test. The RFID device should be exposed to the pressure called out for the maximum operating altitude for 2 hours and then returned to atmospheric pressure. Test to determine compliance with applicable equipment performance standards.
4.6.2 - Decompression test	RTCA DO-160 Rev. E or latest, Section 4	Category A1	Category D2	Category D3		Data Integrity	RFID device is not active for the test. After decompression and the 10-minute wait the RFID device is returned to atmospheric pressure. Test to determine compliance with applicable equipment performance standards.
4.6.3 - Over pressure test	RTCA DO-160 Rev. E or latest, Section 4	Category A1	Category D2	Category D3		Data Integrity	No deviation required.
Humidity							
6.3 - Humidity	RTCA DO-160 Rev. E or latest, Section 6	Category A	Category C	Category C		Data Integrity	Required test.
Operational Shocks and Crash Safety							
7.2 - Operational Shocks	RTCA DO-160 Rev. E or latest, Section 7	Category A	Category A	Category A		Data Integrity	Required test. Specify category based on intended usage. Test for data integrity after subjecting part to required shocks.
Vibration							
8.5 - Standard Vibration Test Procedure - Fixed Wing A/C	RTCA DO-160 Rev. E or latest, Section 8	Category S, Curve B	Category S, Curve B	Category S, Curve B		Data Integrity	Required test. RF testing during vibration test is not required. Only use curve B, regardless of intended location in aircraft of the tag. There is no need for accelerometers per 8.3 (b).

Fluid Susceptibility							
1.4 - Fluid Susceptibility	RTCA DO-160 Rev. E or latest, Section 11	Category F	Category F	Category F		Data Integrity	Choose fluid classes per customer requirements. Testing not required during submersion or spray test. Instead, test for data integrity after completion of spraying or submersion procedures, as outlined in DO-160E.
Magnetic Effect							
15.3 - Magnetic Effect	RTCA DO-160 Rev. E or latest, Section 15	Category Z	Category Z	N/A	* 1,2	No Magnetism, Data Integrity	Required test. The RFID Tag shall be tested for magnetic effect if the tag is intended for use in the cockpit environment. Otherwise, test is optional.
Flammability							
14 CFR 25 - Flammability	14 CFR, Section 25.853(a) and Appendix F, Part 1 paragraph (a)(1)(ii)	14 CFR, Section 25.853(a) and Appendix F, Part 1 paragraph (a)(1)(ii)	14 CFR, Section 25.853(a) and Appendix F, Part 1 paragraph (a)(1)(ii)	14 CFR, Section 25.853(a) and Appendix F, Part 1 paragraph (a)(1)(ii)		Flammability per CFR limits	All materials used (including adhesive materials) and or the complete RFID tag should be tested in accordance with 14 CFR FAR 25.853(a) Appendix F, Part I. RFID tags are not called out expressly in any section of Appendix F, and as such, this document directs the user to test in accordance with Paragraph (a)(1)(ii), the eight inch vertical burn test. This is considered the minimum fire test standard to which an RFID tag should be tested. All RFID tag shall be tested in accordance to this standard (Interior, exterior and power plant). Most RFID tags for use on aircraft will be smaller than the test specimen size called out by the standard. As such, the user will have to construct a representative sample of the RFID tag of sufficient length for fire testing (this should include: all the layers that will be used, including the adhesive layer). This requirement is not applicable to small parts (where the greatest dimension is less than 50 mm), that would not contribute significantly to fire propagation.

NOTES to Table 3:

"Equipment" as referred to in DO-160 is defined as a complete RFID Label, consisting of an integrated circuit "chip" attached to a substrate and integrated antenna, and covered with a human-readable printed film and/or machine-readable bar-code.

*--This test must be performed in the following modes, if specified:

1. Tag holds data, but is in inert environment, i.e., it is neither energized nor transmitting.
2. Tag has accepted "handshake" from reader, and data is being transmitted back to reader.

"Data Integrity" - applicant should fill chip's memory and then check to ensure that all information has not changed due to elapsing of time or environmental exposure.

References:

1. ATA SAE AS5678 Specification: http://www.sae.org/technical/standards/AS5678

2. FAA Advisory Circular 20-162: https://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID/74349

3. SPEC2000 site: http://www.spec2000.com/

4. Boeing: http://www.boeing.com/

5. Sun Microsystems APT: http://www.sun.com/aptesting/index.jsp

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