Civil Aviation Administrator of China

Advisory

Circular

No. : AC-21-1317

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The Protection Requirement Of Aircraft HIGH-INTENSITY RADIATE FIELDS (HIRF)

AirplaneAirworthiness Certification Department of CAAC

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Initiated by : CAAC-AAD

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Approved by : Zhou Kaixuan

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1. Purpose

Decrease of the electronic electrical component parameters(such as input voltage, current, power) in the modern aircraft airborne equipments reduces the ability of aircraft electronic and electrical system to subject electromagnetic interference. When those airborne equipments exposed to the radiation environment from the ground, ships, offshore platforms, or aircraft on the radar, radio, television, satellite uplink radiation with high power transmitter whose both numbers and powers were increasing. The functions performed by those equipments would be severely affected, or in severe case, lead to the loss of function or confusion. Compared with analog electronic electrical systems, advanced digital electronic electric system is more susceptible to the influence of the high strength electromagnetic radiation.

Many functions which use to be performed by manual, electromechanical or hydraulic part are performed by the advanced digital electronic system. These advanced systems are accepted rapidly because of the lower operation price, lower crew workload, easier maintenance and so on with in improving the airplane performance and full efficiency.

Driven by a higher efficiency, industry has used more and more composite material to reduce or replace the usage of aluminum alloy. The electrical and electronic system is exposed to more external electromagnetic environment because the composite material's poor shielding effectiveness due to its low conductivity characteristics. According §2×.1301 or §2×.1309 in current CCAR 23/25/27/29, the authority may request HIRF requirement to electrical and electronic system reference the environment standard like DO-160D or ED-14C. However, there is not explicit HIRF requirement in CCAR so that these regulations do not contain adequate or appropriate airworthiness

requirement to protect the aircraft critical system from the adverse effect of HIRF. According §21.11 of CCAR-21-R1, Certification Procedures for Civil Aviation Products and Part, CAAC will prescribe the special condition to establish a level of safety equivalent to that established in current CCAR 23/25/27/29. This AC provide a common principle to prescribe a HIRF special condition in type certifications.

This AC requires the airplane must provide enough protection for HIRF, to prevent the catastrophic condition which caused by the device damaged or function interrupt of the avionics and electrical system that performs the critical function because of direct or indirect effected by HIRF

2. Applicable

This AC applied to both new application of civil aircraft type certification and new system installation that performs the critical function on an exist aviation aircraft.

3. Reference Documents

The proposed Special Condition of HIRF by FAA

FAA/JAR AC/AMJ20-1317 The Certification of the Aircraft for Operating in the High Intensity Radiated Field(HIRF)

FAA Order N8110.71 Guidance for the Certification of Aircraft Operating in High Intensity Radiated Field(HIRF)

RTCA DO-160D/ED-14C Environmental Conditions and Test Procedures for Airborne Equipment;

SAE-ARP5583 Guide to Certification of Aircraft in a High Intensity Radiated Field (HIRF) Environment

4. Related Airworthiness Regulation:

CCAR 21.11、CCAR23.1309、CCAR25.1309、CCAR27.1309、CCAR29.1309 、CCAR23.1529 、CCAR25.1529 、CCAR27.1529 、CCAR29.1529。

5. recommend special condition: recommend use the special condition as follows in the type certification (if applicable): Each electrical and electronic system that performs a critical function must be designed and installed so that the function is not adversely affected during and after the time the airplane is exposed to HIRF environment.

Note: The term “critical functions” means those whose failure would prevent the continued safe flight and landing of the airplane.

6. Background

Although CAAC and other airworthiness authorities were not able to accurately define or control the HIRF energy level where the aircraft exposed during operating so far, to unify aircraft type certification policy to meet the requirement of growing type certification, base on a continuing study done by Aviation Rulemaking Advisory Committee of FAA/JAA Electromagnetic Effects Harmonization Working Group, FAA issued N8110.71 in 2, April,1998. N8110.71 gives a guidance for certification of aircraft in the HIRF environment. Due to various reasons, CAAC has not yet conducted the HIRF environment research of own scope of airspace, would not able to establish an external HIRF requirement with Chinese national conditions independently. However, Our aviation aircraft's design、refit、certification and operating actuality is forcing us to formulate our policy as the standard and consistent requirement of certification of aircraft in HIRF.

There is a little bit difference to HIRF requirement in the policy documents of FAA and EASA. EASA thought the requirement of HIRF verification apply to both critical system and essential system, and ask for aircraft-level test of the critical system. FAA thought the requirement of HIRF verification just apply to critical system, for the critical system, system-level labor test was also acceptable. Considering AC/AMJ20-1317, "Certification of Aircraft Electrical/Electronic Systems for Operation in the High Intensity Radiated Fields (HIRF) Environment", dated June, 1997, joint published by FAA and JAA, there is no essential difference between FAA and EASA. FAA just gave an option. This AC is mainly based on proposal special condition of HIRF of FAA.

7. Type certification procedure

For a new type certificate, a change to an existing TC or supplement TC basis CCAR 23, 25, 27 and 29, authority will issue special condition to require the applicant to compile following requirement in section 7.1.1 or 7.1.2.

7.1.1 The applicant may demonstrate that the operating and ability of the electrical and electronic system that performs the critical function is not adversely affected when the airplane was exposed to HIRF environment table I and II.

Table 1 The aircraft operate in VFR

Frequency	Field strength (volts/meter)	
	Peak	Average
10KHz-100KHz	150	150
100KHz-500KHz	200	200
500KHz-2MHz	200	200
2MHz-30MHz	200	200
30MHz-70MHz	200	200
70MHz-100MHz	200	200
100MHz-200MHz	200	200
200MHz-400MHz	200	200
400MHz-700MHz	730	200
700MHz-1GHz	1400	240
1GHz-2GHz	5000	250
2GHz-4GHz	6000	490
4GHz-6GHz	7200	400
6GHz-8GHz	1100	170
8GHz-12GHz	5000	330
12GHz-18GHz	2000	330
18GHz-40GHz	1000	420
The field strength values are expressed in root-mean-square(RMS) units-measured during the peak of the modulation cycle.		

Table 2 All others aircraft

Frequency	Field strength (volts/meter)	
	Peak	Average
10KHz-100KHz	50	50
100KHz-500KHz	50	50
500KHz-2MHz	50	50
2MHz-30MHz	100	100
30MHz-70MHz	50	50
70MHz-100MHz	50	50
100MHz-200MHz	100	100
200MHz-400MHz	100	100
400MHz-700MHz	700	50
700MHz-1GHz	700	100
1GHz-2GHz	2000	200
2GHz-4GHz	3000	200
4GHz-6GHz	3000	200
6GHz-8GHz	1000	200
8GHz=12GHz	3000	300
12GHz-18GHz	2000	200
18GHz-40GHz	600	200
The field strength values are expressed in root-mean-square(RMS) units-measured during the peak of the modulation cycle.		

7.1.2 The applicant may use a system labor test to demonstrate:

(a) The electrical and electronic system that performs the critical function can stand with 100 volt(RMS)/meter field strength that cover the frequency range of 10 KHz to 18 GHz. It includes the electrical and electronic system that perform critical function in the rotorcraft that approved for IFR flight.

(b) The electrical and electronic system that performs the critical function in the rotorcraft that approved for VFR can stand with 200 volt(RMS)/meter field strength that cover the frequency range of 10 KHz to 18 GHz. When demonstrate the compliance of HIRF with labor test, no installation attenuation credit can be used.

7.1.3 Use any method as above to demonstrate the compliance of the spectrum that defined in table 1 or table 2.

7.1.4 For type certification of the rotorcraft that approved for VFR flight, in consideration of HIRF environment and the labor test level, there is not additional requirement for the critical system in the rotorcraft. Environmental requirement and labor test level requirement for VFR rotorcraft in this AC can cover the uniqueness issue that rotorcraft operate at low altitude.

7.1.5 Just like indication of amplitude in many labor instruments, The field strength values are expressed in root-mean-square(RMS) units-measured during the peak of the modulation cycle, generically be called “root-mean-square of the peak”.

7.2 Compliance method, this paragraph describes a compliance method for a new type certificate, a change to an existing TC or supplement TC to show compliance with the requirement HIRF.

7.2.1 Compliance Plan: Applicant should submit a plan to airworthiness authority to show how to meet the requirement of HIRF. The compliance plan should propose a “pass/fail” criteria for the critical system during operating in the HIRF environment.

7.2.2 Identify system critical: Applicant should identify the electrical and electronic systems that preform the critical functions and agree with the authority. This may work with functional hazard assessment and preliminary functional hazard assessment (if necessary).

7.2.3 Candidates for the application of HIRF requirements. The systems performing critical functions that are identified by the hazard analysis are candidates for the application of HIRF requirements. Electronic Flight Control System、Primary Electronic Flight Display and Full Authority Digital Engineer

Control (FADEC) System are samples as the system performing critical function. Certification criterion in section 7.1 should be used for those systems' approval.

7.2.4 Compliance Method: Applicant can use test, analysis, simulate, similarity of exist systems, the combination of these methods or other methods accepted by authority to demonstrate the compliance of HIRF. Just operation experience is not acceptable, because there may be not including the condition that exposed in HIRF environment in the normal operation.

7.2.5 Pass/Fail Criteria: Conclusion that system performance was acceptable can be given if only demonstrated the consider system can continue perform the intend function. The critical functions that performed by electrical and electronic systems must be not adversely affected during the time the aircraft is exposed to the required HIRF environment. These functions must operate normally during and after the time the aircraft is exposed to the required HIRF environment. If a function is provided by multi-system, one or multiply function failure should not cause losing this function during the time the aircraft is exposed to the required HIRF environment. Each affected system that provide these functions should automatically recovers normal operation after the aircraft is exposed to the required HIRF environment, unless this conflicts with other operational or functional requirements of that system. Deviation from system specification is acceptable, but it need be evaluated by authority.

7.2.6 Test method and procedure: RTCA DO-160D section 20 and SAE-ARP5583 provide the information of acceptable procedure. The applicant that choose compliance method section 7.1.1 or 7.1.2 can use one of method as following:

7.2.6.1 Low-level swept frequency test, use to determine the aircraft internal environment measured by electromagnetic field intensity and induction cable current. Applicant should prove that the internal environment is equal or less the labor test level, including interconnecting cable and internal field.

7.2.6.2 Full-sized aircraft test with critical systems that exposed to HIRF environment.

7.2.6.3 Similarity Assessment, If the suggesting system and its installation has meet the requirement of HIRF on other approved aircraft, or there is a similar equipment and its installation that has been approved with HIRF, the applicant can show the compliance with similarity assessment base on equipment type, function, design and installation. If the similarity assessment is not entirely satisfactory, airworthiness authority would request a bulk current injection(BCI) testing that covers the band of 10KHz to 400MHz to verify the

similarity.

7.2.6.4 The labor test level in section 7.1.2 is defined according to RTCA/DO-160D, Section 20, category W(100 volt/meter, 150mA) and category Y(200 volt/meter, 300mA). According RTCA/DO-160D section 20, test current level is defined base on envelope of root-mean-square(RMS) of the peak. As a minimum, the modulations should be used according requirement of category W and category Y that defined in RTCA DO-160D, section 20. Other modulations should elected according the signal that most likely break the equipment when perform the design characteristic test. For example, flight control system may be sensitive to 3Hz square wave modulation, the video signal of CRT display may be sensitive to 400Hz sine wave modulation. If applicant could not determine the worst modulation condition, the default modulations that defined in RTCA/DO-160D section 20. If system manufacturer has performed the labor test that defined in RTCA/DO-160D, section 20 and has be approved by authority, the manufacturer should provide the detail installation standard and instruction of the approved system so that the system could be installed properly according the installation standard.

7.2.6.5 If it is impossible to obtain the system critical function continuously, there should keep an available alternative means of the critical function. Applicant should use test, analysis or similarity assessment to demonstrate that the alternative means can meet the requirement of HIRF uninterruptedly. In any interrupt period caused by test, it should ensure that system can not provide the information that could be misunderstood, the failure should be recognized immediately. System should recover normal operation automatically or manually. The deviation from pass/fail criteria is acceptable if applicant demonstrated that the effect can be ignored, neither cause nor trigger an adverse operating condition for capability of aircraft. Applicant should provide evaluation document to give the principle explain of the acceptance of the deviation. Authority should give the final approval to this document.

7.3 Submit documents: Applicant should submit a competed report to the airworthiness authority to illustrate how to meet the requirements of HIRF, including the test results, analysis and other relative documents in the compliance plan.

7.4 Maintenance: Applicant should provide maintenance requirement to ensure continued airworthiness for the installed systems。The maintenance requirements in type certification include the periodically inspection or test for the structural shield, wires shield, conductor and the parts which protecting the equipment. Applicant should provide engineering verification and proof for

those maintenance requirement.