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Development of a Proposed International Standard for Certification of Aircraft to High Intensity Radiated Fields (HIRF)

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ABSTRACT

Avionic systems performing critical functions in modern aircraft are potentially susceptible to the hazards of electromagnetic radiation from ground and airborne transmitters. The Federal Aviation Administration (FAA) requested that the Society of Automotive Engineers (SAE) coordinate the development of procedures and guidance material which can be used during the aircraft certification process to ensure adequate protection against High Intensity Radiated Fields (HIRF). This paper addresses the technical challenge of drafting a certification procedure and guidance standard, and the management process used by the SAE subcommittee AE4R to converge a diverse range of opinions by its international membership in the shortest possible time.

INTRODUCTION

In response to a letter of request to the SAE–AE4 from the FAA, dated February 10, 1988, a task was undertaken to address the effects of High Intensity Radiated Fields (HIRF) on aircraft. To accomplish this, a new SAE subcommittee, AE4R, was formed to study these effects, compliance issues and to write an SAE committee report as an input to the FAA, who will be drafting an advisory circular (AC) for HIRF certification. This subcommittee has significant international participation and is comprised of EMC and avionic engineers representing airframe, engine, and avionics manufacturers, government authorities and consultants. A relative distribution of membership is shown in Fig. 1. Approximately 20 percent were international participants representing six European countries plus Israel. An unsuccessful attempt was made to include Asian participation.

COMMITTEE STRUCTURE

It is helpful to first describe the committee's panel structure before delving into its operation as a whole. The committee divided the task among three panels. Panel 1 addressed the definition of a worldwide HIRF environment in any airspace where commercial aircraft may fly under current FAR regulations and restrictions. Panel 2 was responsible for writing the draft AC with suggested approaches to proof of compliance. Panel 3 was to prepare a user's guide, to describe in more detail, the corresponding test techniques and analysis methods to verify compliance using the requirements drafted by Panel 2. The three panels operated somewhat autonomously on their tasks, reporting progress and gaining full committee consensus at the close of each meeting. Additionally, executive committee meetings were held as required to coordinate the panels' activities and to delegate issues brought up by one panel for treatment by another.

Let us now return to the operating format of the full committee. Meetings were held three to four times a year with each meeting lasting 2-1/2 days. The fact that a similar effort was being vigorously pursued concurrently in Europe by the European Organization for Civil Aviation

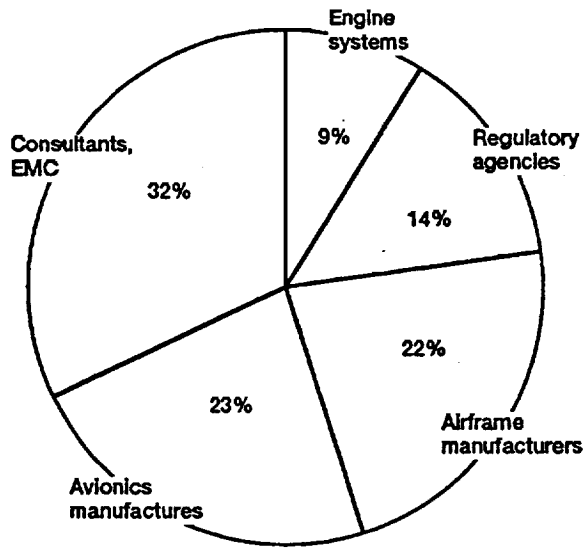

Figure 1.—SAE-AE4R technical committee membership profile.

Equipment (EUROCAE), really provided a total combined effort of six to eight significant input opportunities each year. Every effort was made in international reviews to maximize the quality of the review cycles while minimizing budget pressures on travel expenses. On a few special occasions, ad hoc subpanel meetings were held to acquire unique information from groups such as the Electromagnetic Compatibility Analysis Center (ECAC). A 12-member executive committee was also formed to provide overall continuity and was composed of the SAE Committee Chairman, Secretary, the Panel Chairmen, and representatives of EUROCAE, the FAA and Joint Airworthiness Authorities (JAA).

The full committee met half a day at the beginning and half a day at the end of each meeting (leaving 1-1/2 days for the panels). After the business and latest news, a status report was given by the FAA and JAA reporting progress on the scheduled rules making process. This was followed by technical presentations from members concerning new ideas, analyses, arguments, etc., and was limited to agenda topics. Then on the last day, following the panel meetings, a highly productive "Open Forum" approach was used. This was a 2-hr unrestricted opportunity for members to raise issues or appeal group decisions to the membership as a whole, or simply to express an opinion. This promoted an important avenue of openness in that no one's ideas would be suppressed during formulation of the documents. If a technical rationale could not be garnered, the review process of course would not support a singularity of opinion.

COMMITTEE MEMBERSHIP

Tracking of the committee membership showed a consistent 30 percent new attendance at each meeting. This was primarily because of any particular meeting location's proximity to those with only a casual interest in the activity. Approximately 10 percent of these newcomers would attend the next meeting, displacing those few who dropped off the committee for various reasons. International attendance was very stable after the first few meetings. A consistent number of 70 to 80 attendees was maintained throughout the 4 years. For the purpose of balloting, and to be a member in good standing, attendance at two out of the last four meetings was required.

DRAFT ADVISORY CIRCULAR OVERVIEW

The draft advisory circular concentrates on electrical/electronic system level verification of an entire aircraft. It is based on compliance with the Radio Technical Committee on Aeronautics (RTCA) DO–160 as an equipment level specification. The AC permits multiple verification options or "routes to compliance" at the choice of the certification applicant.

At the root of the process is definition of the electromagnetic environment. This data is tabulated in an appendix of the advisory circular and is divided into three environmental categories. These are described as: "severe," (Table 1) based on the electromagnetic fields that exist anywhere within the FAR flight rules volume worldwide; "normal," (Table 2) based on the 20 mile volume surrounding airports; and the "certification" envi

Table 1.—Severe HIRF Environment

Frequency, Hz	Field strength, V/m	
	Peak	Average
10 to 100 k	50	50
100 to 500 k	60	60
500 k to 2.0 M	80	80
2.0 to 30 M	200	200
30 to 70 M	30	30
70 to 100 M	30	30
100 to 200 M	150	30
200 to 400 M	70	70
400 to 700 M	4020	935
700 M to 1.0 G	1700	170
1.0 to 2.0 G	5000	990
2.0 to 4.0 G	6680	840
4.0 to 6.0 G	6850	310
6.0 to 8.0 G	3600	430
8.0 to 12.0 G	3500	1270
12.0 to 18.0 G	3500	510
18.0 to 40.0 G	2100	750

Table 2.—Normal HIRF Environment

Frequency, Hz	Field strength, V/m	
	Peak	Average
10 to 100 k	30	30
100 to 500 k	30	30
500 k to 2.0 M	30	30
2.0 to 30 M	40	40
30 to 70 M	10	10
70 to 100 M	10	10
100 to 200 M	30	10
200 to 400 M	10	10
400 to 700 M	730	80
700 M to 1.0 G	690	110
1.0 to 2.0 G	1650	180
2.0 to 4.0 G	3000	170
4.0 to 6.0 G	4500	280
6.0 to 8.0 G	700	230
8.0 to 12.0 G	1100	230
12.0 to 18.0 G	730	360
18.0 to 40.0 G	2100	360

ronment, (Table 3) which is derived from the severe environment excluding emitters within Special Use Areas (SUA) [1]. As a next step, the aircraft's electrical systems are categorized as critical, essential, critical noncontrol, or nonessential. Nonessential systems do not require testing beyond DO–160 test levels for the individual equipments. The AC contains a route to compliance for each category and contains a series of tests and/or analyses whose basic descriptions are beyond the scope of this paper [2,3,4]. A brief definition and purpose of each test is described in the AC with detailed application in an accompanying User's Guide.

The User's Guide [5], written by Panel 3, gives the step-by-step interpretation on the process of certification as intended by the AC. Management of the User's Guide development had to rely on maintaining a constant coordination between the Panel 2 and 3 activities.

RESOLUTION OF ISSUES

The committee took action to resolve issues in three important areas. These are: (1) compatibility between U.S. and European ACs, (2) the resolution of discussion topics and (3) the need to solicit and review comments on draft documents.

First, the committee agreed that the worldwide RF environment, as defined above, could be used by U.S. and European authorities to develop their draft ACs. At first, the EUROCAE and SAE developed separate drafts but the two drafts were following significantly different certification philosophies. Ultimately, it was recognized that the two ACs needed to be technically compatible. This was necessary to avoid requiring manufacturers to certify to two separate documents in order to satisfy an international market. The challenge was met by full and open discussion between technical participants and government authorities.

Second, an "issue record" form, Fig. 2, was adopted. This form enables documentation of ideas and concerns, for later resolution, without interrupting the ongoing discussion. It assures the originator of the issue that his or her concern will be dealt with officially. It provides the committee with a means to control each issue and also to document all resulting decisions. This documentation is particularly important as the size of the committee increases and/or the number of subgroups increases. Also, it informs key personnel, who might have missed a critical meeting, what transpired at the meeting. Moreover, it prevents inadvertent altering of past decisions, or altering without proper discussion. In short, the "issues record" assures that an accurate history of the standards writing activity will be maintained.

Third, a "review comment request" form, Fig. 3, was adopted. Its purpose is to solicit and dispose of specific changes to draft documents. This form enables committee members to review documents outside the confines of the committee. It fosters independent thinking. It also provides time to allow for delays due to language diversity and all other delays inherent to a large international organization. The returned comments are evaluated by the executive committee and incorporated into the next draft document prior to the next full committee meeting.

Table 3.—Certification HIRF Environment

Frequency, Hz	Field strength, V/m	
	Peak	Average
10 to 100 k	50	50
100 to 500 k	50	50
500 k to 2.0 M	40	40
2.0 to 30 M	100	100
30 to 70 M	20	20
70 to 100 M	20	20
100 to 200 M	50	30
200 to 400 M	70	70
400 to 700 M	1520	750
700 M to 1.0 G	950	170
1.0 to 2.0 G	2470	180
2.0 to 4.0 G	3500	360
3.0 to 6.0 G	6800	280
6.0 to 8.0 G	1800	330
8.0 to 12.0 G	3500	330
12.0 to 18.0 G	1700	270

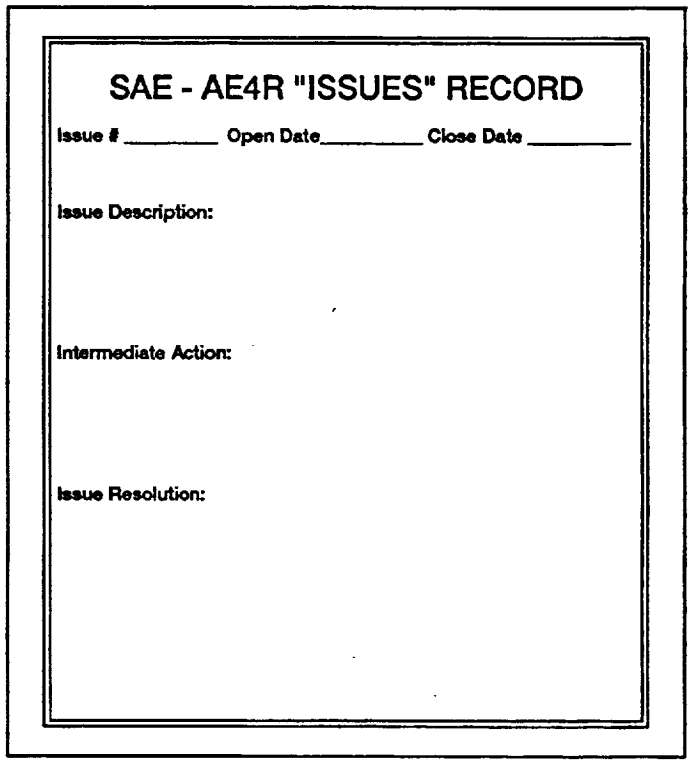

Figure 2.—Issues record form.

Review Comment Request		
Request Number	☐ Users Guide ☐ Advisory circular	
Reviewer's Name	Page_____Section_____ Paragraph_____	Date:
Revise From:		
Revise To:		
Reason for Change:		
Disposition ☐ As Written ☐ As Modified	☐ Request Withdrawn Request Deferred To:	☐ Request Rejected Reason:
Request Dispositioned By: ☐ AE4R Subcommittee ☐ Executive Committee		Date:

Figure 3.—Review comment request.

One generally finds a thread of consistency in the independent submittals of each subparagraph, indicating a growing consensus. Lack of consensus indicates that the paragraph is either poorly written or is technically nonviable. In this case, the best comments are chosen as the new draft baseline or the paragraph is deleted. The executive committee, while evaluating the individual comments, must always be mindful that the final draft will not be approved by the membership if comments are treated capriciously.

KEY ISSUES

The committee documented and acted on 65 issues. Those that were greatest in scope include:

- Emitters to be established in Special Use Areas (SUA)
- Probablistic approach to the environment
- FAA/JAA classification of critical versus essential systems
- Test requirements above 1 GHz
- Types of modulation in the same band
- Pulse versus average field level testing
- Environment assumptions—near field/ far field
- Fuselage attenuation
- Receiver in-band response

The issue of receiver in-band response was resolved by suggesting to the RTCA that receiver antenna inputs be excluded from the requirements within its passband and documented as such in the Minimal Operational Performance Standard (MOPS). As can be seen, the AE4R committee necessitated interactive cooperation with organizations outside the SAE, but within influential control of the airworthiness authorities.

Not all issues resulted in acceptance, perhaps most notably a "probablistic approach" to establishing the environment. The issue was first presented in the "open forum" with action requested by Panel 1 (environments). Over the course of three meetings, advocates presented substantiation of the approach. However, Panel 1 could not support the concept and a full committee vote concurred, closing the issue.

THE REVIEW PROCESS

Prior to balloting of draft 13 as the final committee report, the draft was sent to all committee members along with the review comment form. A total of 250 comments were received. The comments were divided into specific and general categories and further sorted by paragraph and sentence. The Executive Committee met for a week to evaluate each comment with 40 approved as written, 109 modified (or combined with others), 82 rejected as overtaken by previous events, 4 withdrawn, and 31 deferred (mostly Appendix II definitions, handled separately). Another 24 general comments outside the change from/to format were read and factored into the review process. The balloted draft was accepted by the majority. This draft committee report, forwarded to the FAA also is the basis for SAE Aerospace Resource Document ARD50040 [6] recently filed with SAE Headquarters. It should be noted that a complete set of comments was sent to the FAA for reference, anticipating that another round of reviews would be part of the Notice of Proposed Rules Making (NPRM) process.

RECOMMENDATIONS

All standards face obsolescence in the face of advancing technology. However, a strong recommendation was made that government authorities consider regulation of the field strengths of future emitters. This is particularly important in the vicinity of airports. Without some controls on the electromagnetic environment, recertification to higher HIRF levels for in-service aircraft becomes an issue.

LIMITATION OF THE PROPOSED STANDARD

The proposed standard is based on the best technical rationale at the time of its release. All approaches to certification leave open the option to adopt alternative schemes of compliance provided they are derived from the appropriate external environments.

The committee worked diligently in an effort to gain consensus on the issues of the critical/essential system definitions. However, consensus could not be achieved

because of the diversity of application of electronic technologies. Rather than distort the environmental definitions or the routes to compliance, it was decided to allow the user of the document some latitude in negotiating the plan for certification with the cognizant authority [7].

CONCLUSION

The conclusion from this committee's effort is that resolution of difficult technical standards challenges can be met on schedule by using management methods that promote out-of-meeting productivity. These methods are particularly helpful and even necessary when opinions become highly polarized in a diverse group, and consensus seems impossible to achieve. The work of AE4R over the past 4-1/2 years with 15 meetings has been a model for international cooperation in the development of EMC standards for a global market.

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