IN-SITU TESTING OF AIRCRAFT AND SATELLITES USING A TRANSPORTABLE REVERBERATION CHAMBER

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ABSTRACT:
A transportable reverberation chamber with vibrating walls to create high field strength has been developed, called Vibrating Intrinsic Reverberation Chamber (VIRC). It creates a statistically uniform electromagnetic field without the use of a rotating mode stirrer, resulting in a better homogeneity compared to conventional reverberation chambers. The VIRC can be used for high field strength EMI and HIRF testing, or for transfer measurements from outside to the cabin or flight deck. The VIRC creates an isotropic, uniform field so it can be used for finding the weakest spots in a system, because all objects are illuminated in all directions.

I. INTRODUCTION

A reverberation chamber generally consists of a rectangular test room with metal walls and one or two mode stirrer(s), usually in the form of a large paddle, near the ceiling of the chamber [1,2], as shown in Figure 1.

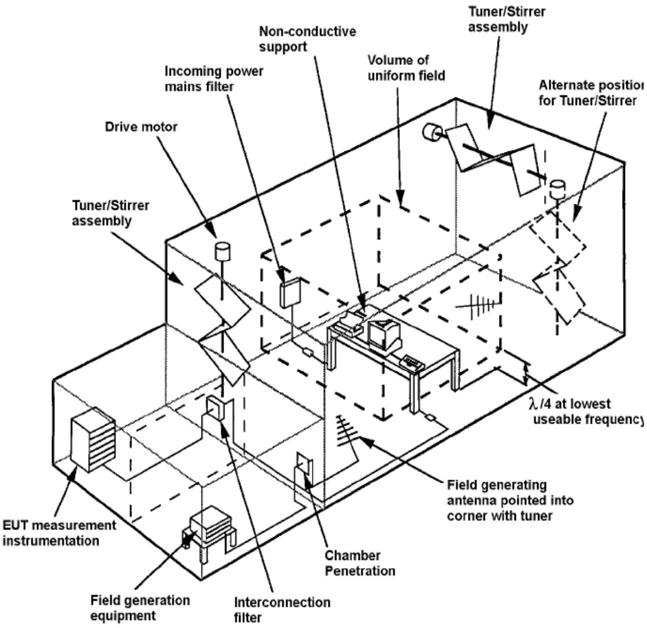

Figure 1: The reverberation chamber as described in IEC-61000-4-21

The equipment under test (EUT) is placed in the chamber and exposed to an electromagnetic field while the stirrer slowly revolves. By changing all angles of the wall-floor-ceiling of a reverberation room in a high velocity compared to the classic mode stirrer in mode stirred reverberation chambers we can use all beneficial effects. This technique is called Vibrating Intrinsic Reverberation Chamber (VIRC) [3,4]. The VIRC is a reverberation chamber where the walls are made of flexible conducting material. It is mounted in a rigid structure and connected to that structure via flexible rubber strings, as shown in Figure 2. By moving one or more ridges or one or more walls the modal structure inside the chamber is changed. Because the frequency shift is much larger compared to what is possible with a conventional mode stirrer, the frequency range of the chamber is extended to lower frequencies compared to conventional (mode stirred) reverberation chambers with equal dimensions. Note the natural corrugation of the flexible walls in Figure 2 which is beneficial for the spatial uniformity too. Another advantage is that the flexible chamber can be erected inside a standard anechoic chamber where the EUT has been installed for standard EMI tests. Furthermore the VIRC does not need extra space inside the laboratory: it can be folded and put away fast. The most important advantage of the flexible structure of the VIRC is that it can be installed in-situ.

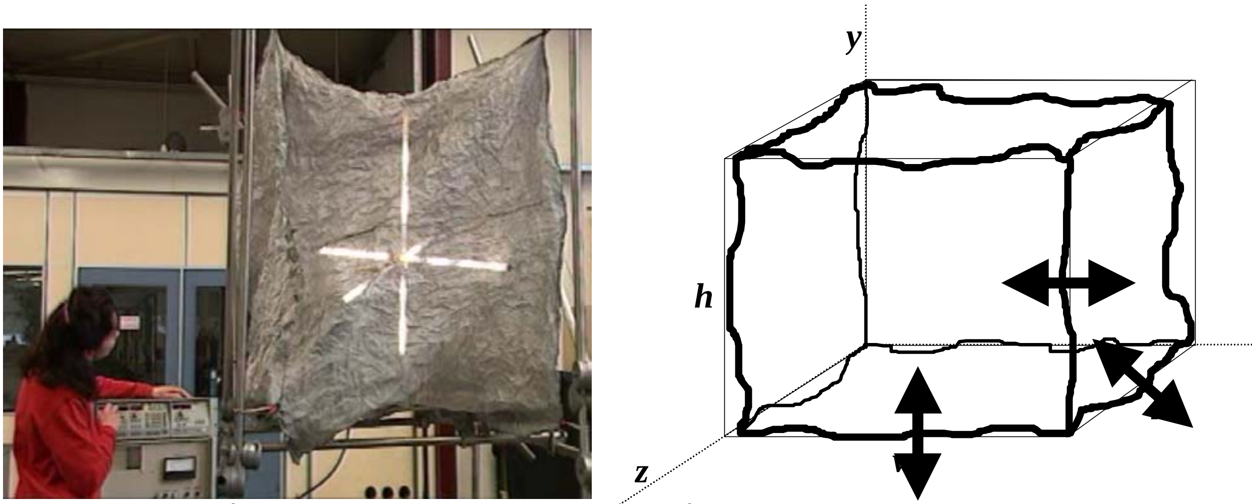

Figure 2: The VIRC: a flexible tent with irregularly shaped walls. The field is stirred by moving the walls

II. SHAKEN OR STIRRED

The conventional chamber makes use of a stirrer or tuner. If the stirrer is rotated continuously, we call it a mode stirred chamber. In this case the field variation is fast. The mode tuned technique makes use of a stepper motor for rotating the tuner to a next position. In this case, the field is stable for some time. This type of reverberation chamber is called mode tuned reverberation chamber. The mode stirred is much faster in measuring than the mode tuned, but for some applications where the equipment under test has a long dwell time the mode tuned is preferred.

For these cases we can use the Tunable Intrinsic Reverberation Chamber (TIRC). It is a VIRC but the walls are <u>not</u> moving or vibrating continuously. The walls can be moved using a stepper motor, or the modes can be changed using a conventional paddle wheel driven by a stepper motor. The fields can therefore be mode tuned in a TIRC, instead of mode stirred in a VIRC. A picture of a prototype is given in Figure 3.

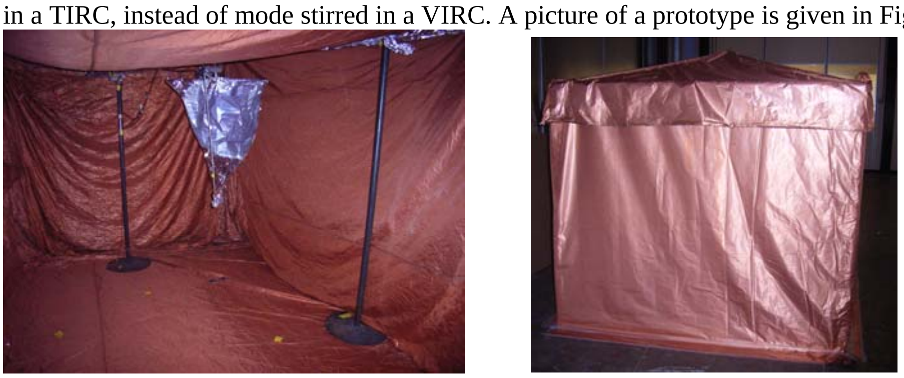
Figure 3: A Tuneable Intrinsic Reverberation Chamber,right outside, right inside

III. IN-SITU TESTING USING A VIRC

A VIRC has been designed and built for in-situ testing of an active phased array antenna. Pictures of this VIRC are shown in Figure 4. The dimensions of this VIRC are 5x3x3m, resulting in a first resonance frequency of 58 MHz. The VIRC was fabricated by a tent manufacturer from the basic material we supplied. The walls were made from metalised (copper) fabric. The seams were overlapping, using double stitch. The interface with the EUT was made via a circumferencial galvanic connection, as shown in Figure 4.

All cable feedthroughs are either a waveguide-beyond-cutoff penetration for non-conducting parts, or a circumferencial electrical connection for all conducting parts, such as cables. The vibration has been created by using automobile wiper motors with an excentric arm which is connected to the VIRC by means of an elastic rope. The VIRC has been validated before actual EMI test were performed. Details can be found in the references. An important parameter is the spatial field uniformity (SFU). The SFU gives the ability to generate an isotropic, randomly polarised field, which is stochastic equal in the whole volume of the chamber, except near the walls. In Figure 5 the vectorial sum of the magnitude of the field strength in the three orthogonal directions, with respect to the mean field strength, per measuring position has been drawn as function of the frequency. From this figure we can conclude that the field strength is within the 0-6dB range for frequencies higher than 150 MHz. Other equipment has been tested. Some products are shown hereafter (no details in paper)

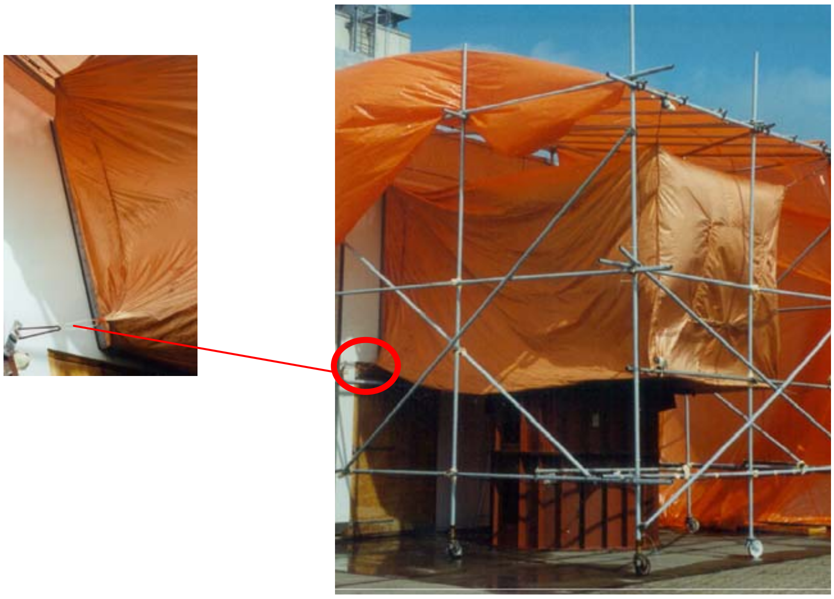

Figure 4: The VIRC as built for in-situ testing

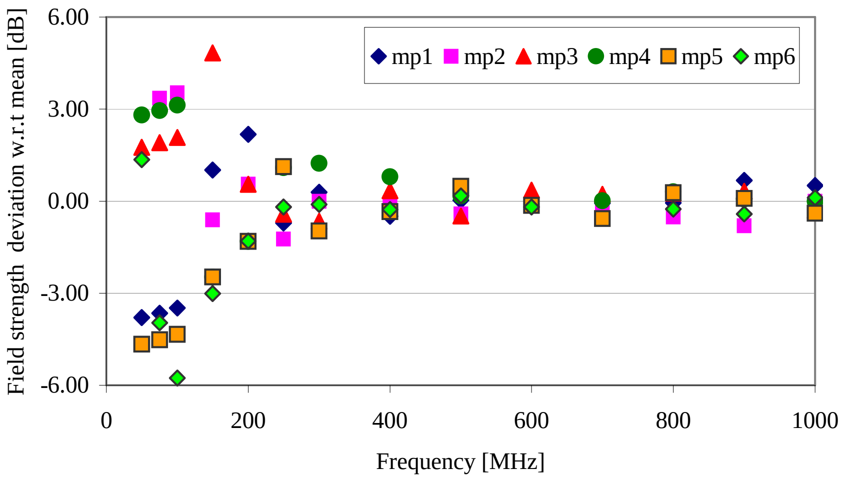

Figure 5: Field uniformity, 6 measuring positions

Figure 6: CEO Thales in VIRC, with a radar system

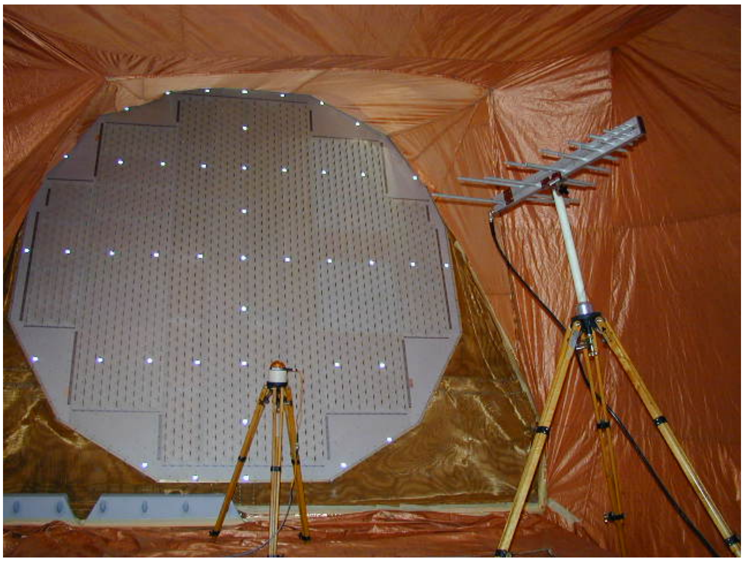

Figure 7: Another radar system in a VIRC

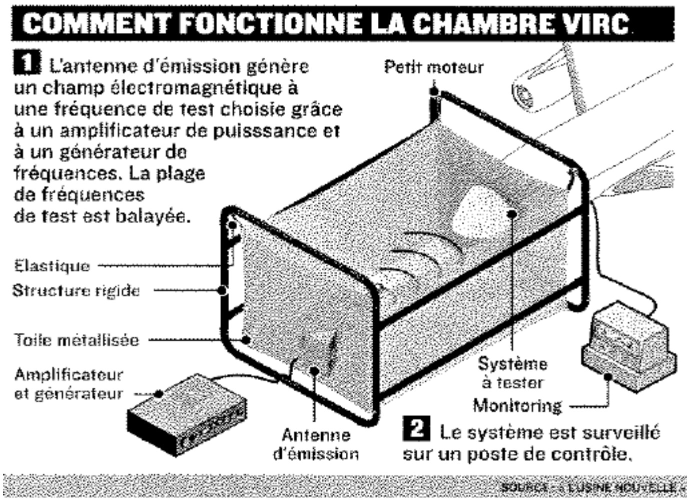

Figure 8: From Usine Nouvelle [5]

IV. HOW TO BUILD A VIBRATING OR TUNABLE REVERBERATION CHAMBER

A reverberation chamber can be built easily. The basic material can be bought from several suppliers. We used Shieldex Kassel from Statex in Germany. The costs are approximately €35,- per square meter. The VIRC (we often say 'tent') is sewed together by a regular tent manufacturer. The best ratio for length, width and depth is 5x4x3 m (or 9x8x7 m). These figures are less dividable which results in a better field homogeneity at low frequencies. Considering a 5x4x3 m tent, you need 94 m^2. Total costs will be approximately € 5000,-.

The tent is hung via elastic ropes in a construction. This can be basic construction worker scaffolding. Experience showed that only 2 corners have to be moved. And if the experiments are performed outside, the wind (in The Netherlands) is sufficient to create sufficient movements of the tent.

The VIRC is calibrated according the basic procedures described in the IEC 61000-4-21 standard. This means performing a lot of measurements and combining the results in such a way that a probability density curve can be created.

In practice you are interested in the differences with respect to a conventional test setup. Therefore two antennas are placed in front of each other in a free space environment (open area, or full anechoic room), and a two-port measurement is performed. Then the same setup is moved to the VIRC and the measurement is repeated. Then the test equipment should be in max-hold with a measurement time larger than the movement of the VIRC. This is in practice less than several 10ms. The difference between the two measurements is the chamber gain. When performing emission measurements this chamber gain should be subtracted from the measured level in order to obtain the free space values.

The VIRC has been used to test several complex systems. The VIRC is in daily use for performing transfer ration measurements on gaskets, seals, hatches, feedthroughs etc. Other interesting applications of reverberation chamber technique for inside an aircraft are:

- absorption (people) measurements in cabin, using the cabin as RC
- coverage of wireless systems (used for video streaming), and understanding and simulating multiple reflections, by using the RC technique
- effect on MIMO systems in these semi-enclosed environments

IV. CONCLUSION

The flexible reverberation chamber (VIRC) creates a spatial uniform and isotropic electromagnetic field. The extremely high field strength which can be generated is very useful, but the main advantage is that EMI measurements can be performed in-situ. The increased dynamic range for emission testing is also beneficial. Other applications involve coupling testing or transfer ratio measurements: penetration of EM fields from outside to the fuselage on an aircraft.

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