TECHNICAL DEVELOPMENT REPORT NO. 231

TEST OF USKON CLOTH TO REDUCE VOR COURSE SCALLOPING

FOR LIMITED DISTRIBUTION

by

Arthur E. Frederick

Electronics Division

March 1954

CIVIL AERONAUTICS ADMINISTRATION
TECHNICAL DEVELOPMENT
AND EVALUATION CENTER
INDIANAPOLIS, INDIANA

TEST OF USKON CLOTH TO REDUCE VOR COURSE SCALLOPING

INTRODUCTION

This report presents the results of an investigation regarding the use of Uskon cloth to reduce VOR course scalloping. Information furnished by Region One concerning the investigation conducted on the Salisbury, Maryland, VOR to reduce the course scalloping disclosed the following: excessive scalloping between the 40° and 60° radials prevented commissioning the facility. A preliminary survey was made in November 1952 by Mr. R. B. Gilroy of Region One to ascertain the cause of the excessive course scalloping in the northeast quadrant. This preliminary survey eliminated the VOR and its associated equipment as the direct cause of the course scalloping. A second investigation was conducted by Mr. Gilroy during January 1953, which narrowed the possible causes of course scalloping to the south and east faces of the Administration Building. The Administration Building is located on a 312° radial, 1200 feet from the VOR. To reduce the scalloping, a strip of Uskon cloth, 4 by 5 feet, was placed on the outside of the VOR antenna shelter in a direct line with the reflecting object and equally spaced above and below the antenna surfaces. It was assumed that the Uskon cloth would attenuate the energy to the reflecting surface which in turn would reduce the course scalloping. Difficulty was experienced because the Uskon cloth, in the vicinity of the VOR antenna, upset the nulls and phasing of the VOR thereby producing bearing errors of large magnitudes. The size of the Uskon cloth strip was reduced until a strip 12 by 22 inches had little effect on the station but produced the desired results. Flight recordings taken with and without the Uskon cloth in position, were forwarded to this Center to substantiate their results.

FIELD AND FLIGHT TESTS

The Technical Development and Evaluation Center ordered a quantity of Uskon cloth to evaluate the findings of Region One. A four-loop VOR system with polarizer was used for this evaluation. The antenna array was placed on a nine-foot diameter counterpoise eight inches above the ground. A screen 150 feet long and 25 feet high, consisting of No. 12 copperweld wires spaced 16 inches apart, was used as the reflecting surface. The reflecting surface was placed approximately 600 feet from the VOR antenna to produce maximum scalloping at a bearing of 46°.

A field strength reading was made at one end of the reflecting screen using a Stoddart Model NMA-5 radio field intensity meter. The receiving antennas were placed 12 feet, 24 feet, and 48 feet above ground. The field strength measurements served as a reference to determine the effect of the Uskon cloth.

A 40-inch square of Uskon cloth was taped to the inside of the antenna shelter as prescribed by Region One. A field strength measurement failed to reveal any change in field intensity at the reflecting surface. A strip of Uskon cloth 40 by 72 inches was installed in place of the 40-inch square of cloth. A second set of field intensity measurements were the same as the first. The 40 by 72-inch strip of Uskon cloth was then suspended from the top of the antenna shelter in a vertical plane 9-3/4 inches from the antenna array. A measurement of field intensity at the reflecting surface indicated a 22 per cent reduction in field strength. The Uskon cloth, remaining in a vertical plane, was then moved horizontally 18 inches from the antennas. The field intensity at the reflecting screen was the same as the original measurement without Uskon cloth.

To substantiate these measurements, the Uskon cloth was removed and a flight check was made. The aircraft flew a circular course of six-mile radius through the scalloped sector. The scalloping amplitude and frequency were recorded. Then the 40-inch square of Uskon cloth was taped inside the antenna shelter in the manner prescribed by the First Region. A second six-mile circular path was flown to record the scalloping frequency and amplitude. The scalloping frequency was the same in both recordings. The scalloping amplitude changed slightly from 6.0° to 5.8° which essentially confirmed the field intensity measurements.

The next set of tests considered the possibility of the Uskon cloth producing omnibearing changes. An instrument truck, equipped with a Collins 51R-2 omnireceiver and associated equipment, was parked about 1,000 feet from the VOR. The 40-inch square of Uskon cloth was placed in position approximately every 50° around the station. At each position the cloth would be taped in place on the outside surface of the antenna shelter. A measurement of the VOR bearing was made at each successive movement of the Uskon cloth. Receiving equipment errors were eliminated by keeping the truck stationary and moving the Uskon cloth about the antenna. The Uskon cloth was reduced in size as each complete revolution was made about the station. The following table shows the maximum error noted for each size of Uskon cloth used:

Size of Uskon Cloth (inches)	Maximum Error (degrees)
40 by 40	5.83°
30 by 30	4.34
20 by 20	2.0
10 by 10	0.36
12 by 22	1.04

The flight recordings of the Salisbury, Maryland, VOR were analyzed. Several discrepancies were noted in these recordings that could be misleading. The equipment used to record the theodolite circles and radial flights was not the same. One aircraft using Bendix receiving equipment measured the condition before Uskon cloth was used and another aircraft using Collins receiving equipment was used to record the results with the 12 by 22-inch piece of Uskon cloth in place. Comparisons of

this type should be made with the same receiver and recording equipment.

It is evident from the recordings supplied that the course deviation indicator (CDI) dampening of the two equipments may not be operating with the same efficiency. The purpose of the dampening is to make the course deviation indicator insensitive to rapid changes in its current. If the aircraft is flying a course such that the scalloping frequency changes through a wide band of frequencies, the course deviation indicators of the two equipments will not see the same magnitude of scalloping error. The greatest magnitude of scalloping error will be observed near, but displaced from, a zero scalloping frequency. As the frequency of the scalloping increases, the wiggle filter dampens the action until no scalloping is observed.

A study of Fig. 21 of Technical Development Report No. 126, entitled, "VHF Omnirange Wave Reflections from Wires" showed the possibility of changes in scalloping by small deviations from a radial flight path. A deviation of 1.5° from a specific radial may produce 100:1 change in scalloping frequency when flying a radial; however, only a minor change in frequency was noted when flying a circle around the station. It was demonstrated at the Center that a series of radial flights using the same aircraft receiver and recording equipment would not agree in scalloping information.

An examination of the Salisbury, Maryland, recordings revealed very little change with or without the Uskon cloth. The course scalloping observed on the theodolite circle with the Uskon cloth in place showed the same or slightly greater scalloping amplitude than the recording without the Uskon cloth. The radial flight with the Uskon cloth in place was much improved over the recording without the Uskon cloth; however, this improvement is nullified by the unreliability of a radial recording. The same improvement is possible by making two consecutive radial flights without any changes in the station.

CONCLUSIONS

After a careful study of the Salisbury, Maryland, data and further tests conducted at this Center, the following conclusions have been made:

1. The Uskon cloth did not reduce the field at the reflecting surface and, therefore, it could not reduce the course scalloping amplitude.

2. The 12 by 22-inch strip of Uskon cloth is capable of producing an omnibearing error of approximately one degree measured at TDEC.

3. The recorded conditions and implied improvements of course scalloping cannot be placed in direct comparison when the recordings were taken with two separate aircrafts and their equipment at two different times.

4. A radial flight check is not a reliable means of measuring course scalloping improvements.

Numerous tests have been conducted at TDEC to determine methods of reducing the field intensity at the reflecting surface without producing additional bearing errors at other azimuths. This approach has been only partially successful. The most successful method to date has been to deflect the energy at the reflecting surface in a vertical direction by the use of a sloped screen.