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SIGNAL-TO-NOISE-RATIO CONDITIONS
AT AMCHITKA, ALASKA

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The signal-to-noise-ratio (SNR) out-of-tolerance condition at Amchitka was analyzed. The issue was raised in a letter sent to National Resource Specialist, ANM-104N by Lyle Wink of AVN-240. The letter states that AVN-240 is concerned about certifying the approach into Amchitka, because the SNR may be below the -6 decibel (dB) limit for Loran C station Port Clarence during certain times of the day. AVN-240 has asked AWS-100 for a waiver on the SNR issue so that they can authorize the issuance of the special instrument approach procedure. In addition, they have requested a new certification tolerance for SNR which will be provided to Anchorage FIFO for future periodic inspections.

The information causing AVN-240 concern was derived from an ACT-140 report CT-140-87-15 titled "Loran C Analysis Of Amchitka, Alaska". The report presented SNR values based on both predicted signal conditions at Amchitka using a Loran C propagation model and limited data measured by Reeves Aleutian Airways (RAA) at Amchitka. Reeves Aleutian Airways used an Advanced Navigation Incorporated ANI-7000 Loran C receiver to collect the data. The analysis showed a one time measurement for SNR of -8 dB using measured field strength and measured atmospheric noise. This measurement technique has been labeled SNR field strength (SNR(FS)). SNR determined from the phase tracking loops (SNR(PH)) was +6 dB. Atmospheric noise during these measurements was 58 dB per microvolt per meter (dB/ μ V/m). The measured field strength was 50 dB/ μ V/m. RAA also supplied atmospheric noise measurements recorded by the same receiver over a 24 hour period. The noise varied from a low of 49 dB/ μ V/m to a high of 62 dB/ μ V/m. If SNR(FS) is calculated using the largest noise value measured over the 24 hour period and the field strength is assumed to be constant, the SNR would be -12 dB as stated in the letter. Similarly it would be expected for SNR(PH) to be reduced 4 dB to +2 dB.

Variation of atmospheric noise and therefore SNR during the day is not unique to Amchitka. This condition occurs at all locations. When the SNR is reduced below acceptable limits it affects signal availability and not necessarily integrity. If signal availability is close to 100 percent, the pilot will seldom have to conduct a missed approach. If the increased noise period is long in duration, the pilot will not be able to conduct an approach into the airport and will be required to land at an alternate airport. If the increased noise level is temporary, like when caused by P-stat, the noise may be reduced by the time the pilot tries to conduct a second approach. At some airports the signal availability will be so low that it should not be considered for IFR conditions. When signal availability is low, it will mean conducting a missed approach and flight to an alternate airport most of the time.

Before addressing the issue of a waiver or new certification tolerances for SNR, the effect of SNR on Loran C receiver performance must be addressed. SNR affects a receiver's ability to acquire on the correct cycle, to detect station outage or blink in a certain period of time, and to some extent the magnitude of position error. The SNR value required for a Loran C receiver to acquire on the correct cycle is higher than to track the signal. Typical limits for tracking are -14 dB to -22 dB. As SNR is decreased the amount of time required for a receiver to detect station outage or blink increases. Detection time criteria of 10 seconds for blink and 15 seconds for loss of signal have been established for nonprecision approaches.

Loran C receivers will be required to meet the detection times and properly acquire in the approach mode, at a -6 dB SNR. This value seems to be within the

not position dependent and is repeatable from day to day.

For flight inspection, measurement of SNR must be as independent as possible from a particular Loran C receiver but still be a good measurement. SNR(FS) is a method to make generic measurements which are definable. Each manufacturer may improve the signal quality for its receiver by implementing clipping or limiting features, filtering, or other special techniques. These techniques will help the receiver operate in lower SNR conditions. The phase tracking loops of a Loran C receiver are the part of the total receiver which measures the Loran C environment. Signal quality measurements obtained from the phase tracking loops are good indicators of how the receiver perceives the signal environment. It will also include any improvements in signal quality that have been derived from special signal enhancement techniques. Caution should be used when relating signal quality obtained from one Loran C receiver model to another because of the differences in special signal enhancement techniques.

The approaches being considered at Amchitka are unique in that the receiver scheduled to be used by RAA for flight guidance is the same model being used to collect the data both by RAA and the FAA. This condition means that SNR(PH) is a more meaningful measurement to use in determining signal adequacy. Therefore, SNR(PH) values measured at Amchitka have more significance to the quality of the Loran C environment than do SNR(FS) measurements for the ANI-7000 receiver. Measured SNR(PH) in figure 2 shows that SNR(PH) was 0 dB or greater for the entire day. A limit of 0 dB for SNR(PH) has been established as acceptable for the limited implementation program. The SNR(PH) limit is applied only if SNR(FS) is below -6 dB. The difference in SNR limits was designed to compensate for the signal enhancement techniques in the ANI-7000 receiver that are included in the SNR(PH) measurements. The approach at Amchitka does in fact meet the criteria for SNR(PH) 24 hours a day.

Caution must be used when evaluating atmospheric noise and field strengths measured by different receivers. Different receivers and installations will exhibit different receiver gains. Different receiver gains will cause the absolute values of measured noise and field strengths to vary if not taken into account. For example field strength measured from Loran station Port Clarence by RAA on April 9, 1987 was 50 dB/ μ V/m. FAATC measured values June 1987 for receiver #1 was 44 dB/ μ V/m and receiver #2 was 40 dB/ μ V/m. Similar differences were obtained for atmospheric noise. SNR(FS) and SNR(PH) measurements are not affected by receiver gain. The calculation of SNR(FS) must use atmospheric noise and field strength measurements from the same receiver unless all measurements have been corrected for receiver gain.

Lowering of the SNR limits at Amchitka should not be considered. Flight checking of the approach by FAATC indicates that SNR(FS) values above -6 dB and SNR(PH) values above 0 dB are achievable. SNR(PH) values above 0 dB should exist most of the time. A check of SNR conditions can be made prior to the approach. SNR information is readily available from the ANI-7000. The pilot would be required to verify SNR values for the weakest station was acceptable prior to making the approach. This method would be similar to the requirements being established for the general public implementation of Loran C approaches. The requirement is for the receiver to raise a flag if the SNR is below -6 dB during an approach. A difference in the methods is that in final implementation the receiver will automatically raise a flag while at Amchitka the process will be pilot initiated. No decrease in safety should result from this method.

current state-of-the-art and is the value currently proposed for the Technical Standard Order (TSO). Low SNR values may also cause the receiver's position to contain more position error due to noisier TD measurements or system lags. This effect has been observed on one particular receiver when the GDOP was high. Protection from poor receiver operation due to low SNR conditions will be provided by the airborne Loran C receiver according to the requirements of the TSO. When SNR values are below -6 dB the receiver shall raise a flag and the pilot must execute a missed approach. The decision as to when the pilot must fly to an alternate airport is not clearly defined. The TSO requirements were created to produce a receiver that could support nonprecision approaches without operational integrity checks.

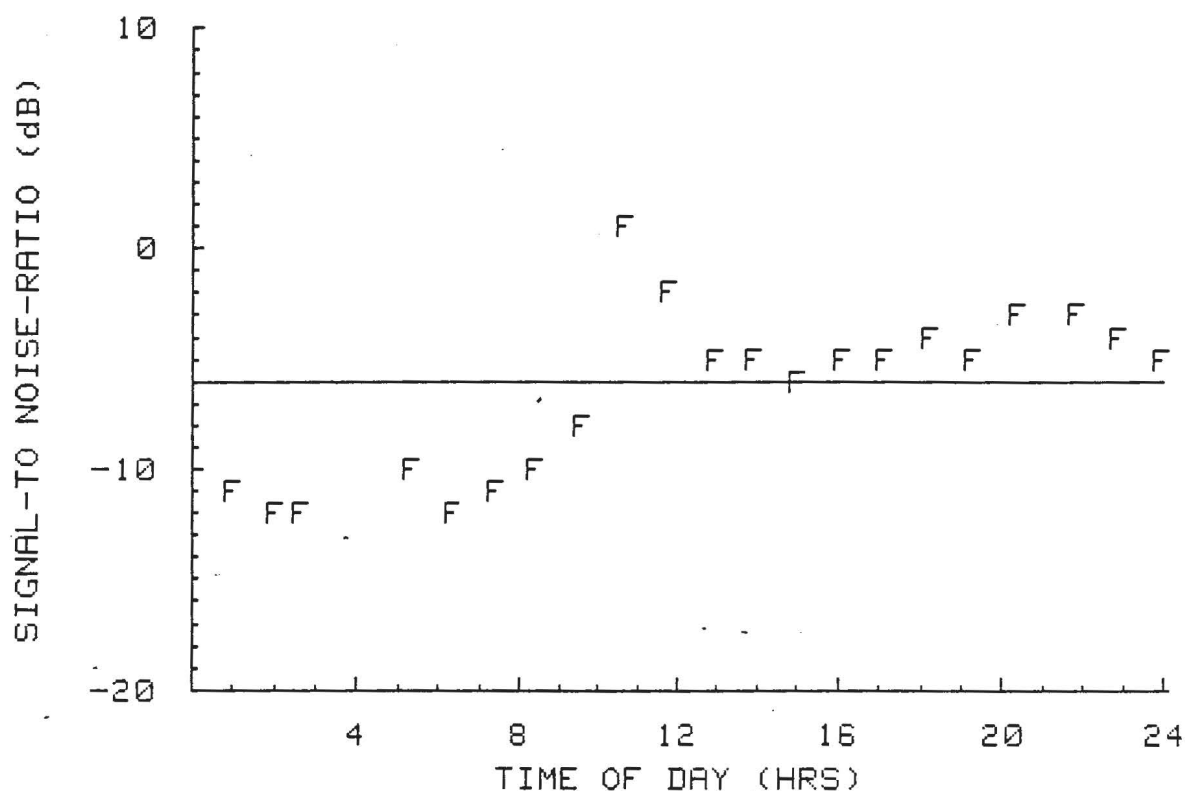
The ANI-7000 receiver used by RAA was not required to meet the criteria contained in the new TSO. Special operational requirements have been added to the aircraft operations specification when conducting Loran C approaches into Amchitka. These additions were necessary to compensate for the receiver not being required to meet the criteria of the new TSO. An operational integrity check, using a Z marker located at Amchitka is required as part of the approach. The Z marker is designed to insure that the receiver is tracking the correct cycle and that the area calibration values are correct. Flight tests by the FAA Technical Center have shown that the ANI-7000 receiver has navigation equipment errors exceeding the requirements of Advisory Circular (AC) 90-45A when making approaches into Amchitka. Similar results were obtained using an AVN flight check aircraft. As allowed in AC 90-45A, flight technical error was modified to compensate for the larger navigation equipment error. To meet the requirements for total system cross track error the flight technical error had to be reduced to 0.28 nmi (95%). In order to meet this operational requirement, the approach must be flown using an autopilot.

The marginal SNR conditions pointed out by AVN-240 do not necessarily mean the approach should not be approved. Results of flight tests conducted by the FAA Technical Center (FAATC) at Amchitka were reported in "Loran C Analysis Of Amchitka, Alaska (Flight Tests)," report CT-140-87-21. The report states SNR(FS) for the lowest station was -6 dB. SNR(PH) for the lowest station was -1 dB. These values were averages for many samples. Atmospheric noise varied from 42 dB/ μ V/m to 49 dB/ μ V/m over the test period. The FAATC data and RAA data show that for certain times of the day the SNR is marginally acceptable.

To investigate the duration of acceptable SNR conditions, measured atmospheric noise for a 24 hour period was used to calculate SNR. Figure 1 shows SNR(FS) data for Loran station Port Clarence for one 24 hour period. Loran station Port Clarence has the weakest signals at Amchitka. From 10 AM to midnight the SNR is above -6 dB. The data was obtained from RAA and is documented in CT-140-87-15. The field strength for Port Clarence was assumed to be 50 dB/ μ V/m. This value was measured on April 9, 1937 but is also the average of 11 samples obtained on three different days and three different times of day. The data appears in table 6 of the above report. From midnight to 10 AM the SNR dipped down to -12 dB. Figure 2 shows SNR(PH) for the same 24 hour period. The data for figure 2 was obtained from the same receiver used in figure 1. The figure shows SNR(PH) was at 0 dB or greater for the entire 24 hour period. Figure 3 shows a plot of the atmospheric noise measured by RAA for one 24 hour period. Superimposed on the figure is noise measured by RAA on three different days and locations. These measurements agree within one or two dB of the 24 hour data collected on the fourth day. From the data it can be concluded that the noise is

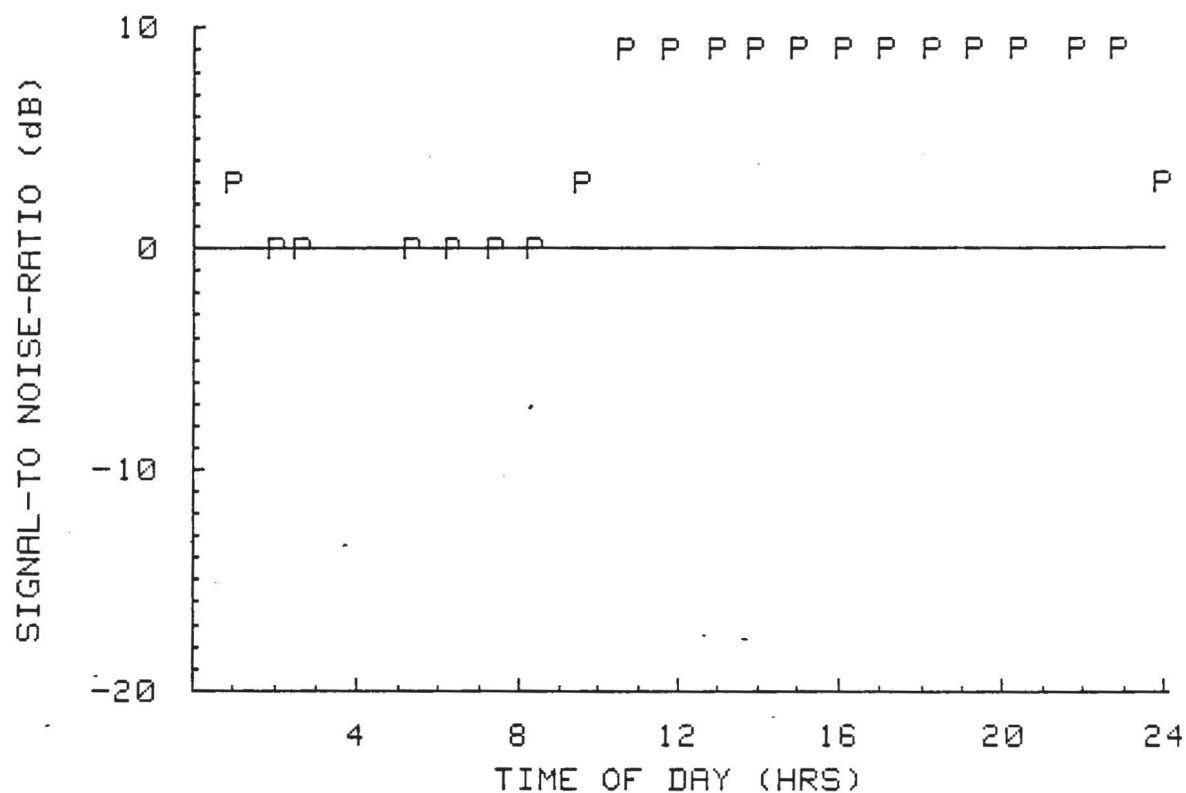
A point which must be remembered is that the approaches into Amchitka have already required changes from the limited implementation requirements and from the expected public use operational requirements. These changes were necessary to accommodate the special conditions found at Amchitka but also to maintain safety. The list includes no local Loran aviation monitor, GDOP greater than 3000 feet per microsecond, no underlying approach, an autocoupled approach to reduce flight technical errors to less than 0.28 nmi (95%) to compensate for navigation cross track errors greater than 0.3 nmi (95%), and an operational integrity check using a Z marker during the approach. The requirement for pilot initiated SNR(PH) verification is one more variation from the limited implementation program.

Based on the above information it is recommended that the approaches into Amchitka be approved provided the pilots are required to check SNR(PH) before making the approach. Data has shown that SNR(PH) remained acceptable for a 24 hour period. Requiring the verification of SNR(PH) before an approach will provide an additional safeguard, but is an additional work load item for the pilots. AWS and AVN must decide if adding one more item to the existing list of variations will have operational significance before issuing final approvals.



LOCATION: AMCHITKA, ALASKA 51N / 179E
DATA FROM REEVES 4/87 USING ANI-7000
FIELD STRENGTH (dB): 50
FAA TECHNICAL CENTER (AMCHS2)

FIG. 1



LOCATION: AMCHITKA, ALASKA 51N / 179E
DATA FROM REEVES 4/87 USING ANI-7000
FIELD STRENGTH (dB): 50
FAR TECHNICAL CENTER (AMCHS2)

FIG. 2.

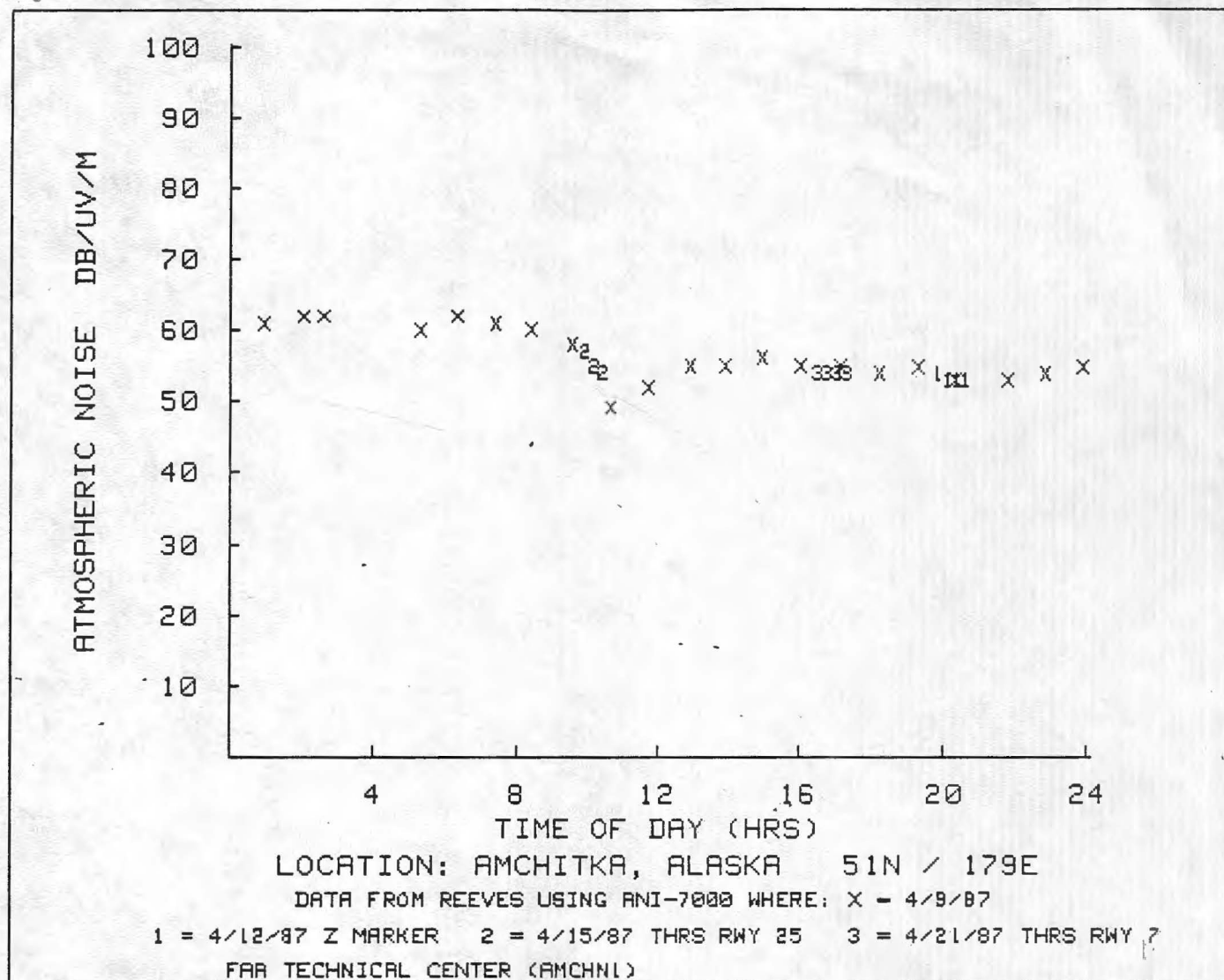


FIG. 3.