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BACKGROUND STATIONARITY OF HIGH RESOLUTION SONAR SYSTEMS.(U)
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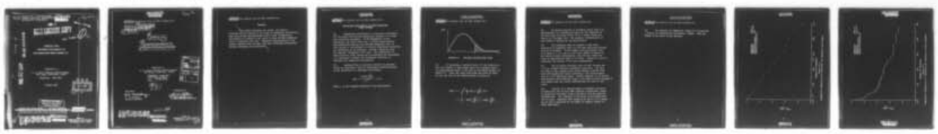

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TECHNICAL NOTE

BACKGROUND STATIONARITY OF HIGH RESOLUTION SONAR SYSTEMS (U)

Submitted to

U. S. Naval Undersea Warfare Center
San Diego, California 92152

Attention: Code D551

8 March 1968

SCIENCES AND SYSTEMS DIVISION • SAN DIEGO LABORATORY

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Approved:

D. V. Holliday
Project Director

Prepared by:

David M. Horton
~~Asst. Project Director~~

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ABSTRACT

This report describes the theory, the applied technique and the results of the study of background stationarity when using large time-bandwidth product sonar transmissions. Stationarity is defined in the theory to mean the RMS background level is invariant with time. Graphical representation of the results indicate that the data does have a Rayleigh distribution thereby confirming the stationarity.

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BACKGROUND STATIONARITY OF HIGH RESOLUTION SONAR SYSTEMS

(C) Background stationarity is a necessary requirement for the proper and accurate operational analysis of a sonar data correlator processor. If the background is non-stationary, the false alarm rate is raised proportionally. Non-stationarity implies that the RMS background level is time variant or the presence of discrete reverberant scatterers are resolvable in the processor, causing a departure from the expected "background only" case. The availability of high resolution sonar system data necessitated the development of a technique to examine the background statistics to determine the background stationarity.

(U) Assuming that a particular interval of processor output is stationary, then its distribution should be given by the definition of a Rayleigh distribution.

$$p(x) = \frac{x \exp\left(-\frac{x^2}{2\sigma^2}\right)}{\sigma^2} \quad , \; x \geq 0$$

Where σ is the standard deviation of the distribution.

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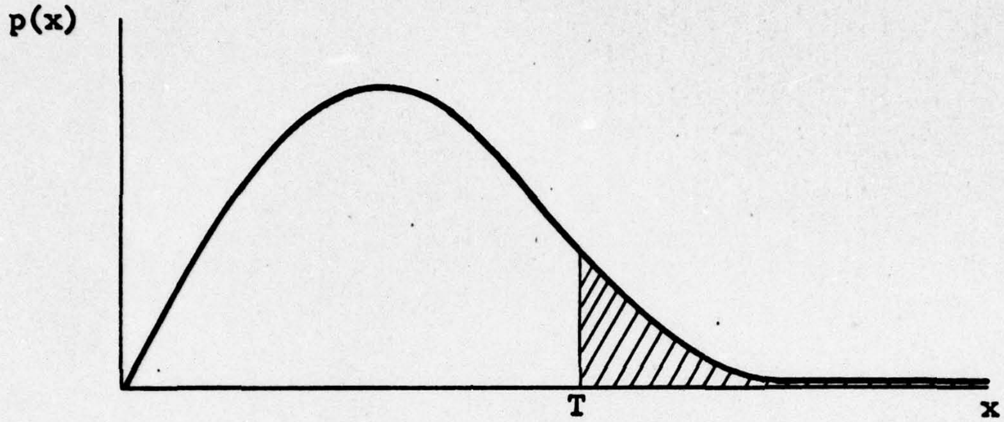

FIGURE B-1. RAYLEIGH DISTRIBUTION CURVE

(U) By selecting a threshold level (T) the fraction of the total number of data points equal to or greater than T are approximately equal to the area of the shaded portion of Figure B-1. Since the total area under the curve is equal to one, the area of the shaded portion is given by:

$$\text{Area} = 1 - \int_0^T \frac{x}{\sigma^2} \exp\left(-\frac{x^2}{2\sigma^2}\right) dx =$$

$$1 - \left(1 - \exp\left(-\frac{T^2}{2\sigma^2}\right)\right) = \exp\left(-\frac{T^2}{2\sigma^2}\right)$$

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(U) By proper selection of threshold levels from 0 to approximately 3σ, plotting the value for the logarithm of the area under the curve versus T^2 on a linear scale will result in a straight line. The physical interpretation of this method as applied to the data follows.

(U) The threshold level is allowed to take equal increments of magnitude from 0 to the peak amplitude obtained from the correlator. If the number of points greater than T or equal to T is n and N is the total number of points in the interval under investigation, then the area under the curve is approximately equal to ln (n/N). Figures B-2 and B-3 illustrate the results of one such investigation.

(C) The correlator processor used in this instance was a 12 bit clipped reference quadrature correlator. The data was from an echo ranging sonar system having a 1000 Hz bandwidth LFM transmitted signal operating in the bottom bounce mode at a 40° depression angle. Several segments of the bottom reverberation from different pings in the same run were analyzed in this manner with the results substantially the same as that shown.

(C) Analysis of a limited number of segments of bottom reverberation from Station MIKE indicate no measurable change of quadrature correlator output statistics from the expected Rayleigh form. The linearity of the curve is maintained past the 3σ value. Departure from linearity in the 4σ to 5σ region can be easily explained by the number of samples treated at those amplitudes.

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(U) For purposes of comparison, Figure B-3 illustrates a section of reverberation containing a signal. Note the change in the scale of the abscissa.

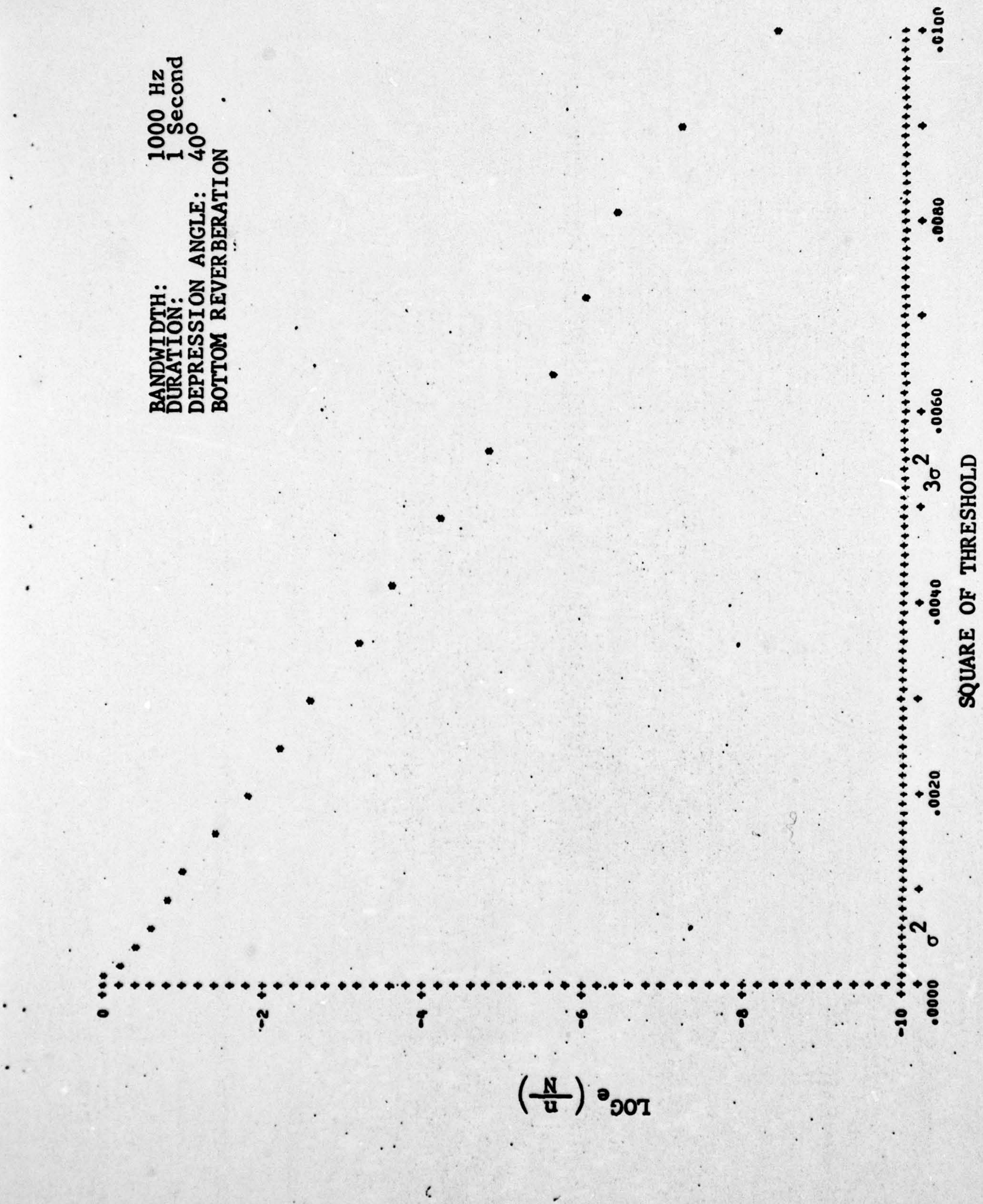

Figure B-2

CUMULATIVE PROBABILITY OF EXCEEDING THE THRESHOLD (NO SIGNAL)

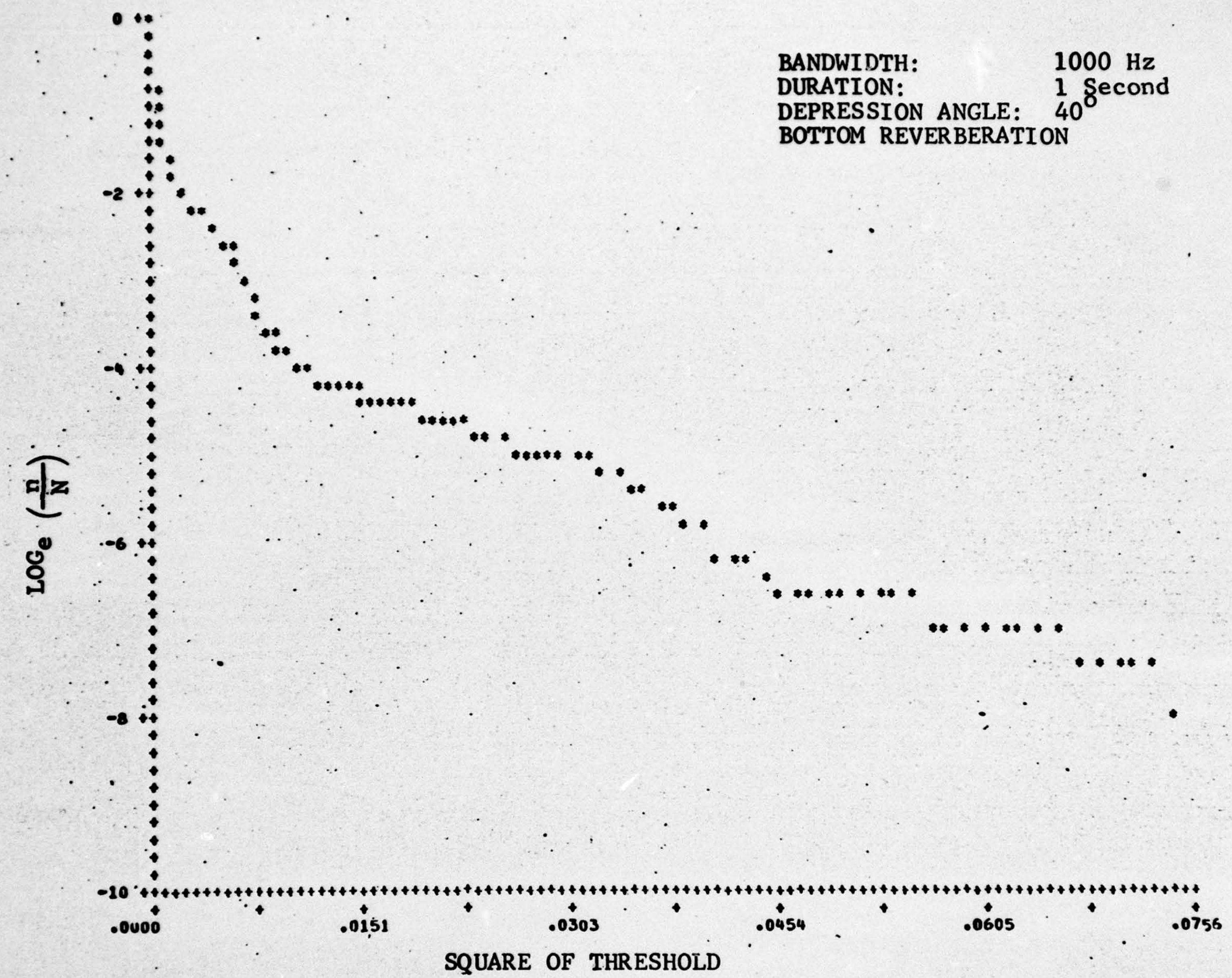

Figure B-3

CUMULATIVE PROBABILITY OF EXCEEDING THE THRESHOLD (SIGNAL PRESENT)