10. MESSAGE FORMATS

10.1 Radar Data Formats. This section specifies message formats and contents for communication between radar sites and the Alaskan ROCC.

10.1.1 Radar to ROCC Digital Radar Messages. Digital radar messages transmitted from the radars to the ROCC shall be in accordance with Interface Control Document ESD ICD 2433-968-1.

10.1.1.1 Radar Message Content. The content of each item in the message format shall conform to the description, bit location and value listed in Interface Control Document ESD ICD 2433-968-1.

10.1.2 ROCC to Radar Request Messages. At present, data requests from the ROCC to the radar are limited to MODE 4 interrogation requests which will utilize the format and message content in accordance with Interface Control Document ESD ICD 2433-968-1. The present configuration will be so arranged that only one channel (No. 2) will carry the data from the ROCC to the radar.

20. CLUTTER MODEL

The clutter model specified herein is to be used for analysis and simulation of the SEEK IGLOO radar environment. It is the basis for performance calculations in response to the specified system performance characteristics in 3.2.1, and it will be used in the evaluation of proposals and subsequent designs. Amplitude and spectral characteristics of clutter are modeled in four major categories: terrain, sea, weather and birds. Models are applicable to both L-band (1.3 GHz nominal frequency) and S-band (3.0 GHz nominal frequency), except where otherwise indicated. Although data are presented to ranges of only 100 nmi, the Alaskan clutter environment will require clutter processing implemented to 140 nmi.

20.1 Terrain Clutter. The amplitude of terrain echoes is characterized by the scattering coefficient σ_o, which is the ratio of the radar cross section (RCS) of a clutter patch to its illuminated area:

$$\sigma_o = RCS/A \tag{1}$$

The illuminated area is given by:

$$A = R\theta_\beta c \tau/2 \tag{2}$$

where R is the radar range to the clutter patch, θ_β is the 3 dB two-way azimuthal beamwidth of the radar, c is the speed of light, and τ is the radar pulse length.

Three modeled amplitude distribution functions (regions) for terrain clutter are provided in Figure 15. The amplitude distributions are given by:

$$P \left[\sigma_c^o \leq \sigma^o \right] = 1 - \exp \left[-\ln 2 \left(\sigma^o/\sigma_m^o \right)^b \right] \tag{3}$$

Equation (3) gives the cumulative probability that the scattering coefficient of the clutter does not exceed the value σ^o. The value of the parameters, σ_m^o and b for the three regions are:

Region I : $\sigma_m^o = 3.249\times10^{-3}$ ($-24.88 dB/m^2$) ; b = 0.6094

Region II : $\sigma_m^o = 7.806\times10^{-4}$ ($-31.08 dB/m^2$) ; b = 0.3245

Region III : $\sigma_m^o = 2.466\times10^{-4}$ ($-36.08 dB/m^2$) ; b = 0.3609

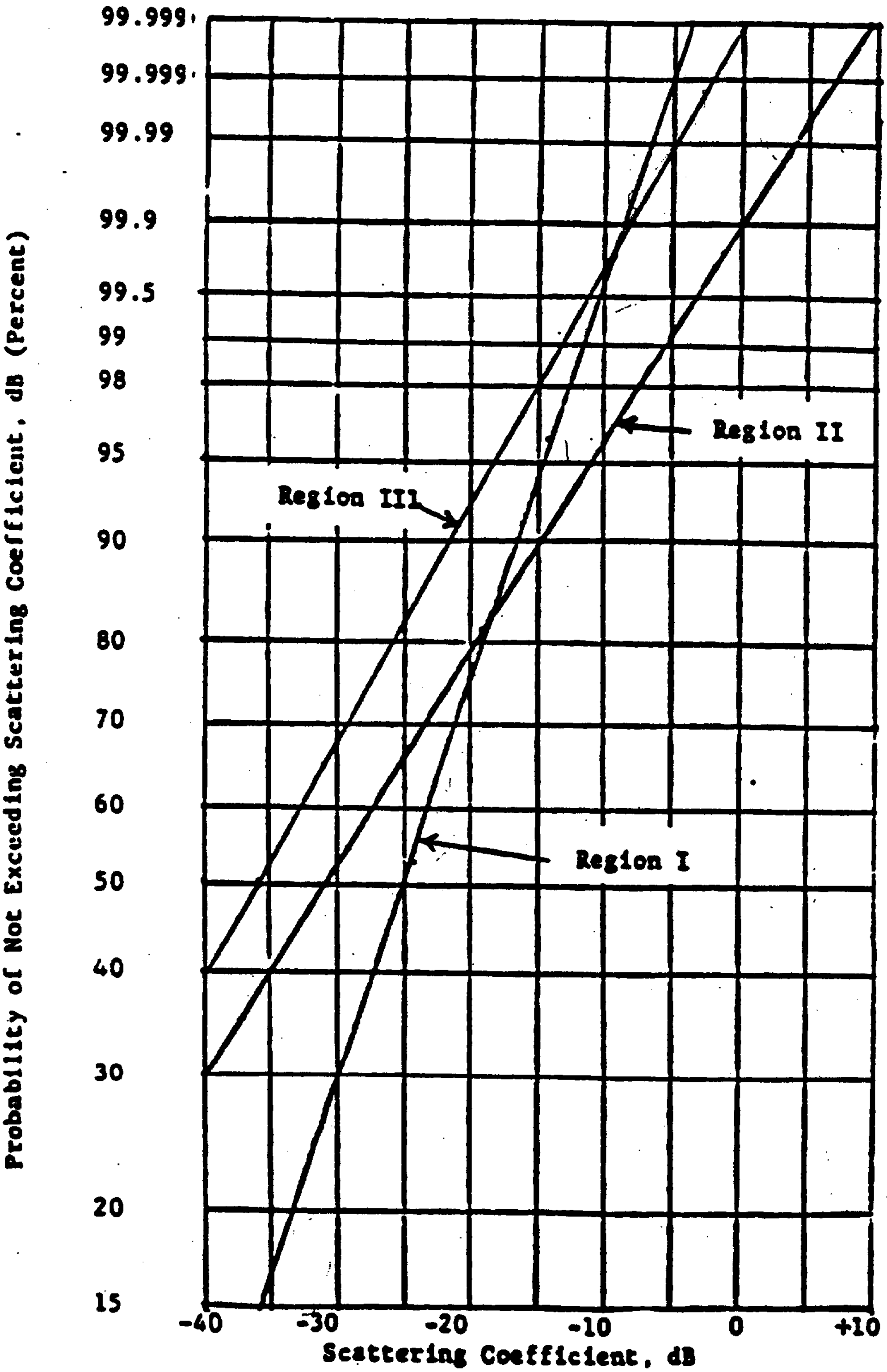

Figure 15. Amplitude Distribution Functions, Terrian Clutter-Weilbull* Fit

*Boothe, R.R., 1969, "The Weilbull Distribution Applied to the Ground Clutter Backscatter Coeffiecient", U.S. Army Missile Command, Report Number RE-TR-69, AD691109.

These distribution functions were derived from clutter measurements in Alaska.* The clutter should be considered to be heterogeneously distributed spatially, as can be expected at the actual sites. That is, areas of intense clutter often occur near shadowed or low clutter areas. Terrain clutter must be characterized by its echo spectrum as well as its amplitude. The two modeled double-sided power spectral densities of terrain clutter echoes are:

$$\text{Mountains:}\quad P(v) = 0.964\,\delta(v) + \frac{0.705}{1 + (v/.023)^{4}} \qquad (4)$$

$$\text{Valleys/Muskeg:}\quad P(v) = 0.46\,\delta(v) + \frac{0.682}{1 + (|v|/0.345)^{3.5}} \qquad (5)$$

where v is expressed in meters/second and $\delta(v)$ is the unit impulse (delta function). In each of (4) and (5), the first term is an idealized representation of the dc component of clutter. (In a real radar system this impulse will be modified by transmitter and receiver instabilities.)

Equations (4) and (5) above are normalized to contain unity total power.

20.2 Sea Clutter. Sea clutter is considered to have a Rayleigh amplitude distribution with a mean scattering coefficient as given in Table VI for sea state 5, considered to be an applicable "worst case" condition.

The power density spectrum of sea clutter is considered to have a Gaussian spread about its mean frequency value with a 3 dB width of 2.5 m/sec (representing approximately sea state 5, or a wind slightly in excess of 20 knots). This mean frequency may have any value corresponding to a doppler velocity between -2.5 m/sec and +2.5 m/sec.

*"SEEK IGLOO Radar Clutter Report", W. L. Simkins, V. Vannicola, J. Ryan, RADC TM-76-18. Dec 1976 (Available in SEEK IGLOO Reading Room).

TABLE VI

SEA SCATTERING COEFFICIENTS

Depression Angle of Radar Beam and Frequency Band	Scattering Coefficient, Horizontal Polarization	Scattering Coefficient, Vertical Polarization
0.1°, L-Band	-65 dB	-60 dB
1°, L-Band	-50 dB	-43 dB
3°, L-Band	-46 dB	-38 dB
0.1°, S-Band	-53 dB	-50 dB
1°, S-Band	-42 dB	-38 dB
3°, S-Band	-37 dB	-35 dB

SI-1613

20.3 Model Site Environment (Land and Sea Clutter). The radar site shall be modeled as having land and sea clutter extending out to 100 nmi from the radar in accordance with Figure 16. The four categories of clutter comprising this environment are specified as follows:

I - Amplitude distribution as given by Region #I, Figure 15; spectral density as given by Equation (5).

II - Amplitude distribution as given by Region #II, Figure 15; spectral density as given by Equation (4).

III - Amplitude distribution as given by Region #III, Figure 15; spectral density as given by Equation (4).

IV - Amplitude and spectral distribution as described in 20.2.

The radar shall be considered to be at a height of 3500 feet above mean sea level (MSL). Region I shall be at nominally 500 feet above MSL. Regions II and III shall contain peaks more than 4000 feet above MSL.

20.4 Weather Clutter. The intense rain precipitation clutter environment is specified to be due to a rain cell having a cylindrical center core consisting of a constant precipitation rate of 10 mm/hour from a 20,000-foot originating altitude to ground level and with a diameter of 2.6 nmi. The rainfall rate tapers off linearly beyond the edge of this core at a slope of 7.14 mm/hour/nmi along a path perpendicular to the edge of the cylinder; i.e., the total width of the cell to its extreme edges is 5.4 nmi. There are 120 such rain cells within a radius of 100 nmi of the radar. The distributed precipitation clutter environment is due to a constant rainfall of 2 mm/hour originating at 20,000-foot altitude and filling the entire surveillance area of the radar. In the presence of precipitation, there will be signal attenuation and clutter having the following modeled characteristics competing with target returns.

20.4.1 Weather Attenuation. The maximum two-way path attenuation due to rain under distributed rain precipitation conditions is 0.0025 dB/nmi at S-Band and negligible at L-Band. The value thus calculated shall be added to the atmospheric absorption loss as given in NRL Report 6930 to obtain the total modeled loss for any propagation path.

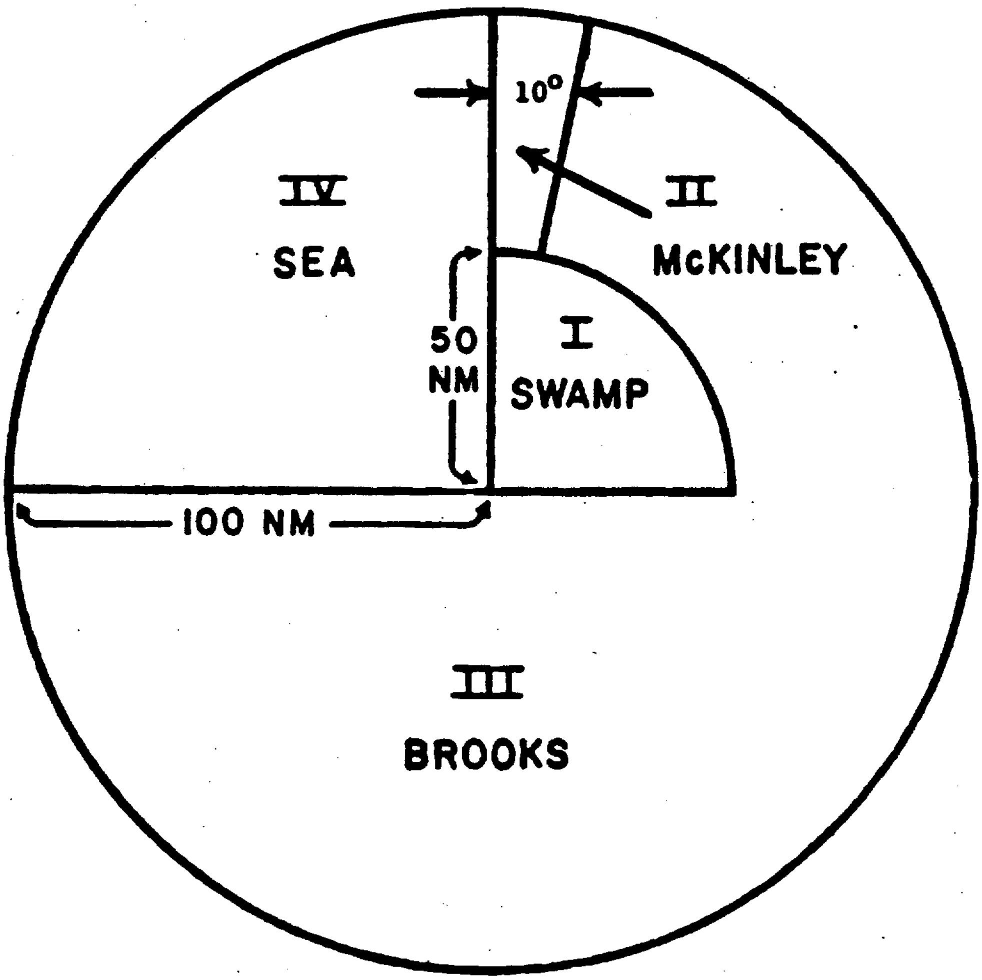

Figure 16. Model Site Clutter Environment

20.4.2 Weather Clutter Magnitude. Intense rain clutter has a cross section per unit volume of 8.10×10^{-10} m^{-1} at L-Band, and 2.27×10^{-8} m^{-1} at S-Band. Distributed rain clutter has a cross section per unit volume of 6.17×10^{-11} m^{-1} at L-Band and 1.73×10^{-9} m^{-1} at S-Band.

Clutter competing with radar target returns shall be computed by multiplication of an appropriate beam volume which intersects the clutter by the clutter cross section per unit volume.

20.4.3 Weather Clutter Spectral Width. The doppler spectrum of backscattered precipitation clutter which fills the beam in elevation has a Gaussian spread about its mean value with

$$W_V = 2.355 \ [1 + 1.411R^2 \ \phi^2]^{1/2}$$

where W is the 3 dB width expressed in meters/seconds, R is the range to the clutter in kilometers, and ϕ is the one-way elevation half-power beamwidth in radians. The mean may assume any radial velocity value between -25 m/sec and +25 m/sec.

Where precipitation clutter does not fill the beam, its spectral width may be calculated analytically by combining the effects of a 1 m/sec random fluctuation due to atmospheric turbulence and a random fluctuation attributable to a wind shear gradient of 4.0 m/sec per kilometer of altitude.

20.4.4 Weather Clutter Polarization Characteristics. The energy backscattered by precipitation clutter when the incident energy is circularly polarized shall possess components both of the same sense as the incident energy and of the opposite sense. The ratio of the opposite sense component to the same sense component is taken to be 15 dB for rain.

20.5 Bird Clutter. Two models of clutter attributable to migrating birds are significant in the vicinity of the MAR stations. These models are summarized in Table VII.

TABLE VII

BIRD CLUTTER MODELS

	Model A (Ducks & Geese)	Model B (Cranes)
Frequency of Occurrence	May through November	1 week in May (Peak) 1 month May/June and Aug/Sept
Number of Flocks	500 | 75% - 0 to 50 nmi 25% - 50 to 100 nmi	40 | 75% - 0 to 50 nmi 25% - 50 to 100 nmi
Number of Birds/Flock	30 - 150	20 - 2000
Dimensions of Flock	200 ft x 200 ft	5 nmi x 1 nmi
Individual Bird Cross-Section	$0.02m^{2*}$	$0.04m^{2*}$
Ground Speed	20 - 80 kts	20 - 80 kts
Altitude and Distribution	50% - 0 to 500 ft 25% - 500 to 5000 ft 25% - 5000 to 10,000 ft	80% - 0 to 5000 ft 20% - 5000 to 10,000 ft

*SWERLING Case I Fluctuation When in Flocks