Specifications Required of SeaSonde Products That Dictate Operating Frequency Band and Transmit Power

A. Signal-to-Noise ratio must exceed 13 dB for surface current extraction from the radar echo

B. Maximum range must reach

1) **200 km for Long-Range Coastal SeaSonde System**
2) **75 km for Low-Band Standard Coastal SeaSonde**
3) **40 km for Mid-Band Standard Coastal SeaSonde**
4) **15 km for High-Band High-Resolution Harbor SeaSonde**

Signal-to-Noise Ratio Dependence on Radar and Environmental Parameters – And Definitions

$$S/N = \frac{P_t\, G_t\, L_c\, D_r\, F^4\, \sigma^o \Delta A\, \lambda^2\, \tau_i}{(4\pi)^3\, R^4\, kT\, F_a}$$

S/N Signal-to-Noise ratio

P_t Transmitter output power (average) -- SeaSonde duty factors are always 50%

G_t Transmit antenna power-gain over earth, including ground losses

L_c Cable losses to transmit antenna

D_r Receive antenna directive gain, excluding ground losses (external noise always dominates receive antenna losses and noise figure in SeaSondes)

F One-way attenuation factor above normal free-space spreading loss experienced by surface wave above lossy spherical earth, raised to fourth power to include two-way radar path for signal power. Calculated from standard computer codes developed at Department of Commerce Institute for Telecommunications Science, [Berry & Chrisman, 1965] based on theory of J. Wait [*Electromagnetic Waves in Stratified Media,* Pergamon Press, 1962], and including effects of sea state roughness [Barrick, D. E., *Radio Science,* 1971, pp. 517-533]

R Range to radar scattering cell at maximum specified distance

σ^o Normalized radar cross section of first-order Bragg scatter from sea at HF, taken from theory and experiments [D. E. Barrick, *IEEE Transactions on Antennas & Propagation,* 1972, pp. 2-10]

ΔA Area inside radar cell at maximum specified range: = $R\,\Delta R\,\Delta\vartheta$, where R is maximum specified range; ΔR is the radar cell size (determined from signal bandwidth); and $\Delta\vartheta$ is the azimuth (bearing) angular width, which for SeaSonde is always 5°

λ Radar wavelength: = $300/f_{MHz}$ (meters)

τ_i Integration time or FFT time-series length (in seconds) for spectral processing; this is 1/B, where B is the effective noise bandwidth of the system

kT Internal receiver front-end noise per unit bandwidth at room temperature, where T = 270°K, and k = Boltzmann's constant = 1.38×10^{-23}

F_a Factor by which external noise at HF exceeds internal noise; obtained from *C.C.I.R. Report No. 322,* International Telecommunications Union, Geneva, 1964. An average value for this factor across the HF band (in dB) is calculated from the following formula that is fitted to the C.C.I.R. data:

$$F_a = 70 - 27.5\ \mathrm{Log10}(f_{MHz})$$

Spreadsheet Calculations Supporting Required Power and Operating Frequency for Four Specified SeaSonde Ranges

a) **Add red dB numbers in second columns to get S/N ratio at bottom;**

b) **Numbers for dB in denominator of equation are shown in parentheses, with appropriate minus signs so all numbers in columns can be added;**

c) **Frequency is rounded to nearest MHz. That is, 5 MHz represents operation in band 4.7-5.2 MHz; 13 MHz represents operation between 12 - 14 MHz; 25 MHz represents 24-27 MHz; and 42 MHz represents 40-45 MHz.**

Frequency (MHz)	5		13		25		42	
P_t	50 w	17 dBw	50 w	17 dBw	50 w	17 dBw	25 w	14 dBw
G_t	1.0	0 dB	1.0	0 dB	1.6	2 dB	1.6	2 dB
L_c		-3 dB		-3 dB		-4 dB		-5 dB
D_r	3.2	5 dB	3.2	5 dB	3.2	5 dB	3.2	5 dB
F^4		-17.1 dB		-25.8 dB		-39.8 dB		-40.1 dB
σ^o		-40 dB		-38 dB		-33 dB		-32 dB
ΔR	3 km		2 km		1 km		200 m	
R	200 km		75 km		40 km		16 km	
ΔA		77.1 dBm2		71.2 dBm2		65.3 dBm2		54.4 dBm2
R^{-4}		-(212.0 dBm4)		-(195.0 dBm4)		-(184.1 dBm4)		-(168.2 dBm4)
λ	60 m		23 m		12 m		7.14 m	
λ^2		36.0 dBm2		27.2 dBm2		21.6 dBm2		17.1 dBm2
$(4\pi)^{-3}$		-(33.0 dB)		-(33.0 dB)		-(33.0 dB)		-(33.0 dB)
$(kT)^{-1}$		-(-204 dBws)		-(-204 dBws)		-(-204 dBws)		-(-204 dBws)
τ_i	1024 s	30.1 dBs	256 s	24.1 dBs	256 s	24.1 dBs	128 s	21.1 dBs
$(F_a)^{-1}$		-(50.8 dB)		-(39.4 dB)		-(31.6 dB)		-(25.4 dB)
S/N		**13.3 dB**		**14.3 dB**		**13.5 dB**		**13.9 dB**