APPENDIX B

POINT TARGETS AND CLEAR AIR RETURNS

The detection capability of the WSR-88D is such as to enable detection of very small targets (targets having a radar and geometric cross-sectional area of a few hundredths of a square meter) to ranges of tens of kilometers. While "point targets" span a large range of radar cross sections, from tens of meters square for a large aircraft to the undetectable, all share some common features of scale. All have an apparent extent (both azimuth and elevation) equal to the two-way antenna pattern.

Since these targets do not fill the radar beam, the basic radar equation for point targets is different than that for distributed targets. For monostatic radars, an expression for return power is given by:

$$P_r = \frac{P_t G^2 \lambda^2}{(4\pi)^3 r^4} \sigma_b L$$

where σ_b is the radar cross section in units of area, and all other symbols are the same as previous. Comparing the above with the radar equation for precipitation, we note that point target detection is not dependent on transmitter pulse width or antenna beam width and has a range dependency of r^{-4} rather than r^{-2}.

Typical detection capability of the WSR-88D for point targets is given in Figure B-1. Scattering from small point targets ($\sigma_b \simeq 10^{-5}$ m^2) or conglomerates of small targets is one type of "clear air return."

True clear air return, though, is radar backscattering due to variation in refractive index of the atmosphere on a scale comparable to the radar wavelength. A quantitative description of the actual scattering mechanism is somewhat complicated; however, the process can be visualized as a reflection due to a mismatch in the transmission medium (the atmosphere) caused by a change in refractive index of the medium.

Clear air return is a volumetric scattering filling the radar beam and the basic radar equation for backscattering, due to refractive index variance, is the same as that for precipitation except that volume reflectivity, η, is expressed in terms of the refractive index structure constant, C_n^2, rather than Z_e. The structure constant is a measure of the mean-square fluctuation of refractive index with distance. Although a measure of different quantities (Z_e a liquid water, C_n^2 is proportional to the refractive index variance) the backscattering can be related through volume reflectivity.

$$\eta = \frac{\pi^5}{\lambda^4} |K|^2 Z_e = 0.39\ \lambda^{-1/3} C_n^2$$

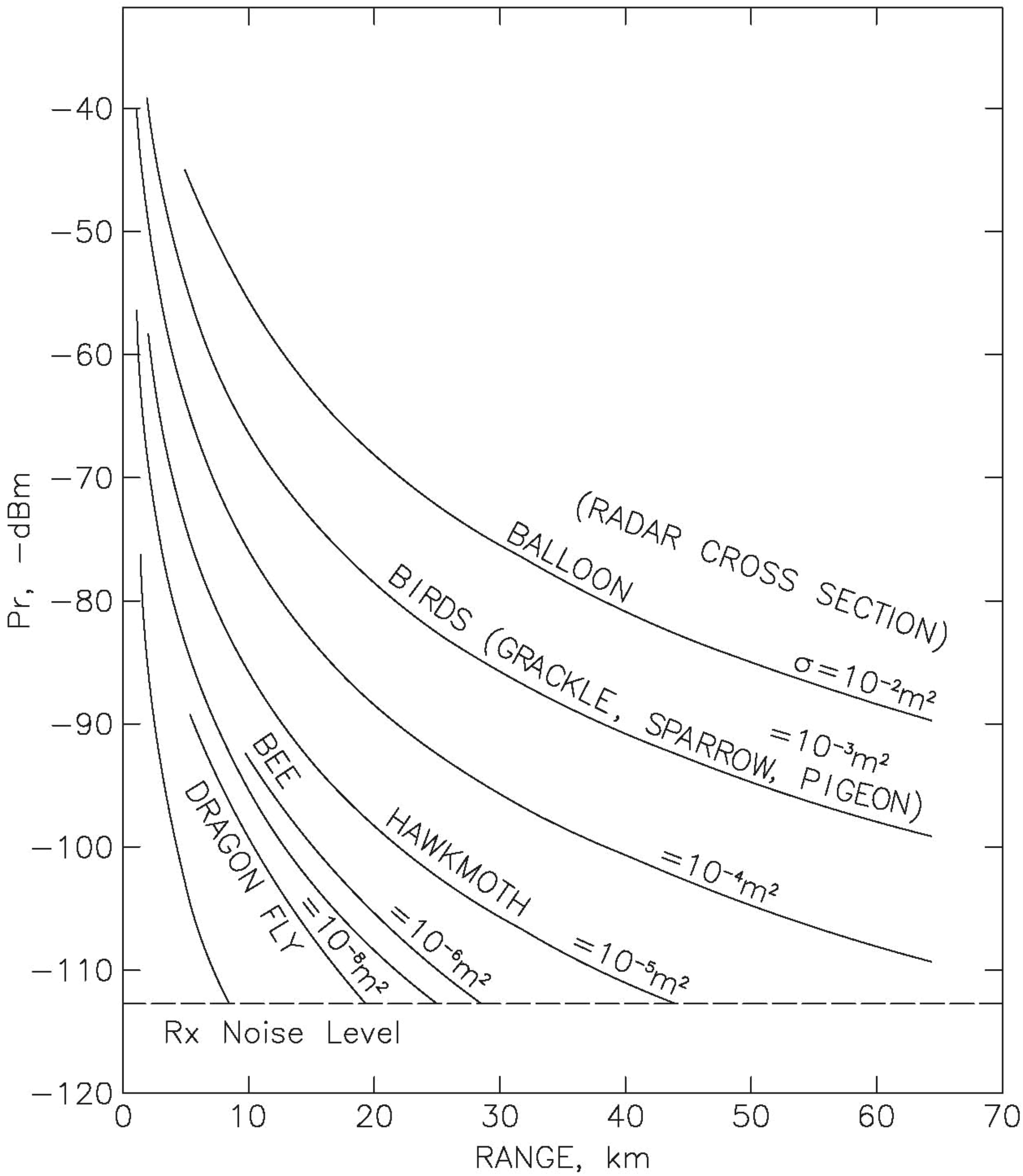

Figure B-1
Typical Point Target Detection Capability of the WSR-88D

and the radar equation for scattering by refractive index fluctuations becomes:

$$P_r = \frac{P_t G^2 \theta^2 c_\tau \lambda^{5/3} (0.39) C_n^2}{2^{10} \pi^2 \ln 2} L$$

The structure constant, C_n^2, varies widely with meteorological condition with a mean value of about 10^{-14} $m^{-2/3}$. Note that η has units of m^{-1} while C_n^2 has units of $m^{-2/3}$. Typical detection capability of the WSR-88D for log C_n^2 can be derived from Figure A-2 by adding 2.52 to log Z_e, i.e., log C_n^2 = 2.52 + log Z_e. Detection to ranges corresponding to the top of the planetary boundary layer is not unusual.

The clear air characteristics and utility in the velocity domain depend on the type of target. Targets capable of independent flight, such as aircraft and birds that are not tracers of the wind, provide little useful information to the meteorologist. The WSR-88D system has the capability to remove these types of returns from the data field by logic based on the target radar cross section and range extent (Point Clutter Rejection).

Small targets, on the other hand ($\sigma_b < 10^{-4}$ m^2), are usually good tracers of the environmental wind and these measurements provide valid wind field information.

Measurements based on refractive index fluctuations are, of course, a direct measure of the air motion.

BIBLIOGRAPHY

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