Radar Equation "Cheat Sheet"

Dead Zone	$(ct)/2$
Range Resolution	$\Delta R = ct/2$
PRF	Pulse Repetition Frequency
PRI	Pulse Repetition Interval = 1/PRF
Unambiguous range	$c/(2PRF)$
Doppler shift	$f_d = \frac{2V_r}{l}$
Unambiguous velocity	$V_{\max} = \frac{lPRF}{4}$
Doppler dilemma	$V_{\max} R_{\max} = \frac{cl}{8}$
Definition of radar reflectivity *h* (m^2 m^{-3})	$h = \sum_{Unit\ Volume} s_i$
Radar reflectivity *h* (m^2 m^{-3})	$s_t = V \sum_{Unit\ Volume} s_i = Vh$
Definition of radar reflectivity factor *z* (mm^6/mm^3)	$z = \sum_{Unit\ Volume} D^6$
Radar equation with incorporating simplified "lobing"	$P_r = \frac{G^2 l^2 P_t s}{64p^3 R^4} \times 16 \sin^4\left(\frac{2ph_a h_t}{lR}\right)$
Radar equation with incorporating simplified "lobing" in region below first peak	$P_r =\approx \frac{4pP_t G^2 s (h_a h_t)^4}{l^2 R^8}$
Definition of refractivity	$N = (n-1)\cdot 10^6$ where *n* is the index of refraction
Distance to horizon (linear model of refractivity)	$d = \sqrt{2kah_a}$ (Consistent Units) $d(km) = 4.12\sqrt{h_a}(m)$ where *a* = diameter of earth, h_a is the antenna height and *k* = 4/3
Speed of radio wave	$c = \sqrt{\frac{m}{e}} = \sqrt{\frac{m_0}{e_0}}\sqrt{\frac{m_r}{e_r}} = c\sqrt{\frac{u_r}{e_r}} \propto c\sqrt{\frac{1}{e_r}}$

General Antenna Formulas

$G =$ Antenna Gain

$l =$ Wavelength (m)

$A_e = \frac{G l^2}{4p}$ Antenna Effective Area (m^2)

$G = \frac{p^2 k^2}{q f}$ q, f are H and V beamwidths (radians), k antenna factor

$G = \frac{p^2}{q^2}$ For circular antennas, q beamwidth (radians)

Parabolic Dish Antennas

$q = \frac{70\, l}{D}$ Beamwidth in degrees, $D =$ dish diameter ($q = \frac{l}{D}$ Beamwidth in radians

Radar Equation for Point Targets

$P_r = \frac{G^2 l^2 P_t s}{64 p^3 R^4}$	P_t and P_r are transmitted and received power, s is the radar target cross sectional area, R is the distance between target and transmitter, and G is the antenna gain.

Radar Equation for Distributed Targets

$P_r = \frac{G^2 l^2 P_t V h}{64 p^3 R^4}$	P_t is the transmitted and received power, h is the radar target cross sectional area, R is the distance between target and transmitter, and G is the antenna gain. V is the radar pulse volume (see below)

Radar Pulse Volumes

$V_1 = p\,\frac{Rq}{2}\frac{Rf}{2}\frac{h}{2}$ (general) $V_2 = \frac{pR^2q^2h}{8}$ (symetric $q = j$) $V_3 = \frac{pR^2qj}{8\ln(2)}\frac{h}{2}$ (symectric, Gaussian)	h = pulse length, t is the pulse width, q, and f are antenna beam widths.
$P_r = \left(\frac{G^2 l^2 P_t q f c t}{1024\ln(2)p^2}\right)\frac{h}{R^2} = C\frac{h}{R^2}$	Radar equation for distributed targets using symmetric Gaussian antenna. C is the radar constant.

Attenuation of electromagnetic energy in the atmosphere. Solid curve is due to absorption by oxygen. Dashed curve is due to absorption by water vapor.