TOWER TALK ON TEN
(10 GHz TV TOWER REFLECTIONS)

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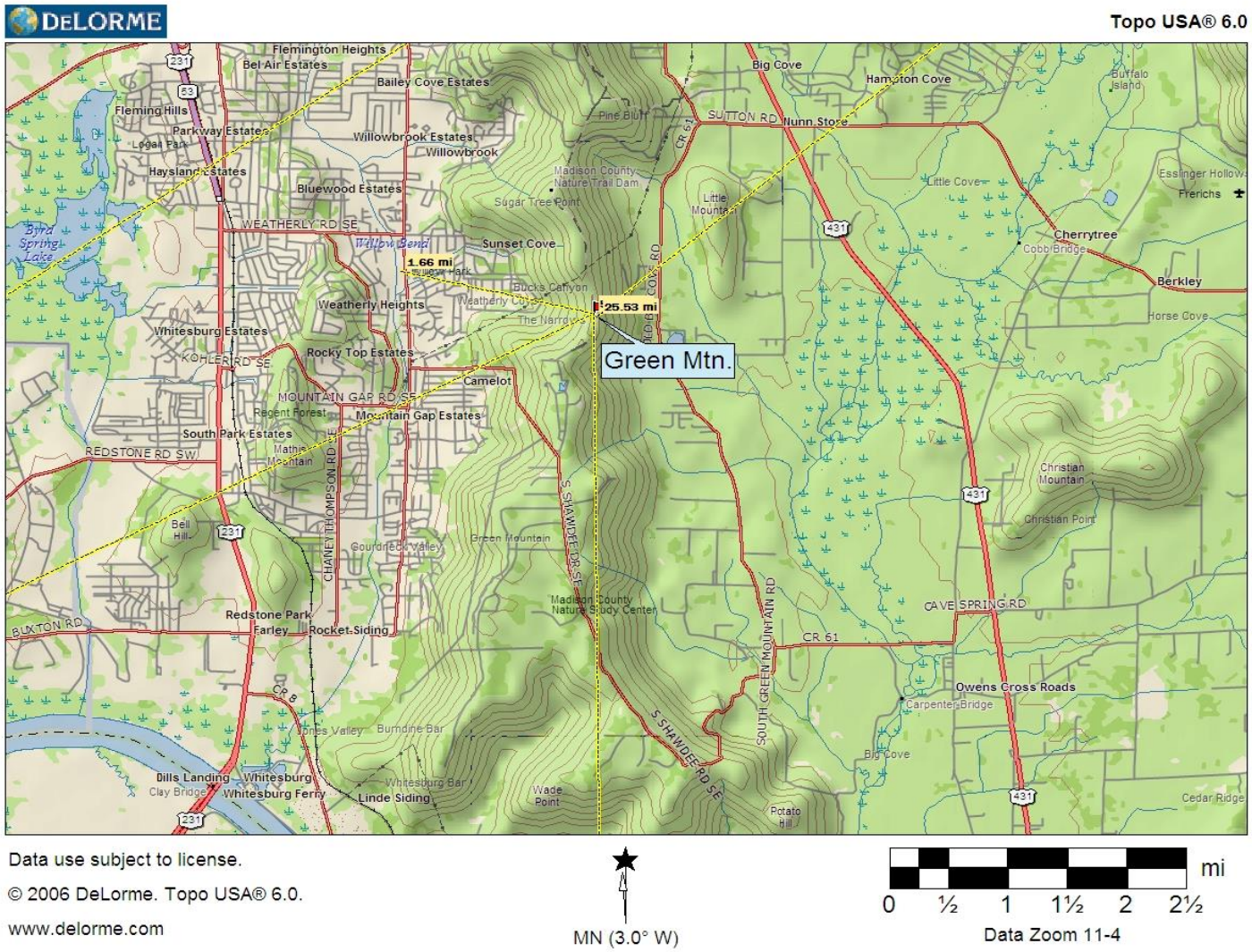
PART I – TV TOWER TALK ON TEN (GOALS AND METHODS)

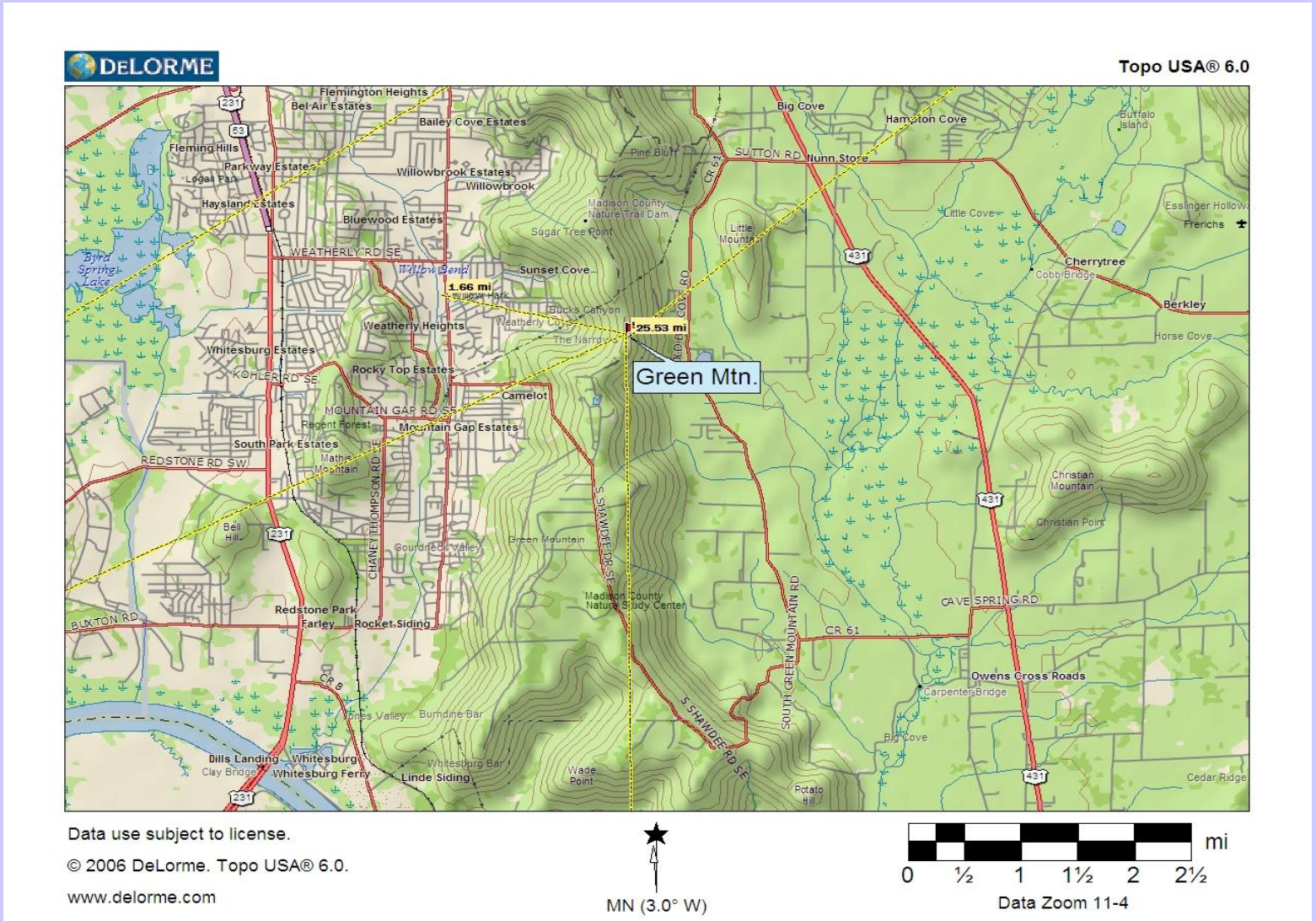
- Extend the 10 GHz communications range
- Team effort for W4ZRZ, K4XR, and K4QF
- Why use the TV transmitting towers?
- What kind of range can be achieved?
- Explain the reflection methodology
- Discuss how to locate the available towers

HOW WE GOT TO THIS POINT



VIEW TO THE SOUTHWEST

TEST FROM WEST SIDE OF GREEN MTN



WHY USE TV TRANSMITTING TOWERS?

- TALLEST OBJECT IN THE NEIGHBORHOOD LOCATED ON THE HIGHEST POINT AROUND
- EXPECTED RANGE DETERMINED BY TOWER'S EFFECTIVE HEIGHT EASILY CALCULATED:

R, miles = range to the radio horizon = $\sqrt{2*h}$

where: R = range in miles

h = height above ground in feet

FINDING TOWER CHARACTERISTICS

•TOWER SPECIFICATIONS: http://wireless2.fcc.gov/UlsApp/AsrSearch/asrRegistrationSearch.jsp

• SEARCH FOR HUNTSVILLE FOR 800 FT. TO 1500 FT, YIELDS:

Structure Type TOWER - Free standing or Guyed Structure used for Communications Purposes

Location - Lat/Long 34-38-00.0 N/086-30-47.0 W; 11,001 NORTH SHAWDEE DRIVE, HUNTSVILLE , AL

Heights (meters) Elevation of Site Above Mean Sea Level = 446.5 meters = 1465 ft.

Overall Height Above Ground (AGL) = 391.4 meters = 1285 ft.

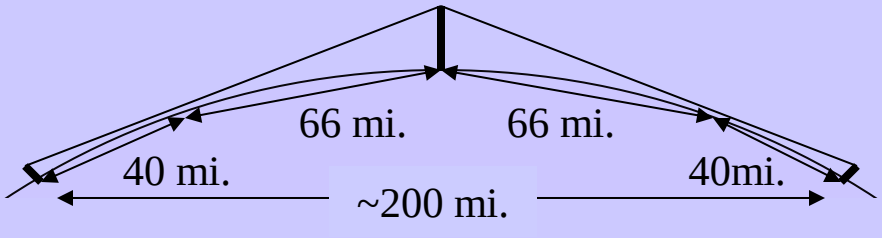
Overall Height Above Mean Sea Level = 837.9 meters = 2750 ft.

Valley ~ 600 ft. ASL

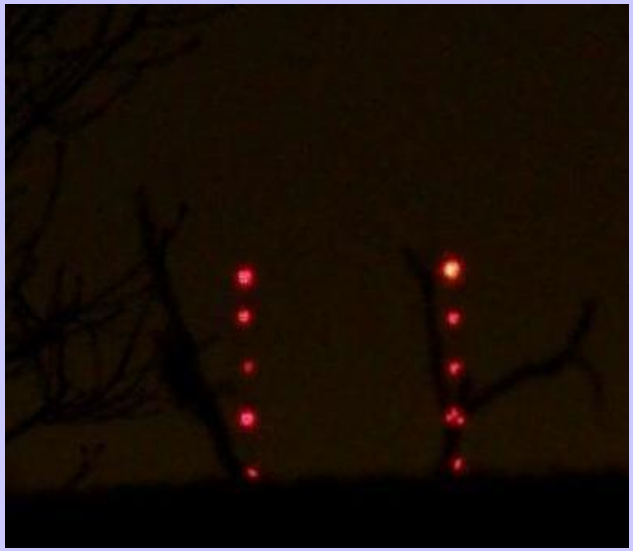
Therefore, tower height above valley ~ 2,150 ft. with radio range = 66 miles

Similar analysis for W4ZRZ with 100 ft. tower on 1,300 ft. hill above 600 ft. ASL valley yields 40 miles range.

RADIO RANGES BASED ON TOWER HEIGHTS

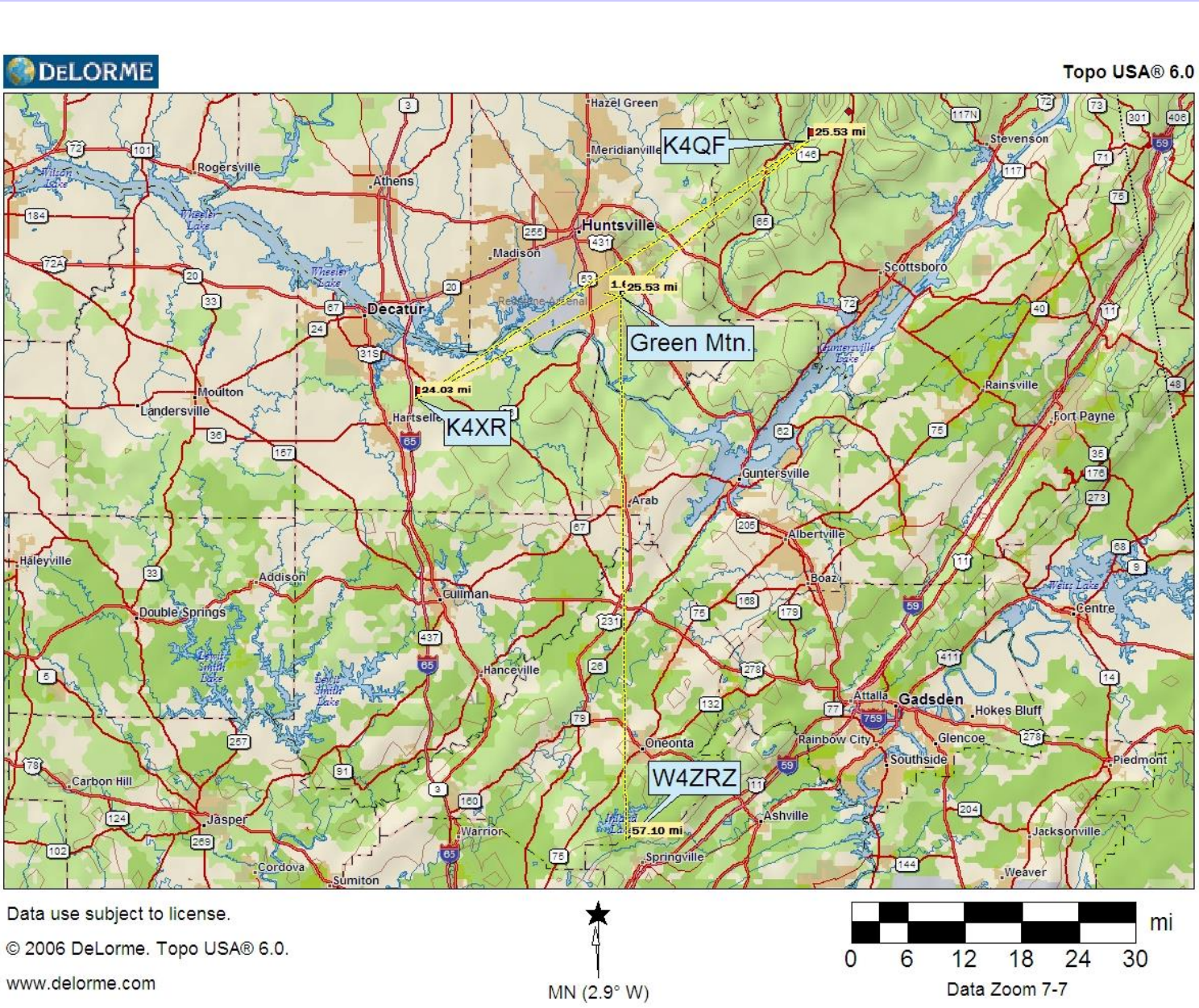


Huntsville TV Tower @ Night, ~25 miles



With 5 of 7 lights visible, ~ 500 ft. of 950 ft. tower is within view.

TOPOLOGY FOR W4ZRZ CONTACT

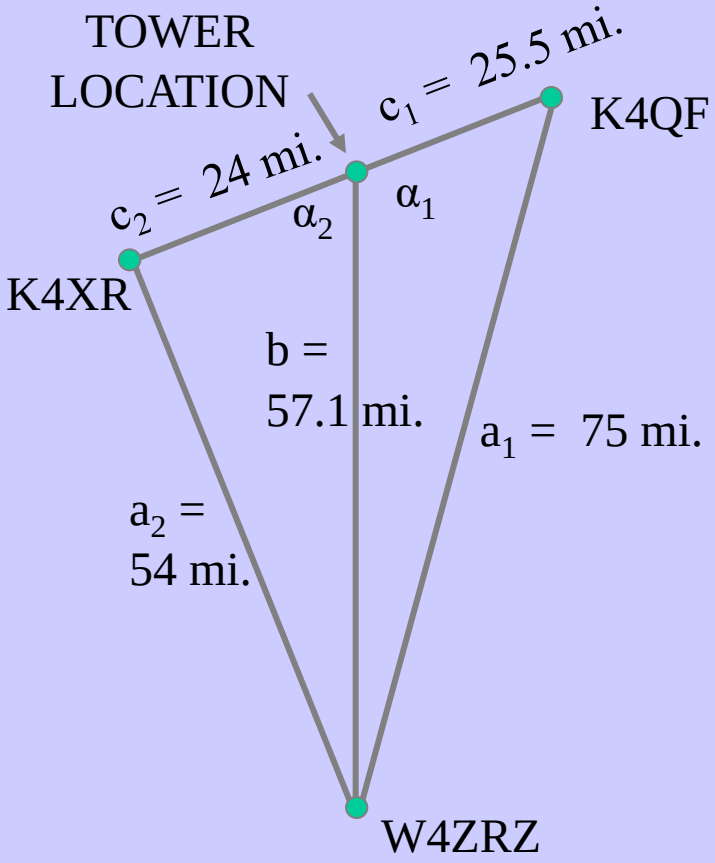


FINDING THE BISTATIC ANGLE

$$\cos \alpha = (b^2 + c^2 - a^2)/(2*b*c)$$

$$\cos \alpha_1 = (b^2 + c^2 - a^2)/(2*b*c)$$
$$\cos \alpha_1 = (57.1^2 + 25.5^2 - 75^2)/(2*57.1*25.5)$$
$$\alpha_1 = 129.5\ °$$

$$\cos \alpha_2 = (b^2 + c^2 - a^2)/(2*b*c)$$
$$\cos \alpha_2 = (57.1^2 + 24^2 - 54^2)/(2*24*57.1)$$
$$\alpha_2 = 70.3\ °$$



BI-STATIC ANGLE CAN ENHANCE OR DEGRADE REFLECTIVITY

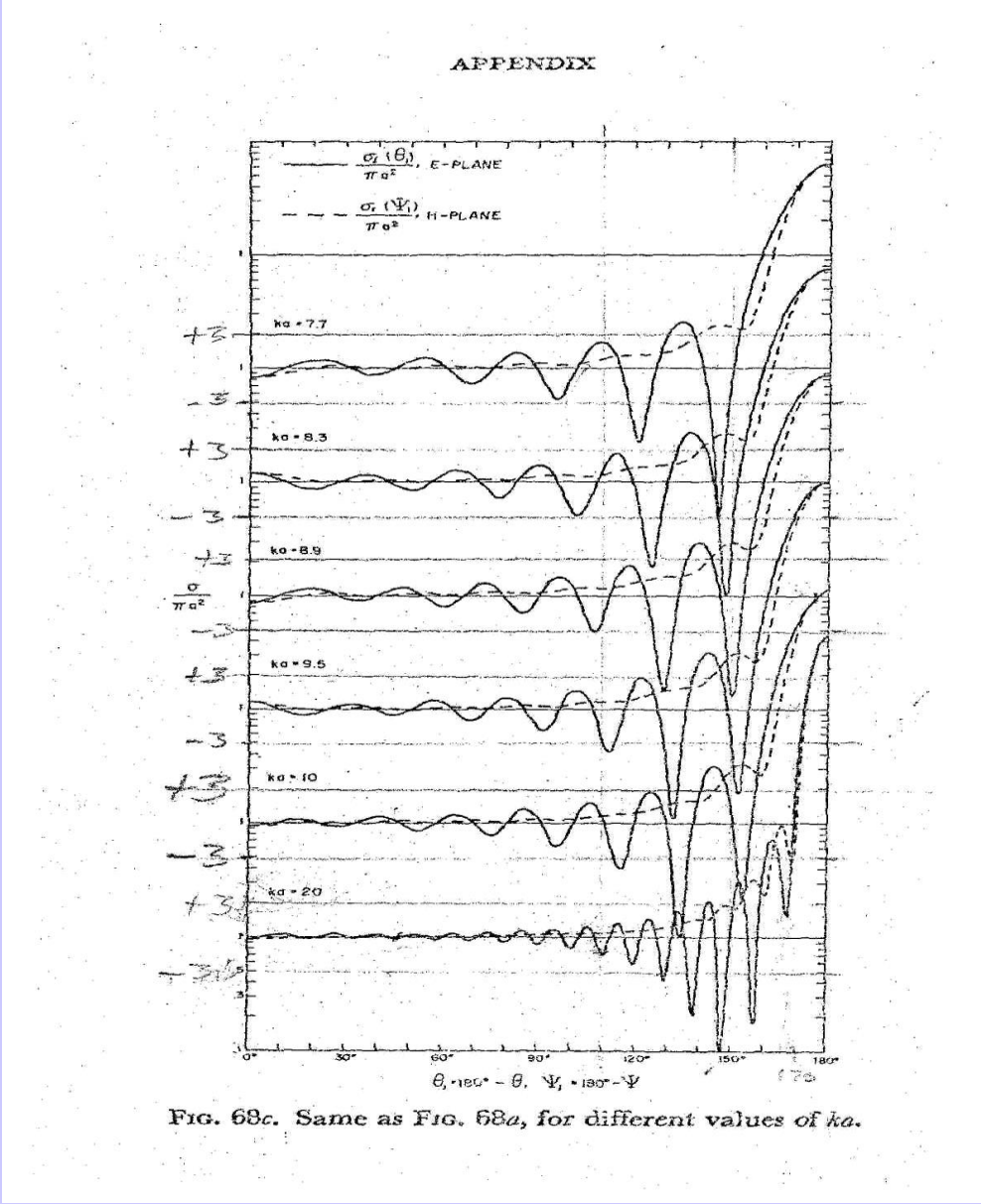


FIG. 68c. Same as FIG. 68a, for different values of *ka*.

FROM "THE SCATTERING AND DEFRACTION OF WAVES" BY KING & WU, HARVARD UNIV. PRESS

TOWER SCATTERING CHARACTERISTICS

- Typical tower leg diameters are 4.5 to 6 in., resulting in circumferences of 12 λ to 16 λ. Tower cross members are many, many wavelengths.
- Tower legs can scatter at any angle. Cross members are probably more directive.
- No known data is available for TV tower modeling.
- For ka (circumference in wavelengths) = 10 λ, scattering curves show sharp, but deep, nulls at 135° and 155°. Nulls appear to be about 5° wide and are ~10 and 6 dB.
- Angle from W4ZRZ to tower to K4XR is 70.3 ° with very little effect on reflectivity of tower.
- Angle from W4ZRZ to tower to K4QF is 129.5 °; could have significant effect.

STATION PARAMETERS

K4XR

ANT. – 2 ft DISHES, FIXED & PORTABLE

TRANSVERTER - DB6NT + AMP.

Po (fixed) = 8 WATTS

Po (portable) = 2.5 WATTS

W4ZRZ

ANT. HT. ASL = 1405 ft.

ANT. – 3 ft. dish

TRANSVERTER – DEMI + AMP.

Po = 8 WATTS

ERP ~ 42 KW.

K4QF

ANT. – 1 ft. DISH

TRANSVERTER – DEMI

Po = 2 WATTS

WHAT TO EXPECT

BISTATIC RADAR RANGE EQUATION:

$Pr = (GrGtPt\sigma_b\lambda^2)/((4\pi^3)R_1^2R_2^2)$

Expressing all terms in meters and taking 10 log of each to get signals in dBm's yields:

$Pr = Gr + Gt + Pt + \sigma_b + \lambda^2 – 33\ dB - 20log(R_1) - 20Log(R_2)$

$Gr=Gt=37\ dB$, $Pt=+39\ dBm$, $\sigma_b=-36.1\ dBsm$, $\lambda^2=-30.8\ dB$, $R_1=57\ mi$, $R_2=25\ mi$.

$Pr = 37dB + 37dB + 39dBm - 36.1dBsm - 30.8dB – 33\ dB - 99.3dB - 92.3dB = -178.5\ dBm$ + tower gain

RADAR CROSS SECTION OF SPHERE

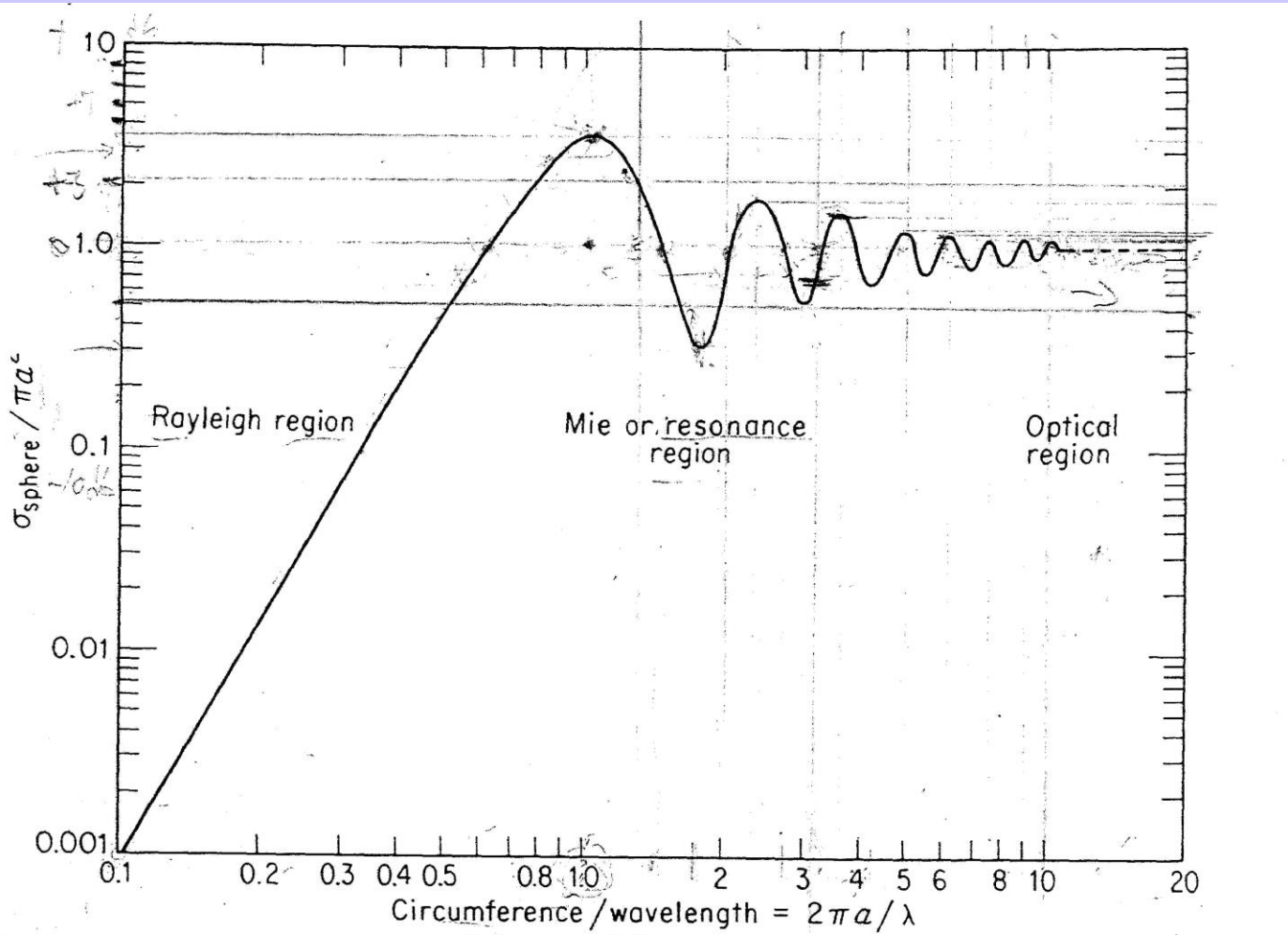
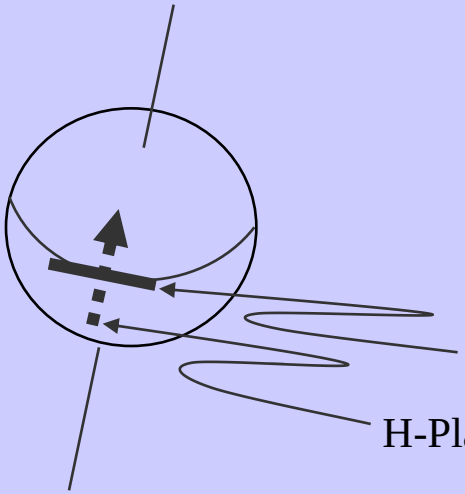
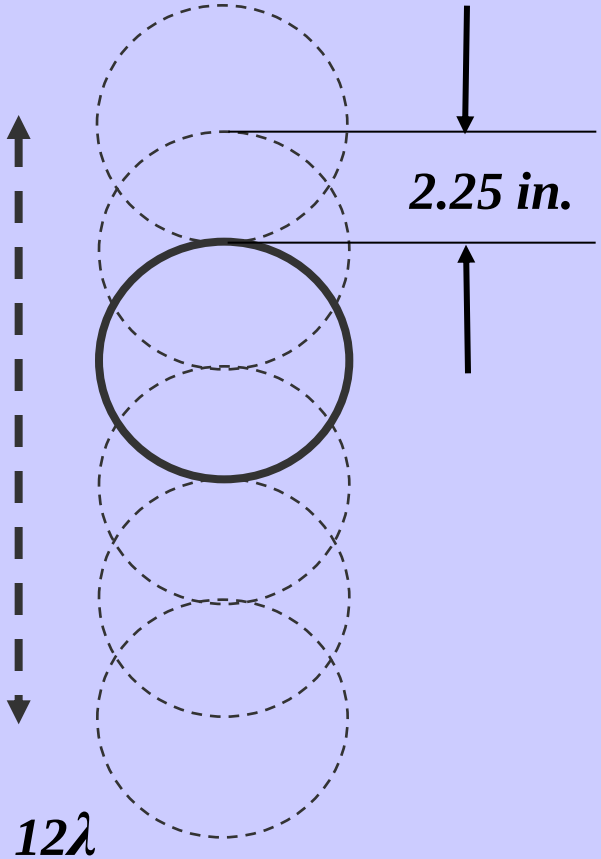


FIG. 2.10. Radar cross section of the sphere. a = radius; λ = wavelength.

FROM: "INTRODUCTION TO RADAR SYSTEMS" BY M.I. SKOLNIK

CYLINDER GENERATION FROM SPHERE OF MOTION



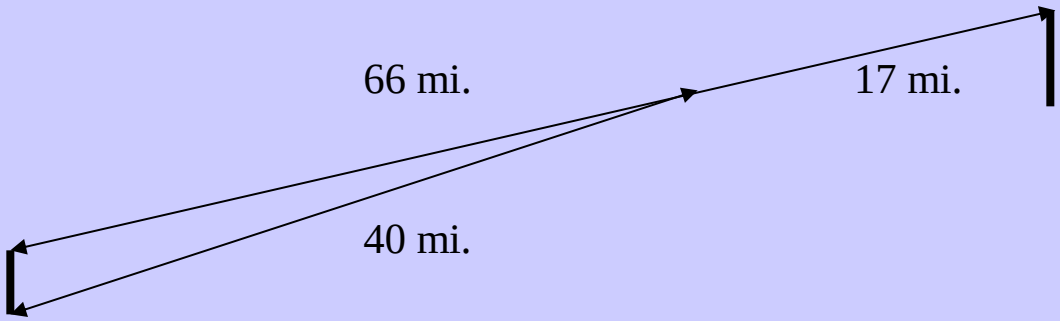


TOWER LEG DIAMETER = 4.5 in. = 11.4 cm.

TOWER LEG CIRCUMFERENCE = 35.9 cm. = 12λ

σb= - 36.1 dBsm

ESTIMATE TOWER REFLECTION GAIN



W4ZRZ's effective height of 600 ft. places his signal at ground level at 40 mi., leaving only 17 mi. (57 – 40 mi.) to tower. Therefore, his antenna can illuminate essentially all of the 1285 ft. tower = 15420 in. For 4.5 in spheres stacked in half sphere increments, 2.25 in., this equates to 6853 spheres or ~ 38.4 dB gain. For tower with 3 legs, add 5 dB for 2 additional legs for a total tower gain of 43.4 dB.

ESTIMATE S/N RATIO

•With tower illumination signal of -178.5 dBm and tower reflection gain of 43.4 dB, available signal level is -135.1 dBm.

- Receiver sensitivity = kTBF, or for 2 KHz BW and 2.5 NF and 1 dB cable loss in dB = -174 dBm/Hz + 33 dB + 2.5 dB + 1 dB = -137.5 dBm.
- Therefore, excess signal is ~ 2.4 dB; sufficient for CW and marginal for SSB.
- Moving station 2.5 mi. from tower increases S/N by 20 dB to 22.4 dB.

RESULTS OF TOWER TESTS W/ K4XR & W4ZRZ

- FIRST TEST WITH K4XR AND K4QF PORTABLE ~ 2 MI. FROM TOWER AND W4ZRZ 57 MI. SOUTH OF TOWER PRODUCED SSB QSO's FOR ALL.
- FOR 2ND TEST, K4QF WORKED K4XR (50 MI.) WITH S8 SIGNALS, EASY SSB CONTACT, PROBABLY DIRECT AND NOT TOWER REFLECTION.
- AFTER FREQUENCY COORDINATION AND TOWER ALIGNMENT WITH K4XR AS REFERENCE SOURCE, K4QF HEARD W4ZRZ WITH SUFFICIENT CW SIGNAL FOR QSO.
- W4ZRZ HEARD K4QF SIGNAL BUT NOT SUFFICIENT FOR QSO.
- CHANGING MY DISH FROM 1 ft. TO 3 ft. DISH SHOULD INCREASE SIGNAL ABOUT 8 dB IF AIMING CAN BE RESOLVED.
- STABALIZING FREQUENCY WILL HELP A LOT! – SEE Part II
- IMPORTANT TO ILLUMINATE SUBSTANTIAL TOWER LENGTH.

TOWER TOP VIEW FROM W4ZRZ

QUESTIONS?