Radio-Tracking of Birds:
Regulation and Ruling of Radio Frequencies

Animal Tracking workshop @ Hula Valley 27-29 Nov 12

Minerva Center for MOVEMENT ECOLOGY

Dr. Haim Mazar; Israeli Ministry of Communications

Vice Chairman ITU-R Study Group 1 (Spectrum Management)

http://people.itu.int/~mazar/


Assisting Ohad Hatzofe (Israel Nature and Parks Auth.)
to ring a **Pelican** in Kibbutz Hazorea near
Megiddo; 30 Nov 10


Gilad Friedman, Or Mazar & Omer Mazar
03-9605594
www.asfir.co.il
w. Guilad Fiedmann
Getting telemetry GPS position
from long legged buzzard
Lachish 6 May11

Telemetry on Short-toed eagle

4

Max range is about 15km free line of sight or 300m in a dense forest

Radio dataloggers specs

output power: 10dBm
RF: 868.3 MHz
Occupied bandwidth :390kHz

Radio Basestation specs 2way (local)

output power: 17dBm
RF: 869.525 MHz
Occupied bandwidth :118kHz

e-obs Animal Dataloggers

PTT-100 70g Argos/GPS Specifications

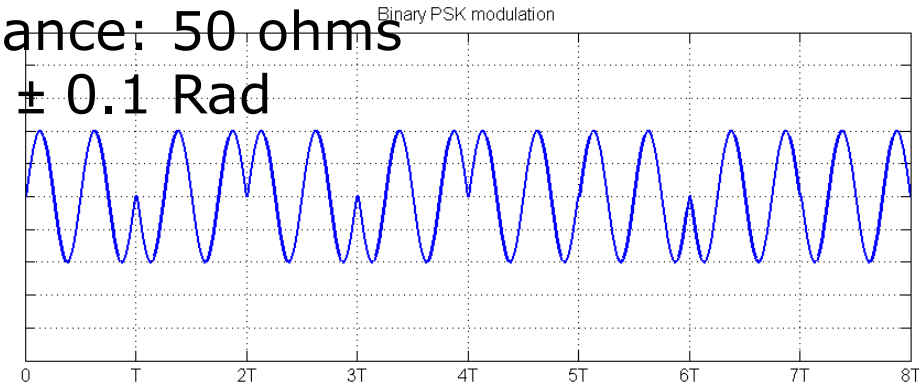
GPS location, also **TOA**

RF: 401.650 MHz ± 36 kHz emitting 1 direction to Argos non-geo satellites; worldwide acquisition including doppler shift for small birds

Power output: 200mW Output impedance: 50 ohms

Modulation Tri Phase **PSK**: ± 1.1 Rad ± 0.1 Rad

Transmission interval: 45 to 120 sec

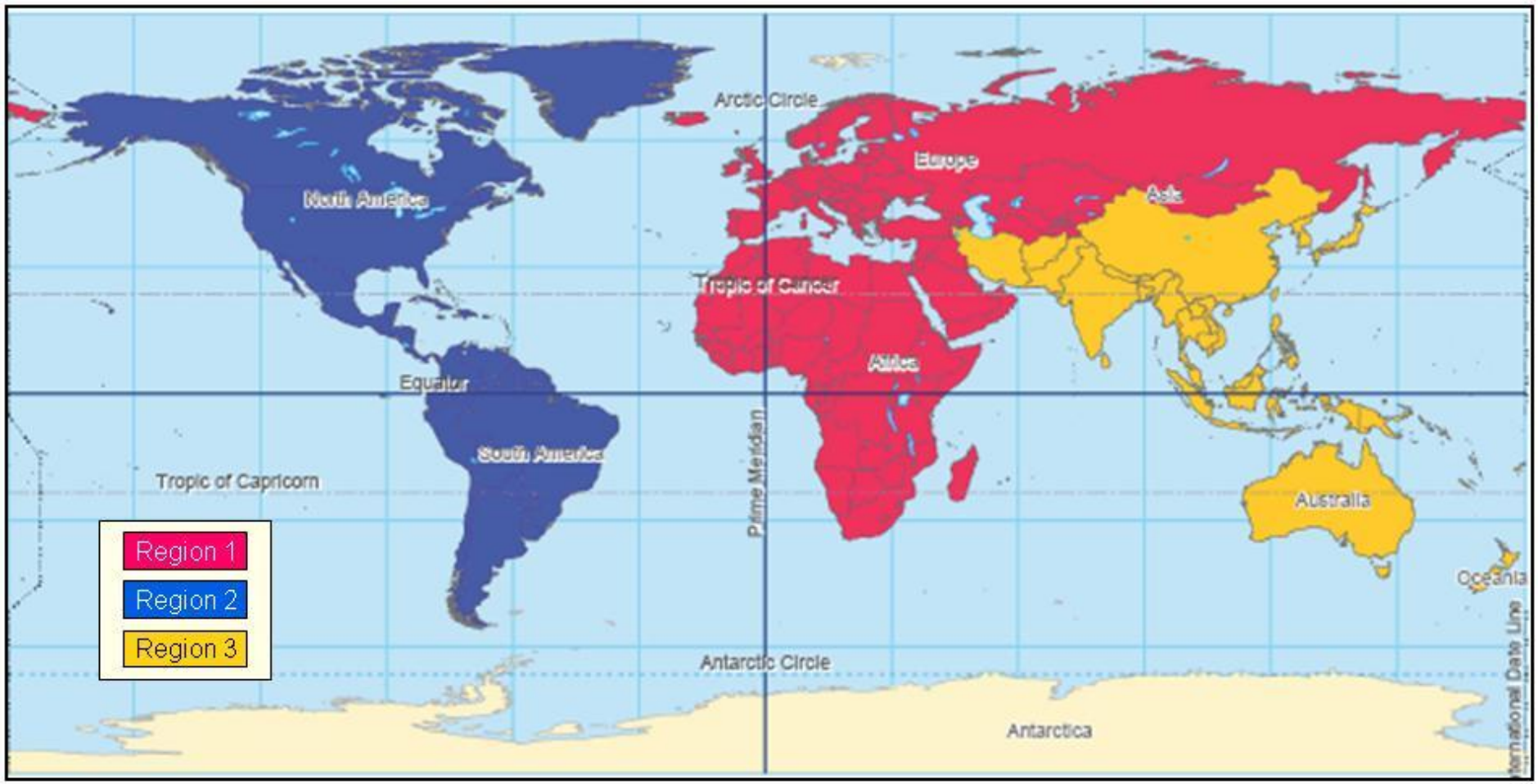


Microwave Telemetry

GSM Transmitter's is GSM20-70; version sent 70g solar Argos/GPS PTT:

The maximum power output is 2W.
It is quad band at 850/900/1800/1900 MHz
FCC ID: QIPBGS2
Industry Canada #: 7830A-BGS2
IMEI: 35649604

ITU 3 Regions



ERC Rec 70-03 Relating to the use of Short Range Devices (SRD): annex 1: non-specific SRD

9 October 2012

Frequency Band		Power / Magnetic Field	Spectrum access and mitigation requirements
f	433.050-434.790 MHz	10 mW e.r.p.	< 10 % duty cycle (note 1)
f1	433.050-434.790 MHz	1 mW e.r.p. -13 dBm/10 kHz	No requirement except for (note 4bis)
f2	434.040-434.790 MHz	10 mW e.r.p.	No requirement except for (note 4bis)
g	863-870 MHz (note 3 and 4)	≤ 25 mW e.r.p.	≤ 0.1% duty cycle or LBT (note 1 and 5)
		≤ 25 mW e.r.p. Power density : - 4.5 dBm/100 kHz (note 7)	≤ 0.1% duty cycle or LBT+AFA (note 1, 5 and 6)
		≤ 25 mW e.r.p.	≤ 0.1% duty cycle or LBT+AFA (note 1 and 5)
g1	868.000-868.600 MHz (note 4)	≤ 25 mW e.r.p.	≤ 1% duty cycle or LBT+AFA (note 1)
g2	868.700-869.200 MHz (note 4)	≤ 25 mW e.r.p.	≤ 0.1% duty cycle or LBT+AFA (note 1)
g3	869.400-869.650 MHz	≤ 500 mW e.r.p.	≤ 10% duty cycle or LBT+AFA (note 1)
g4	869.700-870.000 MHz (note 4bis)	≤ 5 mW e.r.p. ≤ 25 mW e.r.p.	No requirement up to 1% duty cycle or LBT+AFA (note 1)
h	2400.0-2483.5 MHz	10 mW e.i.r.p.	No requirement
i	5725-5875 MHz	25 mW e.i.r.p.	No requirement

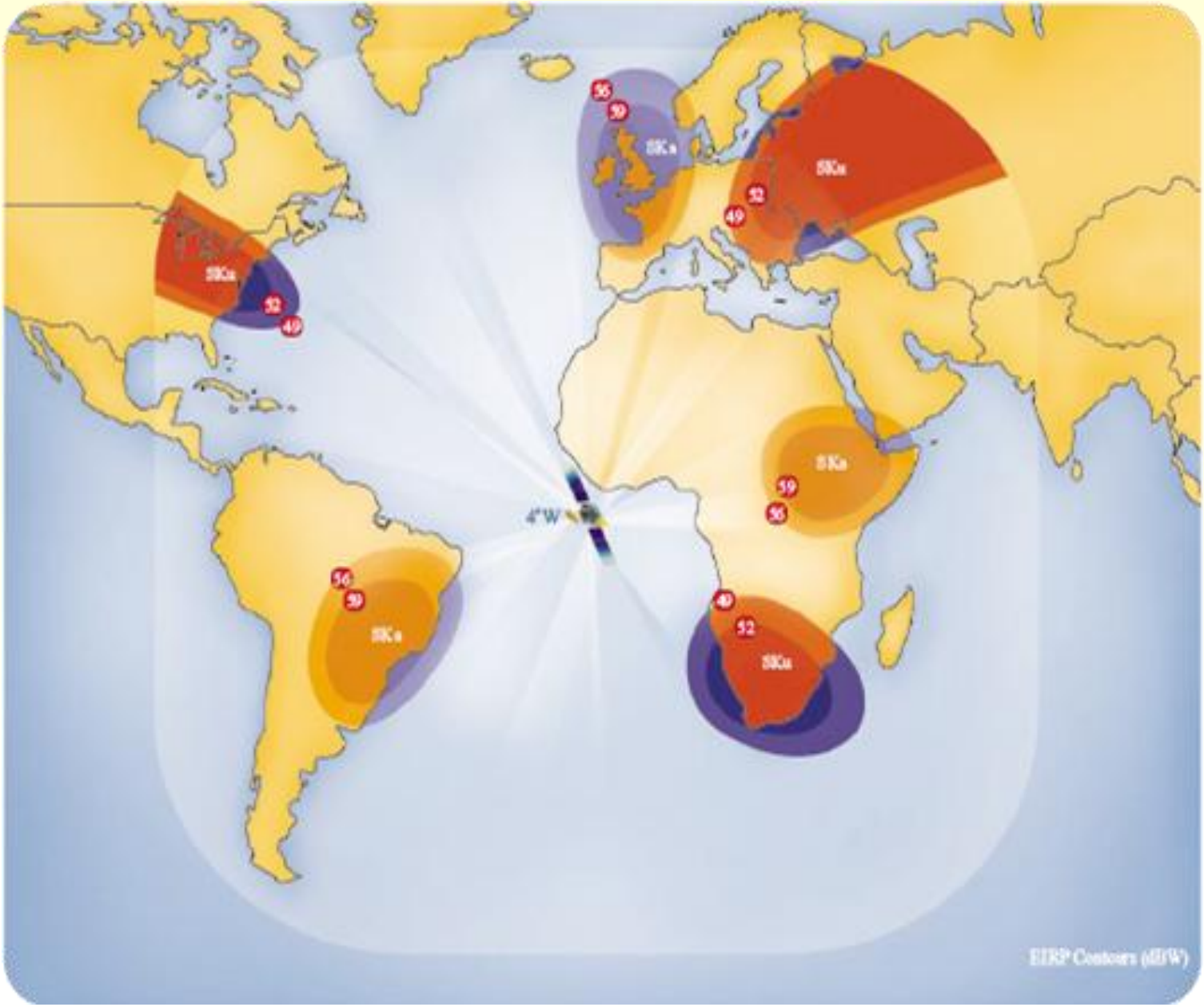
Rec 70-03 annex2 : Tracking, Tracing & Data Acquisition

	Frequency Band	Power / Magnetic Field	Spectrum access and mitigation requirements	Channel spacing	Notes
c	169.4-169.475 MHz	500 mW e.r.p.	< 1% duty cycle	Max 50 kHz	Asset Tracking and Tracing

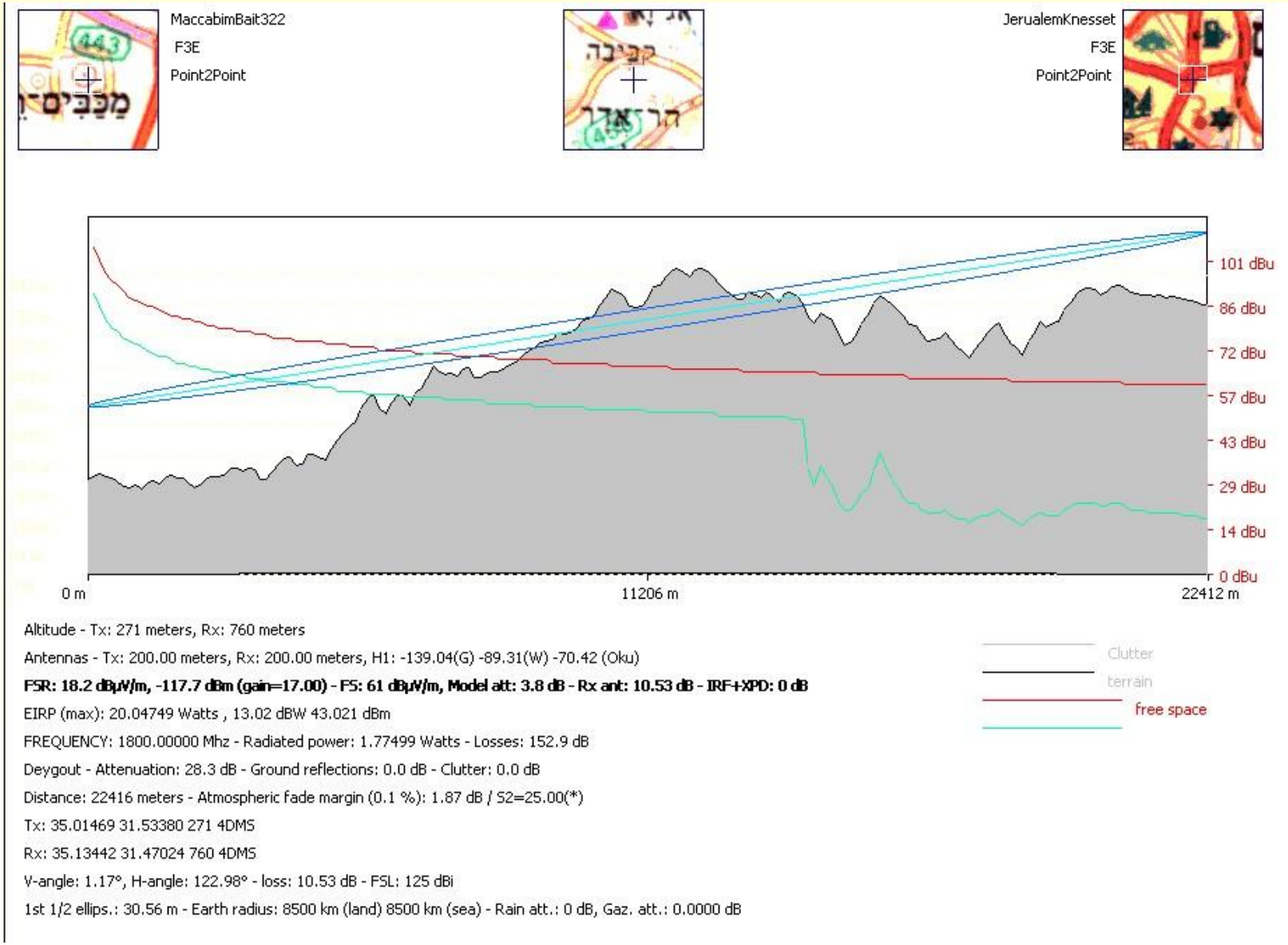
70-03 ann. 11: Radio Frequency Identification Applications, inc. tracking

	Frequency Band	Power / Magnetic Field	Spectrum access and mitigation requirements	Channel spacing	Notes
a1	2446-2454 MHz	≤500 mW e.i.r.p.	No requirement	No spacing	
a2	2446-2454 MHz	>500 mW-4 W e.i.r.p	≤ 15% duty cycle FHSS techniques should be used	No spacing	Power levels above 500 mW are restricted to be used inside the boundaries of a building and the duty cycle of all transmissions shall in this case be ≤15 % in any 200 ms period (30 ms on /170 ms off).
b1	865.0-865.6 MHz	100 mW e.r.p.	No requirement	200 kHz	
b2	865.6-867.6 MHz	2 W e.r.p.	No requirement	200 kHz	
b3	867.6-868.0 MHz	500 mW e.r.p.	No requirement	200 kHz	

Amos-3 Global Ku & Ka footprints; 1 Sat. covers 40 % of earth



Propagation loss: Profile Maccabim-Jerusalem



Free Space loss, power

PL=PropagationLoss; P_t=T_xPower, P_r=R_xPower; d=distance, λ=wavelength, A_e =Effective ant. area

Assuming g_r & g_t = 1, at d, power density = $\frac{P_t}{4\pi d^2}$

$$A_e = \frac{g_r \lambda^2}{4\pi}$$

$$PL = \frac{P_t}{P_r} = \frac{P_t}{\left[(P_t \div 4\pi d^2) \bullet \frac{\lambda^2}{4\pi}\right]} = \left(\frac{4\pi d}{\lambda}\right)^2$$

$$PL(dB) = 10\log\left(\frac{4\pi d}{\lambda}\right)^2 = 20\log\left(\frac{4\pi d}{\lambda}\right)$$

$$PL(dB) = 20\log(d_{kM} / \lambda_m) + 82 = 82 + 20\log d_{kM} - 20\log\lambda_m$$

$$PL(dB) = 20\log d_{kM} f_{MHz} + 32.44 = 32.44 + 20\log d_{kM} + 20\log f_{MHz}$$

$$E_0 = \frac{\sqrt{30 \cdot P_t \cdot g}}{d} = \frac{\sqrt{30 \cdot EiRP}}{d}$$

Radar free-space basic transmission loss

σ: radar target cross-section *d*: distance from the radar to the target λ: wave length

$$P_{TARGET} = PFD \cdot A_e = \left(\frac{G_T P_T}{4\pi d^2}\right) \times \sigma$$

$$P_{received} = \left(\frac{G_T P_T}{4\pi d^2}\right) \times \sigma \times \left(\frac{1}{4\pi d^2}\right) \times \left(\frac{G_T \lambda^2}{4\pi}\right) = P_{Transmit} G^2 \times \sigma \times \left(\frac{\lambda}{4\pi d^2}\right)^2 \frac{1}{4\pi}$$

$$P_{received} = P_{Transmit} \times G^2 \times \sigma \times \frac{\lambda^2}{(4\pi)^3 d^4}$$

d: distance (**kM**) *f* :frequency (MHz)

$$PL = 103.4 + 20 \log f + 40 \log d - 10 \log \sigma \quad \text{(dB)}$$

Doppler Shift

Signal scattered from target differs from the transmitter's frequency; *Doppler shift* depends on the range rate toward emitter

1 way *Doppler shift*

$$f_{doppler} = \frac{v_{close}}{\lambda} = f_{tr}\frac{v_{close}}{v_{signal}}$$

2 way *Doppler shift*

$$f_{doppler} = \frac{2v_{close}}{\lambda} = f_{tr}\frac{2v_{close}}{v_{signal}}$$

Ranging, Doppler Shift; Ambiguity balance

$2d = v \times \Delta t \quad \Delta t = 2d/v$

Ambiguity when $\Delta t = 2d/v = 1/prf$

$$f_{doppler} = \frac{2v_{close}}{\lambda} = f_{tr}\frac{2v_{close}}{v_{signal}}$$

Ambiguity $f_{doppler} = prf$

Caesar Vespasianus ,Flavius Josephus, Yodfat Siege

Regulation, ruling and fees of RF in Israel

Licenses, type-approval, acceptance & temporarily approvals

Like Europe in Region 1 , but American land mobiles

Fresnel zone

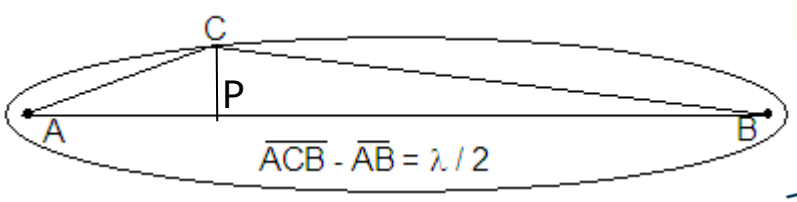
- The Fresnel zone is the ellipsoid that stretches between the two antennas; locus of points such that the difference between the direct path $\overline{AB}$ and the indirect path $\overline{ACB}$ is half the wavelength. λ = The wavelength of the transmitted signal F_n is the n^{th} Fresnel zone radius d ($\overline{AB}$)= d_1 ($\overline{PA}$)+ d_2 ($\overline{PB}$), F gets the same unit as λ, d_1 and d_2 (e.g. meter). Units: d_1 , d_2 , λ in metres

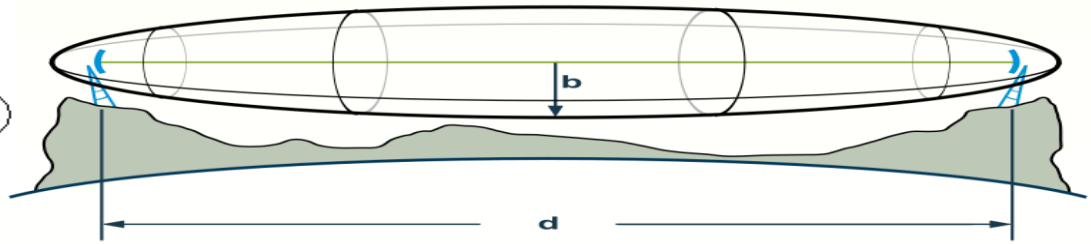
$$F_n = \sqrt{\frac{n\lambda d_1 d_2}{d_1 + d_2}} \qquad F_n = F_1\sqrt{n}$$

- For *f* : frequency (GHz); *d* , d_1, d_2: path lengths (km) F_1 is the radius of the first Fresnel ellipsoid, in metres F_3 is the radius of the third Fresnel ellipsoid, in metres

$$F_1 = 17.3\sqrt{\frac{d_1\, d_2}{f d}} \qquad F_3 = 30\sqrt{\frac{d_1\, d_2}{f d}}$$

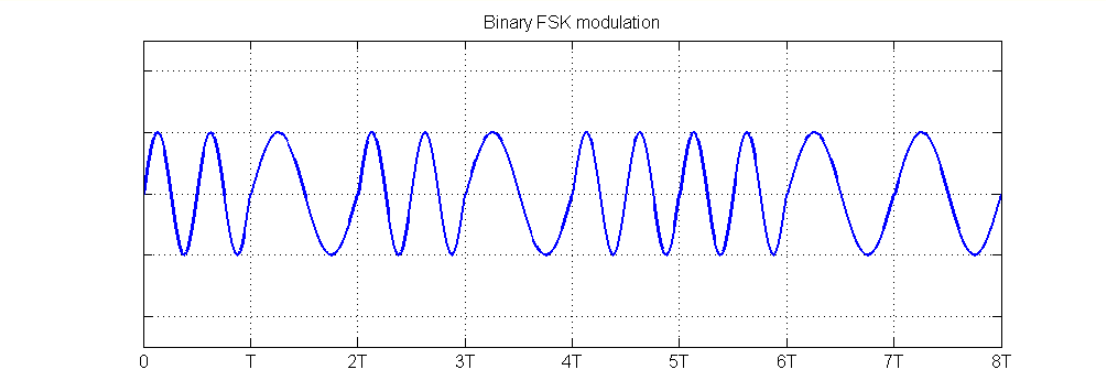
The First Fresnel zone *The Fresnel Ellipsoid*





University of Washington (John Burt, thru Sivan Toledo)

- RF 433 MHz to 434.79 MHz
- BW up to 1 MHz
- Modulation: FSK, MSK (similar Gaussian minimum shift keying; continuous phase frequency shift keyed (CPFSK), OOK (*On-off keying)*
- Power output 10 mW (10 dBm)



תודה על ההקשבה

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