AEM 617

Communications Systems

+

Navigation Systems

Navigation:

1) Visual reference to ground features

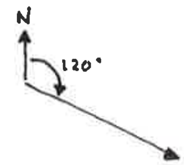
A 

Sectional Chart

2) Dead Reckoning

A —— 50nm 120° True / 95 kts ——→ B

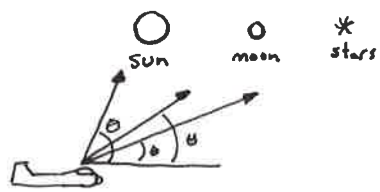
t: 31 minutes



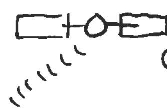
(E6B)

Note: Nautical mile (nm) ≡ 6076.1 ft ≠ 5280 ft

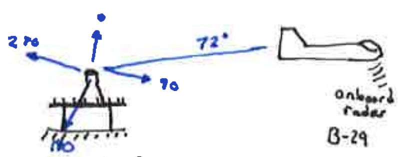
3) Celestial Navigation



4) Radio Communication



GPS array



VOR-DME

phase → azimuth and delay for distance

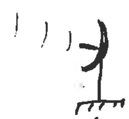
VHF ≈ 108 - 118 MHz

DME ≈ 1 GHz

NDB

Relative bearing

190 - 535 kHz



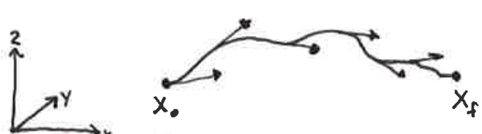
Radar

"Radar contact 5 miles South of airport"

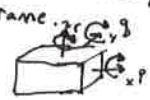
VHF radio

"Skyhawk 1523Y Requesting practice DF"

5) Inertial Navigation



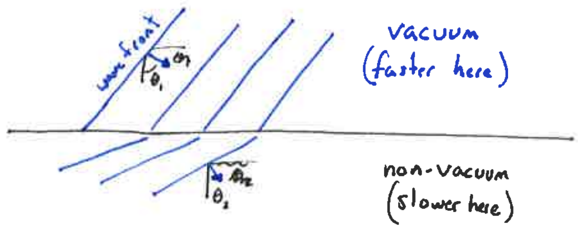
↑ Known initial position ⇒ Measure accelerations and rates in body frame. ⇒ Estimate current position



Antennas

Propagation speed of radio waves (vacuum) $\approx$ 299 792 458 $\frac{m}{s}$ $\equiv c$

In a non-vacuum, propagation is slower than c. For transparent materials, the index of refraction is the ratio of c to v. $(n = \frac{c}{v})$ This is the same as the index of refraction in optics (as can be easily shown)



Snell's law

$n_1 \sin\theta_1 = n_2 \sin\theta_2$

At 589nm ("Sodium doublet" absorption lines in light spectrum from Na), the refractive index for air is 1.0003. Thus the propagation of radio signals is $\approx$ 299 700 000 m/s . (90000 m/s slower)
$\approx 2.997 \times 10^8$

Aside: (Maybe try at home.... be careful) You can see exactly the Na doublet easily.

1) NaCl + H_2O
2) wick of a paper towel piece rolled up
3) lighter + drip wick in flame.
4) Watch 589nm around outside of flame.

In H_2O, n = 1.33. In a diamond, n = 2.419.

EMF wavelength

$c = \lambda f$ "wavelength times frequency is a constant"
(↑ technically $v = \frac{c}{n}$)

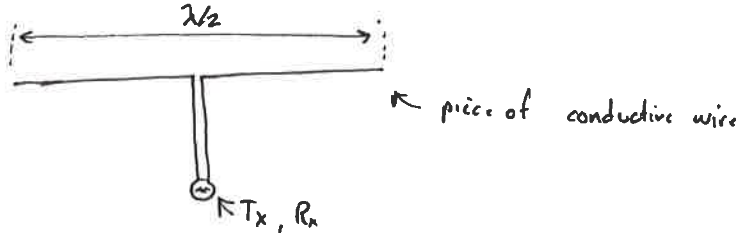
- So 589nm is a frequency of $f = \frac{c}{\lambda} = \frac{299700000 \, m/s}{589 \times 10^{-9} \, m} = \frac{2.997 \times 10^8}{589 \times 10^{-9}} = 5.09 \times 10^{14} \frac{1}{s}$
  $\approx 509000.\,GHz!$
  $\approx 0.5\,pHz$

- A 108 MHz VOR station has a wavelength of $\lambda = \frac{c}{f} = \frac{2.997 \times 10^8 \, m/s}{108 \times 10^6 \, 1/s} =$
  $= 2.78\,m \approx$ 109 inches

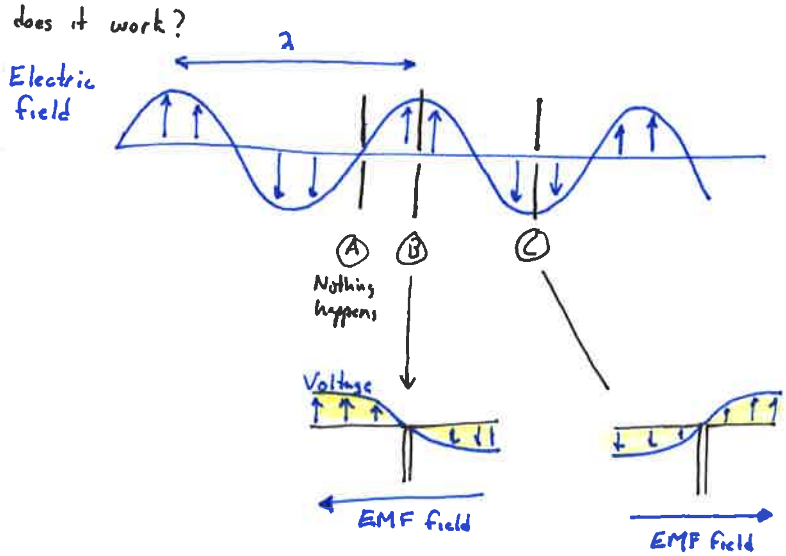
- An NDB at KELK on 243 kHz has a wavelength of
  $\lambda = \frac{c}{f} = \frac{2.997 \times 10^8 \, m/s}{243 \times 10^3 \, 1/s} = 1230\,m \approx 4000\,ft$

One nano second

Dipole Antenna



How does it work?

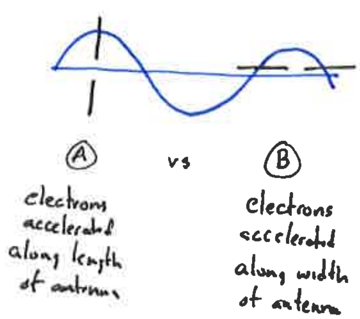


Think of the electric field as pushing electrons back and forth ~~across~~ along wire.

These standing waves of voltage also have a corresponding current.

Radiation pattern

The dipole is strongly directional



In fact the dipole has a pattern shaped like a torus

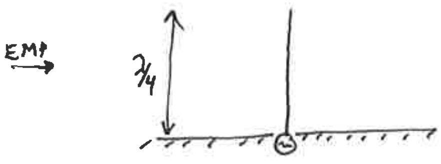
Length:

Wire diameter slightly changes the length

$$L \approx \frac{1}{2} k \frac{c}{f} = \frac{1}{2} k \lambda \quad \text{with} \quad k \approx 0.95$$

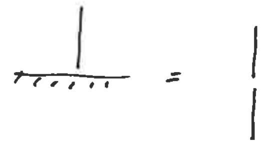
$$L_{[m]} \approx \frac{468}{f_{[MHz]}}$$

Monopole Antenna (1/4 wave monopole) ("Marconi" antenna)



Infinite Ground plane.

Considering symmetry, this is just half of a 1/2 wave dipole

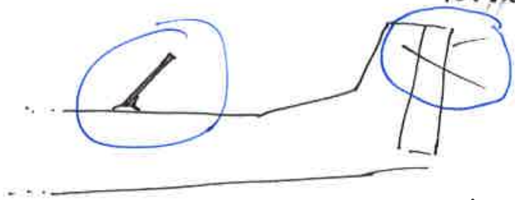


Length:

$\lambda/4$

practical

- VOR at 108 MHz $L = \frac{1}{4} k \frac{c}{f} = \frac{1}{4}\, 0.95\, \frac{2.997\times10^8}{108\times10^6} = 0.694\,\text{m} \approx 27$ inches



1/4 · 0.95 · 2.997×10^8 / 1.0×10^6 converted to inches.

- NDB at 243 KHz $L_{[in]} \approx \frac{2800}{f_{[MHz]}} = \frac{2800}{0.243} = 11500^{in}$

Ever see this? NDB antennas use a different method!!

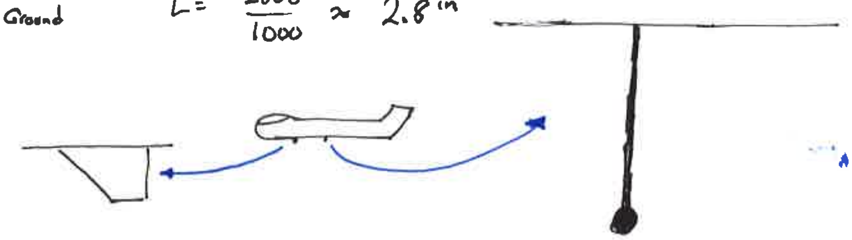
Loop seen on older aircraft

- Transponder

  1030 MHz Gnd to plane

  1090 MHz plane to Ground

$L = \frac{2800}{1000} \approx 2.8^{in}$



- Glide slope

  ≈ 330 MHz $\approx 8.5^{in}$

- Marker Beacon

  75 MHz $\approx 37^{in}$

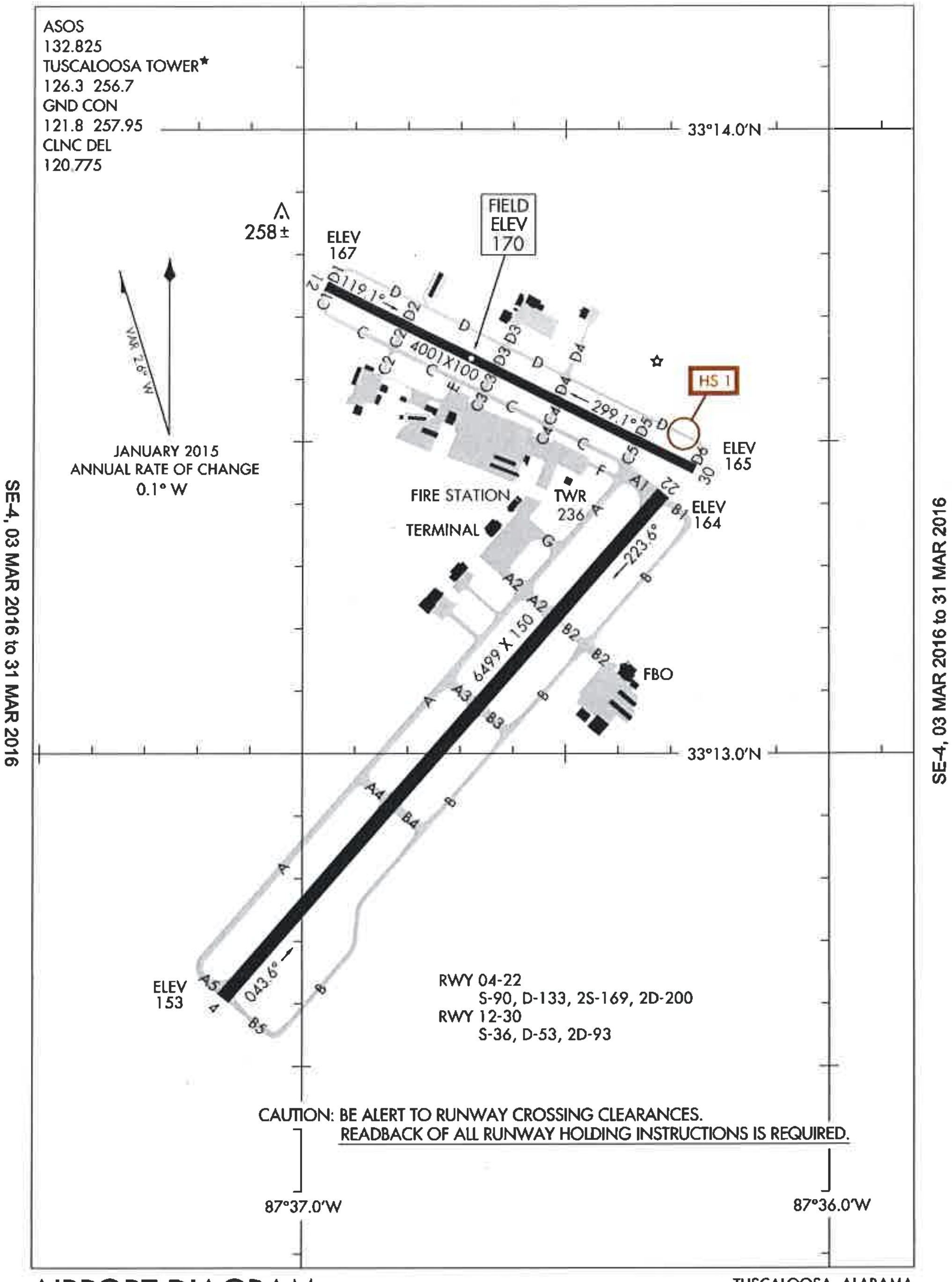
often a "bent" antenna

Marker beacon station is directional (up!!)

AIRPORT DIAGRAM

AL-487 (FAA)

TUSCALOOSA RGNL (TCL)
TUSCALOOSA, ALABAMA



SE-4, 03 MAR 2016 to 31 MAR 2016

AIRPORT DIAGRAM
15232
TUSCALOOSA, ALABAMA
TUSCALOOSA RGNL (TCL)

ILS or LOC RWY 4
TUSCALOOSA RGNL (TCL)

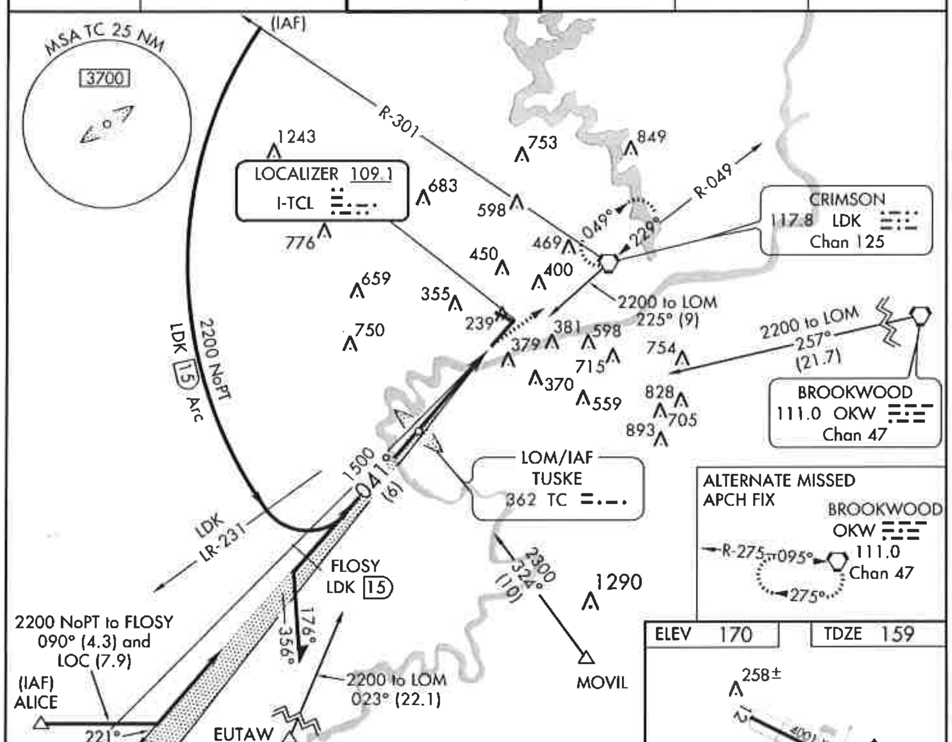
LOC I-TCL	APP CRS	Rwy ldg	6499
109.1	041°	TDZE	159
		Apt Elev	170

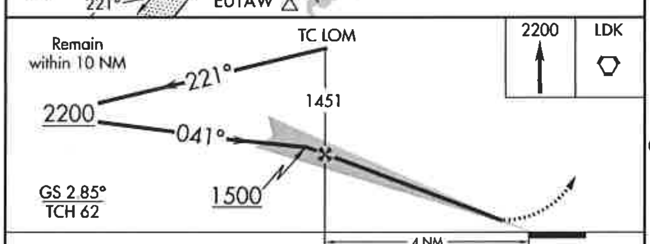
When local altimeter setting not received, use Birmingham altimeter setting and increase all DA/MDA 180 feet and increase S-ILS 4 visibility ¼ mile and S-LOC 4 Cats C/D and Circling Cats C/D visibility ½ mile. For inop MALSR when using local altimeter setting, increase S-LOC 4 Cat C/D visibility to 1 mile. Night landing: Rwy 12, 30 NA.

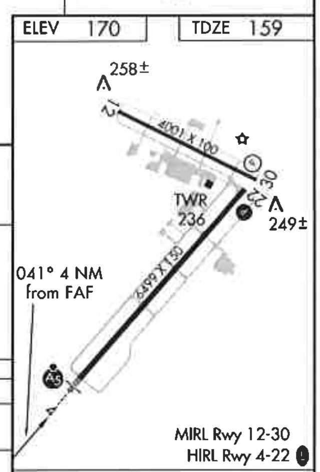
MALSR

MISSED APPROACH: Climb to 2200 direct LDK VORTAC and hold.

ASOS	BIRMINGHAM APP CON	TUSCALOOSA TOWER ★	GND CON	CLNC DEL	UNICOM
132.825	120.15 257.2	126.3(CTAF) 256.7	121.8 257.95	120.775	122.95







CATEGORY	A	B	C	D
S-ILS 4	359-½ 200 (200-½)			
S-LOC 4	520-½ 361 (400-½)		520-⅝ 361 (400-⅝)	
CIRCLING	800-1 630 (700-1)		800-1¾ 630 (700-1¾)	800-2 630 (700-2)

FAF to MAP 4 NM

Knots	60	90	120	150	180
Min:Sec	4:00	2:40	2:00	1:36	1:20

SE-4, 03 MAR 2016 to 31 MAR 2016