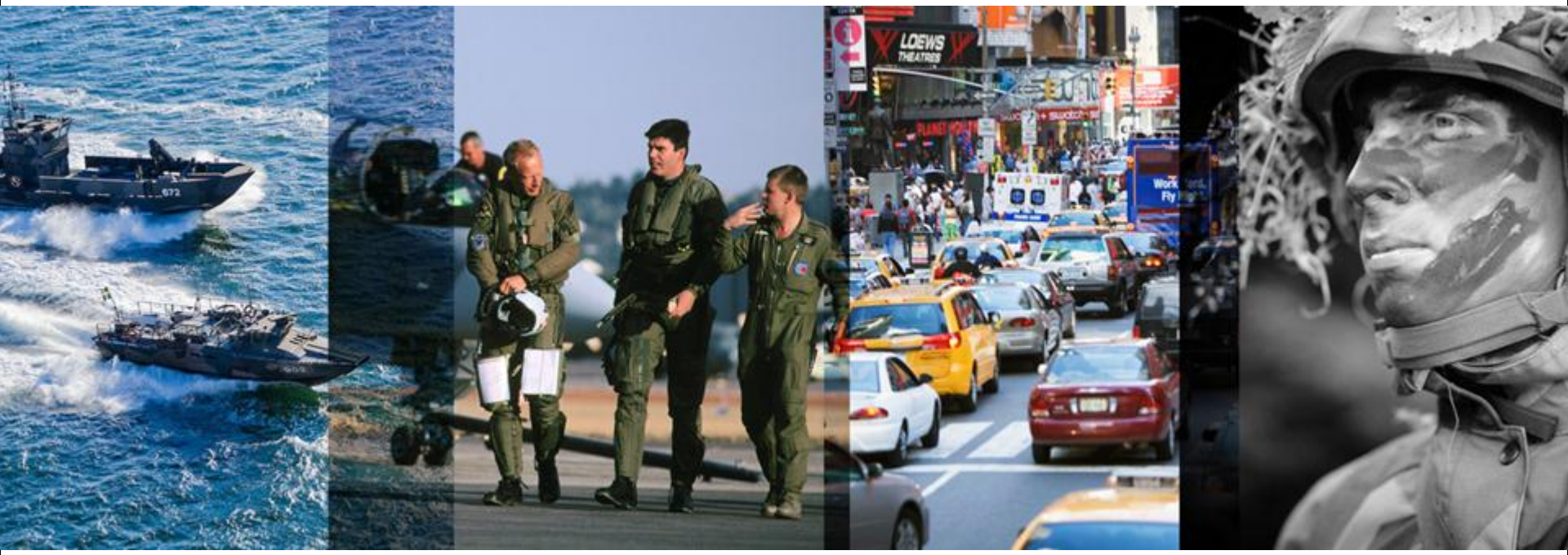
On the Move NVIS communications: Fact or Fiction



André van Heerden
SAAB SYSTEMS GRINTEK
JULY 2011

The Requirement

Reliable Beyond Line Of Sight (BLOS) communications while On The Move (OTM)

Over tactical ranges

Over all types of terrain

At all times of the day or night

Using vehicle mounted antennas that meet the vehicle's operational requirement

OTM & BLOS Communications Options

V/UHF using a ground based repeater system

V/U/SHF using a satellite or airborne repeater system

HF Near Vertical Incident sky-wave (NVIS) propagation

The HF Option

Currently HF remains the most cost effective mode for OTM and BLOS tactical communications

However HF mobile is often found to be unreliable

especially at night

and over the critical 20km to 100km range

Factors affecting the success of mobile NVIS HF communications

Correct frequency allocation for the TOD

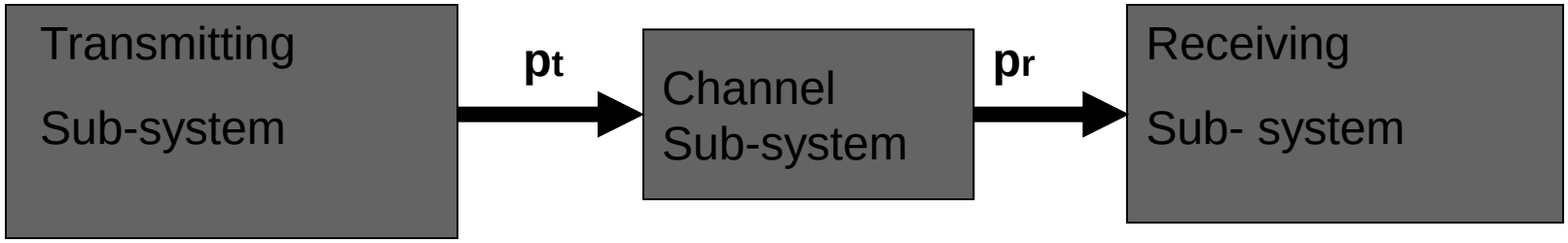
Level of noise and interference

Solar and seasonal effects on the path loss

Correctly installed radio equipment

Antenna system used

The HF Communications System



The channel sub-system is composed of:

The TX & RX antennas and their Antenna Matching Units (AMU)

The propagation medium (The ionospheric path)

The main channel losses occur in the antenna matching to the propagation medium and over the propagation path.

Antenna Matching to the Propagation Medium

The role of the antenna and its impact on HF link performance

Tactical HF antennas on mobile platforms are electrically small. The physical size of the antenna is **<<** than the operational wavelength.

An AMU is required to allow an electrically short antenna to be used over a wide frequency range. The role of the AMU is to match the complex impedance of the antenna to the requirements of the Transceiver, usually 50 ohms resistive.

Small HF antennas and AMU's exhibit loss resistance that impacts negatively on the radiation efficiency of the communications system, especially at low frequencies.

HF Antenna Options for Small Mobile Platforms

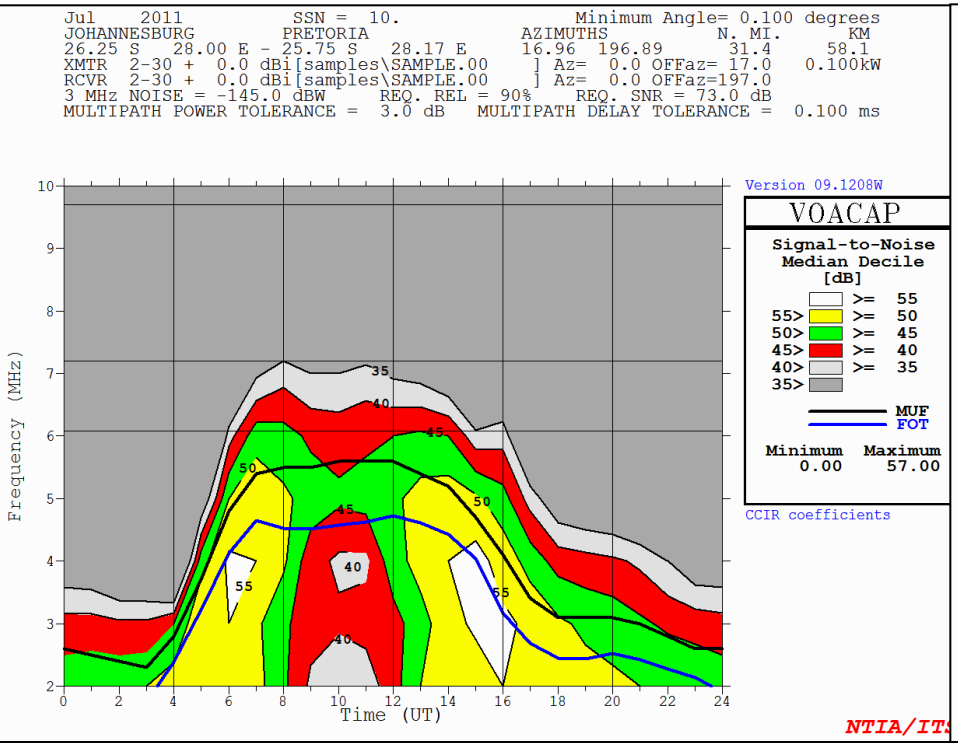
- Whip antenna (2.7m to 10m)
- Small vertically mounted loop antenna (Area 1 m^2 – 3 m^2)

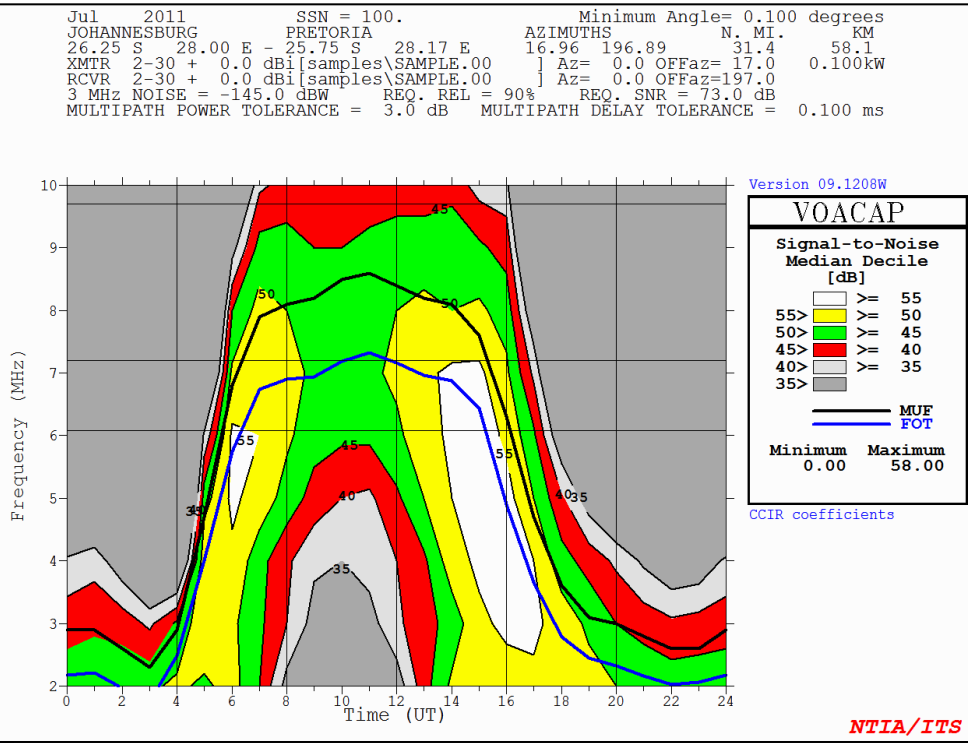
The radiation efficiency of both these antenna types is only a few percent at low frequencies.

Night time NVIS requires the use of low frequencies

Resonate Dipole @ 3MHz ~45m in length

NVIS Frequencies

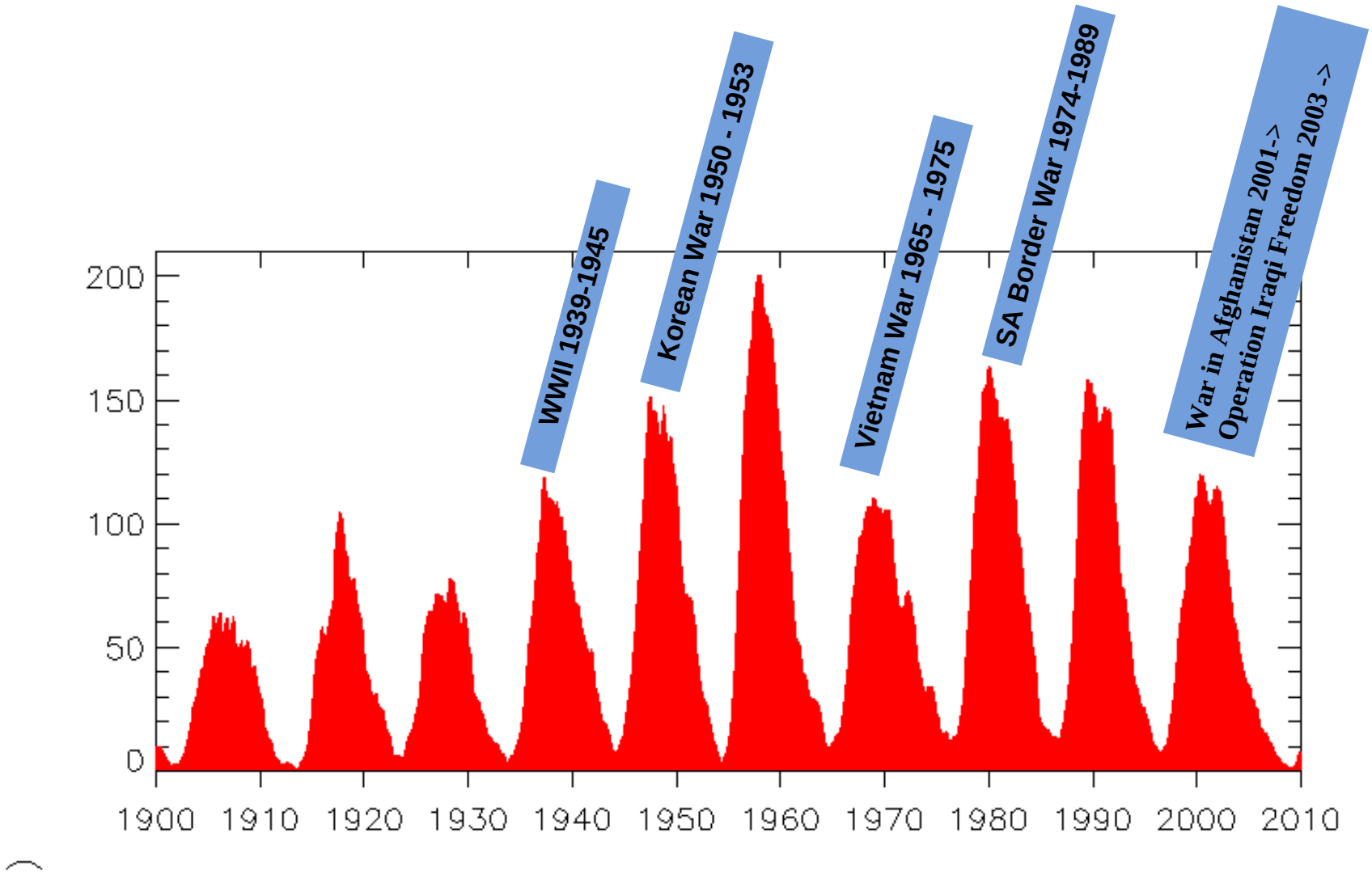




Low Sunspot

High Sunspot

Sunspot number during conflicts



Whip Antenna Characteristics

Vertical polarisation

Narrow tuned bandwidth at low frequencies

Omnidirectional radiation pattern

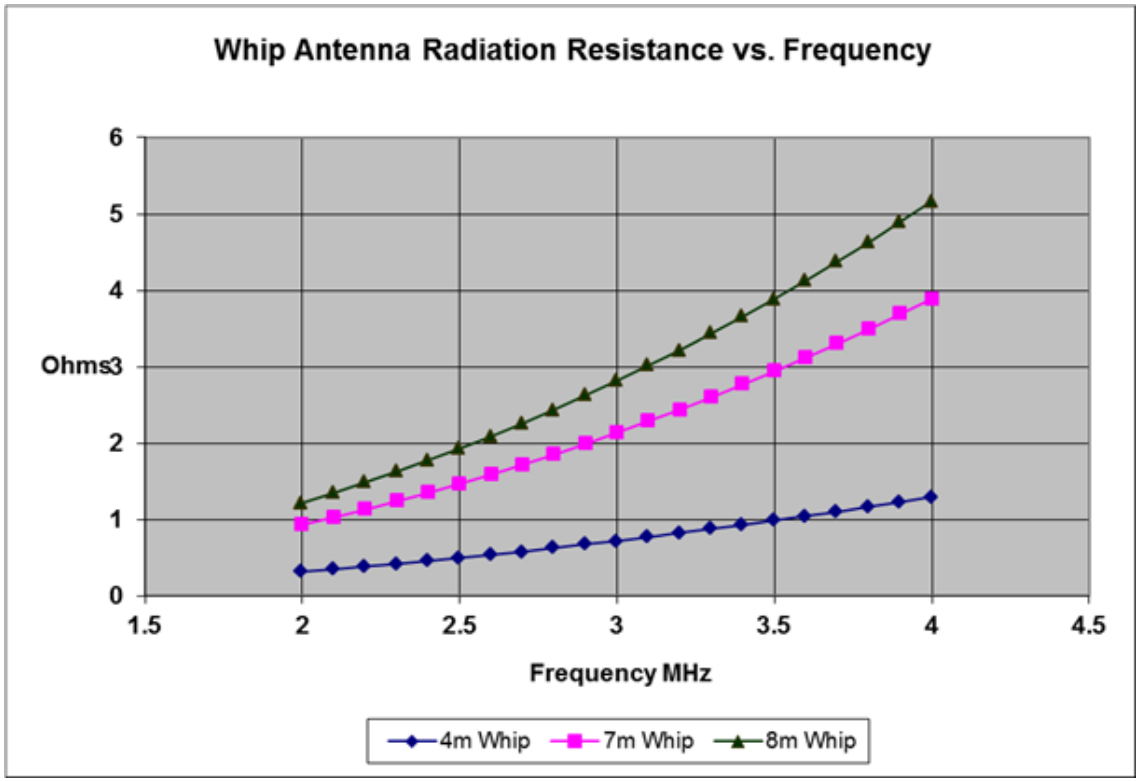
Radiation pattern has a deep null towards the Zenith

Efficiency increases with antenna length and frequency

Mechanically vulnerable

Tuning is influenced by antenna movement

Whip Length?

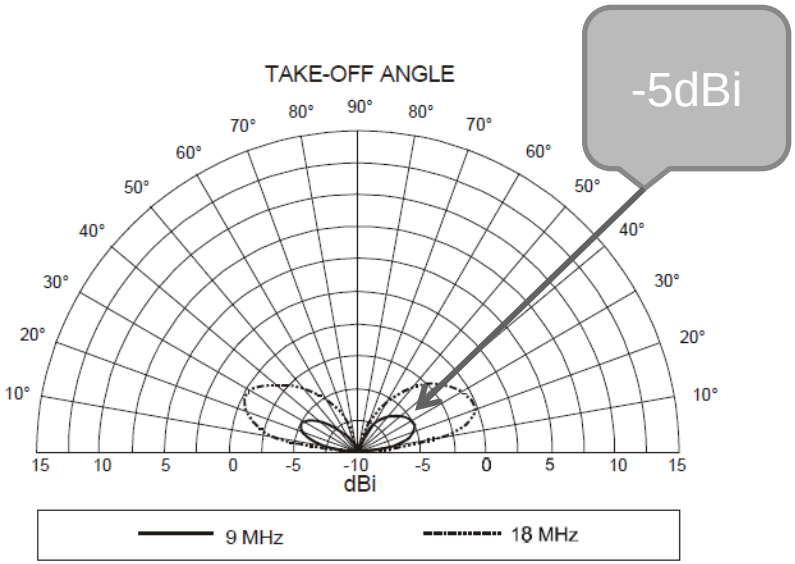


NEC (Numerical Electromagnet Code) Modelling

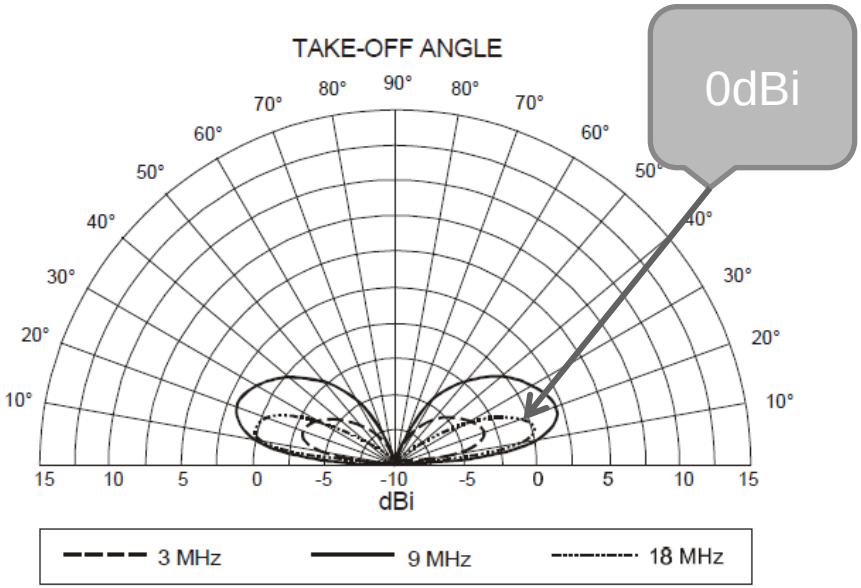
The higher the radiation Resistance the easier the AMU can match the Whip.

Longer the Whip the better the performance !

Whip Length Radiation Efficiency



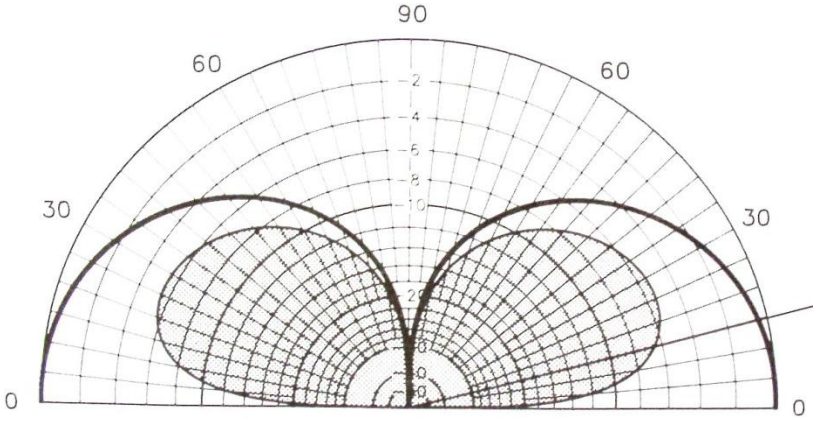
3m Whip antenna



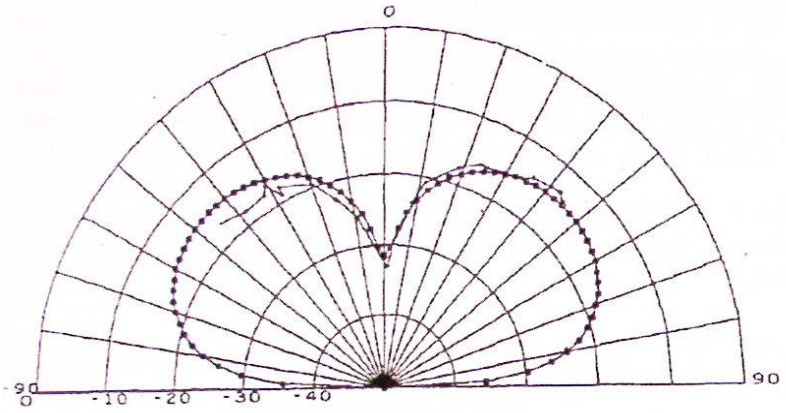
10m Whip antenna

Whip Antenna
Radiation in the Vertical Plane

Calculated
Perfect and good ground



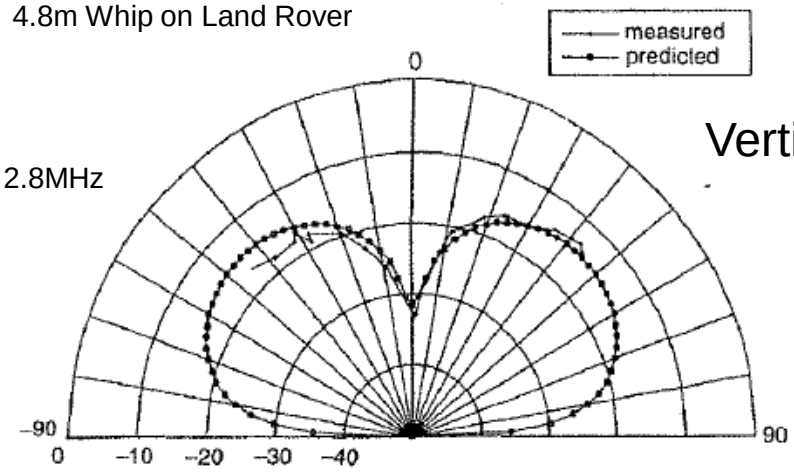
Measured
Good Ground at 2.755MHz

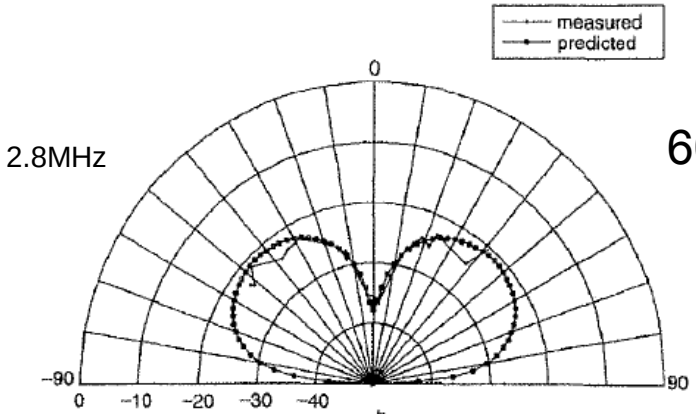


Bend the Whip?

What happens if we bend the whip forward?

4.8m Whip on Land Rover





Low Frequencies: **NOT GOOD**

At the lowest frequencies the whole vehicle whip combination behaves as the radiating device. The reason is that the whip is so short - and hence is very inefficient and becomes even less efficient with increasing tilt angle. The vehicle then radiates like a very short horizontal dipole. Tilting the whip forward tends to kill its radiation resistance because of the anti-phase current induced into the vehicle and the greater the tilt the worse it becomes because of the close anti-phase coupling.

Dr Brian Austin, University of Liverpool

What happens if we bend the whip backwards?

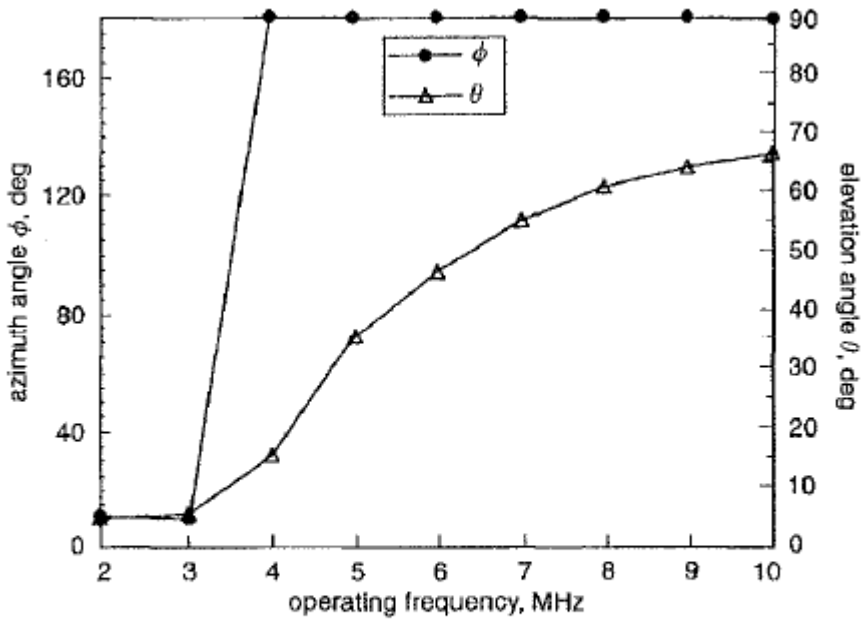
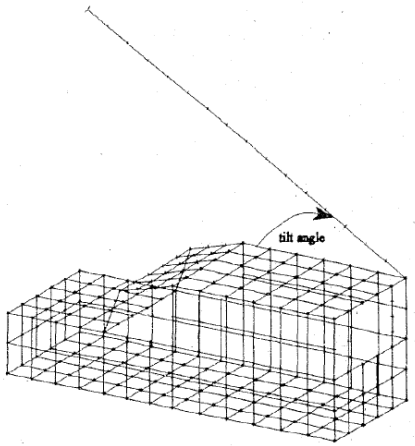


Fig. 3 *Optimum orientation of a 4.8 m whip mounted on a vehicle with respect to frequency*
$\theta = 0°$ corresponds to a vertical whip; $\phi = 180°$ to a rearwards pointing whip



2 – 3MHz : Vertical

5MHz: 35˚ Rearwards

10MHz: 65˚ Rearwards

Dr Brian Austin, University of Liverpool

What does the operating manual say?

USMC Field Antenna Handbook MCRP 6-22D

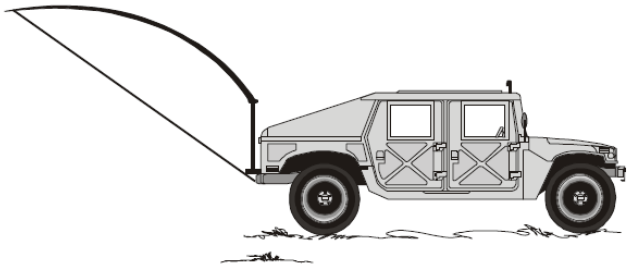


Figure 4-34. AN/MRC-138 with NVIS Antenna.

Tilt antenna at least 30 ˚

Tactical Single Channel Radio Communications Techniques, FM 24-18

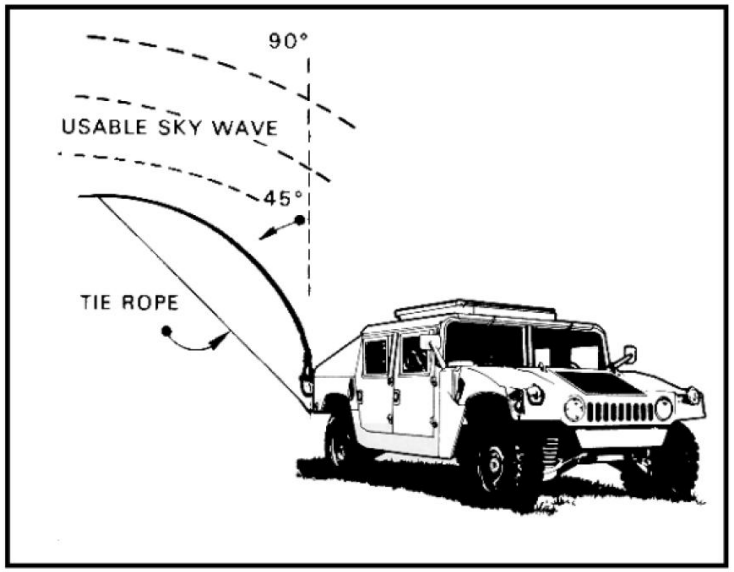


Figure M-9. Tying the whip antenna down.

Vertical Loop Antenna - Advantages

Ideal NVIS radiation pattern. No Zenith null

Low profile – less than 0,8m high

Can be made mechanically very robust

Omnidirectional NVIS radiation pattern

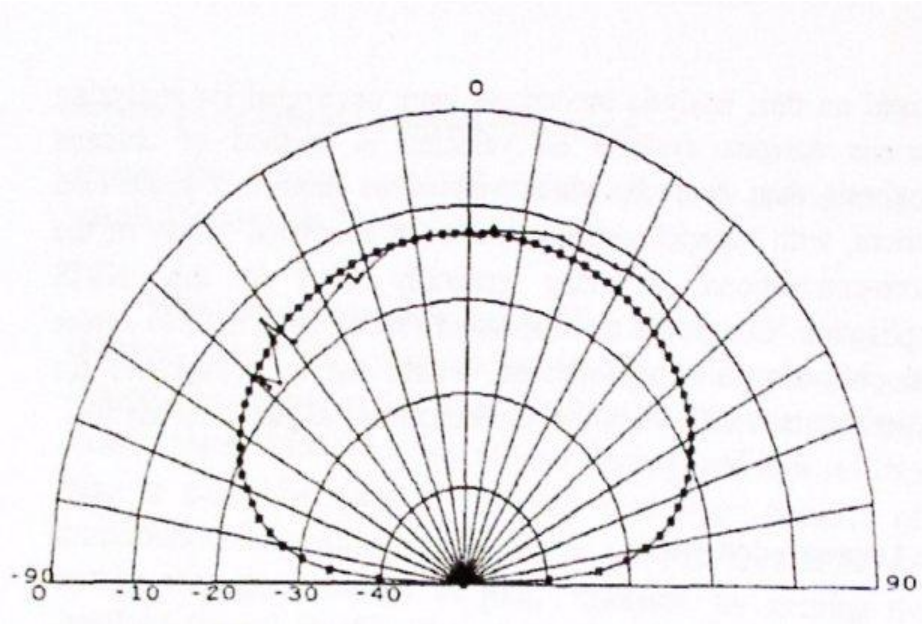
The loop antenna can be characterised

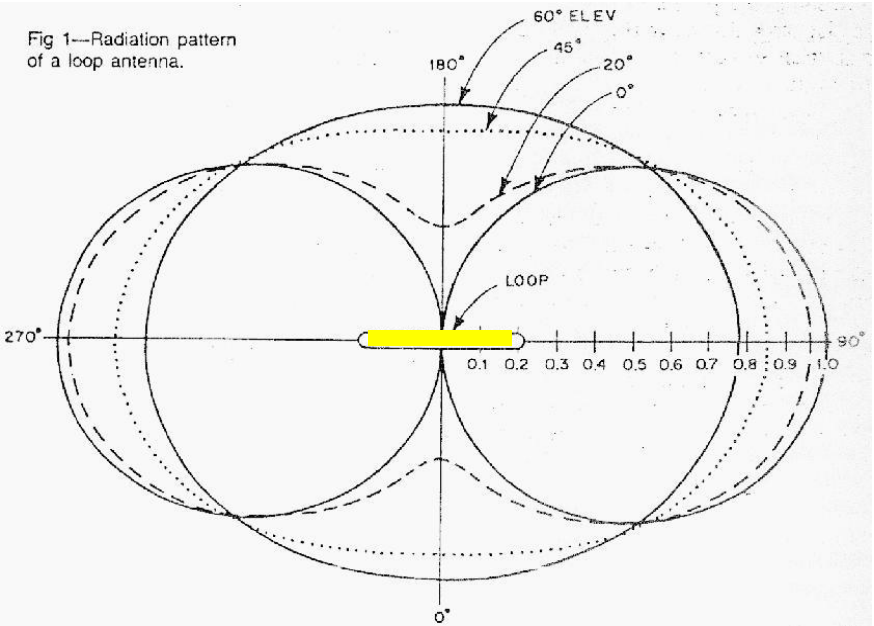
Narrow tuned bandwidth at all frequencies

Vertical Loop Antenna
Radiation in the Vertical & Horizontal plane

Vertical

Horizontal





Vertical Loop Antenna
Special features

Characterisation allows the silent & rapid recall of any frequency.

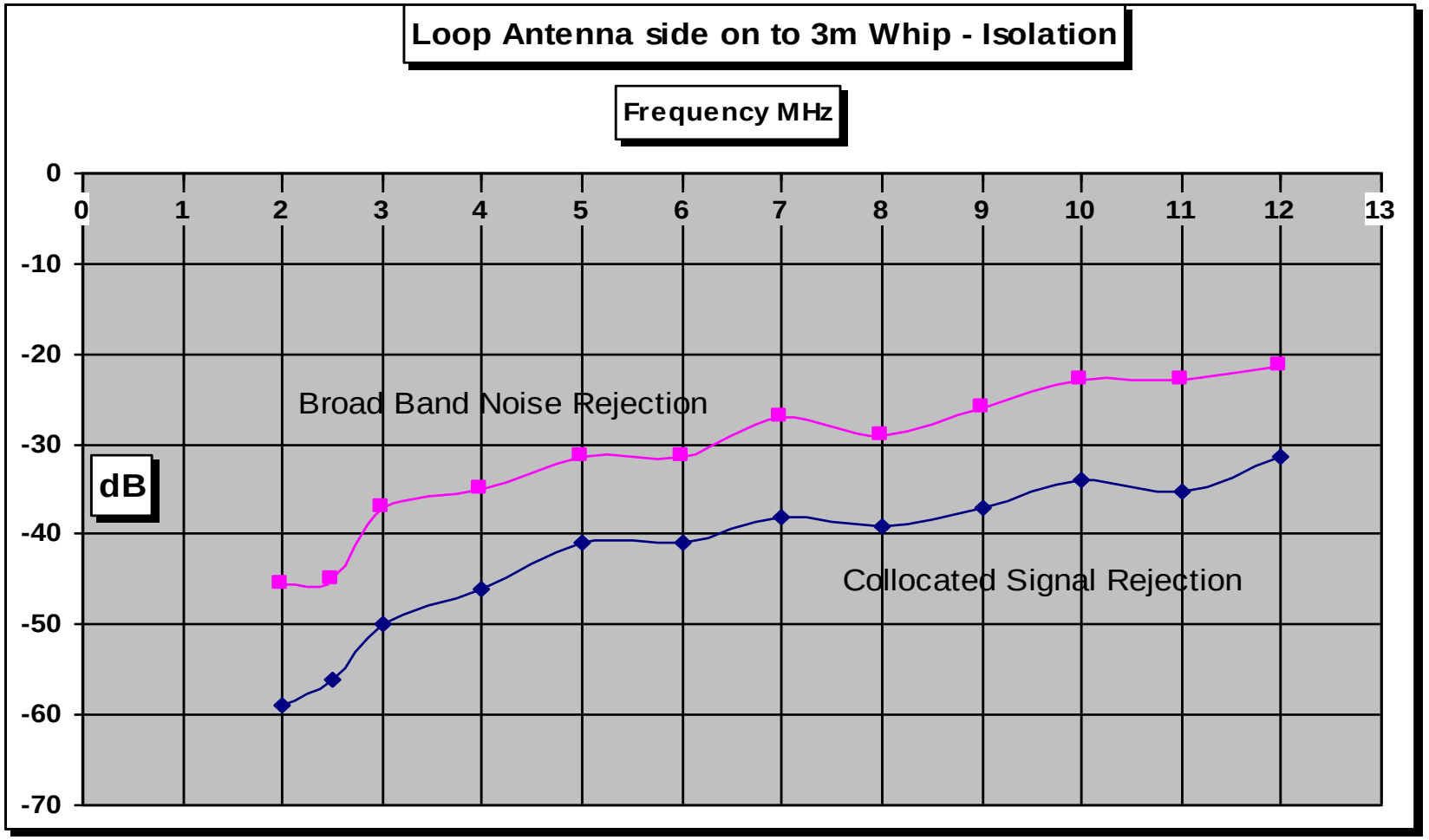
Frequency Agile : ECCM & ALE

The deep null in the low angle radiation pattern and high operating Q make the Loop Antenna an ideal collocated antenna.

The loop acts as a high power pre-selector reducing transmitter spurious radiation and noise and enhancing receiver performance.

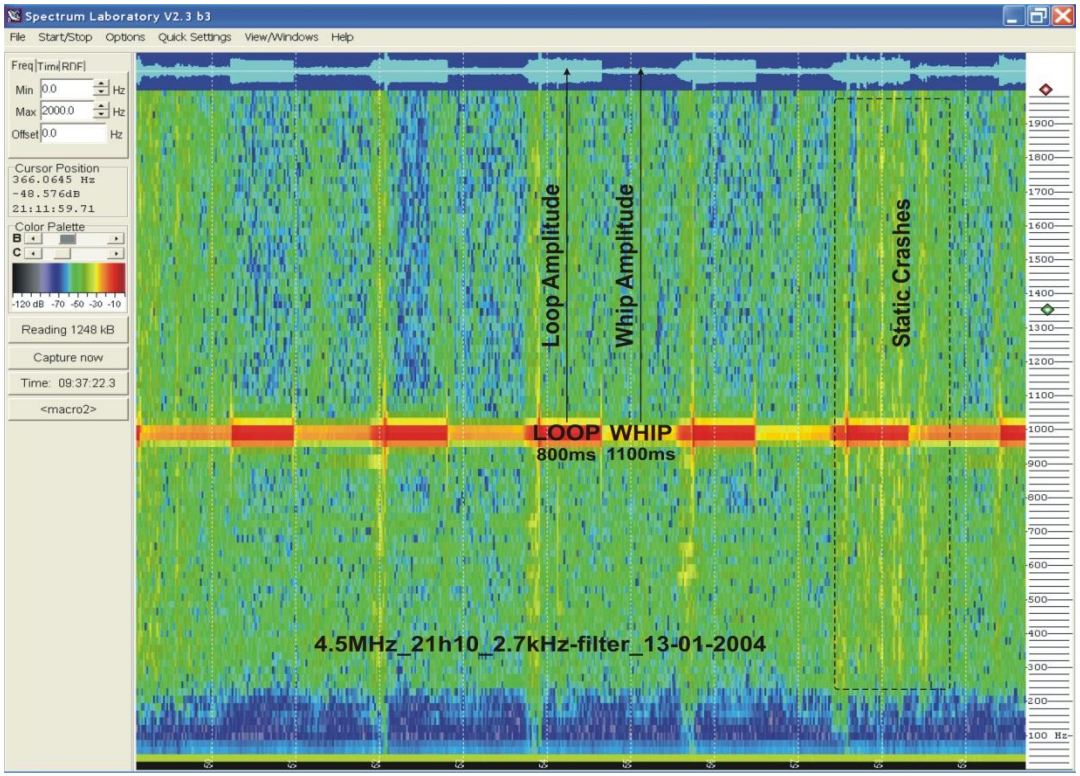
Whip/Loop Collocated Antenna Isolation

1,5m apart - 10% Frequency Separation



Vertical Loop & 3m Whip Antenna signal strength comparison over a 25km NVIS Path

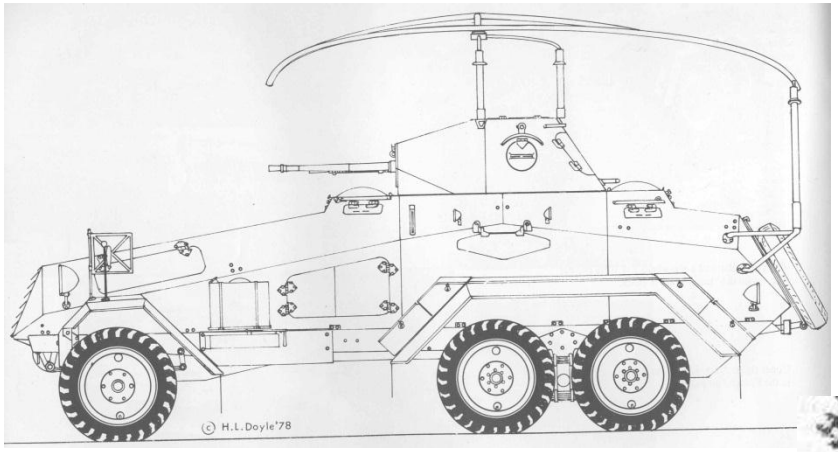
Loop / whip transmitting alternately at a 0,8s - 1,1s rate

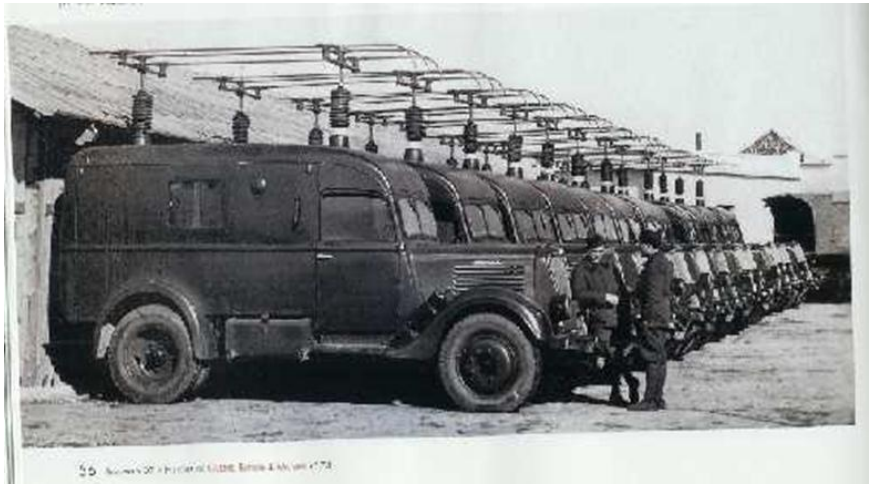


Test Frequency MHz	Loop Antenna Gain over the 3m Whip
2.13	>25dB
2.499	18dB to 20dB
3.0	18dB to 20dB
3.5	14dB to 18dB
4	16dB to 20dB
4.5	12dB to 18dB
5.005	10dB to 16dB
5.451	10dB to 14dB
6	10dB to 12dB
6.505	10dB to 12dB

Current and Past
NVIS
OTM Communications

WW II





PRESENT


Deployed
Frequency Range: 3.0 - 15.0 MHz
Unit Weight: 15kg excluding fixings
Retracted: 1.7m x .95m x .12m
Deployed: 1m height

Harris Corporation

HARRIS

Progress in OTM Loop Antennas

M.J. Packer
Harris Corporation,
RF Communication Division
1680 University Avenue, Rochester, NY, USA, 14610
mpacker@harris.com

SAAB

Background

HARRIS

- Continuous Search for the Better OTM HF Antenna
- Today's Communication Environment
  - Dry Deserts to Rugged Mountains limits LOS
  - Limited Satellite Bandwidth
  - Users Want to Own & Control Hardware
  - Repeaters are Vulnerable
- Users Perception – Small Cellular Phone talks around the world

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Vehicular Loop Antennas

HARRIS

2005 Half-Loop

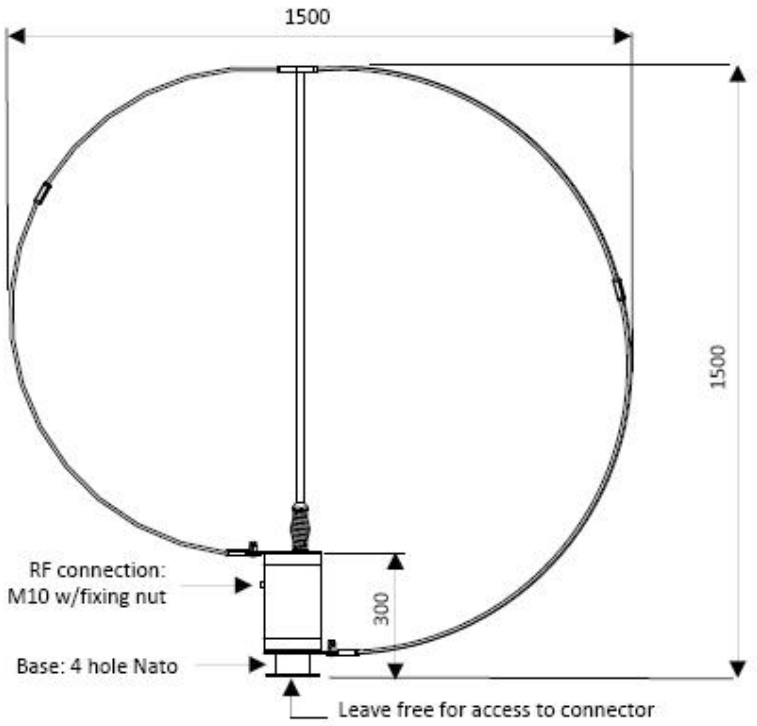
2009 Full-Loop

SAAB

COMROD

HF230L_OTM

HF NVIS Loop Antenna



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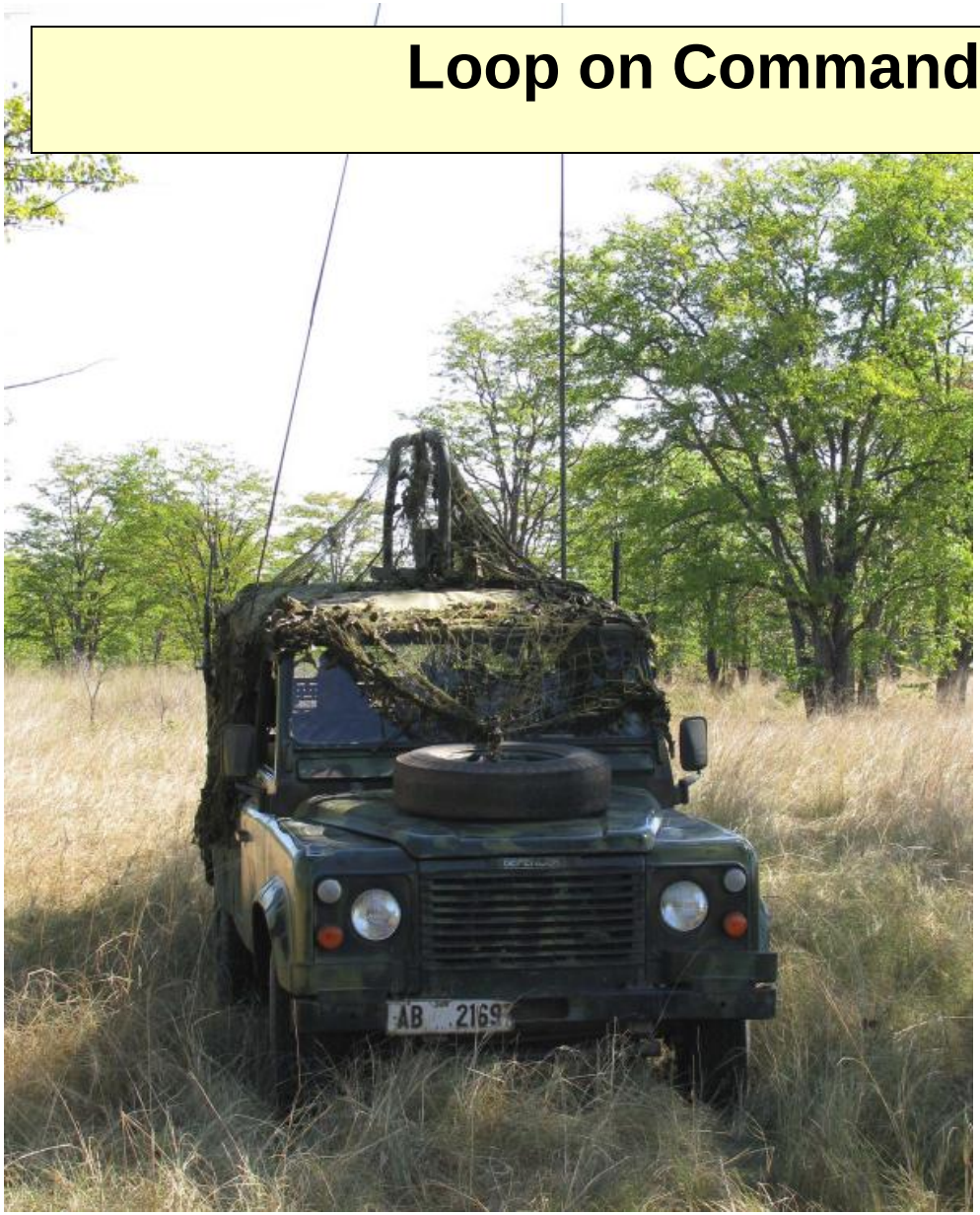
SAAB SYSTEMS GRINTEK

- Lightweight ATU
- Tune Half-Loop Antenna
- 2MHz to 15MHz
- Frequency Agile

AT2222

Loop on SUV

Loop on Command Land Rover



Loop on High Speed Boat

Loop on High Speed Boat

Loop on High Speed Boat

Points to Remember

"You have to know something about HF to use it"

LTC David M Fiedler – US Army

"Nature and Man are the sources of all engineering problems."

Nicholas Maslin - HF Communications A Systems Approach

Conclusion

"Matching World Class Solutions to Shrinking Budgets"

Using: Correct Frequency and antenna deployment

HF
Can provide reliable
Beyond Line Of Sight (BLOS) communications
while On The Move (OTM)

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Thank You