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# Escaping the ‘Dead Zone’: a bottleneck in humanitarian ionospheric radio communications

**Dr. ing. Ben Witvliet** [wit-fleet]
**University of Twente, The Netherlands**

Session: Communications-based Applications and Issues
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# Introduction

# Telecommunication

Transport of information over distances that we cannot bridge with our own physical means (voice, gestures).

# Telecommunication is essential to society

Transport of information over distances that we cannot bridge with our own physical means (voice, gestures).

**Indispensable for**

- Decisions that depend on information from beyond our physical horizon.
- Coordination with others that are beyond our physical horizon.

# Telecommunication after major disasters

**What if all infrastructure is destroyed ?**

Hurricane + flooding, New Orleans, 2005

No communication, no electricity, no roads

Massive earthquake, Nepal, 2015

No communication, no electricity, no roads

# Telecommunication in poor and remote areas

**What if you'd live in an area that never had such infrastructure at all ?**

Flying Medical Services, Tanzania

No communication, no electricity, (no roads)

Médecins sans Frontières, D. R. Congo

No communication, no electricity, (no roads)

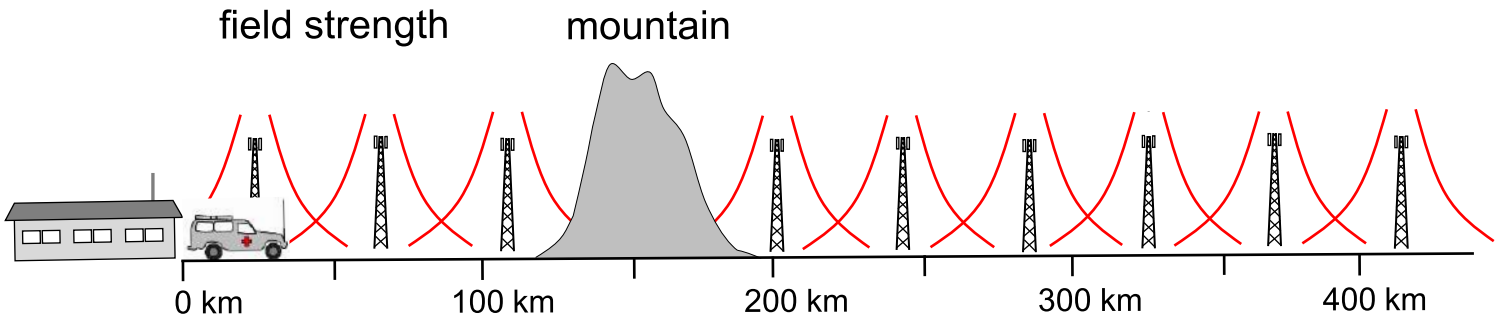
# Ionospheric radio communication

# Cell-phone

## Dense network of base stations and cell towers

Requires $$$ (and time) to install and maintain

Natural obstacles reduce coverage

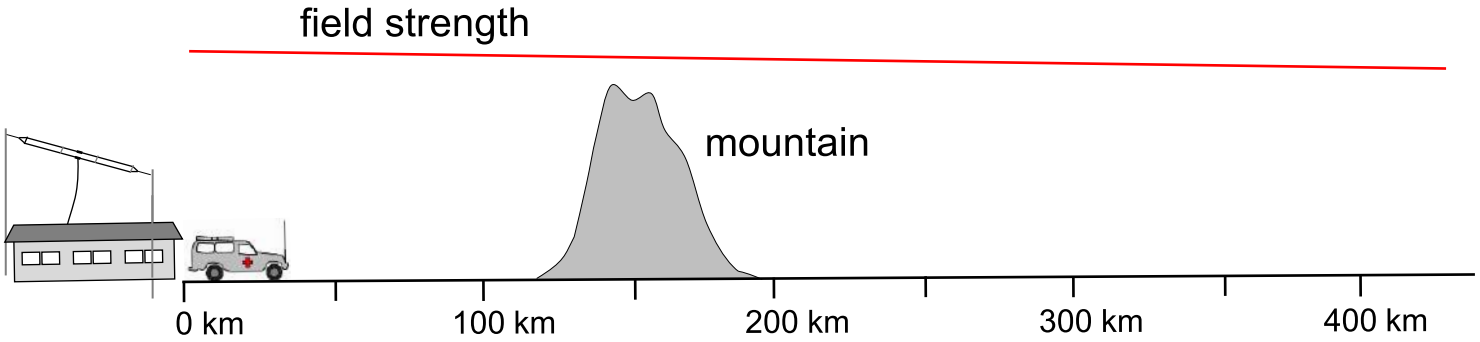


# Ionospheric radio

## Single station will cover the entire area

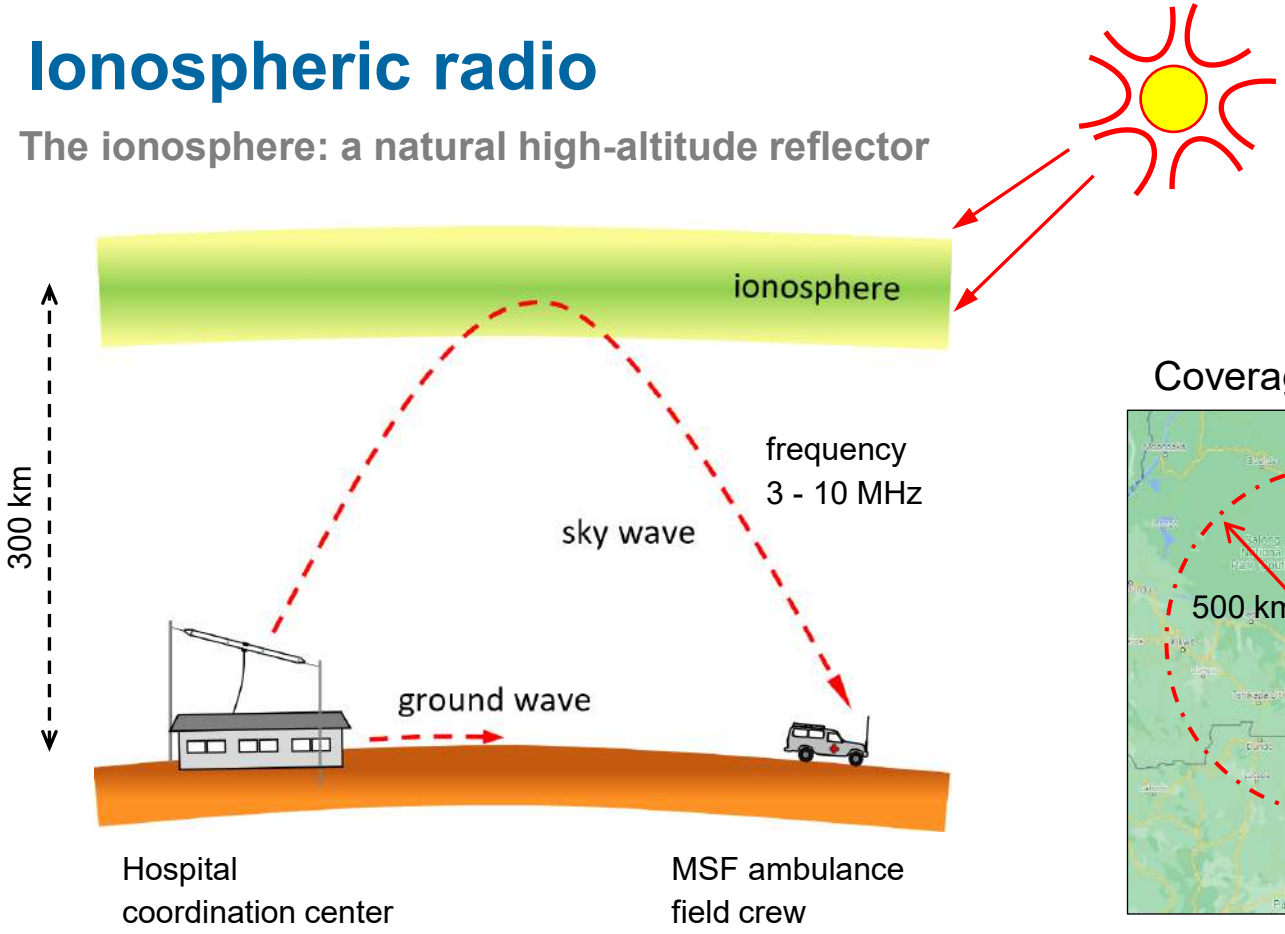
Fast activation, cheap, no toll fees

Independent of terrain, independent of third parties

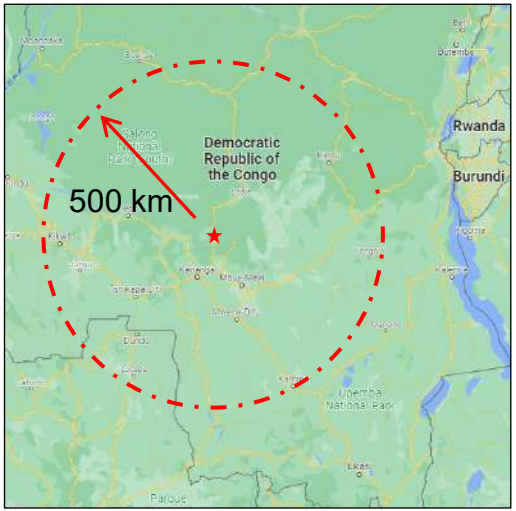


# Ionospheric radio

## The ionosphere: a natural high-altitude reflector




Coverage area (example)



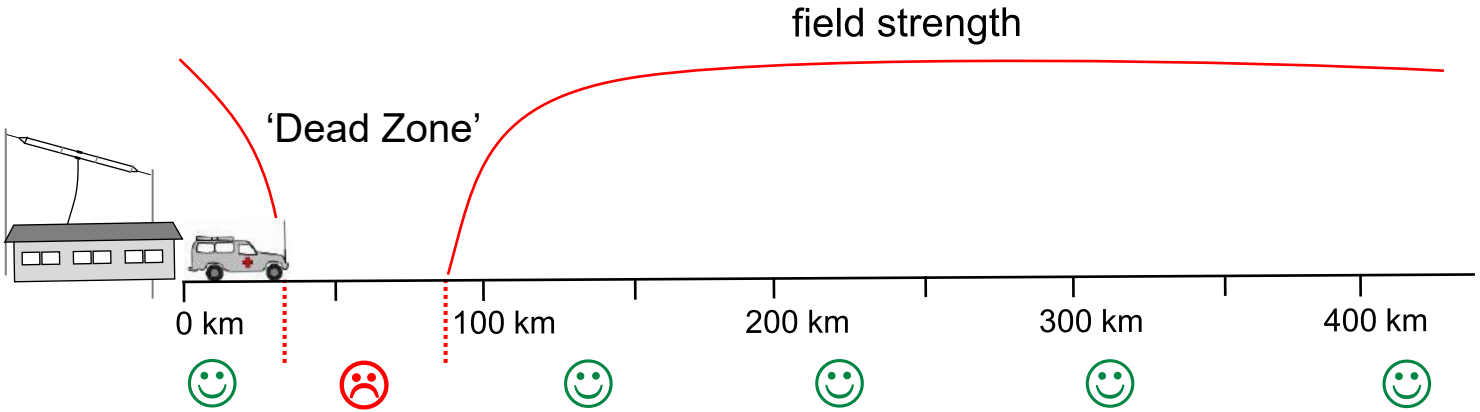
# ‘Dead Zone’ problem

# The ‘Dead Zone’ problem

## A security threat for MSF staff and clients

*Central African Republic, Mali, Guinée Conakry*
*Mozambique, Afghanistan*

MSF is active in
49 LMIC countries



# Mitigation requires understanding

**What is the cause ?  What are the drivers ?**

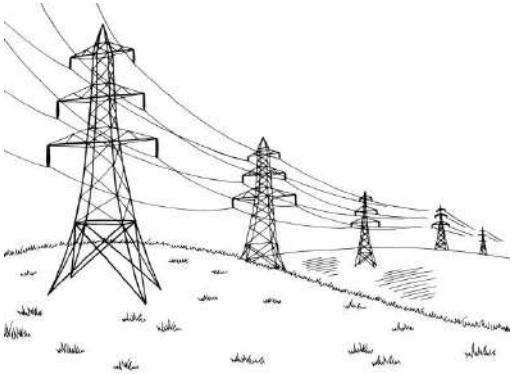
**Possible causes**

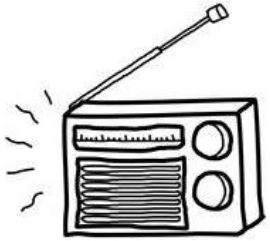
1. Ambient electromagnetic noise
2. Propagation above the critical frequency of the ionosphere
3. Antenna characteristics

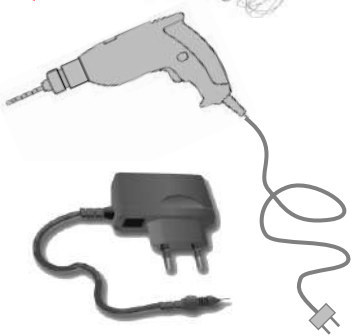
These issues have been investigated *theoretically,*
to prepare for verification measurements and mitigation trials.

# 1. Ambient electromagnetic noise

# Ambient electromagnetic noise

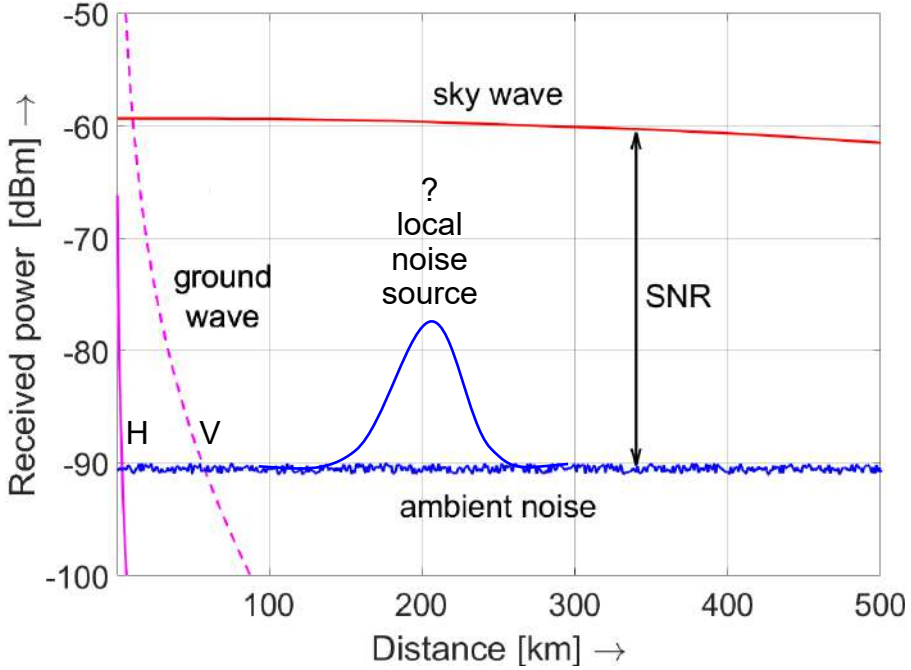






Radio noise caused by lightning and man-made appliances

# Ambient electromagnetic noise




Simulated signal strength assuming isotropic antennas:

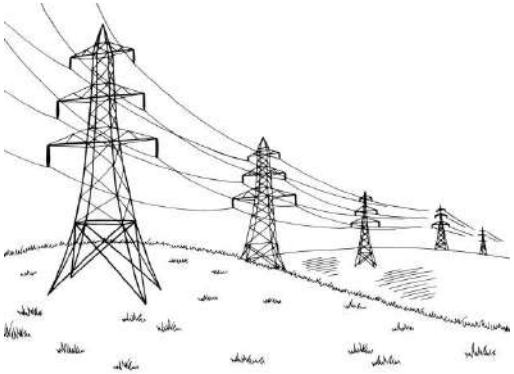
- Sky wave (PropLab Pro)
- Ground wave (NTIA LFMF)

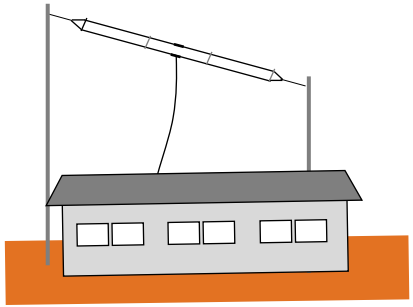
Empirical model for ambient noise:

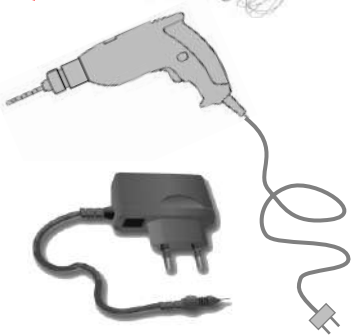
- Rec. ITU-R P.372-14

Signal-to-noise ratio (SNR) independent of distance, unless sources are local

# Ambient electromagnetic noise





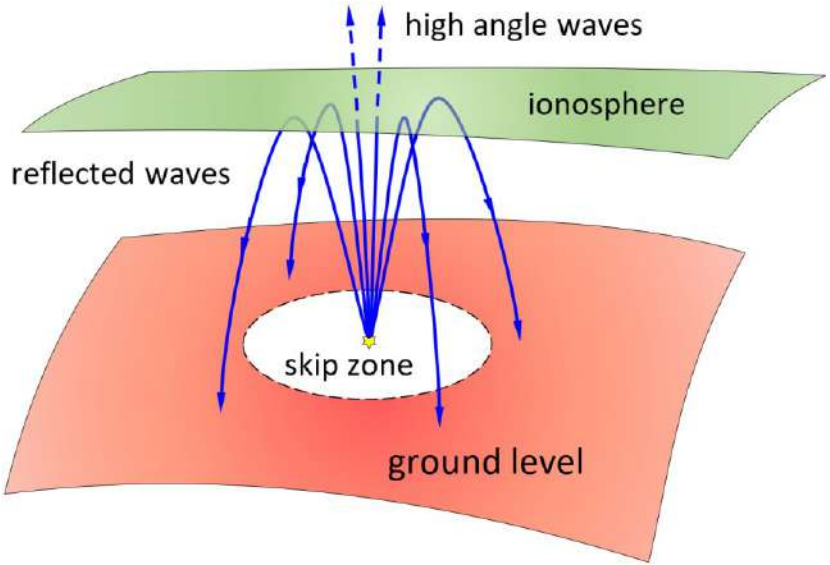


At the hospital:
noise will <u>not</u> change with distance.

**So this is probably not the cause.**

# 2. Transmission above the critical frequency

# Ionospheric reflection depends on wave frequency and angle




The highest frequency that is reflected vertically follows Martyn's 'Secant Law':

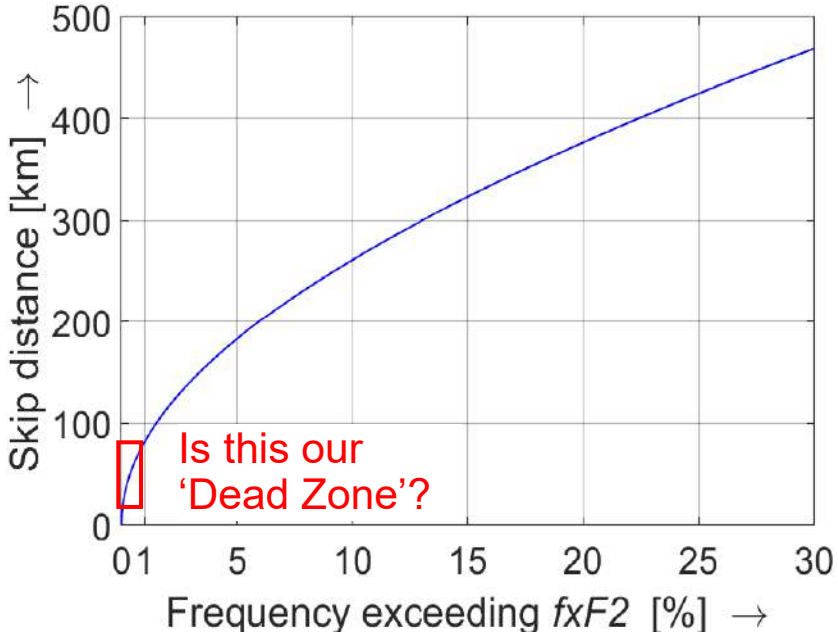
$$f_{max} = f_{xF2} \sec(\theta)$$

where $f_{xF2}$ is the critical frequency of the ionosphere, and θ the incident angle.

For frequencies above $f_{xF2}$ the minimum reflection distance can be calculated, the 'skip distance'.

***Is this the reported 'Dead Zone' ?***

# Therefore the skip distance depends on the wave frequency

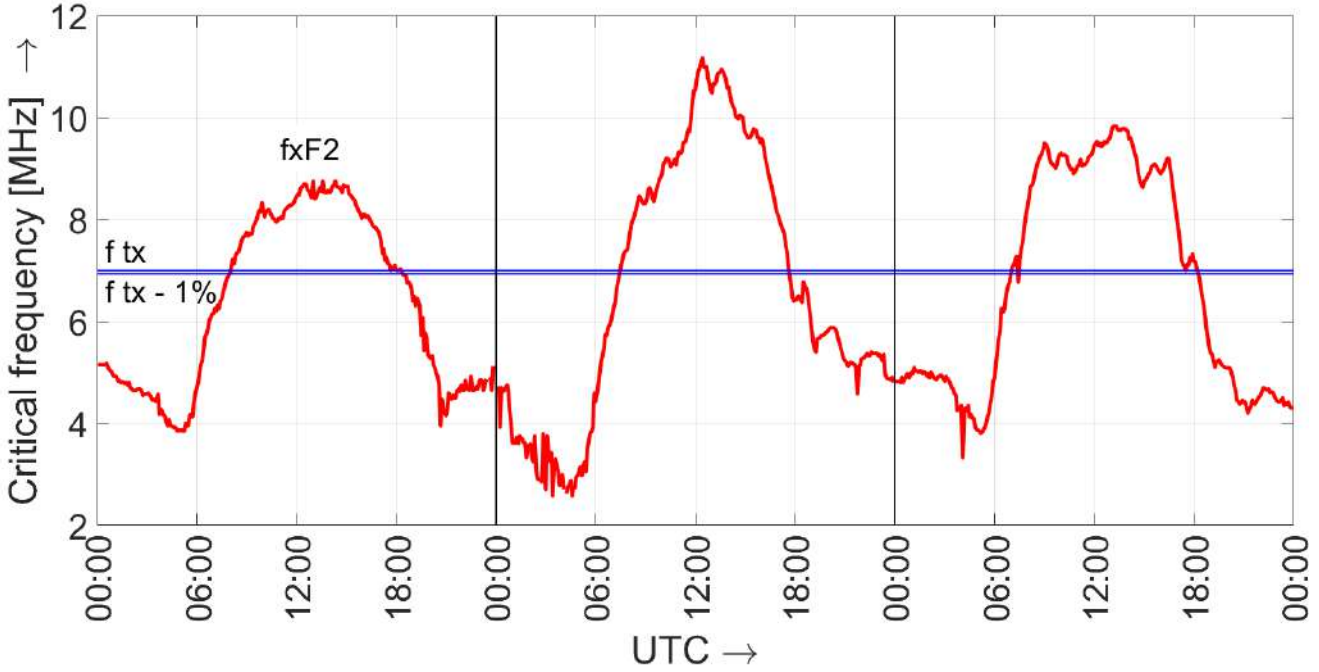



Therefore, above the critical frequency, there is no reception in the 'skip zone' and good reception further out.

Requires a transmit frequency exactly 1% higher than $f_{xF2}$ …

Is that realistic?

# Diurnal variation of *fxF2*




Example: Dourbes ionosonde, 19-21 October 2014

The transmit frequency $f_{tx}$ is fixed, and fxF2 is variable.

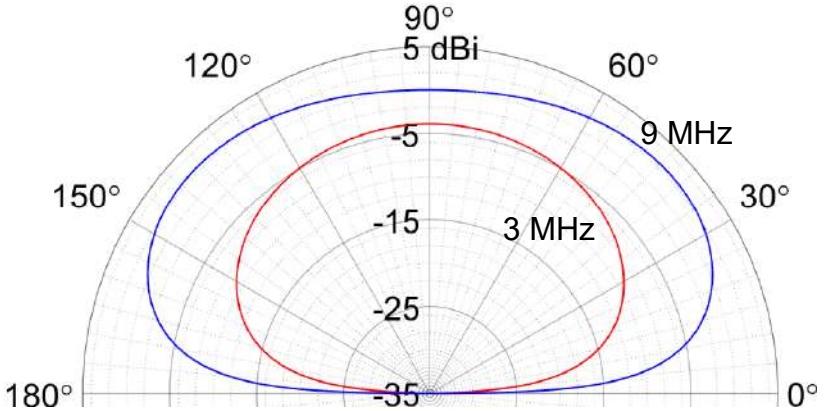
The 1% criterium may exist a short time, but not structurally.

**So this is cannot be the cause!**

# 3. Impact of antenna characteristics

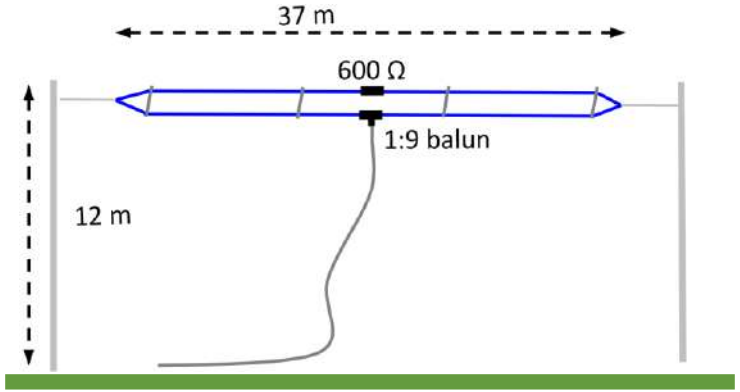
# Antenna at the hospital

Antenna gain versus elevation angle




Good coverage of high angles

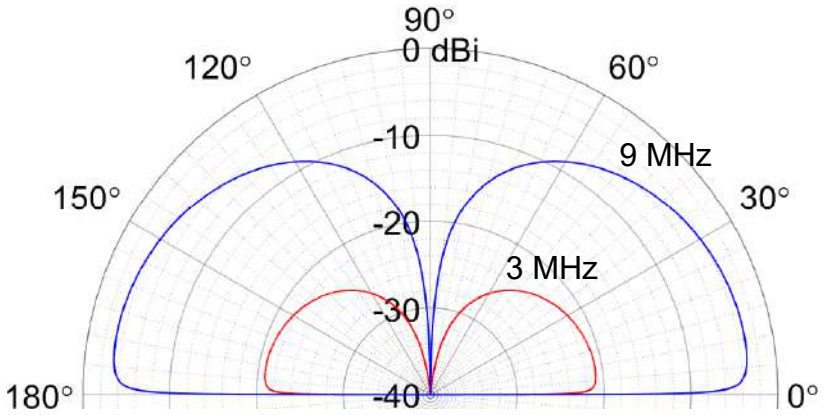
T2FD horizontally polarized wide band antenna




Hospital antenna

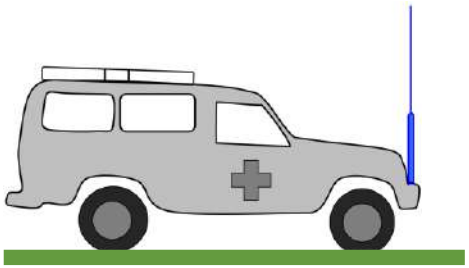
# Antenna on the ambulance

Antenna gain versus elevation angle




Very poor coverage of high angles

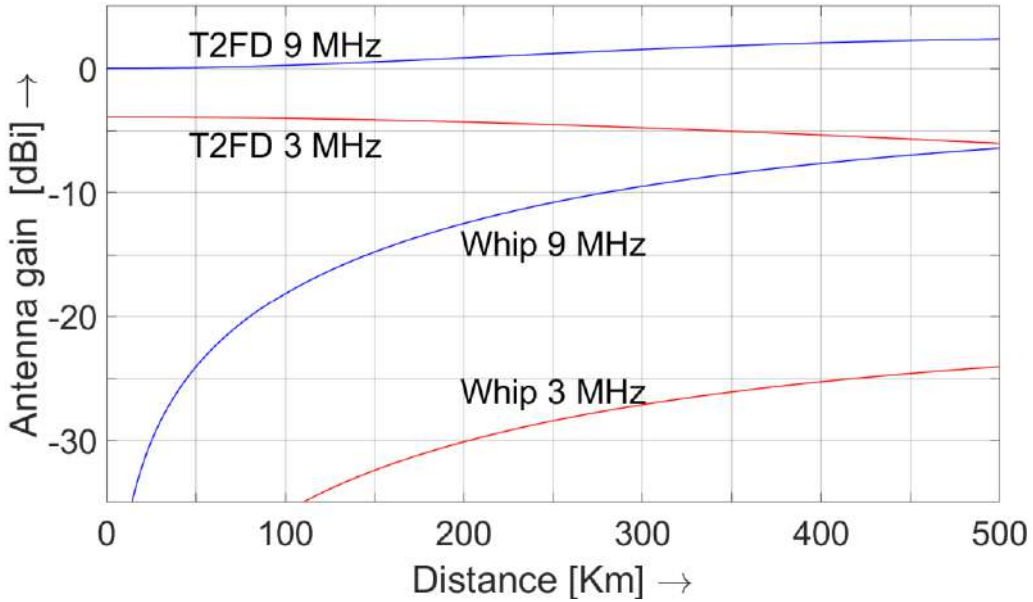
Tuned short vertical whip antenna
2.4 m long (0.02-0.08 λ)



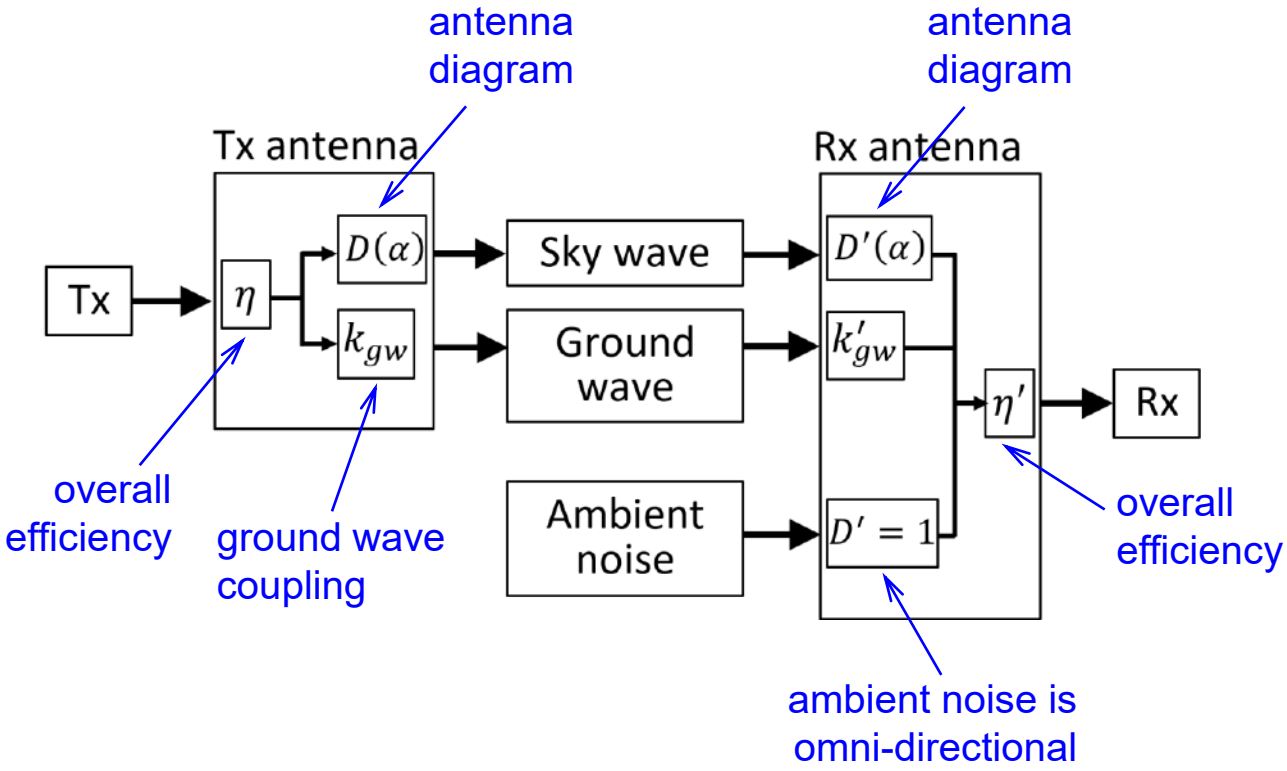
Ambulance antenna

# Antenna gain versus distance

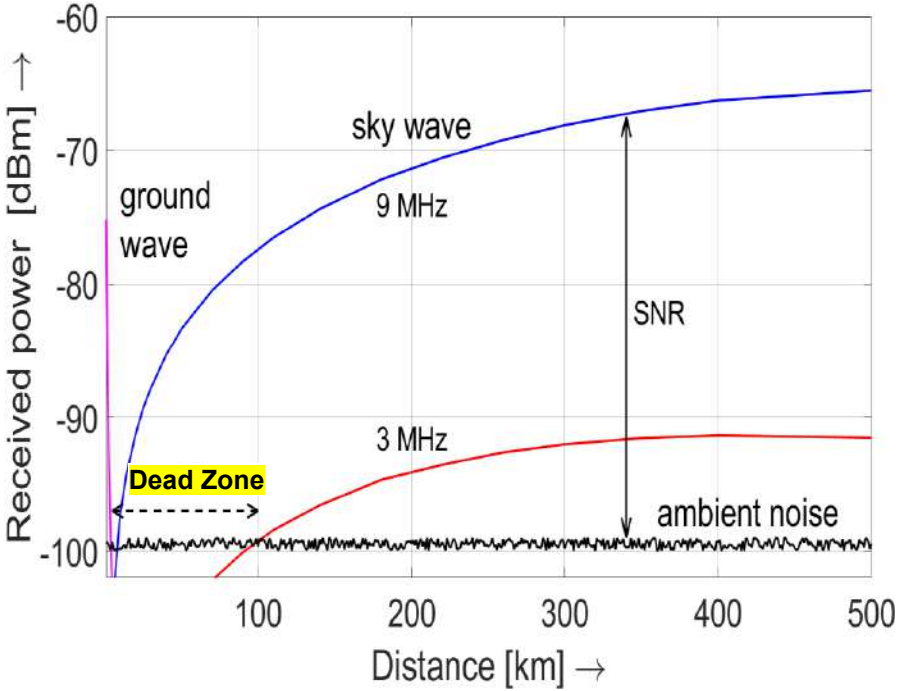
Antenna gain versus distance



# Impact of antenna characteristics



# Antenna gain versus distance




Simulated signal strength using real antennas

The impact of the antenna diagram of the mobile antenna is very significant

**This could very well be the cause of the 'Dead Zone' !**

# Conclusions and further work

# Cause of the ‘Dead Zone’ problem

1. Probably not the ambient noise
2. Probably not a propagation issue
3. Very likely the antenna diagram of the mobile antenna !

This has been a *theoretical* study

Must be verified by measurement:

- ❑ Antenna efficiency versus frequency (both antennas)
- ❑ Antenna diagram (both antennas)
- ❑ Radio noise levels in these countries
- ❑ Radio wave propagation in these countries

# Possible mitigation strategies

Take away the cause:

- Replace the vertical whip antenna on the ambulance with an antenna that has high-angle coverage

Improve the link budget:

- Significantly increase the antenna gain (directivity and efficiency) of the hospital antenna for high angles
- Reduce ambient noise generated at/near the hospital (will improve reception at the hospital)
- Reduce ambient noise generated by the ambulance (will improve reception in the ambulance)

Do both

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https://www.pithia-nrf.eu/.





# Questions?

**Dr. ing. B. A. Witvliet (Ben)**

E-mail: b.a.witvliet@utwente.nl

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