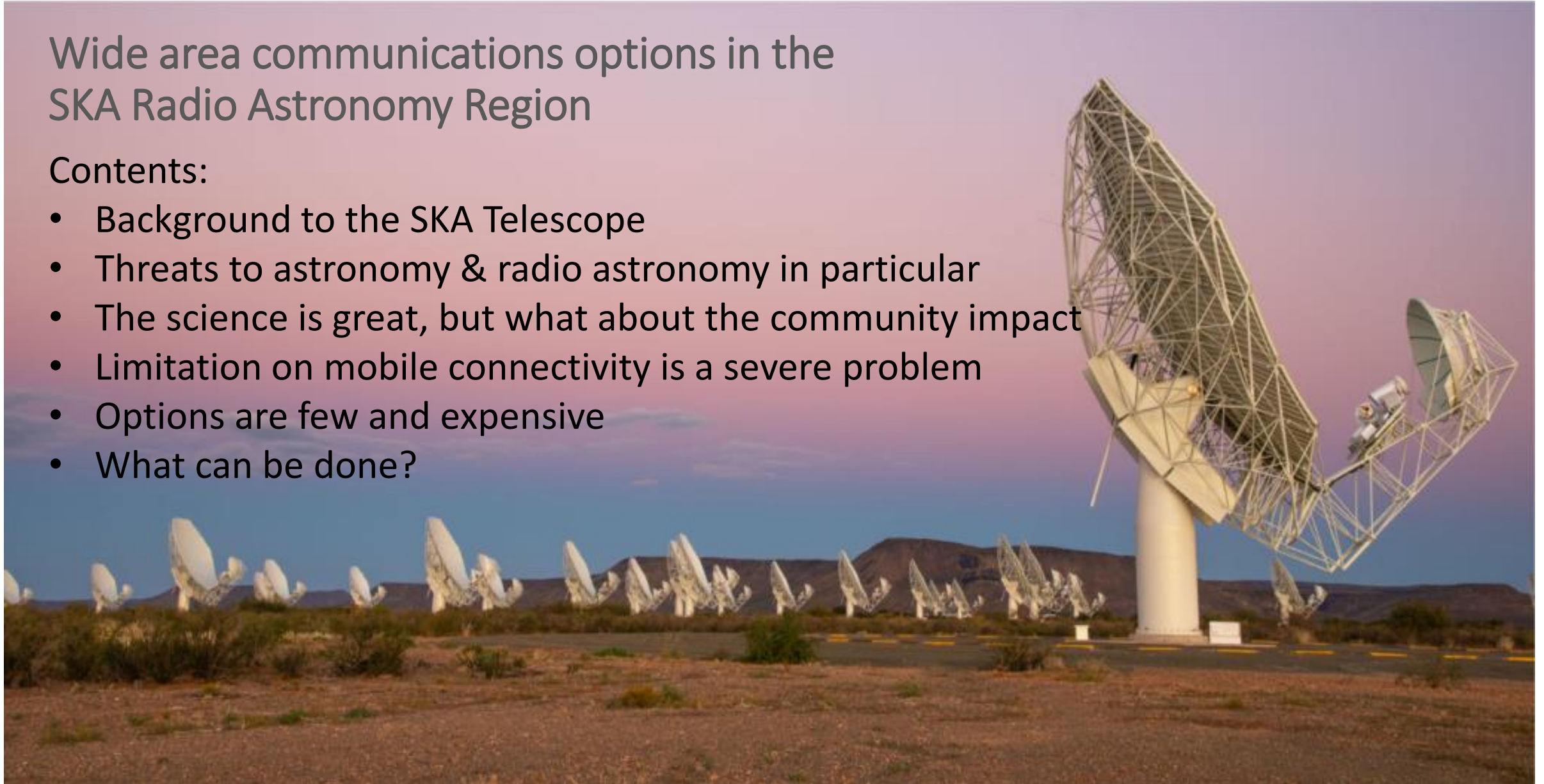


# Wide area communications options in the SKA Radio Astronomy Region

## Contents:

- Background to the SKA Telescope
- Threats to astronomy & radio astronomy in particular
- The science is great, but what about the community impact
- Limitation on mobile connectivity is a severe problem
- Options are few and expensive
- What can be done?



Riaan Wolhuter

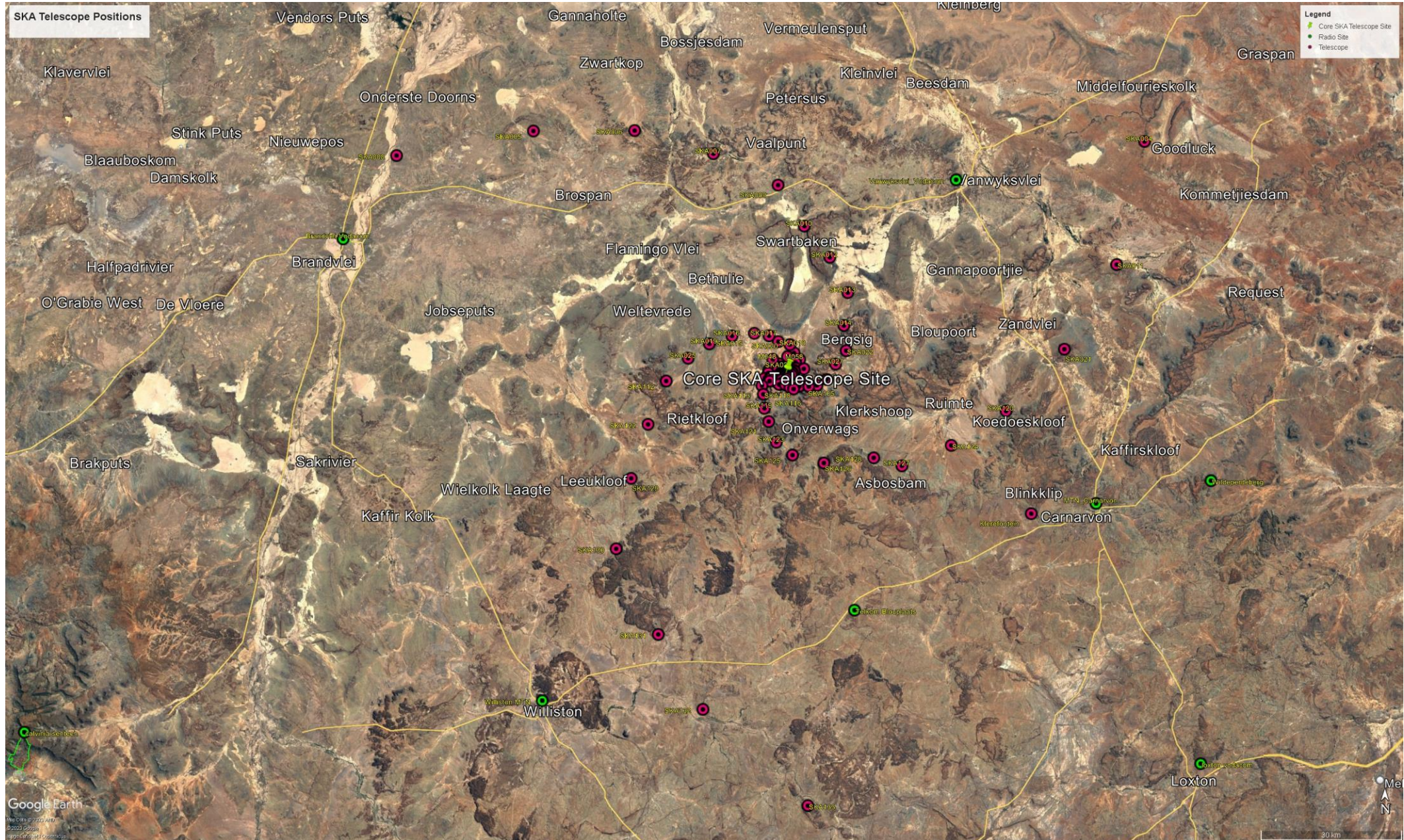
Faculty of Eng: Expo 2024

# Background: The Square Kilometre Array Telescope



- The Square Kilometre Array astronomical telescope project is one of the biggest scientific projects internationally
- Consists of two parts:
  - Low Frequency array in Australia (50 to 350 MHz)
  - High Frequency array in SA and in Africa (300 MHz to 25 GHz)
- Observations should enhance our understanding of the laws of physics active in the universe, such as:
  - The state of the early universe
  - Dark energy
  - Dark matter
- It currently consists of 73 telescopes at a site 80 km from Carnarvon
- Site chosen due to relatively low RF noise levels
- It is a telescope array, based on VLBI (Very Long Baseline Interferometry)
- Total footprint app. 200 x 200 km
- The number of telescopes is scheduled to be expanded to 199 (Has commenced)

# SKA Telescope extent



# Threats to Astronomy: 1. Visual

## Ito a new telescope being constructed in Chile:

(Scientific American Feb 2023)

But the telescope may never achieve its goals if the sky fills with bogus stars. New swarms of satellite constellations, such as SpaceX's Starlink, threaten to outshine the real celestial objects that capture astronomers' interest—and that humans have admired and pondered for all of history.

At present.....

and now more

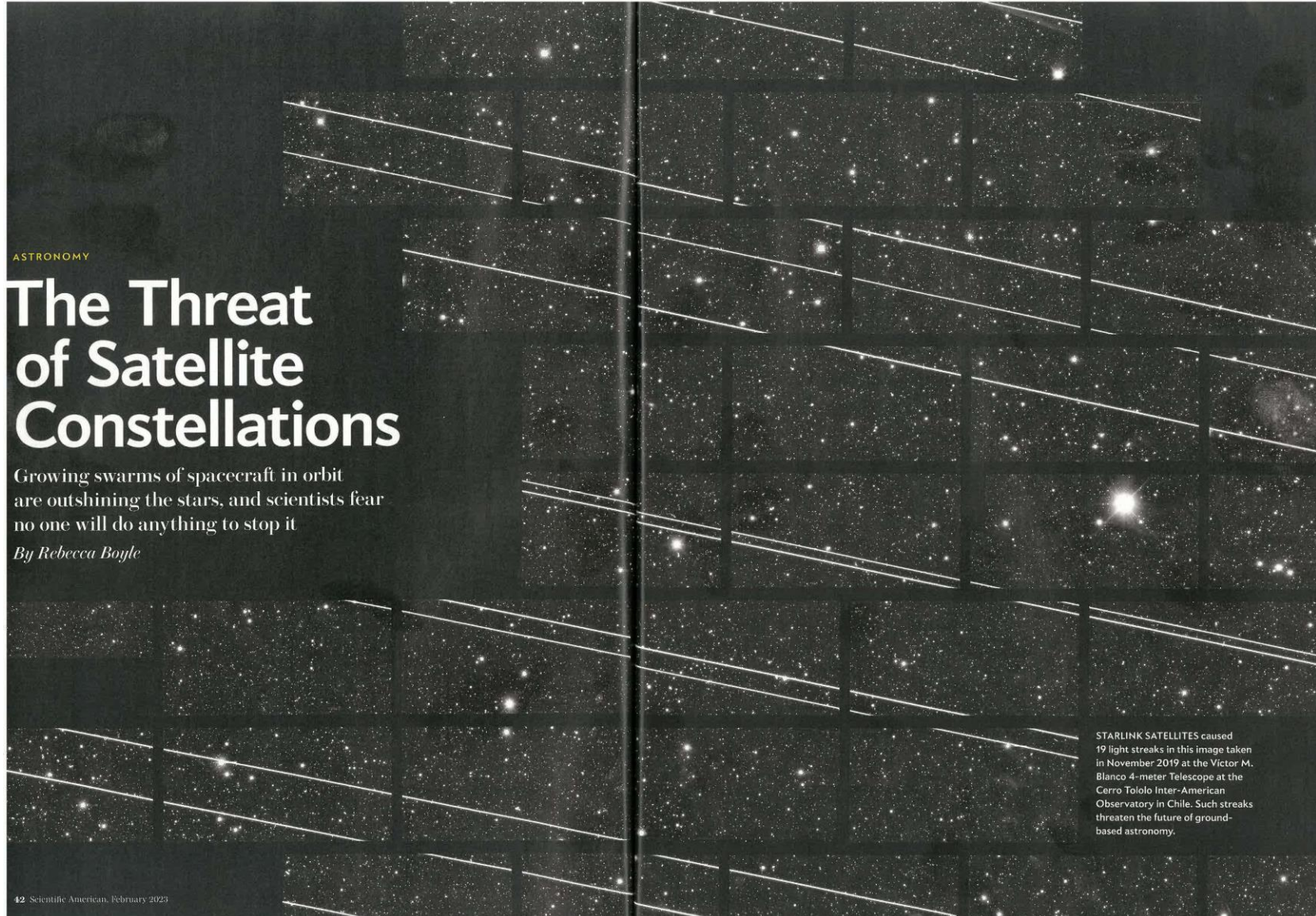
than 5,400 satellites orbit Earth at any given time.

Half of which is from SpaceX - Starlink.....

“This is a deeper cultural question. Should Elon Musk control what people see in the night sky?”

—Meg Schwamb *Queen's University Belfast*

# Huge problem already



Scientific American Feb 2023

**It's getting much worse and the future prospects are frightening....**

**According to permits filed with the world's two leading telecommunications agencies—the U.S. Federal Communications Commission and the International Telecommunication Union (ITU)—a combined 431,713 satellites in 16 constellations are planned to launch in the coming years.**

# Threat No. 2: Radio Frequency Interference (RFI)

Emitted by a huge variety of sources, e.g.:

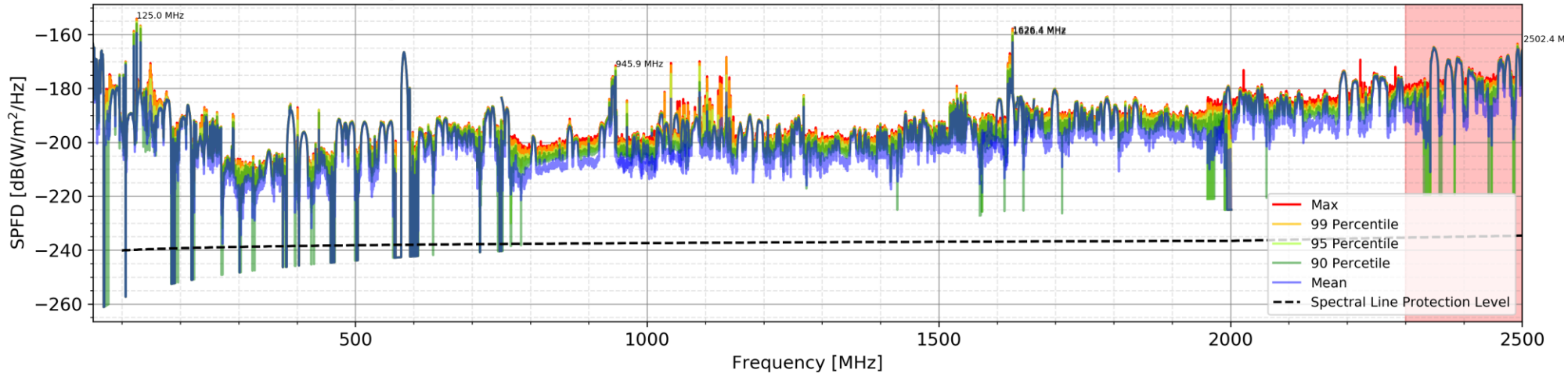
- Mobile communications
- Fixed radio transmissions
- Satellite communications
- Vehicles
- Electric fences
- Tools and household equipment
- Computer equipment
- Many more...

## Problem:

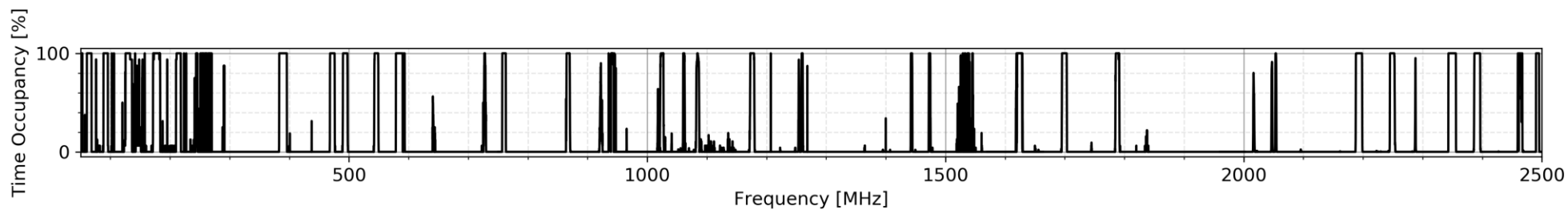
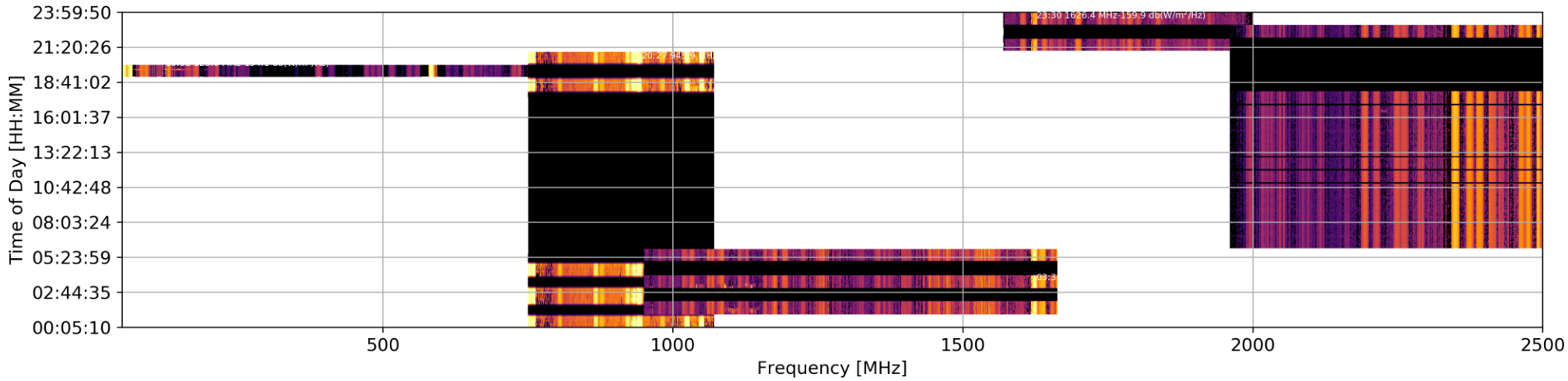
- Astronomical observations are obscured at the frequency bands where the emissions occur, ie. rendering the telescope partially blind in the non-visual spectrum



RFI Monitoring Station ASC - Fri May 19 00:00:00 2023 to Fri May 19 23:00:00 2023 (f = 50 to 2500 MHz)



Example RFI spectrum as monitored by the SKA



# RFI limits

- The threshold limits applicable in the area are the South African Radio Astronomy Services Protection Levels (SARAS)
- The SARAS levels are implementation of ITU recommendation 769.2 (ITU-R RA769.2) and define an interference level applicable to the most sensitive areas of the SKA site
- The telescope receivers are helium cooled to app. 10K and extremely sensitive  
Put into perspective: **90 dB better than your typical cellphone, ie. factor  $10^8$**   
or, the signal from a phone on the moon can be received
- Protection against RFI to observation and scientific integrity, is critical

# Impact on communities and inhabitants in the KCAAA (1)

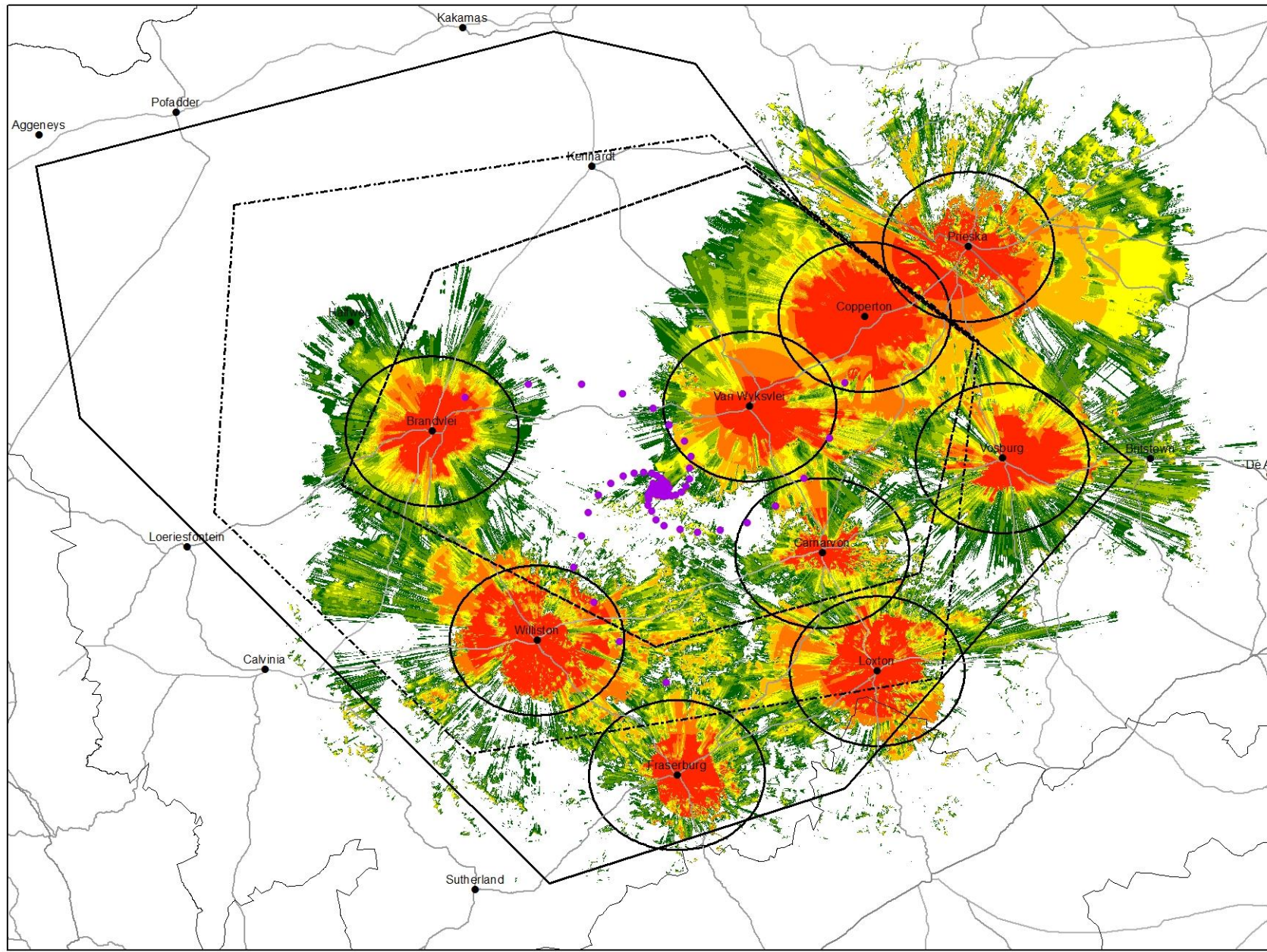
- Regulations from December 2018, restrict usage of the radio frequency spectrum in the KCAAA
- Telecomms operators require a permit from the Astronomy Management Authority (AMA) to continue operating
- The practical- and social requirements of the population are mostly irreconcilable with the scientific objectives
- Many misunderstandings in the engagement processes with the community, (Assaf report 2021)
- Typical findings of the report:
  - “We have been here first and for decades”
  - “You said we shall not be worse off than before and now?”
  - “What has come of the promise to do something about the jackals in your area?”

**Difficult PR problem !**

## Impact (2)

- Probably most problematic and unpopular:  
Mobile phone coverage has been drastically reduced and limited to towns
- Local private data networks severely restricted
- Personal safety and emergency concerns
- Business and financial impact
- General social consequences ito reduced, or eliminated personal contact
- General negative sentiments towards the project among many inhabitants
- Rural inhabitants are the worst affected  
(App 600 farms in the area of which +- 60% are permanently occupied)

# Mobile coverage before:



**Legend**

- SKA Phase 1
- ▭ Karoo Central Astronomy Advantage Area 1
- ▭ Karoo Central Astronomy Advantage Area 2
- ▭ Karoo Central Astronomy Advantage Area 3
- ▭ 35 KM buffer

**GSM900\_Original**

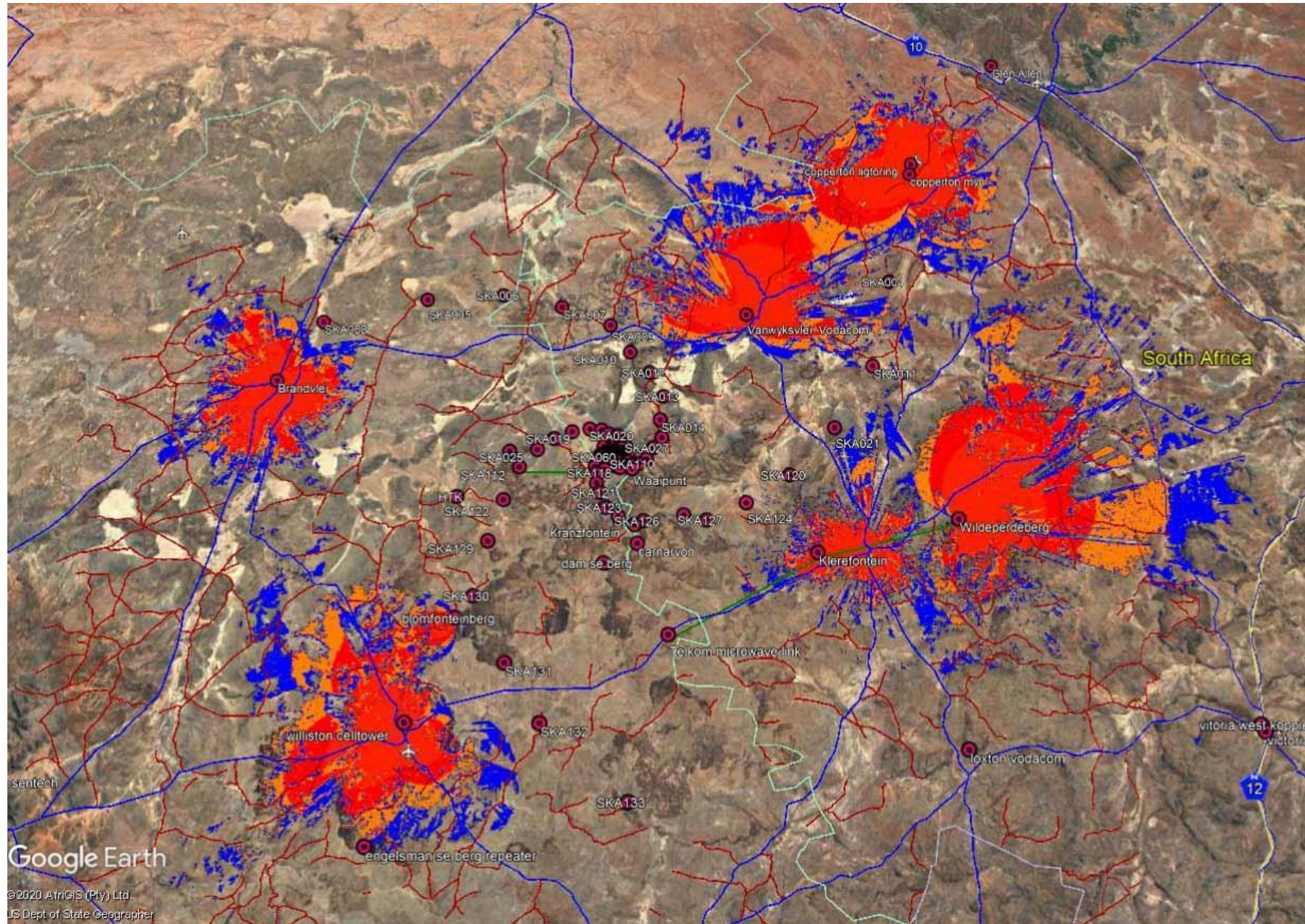
**LEGEND**

- Best Signal Level (dBm) >=-100
- Best Signal Level (dBm) >=-95
- Best Signal Level (dBm) >=-90
- Best Signal Level (dBm) >=-85
- Best Signal Level (dBm) >=-80
- Best Signal Level (dBm) >=-75
- Best Signal Level (dBm) >=-70

0 20 40 80 120 160 Kilometers



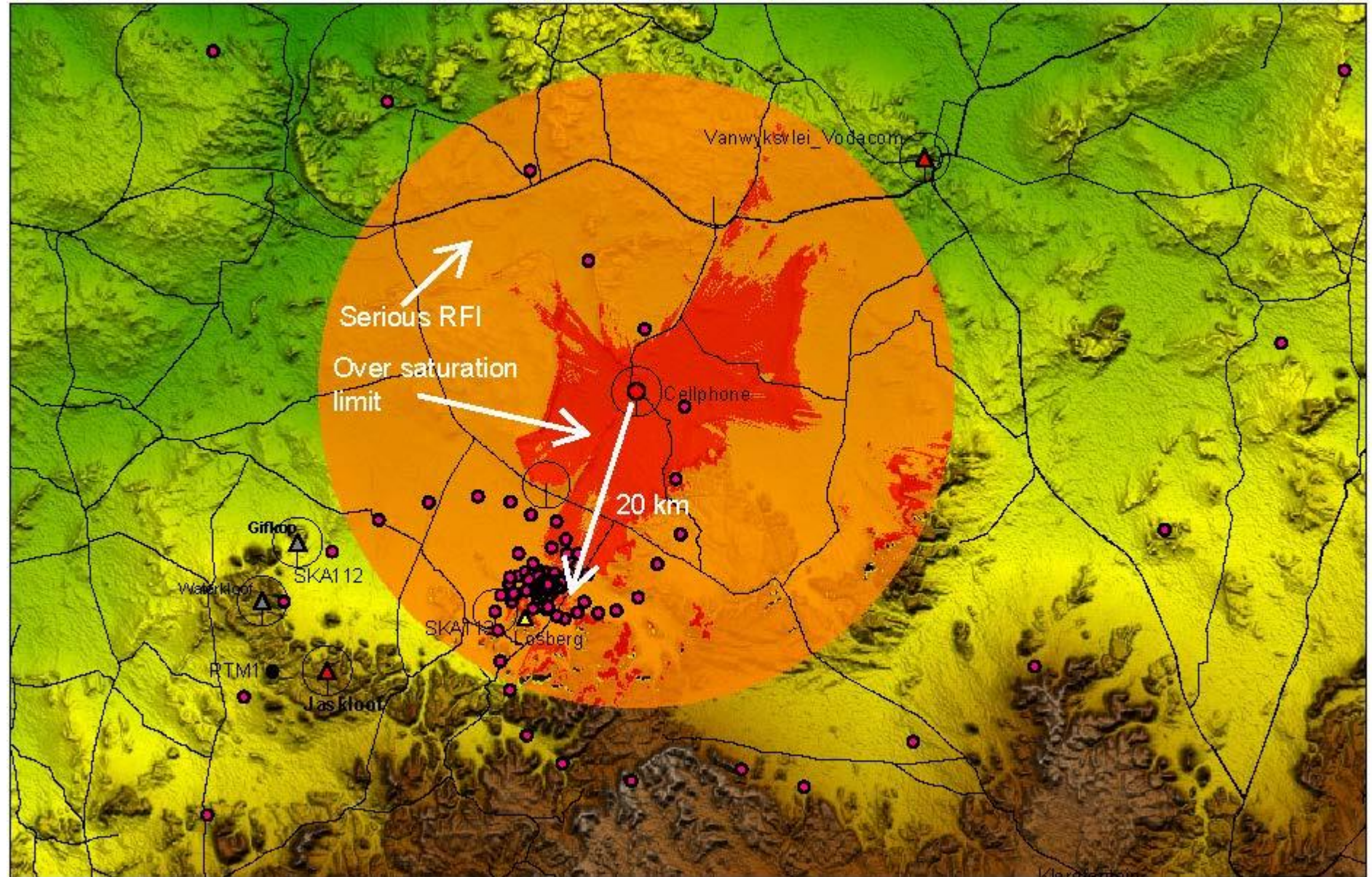
# After:



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IS Dept of State Geographer

# Mobile phone impact

- A phone used **20 km** from the core telescopes will render observations totally useless
- A saturated telescope receiver does not receive anything



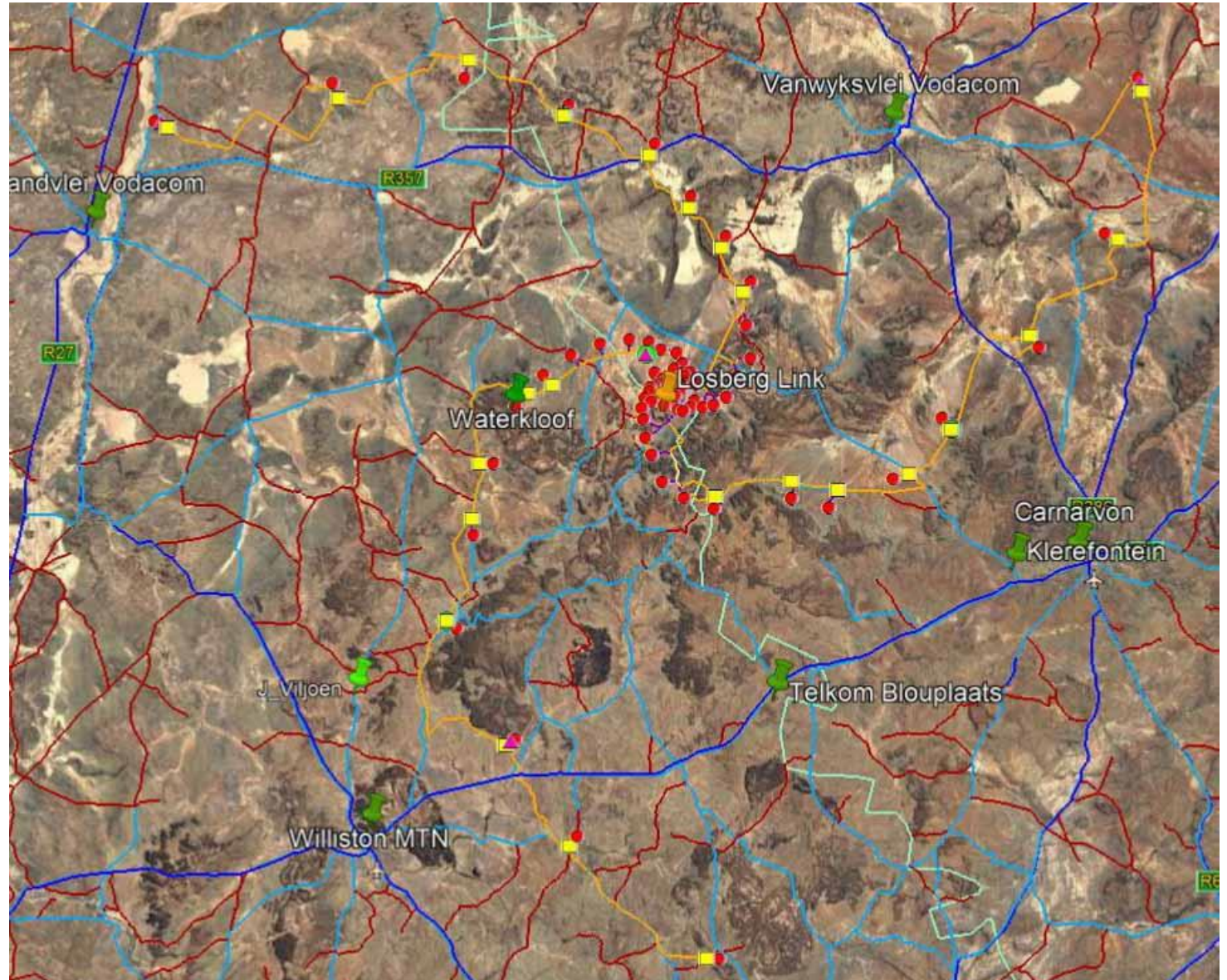
# What can be done?

## 1. Satellite data access to fixed locations:

Subsidised service by SARA0 – Not very expensive, but still unaffordable by many and it does not provide mobile access

## 2. Terrestrial connections via SKA fibre infrastructure where feasible

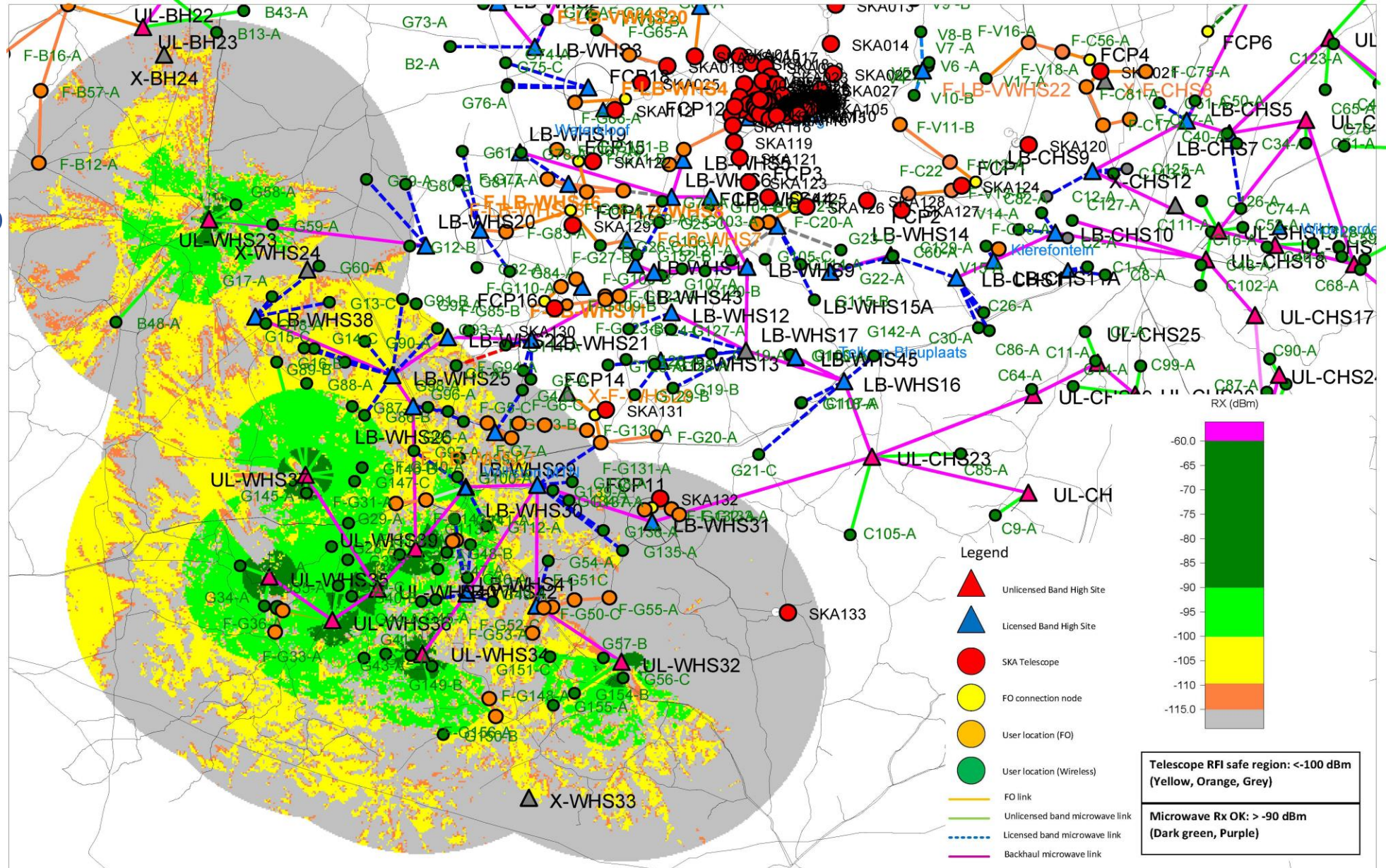
(The yellow routes)



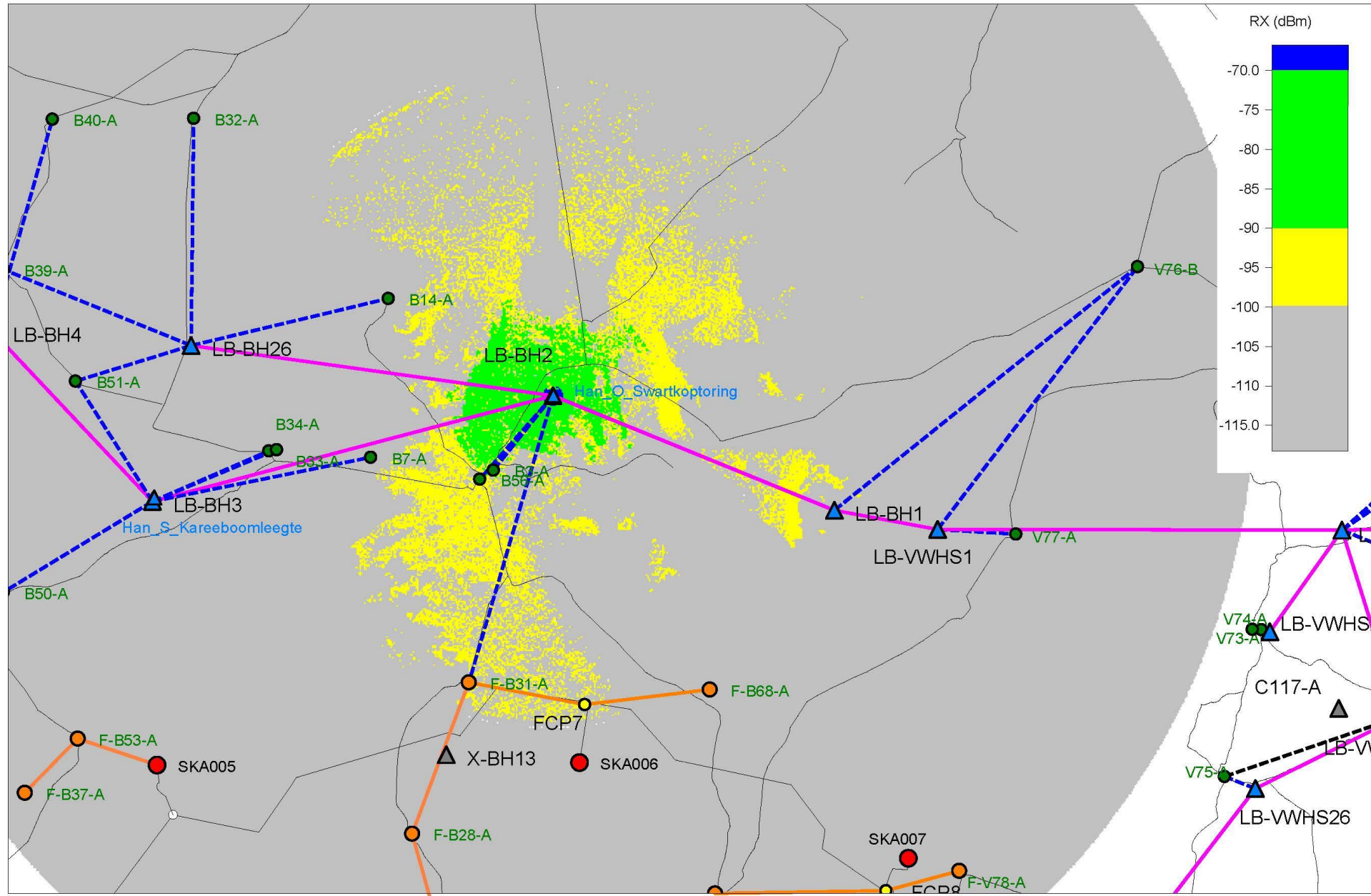


### 3. Terrestrial network via microwave links

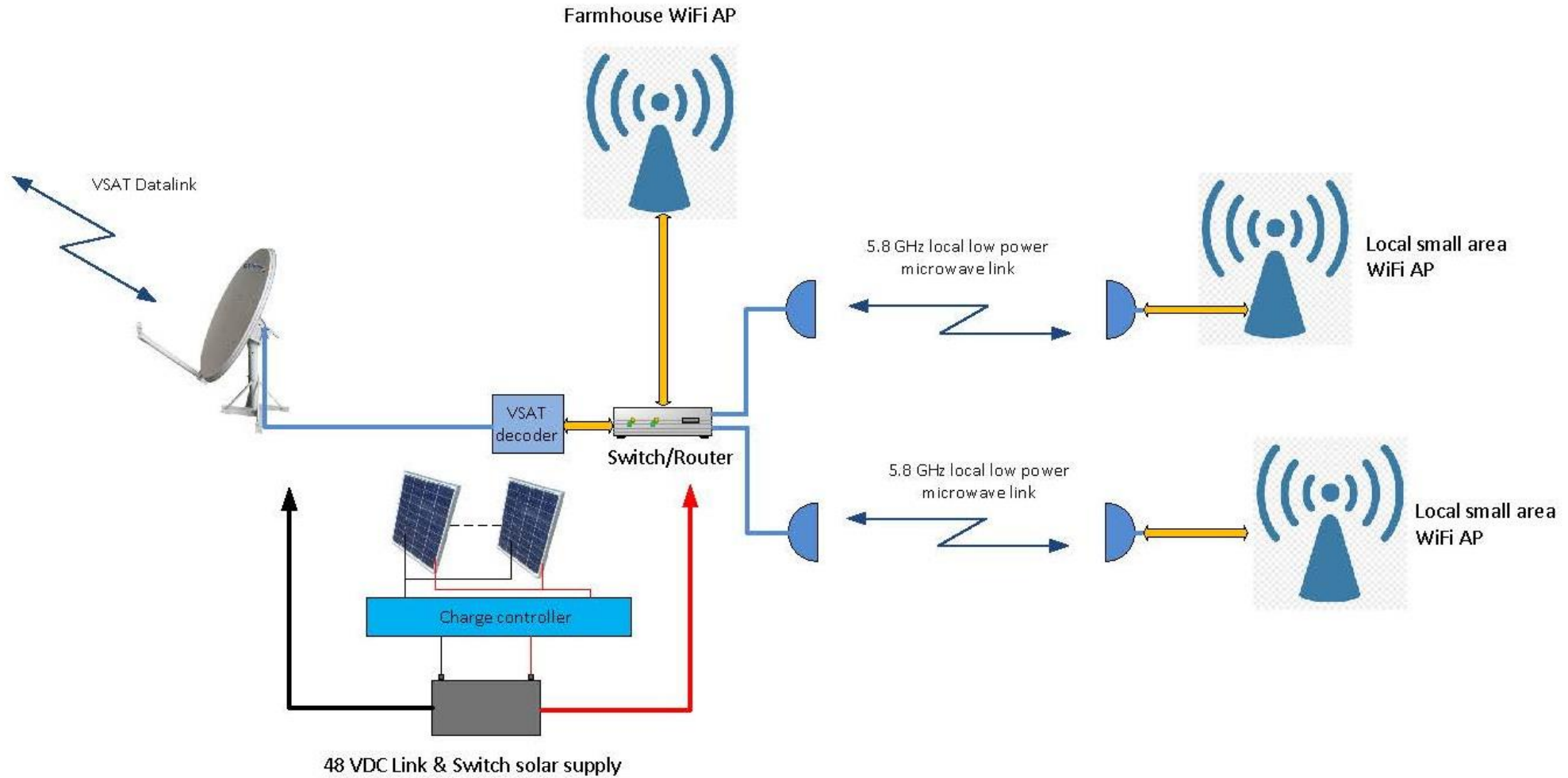
- Design critical to ensure RFI compliance
- Still no mobile solution



# 4. Local LTE (4G) picocell where situation allows



# Possible local network configuration



## Problem:

- Most of the above are **expensive solutions** due to low user density and consist of fixed infrastructure with limited local mobile footprint, eg. WiFi
- Clearly no simple quick fix

## Priority requirement:

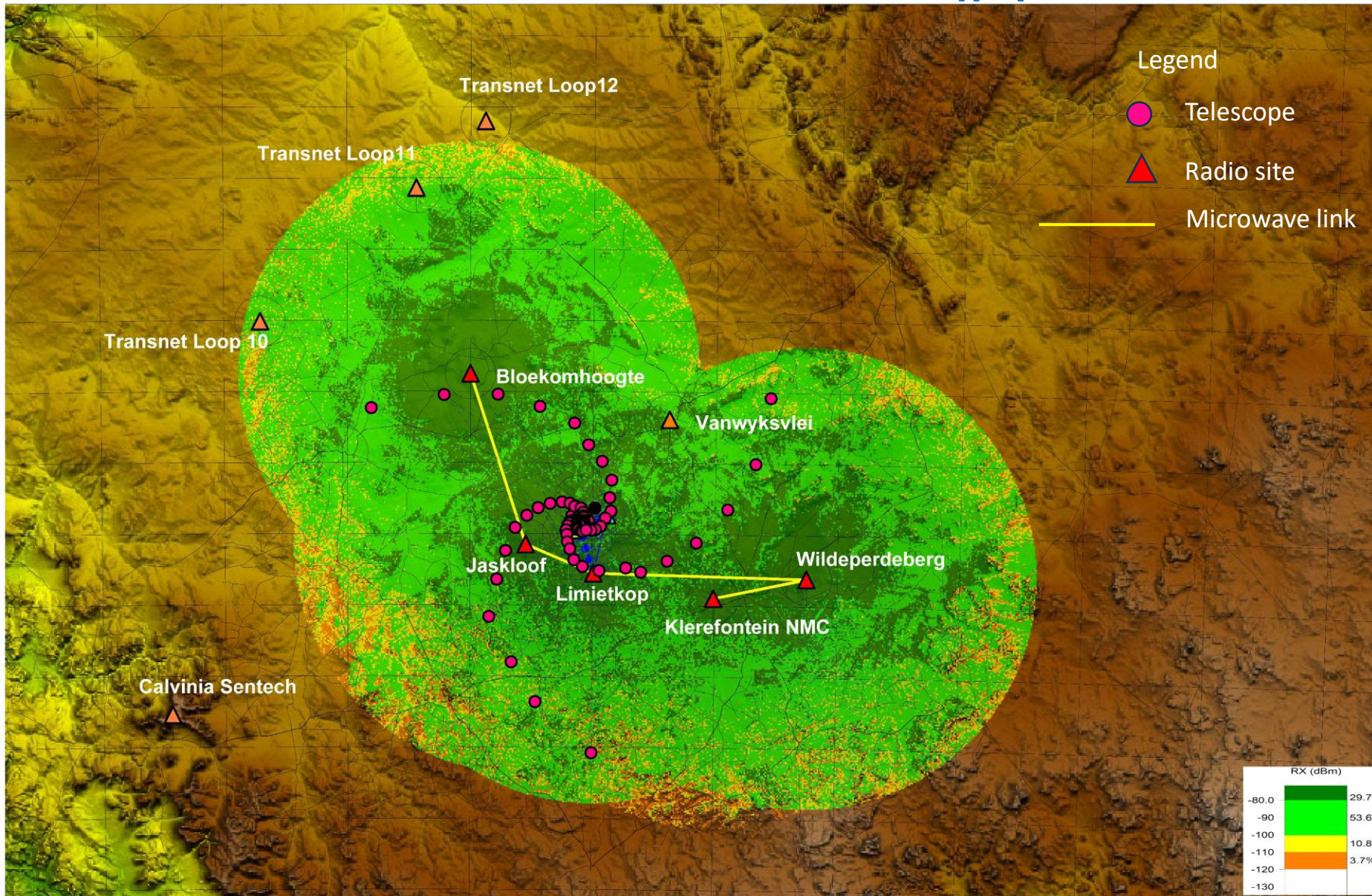
Mobile personal point to point voice communications for:

1. Emergency
2. Business operations
3. General personal communications

## Compromise solution:

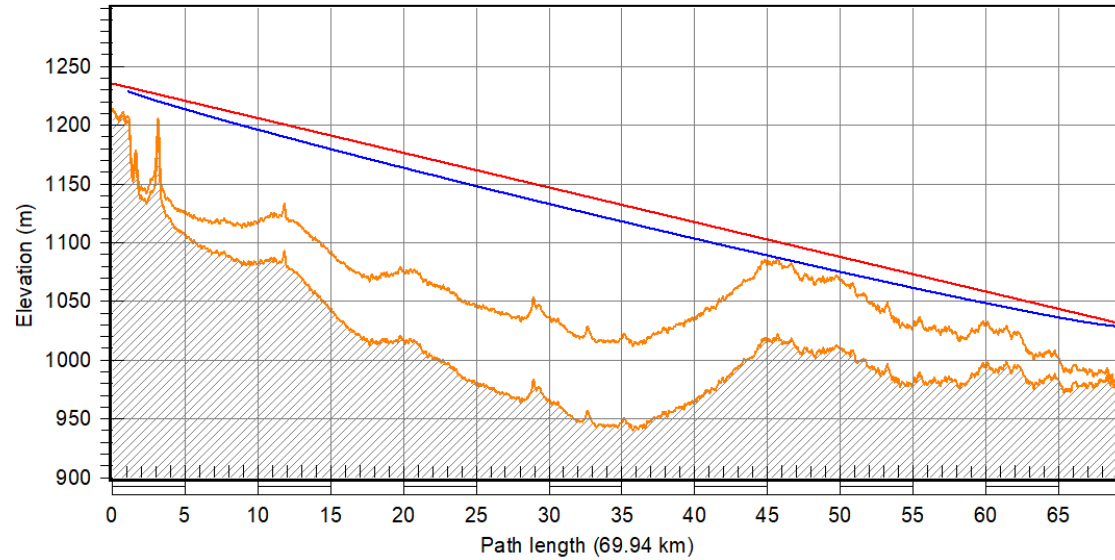
- To at least enable emergency- and personal communications
- Study undertaken to most feasible solution, practicality and telescope RFI compatibility
- Digital Mobile Radio (DMR) VHF Low Band network the most feasible for coverage and RFI compliance
- Operational frequency in the 40 MHz band
- GSM type system, providing seamless roaming between repeater sites
- Phase 1 (under construction) has 5 microwave connected repeaters and a network management centre (NMC) at Klerefontein
- Narrow band system, so no practical data connectivity, but access to the general telephony infrastructure (fixed and mobile) is possible
- 24 Hour NMC planned at Klerefontein for emergencies
- Phase 2 will add another 6 to 7 repeater sites

# VHF Low Band 40 MHz coverage prediction: Phase 1



Signal coverage and Microwave links designed with help of Digital Terrain Models

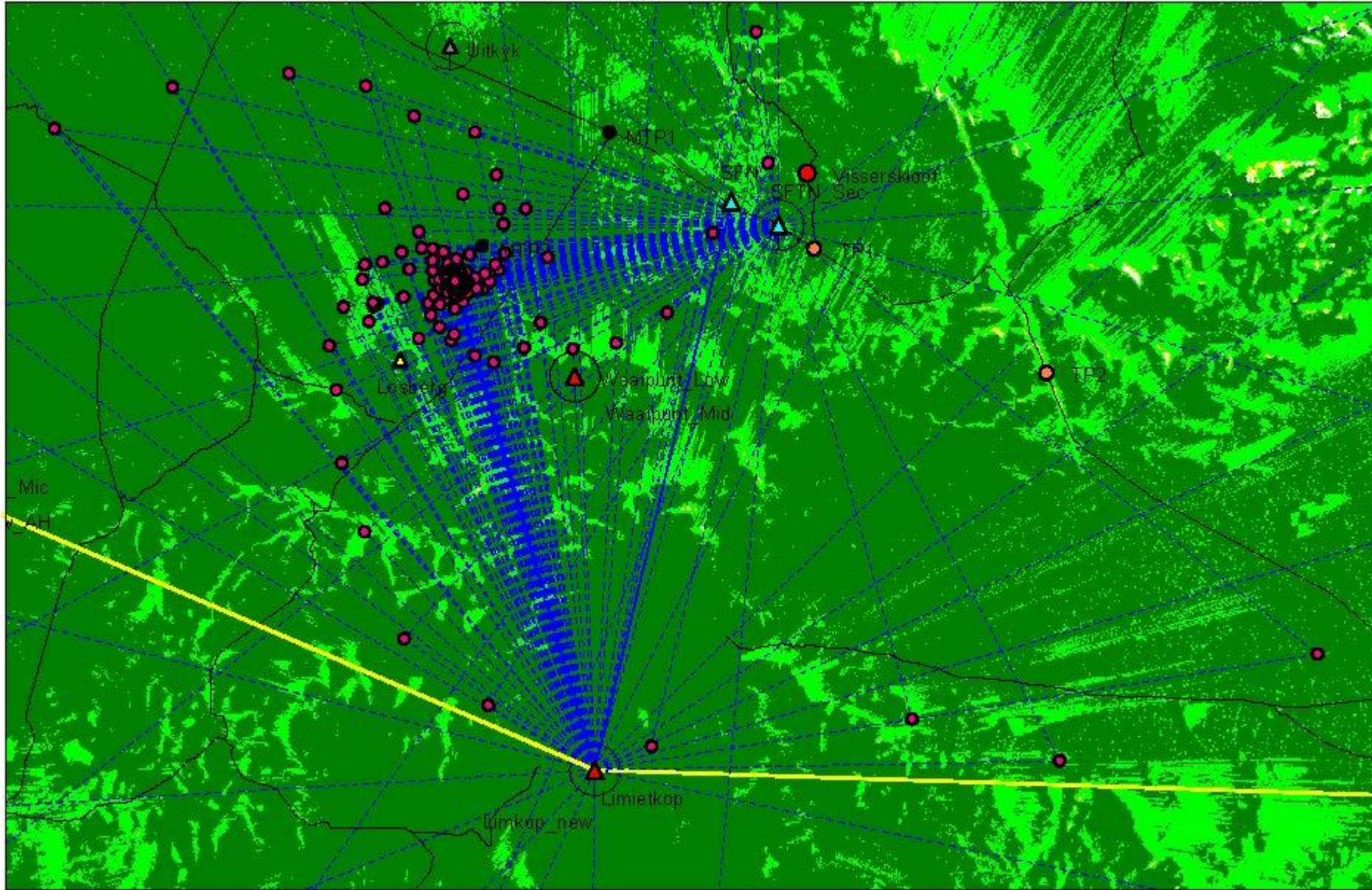
# Typical terrain profile and calculation for one of the Microwave links



F = 26000.00 MHz K = 1.33 %F1 = 100.0, 60.0

	JKLF_Mic	Bloekomhoogte_40
Latitude	30 47 13.96 S	30 11 15.35 S
Longitude	021 13 35.13 E	020 59 59.33 E
True azimuth (°)	341.82	161.93
Vertical angle (°)	-0.41	-0.07
Elevation (m)	1213.97	988.14
Antenna gain (dBi)	47.00	47.00
Antenna height (m)	21.71	40.99
TX loss (dB)	0.00	0.00
RX loss (dB)	0.00	0.00
TX power (dBm)	20.00	20.00
EIRP (dBm)	67.00	67.00
Receive signal (dBm)	-52.12	-52.12
Thermal fade margin (dB)	27.88	27.88
Effective fade margin (dB)	27.88	27.88
Annual 2 way multipath availability (%)	99.68765	
Annual 2 way multipath unavailability (sec)	98503.82	

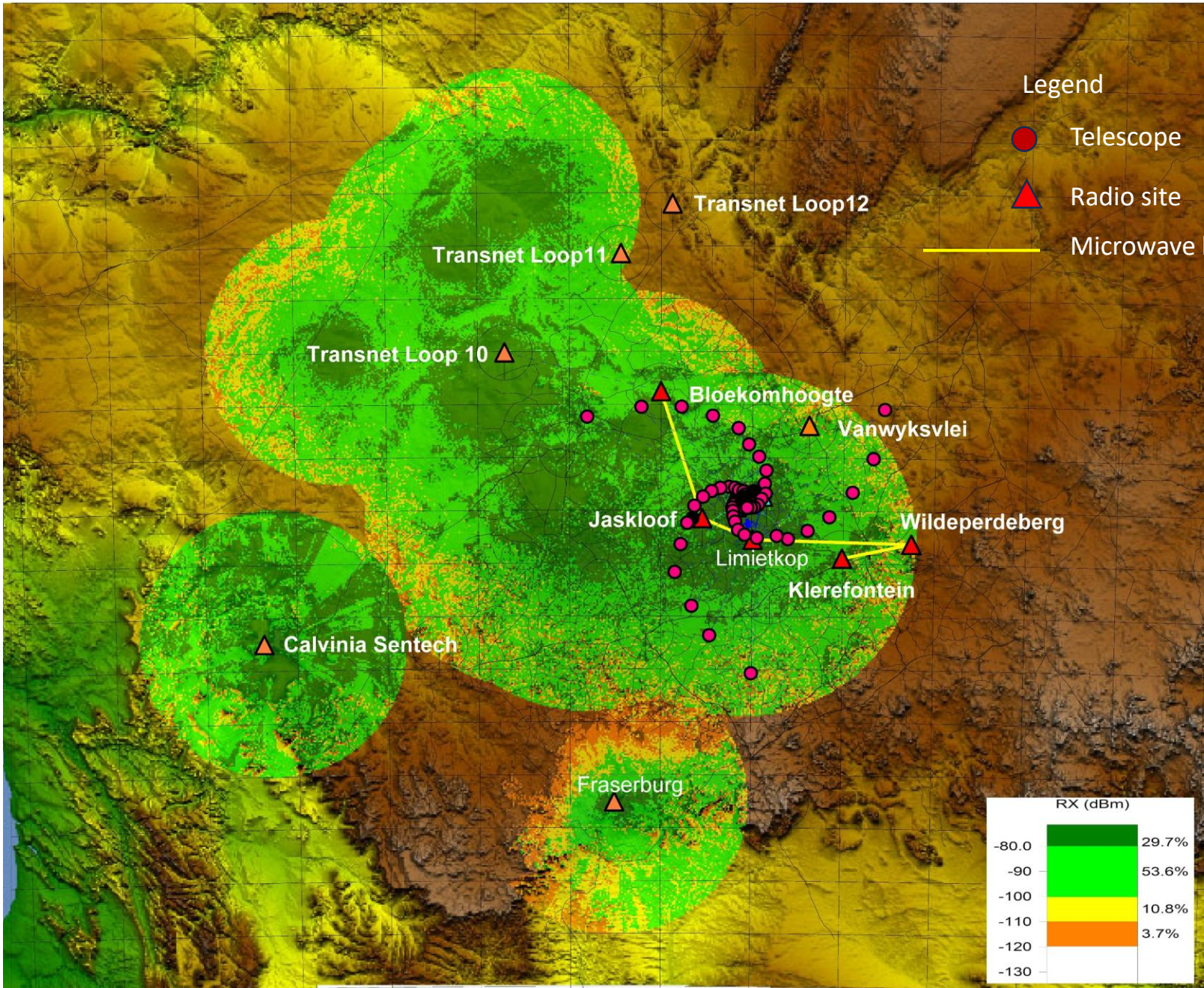
# Point to point calculations to verify RFI safety



RFI level calculated caused by EACH radio site and to EACH telescope



# VHF Low Band 40 MHz coverage prediction: Phase 2 Concept



- Very big potential area
- Exact coverage required still to be finalized with community reps
- Engineering detail design to commence afterwards

# What about mobile satellite connectivity?

- Yes, it is probably coming:

**“SpaceX Wants You to Connect Your Smartphone Directly to Starlink”**

**BUT....**

**“AT&T Asks FCC to Block T-Mobile From Expanding Network With SpaceX Satellites”**

“AT&T says it doesn't want possible interference with its own cell service.”

**AND...**

“Other companies are working to offer space-based mobile broadband, including Texas-based AST SpaceMobile, which recently launched a test satellite with a **huge array of antennas**”

*(cnet Dec 2022)*

- Technically not simple, due to mobile phone power and antenna constraints
- **Not without a new set of problems for astronomers**

# Summary

- SKA a fantastic project with some non-scientific spin-off to the area, BUT
- Cost for the inhabitants its inconvenience, financials, safety, socially and emergencies
- We keep migrating towards an ever increasing connected world, but they cannot due to restrictions on communication options
- Efficient communications vital towards growth in modern societies
- Satellite internet access helps, but is fixed (at present at least)
- The lack of mobile connectivity is probably the major concern
- So how do we connect communities in a radio-silence protected region?

**Can do to some extent, but with restrictions. No magic solution!**

**Thank you!**

**??**