Cape Town TVWS trial: Technical Monitoring and Evaluation Report

Presented by
Dr Ntsibane Ntlatlapa
CAM: Networks and Media

08 November 2013

www.csir.co.za

CSIR
our future through science

Acknowledgements

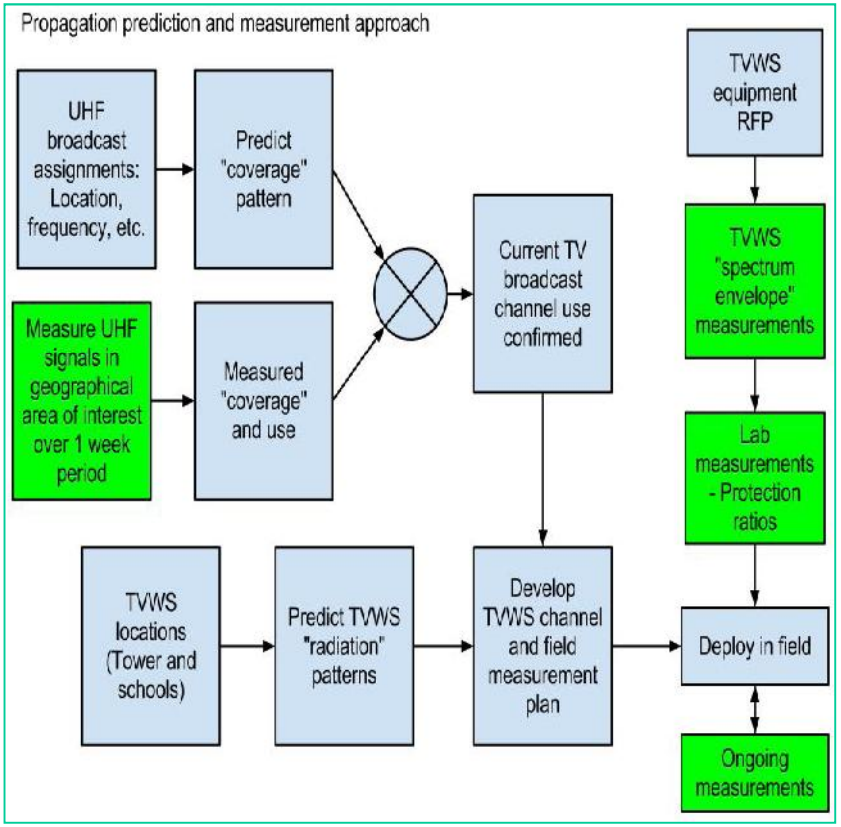

science & technology
Department:
Science and Technology
REPUBLIC OF SOUTH AFRICA


the doc
Department:
Communications
REPUBLIC OF SOUTH AFRICA

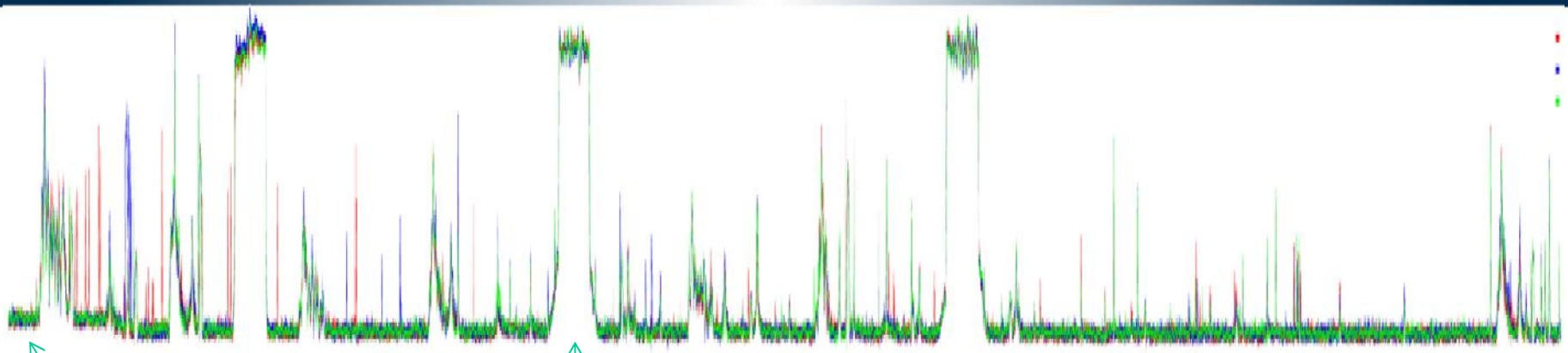
- The objectives of the trials are
  - to demonstrate that wireless devices (or TVWS devices) can operate on TV frequencies without causing any interference to the incumbents and
  - to obtain regulatory support for TVWS technology and the use of TV White Spaces for the delivery of broadband.

Ensuring non-interference

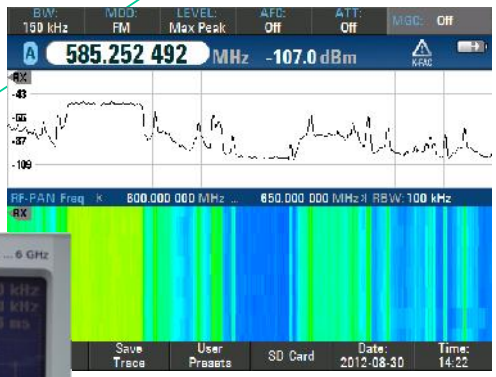
- Identify availability of white space in terms of unused and underused frequency bands
  - at the desired location, for the desired period of time, by analysis based on existing data and measurements;
- Test white space equipment to ensure
  - Correct spectrum power mask/envelope;
  - Correct behaviour;
- Estimation of the protection ratios and actual availability of white space in terms of the WSDs and TV performance parameters;
- Monitor for interference during operation.



- These factors were considered to predict white spaces availability:
  - Difference of distances from the TV station and white space transmitters to the TV viewers
  - Acceptable average level of noise in the channel
  - Acceptable quantity of occasional (sporadic) signals and acceptable level of occupancy
  - Leakage into the channel from the neighbouring channel
- Eight channels were predicted to be available in the 470 – 694 Mhz range



- 470 MHz – 854 MHz (8 MHz TV channels):
  - some analogue TV,
  - some digital TV and
  - some white spaces



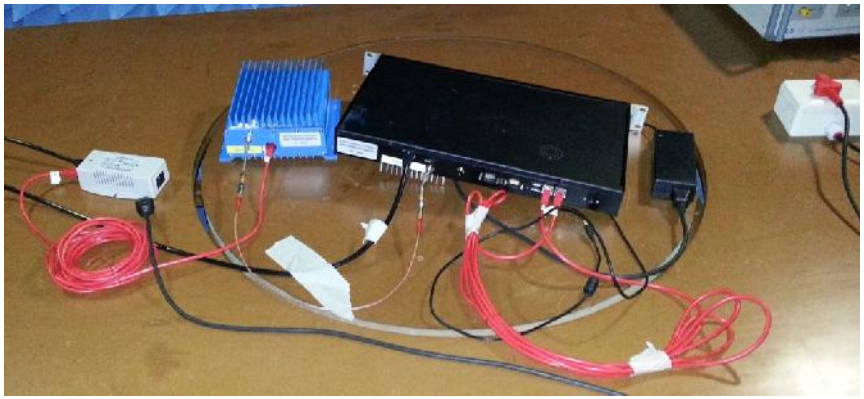
- Are there white spaces in Tygerberg (area of the trial)? …
- **➔ YES**
  - Eight TV channels were found unused (locally; with high safety margin)
  - Finally, six channels were then selected as the most suitable

- Does the equipment have an appropriate (narrow and steep enough) spectrum mask?

  e.g.

  - 99.9% of power is contained within 6.48 MHz ±0.03 MHz (compare to the width of TV channel of 8 MHz)

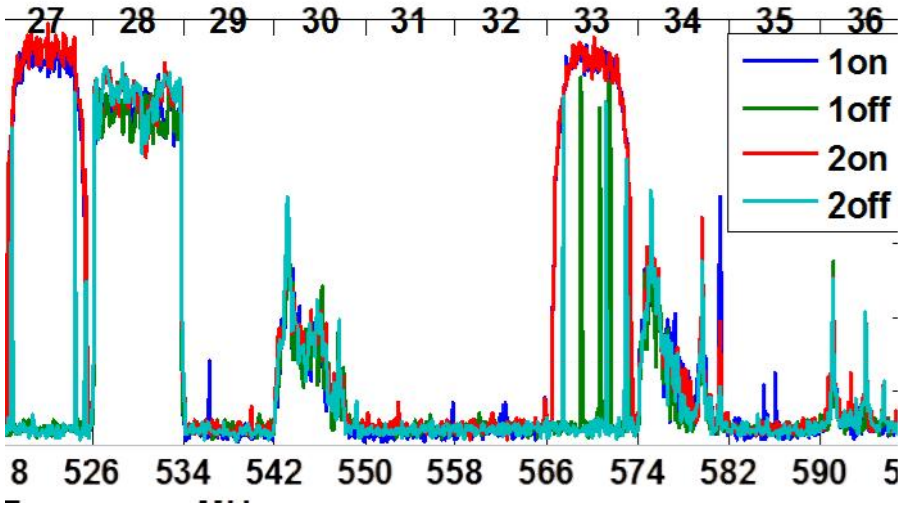
➔ **YES**

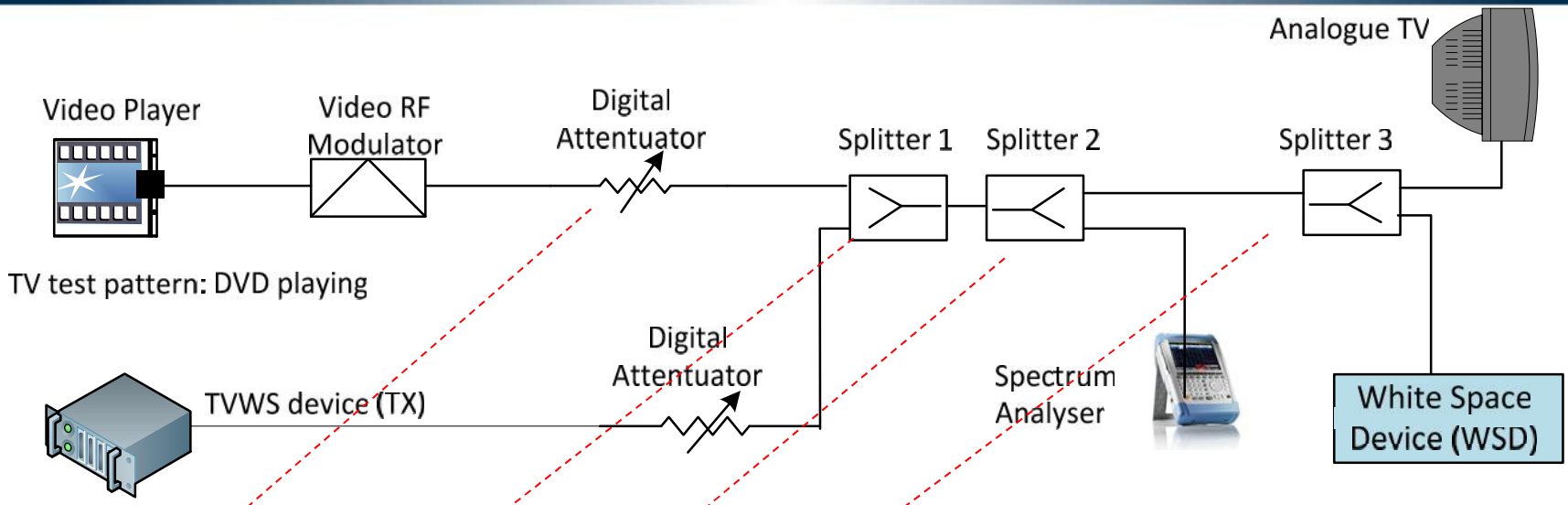


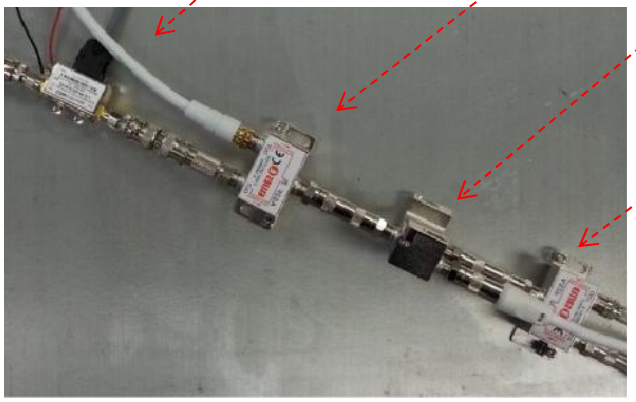
- Does the equipment behave to minimize possibility of interference (e.g. terminal talks only on request of base station, and base station talks only after it knows where a usable white space is)?

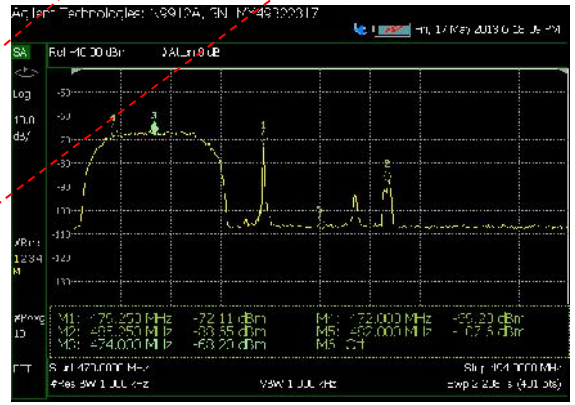
➔ **YES**

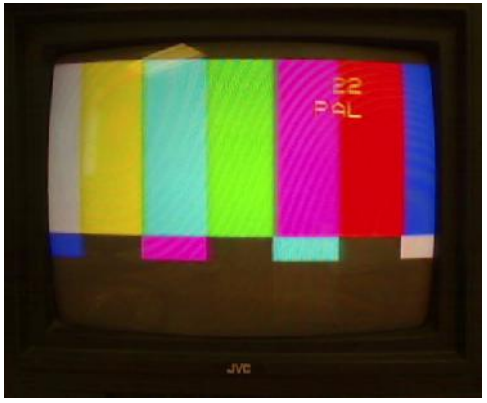
- To confirm the shape of spectrum emissions due to a TVWS network,
  - spectrum scans made on live network nodes were compared to the scans made on the same but switched-off network nodes.
  - The difference between these results confirms that the spectrum emission masks due to WSDs are well contained.
- Conclusion: The operation of WSDs was as expected.



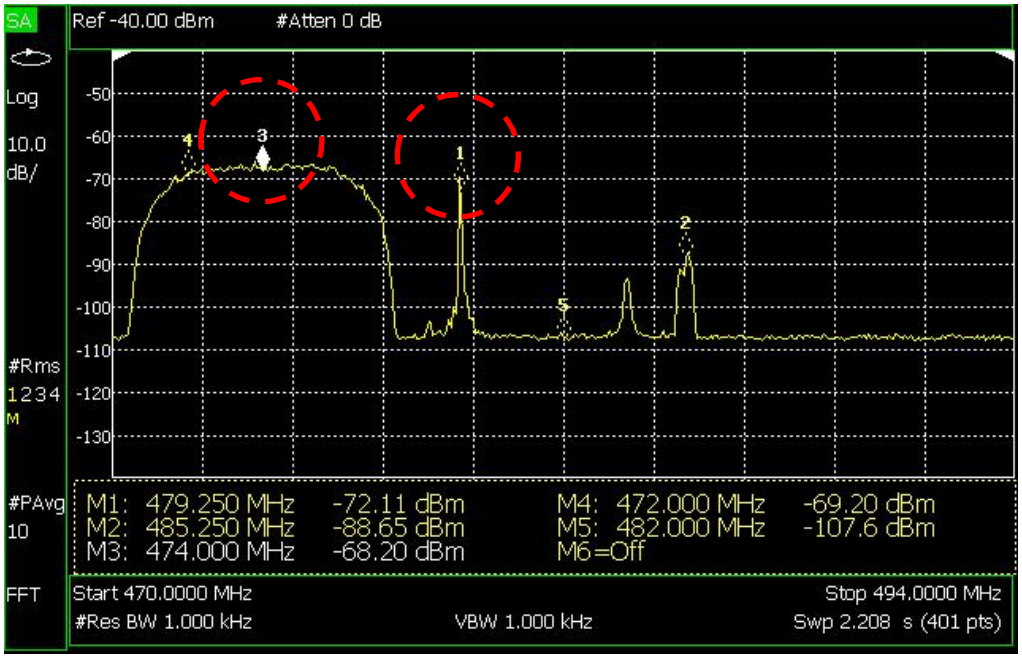








Laboratory set up



Observe the difference between maximum amplitude of the video carrier of the TV signal (1) and the max amplitude of WSD (3)

Given these levels of perceived quality impairment

- **5** Imperceptible
- **4** Perceptible but not annoying
- **3** Slightly annoying
- **2** Annoying
- **1** Very annoying

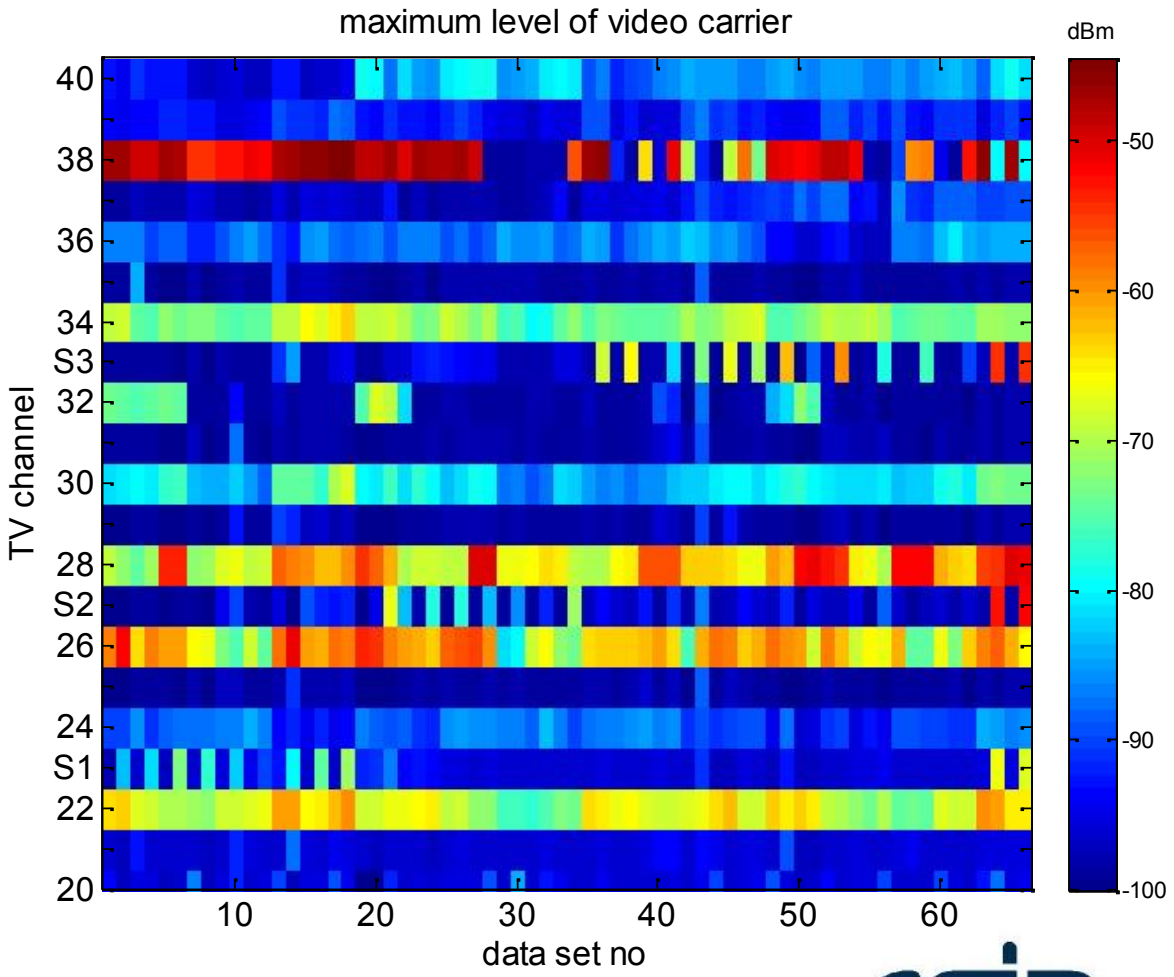
and using this test Case: Adjacent channel interference by WSD to TV signal

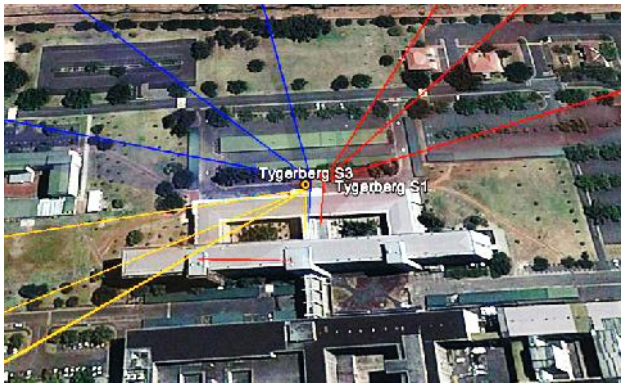
The TV signal level was kept at around -51.3 dBm and WSD signal strength was varied using the digital attenuator 2, repeated several times.

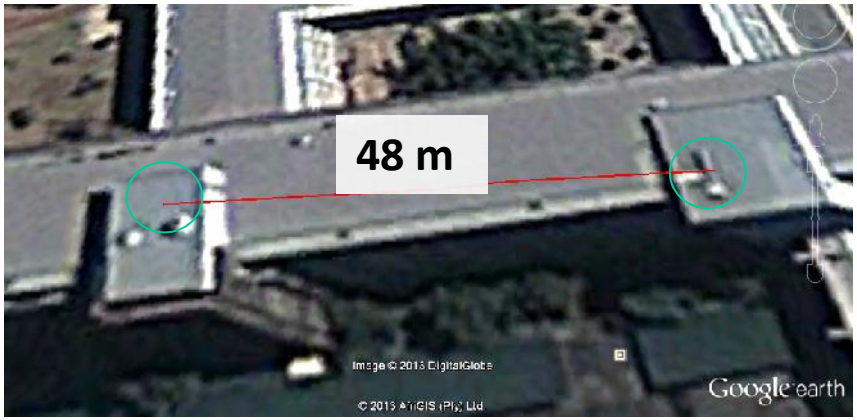
we can conclude that maximum amplitude of the video carrier of the TV signal should exceed the max amplitude of WSD with digital modulation by at least

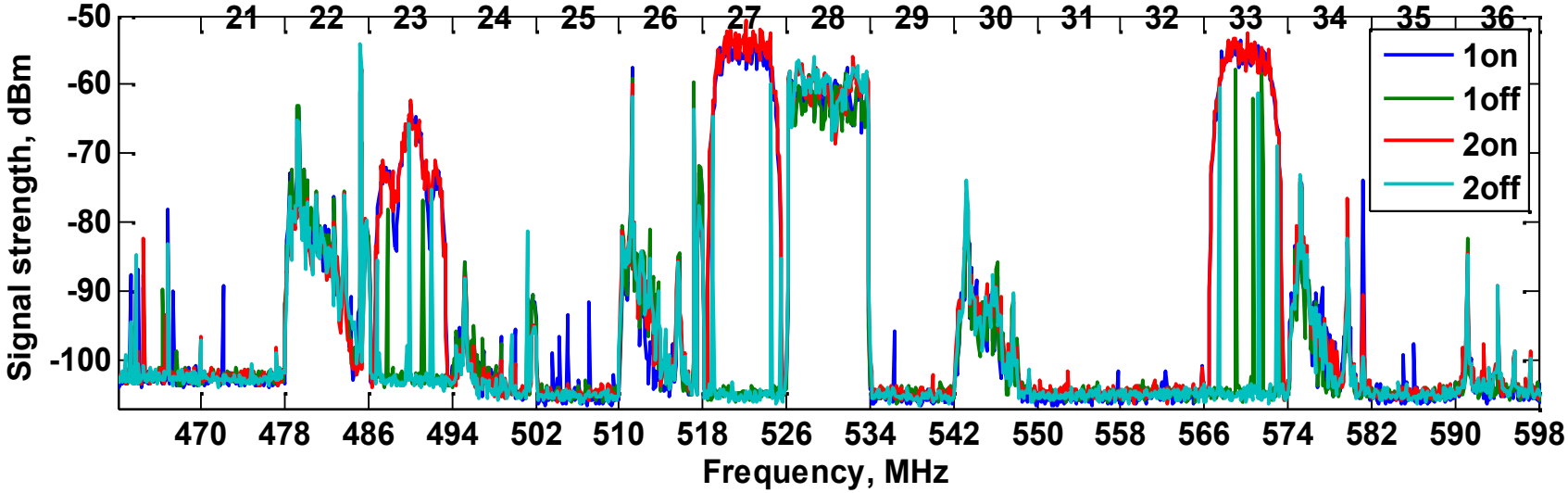
- 1 dB for level 4 quality at N-1
- -4.5 dB for level 4 quality at N+1
- 6 dB for level 5 quality at N-1
- 0 dB for level 5 quality at N+1

- Shows video signals strength for a given location/TV channel
  - Limited to channel 40 for picture clarity
- S1-S3 denote the three TV channels used to support services on the 3 sectors
- Datasets correspond to the measurement sites and WS transmitter's **ON** / **OFF** state




Tygerberg S3
Tygerberg S1


48 m
Image © 2013 DigitalGlobe
© 2013 AfriGIS (Pty) Ltd
Google earth


Signal strength, dBm
-50
-60
-70
-80
-90
-100
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
470
478
486
494
502
510
518
526
534
542
550
558
566
574
582
590
598
Frequency, MHz
1on
1off
2on
2off

On analysis the following were observed:

- For WSD channel 23
  - channel 22: protection ratio are well satisfied;
  - channel 24: TV signal too low.
- For WSD channel 27
  - channel 26: PR almost always satisfied except at one measurement; interference can be contained within 32m* of the WSD.
  - channel 28: This is a digital TV channel
- For WSD channel 33
  - channel 32: broadcasting intermittent;
  - channel 34: PR satisfied at two of the schools and not always satisfied at the other two. interference can be contained within 160m* of the WSD.

*radius within which the interference is contained was calculated using this formula

$$R = D.10^{(dPR/20)}$$

Conclusions

- We have observed that for analogue TV channel:
  - WSD can be operated on the adjacent channel on its right-hand side without causing interference.
  - WSD may be operated on the adjacent channel on its left-hand side without causing interference, however if transmission power of the WSD is kept at the maximum there maybe a possibility of causing interference within the 160m radius of the WSD.
- On the basis of the above observations, we recommend that
  - Trial results constitute sufficient basis for initiation of required regulatory process
  - A geo-location database be used for TVWS networks.
    - The database must be able to estimate protection ratios for each of the adjacent channels for both Analogue and Digital TV and
    - Provide transmission power levels to the WSDs for each of the available channels.

Thank You!!!

For more information on CSIR research in this area, contact:

nntlatlapa@csir.co.za

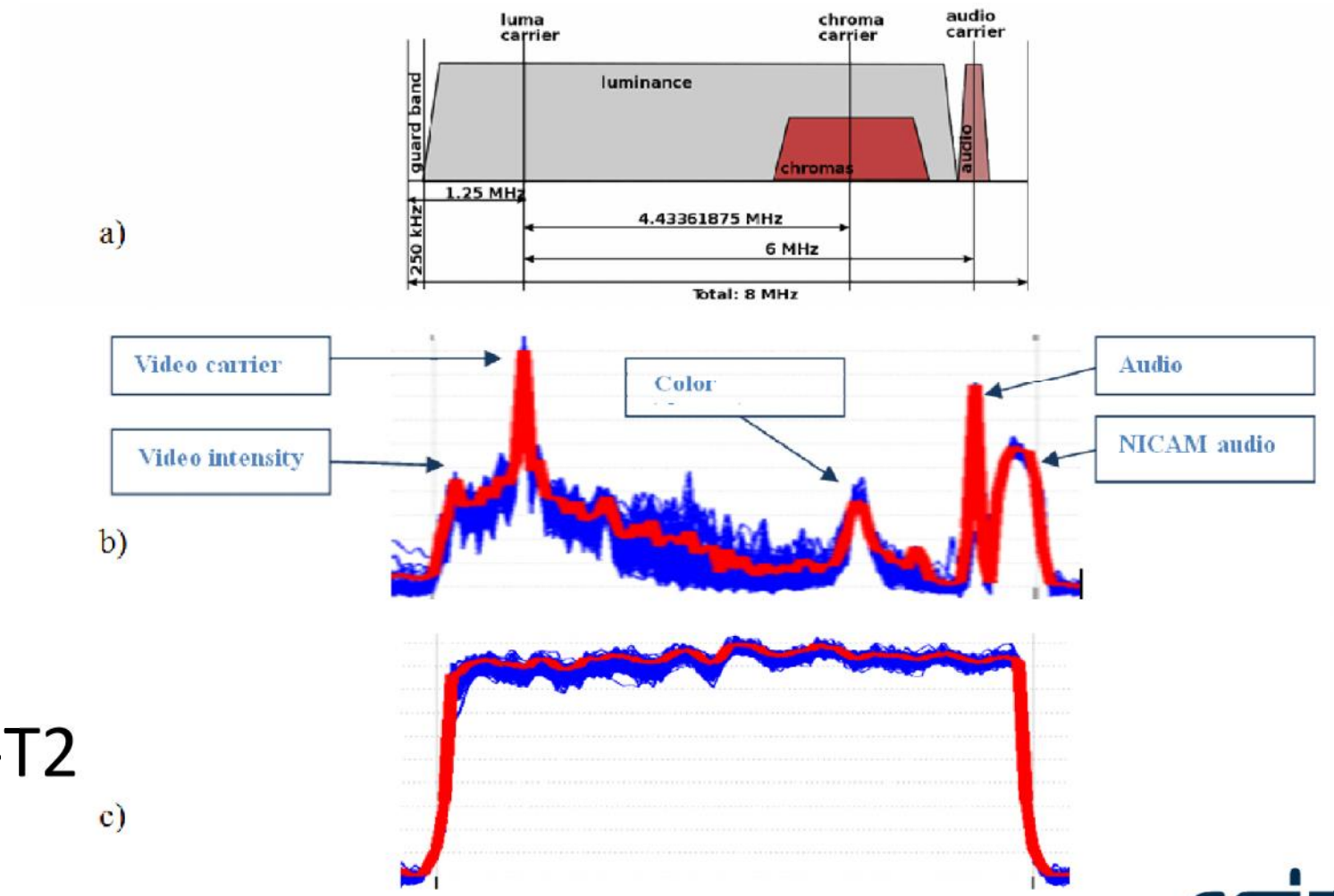
CSIR

our future through science

ADDITIONAL SLIDES

Background – TV signals

- PAL-I



- DVB-T2

On the definition of available white space bandwidth

- Several factors may need to be considered:
  - Acceptable average level of noise in the channel
  - Acceptable quantity of occasional (sporadic) signals and acceptable level of occupancy
  - Leakage into the channel from the neighbouring channels
  - Difference of distances from the TV station and white space transmitters to the TV viewers

PR estimated from lab measurements: Preliminary results

TV picture quality impairment level	Peak of TV video carrier to peak of BS signal strengths ratio, dB	
	Lower (N-1) channel	Upper (N+1) channel
5 – Imperceptible impairment	3.7	0.4
4 – not annoying *(hardly noticeable noise)*	-0.2	-1.6
3 – slightly annoying *(noise starts to be visible)*	-3.9	-3.6
2 – annoying *(noise well visible)*	-7.8	-6.6
1- very annoying *(strong noise present)*	-12.7	-9.6

Studying compatibility: Field + Lab → Interference radius

Methodology

1. Field strength data for TV channel ***S**tv* and ***S**wsd* from the Cape Town field trip
2. Protection ratio ***PR*** measured in the lab
3. Permitted level of WSD emissions at the point where data in (1) was measured:
   - ***S**permitted* = **S***tv* - **PR**
4. How much of additional attenuation is required

   ***Delta** = **S**wsd – **S**permitted*
5. Free space attenuation loss can be used to back calculate the distance required to have WSD signal below ***S**permitted*
   - Assume large distance to TV station
   - 10% error in distance → 0.9 dB error