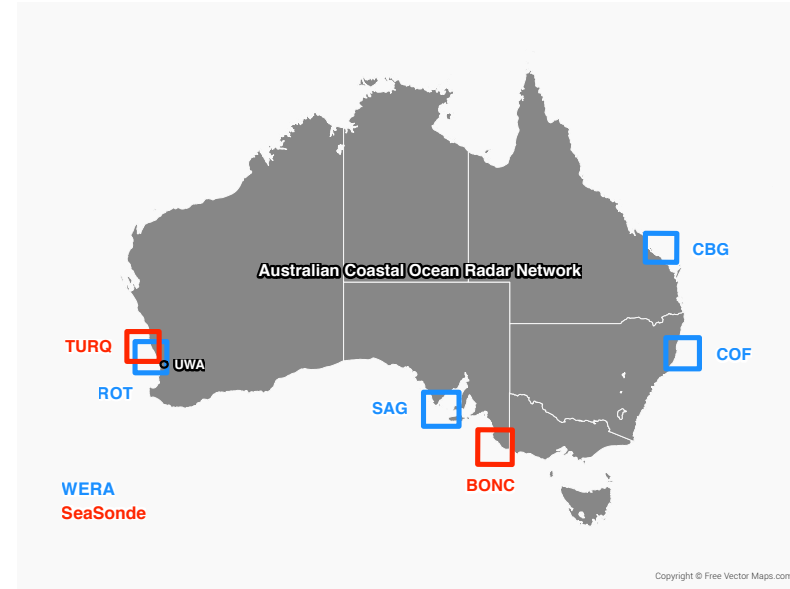


RF noise and interference within the ITU bands the ACORN experience

Simone Cosoli
School of Civil, Environmental and Mining Engineering
The UWA Oceans Institute
The University of Western Australia

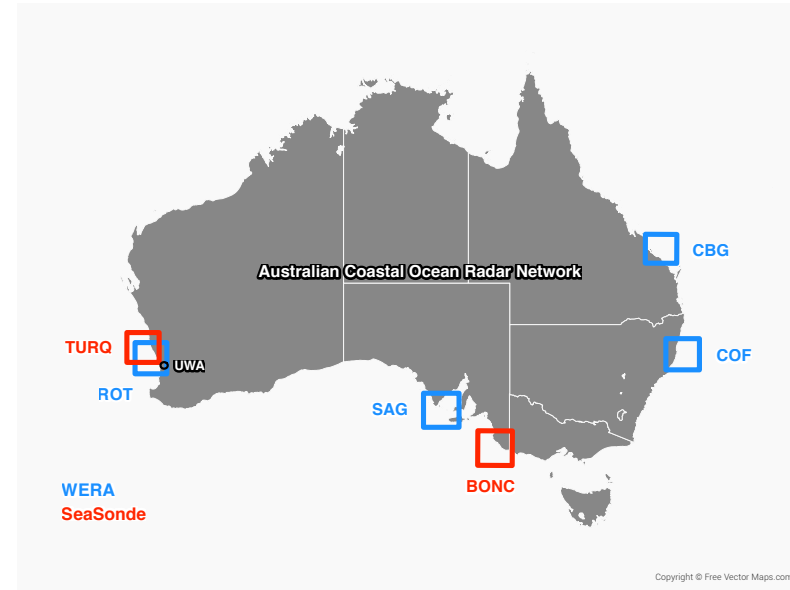
Outline

- ITU WRC-12 and ACMA prerequisites
- Australian Coastal Ocean Radar Network – ACORN
- Critical points: interference issues
- Mitigation efforts



ACORN

- Australian Coastal Ocean Radar Network (ACORN) is a facility of the Integrated Marine Observing System (IMOS)
- James Cook University (2007–2014)
- University of Western Australia (2014-)
- Primary application is to study dynamics of the major Australian current systems
- Free public access to HF radar data through the IMOS Ocean Portal
- 12 HF radar stations arranged in pairs at 6 sites around the coast
- Network includes both SeaSonde & WERA
- Expansion in NSW region (2-4 SeaSonde)



WRC-12: Agenda Item 1.15 (1)

- Oceanographic Radars (ORs) provide information on current, wave and wind conditions over coastal maritime areas, afford societal benefit via improved understanding of issues such as coastal pollution, fisheries management, search and rescue, beach erosion, maritime navigation and sediment transport.
- to consider possible allocations in the range 3–50 MHz to the radiolocation service for oceanographic radar applications, taking into account the results of ITU-R studies, in accordance with Resolution 612 (WRC-07)
- Very little alignment on proposed bands and bandwidths between administrations let alone between regional groups going into WRC-12.
- APT proposal comprised 21 separate ASPs of which 18 referred to frequency bands, and three to regulatory provisions.
- Australia supported only four of the band-related ASPs and abstained on four, as well as supporting the three regulatory provisions.
- ITU-R studies have shown that **sharing is not straightforward due to significant sky-wave propagation issues.**
- **Most proposed bandwidths were larger than that required for an Oceanographic Radar to operate effectively in a given band and for its intended application.**

WRC-12: Agenda Item 1.15 (2)



THE UNIVERSITY OF
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AUSTRALIA

Outcome

- The Australian position was re-assessed and modified throughout the drafting process.
- Agreement was reached on a mix of either secondary or primary allocations with footnotes requiring protection of the fixed and or mobile services.



Australian
Communications
and Media Authority

Frequency assignment practice

Guideline No. 6 – use of the radiolocation service between 3 and 50 MHz to support oceanographic radar operations

Attachment 1

Special conditions text

Conditions of operation which apply to an individual licence are printed on the apparatus licence under the heading 'Special Conditions'.

The ACMA's policy is that an accredited person should specify on the Frequency Assignment Certificate all the conditions the frequency assignment will be subject to, including those conditions required by ACMA documentation. Information about this policy is available on the ACMA [website](#).

Special condition OR1—oceanographic radar (operation pending international coordination)

Where a licence is to be issued, pending the outcome of the ITU notification process, the following special condition is to be applied to the licence:

The continued authorisation of the service under this licence is conditional on a favourable finding under the provisions of Article 11.31 of the Radio Regulations of the International Telecommunication Union (ITU). In the event of an unfavourable finding, the licensee may be required to cease operation or operate under amended conditions.

Special condition OR2—oceanographic radar (protection of the fixed and mobile services)

The following special condition is to be applied to all licences that authorise the operation of oceanographic radars in a frequency band subject to International Footnote 132A (refer Table 1):

A station authorised under this licence must not cause harmful interference to, or claim protection from, fixed or mobile services operating in accordance with the Australian Radiofrequency Spectrum Plan or the Radio Regulations of the International Telecommunication Union.

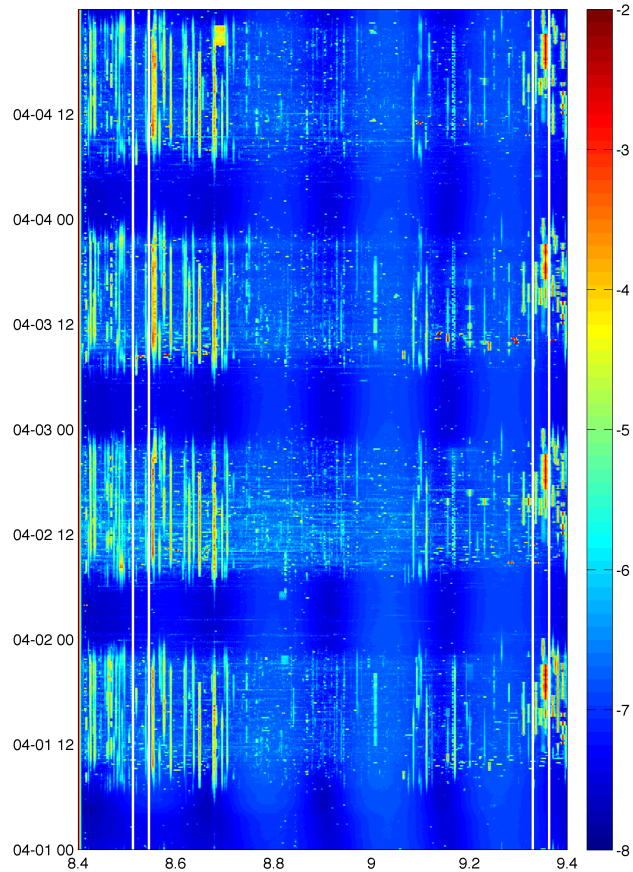
Interference issues

**ACORN radars operate within the ITU frequency bands
– however with secondary-type licenses**

- Major leakage outside the licensed band for SeaSonde systems
- Primary users may use the band 1 week / year: band use and sharing must be negotiated with each individual user
- Major problem for WERA radar systems
- ACMA issuing breach complaints (3KD/day fine + 1-y jail)
- RF Common issue reported in various areas (i.e., Mediterranean Sea)

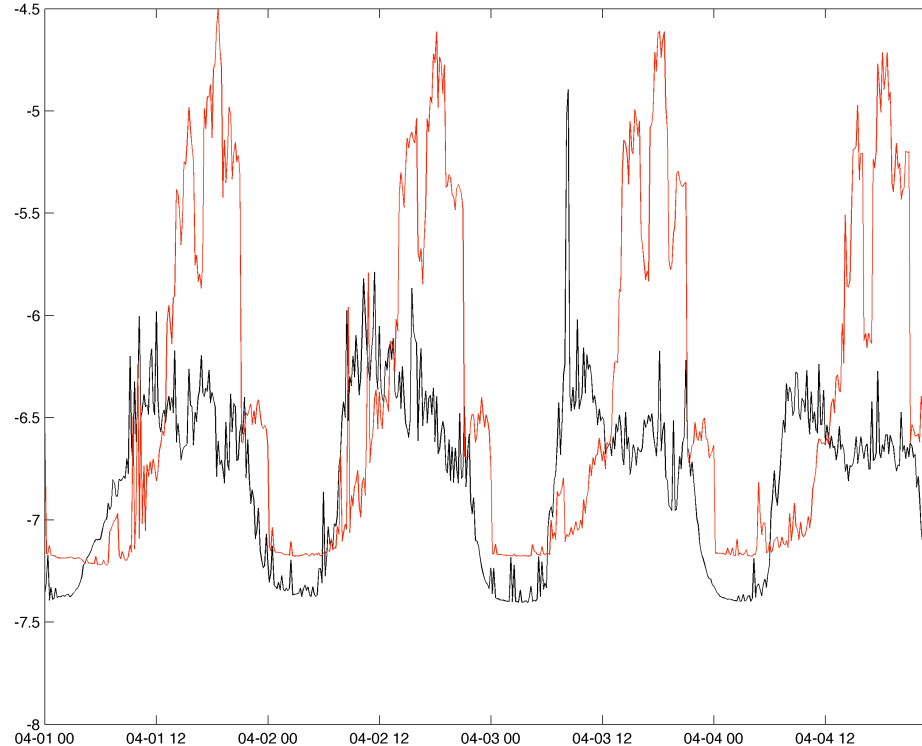
Interference issues

RF scans at CWI for time interval 2015-04-01 00:00:00 - 2015-04-05 00:00:00

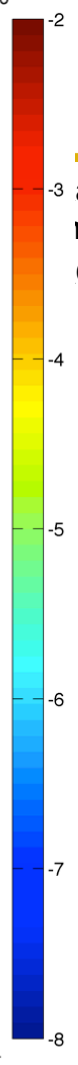
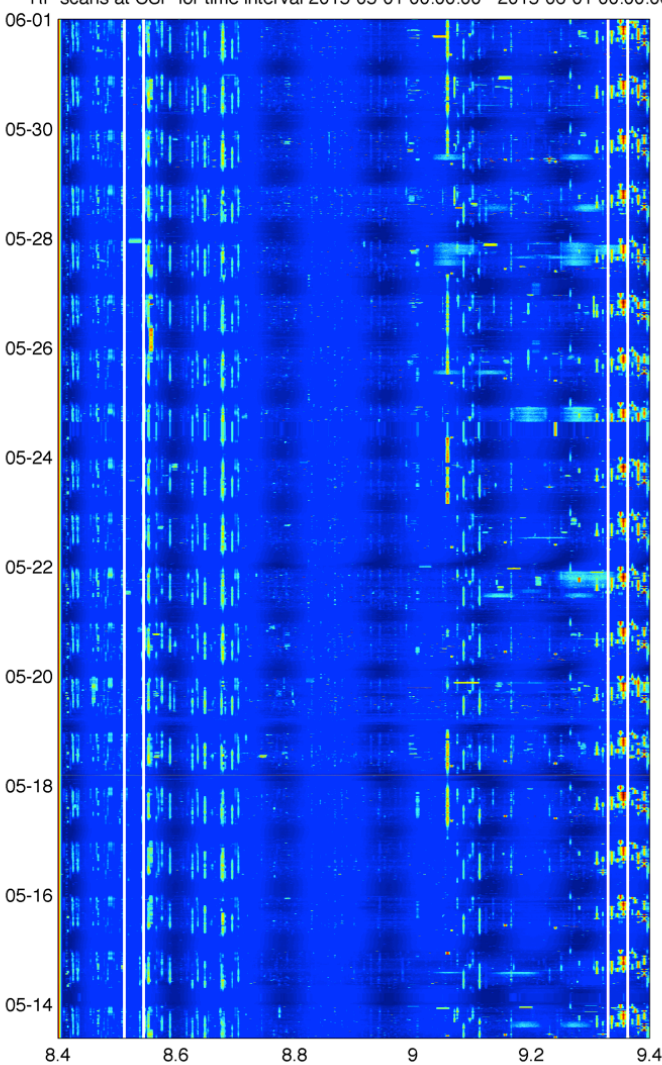


Radio frequency scans from CWI WERA radar shows clear intensification in the band-averaged power level *after* the frequency change
ACMA strongly “discourages” operations at previous non-ITU frequencies

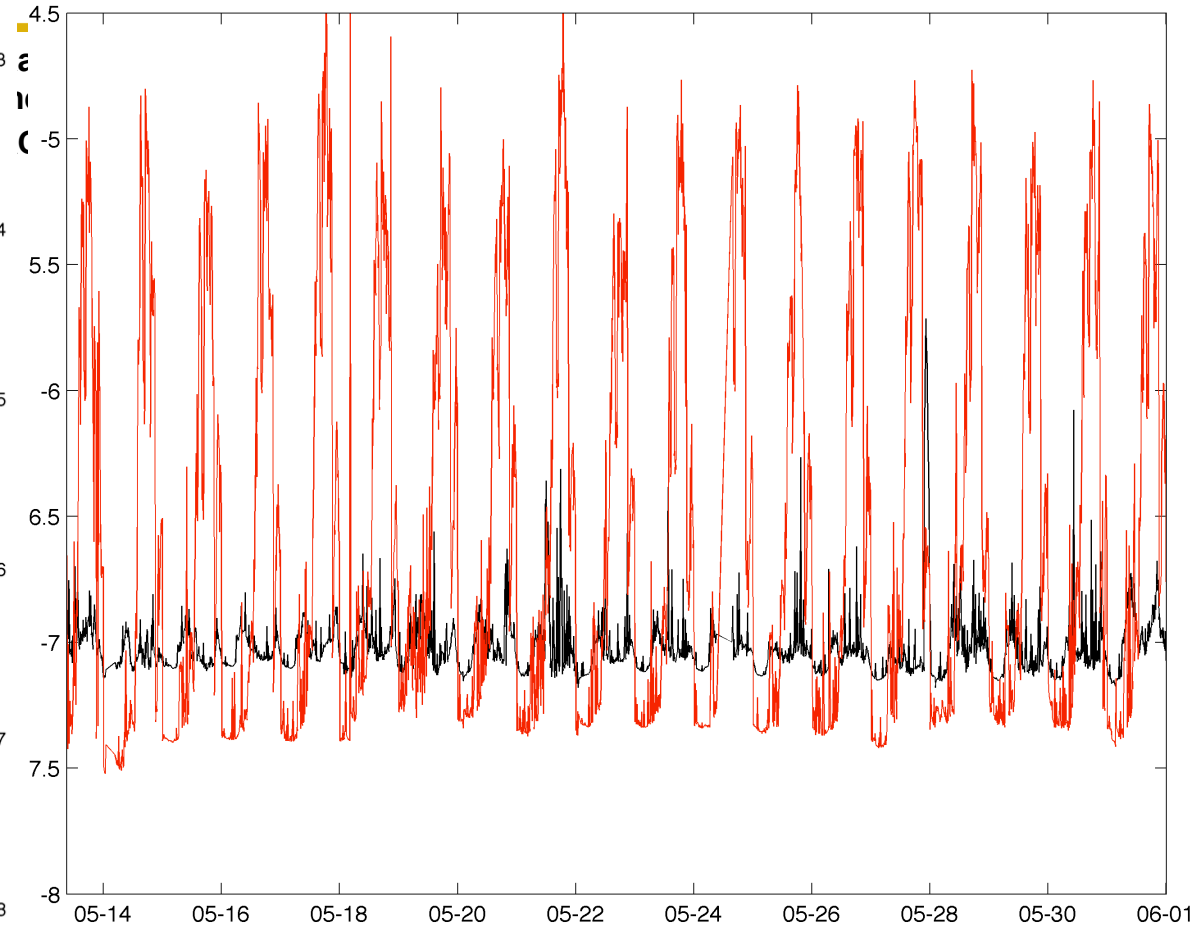
band-average power level at CWI for time interval 2015-04-01 00:00:00 - 2015-04-05 00:00:00



RF scans at CSP for time interval 2015-05-01 00:00:00 - 2015-06-01 00:00:00



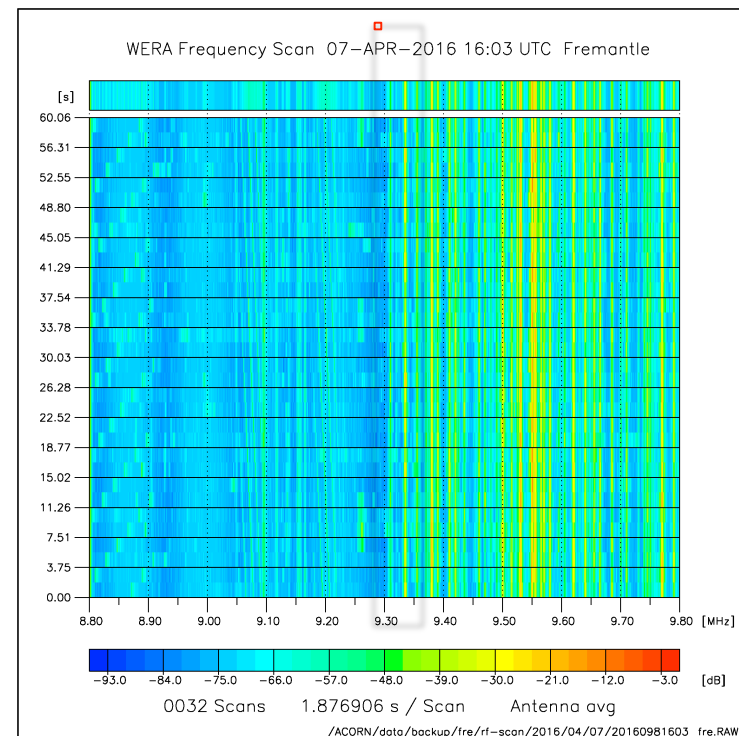
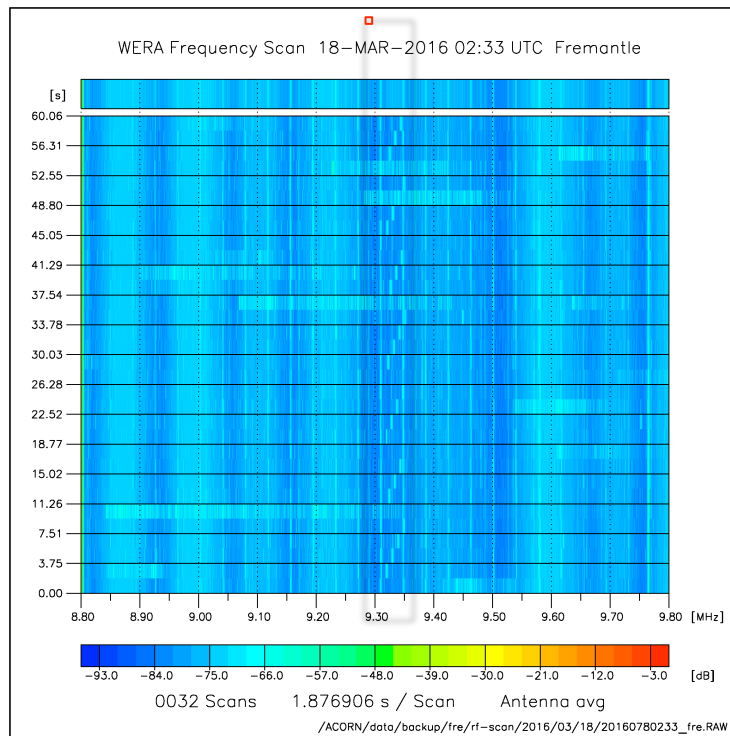
band-average power level at CSP for time interval 2015-05-01 00:00:00 - 2015-06-01 00:00:00



Interference issues (13.5 – 9.33 MHz)

Response of the WERA radar systems is variable:

- may be significantly affected – major artifacts in the radial current field
- may be not affected at all – directivity in the RX array filters the noise
- directivity in the main TX lobe (~90dB front/rear att; ~ 50-60 dB att ~60°) low TX power (4W / ant) and short-term bursts (5 min on / 5 min off) ensure minimum propagation over land

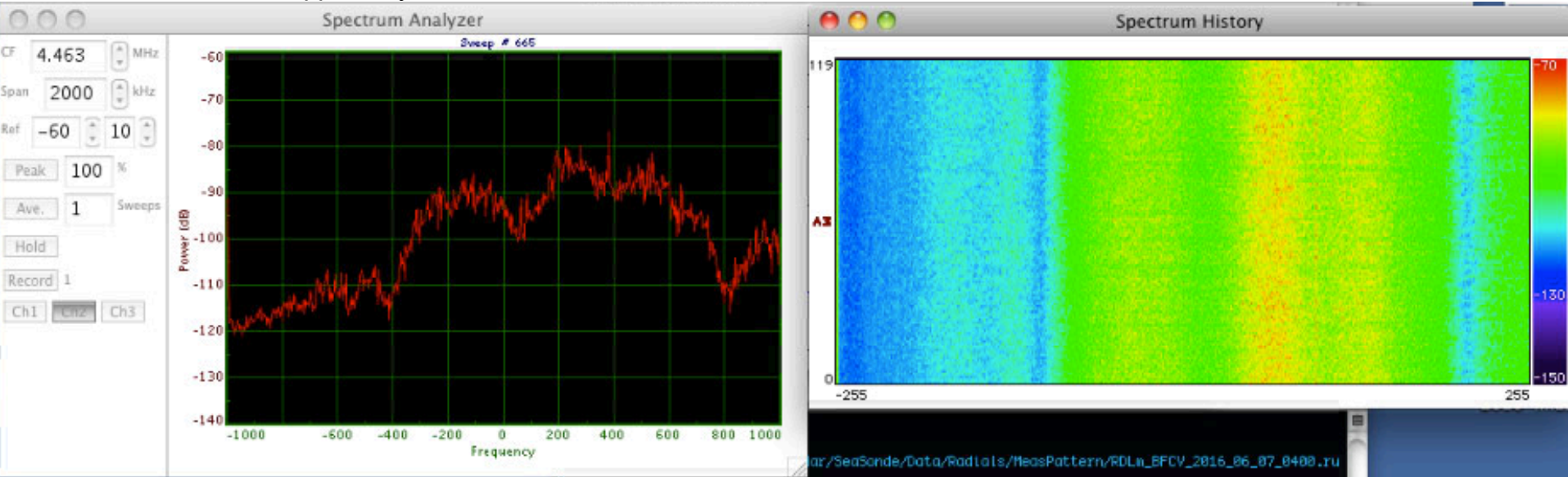


Interference issues (4.338-4.488 MHz)

Origin and impacted users vary

e.g. SA BONC radar node – data used for upwelling and salmon fishery industry

- broad-band noise from the power line: may be local or distant source – transmission line may act as a long-wire antenna
- complete loss of Bragg across all ranges
- difficult to deal with – apparently correlated with rain





Standard practices: RT monitoring, calibrations

System Status Events

Time	Event	Source	Message
20160913 161853	SeaSondeAcquisition	00802 Notice	CrossSpectra_1 glitched 4 range sweeps detected.
20160913 161853	SeaSondeAcquisition	00803 Notice	CrossSpectra_1 Saved #336 "CSQ_GHED_16_09_13_161021.cs"
20160913 162321	SeaSondeController	00313 Generic	RC1:Periodic Status Check #1435
20160913 162725	SeaSondeAcquisition	00804 Notice	RangeSeries Saved #337 "Rng_GHED_2016_09_13_161853.rs"
20160913 162725	SeaSondeAcquisition	00805 Notice	CrossSpectra_1 glitched 8 range sweeps detected.
20160913 162725	SeaSondeAcquisition	00806 Notice	CrossSpectra_1 Saved #337 "CSQ_GHED_16_09_13_161853.cs"
20160913 162811	Archivalist	01071 Success	Archiving "CS"...
20160913 163321	SeaSondeController	00314 Generic	RC1:Periodic Status Check #1440
20160913 163557	SeaSondeAcquisition	00807 Notice	RangeSeries Saved #338 "Rng_GHED_2016_09_13_163557.rs"
20160913 163557	SeaSondeAcquisition	00808 Notice	CrossSpectra_1 glitched 2 range sweeps detected.
20160913 163557	SeaSondeAcquisition	00809 Notice	CrossSpectra_1 Saved #338 "CSQ_GHED_16_09_13_163557.cs"
20160913 163800	Archivalist	01072 Success	Archiving "RDLm"...
20160913 163803	Archivalist	01073 Warning	At 09/13/2016 17:23:00 will archive "RDLm"
20160913 164322	SeaSondeController	00315 Generic	RC1:Periodic Status Check #1445
20160913 164429	SeaSondeAcquisition	00810 Notice	RangeSeries Saved #339 "Rng_GHED_2016_09_13_164429.rs"
20160913 164429	SeaSondeAcquisition	00811 Notice	CrossSpectra_1 glitched 1 range sweeps detected.
20160913 164429	SeaSondeAcquisition	00812 Notice	CrossSpectra_1 Saved #339 "CSQ_GHED_16_09_13_163557.cs"
20160913 164518	Archivalist	01074 Success	Archiving "RDLm"...
20160913 164524	Archivalist	01075 Success	Archiving "RDLi"...
20160913 164527	Archivalist	01076 Success	Archiving "CSS"...

CSPro - Recent Status Lines

Time	Event	Source	Message
2016/09/13 16:36:18	Reading	'CSQ_GHED_16_09_13_162726.cs'.	
2016/09/13 16:44:23	Waiting...	0:08:30	
2016/09/13 16:44:53	Reading	'CSQ_GHED_16_09_13_163557.cs'.	
2016/09/13 16:44:53	File written	'CSS_GHED_16_09_13_1630.cs'. #averages = 215.	
2016/09/13 16:52:28	Waiting...	0:08:00	

Spectra Map

AnalyzeSpectra — sleep — 96x20

19 Sweeps To Next CS

RC1 RF Monitor

Center Freq.: 4.463800MHz : Bandwidth: 25.7kHz : SupRate: 1.00Hz : Xmit: 50 : PLL: 50 : PPS Align: 100.0us

Range Cutoff: 175.10km : Range Step: 5.825km : Receiver: 24°C : 30°C : Valid: AWG3 3.02

Check #1452 : Receiver Settings match stored.

Picture 10, Picture 1, ghed, data01, data02, Time Machine Backups, TM, 20160708_spectrum_scans, APMs, tmp, 5.2115 Operating

???

Interference issues (4.338-4.488 MHz)

Origin and impacted users vary

e.g. SA BONC radar node – data used for upwelling and salmon fishery industry



Impacted bands:

4467.0kHz (center, RX), 3kHz BW, 10KW pY
TX

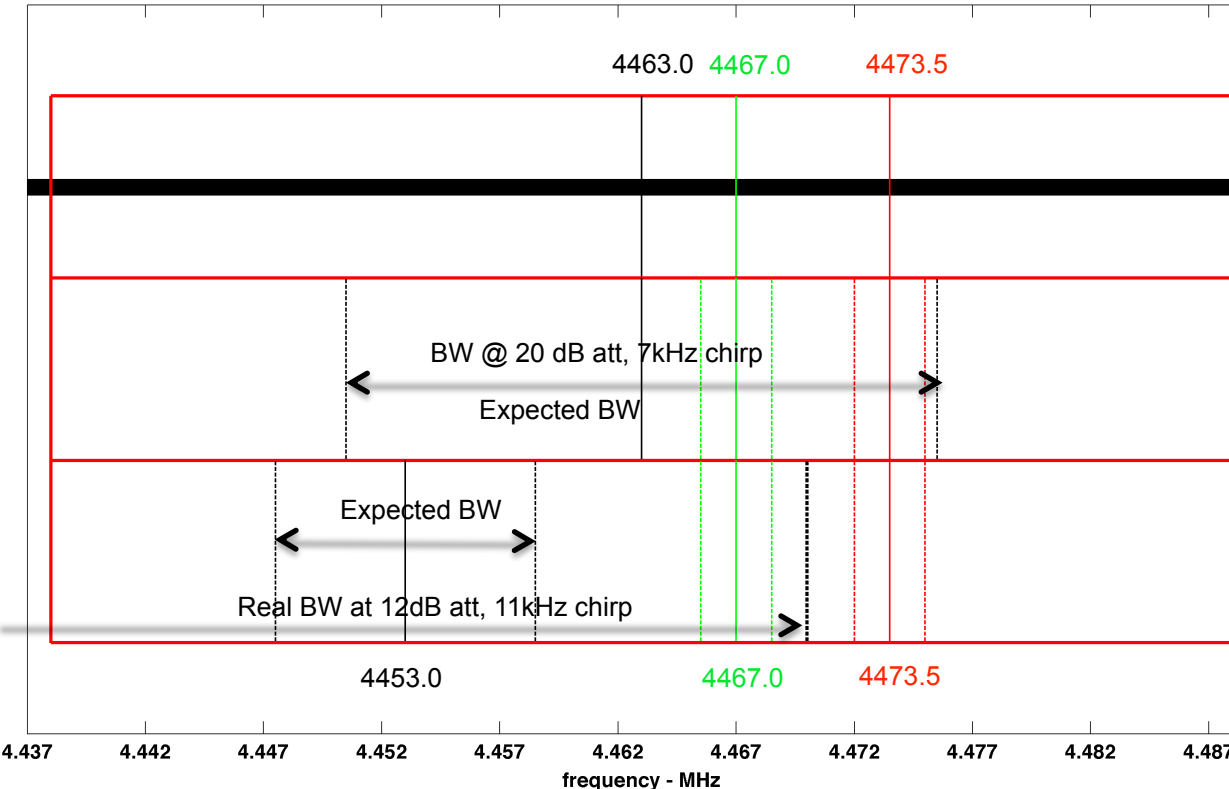
**4373.5kHz (center, RX), 3kHz BW, 10KW
pX TX**

Not site-specific but AU-wide frequency band
allocated to Defense

Temporary operating settings – negotiated
with ACMA but still under monitoring:
4.453MHz, 11kHz BW, 12dB att (~4W TX)

Roadmap for mitigation measures and
strategies plus quarterly updates to ACMA as
for its implementation

Interference issues (4.338-4.488 MHz)



Temporary operating settings – negotiated with ACMA :

4.453MHz, 11kHz BW, 12dB att (~4W TX)

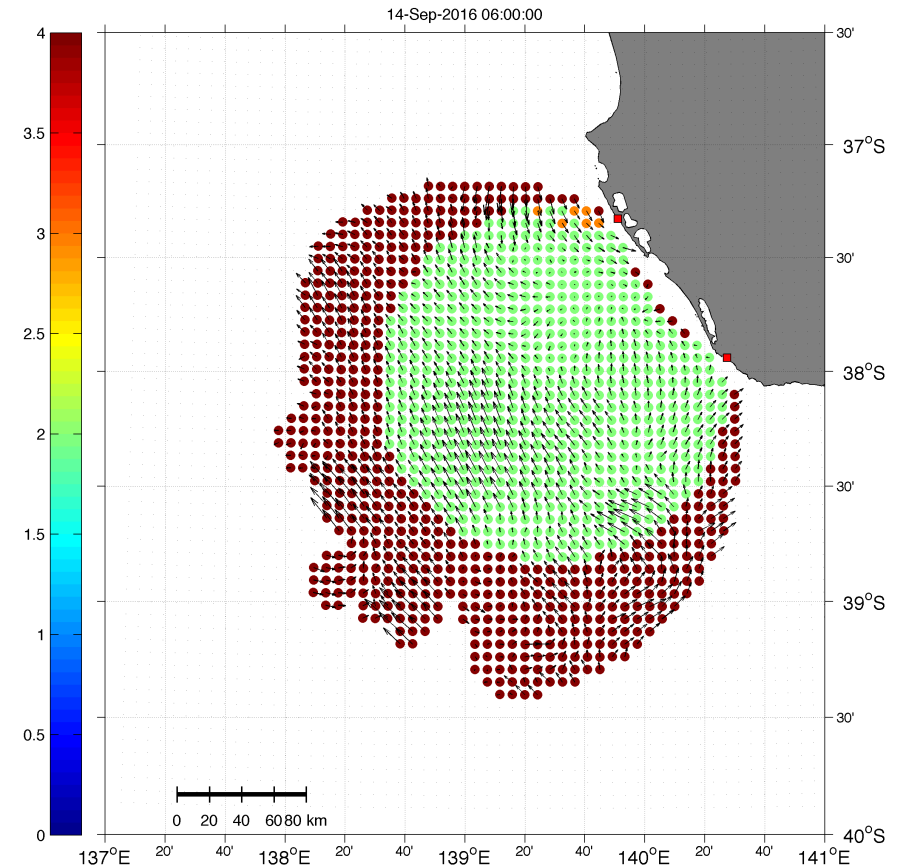
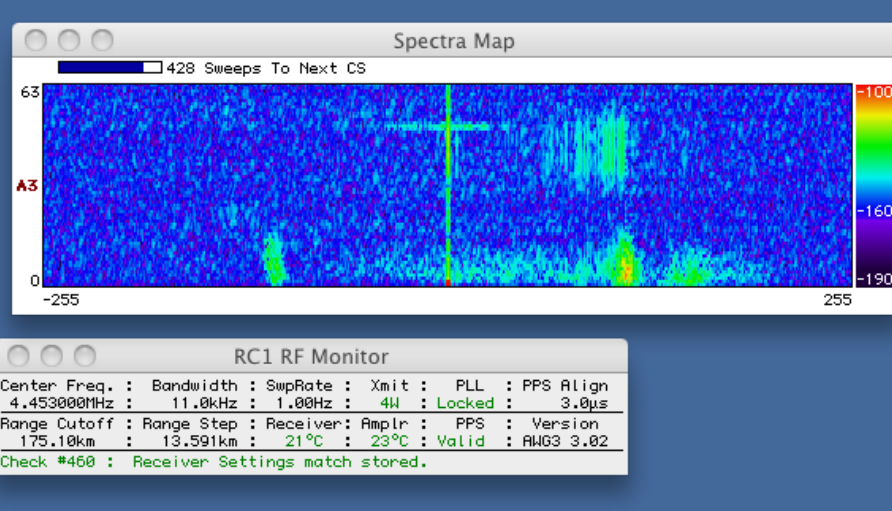
**Should not extend outside
4.438-4.463MHz**

**Leakage up to 4.430-4.470MHz still impacts
a primary band (AF)**

Mitigation steps:

- a, modification of the SS chirp (via hardware / software)**
- b, improve directionality**
- b, decrease power and BW**
- c, installation of an improved design of the SS twin-TX (simulated)**
- d, systems relocation**

Interference issues (4.338-4.488 MHz)



Increased attenuation (12dB) and decreased BW (11kHz)

Good SNR / range coverage up to 200km

1st-order Bragg up to 30dB

Pros: No need of high TX power at lower frequencies

Interference issues (4.338-4.488 MHz)

SS Twin TX setup improves directionality through phase offset between front-rear TX antennas

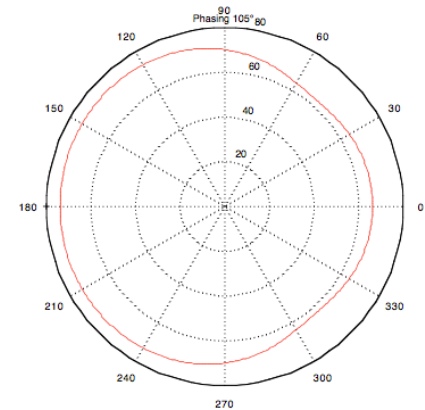
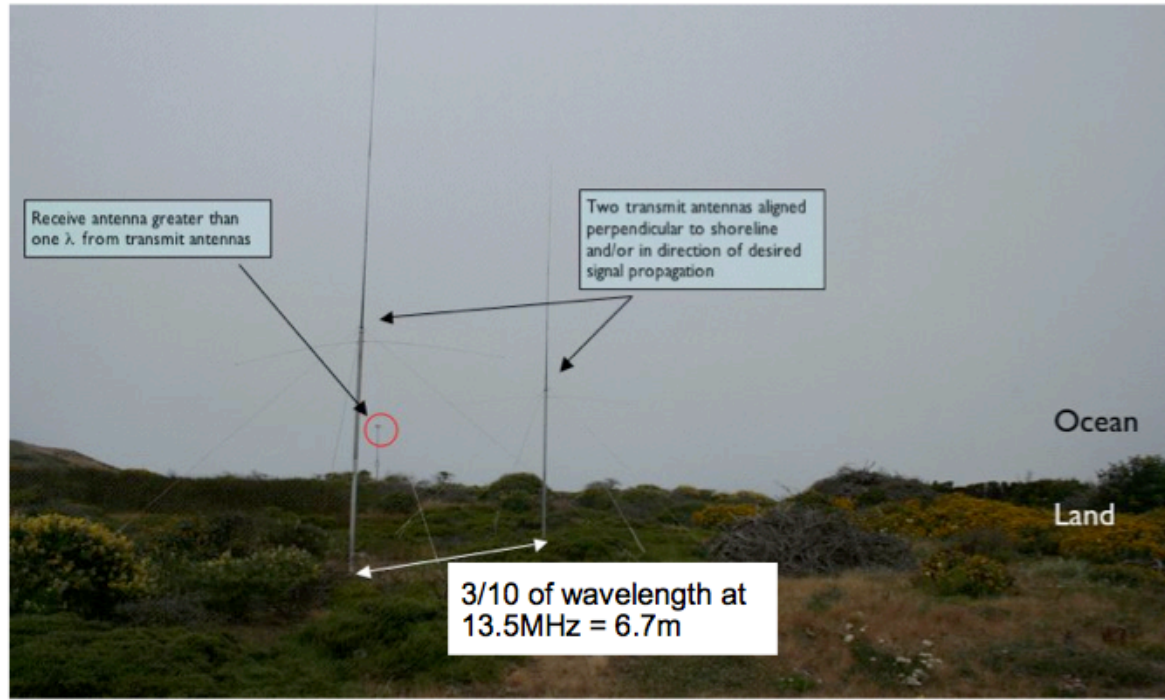
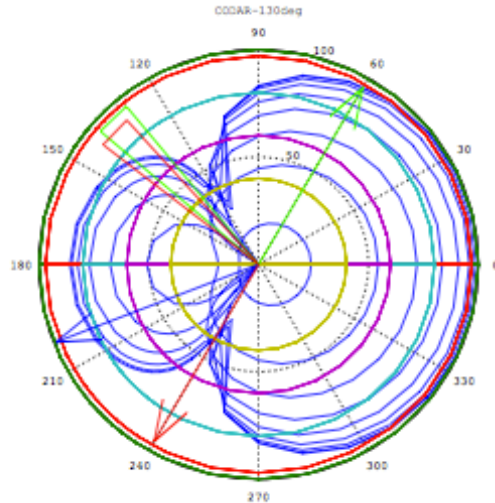
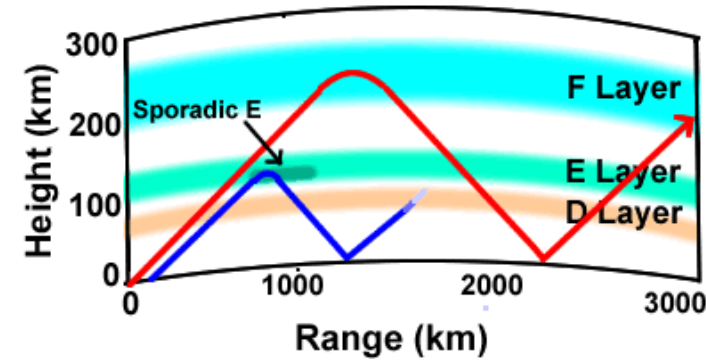


Figure 1. Theoretical calculation of twin transmit pattern with 105° phasing between elements.

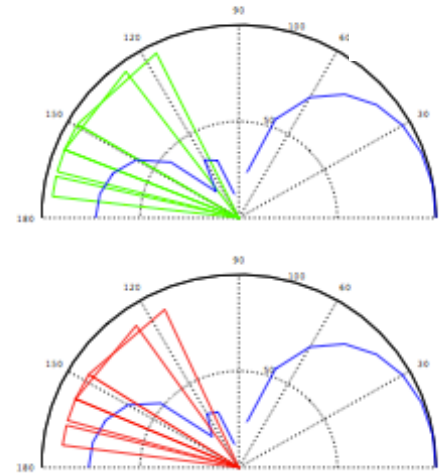
Figure 1. Twin transmit antennas

Interference issues (4.338-4.488 MHz)

- SS Twin TX setup to improvement – site specific simulations that account for skywave propagation (ionospheric reflection)
- Different antenna spacing and front-rear phasing offset to minimize skywave propagation:
 - Simplified but realistic far-field physics, ground conditions, ...



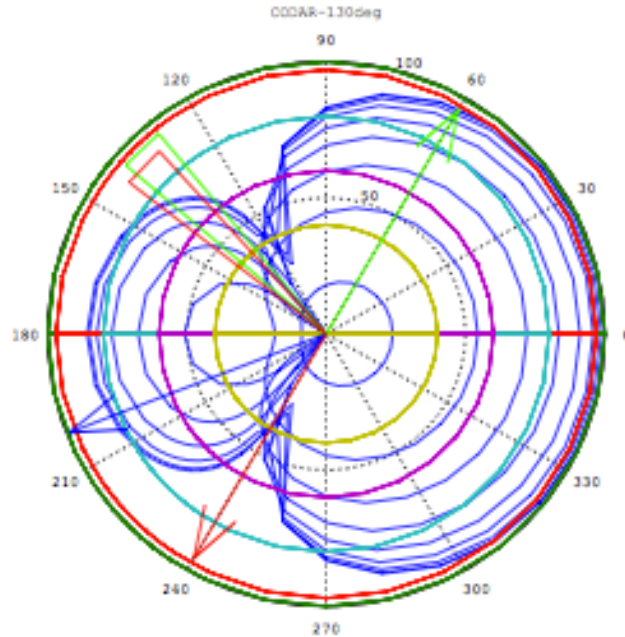
(a) Azimuthal Response



(b) Elevations

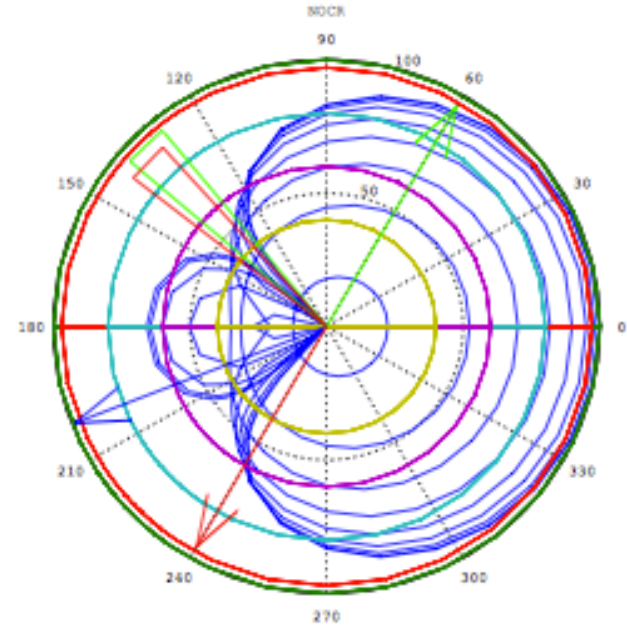
Fig. 3. Beam pattern CODAR Seasonde 130°φ as described in [3]

Interference issues (4.338-4.488 MHz)



(a) Azimuthal Response

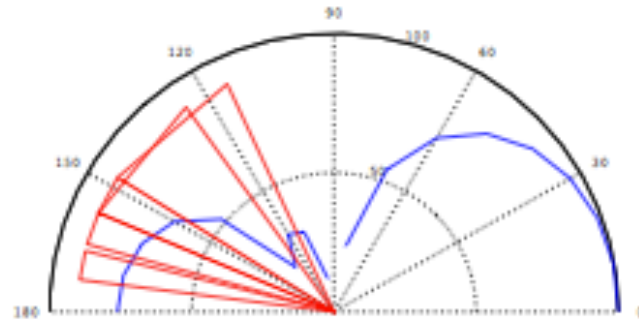
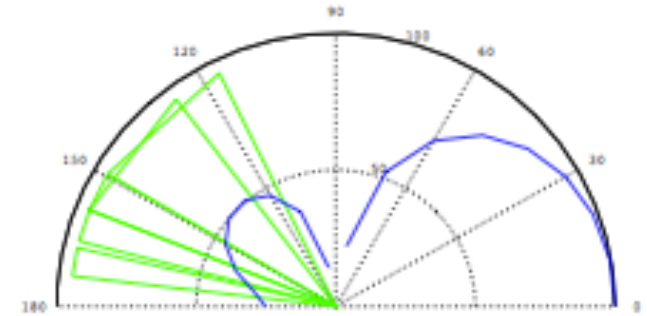
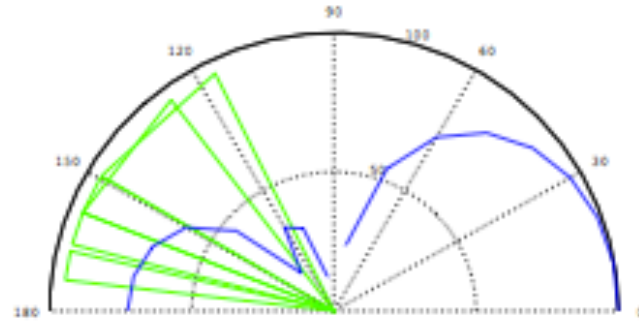
Default twin-TX config



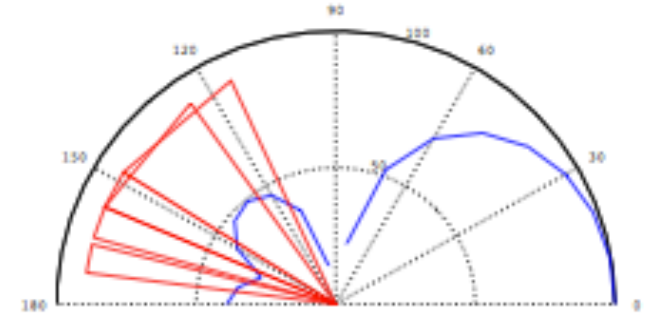
(a) Azimuthal Response

Proposed twin-TX config

Interference issues (4.338-4.488 MHz)



(b) Elevations



(b) Elevations

Summary

- HFR are considered important tools for research, monitoring of coastal maritime areas, fisheries management, search and rescue, beach erosion, maritime navigation and sediment transport.
- Specific frequency bands have been allocated internationally in the range 3–50 MHz, in accordance with Resolution 612 (WRC-07)
- Issued HFR licenses are either primary or secondary, with no protection from primary uses; most of the time negotiation with primary users is required for operations
- RF is a common issue at a global level within the HFR community
 - RF can affect the HFR operations to primary users
 - HFR operations can affect other licensed primary users
- Mitigation measures are needed and required for ACORN radars to operate
 - Decreased TX and BW but with severe limitations in angle resolution
 - Improvement of