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Canada's Third Generation High Frequency Surface Wave Radar for Persistent Surveillance of the 200 Nautical Mile EEZ

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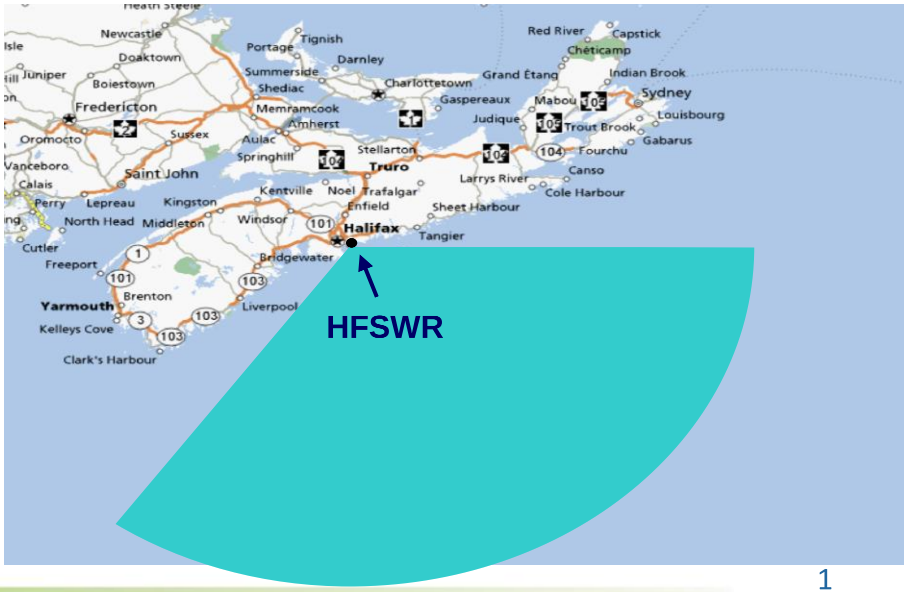
Canada

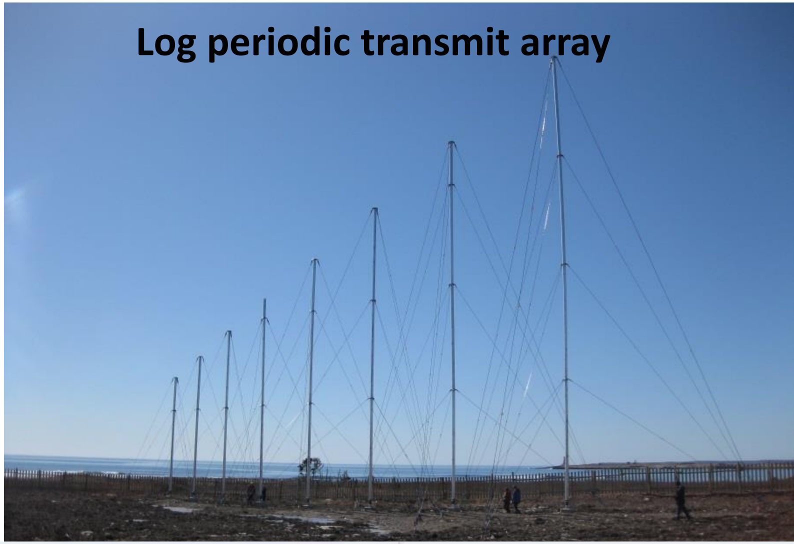
High Frequency Surface Wave Radar (HFSWR)

- Third Generation HFSWR
  - Developed by Raytheon Canada under DRDC's Persistent Active Surveillance of the Exclusive Economic Zone (PASE) Project
  - Provides persistent surveillance of surface vessels within Canada's Exclusive Economic Zone (EEZ)
  - meets 2009 Industry Canada spectrum management guidelines for operation on a Non-Interfering Basis/Non-Protected basis
  - operates with minimal risk of causing harmful interference
  - provides enhanced detection and tracking performance for smaller vessels

Coverage of Canada's EEZ



HFSWR electronics shelter and antenna arrays



Vessel classes for evaluation with HFSWR

SMALL VESSEL : Fishing trawler

Tickled Pink
Dimensions: 13 m x 6 m

MEDIUM VESSEL: Supply vessel

Panuke Sea
Dimensions: 81 m x 16 m

LARGE VESSEL: Ocean-going cargo vessels

Valiant Ace
Dimensions: 200 m x 32 m

YM Great
Dimensions: 279 m x 40 m

HFSWR performance specification

	VESSEL TYPE	MAXIMUM DETECTION RANGE (km)		
		Sea States 0-4* *0-15 knot wind* day/night	**Sea States 5-6** *15-25 knot wind* day/night	**Sea State 7** *25-35 knot wind* day/night
	**Small Vessel**	230/210	75/75	
	**Medium Vessel**	300/220	300/220†	180/180†
	**Large Vessel**	370/260	370/260	370/260

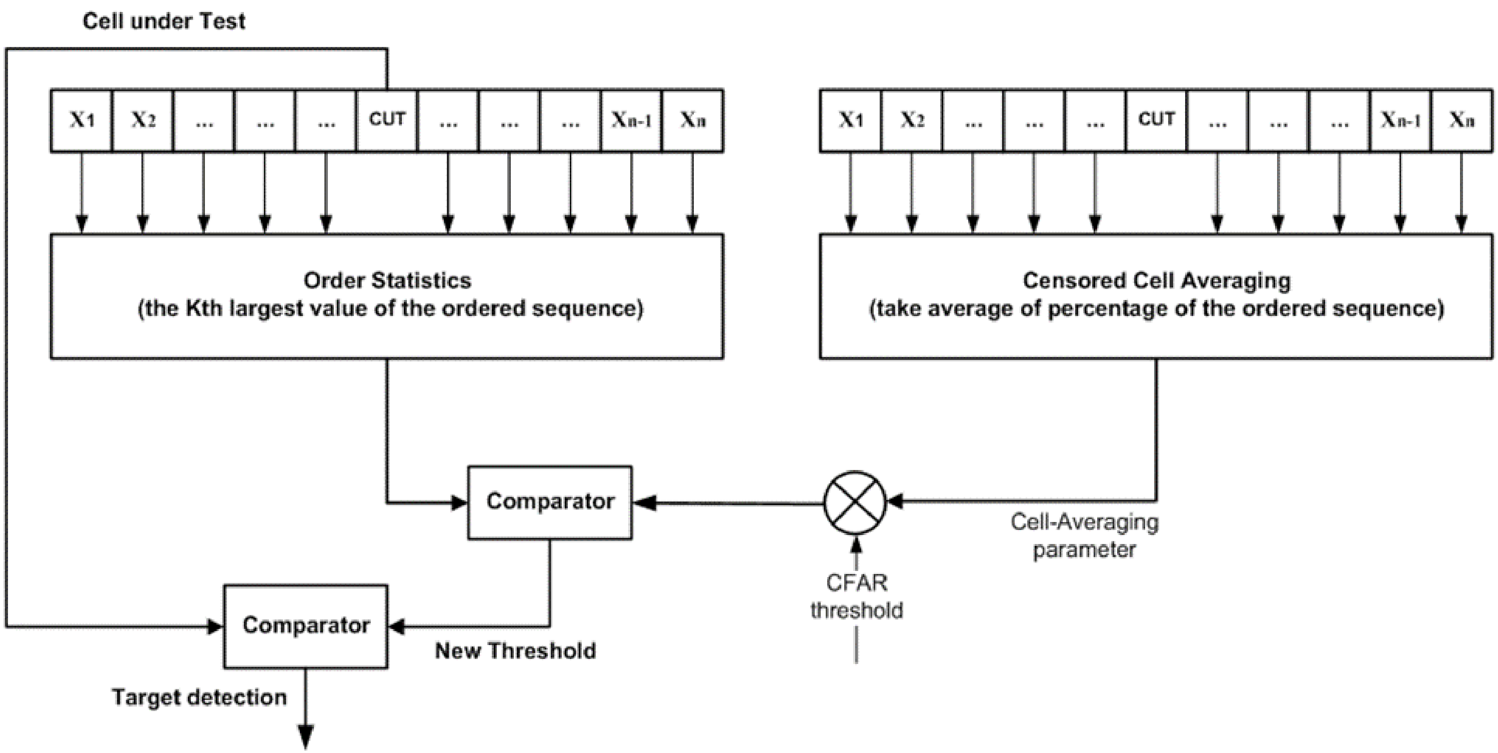
† These day time and night time detection ranges are approximately double those achieved with first-generation HFSWR technology

* Douglas sea scale

Adaptive Aspects of 3rd Generation HFSWR

- Detection: Adaptive Constant False Alarm Rate (CFAR)
  - **Adaptive modifications to Ordered Statistics (OS) CFAR**
- Tracking Techniques
  - Feature aided tracking
  - Adaptive track promotion logic
  - Enhanced tracking filters
- Spectrum Monitoring
  - **Pro-active frequency decision logic**

Hybrid CFAR


Cell under Test
X1
X2
...
...
...
CUT
...
...
...
Xn-1
Xn
Order Statistics
(the Kth largest value of the ordered sequence)
X1
X2
...
...
...
CUT
...
...
...
Xn-1
Xn
Censored Cell Averaging
(take average of percentage of the ordered sequence)
Comparator
Cell-Averaging
parameter
CFAR
threshold
Comparator
New Threshold
Target detection

Baseline OS CFAR vs Adaptive OS CFAR

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- **Baseline CFAR**
  - The baseline PASE OSCFAR window of 3 Doppler cells by 33 Range cells is applied in all areas. OS CFAR has a rank order parameter of Kos of 45% and Threshold of 8 dB.

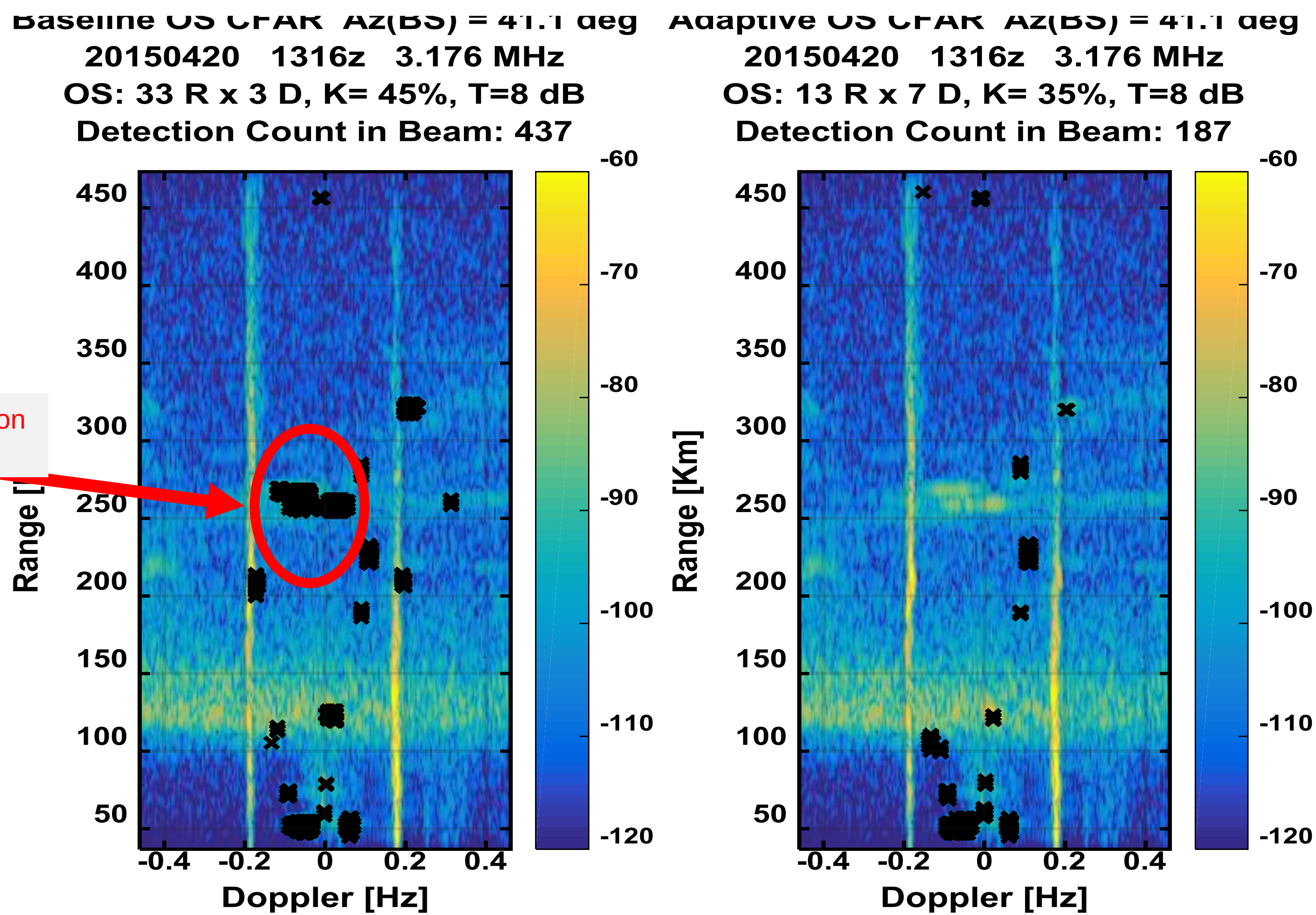
- **Adaptive CFAR Technique**
  - A OSCFAR window of 7 Doppler cells by 13 Range cells is applied in all areas outside of the immediate Bragg clutter regions. OS CFAR parameters with Kos of 35% and Threshold of 8 dB are used.

  - The Bragg peak power point is detected based upon expected locations which are deterministic from carrier frequency. All R-D cells within +/- 3 Doppler cells from peak have a 3 Doppler by 33 range cell window with Kos at 65% and Threshold of 12 dB.

Baseline OS CFAR vs Adaptive OS CFAR

- Baseline OS CFAR setup on left (as used in PASE) with adaptive foot print OS CFAR on right.

Eliminate hits on clutter



Baseline OS CFAR vs Adaptive OS CFAR

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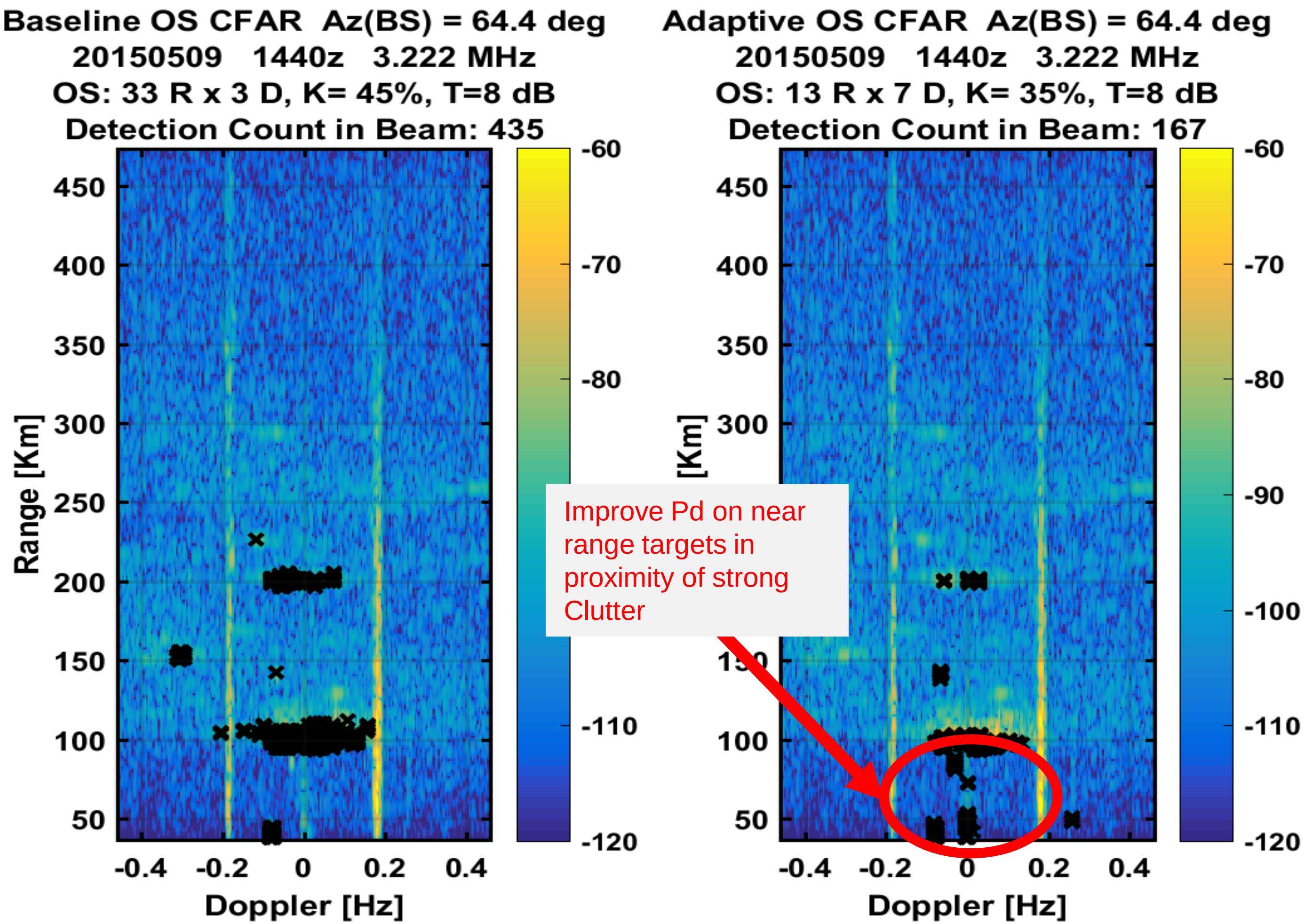
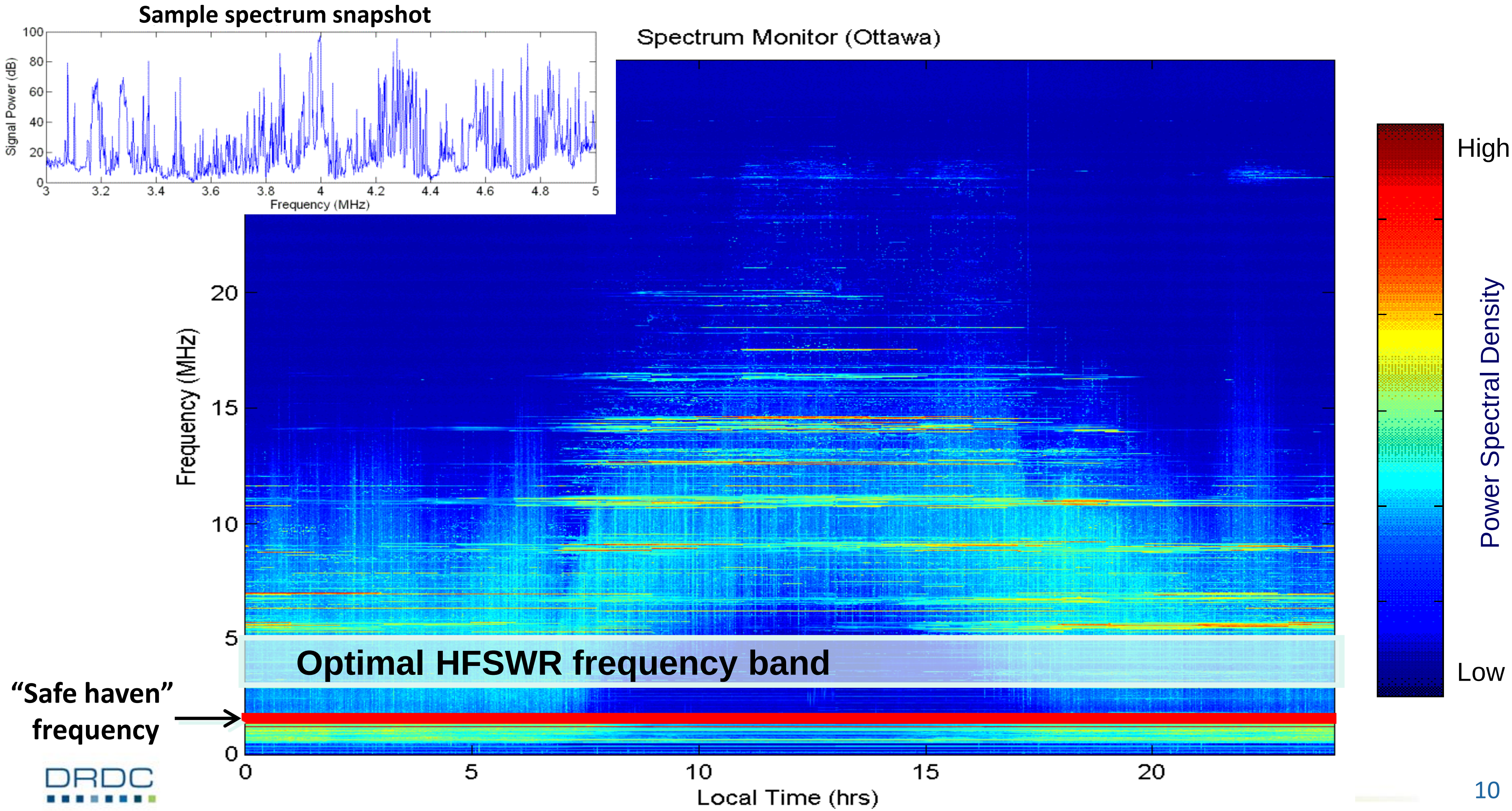
- Baseline OS CFAR setup on left (as used in PASE) with adaptive foot print OS CFAR on right.



Skywave interference problem



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PRISM - Intelligent Spectrum Management

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Top level block diagram of Spectrum Management Processing – 3 prime components

1)Wide Band Monitoring and Occupancy Determination

– Spectral processing of the operating band

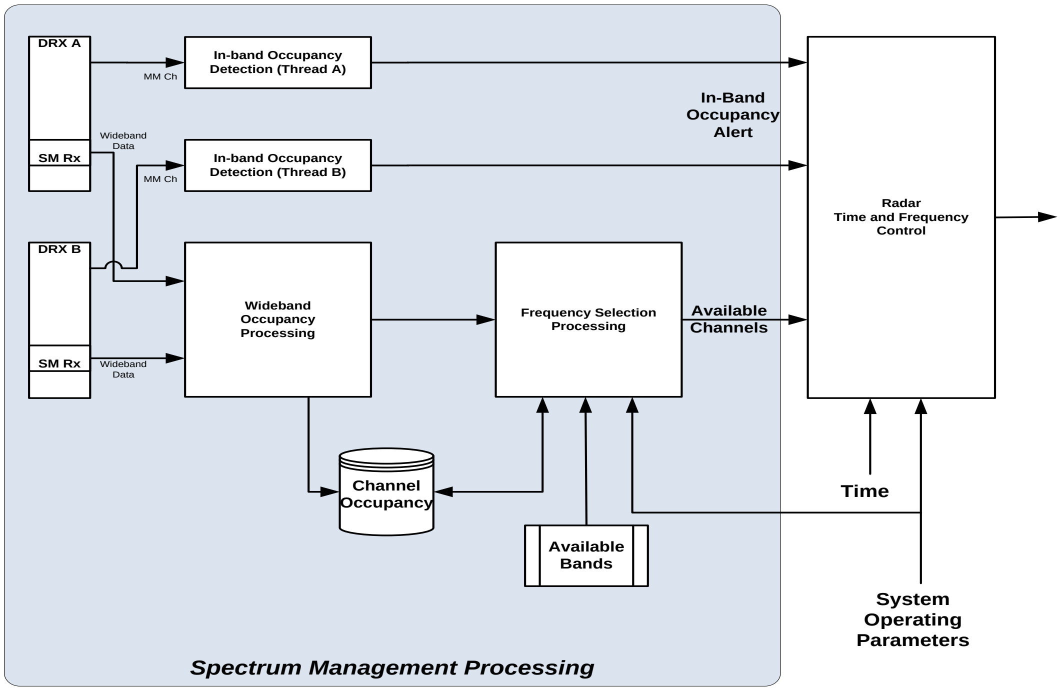
– On whenever the Radar is Operational

2)In-Band User detection

– Operates whenever the radar has selected a frequency channel on which to operate or is operating on

3)Frequency Decision Logic

– Determines the optimum frequency of operation based upon a set of rules and occupancy statistics



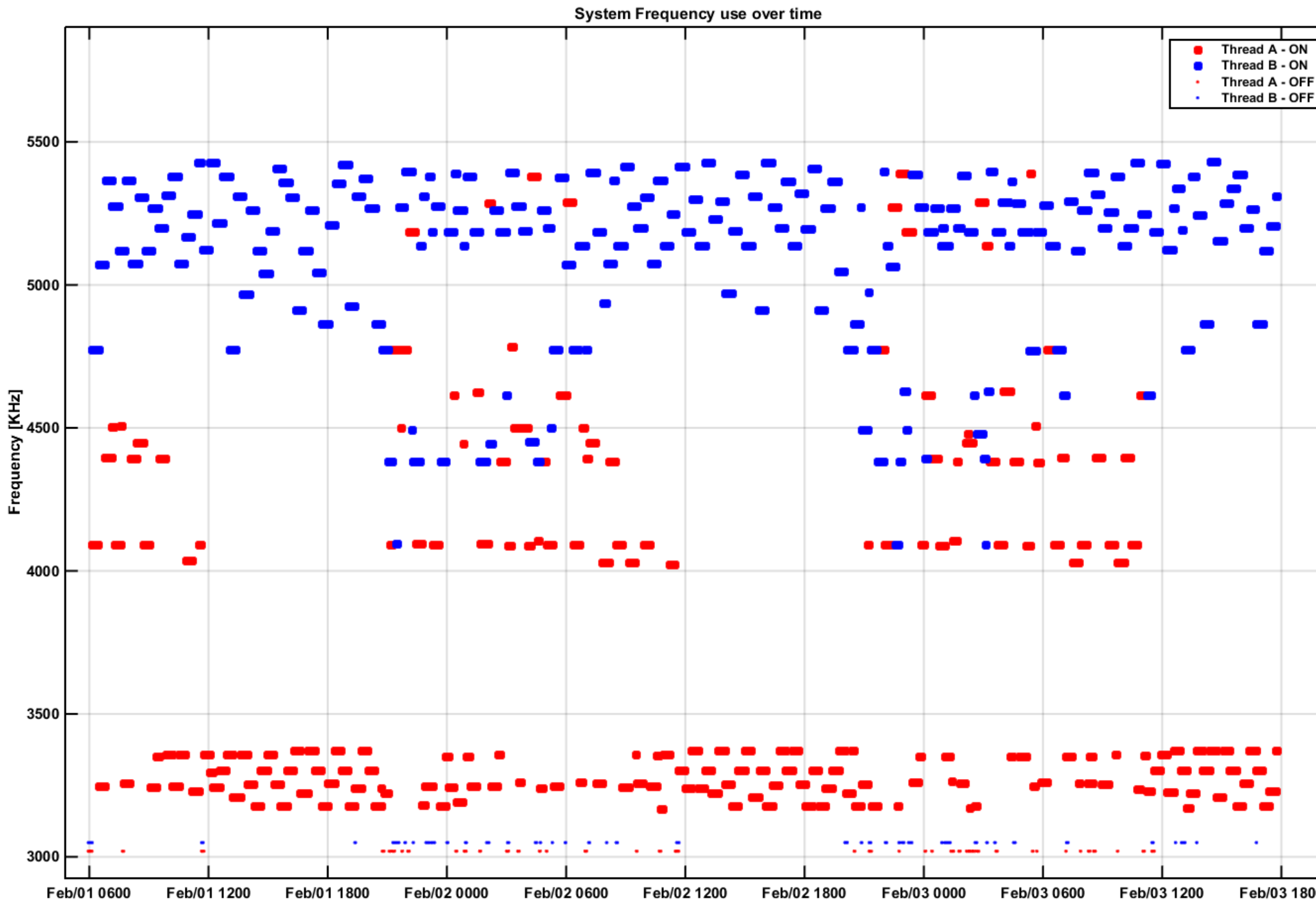
PRISM – Design Highlights

- Wideband ADC prove 2.5 MHz of spectral information per sweep (3 to 5.5 MHz)
- Wideband and in-band spectral processing sweep the entire band (3-5.5 MHz) at 240 sweeps/sec with frequency resolution of 500 Hz (Sweep rate is 2 msec).
- Two independent spectrum processing channels with separate antennae provide redundancy
- Past spectral use is monitored and used in ranking of open channels. Time depth of past use is adjustable but is typically 2-4 hours.
- Impulsive noise is removed
- In-band user detection is derived from mis-matched data channels.
- Adjustable thresholds and M of N sweep processing accurately measure past channel use. Thresholds typically set to 6 dB above estimated noise floor.
- Operational bandwidth is controlled by a family of waveforms. Typically 15 to 40 kHz in 5 kHz steps.

WIDE BAND DIGITAL DIRECT CONVERSION PROVIDE A RAPID SWEEP RATE

Example of frequency selection with spectrum management

Dates: Feb 1-3, 2015
Start time: 2:00 am local
Total duration: 58 hours



Conclusions

- Third Generation HFSWR provides persistent surveillance of surface vessels in Canada’s EEZ.
- Adaptive OS-CFAR generates better estimates of interference levels to reduce false alarms caused by ionospheric interference and clutter.
- Intelligent spectrum management selects radar frequency of operation based on occupancy statistics and frequency decision logic.
- These techniques enhance detection performance in challenging interference environments, while operating on a non-interfering basis with other HF users.

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