ROYAL CANADIAN MARINE
SEARCH & RESCUE
Saving Lives on the Water

CHIRP Solid State vs. Open Array Radar Tests

Station 1 & Station 20 - March 2018 (Quantum)
Station 1 & Station 25 – August 2019 (Quantum II)

Executive Summary

In March 2014 Station 1 performed a series of radar tests triggered by concerns around the performance of 4 kW 24” closed radome units commonly used on RCM-SAR vessels. The main conclusion of these tests was a clear superiority of 12 kW 48” open array radars for SAR operations. In March 2018 Stations 1 and 20 were asked by the Region to compare the 48” open array radar to the new CHIRP solid state radars appearing on the market. In August 2019 the same tests were performed by Stations 1 and 25 with a second generation CHIRP radar with Doppler. Neither CHIRP tests performed were as thorough as the 2014 series due to lack of time and resources but offer a reasonably accurate picture of the performance of both radar types.

Whereas it was obvious after the 2014 tests that the 4 kW radome units performance is unacceptable, the verdict on CHIRP solid state units is not as clear cut. An experienced radar operator will likely rapidly become irritated with the poor image quality. Inexperienced operators might feel reassured by the enlarged target rendering, but it comes at a steep price of lower target discrimination and poor contour detail. The detection of small high-speed targets is adequate but not great. The second generation CHIRP radars (i.e. Quantum 2) do offer better performance than the first generation, but it still not comparable to an open array unit.

As noted in 2014 our concern is that most volunteer RCM-SAR crew have relatively limited radar experience, which therefore calls for radar units with high rpm and longer distance detection ability to allow the crew more reaction time. Considering the mission critical nature of radar devices for SAR vessels we would strongly recommend the higher performance 12 kW 48” open array units. Full conclusions and recommendations can be found on page 19.

Tested Configurations

The following configurations were tested (see section 5 for more details):

1) CHIRP solid state first generation, 20 W, factory tuned, mounted on SAR-20 (called “CHIRP 1” in the test results).

2) CHIRP solid state second generation with Doppler, 20 W, factory tuned, mounted on SAR-25 (called “CHIRP 2” in the test results).

3) 48” open array, 12 kW, factory tuned, mounted on SAR-1B (called “Open Array” in the test results).

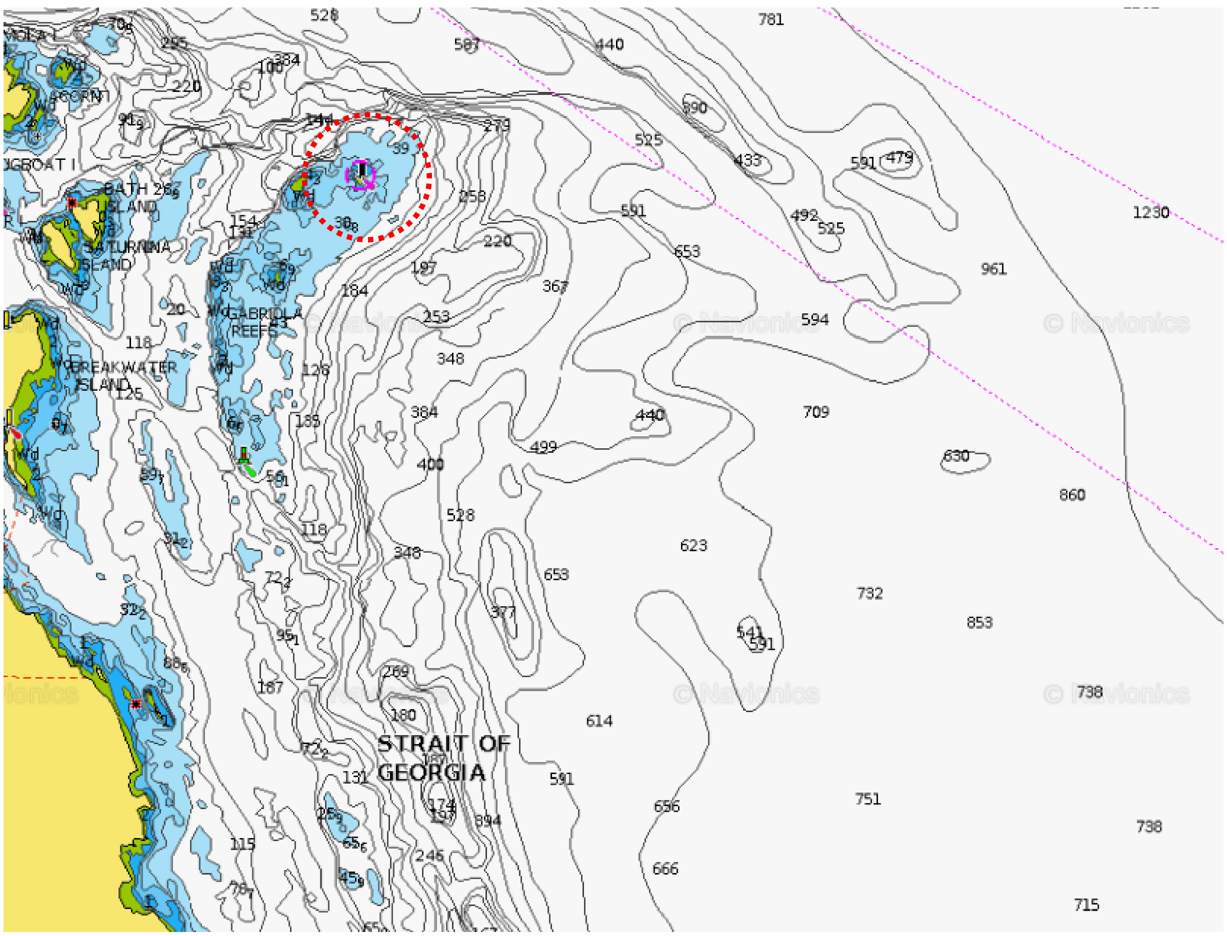
Test Environment

Contrary to the 2014 tests, we did not have a “standard” moving target at our disposal in 2018 and 2019 so we used both test boats as targets. This was not ideal as each boat has a slightly different radar profile, and both boats present a larger profile than the original target boat used in 2014 (a 733 RHIB with minimal superstructure and no radar reflectors). See the “Test Interpretation” section for details on the effects of this target difference. The target vessel had its radar in standby throughout the tests.

A small plastic 10’ dinghy was used as a secondary target for detection of smaller targets (e.g. kayaks).

The fixed target was a standard navigational aid with a Racon and an effective echoing area of roughly 15m². The tests used Thrasher Rock beacon, which is situated off Gabriola Reefs (see the red dotted circle on the chart at approximately 49°09’00 N, 123°38’30 W).

Weather for both test runs was clear skies, light winds, a 1 ft chop, and good to perfect visibility.



Radar Setup

All tests were conducted with the radar set to Harbour Mode, automatic gain, automatic sea state, rain filter off. Enhanced Echo mode was turned off on both units. Only the radar range setting was changed during the tests.

Test Protocol and Results

Both stationary (fixed) and moving targets were detected, at various vessel speeds. Additionally, the discrimination resolution of the radars was tested by verifying their ability to distinguish two close-by targets.

The goal of the tests was to emulate situations that are most common and critical for coastal SAR vessels. We therefore focussed on the detection of small vessels (the SAR vessels and the 10' dinghy) and small land features, both at slow and high speeds, at distances under 3nm. The various tests and results are listed below.

We did not have the time to do full series of measurements for both radars. In particular we did not perform with SAR-1B the side-angle tests and most of the tests moving away from the target, since a rotating open array performs equally well under all angles as observed in the 2014 tests.

In some cases there was a significant difference between the intermittent detection of a target (target detected every 2nd or 3rd scan) and continuous detection (target detected every scan). In such cases both measurements are listed, with an "i" for the intermittent detection and a "c" for the continuous detection. If there was little difference between the two measurements, a single data point is listed.

At closer ranges, targets were sometimes immediately and continuously detectable (i.e. at the outer edge of the screen). In such case the measurement is printed in *italics*.

If a target was not detectable at a defined range, the cell is marked with a "-". If a range was not used during the test the cell is left blank is marked "NT"

Note that the CHIRP solid state radars have intermediate range settings (1, 2 and 4nm) not available on the open array radar. We did not use these intermediate ranges for our tests with CHIRP 2.

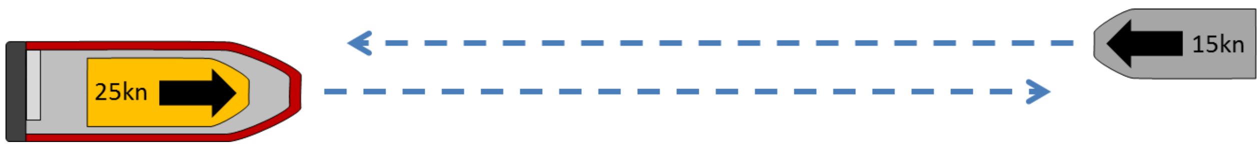
1. Moving target detection

Starting at 2 nm from the target the SAR vessel is driven at medium speed (10 kn) towards the target moving on a perpendicular course towing the small dinghy. The table shows the distance at which the primary target is detected, and the distance at which the secondary small towed target is detected.

Speed (kn)	Range (nm)	Target detected at (nm) forward			Small dinghy target detected at (nm) forward		
		CHIRP 1	CHIRP 2	Open Array	CHIRP 1	CHIRP 2	Open Array
10	6.0	1.25 i	2.0 i 1.5 c	2.0 i 1.8 c	-	-	-
10	3.0	1.25 i	2.0 i 1.5 c	2.0 i 1.75 c	-	-	-
10	1.5	1.25 i 0.75 c	1.5 i 1.1 c	*1.5*	-	-	-
10	1.0	1.0 i 0.75 c	NT	NT	-	NT	NT
10	0.75	*0.75*	*0.75*	*0.75*	0.3 i 0.2 c	-	0.3 i 0.25 c
10	0. 5	*0.5*	*0.5*	*0.5*	0.3 i 0.2 c	0.2	0.3

Note that on the CHIRP 1 the small dinghy target becomes intermittent again under 0.1 nm.

2. Moving target detection at speed



Starting 2 nm apart the target vessel and the SAR vessel drive towards each other. The target vessel proceeds straight toward the SAR vessel at a fixed 15 kn speed then continues past the SAR vessel holding course. The SAR vessel drives at 25 kn. The table shows the distances at which the target is first detected, and the distance at which the target disappears after the vessels have past each other and continue on their respective courses.

Speed (kn)	Range (nm)	Target detected forward at (nm)			Target vanishes aft at (nm)		
		CHIRP 1	CHIRP 2	Open Array	CHIRP 1	CHIRP 2	Open Array
25	6.0	NT	1.8 i 1.25 c	NT	NT	1.5 i 1.25 c	NT
25	3.0	NT	2.0 i 1.7 c	2.2	NT	1.5 i 1.25 c	1.7 i 1.4 c
25	2.0	1.8 i 1.25 c	NT	NT	0.8	NT	NT
25	1.5	1.5 i 1.0 c	*1.5*	*1.5*	0.8	1.5 i 1.25 c	*1.5*
25	0.75	*0.75*	*0.75*	*0.75*	*0.75*	*0.75*	*0.75*
25	0.5	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*

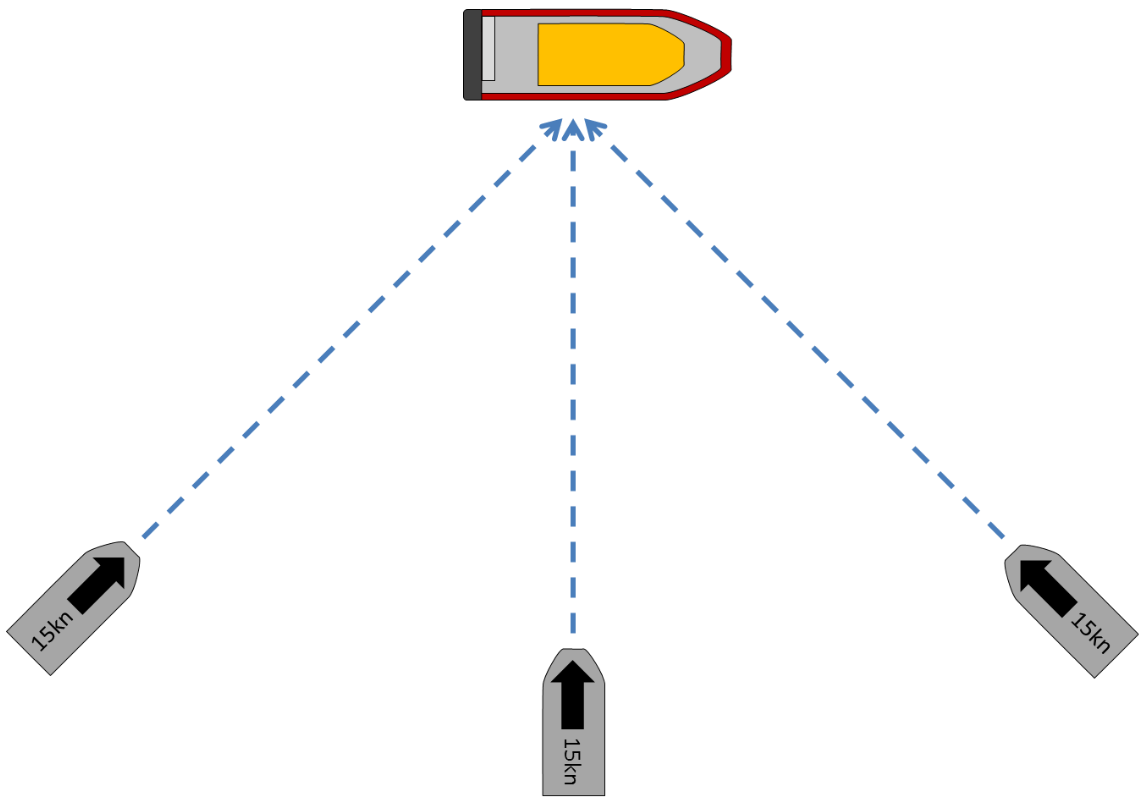
3. Target resolution – side by side

The target vessel is positioned 35 meters to the side of the fixed target. The SAR vessel starts 1.5 nm from the target and drives at 5 kn towards the fixed target. The table shows the distances at which the target vessel first detaches from the light, the distances at which the separation becomes constant, and the same measurements with the SAR vessel driving away from the targets on an opposing course (for the CHIRP 1 on SAR-20 only).

Speed (kn)	Range (nm)	Target intermittently separated (nm) forward			Target constantly separated (nm) forward		
		CHIRP 1	CHIRP 2	Open Array	CHIRP 1	CHIRP 2	Open Array
5	6.0	-	0.8	NT	-	0.8	NT
5	3.0	-	0.9	NT	-	0.9	NT
5	1.5	0.75	1.1	0.75	0.35	0.9	0.6
5	1.0	0.75	NT	NT	0.35	NT	NT
5	0.75	0.5	*0.75*	*0.75*	0.3	*0.75*	0.6
5	0.5	0.4	*0.5*	*0.5*	0.3	*0.5*	*0.5*

Speed (kn)	Range (nm)	Target constantly separated until (nm) aft		Target intermittently separated until (nm) aft	
		CHIRP 1	CHIRP 2	CHIRP 1	CHIRP 2
5	6.0	-	0.8	-	0.8
5	3.0	-	0.9	-	0.9
5	1.5	0.4	0.6	0.7	1.1
5	1.0	0.4	NT	0.6	NT
5	0.75	0.5	0.6	0.6	*0.75*
5	0.5	*0.5*	*0.5*	*0.5*	*0.5*

4. Target detection – side angles



The SAR vessel is stationary in open water. The target vessel drives at 15 kn at 45°, 90° and 135° towards the stationary SAR vessel, starting 2 nm away. The table shows the distances at which the target is first detected, and then the distance at which the signal becomes constant. These tests we only performed with the CHIRP units since the 2014 showed no angular variation for open array units.

4.1 – at 45° from the bow

Speed (kn)	Range (nm)	Target detected intermittently at (nm)	Target detected constantly at (nm)	Target detected intermittently at (nm)	Target detected constantly at (nm)
		CHIRP 1	CHIRP 1	CHIRP 2	CHIRP 2
15	6.0	NT	NT	NT	NT
15	3.0	1.5	1.25	1.2	0.8
15	1.5	1.35	1.25	1.3	1.0
15	0.75	*0.75*	*0.75*	*0.75*	*0.75*
15	0.5	*0.5*	*0.5*	*0.5*	*0.5*

4.2 – at 90° abeam

Speed (kn)	Range (nm)	Target detected intermittently at (nm)	Target detected constantly at (nm)	Target detected intermittently at (nm)	Target detected constantly at (nm)
		CHIRP 1	CHIRP 1	CHIRP 2	CHIRP 2
15	6.0	NT	NT	1.5	1.3
15	3.0	1.4	0.8	1.5	1.3
15	1.5	1.2	0.8	*1.5*	1.3
15	0.75	*0.75*	*0.75*	*0.75*	*0.75*
15	0.5	*0.5*	*0.5*	*0.5*	*0.5*

4.3 – at 135° from the bow (or 45° from the stern)

Speed (kn)	Range (nm)	Target detected intermittently at (nm)	Target detected constantly at (nm)	Target detected intermittently at (nm)	Target detected constantly at (nm)
		CHIRP 1	CHIRP 1	CHIRP 2	CHIRP 2
15	6.0	NT	NT	1.4	1.1
15	3.0	1.5	1.2	1.4	1.1
15	1.5	1.5	1.2	1.4	1.1
15	0.75	*0.75*	*0.75*	*0.75*	*0.75*
15	0.5	*0.5*	*0.5*	*0.5*	*0.5*

5. Test details

5.1 – SAR-20 with CHIRP 1 Solid State Radar (First Generation)

Date of test	3-Mar-2018
Start time	09:00
End time	13:00
Vessel	SAR-20
Height of radar above WL (m)	3 m
Radar type	Raymarine Quantum Q24W – CHIRP Pulse solid state, 20W
Radar speed & tune level	24 rpm equivalent, factory tuned
Display type	Raymarine ES127, ES97 (2x)
Coxswain	Niall Parker
Tester	Boudewijn Neijens
Sea state (ft)	1 ft chop
Wind speed (kn)	5
Visibility (nm)	Unlimited
Rain	None

This unit has not been tuned since installation. It is mounted flat (no forward tilt).

5.2 – SAR-25 with CHIRP 2 Solid State Radar (Second Generation, with Doppler)

Date of test	17-Aug-2019
Start time	10:15
End time	12:15
Vessel	SAR 25
Height of radar above WL (m)	2.5 m
Radar type	Raymarine Quantum 2 Q24D with Doppler – CHIRP Pulse solid state, 20W
Radar speed (rpm) and tune level	24 rpm equivalent, factory tuned
Display type	Axiom 9”
Display software level	3.8.105
Coxswain	Nick Futter
Tester	Boudewijn Neijens
Sea state (ft)	1ft chop
Wind speed (kn)	5 NW
Visibility (nm)	Unlimited
Rain	None

This unit has not been tuned since installation. It is mounted flat (no forward tilt).

5.3 – SAR-1B with 12kW 48" Open Array

Date of test	3-Mar-2018
Start time	09:00
End time	13:00
Vessel	SAR-1B
Height of radar above WL (m)	3 m
Radar type	Raymarine RA3048SHD Open Array, 12kW
Radar rpm & tune	24 or 48 rpm depending on range, factory tuned
Display type	Raymarine ES128 (2x), ES98
Coxswain	Bruce Falkins
Tester	Boudewijn Neijens
Sea state (ft)	1 ft chop
Wind speed (kn)	5
Visibility (nm)	Unlimited
Rain	None

This unit has not been tuned since installation. It is mounted flat (no forward tilt).

Observations

Signal filtering: On the CHIRP 1 solid state unit we observed a significant signal strength reduction for the small dinghy target at distances under 0.1 nm, to the point that the target would often disappear for a few radar sweeps. The same issue was observed with conventional radome units in the 2014 tests**.** The open array unit did not present the same issue.

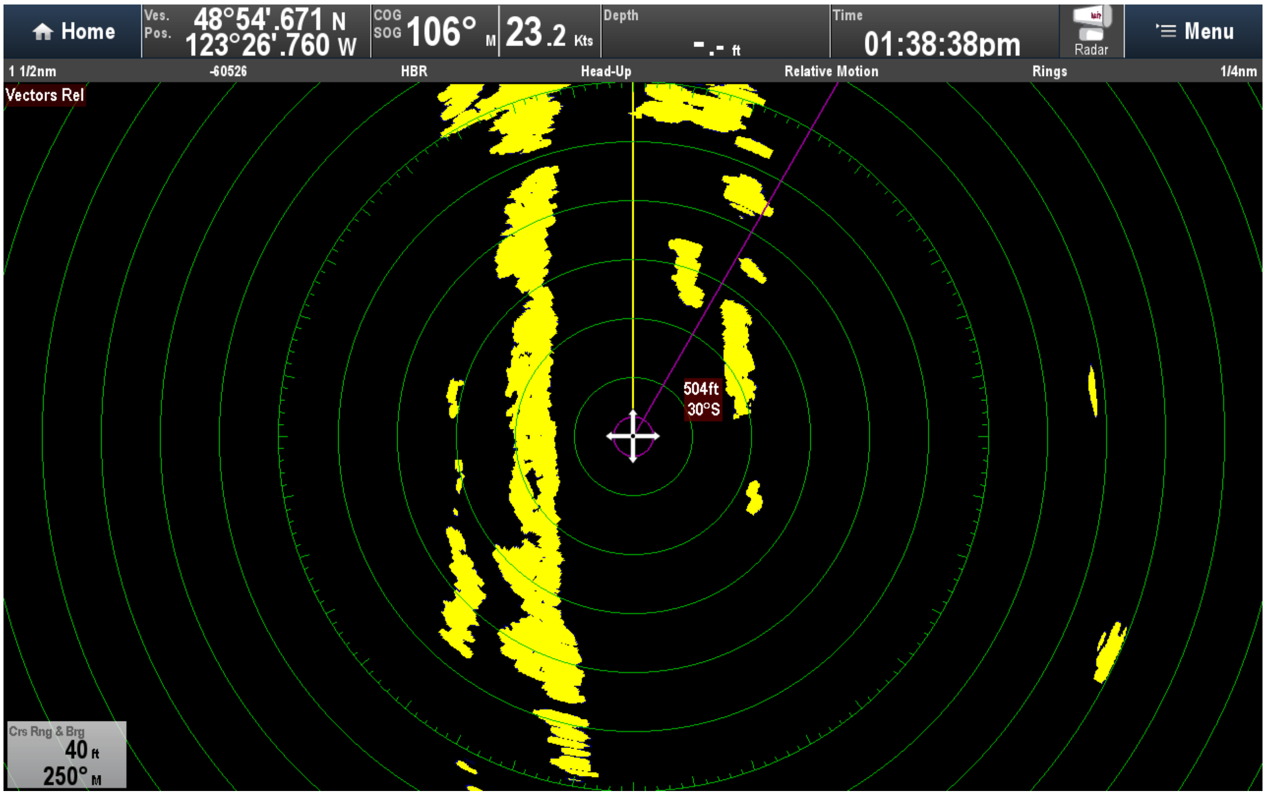
Missed targets: During test 3 the CHIRP 1 radar failed to display a 30' pleasure craft on a parallel course roughly 1 nm abeam. The vessel was not part of the test, but this missed target points to the smaller detection range of the CHIRP 1 unit as evidenced in tests 1 and 2.

The CHIRP 2 seemed more capable at detecting random pleasure craft: a 40' power yacht was detected at 2.3 nm and a 30' sailing vessel at 1.8 nm.

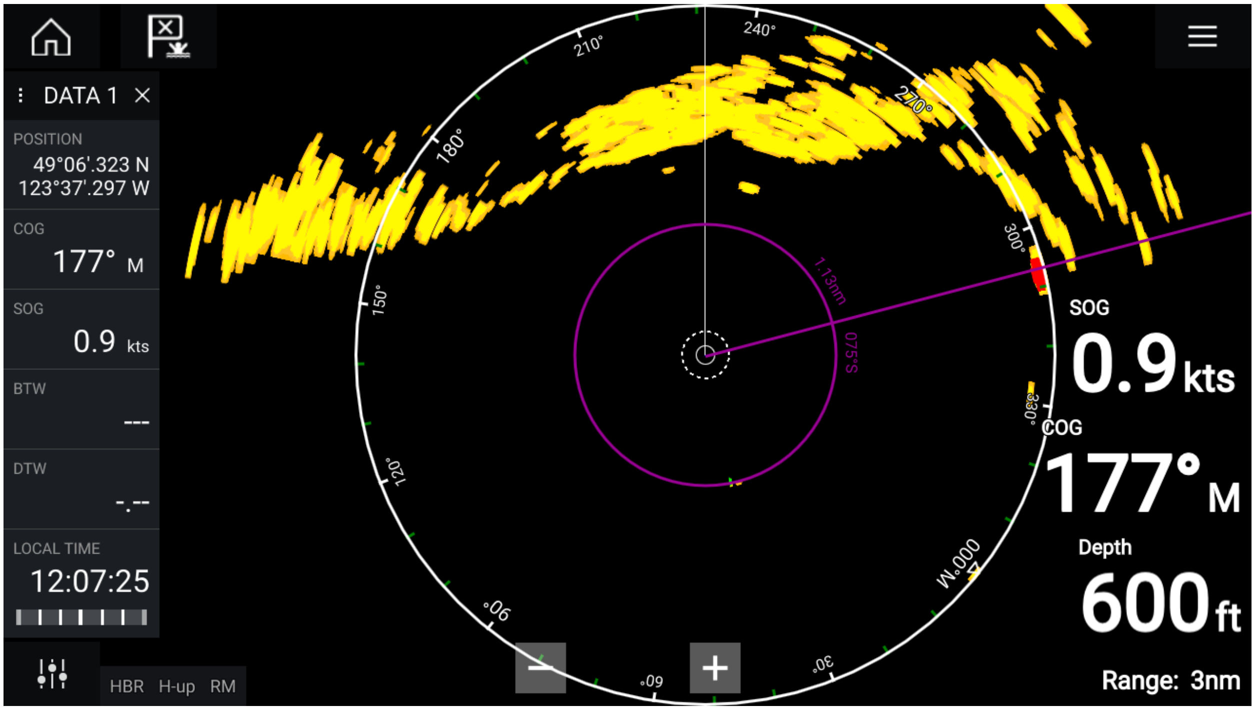
Image resolution and accuracy: the open array presented a much clearer picture of far-away targets and shoreline features. The open array picked up the Racon beacon on Thrasher Rock over 5 nm away, whereas both CHIRP solid state units did not – it only fired off the Racon when it was within a cable (CHIRP 1) or 3 cables (CHIRP 2) of the beacon. Detecting Racons was not formally part of the test but is a useful feature nevertheless. The conventional radome units tested in 2014 also had trouble detecting Racons, often only firing off the Racon when a few cables away.

All vessels were equipped with ES-class or Axiom multifunctional displays, capable of performing screen shots to memory cards. Unfortunately, the SAR-20 team captured screen shots at different moments so the images do not represent the same geographic area and traffic pattern. See images on the next pages.

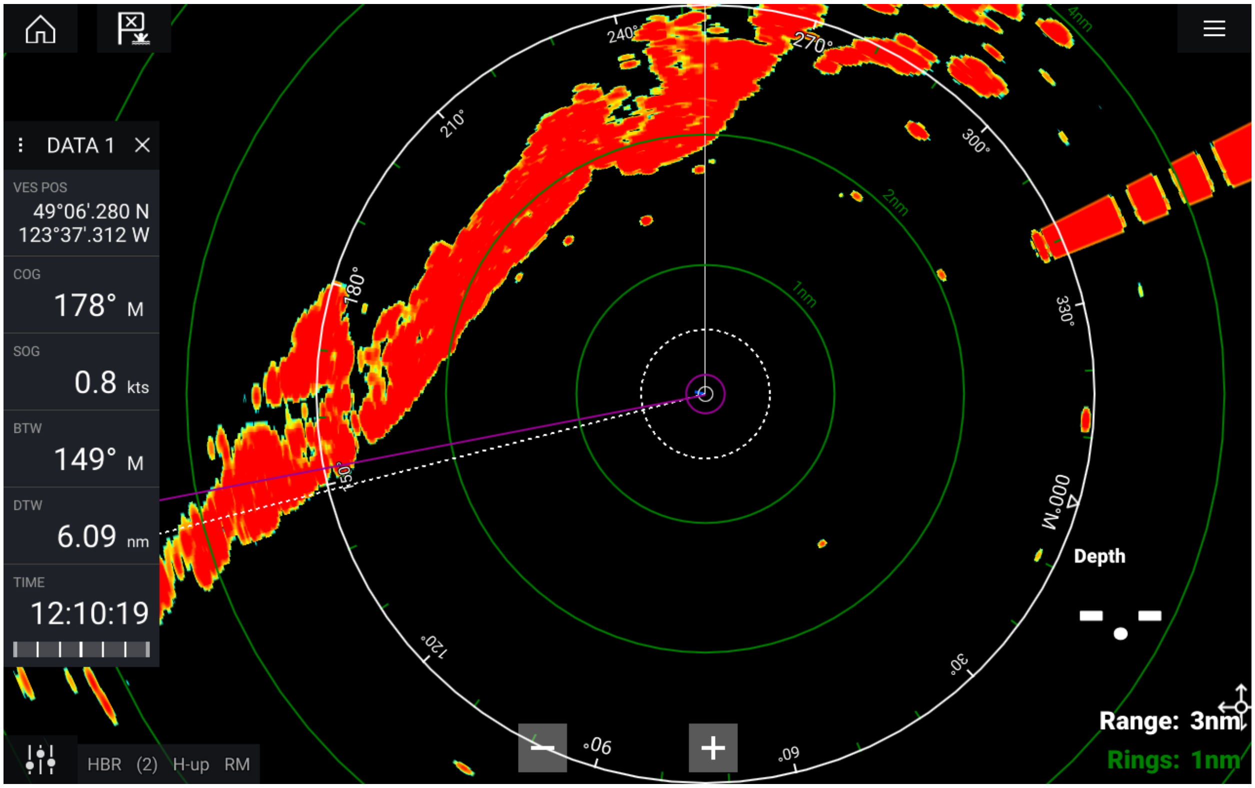
SAR-20 with CHIRP 1 solid state radar: The display was set to monochrome but is capable of displaying multiple colours (which is useful to distinguish close-by targets). Targets and land features tend to show as large “blobs” irrespective of their actual size, making it difficult to recognize specific land features and distinguishing targets close to each other. The unit was quite good at avoiding side-lobe effects and other interference.



SAR-25 with CHIRP 2 solid state radar: The display is multicolour, with red and green used to identify target approaching and moving away from SAR-25 using the Doppler feature (see red target at 310°). Just as with CHIRP 1, targets and land features tend to show as large "blobs" irrespective of their actual size, making it difficult to recognize specific land features and distinguishing targets close to each other. The unit was quite good at avoiding side-lobe effects and other interference. Note the absence of many of the smaller targets detected by the open array unit in the SAR-1B image on the next page.



SAR-1B with 12 kW open array: Note the sharper edges of land features and the variable size of target vessels. Land masses also extend further inland. The unit was quite good at avoiding side-lobe effects and other interference. The Racon signal is visible at 320°. Note the larger number of targets detected compared to the CHIRP 2 picture taken 3 minutes earlier.



Ranges: With the exception of detecting prominent shoreline features and large vessels, the 6 nm range is of little use on SAR vessels. The 6 nm range proved useless in most tests.

The CHIRP solid state units feature additional intermediate range settings (1/16, 3/8, 1, 2 and 4 nm) which might be useful in specific circumstances, although we have had no complaints from users of units not supporting these extra ranges.

When changing ranges on SAR-20 the display often showed all targets (and land features) rotated 90° on its first scan, and then corrected the image on subsequent scans. This might be quite perturbing to inexperienced radar operators and delays the appearance of a useable image when changing ranges. The CHIRP 2 on SAR-25 did not suffer of this issue.

Manufacturer specifications: since the CHIRP solid state units are significantly different from "conventional" magnetron rotating radars, we felt it would be useful to list the key features as stated by the manufacturer. We added the specifications of the Raymarine 24" radome tested in 2014 for reference.

Unit	SAR-20: CHIRP 1 Solid State	SAR-25: CHIRP 2 Solid State	SAR-1B: 48" Open Array	24" Radome (2014)
Transmit Frequency	9354 – 9446 MHz	9354 – 9446 MHz	9405 MHz +/- 20 MHz	9405 MHz +/- 25 MHz
Peak Power	20 W	20W	12 kW	4 kW
Horizontal Beam Width	4.9°	4.9°	1.85°	4.9°
Vertical Beam Width	20°	20°	25°	25°
Rotation Speed	Equivalent of 24 rpm	Equivalent of 24 rpm	24 rpm above 3 nm range 48 rpm at 3 nm or lower	24 rpm
Receiver Noise	<4 db	<4 db	<5 db	<5 db
Doppler Feature	-	Track 25 targets	-	-

Radiation: The CHIRP solid state radars operate at a lower power level than conventional magnetron radars, which in turn limits the amount of emitted radiation. According to the WHO: *"Marine radars can be found on small pleasure boats to large ocean-going vessels. Peak powers of these systems can reach up to 30 kW. Under normal operating conditions, with the antenna rotating, the average power density of the higher power systems within a metre of the antenna is usually less than 10 W/m^2. In accessible areas on most watercraft, these levels would fall to a few percent of present public RF exposure standards."* In other words: even the powerful 12 kW open array is perfectly safe, but crews might nevertheless be reassured by the lower emissions of the CHIRP radars.

Test Interpretation

Comparison to March 2014 tests: since we did not have access to a low-profile target vessel similar to the 733 RHIB used in 2014, it is difficult to do a side-by-side test result comparison. The tables below show a summary of the key findings of all three test sessions. The larger target vessels used in 2018 snd 2019 clearly allowed for earlier detection as evidenced by the 48” open array results, which are consistently better than in the 2014 test. The table below shows the best results obtained by the four technologies tested for the four tests performed on all occasions:

Test Date	**March 2014**		**March 2018**		**Aug 2019**
Unit Type	4 kW 24” Radome	12 kW 48” Open Array	20 W CHIRP 1	12 kW 48” Open Array	20 W CHIRP 2
1 – Moving target perpendicular course	0.5	1.4	0.75	1.8	1.5
2 – Moving target opposing course	0.5	1.5	1.25	2.2	1.7
3 – Target resolution side by side	0.5i 0.4c	1.0i 0.5c	0.75i 0.35c	0.75i 0.6c	1.1i 0.9c
4 – Target detection at side angles	0.7i 0.5c	1.5i 1.2c	1.5i 1.25c	2.2 c (based on test 2 results)	1.5i 1.3c

Tests 1 & 2 – Moving target detection: these tests are most crucial because of the combined speed of both vessels and the limited time for the operator to determine if a risk of collision exists. The open array unit detects small targets roughly two times earlier than the CHIRP 1 solid state unit, and 20-30% earlier than the CHIRP 2 unit. The CHIRP units performed better than the conventional radome units tested in 2014 but are not comparable to open arrays. At 40 knots combined speed SAR-20 with the CHIRP 1 solid state unit detected the moving target with certainty at 1.25 nm, or 110 seconds from collision time. SAR-25 detected the target at 1.7 nm, or 150 seconds before collision. SAR-1B with an open array detected the target at 2.2 nm, or 200 seconds before collision.

Taking into consideration the larger size of the targets used in 2018 and 2019, and adjusting the results back to the 2014 target size, a CHIRP 1 unit would have detected the smaller 733 RHIB target at roughly 0.85 nm, the CHIRP 2 at 1.16 nm and the open array at 1.5 nm. The tests were performed at a combined speed of 40 kn, and the table below extrapolates this to 70 kn – simulating two vessels on a collision course at 35 kn each. At a radar scan speed of 24 rpm, 44 seconds represent 18 radar sweeps which is acceptable for collision avoidance but much tighter than the 77 seconds of an open array, the more so that at ranges of 3 nm and lower the open array rotates at 48 rpm. In the table below the number of radar sweeps in brackets corresponds to 48 rpm.

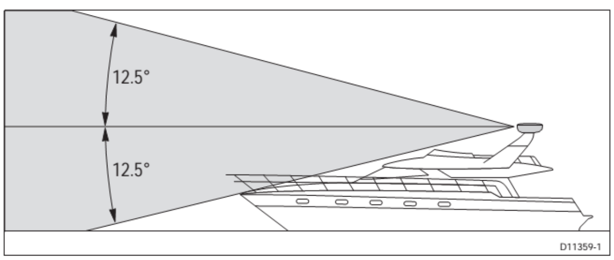
Unit type	**Combined speed (kn)**	**Detection at (nm)**	**Time to collision (sec)**	**Radar sweeps to collision**
4 kW radome	40	0.5	45	18
20W CHIRP 1 solid state	40	0.85	77	31
20W CHIRP 2 solid state	40	1.16	104	42
12 kW open array	40	1.5	135	54 (108)
4 kW radome	70	0.5	26	10
20W CHIRP 1 solid state	70	0.85	44	18
20W CHIRP 2 solid state	70	1.16	60	24
12 kW open array	70	1.5	77	31 (62)

Test 1 – Very small target detection: The open array unit was slightly better at detecting the very small dinghy target. The CHIRP 1 solid state unit “lost” the dinghy when it was approximately 0.1 nm away.

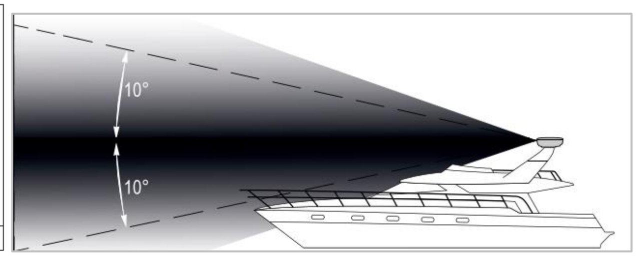
Test 3: Since in 2014 all units were better at detecting small targets in front of a fixed target than targets side by side we only tested the latter in 2018 and 2019. The open array performed slightly better than in 2014 as expected. The CHIRP 1 solid state unit performed equal or worse than the 2014 radome units despite having to detect a larger target. The CHIRP 2 did surprisingly well in this test, possibly because the radar on SAR-1B was inadvertently left on at the time of this test. The horizontal beam width of the CHIRP solid state units is similar to that of radome units (i.e. 4.9°, compared to the much narrower 1.85° for 48” open array units), which explains the CHIRP 1 poor performance.

Test 4: The CHIRP 1 solid state unit detects targets at roughly the same distance from all angles. The CHIRP 2 has significantly poorer detection at 45° from the bow. Maximum detection distances are roughly half to 2/3 of the open array results.

Tilted units: the 2014 tests indicated that Type 2 vessels with radar units tilted forward 7° performed better, as these vessels tend to ride bow up and were at times dangerously close to the bottom of the 12.5° detection range. The CHIRP solid state radars have an even narrower 10° vertical half beam width which could become a serious concern on vessels that ride bow up and/or in heavy weather. SAR-20 rides relatively flat and did not seem to be affected during the tests. On SAR-25 we saw a significant degradation of performance with the bow up: detection of a target on an opposing course (test 2) degraded from 1.5 nm at 25 kn to 1 nm at 15 kn, highlighting the sensitivity of CHIRP units to trim.



Raymarine radome and open array units



Raymarine CHIRP solid state units

Conclusions

The new CHIRP 2 solid state radar is slightly better than its CHIRP 1 predecessor but is still inferior to a 12 kW 48” open array unit. CHIRP units did generally perform better than conventional magnetron 4 kW radomes. In particular, we noted:

- Poor image resolution. This makes it hard for the navigator to cross-reference the radar image with the chart plotter or paper charts; and to distinguish targets close to each other.
- Dropped signals for close-by very small targets (on CHIRP 1).
- Detection distances have slightly improved with CHIRP 2 but are still short of open array performance, although better than conventional radomes.
- Average target discrimination. The CHIRP units have a tendency to enlarge and blur target images, which might be useful for novice radar operators to detect smaller isolated targets but makes it difficult to distinguish targets close to each other and might therefore hinder searches for targets close to shore.
- The Doppler feature of the CHIRP 2 unit might help novice operators quickly determine if a target is approaching or not, but we found the red and green colouring of targets to only be effective on larger targets where it is typically trivial to determine visually of the target is approaching or moving away.
- The CHIRP solid state units operate at 24 rpm at all times whereas the open array unit accelerates to 48 rpm at ranges of 3 nm and lower – which are the ranges typically used by SAR vessels. In other words: the open array unit will refresh twice as frequently in close quarters, i.e. when it matters most.
- Screen image rotated at first scan after range change – compounding the issue of longer detection times on the CHIRP 1 unit. The CHIRP 2 unit did not present this bug.
- Inability to detect Racons with CHIRP units despite operating at the same bandwidth as conventional radars.

In summary: contrary to the 4 kW radome unit, the CHIRP units did not present any fatal flaws – they are merely inferior in most aspects to the 12 kW open array unit. An experienced radar operator will likely rapidly become irritated with the poor image quality. Inexperienced operators might feel reassured by the enlarged target rendering, but it comes at a steep price of lower target discrimination and poor contour detail. The detection of small high-speed targets has improved with CHIRP 2 but is still not great. Ideally, we should organize a test of a CHIRP 2 unit with the same low profile target used in 2014 to gain a better understanding of its detection capabilities on such low signature targets.

As noted in 2014 our concern is that most volunteer RCM-SAR crew have relatively limited radar experience, which therefore calls for radar units with high rpm and longer distance detection ability to allow the crew more reaction time.

Recommendations

Whereas it was obvious after the 2014 tests that the 4 kW radome units performance is unacceptable, the verdict on CHIRP solid state units is not as clear cut. The CHIRP 2 units are getting closer to acceptable performance. Nevertheless, considering the mission critical nature of radar devices for SAR vessels we would strongly recommend the higher performance 12 kW 48” open array units.

The narrow vertical beam width of CHIRP units is a potential concern, especially in heavy weather. Should RCM-SAR elect to install such solid state units, we highly recommend the units be tilted to compensate for the typical riding angle of the vessel.

B. Neijens – Station 1, September 2019