Networked Radar Capability for Adapt_MFR

Adapt_MFR V 3.2.8 Experiment results and software debug updates

Prepared by:

B. Yue

C-CORE
400 March Road, Suite 210 Ottawa ON K2K 3H4

Project Manager: Dr. Peter Moo 613-998-2879
Contract Number: W7714-125424/001/SV
Contract Scientific Authority: Dr. Peter Moo, Defence Scientist, 613-998-2879

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Abstract

This report summarizes the experiments done for DRDC Ottawa by C-CORE under task 4 of Contract W7714-125424/001/SV. Four scenarios with different missile setups were designed to test the radar resource management (RRM) capability of the Adaptive Multi-Function Radar simulator (Adapt_MFR). A two-radar network system was simulated and radars were setup to work together in one of the three RRM types:

1. Coordinated network system with permanent assignment, the radar assigned to a track is not changed once initially assigned;
2. Coordinated network system with dynamic assignment, the assigned radar to a track changes at each track update based on the current calculated range and priority results;
3. Independent radars, each radar in the network works independently for detection and tracking tasks

For each simulation, a number of metrics were calculated and plotted to evaluate the detection and tracking performance of the network. Several coding errors in the metrics calculation function and Adapt_MFR software were identified during the results analysis. The related code was modified accordingly in this task. The metrics plots before and after the modification were displayed for verification purpose.

Executive Summary

DRDC Ottawa has contracted C-CORE for software support services relating to tracking and radar resource management (RRM) using a stand-alone Interactive Multiple Model Nearest Neighbour Joint Probabilistic Data Association (IMM-NNJPDA) tracker (IMM tracker) and an Adaptive Multi-Function Radar simulator (Adapt_MFR). The work under this task continues upon previous work with the aim of testing and evaluating the advanced RRM capabilities of the Adapt_MFR system.

Four scenarios with different missile setups (as targets for the radar network) were designed to test the RRM capability of the Adapt_MFR simulator. A two-radar network system was simulated and setup to work together in one of the three RRM types:

1. Coordinated network system with permanent assignment, the radar assigned to a track is not changed once initially assigned;

2. Coordinated network system with dynamic assignment, the assigned radar to a track changes at each track update based on the current calculated range and priority results;

3. Independent radars, each radar in the network works independently for detection and tracking tasks.

For each simulation, a number of metrics were calculated and plotted to evaluate the detection and tracking performance of the network. Several coding errors in the metrics calculation function and Adapt_MFR software were identified during the results analysis. The related code was modified accordingly in this task. The metrics plots before and after the modification were displayed for verification purpose.

Several conclusions can be drawn from the experiments:

1. When radar works independently, its position relative to the missile trajectory is very critical to its success in detection and tracking performance. The best detection area is the area covered by the smaller azimuth scan angles of the radar.

2. The radar network working cooperatively always improves the detection and tracking performance compared to the individual radars working independently when the complexity of the missile profile increased to a certain level. The communications between the radars and track assignment algorithms of the coordinated network play the key function in the performance. The coordinated networks can be overloaded.

3. The two coordinated RRM types (RRM Types 1 and 2) did not demonstrate significant difference in their detection and tracking ability given the same network setups and same missile profile.

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1 Introduction

DRDC Ottawa has contracted C-CORE for software support services relating to tracking and radar resource management (RRM) using a stand-alone Interactive Multiple Model Nearest Neighbour Joint Probabilistic Data Association (IMM-NNJPDA) tracker (IMM tracker) and an Adaptive Multi-Function Radar simulator (Adapt_MFR). As the experiment part of task 3, the work in this report continues upon all the previous tasks (refer to all the documentations listed in the References section for all the previous tasks) with the aim of testing and evaluating the advanced RRM capabilities of the Adapt_MFR system.

Four scenarios with different missile setups (as targets for the radar network) were designed to test the radar resource management (RRM) capability of the Adaptive Multi-Function Radar simulator (Adapt_MFR). A two-radar network system was simulated and setup to work together in one of the three RRM types:

1. Coordinated network system with permanent assignment, the radar assigned to a track is not changed once initially assigned;
2. Coordinated network system with dynamic assignment, the assigned radar to a track changes at each track update based on the current calculated range and priority results;
3. Independent radars, each radar in the network works independently for detection and tracking tasks.

For each simulation, a number of metrics were calculated and plotted to evaluate the detection and tracking performance of the network. Several coding errors in the metrics calculation function and Adapt_MFR software were identified during the results analysis. The related code was modified accordingly in this task. The metrics plots before and after the modification were displayed for verification purpose.

All software development and testing took place using MATLAB. Note that this report refers to the current version (3.2.8) of the Adapt_MFR software that has been modified up to the time this report was released. Figure 1 illustrates the current architecture of the simulation loop of the Adapt_MFR simulator.

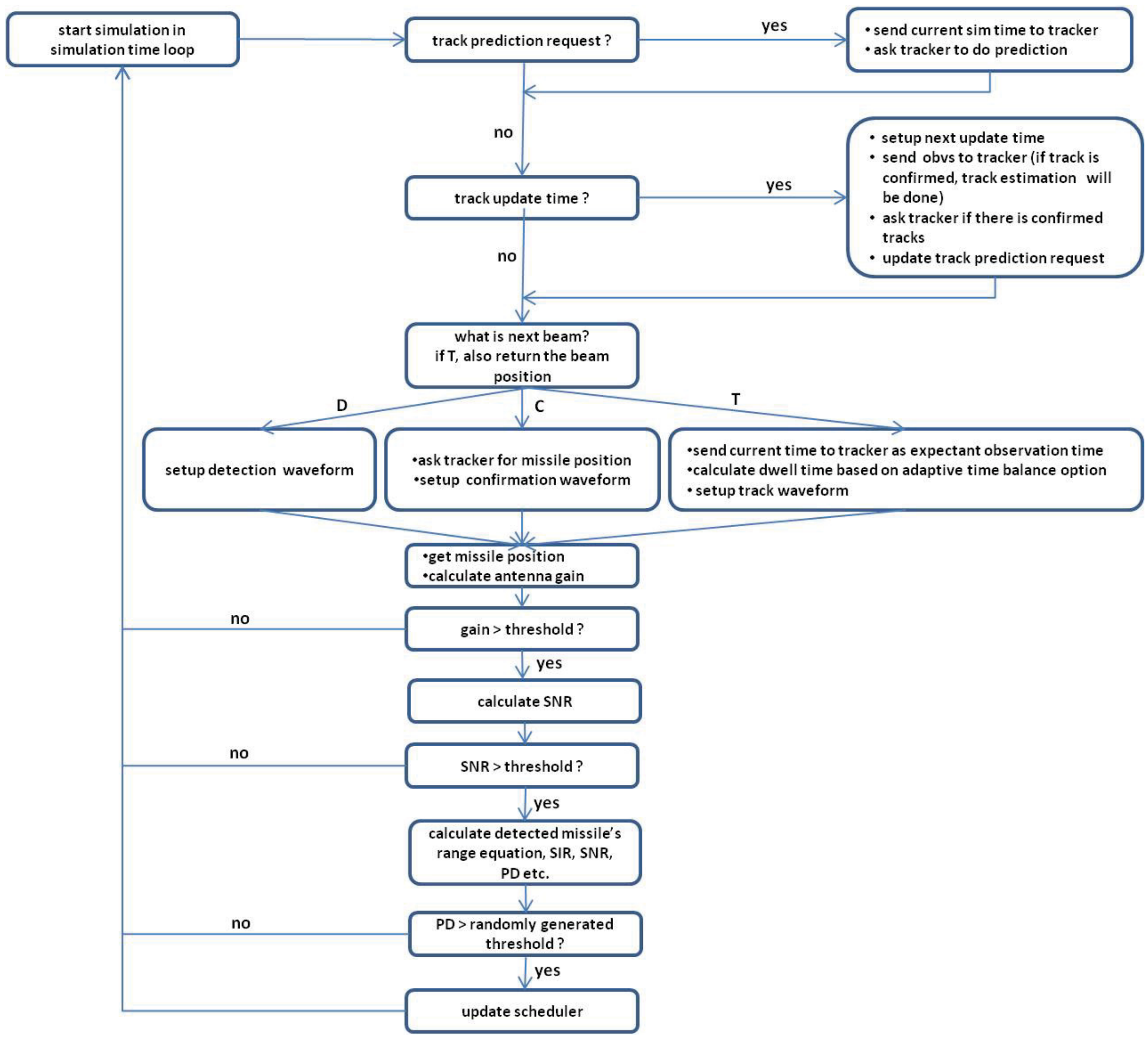


Figure 1: *Flowchart of Adapt_MFR (v3.2.8) simulation loop*

2 Experimental Scenarios and Results

2.1 Simulation setups

Three missile trajectory types were simulated in each scenario: straight line, U-turn, and weave trajectories. The parameters used to define the three trajectory types are listed in Table 1. The targets in each scenario were created using the Adapt_MFR GUI Missile Editor.

Table 1: *Target trajectory types*

Trajectory type	*Leg #*	*Duration* (s)	*Head** (deg)
1	1	200	0
2	1	70	0
	2	20	180
	3	110	0
3	1	5	0
	2	5	-45
	3	20	110
	4	20	-90
	5	25	90
	6	15	-150
	7	25	180
	8	30	-120
	9	20	80
	10	5	-55
	11	5	25
	12	5	45
	13	20	-45

* Head: target heading at end of leg relative to start degree, CCW is positive direction.

Table 2 lists the three RRM types simulated in this task. Permanent assignment means the radar assigned to a track is not changed once initially assigned; dynamic assignment means the assigned radar changes at each track update based on the current calculated range and priority results; each radar works independently when the independent type is chosen. Track assignment is based on minimum range of the missile to the radars and the maximum fuzzy logic priority. If the range or priority are the same the other parameter is used to determine assignment. If both are the same the track is assigned to Radar 1.

The radar system parameters used by Adapt_MFR for all scenarios are listed in Table 3.

Table 2: *RRM types*

RRM Type	*Track assignment*
Type 1	coordinated system with permanent track assignment, min range then max priority
Type 2	coordinated system with dynamic track assignment, min range than max priority
Independent RRM	independent radars, no coordination between radars

Table 3: *Adapt_MFR parameters used in simulations*

Radar 1,2	Azimuth boresite*: 90 degree Elevation boresite*: 0 degree Antenna height: 30 m
Track update rates:	Target priority $\geq$ 0.75: update rate = 1.5 s Target priority $<$ 0.75: update rate = 3 s
Scenario lenght	200 s

* 0 degree is north, CW is positive direction.

The coordination system that the scenarios employed is displayed in Figure 2. For all scenarios, Radar 1 is always located at the origin of the coordination system and the initial missile position parameters are thus defined with respect to Radar 1. All the missile trajectory figures displayed in this section are the trajectory projections on the ”Top view plane”.

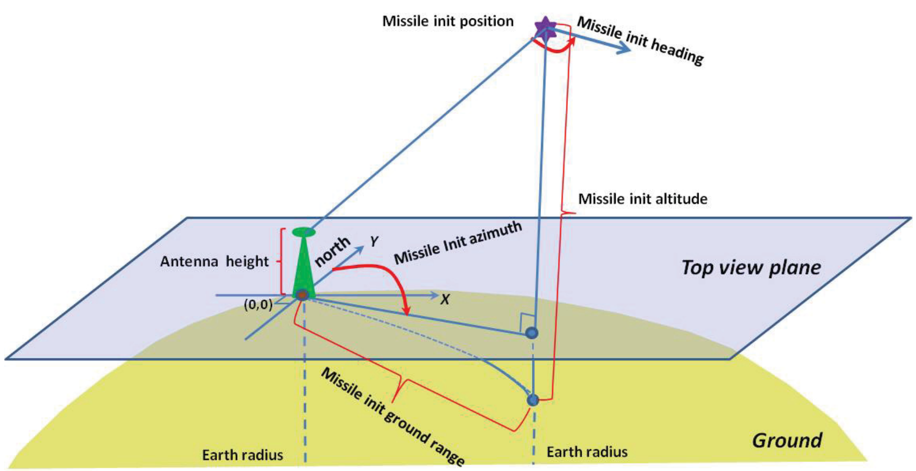


Figure 2: *Coordination system of the experimental scenarios*

2.2 Scenario B

In this scenario, a two-radar network system with 30 missiles was modeled. Radar 1 was positioned at [0,0] and Radar 2 at [0,-10km] as shown in Figure 3, the top view of the radar and missile trajectories. The trajectories of Missile 14, 18 and 19 are highlighted with orange colour which will be analyzed later in this section. The initial position of each missile is indicated by a red triangle. Missile initial parameters are given in Table 4. Constant speed and altitude for each missile were used.

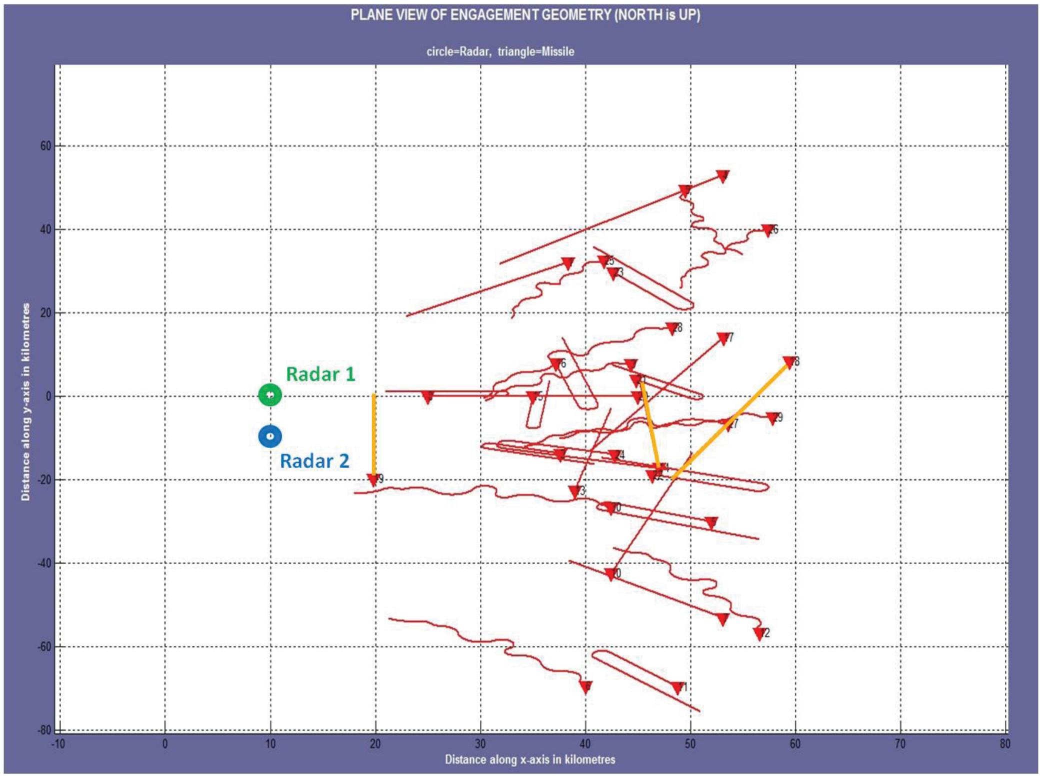


Figure 3: *Radar positioning and missile trajectories for Scenario B*

Table 4: *Scenario B missile parameters*

Target ID	*altitude* (m)	*Head* (deg)	*Range* (km)	*Velocity* (m/s)	*Azimuth* (deg)	*RCS* (m^2)	*Trojectory type*
1	500	0	50	100	90	50	1
2	750	0	40	100	110	50	2
3	600	3	45	100	80	75	3
4	500	0	75	150	45	75	1
5	750	5	60	150	120	50	2
6	600	0	80	150	150	50	3
7	500	2	75	100	135	75	1
8	750	-180	25	100	90	75	2
9	600	45	70	100	45	50	3
10	500	-60	60	150	135	50	1
11	750	3	85	150	145	75	2
12	600	-30	80	150	135	75	3
13	500	-70	45	100	120	50	1
14	750	-65	50	100	110	50	1
15	600	85	35	100	90	75	2
16	500	90	38	150	78	75	2
17	750	50	55	150	75	50	1
18	600	60	60	150	82	50	1
19	500	-45	28	100	135	75	1
20	750	0	45	100	90	75	1
21	600	135	45	100	85	50	2
22	500	180	50	150	112	50	2
23	750	90	52	150	55	75	2
24	600	0	45	150	108	75	2
25	500	0	53	100	52	50	3
26	750	5	55	100	66	50	3
27	600	0	54	100	97	75	3
28	500	5	51	150	71	75	3
29	750	2	58	150	95	50	3
30	600	5	50	150	122	75	3

Head : 0 degrees is towards Radar 1, CCW is positive direction.
Range : initial ground range on top view plane.
Azimuth : degree from north to target, CW is positive direction

The track completeness, track occupancy and frame time of the three RRM type networks are shown in Figure 4, 5 and 6. According to these metrics, RRM Type 1 and 2 have similar performance and they have less track occupancy values and less frame time than the radars for Independent RRM.

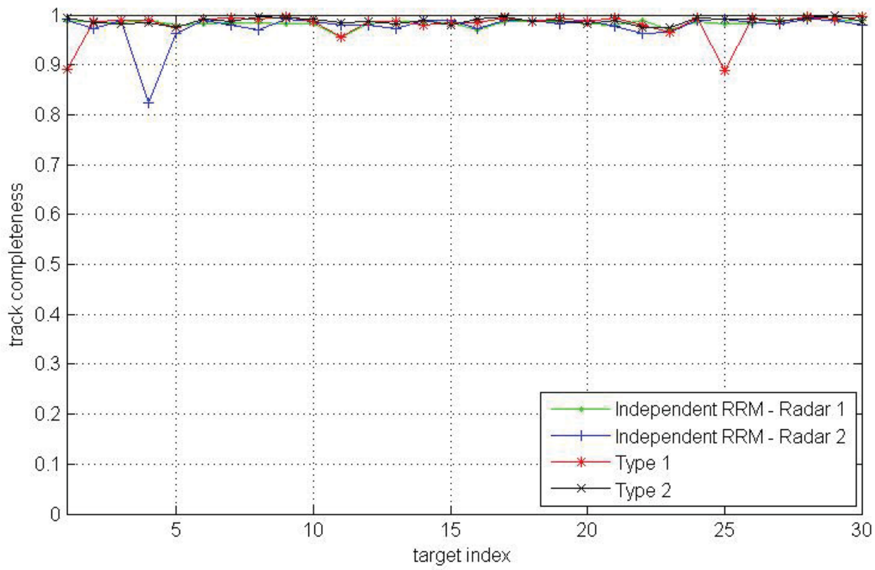


Figure 4: *Track completeness of Scenario B*

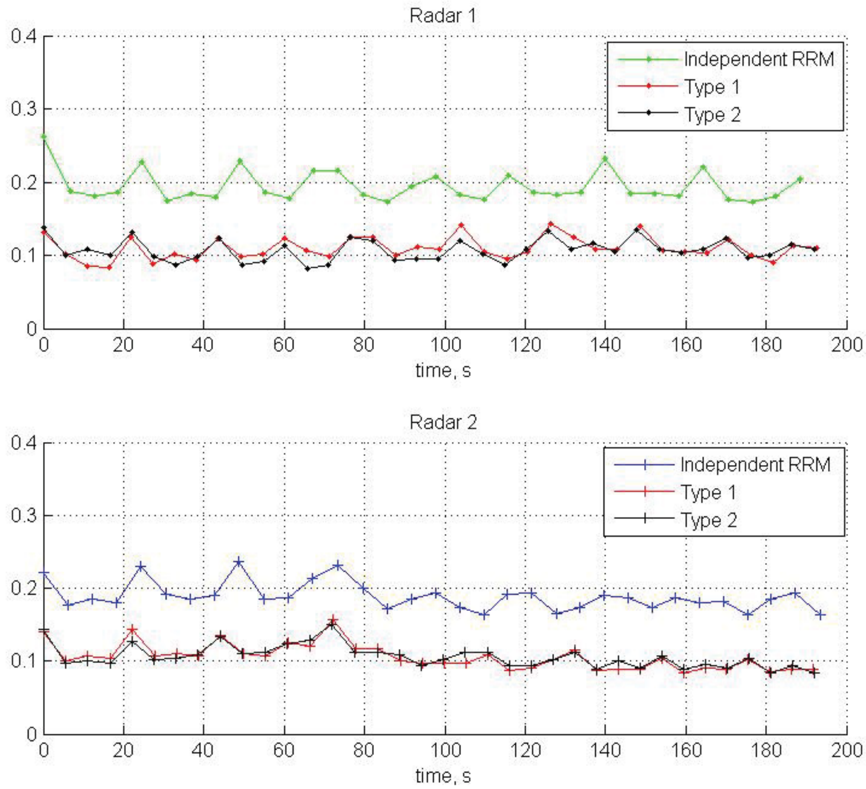


Figure 5: *Track occupancy of Scenario B*

The tracker performance in RRM Type 1 and 2 network are compared using the absolute position error metrics, which is the absolute distance error between the estimated missile position by the tracker and the real position of the missile. It was noted that there are two external reasons that can cause the absolute position error: the relative position of the missile to the radar and the relative position of the missile in the overall missile profile. One source of the position error related to network is the RRM type. The absolute position errors of three missiles, Missile 14,18 and 19 highlighted in Figure 3, are plotted in Figure 7. One can see that for Missile 14 displayed in Figure 7 (a), when its trajectory crossed the trajectories of the two weaving missiles (Missile 27 and 29), the tracker performance of the RRM Type 1 network was not as accurate as Type 2.

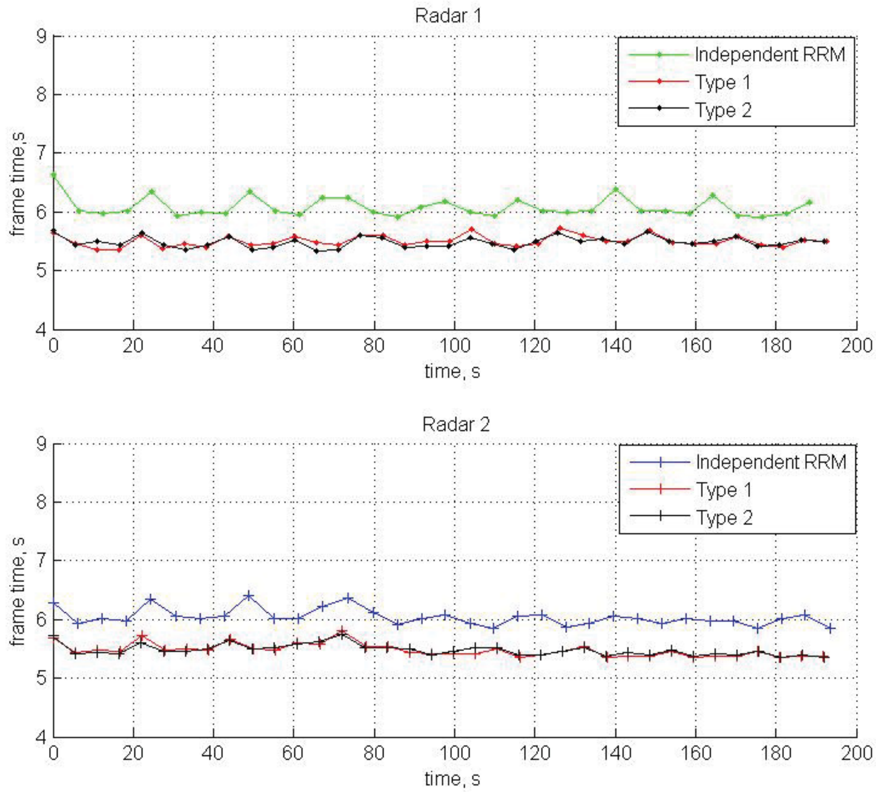


Figure 6: *Frame time of Scenario B*

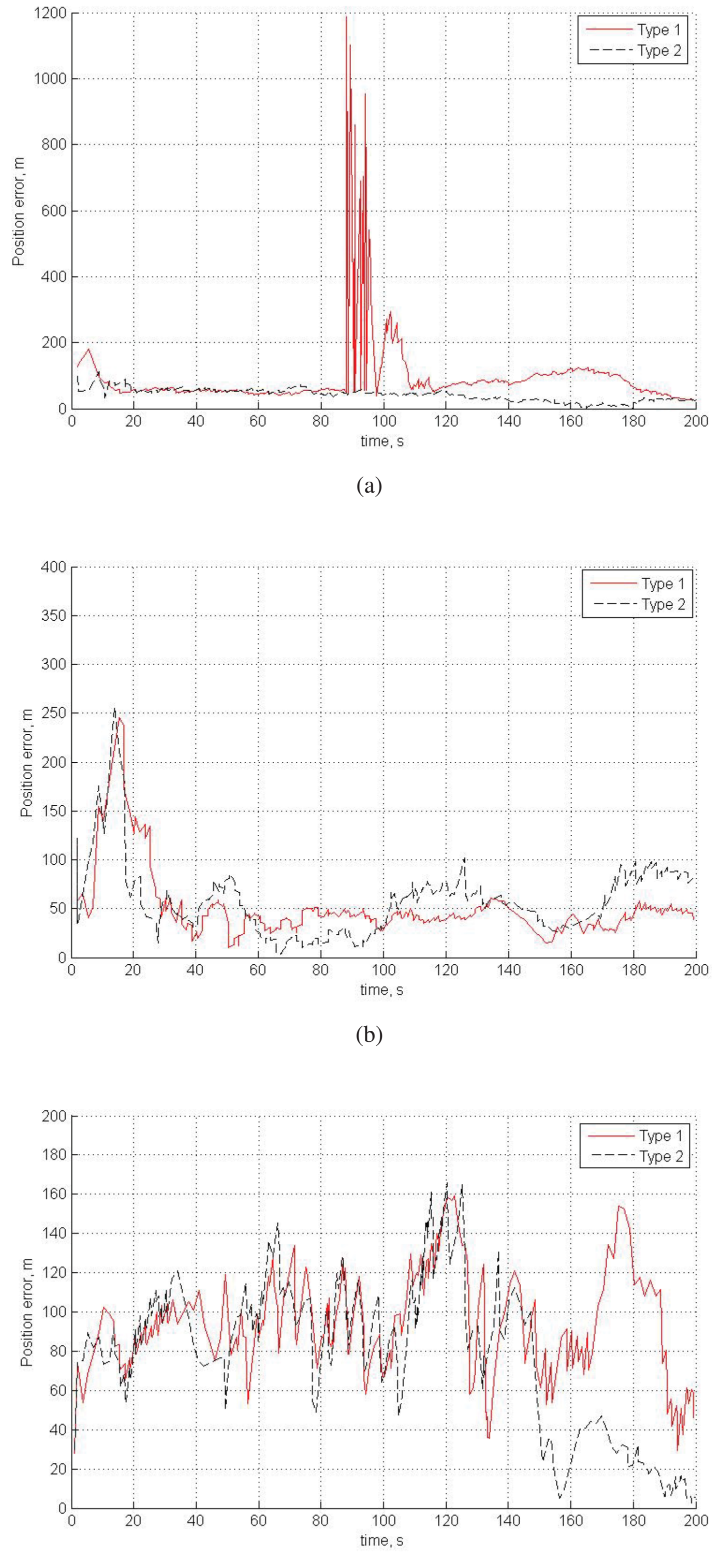


Figure 7: *Scenario B target position errors (between estimated and real positions). (a) Target 14. (b) Target 18. (c) Target 19.*

2.3 Scenario B2

In this scenario, the same two-radar network system with the same 30 missiles as Scenario B was modeled except that different initial values were used for the velocity and RCS. Figure 8 shows the top view of the radar and missile trajectories. Missile initial parameters are given in Table 5. Constant speed and altitude for each missile were used. With a faster velocity in this scenario, one can see that the trajectories of the missiles are longer than Scenario B.

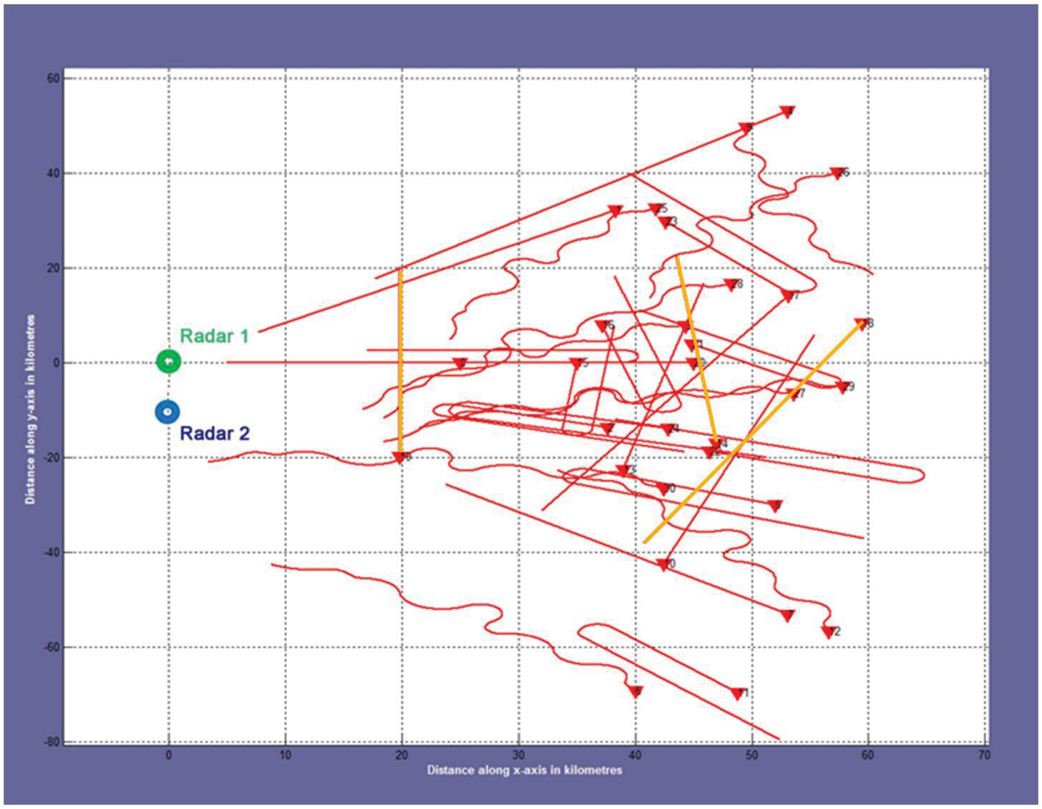


Figure 8: *Radar positioning and target trajectories for Scenario B2*

Table 5: *Scenario B2 missile parameters*

Target ID	*altitude* (m)	*Head* (deg)	*Range* (km)	*Velocity* (m/s)	*Azimuth* (deg)	*RCS* (m^2)	*Trojectory type*
1	500	0	50	200	90	5	1
2	750	0	40	200	110	5	2
3	600	3	45	200	80	10	3
4	500	0	75	250	45	10	1
5	750	5	60	250	120	5	2
6	600	0	80	250	150	5	3
7	500	2	75	200	135	10	1
8	750	-180	25	200	90	10	2
9	600	45	70	200	45	5	3
10	500	-60	60	250	135	5	1
11	750	3	85	250	145	10	2
12	600	-30	80	250	135	10	3
13	500	-70	45	200	120	5	1
14	750	-65	50	200	110	5	1
15	600	85	35	200	90	10	2
16	500	90	38	250	78	10	2
17	750	50	55	250	75	5	1
18	600	60	60	250	82	5	1
19	500	-45	28	200	135	10	1
20	750	0	45	200	90	10	1
21	600	135	45	200	85	5	2
22	500	180	50	250	112	5	2
23	750	90	52	250	55	10	2
24	600	0	45	250	108	10	2
25	500	0	53	200	52	5	3
26	750	5	55	200	66	5	3
27	600	0	54	200	97	10	3
28	500	5	51	250	71	10	3
29	750	2	58	250	95	5	3
30	600	5	50	250	122	10	3

The track completeness, track occupancy and frame time of the three network types are shown in Figure 9, 10 and 11. This scenario generated similar results as Scenario B: the detection and tracking ability of RRM Type 1 and 2 are superior to that of Independent RRM.

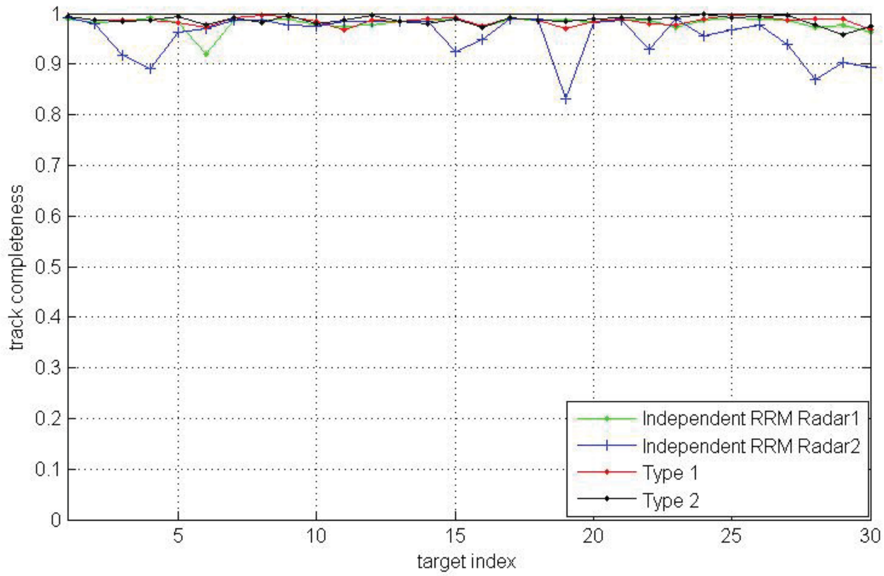


Figure 9: *Track completeness of Scenario B2*

The absolute position errors of Missile 14,18 and 19 are plotted in Figure 12. This time, Missile 18 generated the biggest error when detected by the RRM Type 1 network.

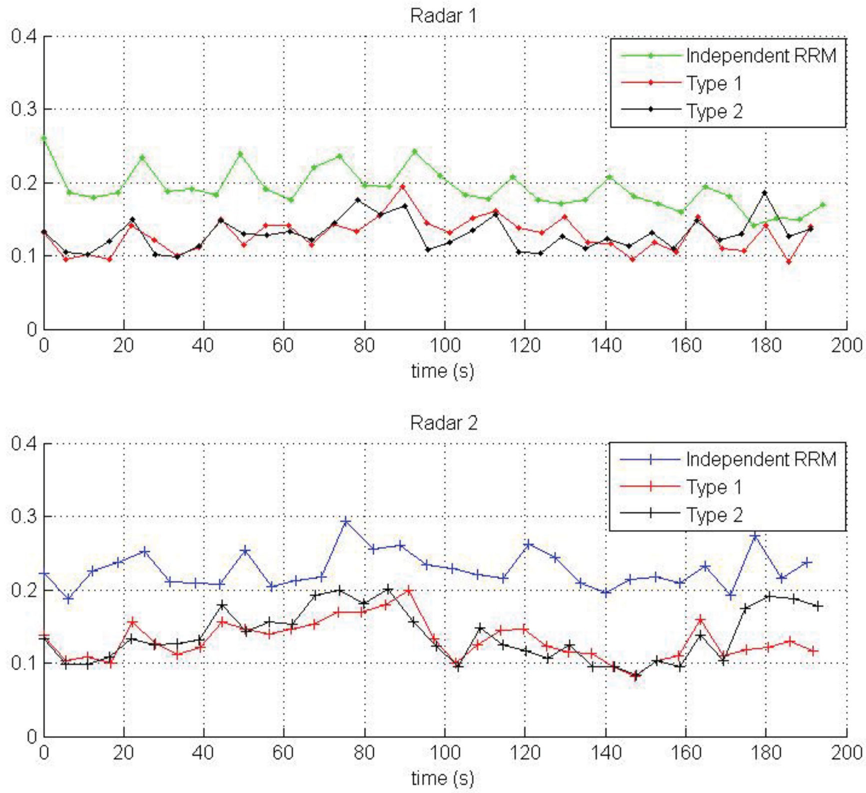


Figure 10: *Track occupancy of Scenario B2*

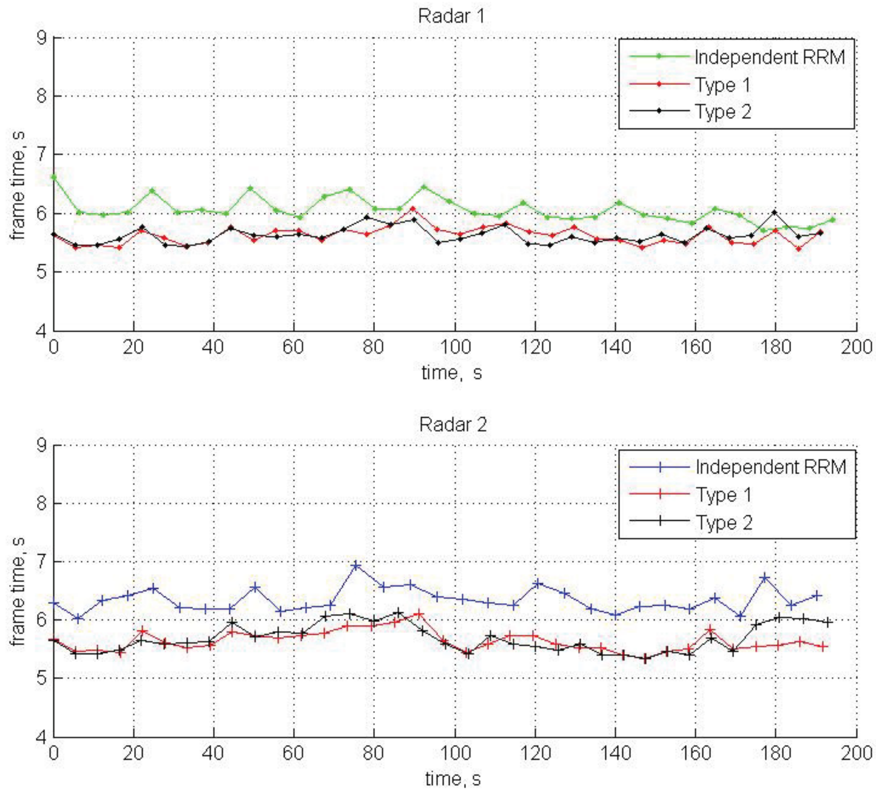
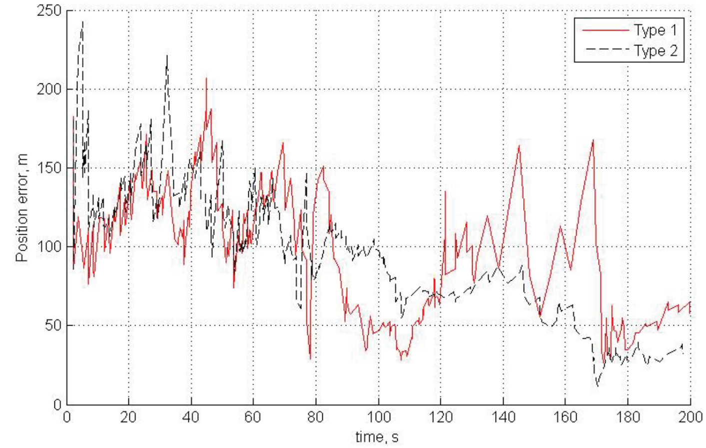
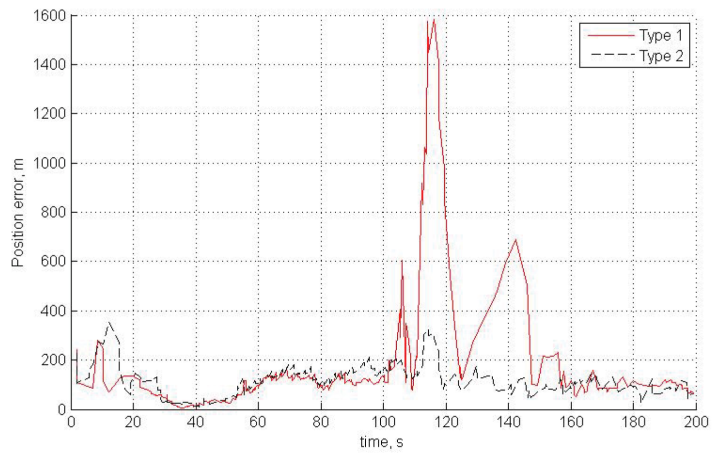


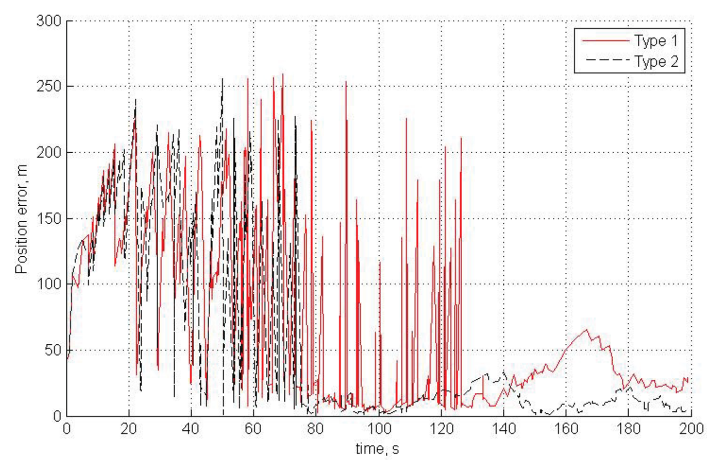
Figure 11: *Frame time of Scenario B2*



(a)



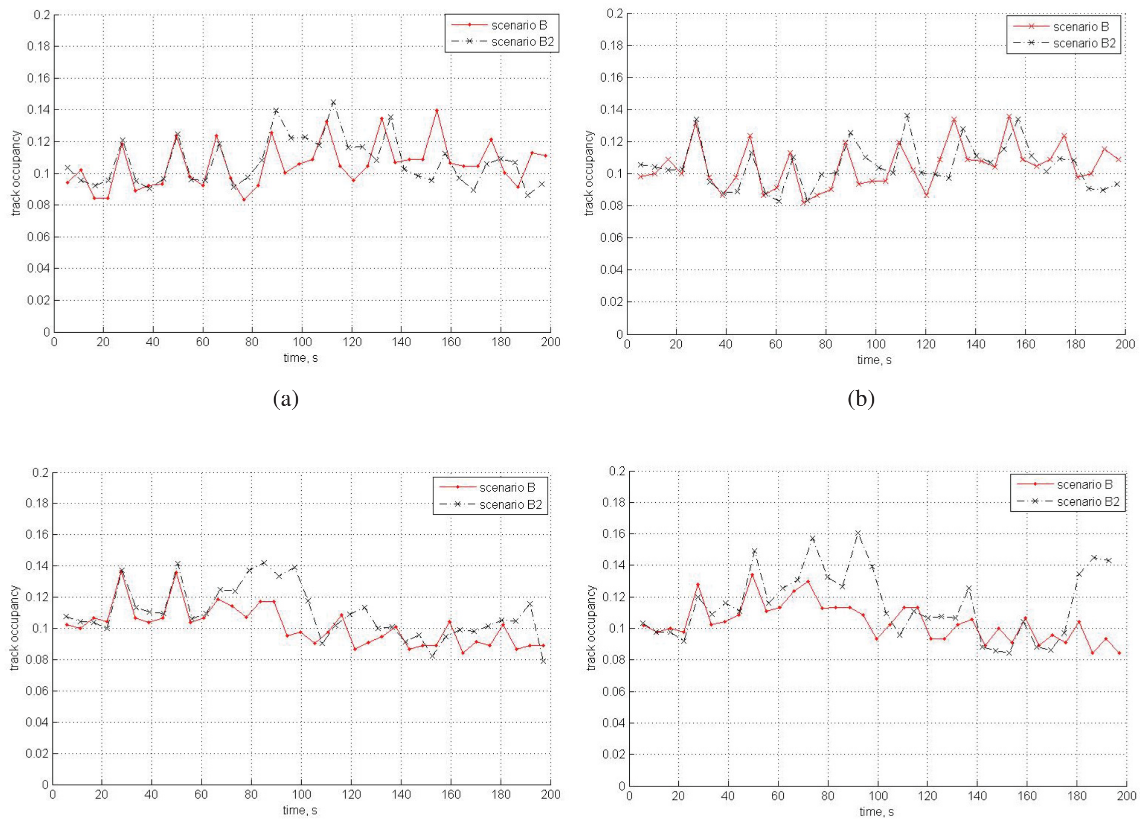
(b)



(c)

Figure 12: *Scenario B2 target position errors (between estimated and real positions). (a) Target 14. (b) Target 18. (c) Target 19.*

Figure 13 compares the track occupancy of RRM Type 1 and 2 networks of Scenario B and B2. For Radar 1, the track occupancies of the two scenarios in RRM Type 1 and 2 do not have significant difference. For Radar 2, the track occupancies of Scenario B2 are all slightly higher than Scenario B for both RRM Type 1 and 2.



(a) (b) (c) (d)

Figure 13: *Track occupancy comparison between Scenario B and B2. (a) Radar 1 with RRM type 1. (b) Radar 1 with RRM type 2. (c) Radar 2 with RRM type 1. (d) Radar 2 with RRM type 2.*

However, by checking the track occupancy and frame time plots of these two scenarios in the previous plots, one can see that RRM Type 1 and 2 have less track occupancies and less frame time compared to Independent RRM for both scenarios. This means that the two coordinated RRM types can improve the performance of the radars in the detection and tracking tasks by allowing radars to spend more time on detection over their coverage areas.

2.4 Scenario C

In this scenario, to increase the complexity of the missile profile, 10 new missiles with straight line trajectories were added to the missile list of Scenario B. Radar 1 was positioned at the same position [0,0] and Radar 2 was moved to [0,-20km]. Figure 14 displays the top view of the radar position and missile trajectories. Missile initial parameters are given in Table 6, the last 10 missiles are the new ones. Constant speed and altitude for each missile were used.

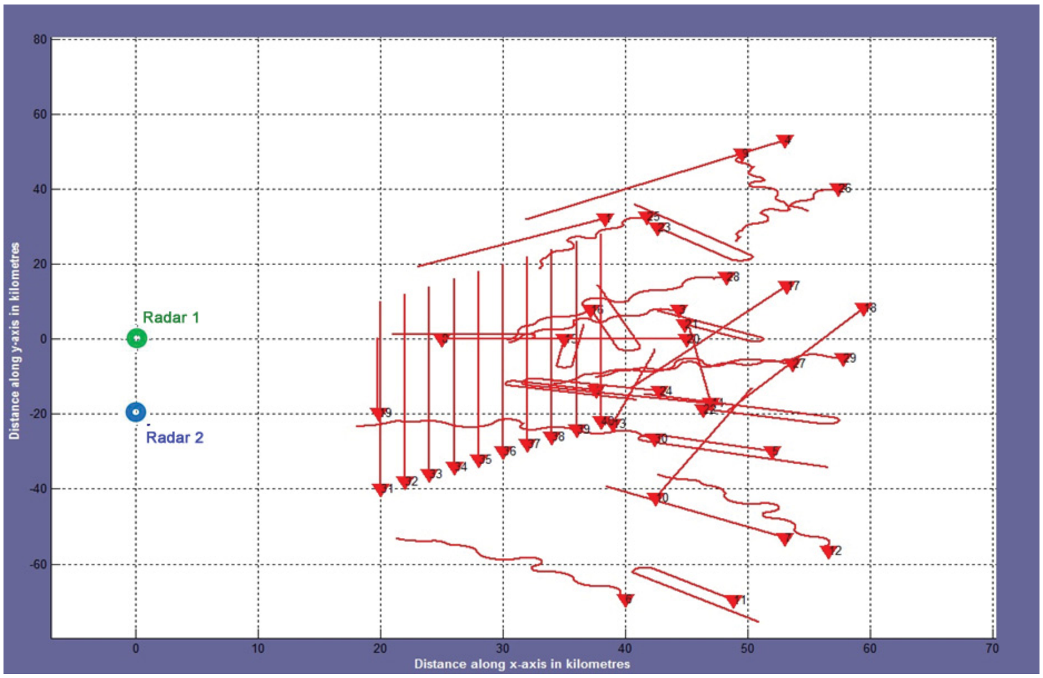
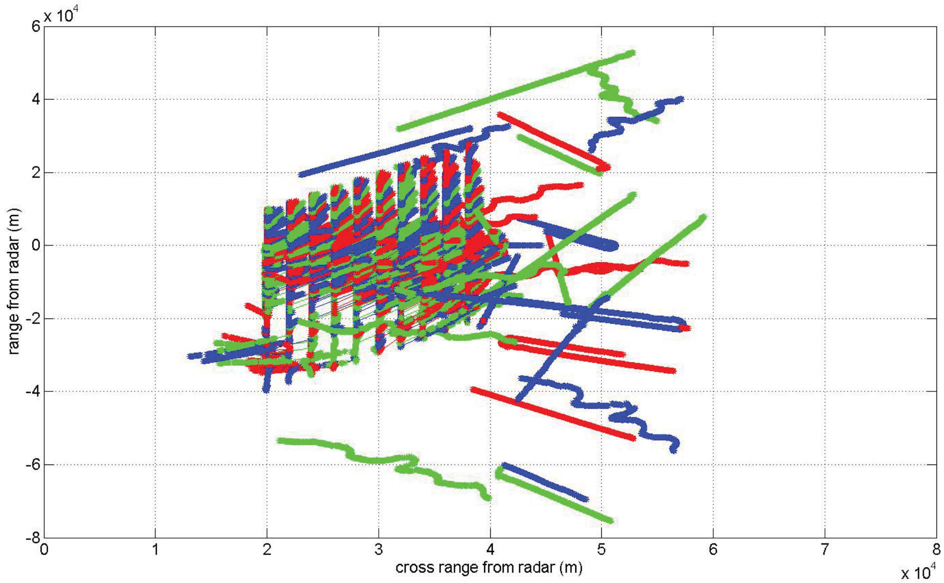


Figure 14: *Radar positioning and target trajectories for Scenario C*

Table 6: *Scenario C missile parameters*

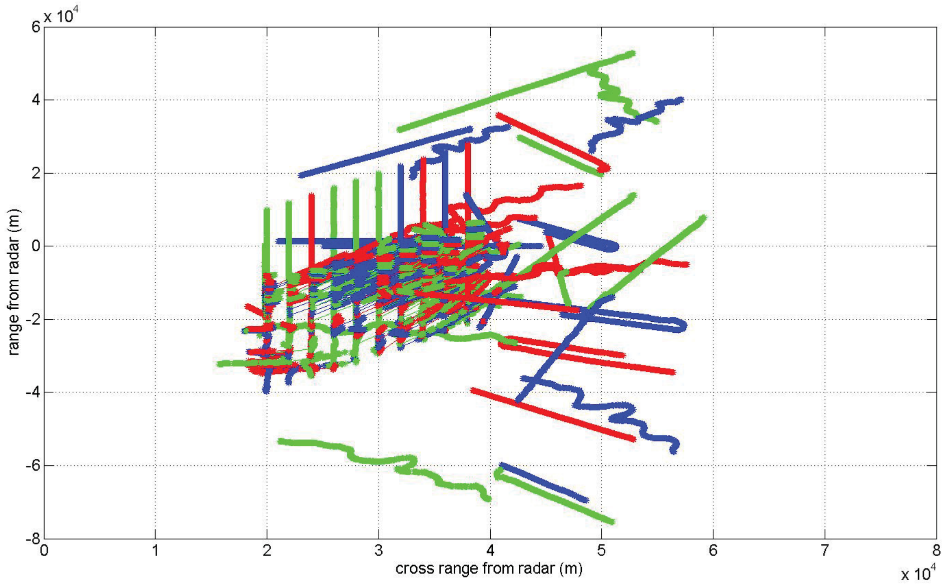
Target ID	*altitude* (m)	*Head* (deg)	*Range* (km)	*Velocity* (m/s)	*Azimuth* (deg)	*RCS* (m^2)	*Trojectory type*
1	500	0	50	100	90	50	1
2	750	0	40	100	110	50	2
3	600	3	45	100	80	75	3
4	500	0	75	150	45	75	1
5	750	5	60	150	120	50	2
6	600	0	80	150	150	50	3
7	500	2	75	100	135	75	1
8	750	-180	25	100	90	75	2
9	600	45	70	100	45	50	3
10	500	-60	60	150	135	50	1
11	750	3	85	150	145	75	2
12	600	-30	80	150	135	75	3
13	500	-70	45	100	120	50	1
14	750	-65	50	100	110	50	1
15	600	85	35	100	90	75	2
16	500	90	38	150	78	75	2
17	750	50	55	150	75	50	1
18	600	60	60	150	82	50	1
19	500	-45	28	100	135	75	1
20	750	0	45	100	90	75	1
21	600	135	45	100	85	50	2
22	500	180	50	150	112	50	2
23	750	90	52	150	55	75	2
24	600	0	45	150	108	75	2
25	500	0	53	100	52	50	3
26	750	5	55	100	66	50	3
27	600	0	54	100	97	75	3
28	500	5	51	150	71	75	3
29	750	2	58	150	95	50	3
30	600	5	50	150	122	75	3
31	750	-26.57	44.72	250	153.43	5	1
32	750	-30.07	43.91	250	149.93	5	1
33	750	-33.69	43.27	250	146.31	5	1
34	750	-37.41	42.80	250	142.59	5	1
35	750	-41.19	42.52	250	138.81	5	1
36	750	-45.00	42.43	250	135.00	5	1
37	750	-48.81	42.52	250	131.19	5	1
38	750	-52.59	42.80	250	127.41	5	1
39	750	-56.31	43.27	250	123.69	5	1
40	750	-59.93	43.91	250	120.07	5	1

The new added missiles increased the difficulty of the detection and tracking tasks. Figure 14 shows the track prediction results from the tracker using the three RRM type networks. Not like Scenario B and B2, the coordinated RRM type 1 and 2 networks could not improve the tracking results compared to the Independent RRM, both failed to track the 10 new missile trajectories especially the RRM Type 1 network. For the two radars in Independent RRM, their locations relative to the targets plays a critical role in their performance. Radar 2 completely failed in tracking the 10 new missiles while Radar 1 could successfully estimate the trajectories of all the missiles.



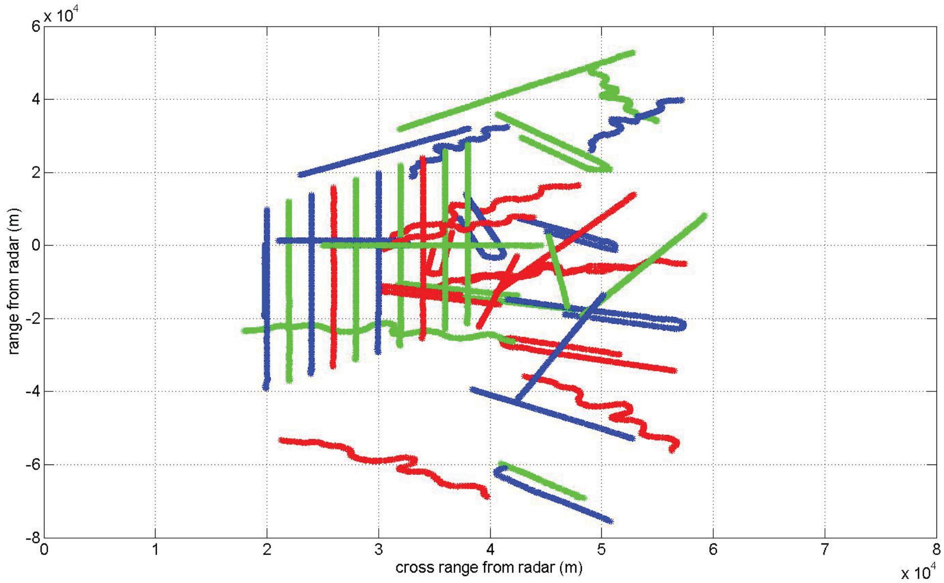
x 10^4
range from radar (m)
cross range from radar (m)
x 10^4

(a)

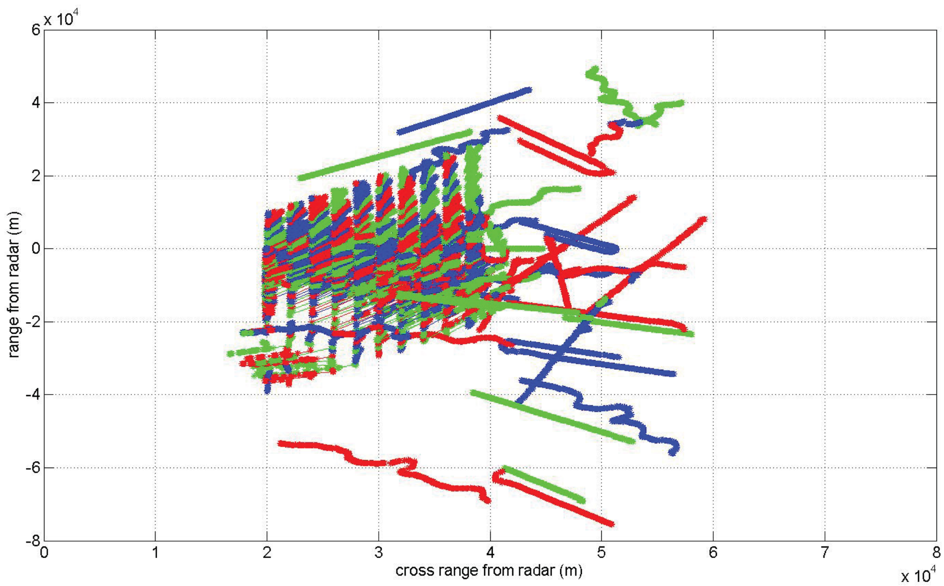


x 10^4
range from radar (m)
cross range from radar (m)
x 10^4

(b)



(c)



(d)

Figure 14: *Scenario C missile track estimation results from tracker. (a) RRM type 1. (b) RRM type 2. (c) Radar 1 of Independent RRM. (d) Radar 2 of Independent RRM.*

The track completeness, track occupancy and frame time of the three network types are shown in Figure 15, 16 and 17. They also show that Radar 1 for Independent RRM had the best track completeness and took lest time in tracking, Radar 2 for Independent RRM has the worst cases.

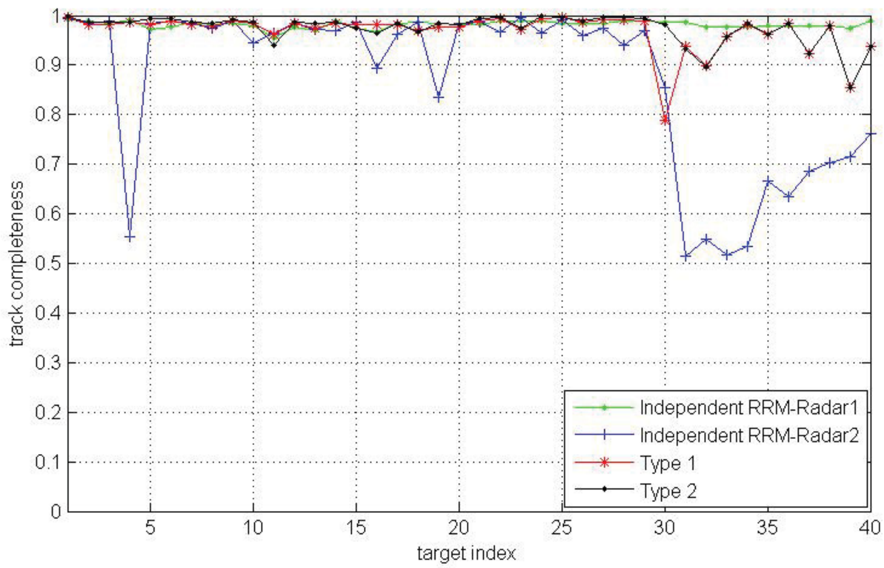


Figure 15: *Track completeness of Scenario C*

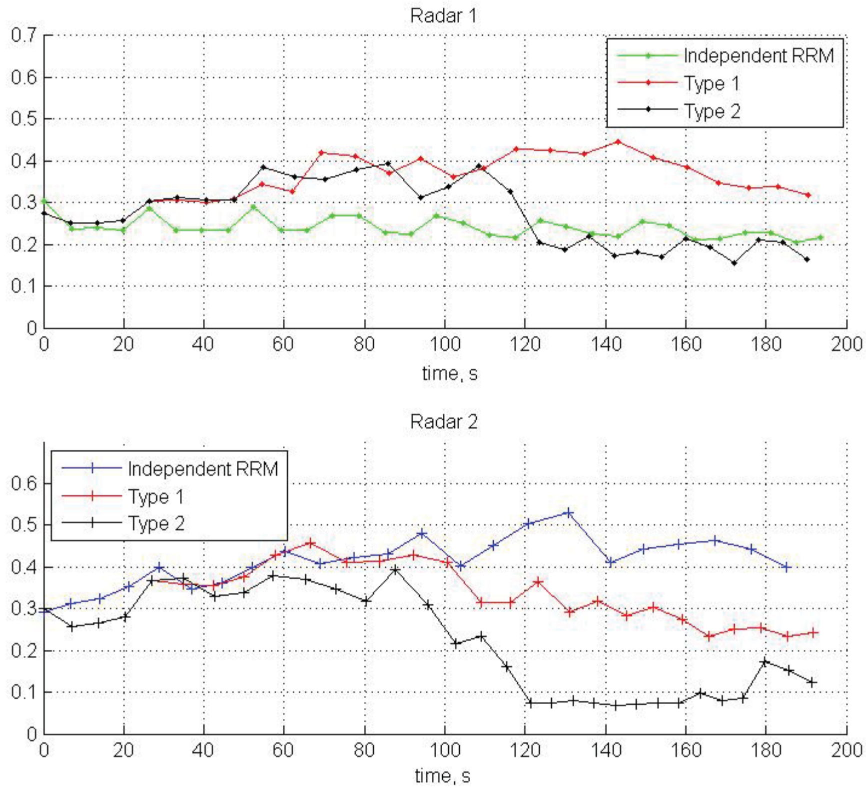


Figure 16: *Track occupancy of Scenario C*

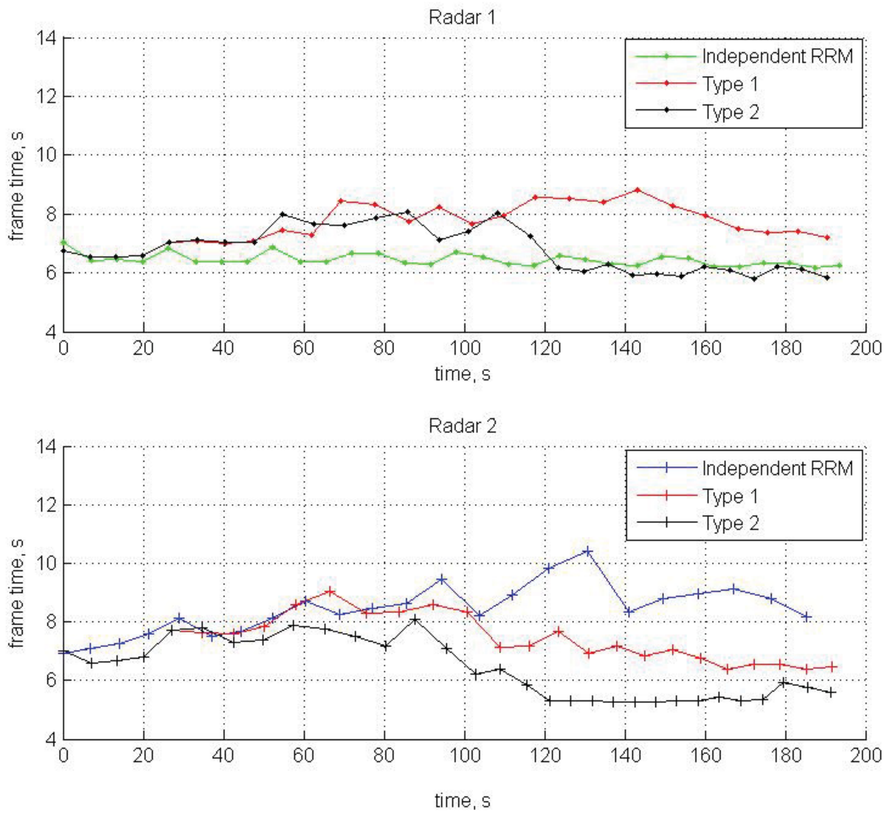


Figure 17: *Frame time of Scenario C*

2.5 Scenario D

In this scenario, the velocity and RCS of the 40 missiles of Scenario C are changed and another 20 new missiles with U-turn and weave trajectories are added. The two radars were located at the same position as Scenario C. Figure 18 displays the top view of the radar position and missile trajectories, and the 20 new missiles are also shows in Figure 19 for a better view. Missile initial parameters are given in Table 7. Constant speed and altitude for each missile were used.

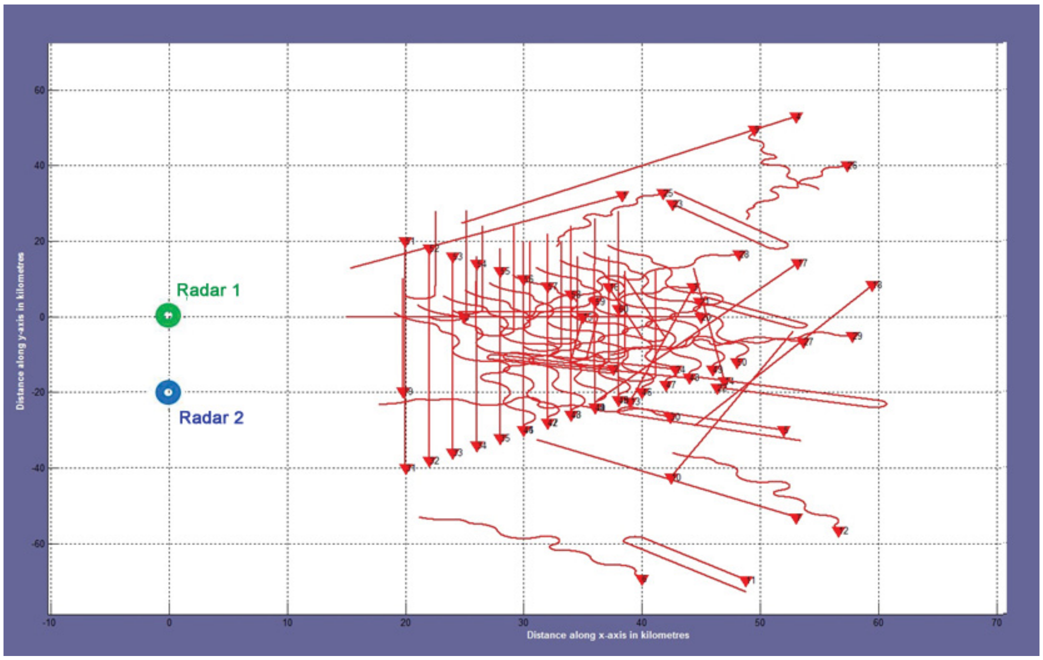


Figure 18: *Radar positioning and target trajectories for Scenario D*

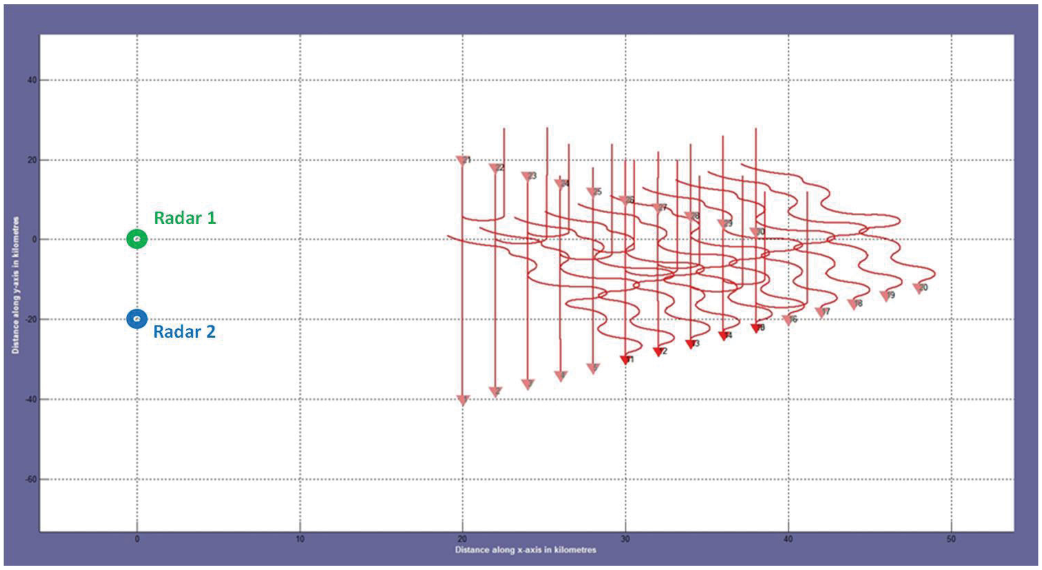


Figure 19: *The trajectories of the last 20 missiles in Scenario D*

Table 7: Scenario D target parameters

Target ID	*Altitude* m	*Head* deg	*Range* km	*Velocity* m/s	*Azimuth* deg	*RCS* m^2	*Trajectory type*
1	500	0	50	200	90	5	1
2	750	0	40	200	110	5	2
3	600	3	45	200	80	10	3
4	500	0	75	250	45	10	1
5	750	5	60	250	120	5	2
6	600	0	80	250	150	5	3
7	500	2	75	200	135	10	1
8	750	-180	25	200	90	10	2
9	600	45	70	200	45	5	3
10	500	-60	60	250	135	5	1
11	750	3	85	250	145	10	2
12	600	-30	80	250	135	10	3
13	500	-70	45	200	120	5	1
14	750	-65	50	200	110	5	1
15	600	85	35	200	90	10	2
16	500	90	38	250	78	10	2
17	750	50	55	250	75	5	1
18	600	60	60	250	82	5	1
19	500	-45	28	200	135	10	1
20	750	0	45	200	90	10	1
21	600	135	45	200	85	5	2

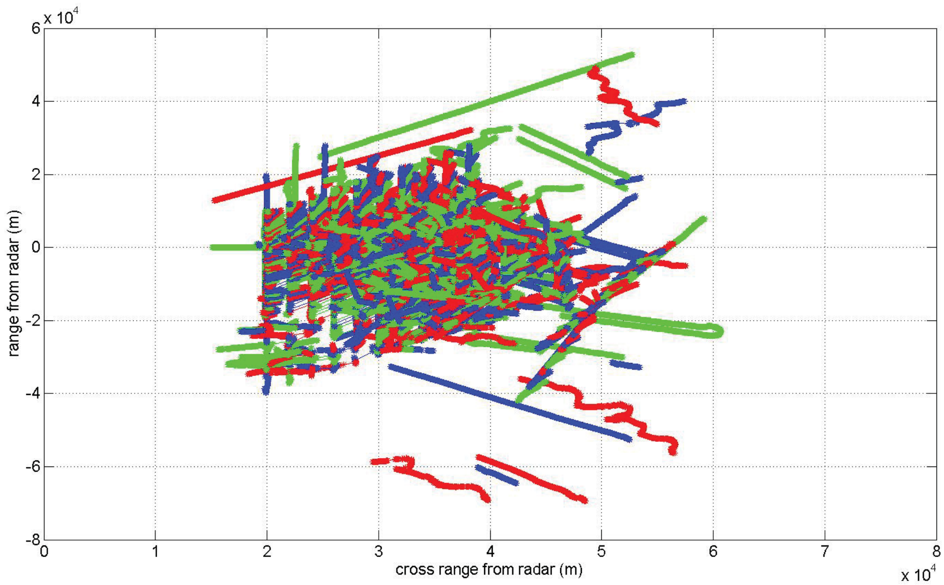
Continued on next page

Table 7 – continued from previous page

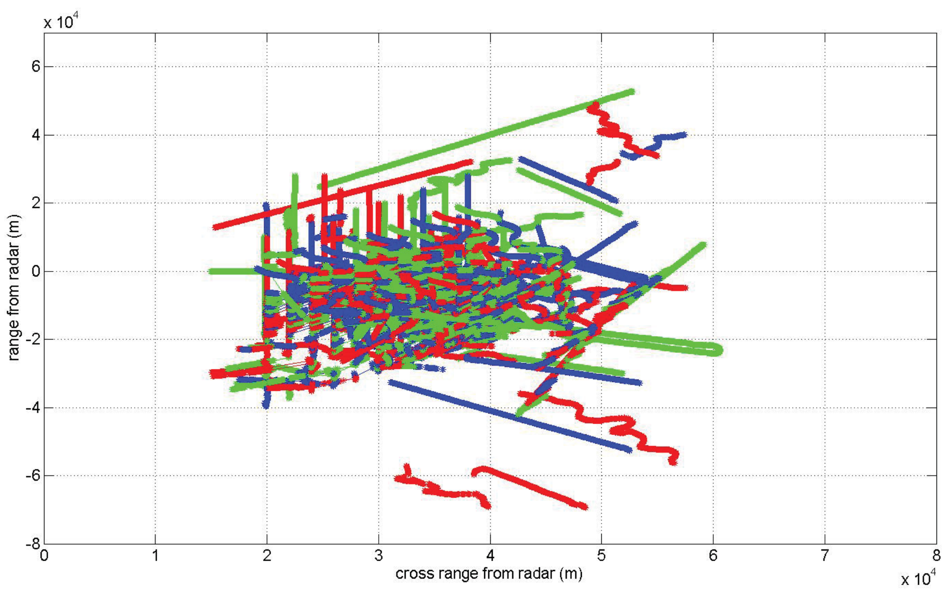
Target ID	*altitude*	*Head*	*Range*	*Velocity*	*Azimuth*	*RCS*	*Trajectory type*
22	500	180	50	250	112	5	2
23	750	90	52	250	55	10	2
24	600	0	45	250	108	10	2
25	500	0	53	200	52	5	3
26	750	5	55	200	66	5	3
27	600	0	54	200	97	10	3
28	500	5	51	250	71	10	3
29	750	2	58	250	95	5	3
30	600	5	50	250	122	10	3
31	750	-26.57	44.72	250	153.43	5	1
32	750	-30.07	43.91	250	149.93	5	1
33	750	-33.69	43.27	250	146.31	5	1
34	750	-37.41	42.80	250	142.59	5	1
35	750	-41.19	42.52	250	138.81	5	1
36	750	-45.00	42.43	250	135.00	5	1
37	750	-48.81	42.52	250	131.19	5	1
38	750	-52.59	42.80	250	127.41	5	1
39	750	-56.31	43.27	250	123.69	5	1
40	750	-59.93	43.91	250	120.07	5	1
41	600	-45.00	42.43	200	135.00	10	3
42	600	-48.81	42.52	200	131.19	10	3
43	600	-52.59	42.80	200	127.41	10	3
44	600	-56.31	43.27	200	123.69	10	3
45	600	-59.93	43.91	200	120.07	10	3
46	600	-63.43	44.72	200	116.57	10	3
47	600	-70.02	46.82	200	109.98	10	3
49	600	-73.07	48.08	200	106.93	10	3
50	600	-75.96	49.48	200	104.04	10	3
51	750	45.00	28.28	200	45.00	5	2
52	750	50.71	28.43	250	50.71	5	2
53	750	56.31	28.84	200	56.31	5	2
54	750	61.70	29.53	250	61.70	5	2
55	750	66.80	30.46	200	66.80	5	2
56	750	71.57	31.62	250	71.57	5	2
57	750	75.96	32.98	200	75.96	5	2
58	750	79.99	34.53	250	79.99	5	2
59	750	83.66	36.22	200	83.66	5	2
60	750	86.99	38.05	250	86.99	5	2

Figure 19 shows the track prediction results from the tracker when different RRM types are used. One can see that this scenario generated similar results as Scenario C even though 20 more missiles were added. The two radars in RRM Type 1 and 2 networks also failed to track the trajectories of the last 30 missiles, and so did Radar 2 for Independent RRM. Even working independently, Radar

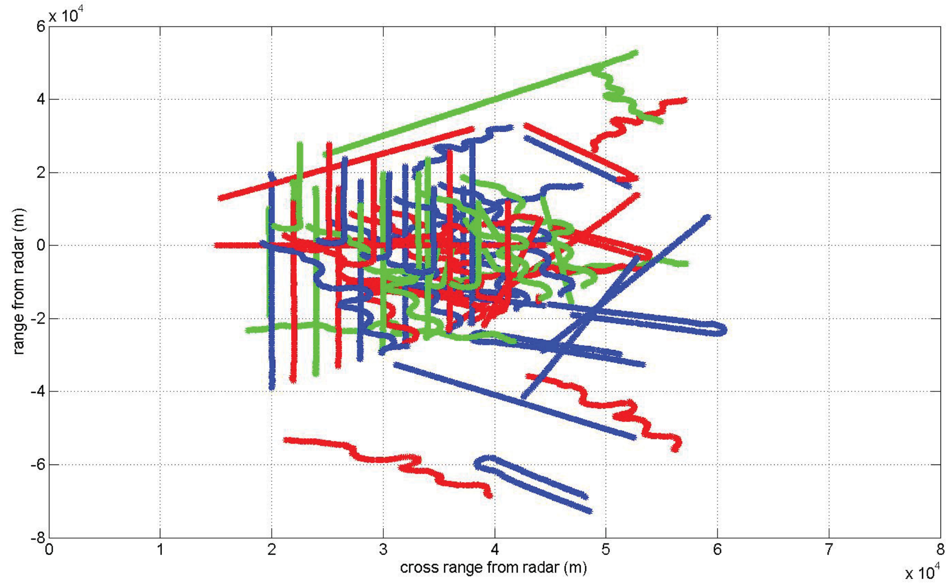
1 was still able to trace all the trajectories of the 60 missiles.



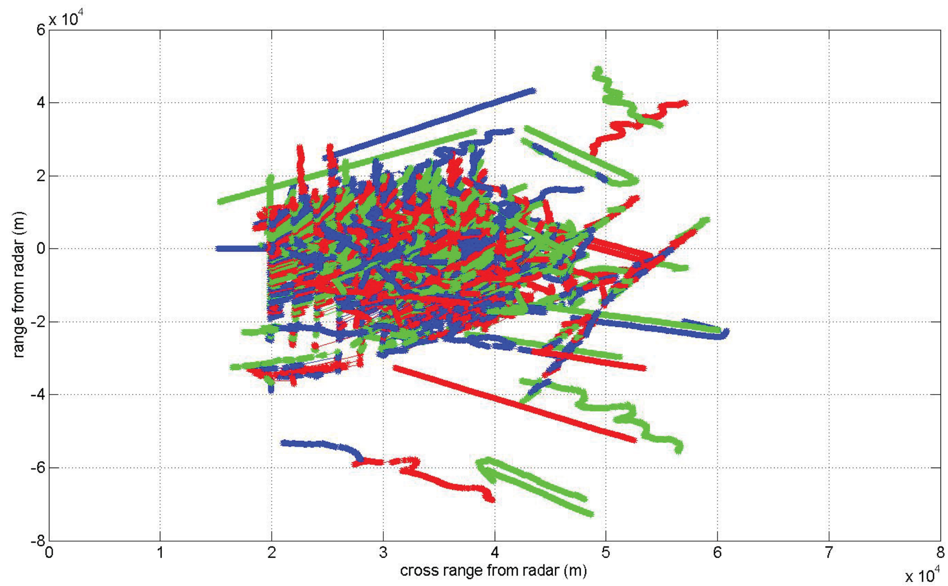
(a)



(b)



(c)



(d)

Figure 19: *Scenario D missile track estimation results from tracker. (a) RRM type 1. (b) RRM type 2. (c) Radar 1 with Independent RRM. (d) Radar 2 with Independent RRM.*

The track completeness, track occupancy and frame time of the three RRM types are shown in Figure 20, 21 and 22. It was noticed that track occupancy and frame time were all increased compared to Scenario C because more missiles were modeled. However, comparing the three RRM types, similar observations can be drawn: Radar 1 for Independent RRM still demonstrated the best track completeness and took less time in tracking, and Radar 2 for Independent RRM had the worst cases.

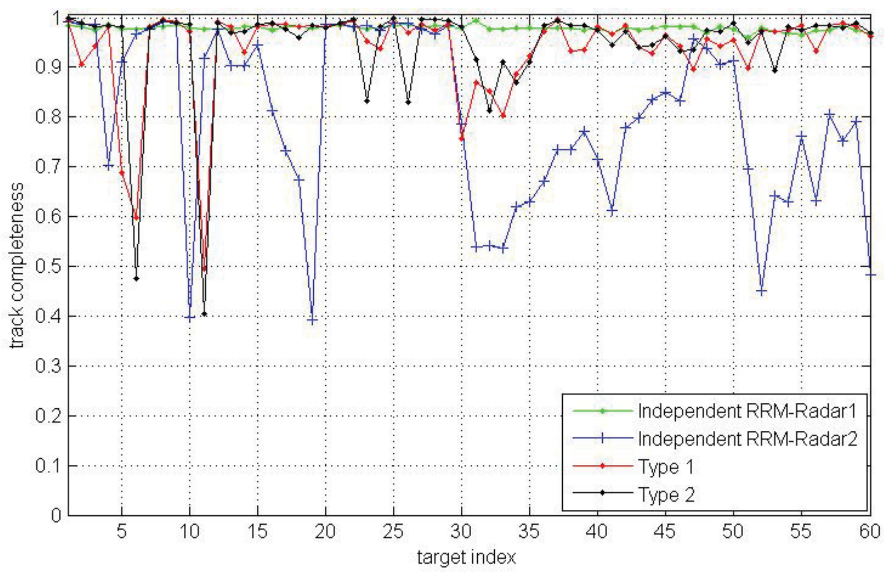


Figure 20: *Track completeness of Scenario D*

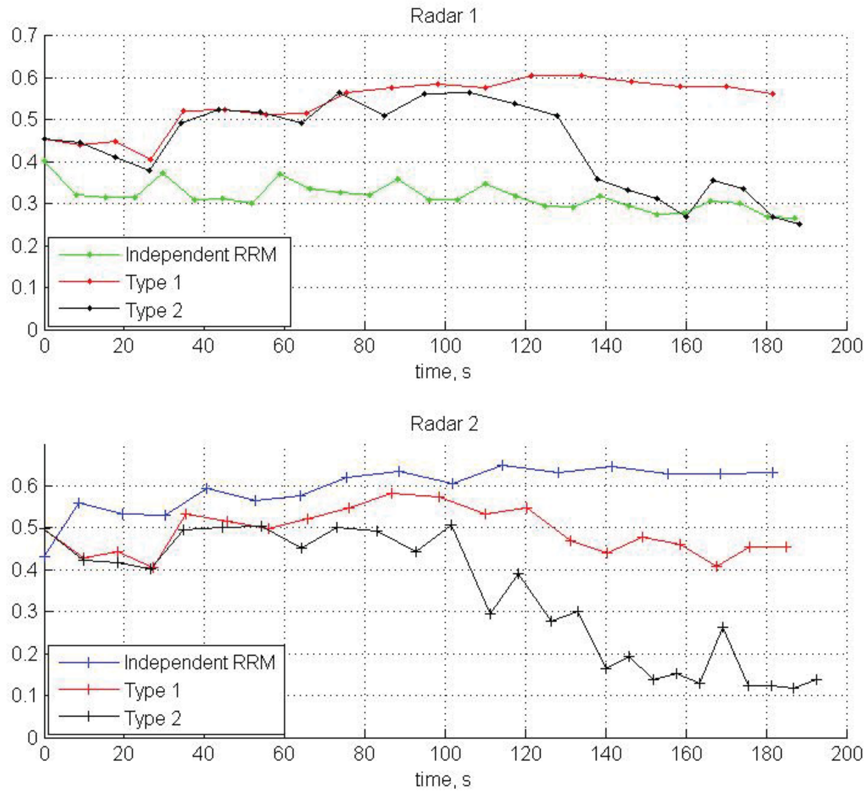


Figure 21: *Track occupancy of Scenario D*

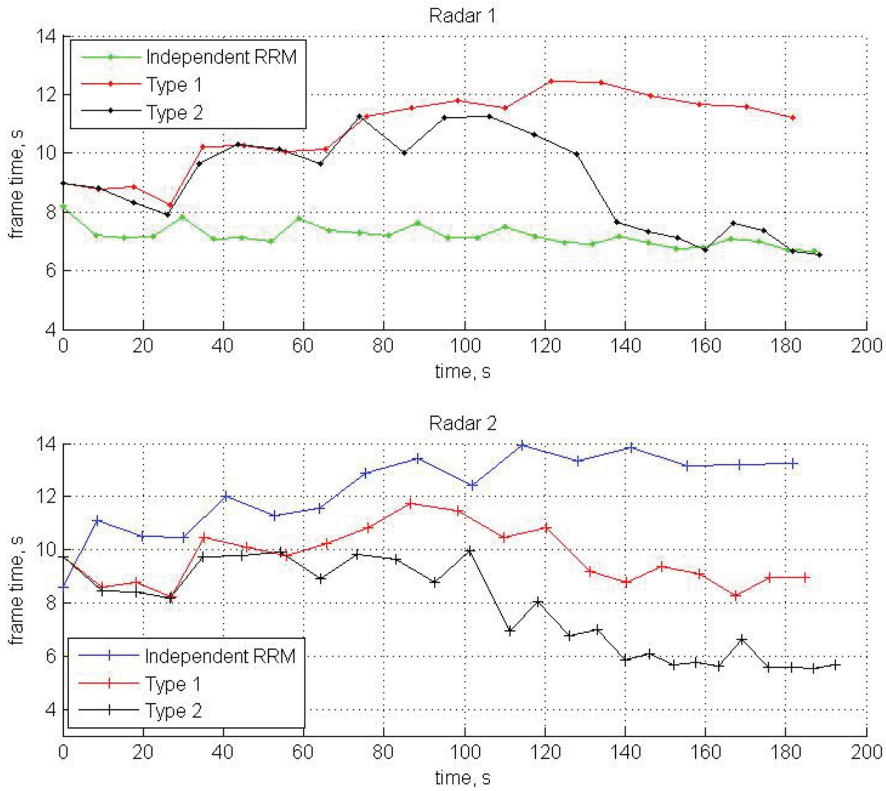


Figure 22: *Frame time of Scenario D*

3 Metrics Calculation Debug

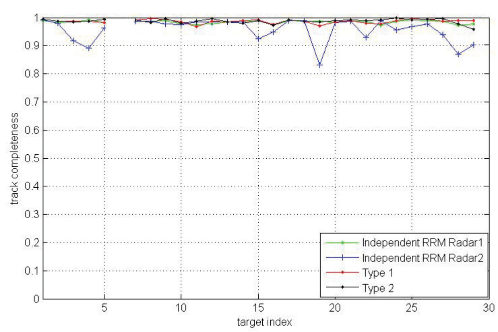
3.1 Track completeness

Description:
The track completenss C is given by:

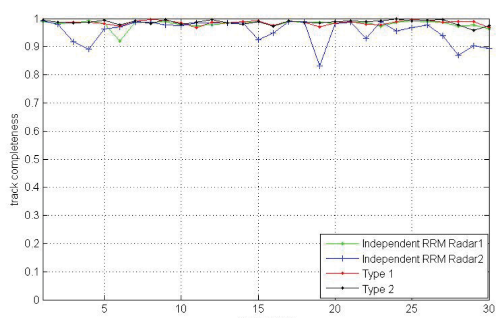
$$\text{track completeness} = \frac{\text{total time interval over which any track number is assigned to target}}{\text{total time that target is in the defined coverage area of radar}}$$

The value of C should be in the range of [0 1].

In the Scenario C experiment, it was noticed that the C values of Missile 6 and 30 were missed as shown in Figure 23 (a). Further investigation found that the C values of both missiles were ”inf” (infinite). Through debugging the metrics calculation function, it was found that the total time that the targets were in the defined coverage area of radars were all zeros. This error was caused by only considering the detectable condition of the last position of the target when calculating the total time. Both of the targets flew out of the coverage area of the network when the simulation ended, so the total time the targets in the defined coverages areas were considered zeros by the function. The error was corrected and Figure 23 (b) shows the track completeness plot of Scenario C after the error was fixed.



(a)



(b)

Figure 23: *Scenario B2 track completeness. (a) old result. (b) new result*

3.2 Track occupancy

Description:
Track occupancy is given by:

$$\text{track occupancy} = \frac{\text{track time}}{\text{frame time}}$$

$$\text{track time} = \text{total time of track + total time of confirmation}$$

$$\text{frame time} = \text{total time of track + total time of confirmation + total time of detection}$$

According to the above equations, if the track time is increased, the track occupancy should be increased and the frame time should also be increased. However, it was noticed that the track occupancy and frame time results of Scenario C conflicted for some frames: their track occupancy was bigger but frame time was smaller.

The problem was caused by the calculation approach in the metrics function in two ways: (1) The dwell time of each tracking beam was considered as a constant in the metrics function. But in fact, the dwell time of each tracking beam is not a fixed value in the simulation, it may be different because different waveforms may be used in each dwell to adapt with target motion. (2) The dwell time of all the confirmation beams was not added to the total track time in each frame. Figure 24 shows track occupancy plots of Scenario C before and after this error was corrected.

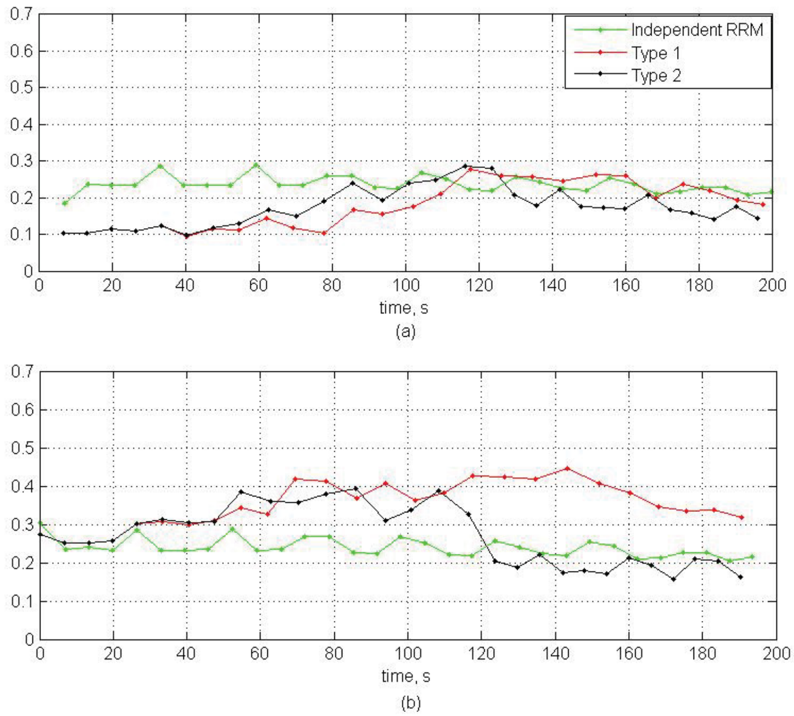


Figure 24: *Scenario C track occupancy. (a) old result. (b) new result.*

3.3 Abnormality in the top view display

Description:
It was noticed that there always exists an abnormality in the top view display of the Adapt_MFR simulator as displayed in Figure 25. As shown in the zoomed in view of the abnormality, it was caused by plotting all the missiles in a simulation at wrong locations. It was assumed that the related code in the display function has not been updated properly during the software development process, so the code causing this abnormality was removed.

Files affected:
.\adapt_mfr_v3.2.8\Gui\cbPlaneView.m

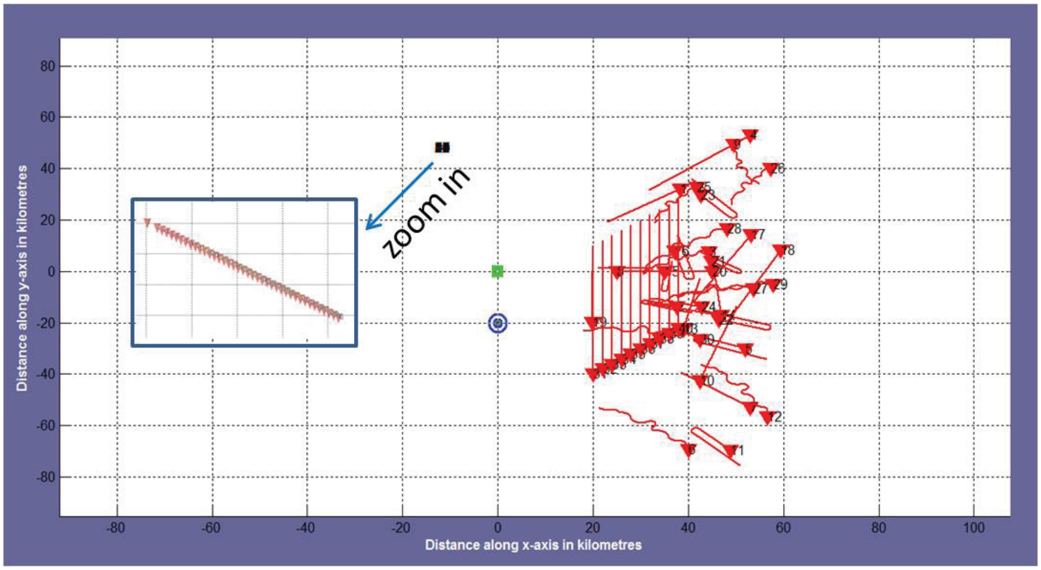


Figure 25: *Abnormality in the top view display*

4 Conclusion

This report summarizes the experiments done for DRDC Ottawa by C-CORE under task 4 of Contract W7714-125424/001/SV. Four scenarios with different missile setups (as targets for the radar network) were designed to test the RRM capability of the Adapt_MFR. A two-radar network system was simulated and setup to work together in one of the three RRM types: (1) coordinated network system with permanent assignment, the radar assigned to a track is not changed once initially assigned; (2) coordinated network system with dynamic assignment, the assigned radar to a track changes at each track update based on the current calculated range and priority results; (3) independent radars, each radar in the network works independently for both detection and tracking tasks. For each simulation, a number of metrics were calculated and plotted to evaluate the detection and tracking performance of the network.

Several coding errors in the metrics calculation function and Adapt_MFR software were identified during the results analysis. The related code was modified accordingly in this task. The metrics plots before and after the modification were displayed for comparison purpose.

Several conclusions can be drawn from the experiments: (1) when radar works independently, its position relative to the missile trajectory is very critical to its success in detection and tracking performance. The best detection area is the area covered by the smaller azimuth scan angles of the radar. (2) The radar network working cooperatively cannot always improve the detection and tracking performance compared to the individual radars working independently when the complexity of the missile profile increased to a certain level. The communications between the radars and track assignment algorithms of the coordinated network play the key function in the performance. The coordinated networks can be overloaded. (3) The two coordinated RRM types (RRM Types 1 and 2) did not demonstrate significant difference in their detection and tracking ability given the same network setups and same missile profile.

5 References

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6. Tracking metrics for the evaluation of radar scheduling, TTCP Technical Report TR-SEN-05-2007, May 2008.
7. DiFilippo, D., McAfee, E., Chen, R., Moore, A., and Dawber B., A Multifunction Radar Simulation for Adaptive Radar Control Studies, TTCP Technical Report, TR-SEN-1-2006, November, 2006.

6 List of symbols/abbreviations/acronyms/initialisms

Adapt_MFR Adaptive Mulitfunction Radar
CW Clock Wise (angular rotation)
CCW Counter Clock Wise (angular rotation)
DRDC Defence Research & Development Canada
DRDKIM Director Research and Development Knowledge and Information Management
MFR Multi-Function Radar
R&D Research & Development
RCS Radar Cross Section
RRM Radar Resource Management
TTCP The Technical Cooperation Program