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Adapt_MFR v3.2.8

Software release notes and RRM Radar assignment updates

B. Brinson
C-CORE

Prepared By:
C-CORE
400 March Road, Suite 201
Ottawa, Ontario K2K 3H4
Contract Project Manager: Dr. Peter Moo, 613-998-2879
PWGSC Contract Number: W7714-125424/001/SV
CSA: Dr. Peter Moo, 613-998-2879

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Defence R&D Canada – Ottawa

Canada

Contract Report
DRDC Ottawa CR 2013-085
August 2013

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Contract Scientific Authority: Dr. Peter Moo 613-998-2879

Defence Research and Development Canada
Contract Report
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Abstract

This report summarizes the work done for DRDC Ottawa by C-CORE under task 3 of contract W7714-125424/001/SV. The work involved augmentation and testing of the radar resource management (RRM) capability of the Adaptive Multi-Function Radar simulator (Adapt_MFR). The capability was added to assign target tracks to specific radars, both permanently and dynamically, based on target range and/or fuzzy logic priority. The effect of this radar assignment on track occupancy and track completeness was investigated. There were definite tracking performance benefits seen due to the assignment of tracks to specific radars. Track occupancy and frame times were reduced with little change in track completeness.

Résumé

Le présent rapport se veut un résumé des travaux effectués par C-CORE pour Recherche et développement pour la défense Canada (RDDC) Ottawa dans le cadre de la tâche 3 du contrat W7714-125424/001/SV. Les travaux visaient l'augmentation et la mise à l'essai de la capacité de gestion de ressources radar du simulateur radar multifonctions adaptatif (Multi-Function Radar MFR) (Adapt_MRF). Nous avons ajouté cette capacité en vue d'associer des poursuites d'objectifs à des radars particuliers de façon permanente et dynamique, en fonction de la distance des objectifs ou des niveaux de priorité de logique floue (ou les deux). Nous avons évalué les répercussions de l'association de radars particuliers sur l'occupation de trajectoire et l'intégrité de poursuite et relevé des avantages clairs sur le plan du rendement. La réduction des durées de trame et d'occupation de trajectoire a très peu influé sur l'intégrité des poursuites.

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Executive summary

Adapt_MFR v3.2.8

B. Brinson; DRDC Ottawa CR 2013-085; Defence Research and Development Canada; August 2013.

Background: 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 augmenting the advanced RRM capability and evaluating the benefits of such capability.

Principal results: The capability to assign target tracks to specific radars based on range and priority was implemented and performance assessments were performed to analyze the benefits and compare them to the previous non-assignment implementation. Track occupancy and frame times were reduced with little change in track completeness meaning that the non-assigned radar(s) spent less time on tracking and more on detection or other tasks.

Significance of results: The track completeness of all targets in the tested scenarios was quite high. Because there was no negative impact on track completeness associated with the reduction of track occupancy, simulations with lower track completeness levels might see an improvement with this radar assignment implementation due to the non-assigned radar having more time to carry out detections.

Future Work: Further research into additional target assignment methods is recommended.

Sommaire

Adapt_MFR v3.2.8

B. Brinson ; DRDC Ottawa CR 2013-085 Recherche et développement pour la défense Canada ; août 2013.

Contexte : Recherche et développement pour la défense Canada (RDDC) Ottawa a conclu un contrat avec C-CORE en vue d'obtenir des services de soutien logiciel liés à la poursuite et à la gestion de ressources radar au moyen d'un suiveur autonome à modèles multiples interactifs (Interactive Multiple Model IMM) d'association probabiliste conjointe de données (Joint Probabilistic Data Association JPDA) du plus proche voisin (Nearest Neighbour NN) (IMM-NNJPDA). Les travaux réalisés dans le cadre du contrat étaient subséquents à ceux déjà entrepris en vue d'augmenter la capacité poussée de gestion des ressources radar et d'évaluer les avantages de celle-ci.

Résultats : Nous avons mis en œuvre une capacité d'association de poursuites d'objectifs à des radars particuliers selon la portée et le niveau de priorité, puis analyser le rendement de cette capacité en vue d'en déterminer les avantages et de comparer ceux-ci avec la non-association antérieurement mise en œuvre. La réduction des durées de trame et d'occupation de trajectoire a très peu influé sur l'intégrité de la poursuite, ce qui signifie que le ou les radars non associés accordaient davantage de temps à des tâches autres que la poursuite, comme la détection.

Portée : Lors des scénarios mis à l'essai, l'intégrité de la poursuite des objectifs était très élevée. Puisque la réduction de l'occupation de trajectoire n'entranait aucune répercussion négative sur cette intégrité, la mise en œuvre d'une association de radars peut améliorer les simulations effectuées selon des niveaux d'intégrité inférieurs, les radars non associés ayant ainsi davantage de temps pour effectuer les détections.

Recherches futures : Nous recommandons davantage de recherche sur des méthodes supplémentaires d'association d'objectifs.

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1 Introduction

This report summarizes the work done by C-CORE under tasks 3 of contract W7714-125424/001/SV involving augmentation and testing of radar resource management (RRM) capabilities of the Adaptive Multi-Function Radar simulator (Adapt_MFR) in use by DRDC Ottawa. RRM capability was previously implemented in Adapt_MFR version 3.2.7 (refer to [3] and [4]).

Track assignments to specific radars was further modified and tested. Performance assessments were performed to analyze the benefits of different track assignment methods versus the non-assignment implementation. Specifically, the effect of radar assignment on track occupancy, frame time, and track completeness was investigated with the goal of determining which track assignment method would most improve track performance.

This report is composed of two main sections. The first section deals with modifications and additions to the Adapt_MFR simulator. It is presented as software release notes and contains a description of bug fixes and new functionality. The second section describes the radar assignment work and testing that was performed during the task. Conclusions and recommendations follow to end the report.

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 files that have been modified up to the time this report was released.

2 Software release notes

The Adapt_MFR simulator was upgraded with the capability to assign tracks to specific radars based on range and priority on a static or dynamic basis. A number of software bugs were encountered and resolved during testing. Some new functionality was also added to aid in debugging and analysis. These modifications are described in the following sections.

2.1 Bug fixes

During implementation and testing a number of software bugs were encountered and are described in the following sections.

2.1.1 Time balance fix for unassigned and newly confirmed tracks

Description:
Each newly confirmed track is assigned a time balance value that is incremented upon every look and decremented when a track beam is assigned to that track. There is a time balance structure for each track for every radar. When a track is assigned to a specific radar the time balance value for the other radar is never decremented. If the radar assignment changes back to the non-assigned radar after a large period of time the time balance value is quite large compared to the other tracks that have been consistently decremented. Even after being decremented a number of times the value was larger than the others. Because of this the track was given a large number of sequential track beams, which in turn effects track occupancy. This same problem also occurred with newly confirmed tracks later in the scenario. The initial time balance value was much larger than the others that had been decremented consistently.

This problem was resolved by modifying the time balance value for newly confirmed and newly assigned (or re-assigned) tracks based on the minimum time balance value of all of the other tracks and the tracks own calculated decrement value. This way the track will have a track beam assigned almost, if not, immediately but the time balance value will be decremented and the track not assigned an immediate subsequent track beam.

Files affected:
.\Main\whats_next_adaptive.m

2.1.2 Roster functionality removal

Description:
Roster functionality was removed due to situations where observations were not gating with their existing tracks because the track was not in the roster at the time the observation was sent to the tracker for gating. This resulted in many new tentative tracks that were never promoted to confirmed tracks and in turn deleted. Now observations are gated against all existing tracks.

Files affected:
.\IMM_Tracker\filter\observational_update-MostDynamicGating.m

.\IMM_Tracker\filter\observational_update.m
.\IMM_Tracker\filter\observational_update_pseudo.m

2.1.3 Fix for boresight azimuth angles

Description:
Use of boresight azimuth angles other than 90 degrees resulted in poor tracking or loss of tracking. This was due to varied missile angle definitions throughout the code and an incorrect comparison method for limiting tracking beyond a defined angle from boresight. All missile azimuth angles are now defined from 0 to 180 degrees or 0 to -180 degrees. When comparing missile azimuth to boresight for the track angle limitations the missile azimuth is temporarily defined as 0 to 360 degrees to be compatible with the boresight angle definition. A track range rate adjustment was also required when the boresight azimuth was between 180 to 360 degrees and the track azimuth was also located within those angle limits.

Files affected:
.\Main\trajctry_rev.m
.\Main\trajctry_unrev.m
.\Main\trajctry_unrev_xyz.m
.\Main\trajctry_unrev_xyz2.m
.\Main\adaptmfr_run.m
.\Main\intersects_m.m
.\Gui\saveMissParams.m
.\Old_Mfarsim\makRot.m

2.1.4 Fix for Lambda calculation

Description:
A lambda calculation was modified in the missile trajectory initialization function. A divide by zero situation would cause NaN results that would crash the simulation. A fix was implemented by detecting the potential divide-by-zero and using an alternate calculation to determine lambda.

Files affected:
.\Main\init_missile_trajectory.m

2.1.5 Radian to degrees calculation removal

Description:
An incorrect angle conversion from radians to degrees was removed from the missile trajectory plotting tool in the GUI.

Files affected:
.\Gui\cbTrajectoryprofile.m

2.1.6 Various typos or missing parameters

Description:
Several files had typos that were not critical to the simulation. Other files had variables with missing parameters or parameters that were not updated properly. These errors had subtle effects on the tracking performance that were identified during debugging. The typos were fixed and missing parameters were added and updated properly.

Files affected:
.\Main\editUiControl.m
.\Main\add_false_alarms.m
.\Main\update_scheduler.m
.\Main\get_antenna_gain.m
.\Main\doppler_mfr.m

2.1.7 False alarm detections fix

Description:
The false alarm functionality was updated to support the multi-radar single tracker implementation. Specifically there were missing parameters that had been added for real observations but not for the false alarms. When false alarms were activated the simulator would crash. These parameters were added.

Files affected:
.\Main\add_false_alarms.m
.\Main\adaptmfr_run.m
.\Main\trajctry_rev.m

2.1.8 Case of function names

Description:
Several files called functions by the lower case version of the function name. This is not supported in the newer versions of MATLAB. The correct function name cases were implemented.

Files affected:
.\Gui\cbPlotParameters.m
.\Gui\cbRad_adapt.m
.\Gui\cbRad_antenna.m
.\Gui\cbParams_adapt.m
.\Old_Mfarsim\dBToLin.m
.\Main\rflct_land.m
.\Main\compute_radarRangeEquation.m
.\Main\detSNR.m
.\Main\doppler_mfr.m
.\Main\phase_noise.m

.\Main\surfMfr4Mod_dted.m
.\Main\volTest6.m

2.2 New functionality

The Adapt_MFR simulator was upgraded with additional functionality. The capability to assign tracks to specific radars was improved upon from the previous release. A single tracker was implemented to handle tracking from all radars. The GUI-based missile editor was changed to save and load user modified missile data. Other miscellaneous changes and metrics support modifications were also made. These changes are described in the following sections.

2.2.1 Conversion to single tracker for multi-radar simulations

Description:
The simulator was modified to allow for either independent trackers per radar or a shared tracker representing a networked radars scenario. In the networked radar case, each track is updated with detections from both radars unless the track has been assigned to a specific radar. This is discussed in the following section.

Files affected:
.\IMM_Tracker\IMMTracker.m

2.2.2 Assignment of tracks to specific radars

Description:
Functionality was implemented to allow for the assignment of tracks to specific radars (either permanently or dynamically) based on either range to target or fuzzy logic priority value. In cases where the range or priority values are the same the assigned is based on the other parameter. In cases where both parameters have the same value the track is assigned to radar 1.

Once a track is assigned to a specific radar only that radar will actively track the target. Observations and detections from the other radars due to surveillance beams are utilized but track beams are not scheduled for the non-assigned radars. A problem that arose from this was the deletions of non-assigned tracks due to lack of updates. This was prevented by adding flags to the track structure to mark the track to allow deletion as well as defining the time the deletion was allowed. See section 3.1 for additional info.

Files affected:
.\IMM_Tracker\filter\track_deletion.m
.\IMM_Tracker\filter\track_deletion4.m
.\IMM_Tracker\IMMTracker.m
.\Main\adaptmfr_run.m
.\Main\whats_next_adaptive.m

2.2.3 Change of reference frame for priority calculations

Description:
To support the shared tracker\networked radar implementation the track parameters used to calculate fuzzy logic priority for a track and radar pair were converted back to the corresponding offset

radar reference frame. This is because track parameters sent to the tracker are converted to the reference frame of a radar at x,y position 0,0. Priority calculations are performed at the original offset x,y radar locations.

Files affected:
.\Main\whats_next_adaptive.m
.\Main\horizon_test2.m - new file
.\Main\trajctry_unrev_xyz2.m - new file

2.2.4 Option for track update rates based on two level priority

Description:
Functionality was implemented to allow for assignment of track update rates based on a two level priority system. The user can modify update rates are used for each priority level and the priority level threshold can also be user modified. Previously a three level (high, medium, low) priority system was used. Either the two level or three level priority system can be activated by setting a user flag. If the three level system is used the high and medium update intervals can still be user modified (the low update rate is based on surveillance beam scheduling) but the priority thresholds are currently hard coded as high >= 0.7 and medium <0.7 and >0.3. The low priority level is 0.3 or lower.

Files affected:
.\Main\adaptmfr_run.m
.\Main\whats_next_adaptive.m

2.2.5 Missile editor changes

Description:
The missile editor was changed to allow for both saving to and loading from missile data files of missile parameters in the GUI. Previously missile parameters entered in the GUI were saved with the scenario file. Missile data could be loaded from external data files but could not be modified within the GUI.

Files affected:
.\Gui\cbConsolidate.m
.\Gui\cbLoadParams.m
.\Gui\cbMissileParams.m
.\Gui\cbPlaneView.m
.\Gui\cbpViewAzimuth.m
.\Gui\cbTrajectoryProfile.m
.\Main\editUiControl.m
.\Main\adaptmfr_run.m

2.2.6 Independent confirmation beam count for each radar

Description:
Independent confirmation beam counts were implemented in the shared tracker. Previously in some cases the confirmation count threshold would be exceeded and the tentative track deleted before it could be promoted to a confirmed track. This was due to multiple radars creating the tentative track simultaneously. Note that only confirmed tracks are assigned time balancing parameters and in turn can be assigned to specific radars. During the initial detection phase all radars will attempt to create tentative tracks.

Files affected:
.\IMM_Tracker\filter\track_deletion.m
.\IMM_Tracker\models\CV\cvinit.m

2.2.7 Additional parameters added to Radar response for metrics support

Description:
The following additional parameters were added to the Radar response for metrics support:

beam_type
Identifies which type of beam resulted in the response:

1. detection
2. confirmation
3. track
4. cue

iface
Identifies which radar resulted in the response

cent_flag and *num_comb*
Identifies if this response was centroided and how many responses were combined

Files affected:
.\IMM_Tracker\IMMTracker.m
.\Main\adaptmfr_run.m
.\Main\centroid_detections.m
.\Main\set_schedular.m
.\Main\update_schedular.m
.\Main\whats_next_adaptive.m

2.2.8 Additional parameters added to Radar structure for metrics support

Description:
The following additional parameter was added to the Radar structure for metrics support:

desired_trk_num

Identifies which track a beam has been scheduled for (beam is scheduled in whats_next_adaptive.m)

Files affected:
.\Gui\cbLoadParams.m
.\Gui\cbDefaultParameters.m
.\Main\adaptmfr_run.m
.\Main\whats_next_adaptive.m

2.2.9 Pseudo flag passed through to cv_init function call

Description:
The pseudo track flag was passed through to the cv_init function to allow for both informative run time messages and debugging\analysis in the metrics scripts.

Files affected:
.\IMM_Tracker\filter\tentative_track_update.m
.\IMM_Tracker\models\CV\cvinit.m

2.2.10 User prompt to save data after simulation failure

Description:
The option was implemented to allow the user to choose whether to save simulation data or not upon simulation failure. Previously the data was always saved but this resulted in large amounts of unwanted files during debugging.

Files affected:
.\Main\adaptmfr_run.m

2.2.11 Save missile and adapt_MFR configurations as unique files after simulation

Description:
The missile configuration parameters and adapt_MFR setup are saved with unique identifying filenames upon simulation completion. The unique identifiers are based on the date and time and some of the simulation parameters and match the identifier used for the other saved simulation data files. This is beneficial for metrics and debugging purposes.

Files affected:
.\Main\adaptmfr_run.m

2.2.12 Option to disable pseudo track updates

Description:
During debugging the option was implemented to disable pseudo track updates using a flag parameter. Pseudo updates originate from centroided surveillance beam detections.

Files affected:
.\IMM_Tracker\filter\observational_update_pseudo.m
.\IMM_Tracker\IMMTracker.m
.\Main\adaptmfr_run.m

2.2.13 Additions for multi-radar plotting

Description:
Several of the GUI plotting functions were updated to allow for multi-radar scenarios.

Files affected:
.\Gui\cbAnalysis.m

2.2.14 Simulation plane view zoom option

Description:
The option was added to allow the user to zoom in on the GUI plane view plot using a bounding box rather than a general zoom based on the plot center point.

Files affected:
.\Gui\cbPlaneView.m

2.2.15 Added target numbers to track index function for debugging

Description:
The target numbers were added to the output of the track indexing function for debugging purposes.

Files affected:
.\IMM_Tracker\filter\ids2indicies.m

3 Track assignment updates

Additional testing was performed to verify the networked radar modifications and to assess the performance benefits of coordinated RRM versus independent RRM using different track to radar assignment methodologies.

3.1 Track assignment methodology

Track assignment means that a track has been assigned a specific radar to perform track updates. Radars will not schedule track beams for targets they are not assigned to however the track can be updated by other radars indirectly due to surveillance beams and when multiple targets are detected in the same track beam. Depending on the coordinated management type selected by the user the track assignment will be based on the minimum range of the radar to the target or the maximum fuzzy logic priority result. If the range or priority results are the same the other parameter is used to determine assignment. If both are the same the track is assigned radar 1.

Table 1 lists the coordinated management types. 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/or priority results. Figure 1 and Figure 2 show results from a 30 target scenario using both methods respectively.

Table 1: *Coordinated management types*

Index	*Track assignment type*
0	max priority
1	min range than max priority, simulation permanent
2	min range than max priority, track update dynamic
3	N/A, independent radars

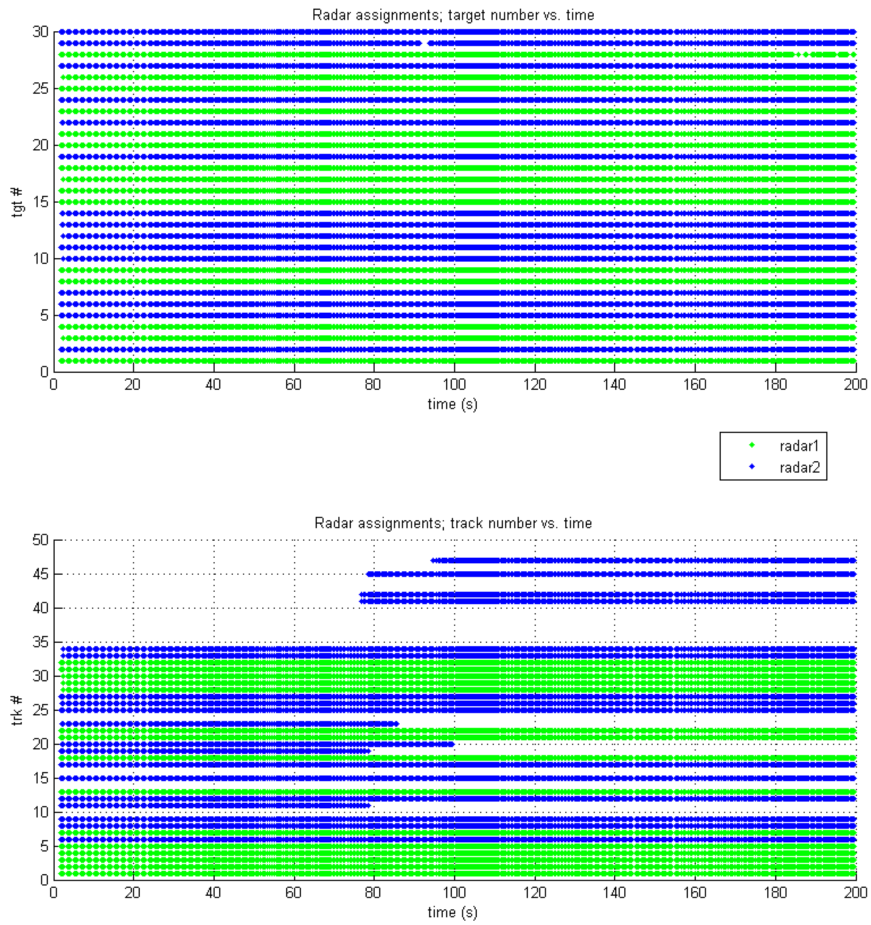

Figure 1: *Static radar assignment*

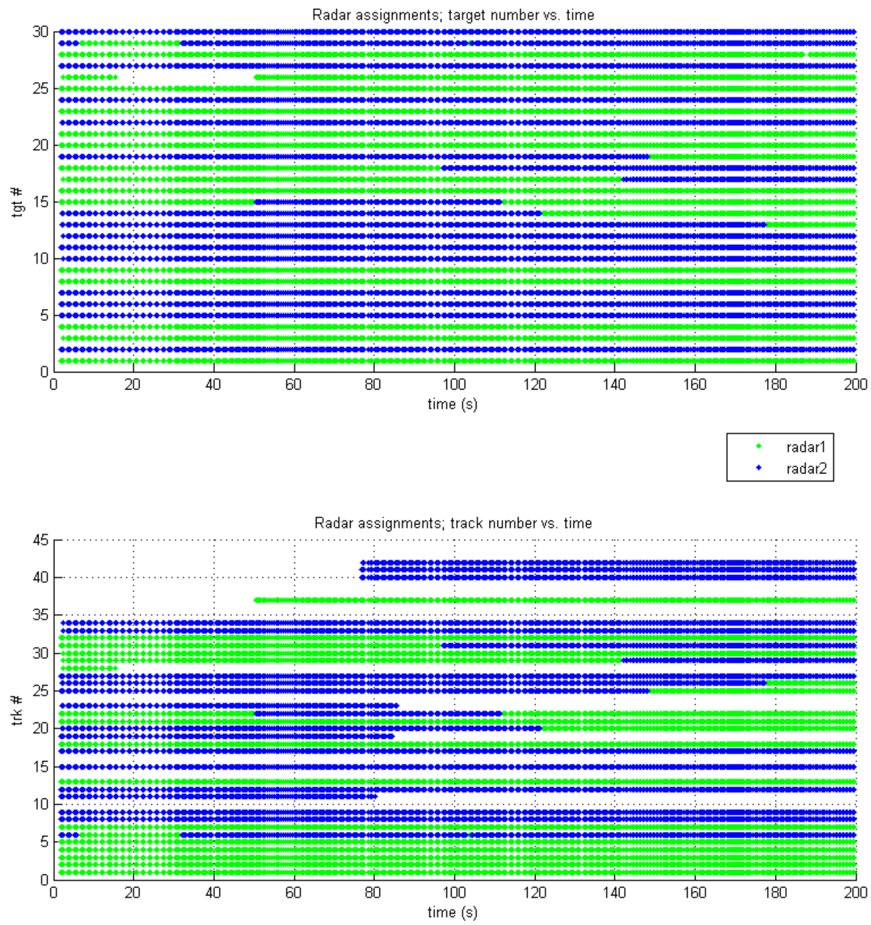

Figure 2: *Dynamic radar assignment*

3.2 Performance assessment

The resultant scenario output file name format is as follows:
date_time num_targets cmt_type num_radars version two_level_priority_threshold

The results described in this report correspond to the following files:
201362911_30_tgts_cmt_3_2_radars_adapt_V328_tlput_75
201362911_30_tgts_cmt_1_2_radars_adapt_V328_tlput_75
201362911_30_tgts_cmt_2_2_radars_adapt_V328_tlput_75
201362910_12_tgts_cmt_3_2_radars_adapt_V328_tlput_75
201362910_12_tgts_cmt_1_2_radars_adapt_V328_tlput_75
201362910_12_tgts_cmt_2_2_radars_adapt_V328_tlput_75

Two new simulations were created. One modeled two radars (one at position [0,0] and the other offset in x and y space) and twelve targets. The other modeled the same two radars with an additional 18 targets (for a total of 30). The main goal of this testing was to compare the track quality of each radar and to identify where a coordinated network of radars would be superior to the current independent RRM implementation. One radar was positioned at [0,0] in [x,y] space while the second radar was given no x offset and a y offset of -10 km as shown in Figure 4 with 12 targets and in Figure 5 with 30 targets. The non-offset radar is shown in green, the offset radar is shown in blue and the various target trajectories are shown in red.

The targets were created using the adapt_MFR GUI missile editor (Figure 3).

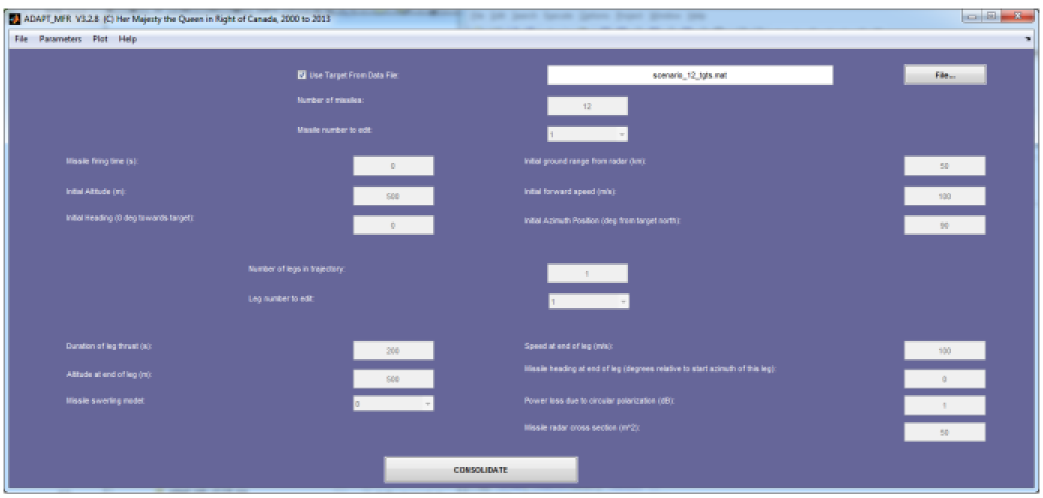

Figure 3: *adapt_MFR missile editor*

The following target parameters can be modified in the missile editor. Each parameter matches those shown in Table 2 and Table 3 for the 12 and 30 target scenarios respectively. Constant speeds and heights were used. Trajectories for each target are defined in Table 4.

Tgt_ID
Missile number

Alt
Initial altitude (m)

Head
Initial Heading (0 degrees towards Radar 1; positive angle is CCW)

Rng
Initial ground range from Radar 1 (km)

V
Initial forward speed (m/s)

Az
Initial Azimuth Position (degrees from target north; CW positive)

RCS
RCS (m^2)

Traj_type
Trajectory type (see Table 4)

Table 2: *12 target scenario parameters*

Tgt_ID	*Alt* (m)	*Head* (deg)	*Rng* (km)	*V* (m/s)	*Az* (deg)	*RCS* (m^2)	*Traj_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	-225	60	150	135	50	1
11	750	3	85	150	145	75	2
12	600	30	80	150	135	75	3

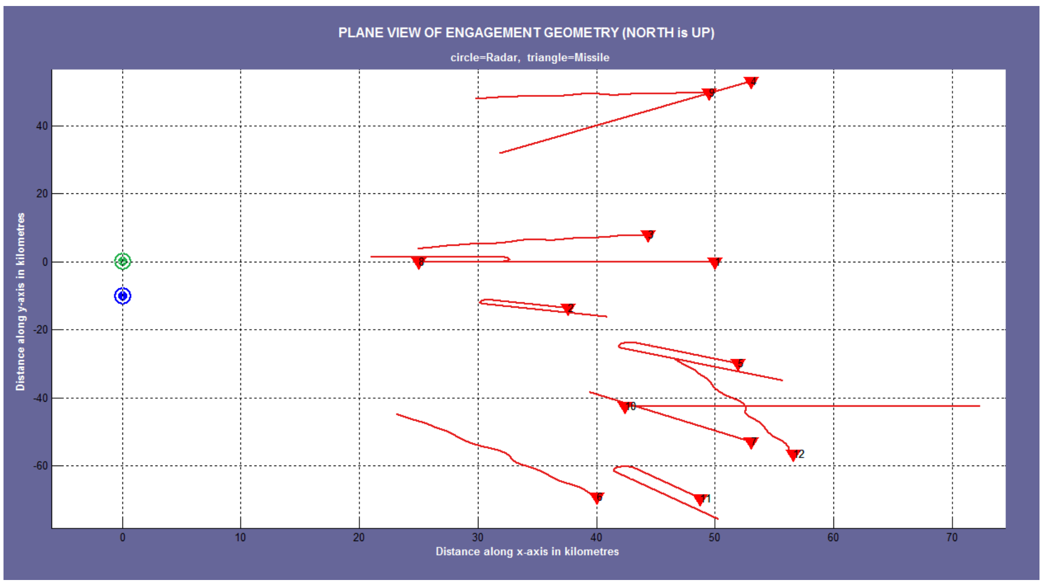

Figure 4: *Radar positioning and target trajectories for the 12 target test scenario*

Table 3: *30 target scenario parameters*

Tgt_ID	*Alt* (m)	*Head* (deg)	*Rng* (km)	*V* (m/s)	*Az* (deg)	*RCS* (m^2)	*Traj_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

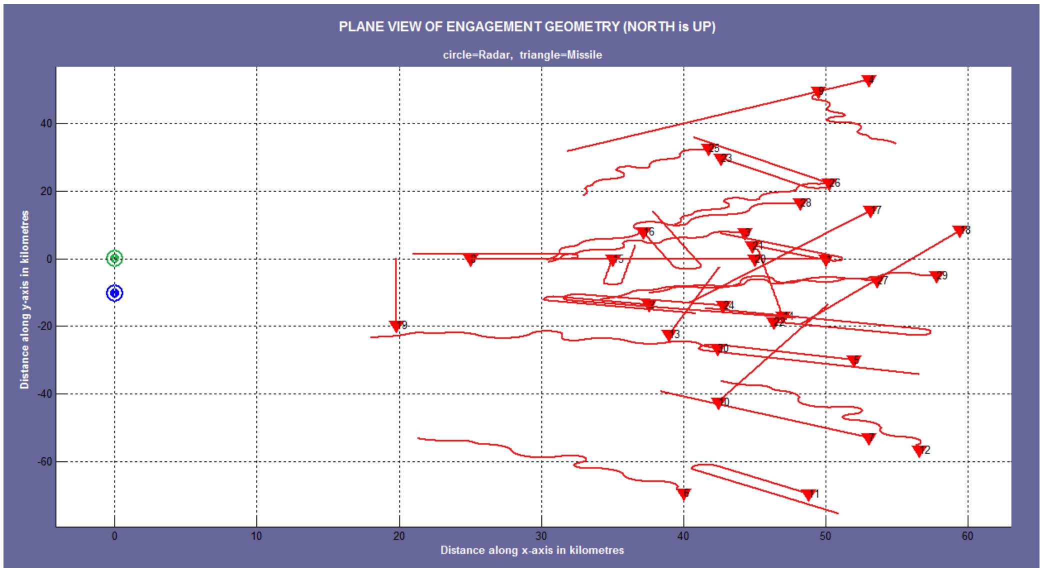

Figure 5: *Radar positioning and target trajectories for the 30 target test scenario*

Target trajectories are defined in leg segments of a specified duration with heading changes where appropriate. Speed and height remained constant in the 12 and 30 target scenarios tested. The values assigned to the parameters listed below are shown in Table 4.

Traj_type
Trajectory type index

Leg #
Leg #

Dur
Leg duration (s)

Head
Missile heading at end of leg relative to start (degrees CCW positive)

Table 4: *Target trajectory parameters*

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

By comparing the results across the two radars the hope was that track completeness would change very little but the track occupancy of the non-assigned radar(s) would lower. This would highlight the benefits of coordinated radars.

Figure 6 shows the track completeness for the 30 target scenario when using two independent radars, and coordinated management types 1 and 2. The track completeness results for the CMT scenarios are similar and in some cases better (with higher track completeness) than those of the independent radar.

Figure 7 shows the track occupancy of radar 1 for the 30 target scenario when two independent radars, and coordinated management types 1 and 2. Figure 8 shows the track occupancy of radar 2. The track occupancy results for the CMT scenarios are better (with lower track occupancy) than the independent radar results. Notice that when the track occupancy of radar 1 increases the occupancy of radar 2 decreases. This shows that the targets are changing radar assignment.

Figure 9 shows the frame time of radar 1 for the 30 target scenario when two independent radars, and coordinated management types 1 and 2. Figure 10 shows the frame time of radar 2. The frame times for the CMT scenarios are lower than those of the independent radars. This corresponds to the reduced track occupancies.

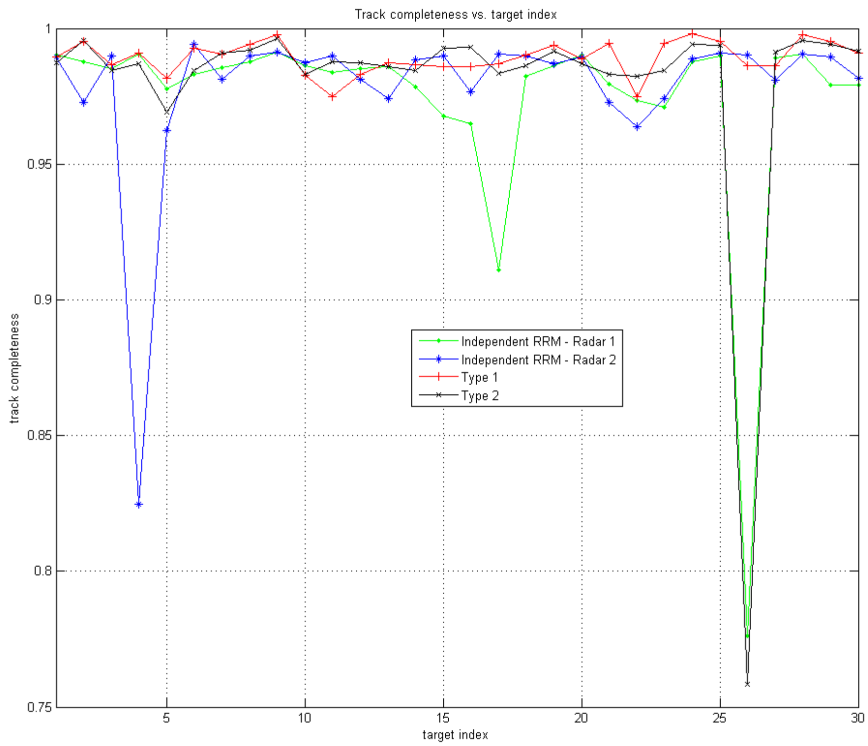

Figure 6: *Track completeness vs. target index, for the 4 cases: independent RRM - Radar 1; independent RRM - Radar 2; Type 1; Type 2, 30 target scenario*

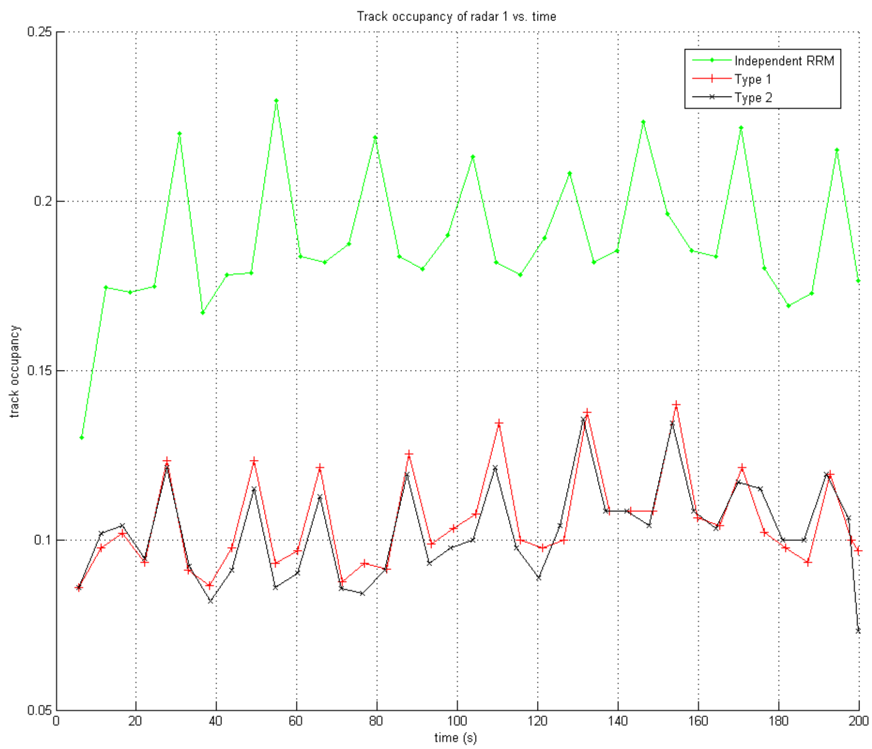

Figure 7: *Track occupancy of radar 1 vs. time, for independent RRM, type 1 and type 2, 30 target scenario*

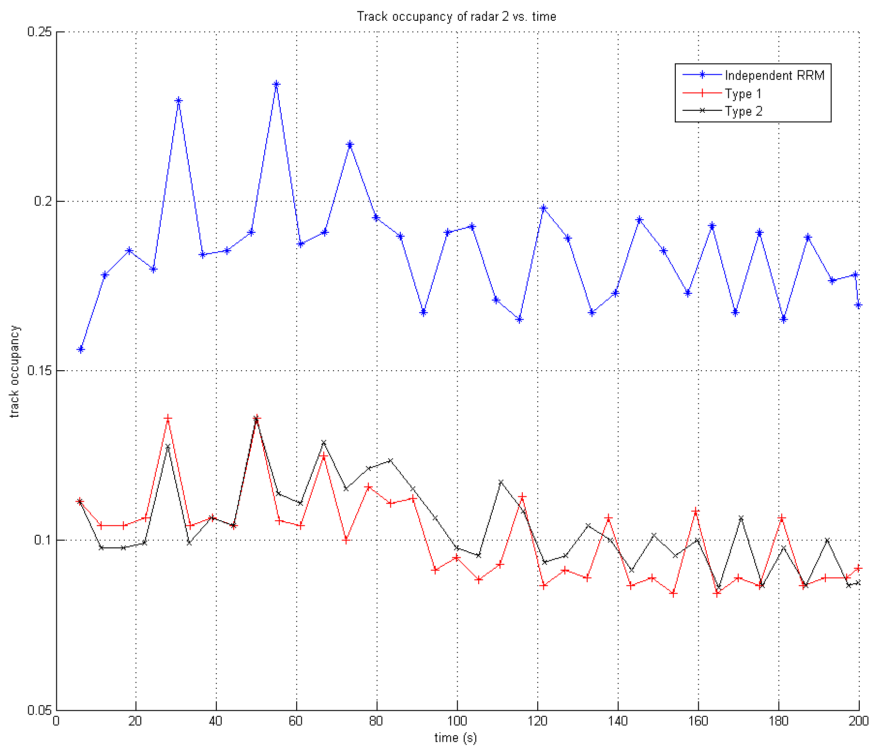

Figure 8: *Track occupancy of radar 2 vs. time, for independent RRM, type 1 and type 2, 30 target scenario*

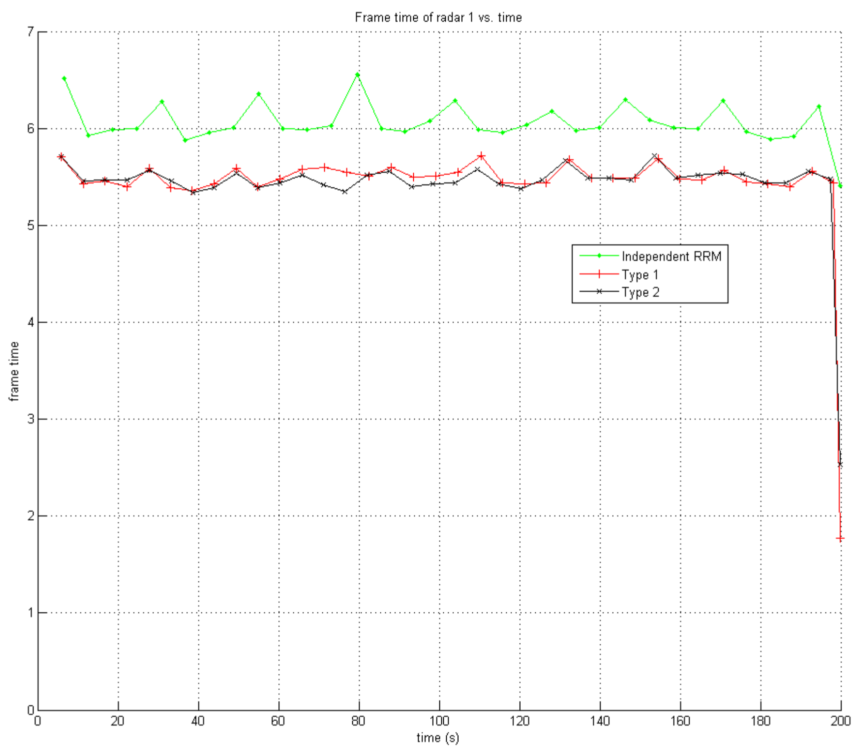

Figure 9: *Frame time of radar 1 vs. time, for independent RRM, type 1 and type 2, 30 target scenario*

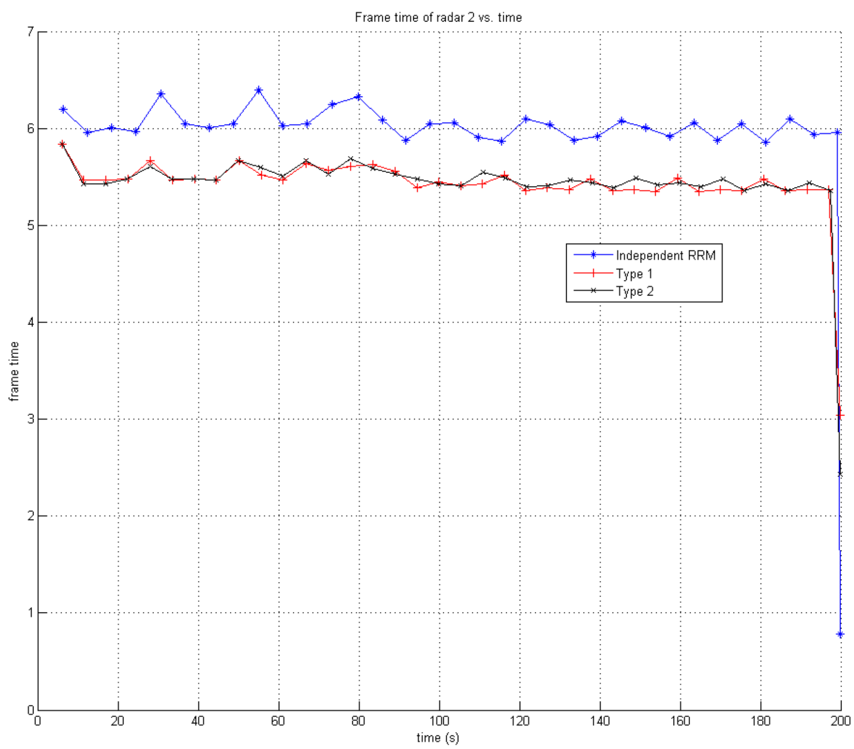

Figure 10: *Frame time of radar 2 vs. time, for independent RRM, type 1 and type 2, 30 target scenario*

Figure 11 shows the track completeness for the 12 target scenario when using two independent radars, and coordinated management types 1 and 2. As with the 30 target scenario, the track completeness results for the CMT scenarios are similar and in some cases better (with higher track completeness) than those of the independent radar.

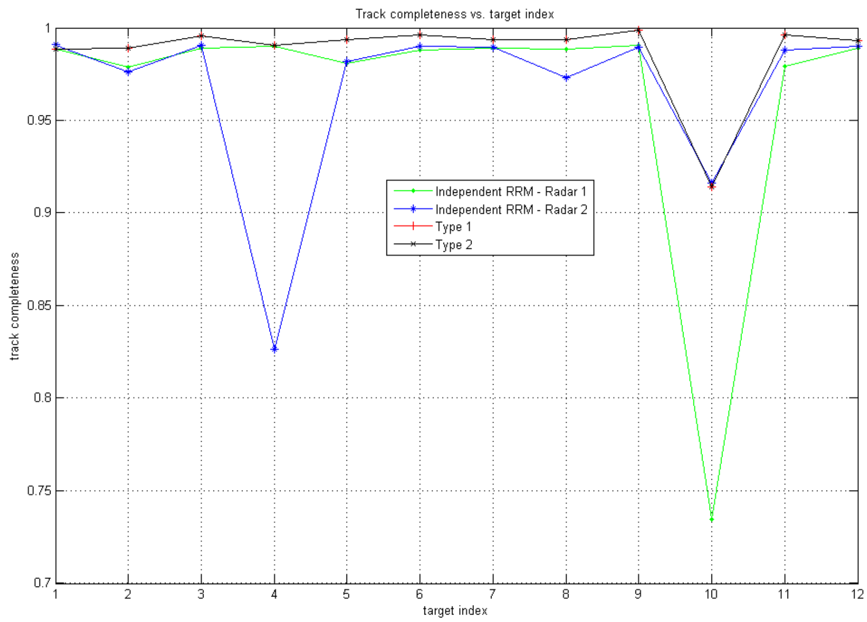

Figure 11: *Track completeness vs. target index, for the 4 cases: independent RRM - Radar 1; independent RRM - Radar 2; Type 1; Type 2, 12 target scenario*

Figure 12 shows the track occupancy of radar 1 for the 12 target scenario when two independent radars, and coordinated management types 1 and 2. Figure 13 shows the track occupancy of radar 2. Again, the track occupancy results for the CMT scenarios are better (with lower track occupancy) than the independent radar results. The track occupancy results for CMTs 1 and 2 are the same because the CMT 2 radar assignments did not change during the scenario.

Figure 14 shows the frame time of radar 1 for the 12 target scenario when two independent radars, and coordinated management types 1 and 2. Figure 15 shows the frame time of radar 2. As before, the frame times for the CMT scenarios are lower than those of the independent radars corresponding to the reduced track occupancies. Like the track occupancy results, the frame time results for CMTs 1 and 2 are the same because the CMT 2 radar assignments did not change during the scenario.

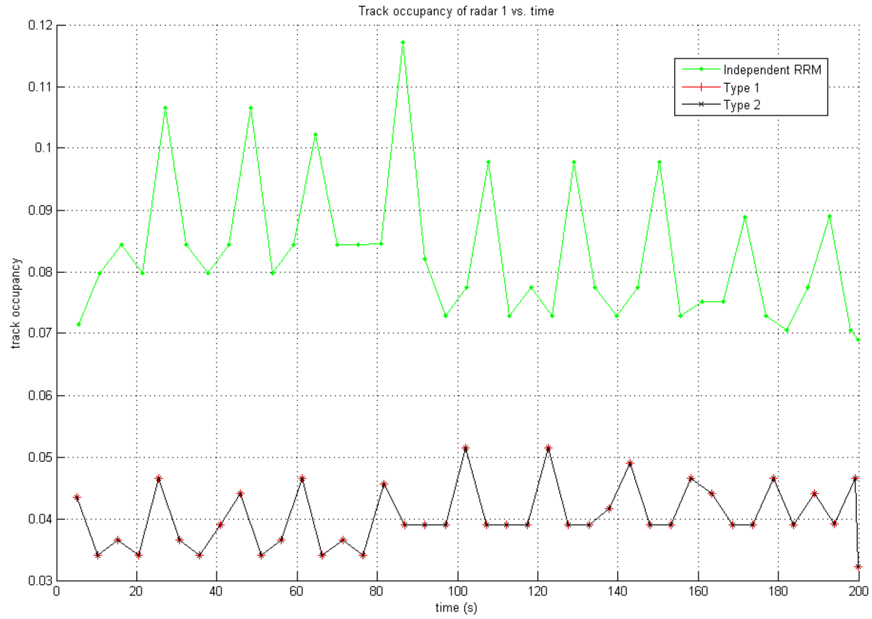

Figure 12: *Track occupancy of radar 1 vs. time, for independent RRM, type 1 and type 2, 12 target scenario*

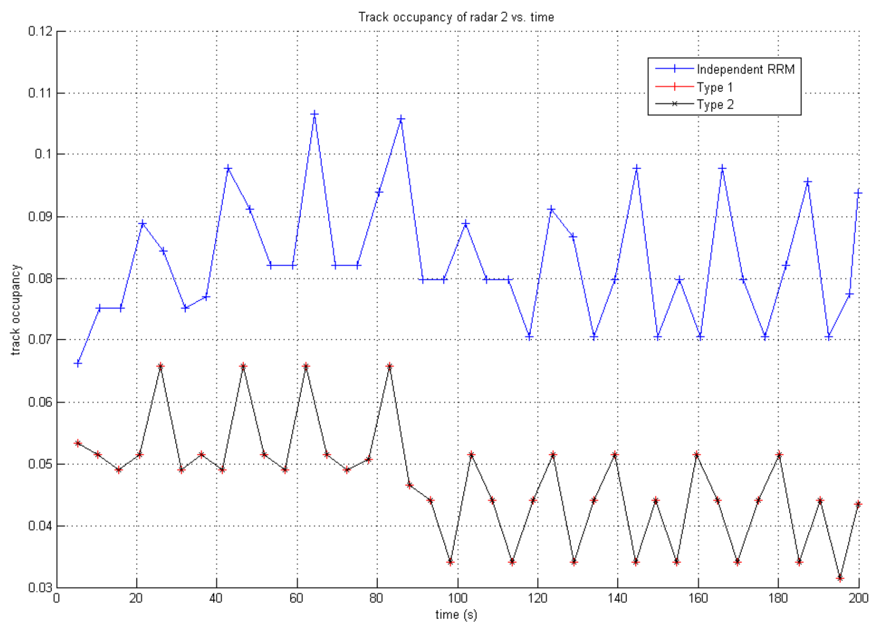

Figure 13: *Track occupancy of radar 2 vs. time, for independent RRM, type 1 and type 2, 12 target scenario*

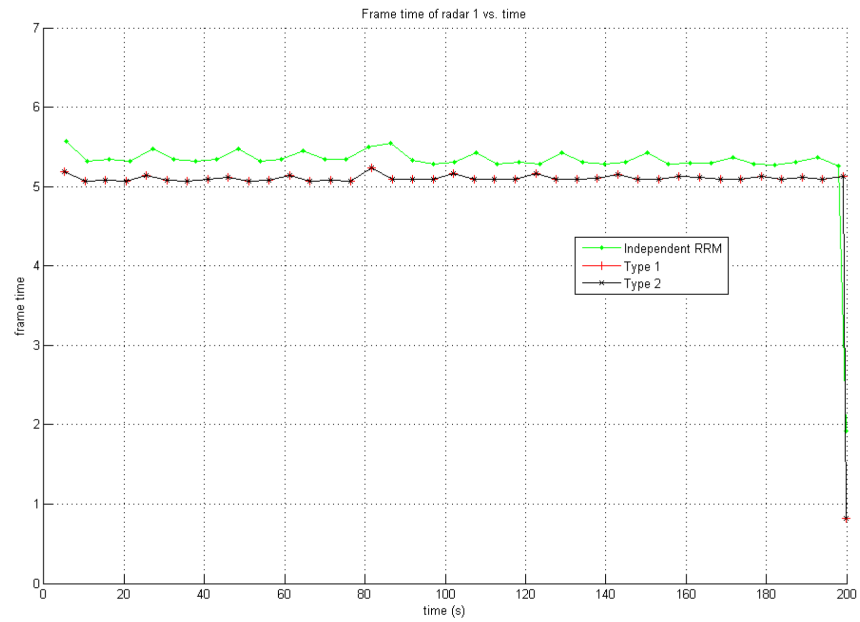

Figure 14: *Frame time of radar 1 vs. time, for independent RRM, type 1 and type 2, 12 target scenario*

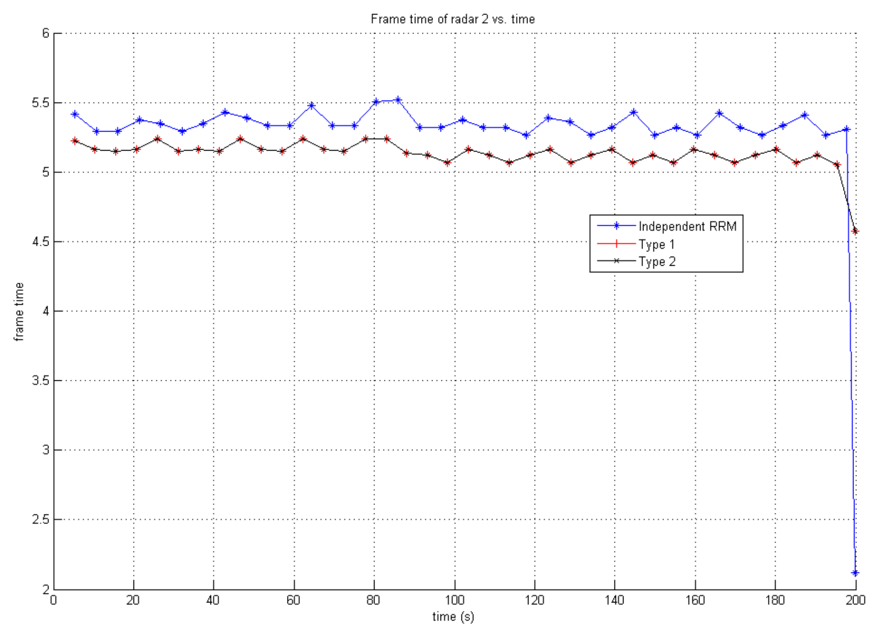

Figure 15: *Frame time of radar 2 vs. time, for independent RRM, type 1 and type 2, 12 target scenario*

4 Conclusion

This report summarized the work done under task 3 of contract W7714-125424/001/SV. Methods were implemented to assign tracks to specific radars based on range and fuzzy logic priority on both dynamic and permanent bases.

Performance assessments were performed to analyze the benefits of radar assignment (in networked radar scenarios) versus the non-assignment (multiple independent radars) implementation. Analysis of the effect of radar assignment on track completeness, frame times, and track occupancy showed that radar assignment reduced track occupancy and frame times with no significant negative impact on track completeness.

5 Recommendations for future updates

The current track assignment scheme assigns the radar based on minimum range or fuzzy logic priority on a permanent or dynamic basis. Additional and more complex track assignment methods could be investigated.

Targets located to the left (lower value x position) of the radar, when the radar boresight azimuth(s) is pointed in that direction are tracked more poorly than for the mirrored (in the x direction) scenario when using an offset radar position. This is probably due to an issue with the reference frame conversions. This should be further investigated.

The following hard coded variables should be moved into the GUI:

user_simulation_end_time
: Variable to allow user to hard set simulation end time, set to *realmax* to allow simulation to run normally.

target_figures_flag
: Set to 1 to create range, range rate, az, el, id, conf, and priority for every target during run time.

tgts_debug_list
: List of target to display track debug info during run time.

coordinated_management_type

max priority

min range than max priority, simulation permanent

min range than max priority, track update dynamic

N/A, independent radars

allow_pseudo_updates
: Allow centroided target returns to be passed to tracker 0 = off, 1 = on. Pseudo updates originate from centroided surveillance beam detections.

usecentroids
: Centroiding of detection beam detections 0 = off, 1 = on.

usefalsealarms
: 0 = false alarms off, 1 = false alarms on

usecosang
: 0 = angle off of boresight beamwidth effect off, 1 = angle off of boresight beamwidth effect on

usenewsigmas
0 = 18/02/09 sigma mod off, 1 = 18/02/09 sigma mod on

staticrandflag
0 = random numbers vary per simulation, 1 = random numbers are generated from a static seed for repeatable simulations

adaptive_time_balancing
1 = adaptive time balancing and number of pulses based on time balancing priority, 0 = non adaptive; no priority

update_rate_modifier
reduce update rate interval to 1/Nth

non_adaptive_track_occupancy_percent
Non adaptive track occupancy percentage

trk_beam_scan_limit
Track beam scan limits in Az and El (degrees).

two_level_priority_level_update_rate_assignment & *two_level_priority_level_update_rate_assignment_thres*
Track update rates based on a two level priority system. User can modify update rates for each priority level and the priority level threshold can also be user modified.

6 References

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This report summarizes the work done for DRDC Ottawa by C-CORE under task 3 of contract W7714-125424/001/SV. The work involved augmentation and testing of the radar resource management (RRM) capability of the Adaptive Multi-Function Radar simulator (Adapt_MFR). The capability was added to assign target tracks to specific radars, both permanently and dynamically, based on target range and/or fuzzy logic priority. The effect of this radar assignment on track occupancy and track completeness was investigated. There were definite tracking performance benefits seen due to the assignment of tracks to specific radars. Track occupancy and frame times were reduced with little change in track completeness.

Le présent rapport se veut un résumé des travaux effectués par C-CORE pour Recherche et développement pour la défense Canada (RDDC) Ottawa dans le cadre de la tâche 3 du contrat W7714-125424/001/SV. Les travaux visaient l'augmentation et la mise à l'essai de la capacité de gestion de ressources radar du simulateur radar multifonctions adaptatif (Multi-Function Radar MFR) (Adapt MRF). Nous avons ajouté cette capacité en vue d'associer des poursuites d'objectifs à des radars particuliers de façon permanente et dynamique, en fonction de la distance des objectifs ou des niveaux de priorité de logique floue (ou les deux). Nous avons évalué les répercussions de l'association de radars particuliers sur l'occupation de trajectoire et l'intégrité de poursuite et relevé des avantages clairs sur le plan du rendement. La réduction des durées de trame et d'occupation de trajectoire a très peu influé sur l'intégrité des poursuites..

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Adapt_MFR; multi-function radar simulator; tracker; IMM tracker; adaptive scheduler; fuzzy logic; distributed radars; radar resource management