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MiDLE Software User Manual

Version V6.0

Robert G. Szeker

Defence R&D Canada – Ottawa

Contract Report
DRDC Ottawa CR 2013-075
August 2013

Canada

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Abstract

This document is a software user manual for the MiDLE (Missile Detection in the Littoral Environment) software. MiDLE, developed by DRDC over the last ten years, is a flexible, high-fidelity model designed to predict the detection performance of naval radar systems operating against anti-ship missiles in a littoral environment. This version of the software was developed under contract to include a graphical user interface designed to make the software more accessible to non-expert users and some additional features. The main features of the software are described. Instructions for the installation and execution of the software are also provided.

Résumé

Le présent document est le guide d'utilisation du logiciel MiDLE (Missile Detection in the Littoral Environment [détection de missiles en région côtière]). Le MiDLE est un logiciel adaptatif à haute fidélité développé par RDDC au cours des dix dernières années. Ce modèle est conçu pour prévoir la capacité de systèmes radar navals de détecter des missiles antinavires en milieu littoral. Cette version du logiciel a été développée dans le cadre d'un contrat afin d'ajouter une interface graphique conçue pour faciliter l'accès au logiciel pour les utilisateurs non experts, ainsi que d'autres fonctions supplémentaires. Les fonctions principales du logiciel sont décrites dans le guide. Vous y trouverez également les instructions en vue de l'installation et l'exécution du logiciel.

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March 2013

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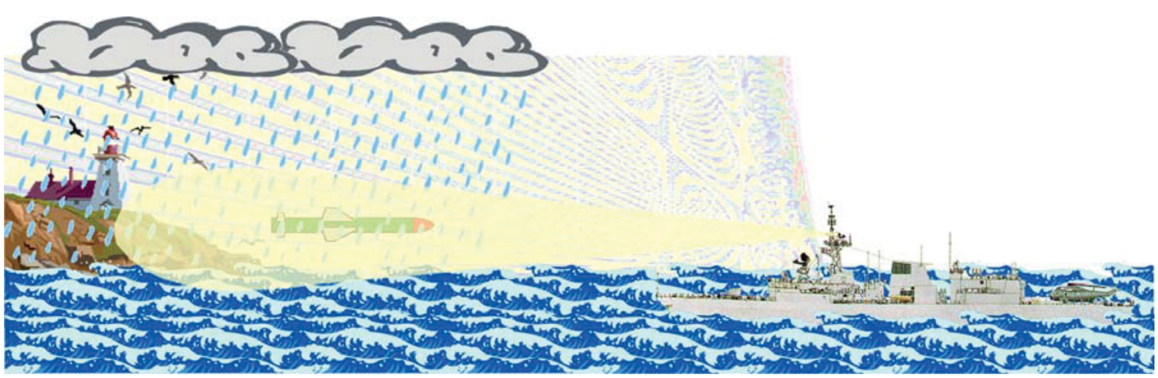

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1. Purpose

This document contains the Software User's Manual (SUM) for the installation and operation of the of the MiDLE (Missile Detection in the Littoral Environment) version 6.0 software. The purpose of this document is to provide sufficient level of information to a non-expert user to successfully install and operate the software on a MS Windows based computer.

2. Background

MiDLE is a flexible, high-fidelity model designed to predict the detection performance of naval radar systems operating against anti-ship missiles in a littoral environment. Particular emphasis is placed on aspects of coastal environments that can significantly affect detection performance, such as three-dimensional variation in atmospheric refractivity and wind velocity, two-dimensional variation in surface clutter properties, sharp clutter differences at the land-sea interface, etc. Particular emphasis is also placed on radar system characteristics that will significantly affect detection performance in coastal environments, such as clutter leakage through antenna side lobes and pulse compression range side lobes, receiver saturation, eclipsing, range-folded clutter returns, etc. MiDLE has the capability to provide detection performance predictions for scenarios in simple generic environments as well as for site-specific scenarios. In the case of a site-specific scenario, an accurate characterization of the environment is required as an input to the model.[1]

3. Main Features

The main features of MiDLE consist of the specifications for modelling of the environment, RF propagation and clutter, radar, target, jamming, signal processing, and for the specification of calculations methods and the generation of calculation results.

3.1 Environment Specification

- Refractivity structure specified by a single height profile or by three-dimensional data in the Hazard Prediction Assessment Capability Format (HPAC) produced by Environment Canada's Global Environment Multiscale (GEM) numerical weather prediction model,
- Surface wind velocity specified by a single vector or as a two-dimensional field derived from wave model data or HPAC data,
- Wave height specified as a single value or as a two-dimensional field derived from wave model data,
- Swell direction specified as a single value or as a two-dimensional field derived from wave model data,

[1] Sections 2. to 3.8 adapted from *Missile Detection in the Littoral Environment (MiDLE)*, Alan Thomson, RAST, DRDC Ottawa, April 11, 2011.

- Elevated terrain based on Canadian Digital Elevation Data (CDED) or Digital Terrain Elevation Data (DTED),
- Terrain land cover type specified as a single value or as a function of space based on land use database,
- Precipitation structure specified by a single rain rate value, a single height profile (stratiform precipitation), or by three-dimensional weather radar data.

3.2 Propagation and Clutter Modelling

- RF propagation using parabolic equation methods.
- Sea and lake clutter:
    - GIT reflectivity,
    - Gaussian Doppler spectrum,
    - K-distribution statistics (amplitude).
- Land clutter:
    - Reflectivity from tables in Billingsley [2],
    - Exponential AC Doppler spectrum plus DC component,
    - Compound Weibull/exponential statistics (power).
- Weather clutter:
    - Three-dimensional reflectivity factor field derived from defined precipitation structure,
    - Doppler spectrum based on raindrop size distribution, three-dimensional wind field derived from HPAC data, and turbulence,
    - Rayleigh statistics (amplitude).

3.3 Radar System Modelling

- Electronically or mechanically (or hybrid) scanning antenna,
    - sin x / x , Gaussian, cosecant-squared, or user-defined gain patterns,
    - Clutter leakage through antenna gain pattern side lobes,
    - Antenna gain pattern side lobe suppression.
- Multiple burst transmission (electronic scan) varying frequency, pulse repetition frequency (PRF), and number of pulses per burst.
- Linear frequency modulation or phase coded pulse compression including:

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[2] Billingsley, J. B. (2002). Low-angle radar land clutter: Measurements and empirical models. William Andrew Publishing, Inc., p 703.

  - Range side lobes,
  - Receiver frequency weighting,
  - Eclipsing effects,
  - Doppler effects.
- Range-folded clutter, with and without fill pulses,
- Sensitivity time control,
- Finite dynamic range (magnitude clipping, phase preserved).

3.4 *Target Modelling*

- Constant or aspect dependent radar cross section.
- Missile:
  - g-force constrained three-dimensional trajectory,
  - Tangential acceleration,
  - Terminal manoeuvres,
  - Swerling statistics.
- Projectile:
  - Ballistic trajectory,
  - Swerling statistics.

3.5 *Jamming Modelling*

- Stand-off noise barrage.

3.6 *Signal Processing*

- Envelope or square-law detector,
- MTI,
- FFT (with or without time domain windowing), non-coherent integration, or coherent integration processing,
- Binary integration (M of N detection).

3.7 *Calculation Method*

- 12900+ lines of IDL code,
- Modified Advanced Propagation Model (APM, SPAWAR):
  - Spectral masking to determine propagation factor at the surface,
  - Extraction of grazing angles,
  - Binary output files,

    - Parallel processing employing multiple CPUs.
  - I,Q level modelling,
  - Monte Carlo evaluation of detection thresholds and probabilities:
    - Extreme value theory for low probabilities of false alarm.

3.8 Calculation Results

- Probability of detection at locations of missile illumination:
  - For each burst,
  - For each dwell.
- Various intermediate quantities such as propagation factors, clutter powers, target powers, I and Q data, etc.

4. Software Components

MiDLE Version V6.0 consists of the following IDL procedure source files, organized into directories as shown in the next sections.

4.1 Source Files

Directory	Component filename	Date modified	Size (KB)
GUI	calc_tick_value.pro	15/12/2011	2
	calc_trajectory_data.pro	13/08/2012	1
	check_files.pro	05/03/2013	7
	common_block.pro	21/02/2013	3
	common_defs.pro	24/03/2013	13
	ConParamsControl.pro	20/02/2013	86
	ContourColorsSelection.pro	08/03/2013	18
	DetectionDisplay.pro	06/02/2013	9
	DiagnosticsDisplay.pro	10/02/2013	41
	EnvParamsControl.pro	24/03/2013	208
	EP_event_handlers.pro	19/12/2012	5
	EP_menu_handlers.pro	10/02/2013	51
	EP_param_handlers.pro	25/03/2013	90
	EP_plot_handlers.pro	10/02/2013	25
	ExpertParamsControl.pro	25/03/2013	40
	GenerateMF4Plot.pro	20/02/2013	72
	GenerateMPPlot.pro	10/03/2013	60
	GeneratePDPlot.pro	20/02/2013	71
	GeneratePRMPlot.pro	20/02/2013	83
	GeneratePSCPlot.pro	20/02/2013	109
	GenerateSC4Plot.pro	20/02/2013	78
	init_MiDLE.pro	10/03/2013	24
	JammerParamsControl.pro	25/03/2013	45

Directory	Component filename	Date modified	Size (KB)
GUI	KML_generate.pro	10/02/2013	3
	LC_colortable2.pro	18/02/2013	28
	LC_lookupindex.pro	18/02/2013	4
	line_legend.pro	19/12/2012	6
	MiDLE_GUI_main.pro	10/03/2013	103
	MissileParamsControl.pro	05/03/2013	62
	PPI_DCHT_plot.pro	28/01/2013	13
	PPI_REFF_plot.pro	10/03/2013	25
	PPI_SCP_plot.pro	02/01/2013	15
	PPI_SREF_plot.pro	10/03/2013	15
	PPI_SWDR_plot.pro	20/02/2013	18
	PPI_WCP_plot.pro	28/01/2013	15
	PPI_WVDR_plot.pro	11/03/2013	20
	PPI_WVEL_plot.pro	20/02/2013	19
	PPI_WVHT_plot.pro	28/01/2013	11
	process_dem.pro	16/03/2013	14
	process_dtd.pro	04/01/2013	28
	process_gnd_elevation.pro	30/11/2010	20
	process_shapefile3.pro	17/02/2013	9
	ProcessAntPattern.pro	14/12/2011	5
	ProgramExecControl.pro	25/03/2013	84
	ProjectileParamsControl.pro	05/03/2013	36
	RadParamsControl.pro	23/02/2013	161
	read_all_CDED.pro	16/03/2013	23
	read_all_LANDC.pro	16/03/2013	24
	reset_MiDLE.pro	05/03/2013	15
	SignalParamsControl.pro	24/03/2013	21
	threataxis_loc.pro	05/10/2011	2
	vship_mesh_process.pro	14/12/2011	7
	zoom_advance.pro	13/12/2012	2
MAIN	AngleScale.pro	11/02/2012	6
	AngleScaleJammer.pro	26/08/2011	4
	APM_readOut.pro	26/07/2010	5
	atten_0D.pro	08/08/2012	5
	atten_1D.pro	08/08/2012	6
	atten_3D.pro	08/08/2012	6
	Ballistic.pro	07/02/2013	7
	BBRef.pro	29/08/2011	5
	betavar.pro	26/08/2011	3
	bpfa.pro	06/09/2011	2
	call_APM_DLL_F2surf.pro	25/03/2013	14
	call_APM_DLL_F2surf_StandardOmni.pro	25/03/2013	12
	call_APM_DLL_jammer.pro	25/03/2013	14
	call_APM_DLL_target_graze.pro	25/03/2013	14

Directory	Component filename	Date modified	Size (KB)
MAIN	call_APM_F2surf_StandardOmni.pro	03/08/2012	12
	cc.pro	26/08/2011	2
	CircleSmooth.pro	25/03/2013	36
	ClutterRangeWeights_SM.pro	06/03/2013	16
	corkscrew2.pro	24/09/2011	2
	define.pro	04/03/2013	55
	DefineAntennaPattern.pro	20/12/2011	27
	DefineJammerAntennaPattern.pro	26/08/2011	6
	DefineReflectivity_mod.pro	06/03/2013	36
	DefineScan.pro	09/02/2013	10
	DefineTerrain.pro	22/03/2013	38
	DefineTerrain_jammer.pro	22/03/2013	35
	DefineWaves.pro	24/01/2012	19
	DefineWbShapeParameter.pro	28/08/2011	20
	DefineZ.pro	07/02/2013	14
	dwellPd.pro	28/08/2011	3
	EclipseWeights.pro	03/10/2011	2
	erlang.pro	28/08/2011	1
	FullScanIQ_SM.pro	06/03/2013	33
	FUNC_RAYBINLUT.pro	28/08/2011	2
	gammavar.pro	28/08/2011	3
	gasattenrate.pro	28/08/2011	3
	genchivar.pro	28/08/2011	2
	jamF4.pro	09/08/2012	7
	jammer.pro	14/08/2012	8
	KShapeParameter.pro	28/08/2011	2
	landspec_noTruncation.pro	28/08/2011	3
	LimitMissile.pro	05/03/2013	8
	LimitWeatherClutter.pro	05/03/2013	4
	LKB002_stability_m.pro	28/01/2012	2
	LKB002_stability_t.pro	28/01/2012	2
	ll_arc_distance_array.pro	28/08/2011	4
	loop_split.pro	18/10/2011	6
	loop_split_SM.pro	06/03/2013	6
	MakeFiles_APM_F2surf.pro	02/08/2012	14
	MakeFiles_APM_jammer.pro	28/08/2011	15
	MakeFiles_APM_missile_graze.pro	02/08/2012	15
	map_2points_array.pro	28/08/2011	9
	map_continents_modified.pro	28/08/2011	20
	mergeLWKD.pro	24/08/2012	13
	mgit.pro	07/10/2011	4
	MiDLE.pro	25/03/2013	65
	missileIQ_SM.pro	25/03/2013	38
	MissileRCS.pro	07/02/2013	5
	MissileStat.pro	12/10/2011	10

Directory	Component filename	Date modified	Size (KB)
MAIN	MissileStat_IQ.pro	12/10/2011	9
	MissileTrajectoryE.pro	23/03/2013	13
	MissileTrajectoryM.pro	23/03/2013	11
	mkrand.pro	30/08/2011	2
	mWbrand.pro	30/08/2011	2
	noise.pro	06/03/2013	2
	NSWC_blend.pro	24/08/2012	22
	propagation_SM.pro	06/03/2013	35
	query_grib_file.pro	24/08/2012	5
	query_grib_record.pro	24/08/2012	4
	RangeWeightingLFM.pro	18/11/2011	5
	RangeWeightingMseq.pro	18/11/2011	5
	read_grib.pro	24/08/2012	31
	read_grib_record.pro	24/08/2012	3
	readHPAC_SM.pro	06/03/2013	51
	readHPAC_jammer_SM.pro	06/03/2013	49
	scpow_SM.pro	06/03/2013	77
	scpow_IQ_SM.pro	06/03/2013	68
	seaspec_noTruncation.pro	30/08/2011	3
	SetHeightLWKD.pro	26/09/2011	2
	sidelobeLevel.pro	30/08/2011	2
	singleM.pro	25/01/2012	6
	splitTrajectory.pro	30/07/2012	9
	sppar.pro	30/08/2011	5
	STCclutter.pro	08/08/2012	2
	STCmissile.pro	30/08/2011	2
	tatten_0D.pro	07/08/2012	5
	tatten_1D.pro	08/08/2012	6
	tatten_3D.pro	08/08/2012	6
	ThreshProb_SM.pro	22/03/2013	48
	Trajectory_files.pro	25/03/2013	10
	truncate_norm.pro	30/08/2011	2
	URP_META_READER_MiDLE.pro	10/03/2013	14
	WbShapeParameter.pro	12/10/2011	4
	wcpow_0D_SM.pro	25/03/2013	25
	wcpow_1D_SM.pro	25/03/2013	31
	wcpow_3D_SM.pro	25/03/2013	42
	WeatherSpec.pro	07/10/2011	11
	weave3.pro	24/09/2011	4
	Weibull.pro	30/08/2011	2
	WindShear.pro	27/01/2013	49
	WindShear_3D_SM.pro	06/03/2013	57

4.2 *Data and Executable Files*

MiDLE uses input from numerous data files during execution. It also calls several executable and library files. These files must reside in a directory structure as shown below. The files must be copied from the data CD of the MiDLE distribution. This is explained later in detail in the Software Installation and Configuration section.

< ROOT DIRECTORY >
- APM
- DATA
- ELDATA
- GRIB
- HELP
- IMAGES
- LC_GEOBASE
- LCDATA
- LWKD
- OUTPUT

4.2.1 APM directory

The APM directory contains the APM dynamically linked library (DLL) and APM executable files. This directory typically contain several versions of the APM program, for example *SBAPM2305_x64.dll*, *SBAPM2305.exe*, etc. As the APM DLL was originally built from FORTRAN code, supporting files such as *DFFORT.DLL* are also included. The APM directory must contain a subdirectory named 'OUTPUT' as this is where the propagation factor and other calculation results are placed. This directory will normally contain files of the type **.dat*.

4.2.2 DATA directory

This directory contains miscellaneous data files used by MiDLE. These include object files for 3D mesh surfaces, meteorological data files, missile radar cross-section data, KML file template, etc. During execution MiDLE may also store intermediate results of terrain elevation and land cover data in this directory.

4.2.3 ELDATA directory

This directory contains terrain elevation data. The files contained in this directory are of the type **.el1* or **.el2*, where the number specifies the corresponding DTED or CDED level. When 'raw' DTED or CDED files are copied into this directory, MiDLE can convert them into **.el1* or **.el2* files which are in a format that can be more quickly processed. Level 1 files use a 1201x1201 grid size whereas level 2 files use a 3601x3601 grid. The user is given the option to keep or delete the original files after processing is complete.

4.2.4 GRIB directory

This directory as a minimum contains the *wgrib.exe* program and the *cygwin1.dll* file. The executable is spawned by MiDLE to process wave data grib files.

4.2.5 HELP directory

This directory contains several text files that are read and displayed by MiDLE when the user clicks on the different items contained in the 'Help' pull-down menu.

4.2.6 IMAGES directory

This directory contains the various image files used by the program.

4.2.7 LC_GEOBASE directory

This directory is used as a convenient depository of 'raw' land cover files obtained from Natural Resources Canada GeoBase website or from other sources. When these files are copied and pasted into the LCDATA directory, they can be optionally processed by MiDLE .

Land cover data files are normally 'shapefile' set consisting of 3 parts; the shapefile itself *(*.shp* file), the vector file (**.shx*) and the database file (**.dbf*). These files must all exist else MiDLE will issue a warning and terminate processing. The projection file (**.prj*) is not required.

4.2.8 LCDATA directory

This directory contains the land cover files used by MiDLE. When land cover shapefiles are placed into this directory, MiDLE will detect them and ask for permission to process them. Processing normally takes only a few seconds and an auxiliary pop-up window displays the results. MiDLE will process all shapefiles in this directory and optionally delete the original files when processing is complete. The output files generated are of a similar in form to the terrain elevation data files and are of the type **.lc2*. As with terrain elevation data files, the number indicates the level, where a 1 corresponds to a 1201x1201 grid and a 2 corresponds to a higher resolution 3601x3601 grid.

4.2.9 LWKD directory

This directory contains the LWKD executable file *LWKD.exe* and several auxiliary files. LWKD is spawned by MiDLE to calculate the low-level refractivity profile. As the LWKD processing is parallelized, the master process will create additional subdirectories within this directory, one for each slave process. Each subdirectory will contain a copy of *LWKD.exe* and serves as a holder for the temporary files generated.

4.2.10 OUTPUT directory

This directory contains all output files and intermediate files generated by MiDLE. Contrary to its name, it also contains most of the input files used by the program. Hence its purpose is both for file input and output during execution.

Several files exist in this directory of the form **_default.dat* containing default data. These files should never be deleted. The purpose of these default files is so that a user can run MiDLE immediately after it is launched, without having to reconfigure any controls. The program will never overwrite any of these default files and will issue a warning if the user attempts to do so.

1) *BallisticPath_default.dat*
2) *ClutterRangeWeights_default.dat*
3) *dbz_default.dat*
4) *ExtractedSurfaceF4_default.dat*

5) *Jammer_default.dat*
6) *Lec_default.dat*
7) *MissileF4th_default.dat*
8) *MissilePath_default.dat*
9) *MissileRangeWeights_default.dat*
10) *SCAzBeamshapeLossData_default.dat*
11) *Sum_default.dat*
12) *Terrain_default.dat*
13) *ThreshProb_default.dat*
14) *WCAzBeamshapeLossData_default.dat*
15) *WCElBeamshapeLossData_default.dat*
16) *WeatherClutter_0D_default.dat*
17) *WeatherClutter_1D_default.dat*
18) *WeatherClutter_3D_default.dat*

Each time MiDLE is launched, it creates the following files in the OUTPUT directory:

- *ProgExecCntlParams.sav* – this file contains the default program execution global variables that are used to initialize the Program Execution Control Panel (e.g. gNoPrecipitation, gOldMissilePath, etc.) as well as the default file names listed above. This file is used by MiDLE to restore all settings to the startup state when reset is pressed in the Program Execution Control panel.

- *MiDLE_RuntimeInfo.sav* – this file is created in the IDL development environment and holds the program creation date, the operating system descriptor, the system architecture and the IDL release version number. This file is restored in the runtime (RT) environment and its contents can be viewed using the *Help->About* pull-down menu.

- *ProgDefaultParams.spf* – this file is created by MiDLE at program launch and stores all parameters used. Since the total number of parameters is too large to fit into a single IDL savefile, the **.spf* file actually contains pointers to two savefiles; *ProgDefaultParams_1.sav* and *ProgDefaultParams_2.sav*. The file is used to initialize the program to its startup state when *Program->Reset* is pressed.

- *ProgDefaultFiles.sav* – this file contains the default file name global values 1 to 18 listed above. It is used to initialize MiDLE to its startup state when *Program->Reset* is pressed.

As MiDLE is highly parallelized, the program routinely creates files intended for slave processes during its execution. These files are of the type:

1) **_loop_slave.pro* - procedure source file containing IDL code
2) **_loop_slave.sav* - executable save file
3) **_loop.dat* - data file

The 'procedure' file contains code intended for slave processes to execute and is only created in the IDL development environment. The file is generated by calling the *loop_split_SM.pro* procedure. This procedure compiles the source file, along with other IDL functions required for its execution into an executable 'save' file. The 'data' file holds all data that slave process requires during execution. In the RT environment, the executable file must exist in the OUTPUT directory.

If the diagnostic mode is selected, MiDLE creates the *diagnostic.log* file in this directory. The file is appended while the program is in diagnostic mode until it reaches a limit of about 150-Kbytes. At this point the user is asked if the log file should be deleted. The log file can be opened or deleted by the user at any point as MiDLE will re-create it if it does not exist.

In addition to the files mentioned above, MiDLE will place all files created by the user during execution. These include missile trajectory waypoints, intermediate data files, **.kml* or **.kmz* files for importing into Google Earth, and others. Care should be exercised by the user when deleting or modifying files in this directory.

5. Software Installation and Configuration

5.1 Development Environment

For installation into the IDL development environment, the MiDLE V6.0 software requires that IDL version 8.1 or greater is installed and licensed. The computer should be running the 64-bit version of MS Windows Vista or MS Windows 7. Other operating systems have not been tested.

Create a root directory and copy the contents of CD #1 to it, then copy the contents of the data CDs. For example, if the root directory created is C:/MiDLE/MiDLEV6/V6/ the directory structure should be as shown below:

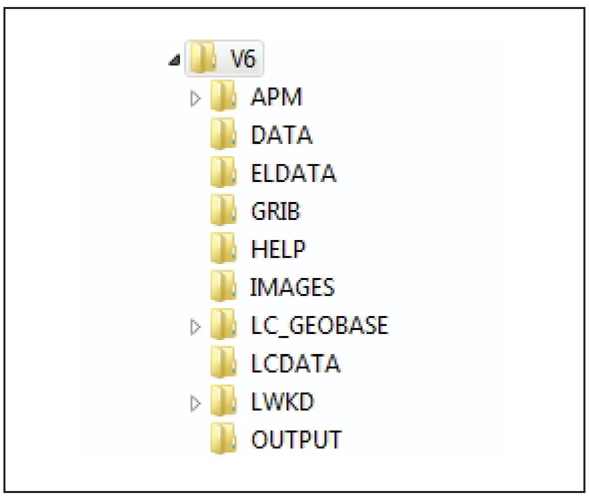


Figure 1: MiDLE Root Directory Structure

The files contained in each directory shown in Figure 1 is explained in Section 4.2.

If MiDLE source files are also included in software the distribution, it is recommended that a separate workspace directory is created and the files copied to the appropriate folders:

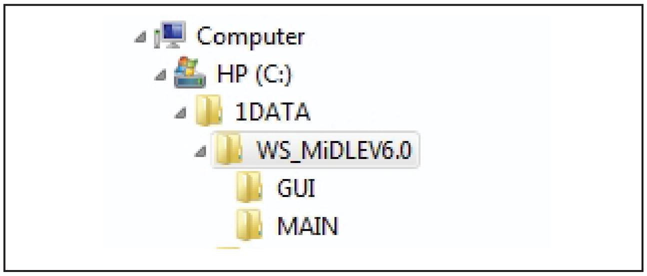


Figure 2: MiDLE Workspace Directory Structure

During execution, MiDLE calls the Advanced Propagation Model (APM) dynamically linked library (DLL) module. When the APM DLL module executes, it requires that a file called *DFORRT.DLL* is found. The *DFORRT.DLL* file is located in the APM subdirectory and the 'Path' environment variable should include it.

For example if the root directory structure is set up as shown in Figure 1, using the Control Panel, go to Environment Variables and add the path as shown in Figure 3:

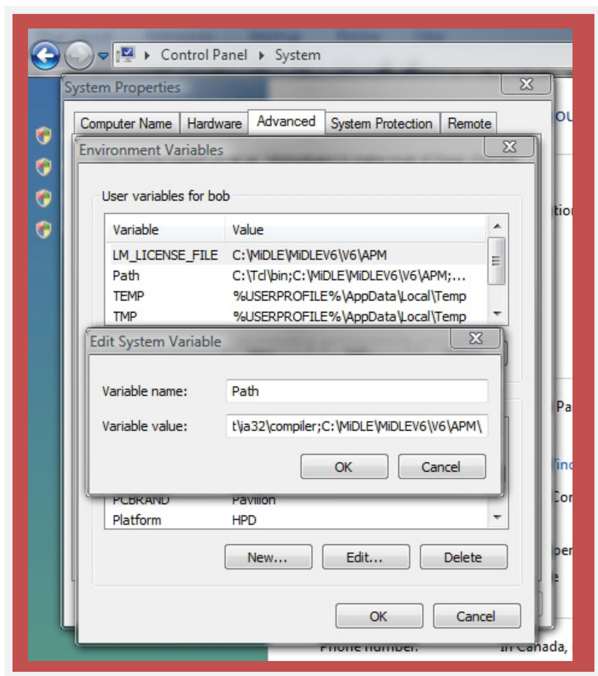


Figure 3: Setting the Path Environment Variable for DFORRT.DLL

The IDL project should be built as follows. Start IDL and create a new project, setting the workspace to the directory defined previously. Note that in Figure 4 MiDLE_V6.1 is used as the project name is completely arbitrary.

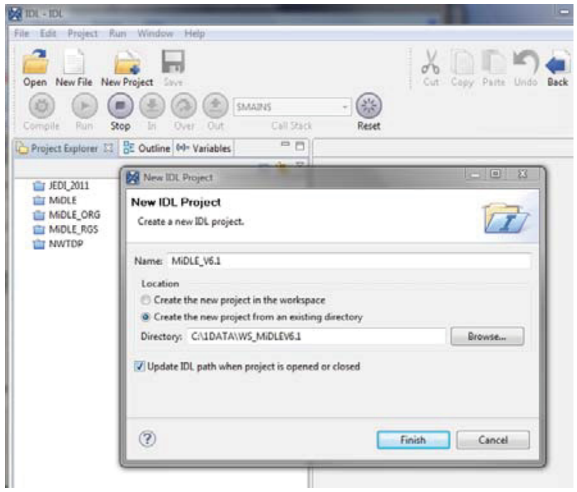


Figure 4: Creating the MiDLE V6.0 Project

The project created should show the GUI and MAIN folders containing the MiDLE source files.

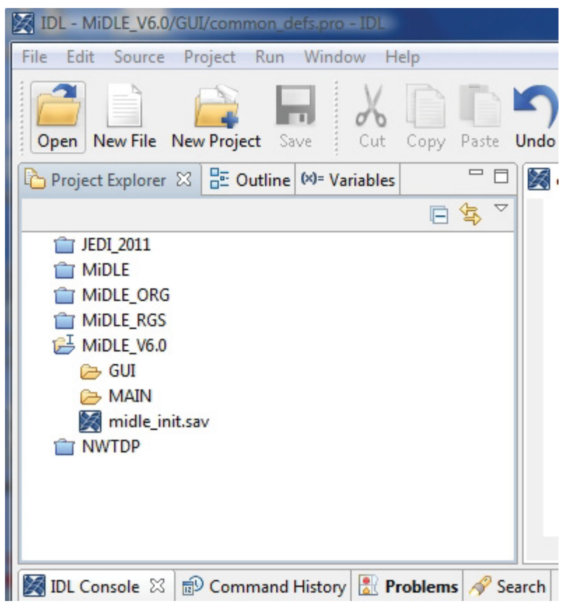


Figure 5: The Completed MiDLE V6.0 Project

Expanding the GUI and MAIN folders shows the IDL procedures included in the project. A few preliminary steps need to be completed before the MiDLE_V6.0 project can be built and executed. Open the GUI folder and click on the *common_defs.pro* file. Modify the gDirectory and gWorkspace global variables as shown in Figure 6.

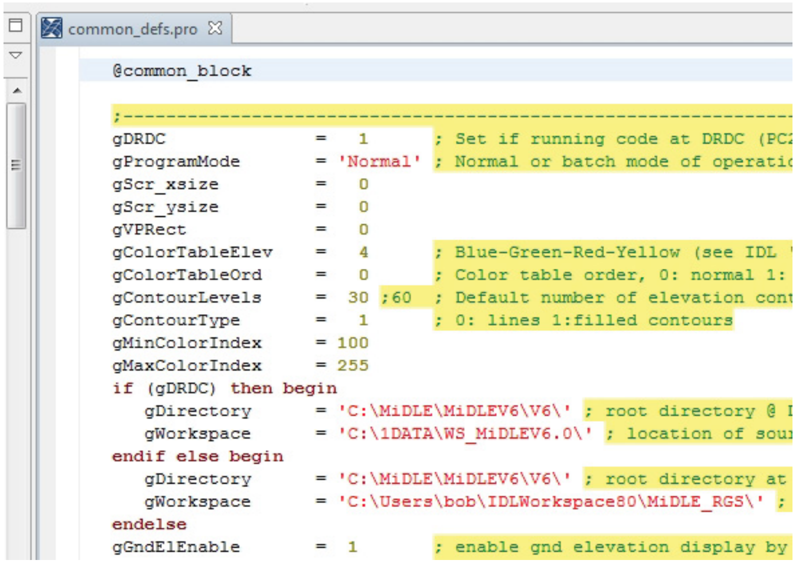


Figure 6: Modifying the gDirectory and gWorkspace Globals

The gDRDC global variable should also be set as required to switch to the correct configuration. After these changes are made, *common_defs.pro* should be saved and closed.

The MiDLE distribution may contain files in the GUI and MAIN folder that were included but are not required to build the project. Right click on these files and select 'Toggle Exclude From Build'. The following Figure 6 shows this for the *common_block.pro* file which should exist in the project but should always be excluded from the build. A small red square indicates that the file is excluded.

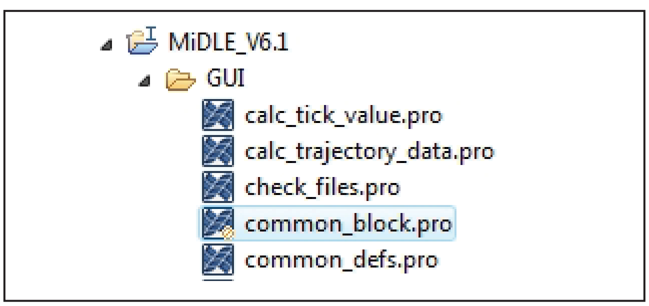


Figure 7: Excluding Files from the Project Build

The following list shows the files that may have been included in the MiDLE software distribution but should be excluded from the project when it is built. (Some of these files can eventually be deleted from the workspace but have been kept for testing and debugging purposes).

GUI

- *common_block.pro* - must exist in folder but always excluded from build
- *LC_colortable.pro*
- *LC_convert.pro*
- *vship_process.pro*

MAIN

- *ClutterRangeWeights.pro*
- *defineReflectivity.pro*
- *FineTuneScenario03Trajectory.pro*
- *FullScanIQ.pro*
- *missileIQ.pro*
- *MissileTrajectoryE_OLD.pro*
- *noise_OLD.pro*
- *propagation_OLD.pro*
- *propagation.pro*
- *readHPAC.pro*
- *readHPAC_jammer.pro*
- *scpow.pro*
- *scpow_IQ.pro*
- *thp_loop_slave.pro*
- *ThreshProb.pro*
- *wcpow_0D.pro*
- *wcpow_3D.pro*

As a final step before building the project, right click on the MIDLE_V6.0 folder and select Properties. In the IDL Build Properties pane check and modify the following boxes:

- Use default IDL project build process
  - Restore save files from referenced projects
  - Compile Project files
  - Execute RESOLVE_ALL
  - Execute IDL Command after compiling project files:
    .COMPILE *svdfit, svdfunct, idlgrlegend__define, idlgrcolorbar__define*
  - Create a save file
    .\midle_init.sav

The above step ensures that the *midle_init.sav* file will be generated each time the project is built and will include all of the required features needed for execution in the RT environment. Alternatively, the *midle_init.sav* file can be built at the command line after the project is compiled as:

```
IDL > CD, C:\1DATA\WS_MiDLEV6.0
IDL > .COMPILE svdfit, svdfunct, idlgrlegend__define, idlgrcolorbar__define
IDL > SAVE, /ROUTINES, FILENAME = 'midle_init.sav'
```

The MiDLE_V6.0 project is now ready to be built. Right click on the MiDLE_V6.0 folder in the Project Explorer pane and select 'Build Project'. The IDL console will display messages as each source file and the required IDL functions are compiled. At this point MiDLE is ready to run in the development environment.

5.2 Runtime Environment

In the runtime (RT) environment, MiDLE is executed without an IDL license using the IDL Virtual Machine Application supplied on the MiDLE distribution CD. This application executes the *midle_init.sav* file. The IDL 'save' file contains the compiled MiDLE source and several IDL functions necessary for program execution.

Copy the runtime files from the distribution CD to your computer. The directory structure should be as shown in the following example:

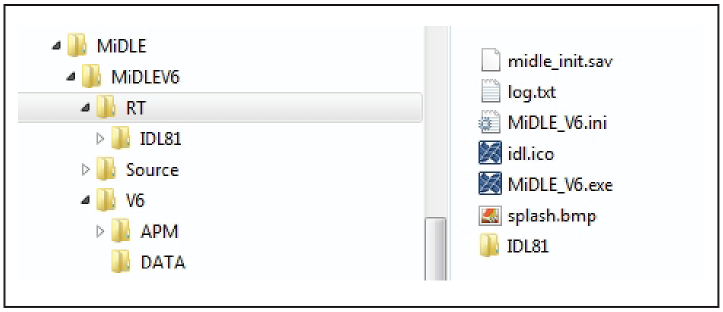
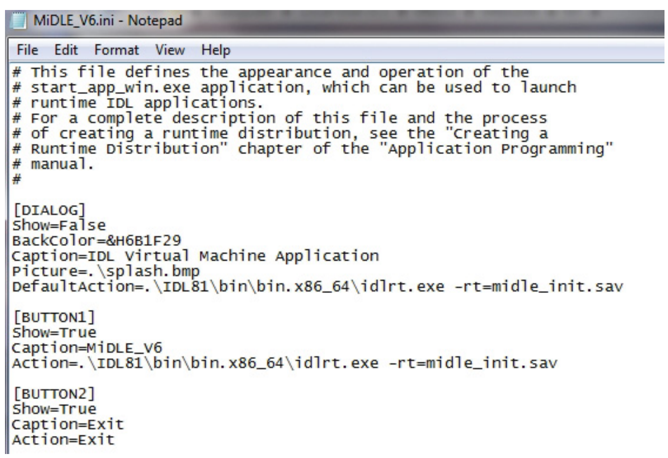


Figure 8: Runtime Directory Structure

In the example of Figure 8, the runtime files are located in the C:\MiDLE\MiDLEV6\RT directory. Edit the *MiDLE_V6.ini* initialization file as shown in the following figure, ensuring that the 'DefaultAction' and 'Action' parameters point to the correct savefile. For example, if the MiDLE savefile is *midle_init.sav,* set these parameters as shown in Figure 9.

When this step is complete, a convenient shortcut to *MiDLE_V6.exe* can be created on the desktop to execute the program.



MiDLE_V6.ini - Notepad

File Edit Format View Help

```
# This file defines the appearance and operation of the
# start_app_win.exe application, which can be used to launch
# runtime IDL applications.
# For a complete description of this file and the process
# of creating a runtime distribution, see the "Creating a
# Runtime Distribution" chapter of the "Application Programming"
# manual.
#

[DIALOG]
Show=False
BackColor=&H6B1F29
Caption=IDL Virtual Machine Application
Picture=.\splash.bmp
DefaultAction=.\IDL81\bin\bin.x86_64\idlrt.exe -rt=midle_init.sav

[BUTTON1]
Show=True
Caption=MiDLE_V6
Action=.\IDL81\bin\bin.x86_64\idlrt.exe -rt=midle_init.sav

[BUTTON2]
Show=True
Caption=Exit
Action=Exit
```

Figure 9: Editing the MiDLE Initialization File

The executable and data files required by MiDLE (e.g. APM DLL, LWKD.exe, terrain elevation data, land cover data, etc.) must be installed on the computer exactly as described in Section 4.2. The files must reside in a directory structure as shown in Figure 1.

To execute MiDLE, double click on the MiDLE_V6.exe or start the program for the desktop shortcut. The Virtual Machine displays the following IDL splash screen:

Figure 10: IDL Virtual Machine Splash Screen

6. Program Execution

6.1 Quick Starting the MiDLE GUI

The program entry point for MiDLE is the *MiDLE_init* procedure contained in the *MiDLE_GUI_main.pro* file. The program can be started from the IDL DE command line as:

IDL > midle_init

or from the RT Virtual Machine application by clicking on the splash screen shown in Figure 10.

MiDLE takes a few seconds to initialize and displays the view shown in Figure 11. A proprietary message is displayed briefly and removed as soon as the cursor enters the main view area. The area at the left bottom half of the screen is for status messages below which the following information is displayed:

- Radar longitude,
- Radar latitude,
- Threat type,
- Threat longitude,
- Threat latitude.

The area on the right bottom half of the screen is where the program displays colour bars for the various plot quantities generated.

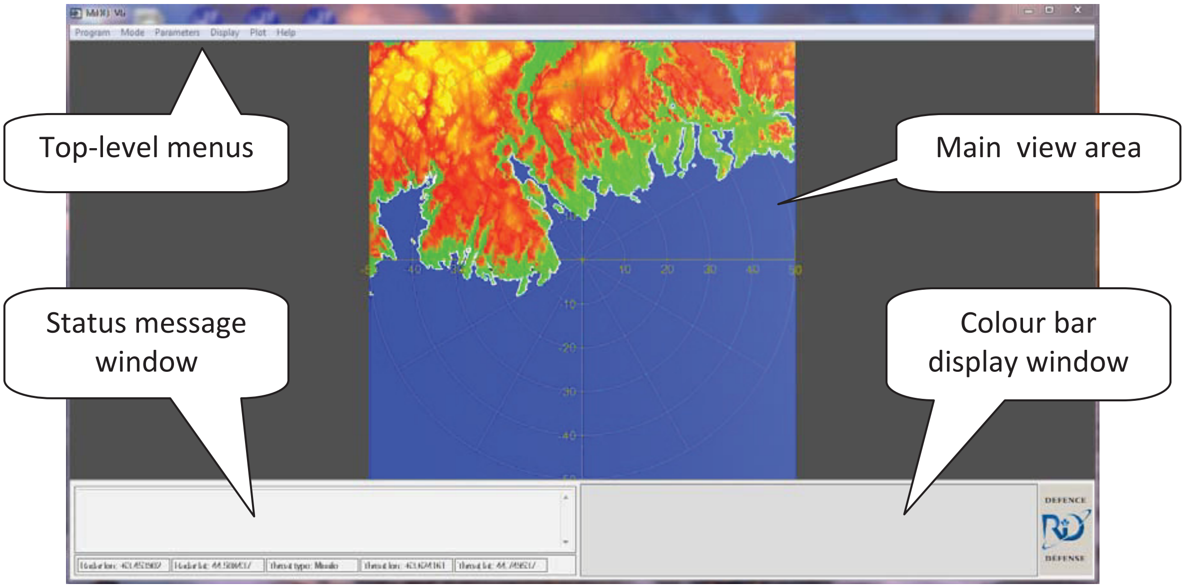


Figure 11: The MiDLE GUI

MiDLE contains default configuration files so that the program can be executed immediately by a non-expert user without the need to set any controls. This default configuration defines a scenario in which the radar platform is located just off the Nova Scotia coast at the entrance to the Halifax harbour. The threat (missile) launch position is located approximately 30-km to the north.

To run MiDLE using the default configuration, click on the top-level 'Program' menu and select 'Start'. Several messages are displayed in the status window as MiDLE executes. The missile flight path becomes visible shortly after the program starts. The missile executes a number of turns along its trajectory.

The MiDLE GUI uses 3D object graphics. The main display area can be manipulated in several ways – it can be zoomed, rotated and translated to optimize the view. A brief explanation of how to manipulate the image is given in the *Help->Keyboard controls* menu. Figure 12 below shows a close up view of the resulting image.

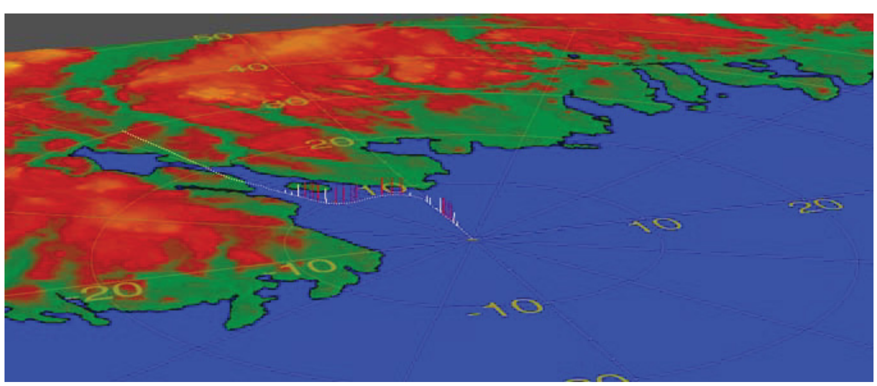


Figure 12: View of the MiDLE Display

The image generated by MiDLE shows the missile's trajectory as a dotted white line. On the trajectory line there are several white and red lines indicating the dwell probabilities of detection at various ranges. Red lines represent locations where the probability of detection (PD) exceeds 90%, for white lines the PD is less than 90% but greater than zero. The probability threshold for detection can be set in the Control Parameters Control panel.

The visual display of PD is meant to give only a qualitative representation. MiDLE can also generate quantitative results of the PD in the form of probability of detection vs. range and probability of detection vs. time plots as shown in later sections.

At this point the user is encouraged to exercise the mouse and numerical keypad controls in manipulating (e.g. zooming in and out, translating and rotating) the view. Advanced display controls are explained in other sections of this document.

6.2 GUI Controls Overview

MiDLE has a wide range of GUI controls for specifying program execution, display, control, radar, environment, signal processing, missile, projectile, jammer, signal processing and expert parameters. These GUI controls are available using the top-level menus and are described in the following sections.

6.2.1 The Program Menu

The program menu contains the following selections:

- Exit
- Reset
- Control
- Start

The 'Start' control should already be familiar – it is used to execute MiDLE. As we have seen in Section 6.1, it can be used to launch MiDLE using its default scenario without having to change any controls. When the program parameters are configured for a new scenario, the 'Start' control is used to commence execution.

The 'Reset' control re-initializes MiDLE to its starting configuration and loads the default scenario. This control is useful if the user gets stuck at any point and wants to reset the program without completely exiting. To exit MiDLE altogether, click on the 'Exit' button. This destroys all internal objects and pointers used by the program and closes the program in an orderly manner.

The 'Control' button opens the Program Execution Control panel as shown in Figure 13. This control panel is used to instruct MiDLE which calculations to perform during its execution.

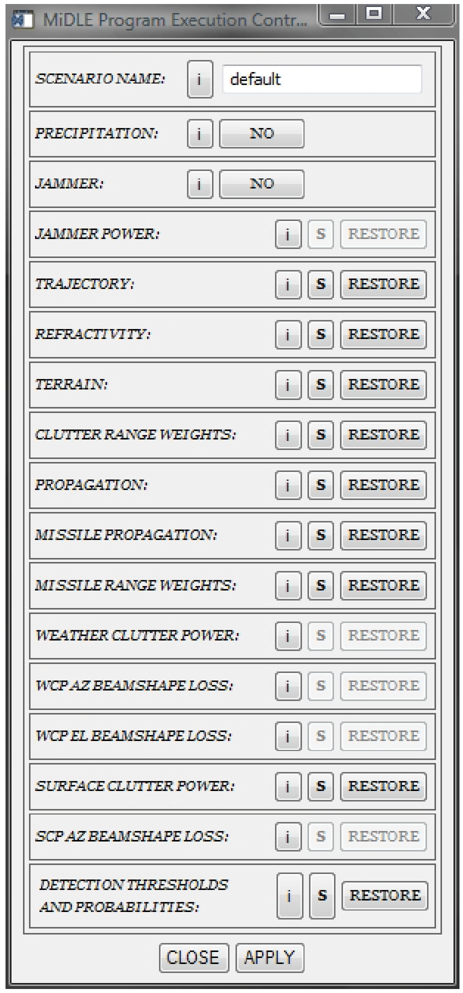


Figure 13: Program Execution Control Panel

When the PEC panel is first open it show the default scenario whereby MiDLE only restores previously saved results. In this mode MiDLE still performs several operations that are always executed irrespective of the control settings, such as displaying the missile trajectory, calculating scanning characteristics and missile radar cross-section, limiting missile data, etc.

Using the PEC panel the user can specify which calculations are to be performed as shown below. None of the selections become active until the APPLY button is pressed

- **Enable or disable precipitation**. If enabled, the user can optionally restore saved values form a file or direct MiDLE to execute weather clutter power (WCP) calculations. If WCP calculations are enabled, the user can direct the program to perform azimuth and elevation beamshape loss calculations or simply restore these quantities from a file. The default WCP files are in the OUTPUT directory and are named *WeatherClutter_nD_default.dat* where n is 0, 1 or 3. The beamshape loss data files are also located in the OUTPUT directory and are named *WCAzBeamshapeLossData_default.dat* and *WCElBeamshapeLossData_default.dat*.

- **Enable or disable a jammer**. If enabled, the user can optionally restore saved values from a file or direct MiDLE to execute jammer power calculations. (If a jammer is enabled and the APPLY button is pressed in the PEC panel, a black cross appears on the view indicating the location of the jammer). The default jammer power file is located in the OUTPUT directory and named *Jammer_default.dat*.

- **Trajectory**. If enabled, MiDLE will calculate the missile or projectile trajectory else it will restore the trajectory data from a file. The default trajectory data files are located in the OUTPUT directory and are named *MissilePath_default.dat* and *BallisticPath_default.dat* respectively. (Another file worth mentioning here is *MissilePath_default.kml* which can be imported into Google Earth for viewing. Generation of **.kml* files is covered elsewhere in this document).

- **Refractivity**. If enabled, MiDLE will calculate the refractivity values else it will restore the refractivity data from a file. The default refractivity data file is located in the OUTPUT directory and named *M_default.dat*.

- **Terrain**. If enabled, MiDLE will calculate the terrain data else it will restore the terrain data from a file. The default terrain data file is located in the OUTPUT directory and named *Terrain_default.dat*.

- **Clutter Range Weights**. If enabled, MiDLE will calculate the clutter range weights else it will restore the clutter range weights from a file. The default clutter range weights data file resides in the OUTPUT directory and named *ClutterRangeWeights_default.dat*.

- **Propagation**. If enabled, MiDLE will calculate the propagation factors (PF) else it will restore the PF values from a file. The default PF file is located in the OUTPUT directory and named *ExtractedSurfaceF4_default.dat*.

- **Missile Propagation**. If enabled, MiDLE will calculate the missile propagation factors (MPF) else it will restore the MPF values from a file. The default MPF file is located in the OUTPUT directory and named *MissileF4th_default.dat*.

- **Missile Range Weights**. If enabled, MiDLE will calculate the missile range weights else it will restore them from a file. The default missile range weights file is located in the OUTPUT directory and named *MissileRangeWeights_default.dat*.

- **Weather Clutter Power**. This control is available only when precipitation is enabled. If WCP calculations are enabled, the azimuth and elevation beamshape loss widgets become selectable.

- **Surface Clutter Power**. If enabled, MiDLE will calculate the surface clutter power (SCP) values else it will restore them from a file. If enabled, the user can optionally direct MiDLE to calculate the azimuth beamshape loss else these values are restored form a file. The default surface clutter power and azimuth beamshape loss data files are located in the OUTPUT directory and named *Sum_default.dat* and *SCAzBeamshapeLossData.dat* respectively.

- **Detection Thresholds and Probabilities**. If enabled, MiDLE will calculate the detection thresholds and probabilities else it will restore these values from a file. The default DT&P data file is located in the OUTPUT directory and is named *ThreshProb_default.dat*.

The topmost widget of the Program Execution Control panel contains the 'Scenario name' entry. When the control panel is first opened this entry shows 'default', indicating that currently the default scenario is loaded and the default files are being used. If for example, the user selects 'execute' for the missile trajectory, presses the APPLY button and starts MiDLE, the following message is displayed:

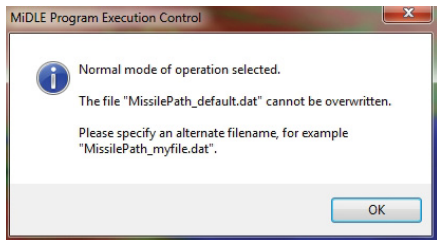


Figure 14: Program Execution Control Warning

The program was designed to protect the default files from being accidentally overwritten. The user must select a new 'scenario' by typing its name into the *Scenario Name* widget. It is important to press the <Enter> key after typing the scenario name.

After the scenario name is changed, it can be inspected for each function (e.g. Trajectory, Refractivity, etc) by pressing the 'S' or select button. This opens up a file dialog box as shown in Figure 15.

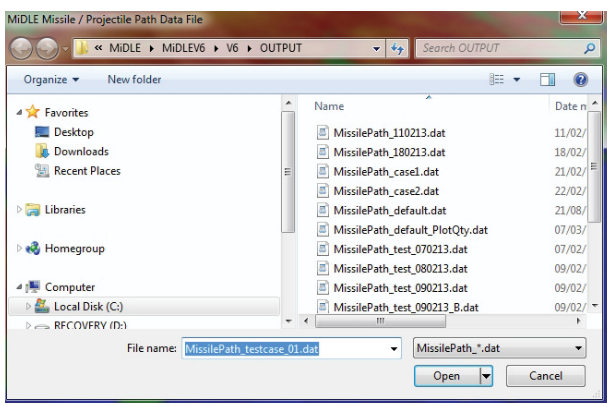


Figure 15: Program Execution Control File Dialog Box

In this example the scenario name specified is 'testcase_01', hence the missile trajectory file will be named as *MissilePath_testcase_01.dat*. The same modifier is subsequently applied to all other files; *M_testcase_01.dat*, *Terrain_testcase_01.dat*, etc.

When MiDLE executes it will either create the new file specified or attempt to restore it. If this file has not been created, the program will issue a warning and use the default file in its place.

Using the file dialog box shown in Figure 15, the user can specify other files to include from previous calculations. In this manner not every function needs to be recalculated if it was already done so for a previous test case. For example, if the refractivity values for the current test case are known to be the same as for a previous one, the user can simply specify the previous file and select RESTORE.

Each function in the Program Execution Control panel has an associated 'i' or information button. Pressing this button opens a window that gives a brief explanation of its function. For example, pressing the 'Scenario Name' info button shows the message generated in Figure 16.

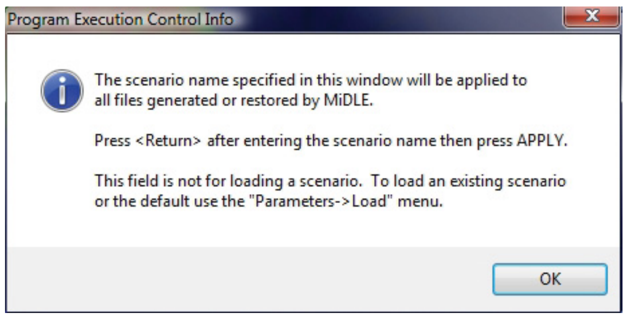


Figure 16: Example Program Execution Control Info Message

6.2.2 The Mode Menu

The mode menu contains the following selections:

- Normal
- Batch
- Diagnostic

The 'normal' mode of operation is set when MiDLE is started and this selection is checked in the Mode menu. In this mode, MiDLE will complete a single run, display the results and stop. When the 'batch' mode of operation is selected and MiDLE is started, a file dialog box is opened as shown in Figure 17.

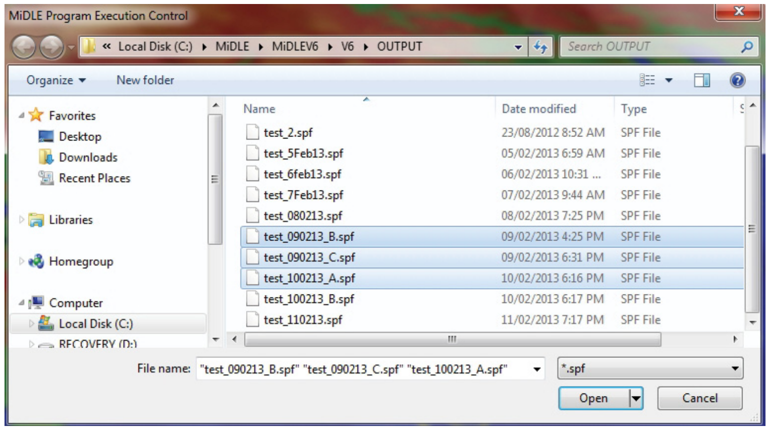


Figure 17: Program Execution Control Batch File Selection

The user can designate multiple files by pressing the <Ctrl> key and clicking on the files to be processed. The batch files are of the type **.spf* or *s*aved parameter files. The files must be created prior to running batch processing using the *Parameters->Load* function discussed in the next section. The **.spf* files basically contain a set of parameters that are restored before MiDLE is executed. In batch mode of operation MiDLE will loop several times and process each file in turn. The output results are saved in the OUPUT directory.

The 'diagnostic' mode is disabled when MiDLE first starts. When this button is clicked, the diagnostic mode becomes enabled and the selection becomes checked. In diagnostic mode all output messages generated are saved to a file in the OUTPUT directory named *diagnostic.log*. Each time MiDLE runs in diagnostic mode it appends this file until the file size becomes very large. When it reaches 150-KBytes the user is asked if the file should be deleted. When MiDLE runs and the *diagnostic.log* is not found it is recreated.

When MiDLE is executed in diagnostic mode, it opens a window displaying all of the current parameters. The user can inspect these parameters before committing to program execution. The parameters display window blocks program execution until it is closed and therefore it is not advisable to run MiDLE with both batch and diagnostic mode set.

An example diagnostic file is shown in Appendix A of this document.

6.2.3 The Parameters Menu

The parameters menu contains the following selections:

- Radar
- Control
- Environment
- Missile
- Projectile
- Signal
- Jammer

- Expert
- Save
- Load

6.2.3.1 Radar Parameters Control Panel

The radar parameters control is used to display the Radar Parameters Control (RPC) panel shown in Figure 18. This control panel contains radar parameter widgets arranged in 3 columns. The RPC panel shows only the first column when it is opened. The user can either expand the panel by dragging it or access the other columns using the scroll bar. Three widgets, the Bursts Setup, the STC Maximum Range and the Normalized Polar Angle Antenna Pattern Setup start sub-control panels when clicked on. Note that the latter one only becomes selectable only when the Polar Angle Pattern Type is 'User'.

Most widgets have an 'R' or reset button to reinitialize them to the current values. All widgets have an 'i' or information button giving a brief description of the parameter. The APPLY button saves all changes made for the current session and CLOSE closes the panel. The RESET button restores all widgets to their default values.

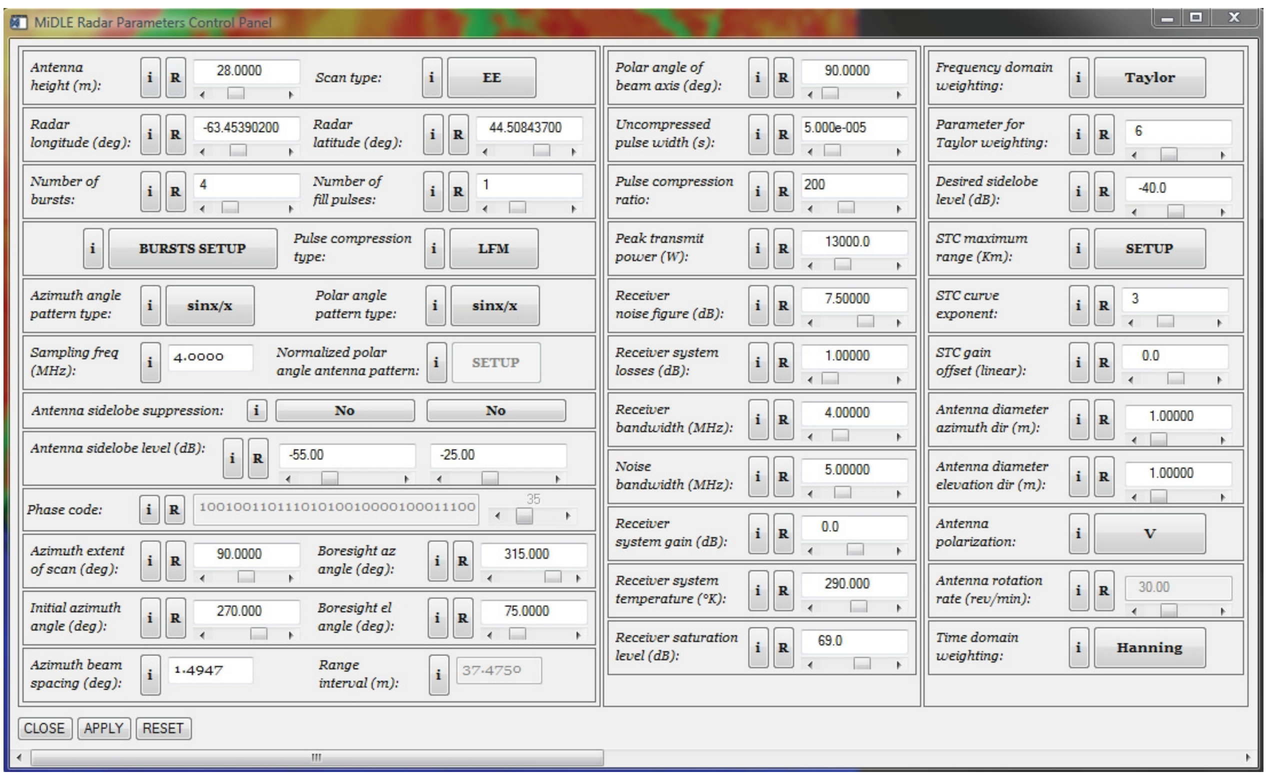


Figure 18: Radar Parameters Control Panel

The RPC panel contains the following parameter controls:

- *Antenna height*....................................... range: 0.0 to 100.0 meters
- *Scan type* .... EE: electronic in vertical, electronic in azimuth
  EM: electronic in vertical, mechanical in azimuth

MM: mechanical in vertical, mechanical in azimuth

- *Radar longitude* .... range: -180.0 to 180.0 degrees
- *Radar latitude* .... range: -90.0 to 90.0 degrees
- *Number of bursts* .... range: 1 to 20
- *Number of fill pulses* .... range: 0 to 4
- *Pulse compression type* .... LFM, Mseq, PhaseCode or none
- *Azimuth angle pattern type* .... sinx/x or Gaussian
- *Polar angle pattern type* .... sinx/x, cosecant², Gaussian or User
- *Sampling frequency* .... variable field: 4.0-MHz default
- *Antenna sidelobe suppression* .... Azimuth: Yes or No
  Elevation: Yes or No
- *Antenna sidelobe level* .... range: -120.0 to 120.0 dB
- *Phase code* 10010011011101010010000100011100001
- *Phase code length* .... range: 1 to 150 (35 default)
- *Azimuth extent of scan* .... range: 5.0 to 180.0 degrees
- *Boresight azimuth angle* .... range: 0.0 to 360.0 degrees
- *Initial azimuth angle* .... range: 0.01 to 360.0 degrees
- *Boresight elevation angle* .... range: 90.0 to 0.0 degrees
- *Initial beam spacing* .... variable field: 1.4947 degrees default
- *Range interval* .... reference field: 37.475 meters default

- *Polar angle of beam axis* .... range: 90.0 to 0.0 degrees
- *Uncompressed pulse width* .... range: 0.0 to 0.001 seconds
- *Pulse compression ratio* .... range: 1 to 600
- *Peak transmit power* .... range: 0.0 to 50000.0 Watts
- *Receiver noise figure* .... range: 1.0 to 10.0 dB
- *Receiver system losses* .... range: 1.0 to 10.0 dB
- *Receiver bandwidth* .... range: 0.0 to 20.0 MHz
- *Noise bandwidth* .... range: 0.0 to 20.0 MHz
- *Receiver system gain* .... range: -10.0 to 10.0 dB
- *Receiver system temperature* .... range: 0.0 to 500.0 degrees K
- *Receiver saturation level* .... range: 30.0 to 90.0 dB

- *Frequency domain weighting* .... Taylor, Hamming or Rectangular
- *Parameter for Taylor weighting* .... range: 0 to 20
- *Desired sidelobe level* .... range: -80.0 to 10.0 dB
- *STC curve exponent* .... range: 0 to 10
- *STC gain offset* .... range: -3.0 to 3.0
- *Antenna diameter in azimuth dir* .... range: 0.0 to 10.0 meters
- *Antenna diameter in elevation dir* .... range: 0.0 to 10.0 meters
- *Antenna polarization* .... Vertical (V) or Horizontal (H)
- *Antenna rotation rate* .... range: 0.0 to 100.0 rev/min
- *Time domain weighting* .... Hanning, Hamming or Rectangular

The RPC panel displays the radar platform's current latitude/longitude position. In the MiDLE GUI the radar position can be changed by holding down the <Alt> key and clicking on the new position in the view. The ‘Radar longitude’ and ‘Radar latitude’ widgets will be updated automatically with the new latitude/longitude values selected. After pressing APPLY the display will be regenerated with the radar shown at its new position.

In this manner the user can place the radar at any geographic location within the view. For example if the new radar position’s elevation is greater than zero meters (above sea level), MiDLE issues a warning and asks for permission to continue. This warning message is shown in Figure 19.

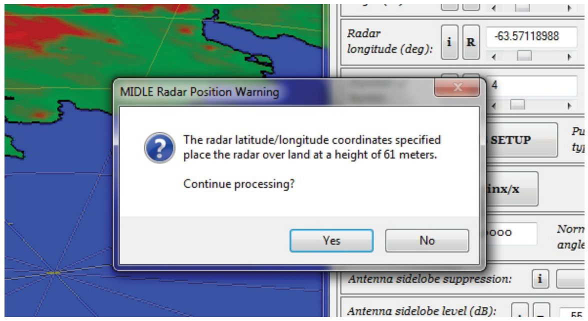


Figure 19: Radar Parameters Control Panel Warning Message

Clicking on the ‘Burst Setup’ button in the RPC panel opens the sub-control panel shown in Figure 20. The default number of bursts is 4, therefore this sub-control panel contains only 4 columns, one for each burst. The maximum number of bursts that can be specified is 20. Parameters shaded gray in the sub-control panel (e.g. pulse repetition interval and wavelength) cannot be edited as their values are functions of other parameters. The currently selected parameter is coloured blue.

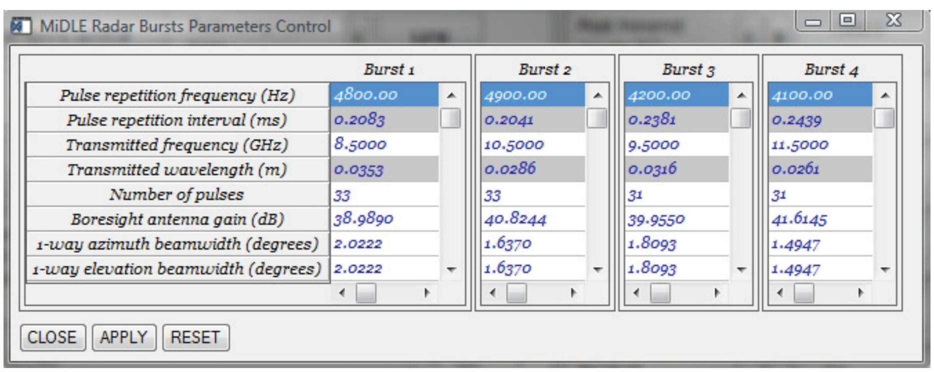


Figure 20: Burst Setup Sub-Control Panel

When the Polar Angle Pattern Type is set to ‘User’, the Normalized Polar Angle Antenna Pattern SETUP button becomes selectable. Clicking on this button opens the sub-control panel shown in Figure 21.

Figure 21: Polar Angle User Pattern Sub-Control Panel

Clicking on the STC Maximum Range button opens the sub-control panel shown in Figure 22.

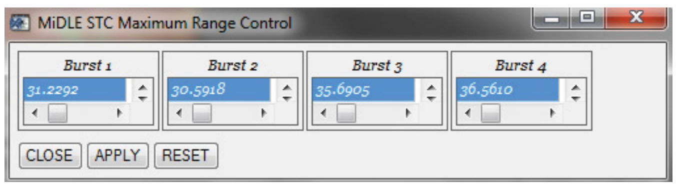


Figure 22: STC Maximum Range Sub-Control Panel

6.2.3.2 Control Parameters Control Panel

The control parameters button is used to display the Control Parameters Control (CPC) panel shown in Figure 23. This control panel contains widgets used initialize various parameters arranged in three columns. The CPC panel is opened showing only the first column. The user can either expand the panel by dragging it or access the other columns using the scroll bar.

Most widgets have an ‘R’ or reset button to reinitialize them to the current values. All widgets have an ‘i’ or information button giving a brief description of the parameter. The APPLY button saves all changes made for the current session and CLOSE closes the panel. The RESET button restores all widgets to their default values.

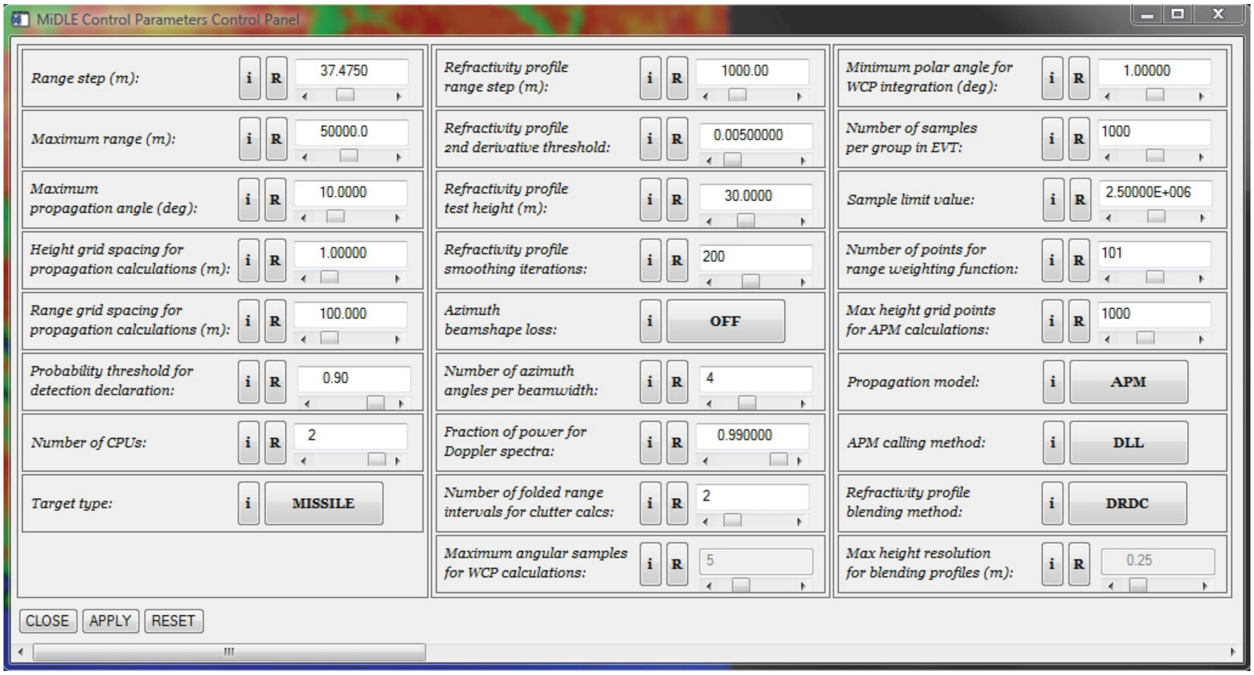


Figure 23: Control Parameters Control Panel

The CPC panel contains the following parameter controls:

- *Range step* .... range: 0.0 to 100.0 meters
- *Maximum range* .... range: 10000.0 to 100000.0 m
- *Maximum propagation angle* .... range: 5.0 to 30.0 degrees
- *Number of characteristic points for antenna pattern* .... range: 0 to 30
- *Height grid spacing for propagation calculations* .... range: 0.0 to 10.0 meters
- *Range grid spacing for propagation calculations* .... range: 0.0 to 1000.0 meters
- *Probability of detection threshold* .... 0.0 to 1.0
- *Number of CPUs* .... range: 1 to ∞
- *Target type* .... Missile or Projectile

- *Refractivity profile range step* .... range: 0.0 to 5000.0 meters
- *Refractivity profile 2nd derivative threshold* .... range: 0.0 to 0.1
- *Refractivity profile test height* .... range: 0.0 to 100.0 meters
- *Refractivity profile smoothing iterations* .... range: 0 to 500
- *Azimuth beamshape loss* .... On or Off
- *Number of azimuth angles per beamwidth* .... range: 1 to 10
- *Fraction of power for Doppler spectra* .... range: 0.0 to 1.0
- *Number of folded range intervals for clutter calculations* .... range: 1 to 10
- *Maximum angular samples for WCP calculations* .... range: 1 to 20

- *Maximum polar angle for WCP integration* .... range: 0.0 to 2.0 degrees

- *Number of samples per group in EVT* ……………………………………….. range: 0 to 2000
- *Sample limit value* ……………………………………………………………………. range: 0.0 to 5000000.0
- *Number of points for range weighting functions* …………………….. range: 1 to 200
- *Max heights grid points for APM calculations* …………………………. range: 1 to 3000
- *Propagation Model* …………………………………………………………………. APM, MRADAR or Other
- *APM calling method* ……………………………………………………………….. DLL or EXE
- *Refractivity profile blending method* ……………………………………… DRDC or NSWC
- *Max height resolution for blending profiles* …………………………… 0.0 to 2.0 meters

The Maximum Range control is important as it is used to define the radar range and the extent of the view displayed by MiDLE. Selecting a different range and pressing APPLY will regenerate the view.

The Target Type widget is 'Missile' by default and this is displayed in the information window of the MiDLE GUI shown in previously in Figure 11. The user can access the Missile Parameters Control (MPC) panel. If the target type is changed to 'Projectile' and the APPLY button is pressed, the missile parameters are no longer selectable and the user can only access the Projectile Parameters Control (PPC) panel. If the MPC panel is currently open and the target type is changed to 'Projectile', the MPC panel is closed as it is no longer applicable. Similarly if the PPC panel is currently open and the target type is changed to 'Missile', the PPC panel is closed.

6.2.3.3 Environment Parameters Control Panel

The environment parameters button is used to display the Environment Parameters Control (EPC) panel shown in Figure 24. This control panel contains environmental parameter widgets arranged in four columns. The EPC panel is opened showing only the first column. The user can either expand the panel by dragging it or access the other columns using the scroll bar. Six of the widgets open sub-control panels when clicked on:

- Power ratio adjust factor,
- Land cover type,
- Bulk met parameters (single point data),
- Refractivity profile (no single point data),
- Reflectivity factor profile,
- Wind velocity profile for weather clutter.

Most widgets have an 'R' or reset button to reinitialize them to the current values. All widgets have an 'i' or information button giving a brief description of the parameter. The APPLY button saves all changes made for the current session and CLOSE closes the panel. The RESET button restores all widgets to their default values.

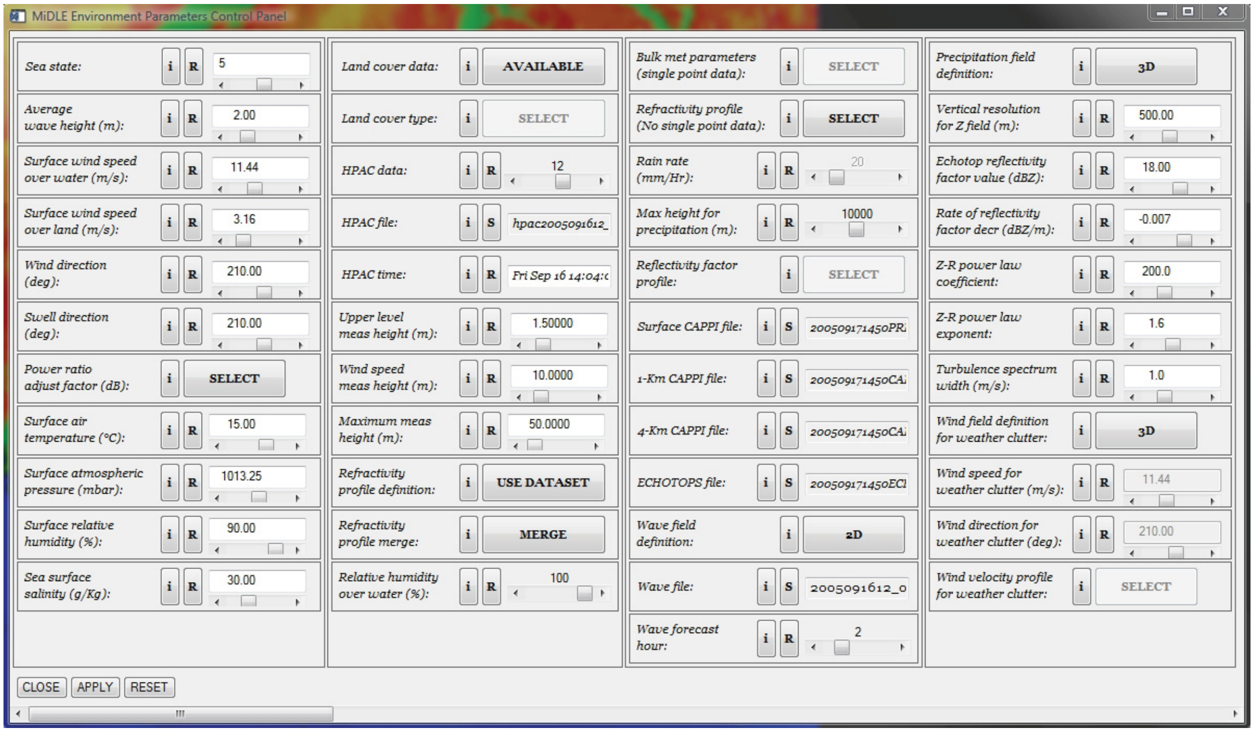


Figure 24: Environment Parameters Control Panel with Precipitation Enabled

The EPC panel contains the following parameter controls:

- *Sea state* .... range: 0 to 9
- *Average wave height* .... range: 0.0 to 10.0 meters
- *Surface wind speed over water*... range: 0.0 to 30.0 m/sec
- *Surface wind speed over land* .... range: 0.0 to 30.0 m/sec
- *Wind direction* .... range: 0.0 to 360.0 degrees
- *Swell direction* .... range: 0.0 to 360.0 degrees
- *Surface air temperature* .... range: -40.0 to 40.0 °C
- *Surface atmospheric pressure* .... range: 800.0 to 1200.0 mbar
- *Surface relative humidity* .... range: 0.0 to 100.0 %
- *Sea surface salinity* .... range: 0.0 to 100.0 g/Kg

- *Land cover data* .... Available or Unavailable
- *HPAC data* .... range: 0 to 20
- *HPAC file* .... text field
- *Upper level measurement height* .... range: 0.0 to 10.0 meters
- *Wind speed measurement height* .... range: 0.0 to 100.0 meters
- *Maximum measurement height* .... range: 0.0 to 2000.0 meters
- *Refractivity profile definition* .... Use LWKD or Use Dataset
- *Refractivity profile merge* .... Merge or No Merge
- *Relative humidity over water* .... range: 90 to 100 %

- *Rain rate* ……………………………………………………………………. range: 0 to 200 mm/Hr
- *Maximum height for precipitation* ……………………………. range: 100 to 20000 meters
- *Surface CAPPI file* ………………………………………………………. text field
- *1-Km CAPPI file* ……………………………………………………………. text field
- *4-Km CAPPI file* ……………………………………………………………. text field
- *ECHOTOPS file* ……………………………………………………….. text field
- *Wave field definition* …………………………………………………. 2D or Wind
- *Wave file* …………………………………………………………………………. text field
- *Wave forecast hour* ………………………………………………. range: 0 to 10

- *Precipitation field definition* ………………………………………. 3D, Profile or Constant
- *Vertical resolution for Z field* ……………………………………. range: 100.0 to 1000.0 meters
- *Echotop reflectivity factor value* ………………………………. range: -50.0 to 50.0 dBZ
- *Rate of reflectivity factor decrease* ……………………………. range: -0.03 to 0.0 dBZ/m
- *Z-R power law coefficient* ………………………………………… range: 0.0 to 600.0
- *Z-R power law exponent* ……………………………………………. range: 0.0 to 3.2
- *Turbulence spectrum width* ……………………………………… range: 0.0 to 3.0 m/sec
- *Wind field definition for weather clutter* …………………… 3D, Profile or Constant
- *Wind speed for weather clutter* ………………………………… range: 0.0 to 30.0 m/sec
- *Wind direction for weather clutter* …………………………… range: 0.0 to 360.0 degrees

Figure 24 shows the EPC panel for the case when precipitation is enabled. Some of the widgets become desensitized when precipitation is disabled such as rain rate, maximum height for precipitation, etc.

The land cover type button becomes selectable when land cover data is unavailable as shown in the above figure. In this case the user can click on the land cover type SELECT button to specify a land cover type that will be used everywhere. The land cover type selection window is shown in Figure 25. The default land cover type is ‘Built up or non-vegetated’ (index 25).

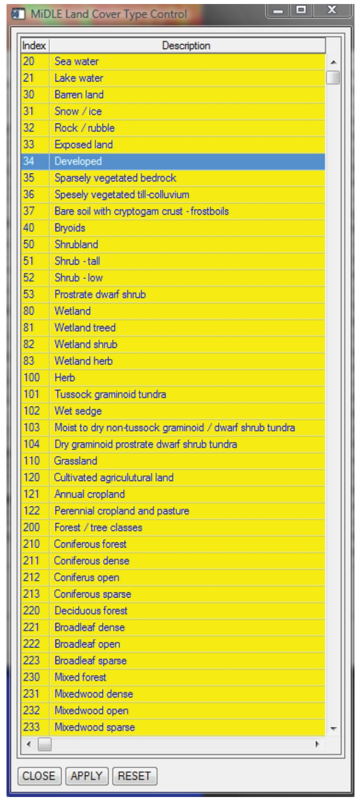


Figure 25: Land Cover Type Selection Sub-Panel

The bulk meteorological parameters button becomes sensitive when there is no HPAC data available (the HPAC data slider widget is set at 0) and the refractivity profile definition is 'Use LWKD'. Clicking on the 'Bulk met parameters' button opens the sub-control panel shown in Figure 26.

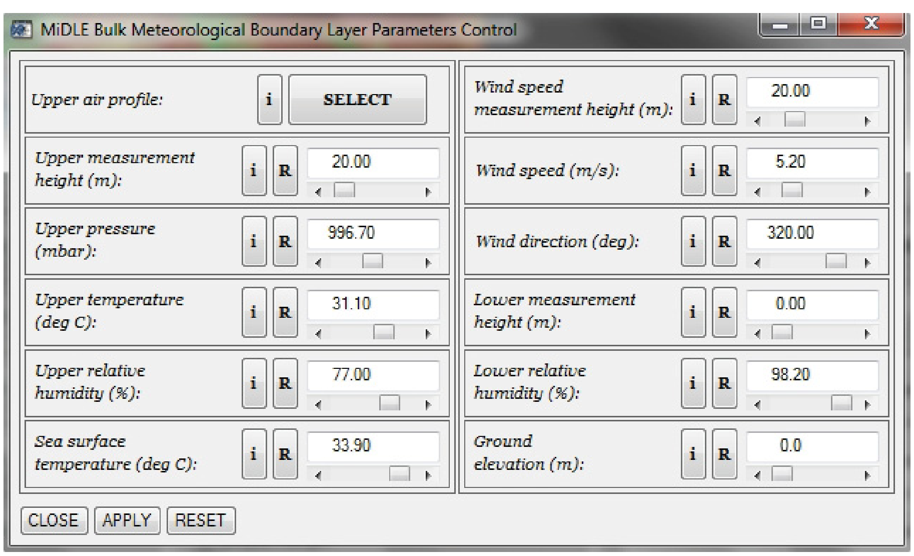
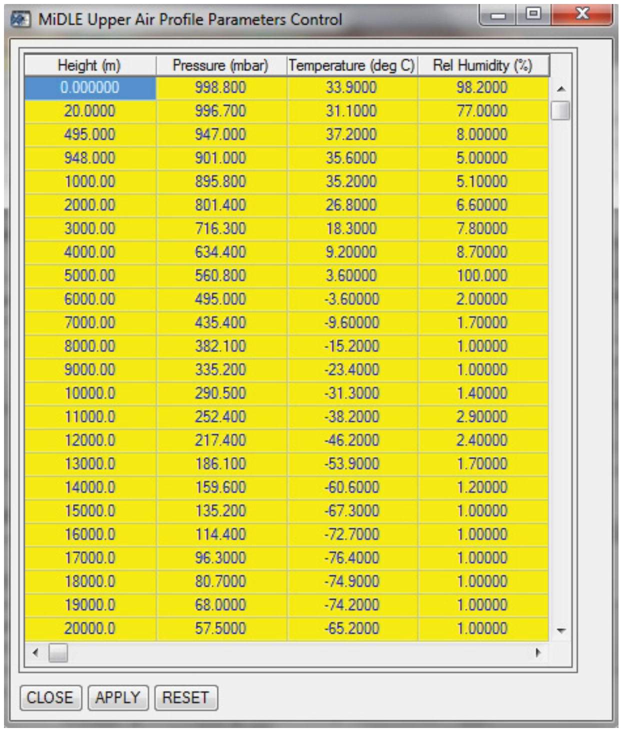


Figure 26: Bulk Meteorological Parameters Sub-Panel

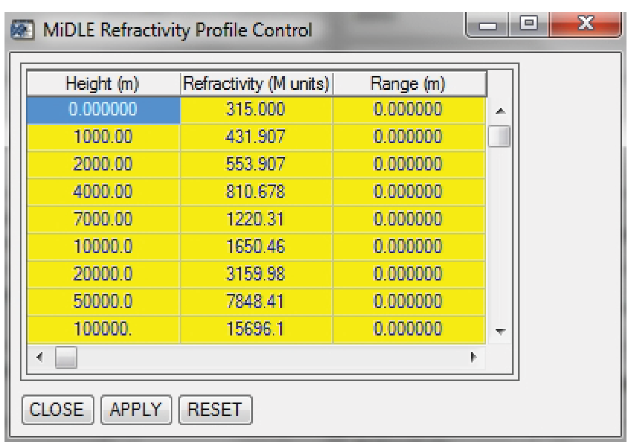
The Bulk Meteorological Parameters (BMP) control panel opens the Upper Air Profile Parameters Control sub sub-panel when the SELECT button is clicked. This is shown in Figure 27.



Height (m)	Pressure (mbar)	Temperature (deg C)	Rel Humidity (%)
0.000000	998.800	33.9000	98.2000
20.0000	996.700	31.1000	77.0000
495.000	947.000	37.2000	8.00000
948.000	901.000	35.6000	5.00000
1000.00	895.800	35.2000	5.10000
2000.00	801.400	26.8000	6.60000
3000.00	716.300	18.3000	7.80000
4000.00	634.400	9.20000	8.70000
5000.00	560.800	3.60000	100.000
6000.00	495.000	-3.60000	2.00000
7000.00	435.400	-9.60000	1.70000
8000.00	382.100	-15.2000	1.00000
9000.00	335.200	-23.4000	1.00000
10000.0	290.500	-31.3000	1.40000
11000.0	252.400	-38.2000	2.90000
12000.0	217.400	-46.2000	2.40000
13000.0	186.100	-53.9000	1.70000
14000.0	159.600	-60.6000	1.20000
15000.0	135.200	-67.3000	1.00000
16000.0	114.400	-72.7000	1.00000
17000.0	96.3000	-76.4000	1.00000
18000.0	80.7000	-74.9000	1.00000
19000.0	68.0000	-74.2000	1.00000
20000.0	57.5000	-65.2000	1.00000

Figure 27: Upper Air Profile Parameters Sub Sub-Panel

When HPAC data is available (e.g. the HPAC Data slider widget is set to a value other than 0), clicking on the Refractivity Profile SELECT button in the EPC panel opens the Refractivity Profile Control sub-panel shown in Figure 28.



Height (m)	Refractivity (M units)	Range (m)
0.000000	315.000	0.000000
1000.00	431.907	0.000000
2000.00	553.907	0.000000
4000.00	810.678	0.000000
7000.00	1220.31	0.000000
10000.0	1650.46	0.000000
20000.0	3159.98	0.000000
50000.0	7848.41	0.000000
100000.	15696.1	0.000000

Figure 28: Refractivity Profile Control Sub-Panel

Clicking on the Reflectivity Factor Profile widget SELECT button in the EPC panel opens the sub-panel shown in Figure 29.

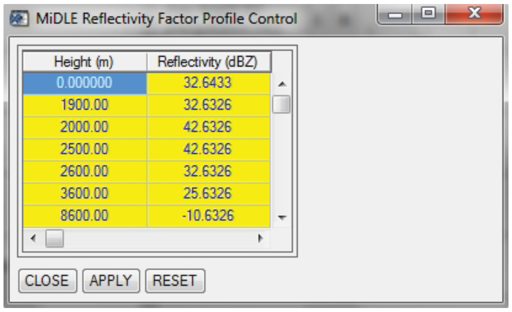


Figure 29: Reflectivity Profile Control Sub-Panel

Clicking on the Wind Velocity Profile for Weather Clutter widget SELECT button in the EPC panel opens the sub-panel shown in Figure 30. Note that this selection is only available if the wind field definition is 'Profile'.

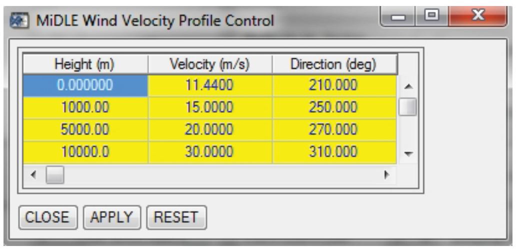


Figure 30: Wind Velocity Profile Control Sub-Panel

Clicking on the Power Ratio Adjustment Factor widget SELECT button in the EPC opens the AC/DC Power Ratio Adjustment Control sub-panel shown in Figure 31.

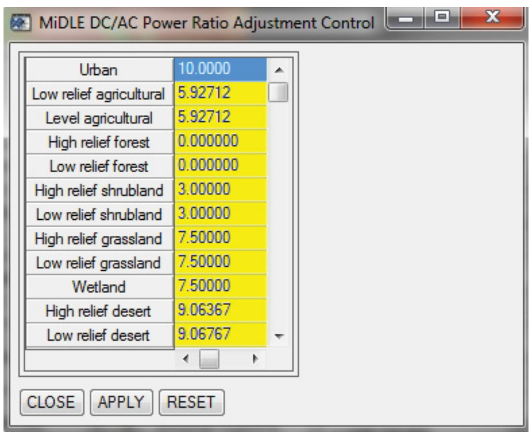


Figure 31: Power Ratio Adjustment Control Sub-Panel

6.2.3.4 Missile Parameters Control Panel

The missile parameters control is used to display the Missile Parameters Control (MPC) panel shown in Figure 32.

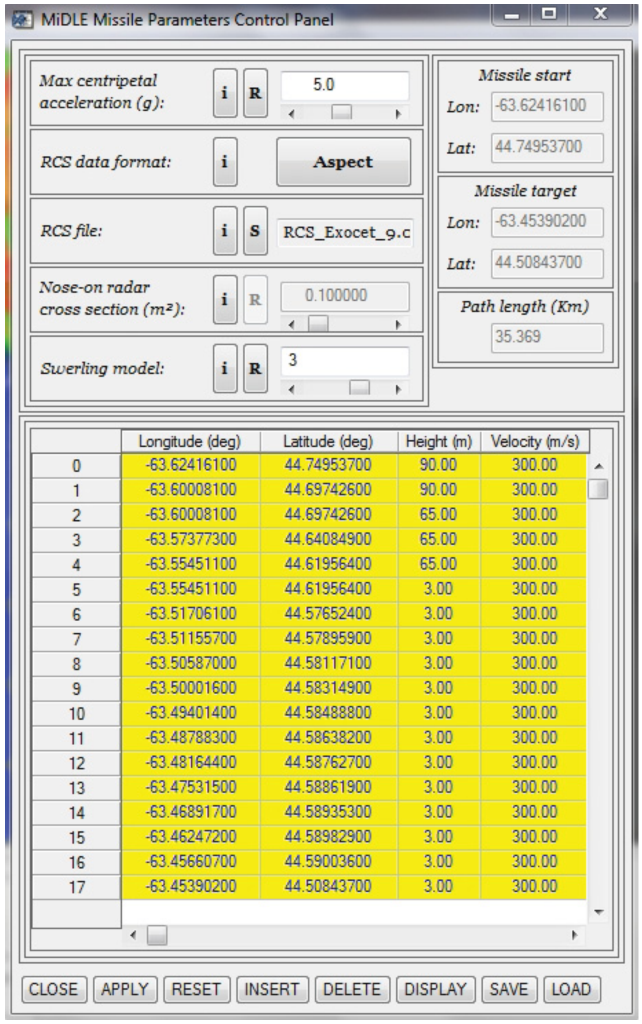


Figure 32: Missile Parameters Control Panel

The MPC panel contains the following parameter controls:

- *Maximum centripetal acceleration* .... range: 1.0 to 10.0 g
- *RCS data format* .... Aspect or Constant
- *RCS file* .... text field
- *Nose-on radar cross section* .... range: 0.01 to 2.0 m²
- *Swerling model* .... range: 0 to 4

The MPC panel is more complex than any of the other control panels as it is used to define the missile trajectory waypoints as well as the missile parameters. When MiDLE is started, the MPC shows the waypoints of the default missile flight path. The missile waypoints can be configured using the INSERT and DELETE buttons as well as by clicking the mouse in the main view area. The waypoints can of course also be edited manually in the MPC waypoints table.

Help on how to use the MCP panel is available by clicking on *Help->Parameters->Missile*. The following paragraphs and figures illustrate a typical case where a new set of waypoints are defined using the existing waypoints table.

Zooming in and rotating the main view area produces the image shown in Figure 33. In this figure waypoint #3 was selected by highlighting it. Notice that the waypoint designator circle in the view changes to red indicating its location. At this waypoint the height of the missile is 65-meters. Changing the height field to 650-meters and pressing <Return> changes the view correspondingly. The location of the waypoint relative to the ground is indicated by a white line.

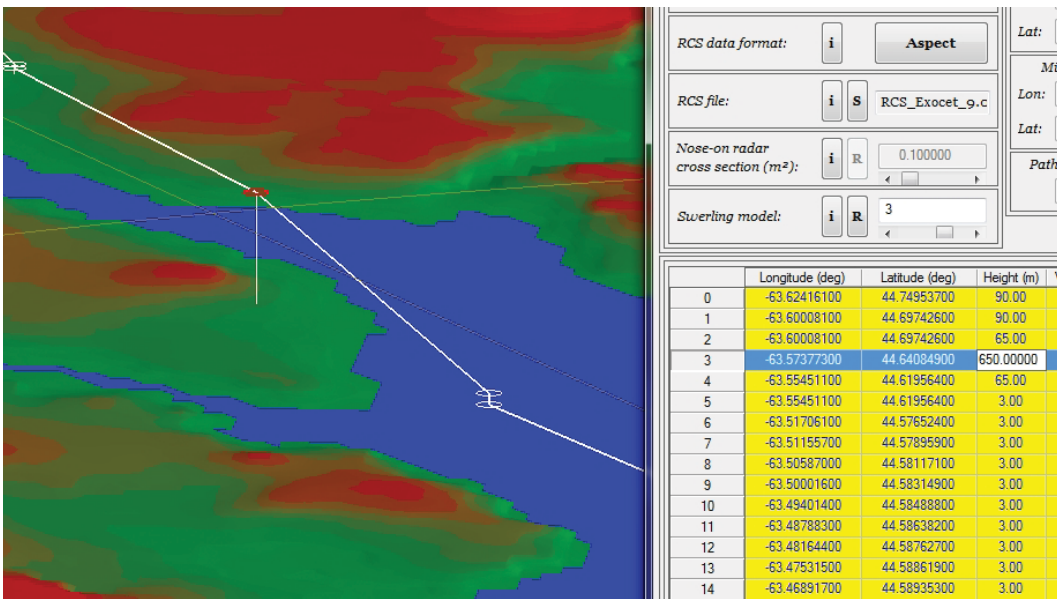


Figure 33: Changing the Missile Height at a Waypoint

In the same manner the missile latitude, longitude and velocity values at any waypoint can be modified by entering values directly in the table. A much faster method to designate waypoints to define a new flight path is by using the left mouse-button and the <Shift> key.

In the following example a new set of waypoints is defined while keeping the missile launch position and destination positions the same. Note that in this case the missile destination (target) is the same as the radar's location but this is not necessarily the case each time.

To define a new set of waypoints between the missile launch and destination positions we first delete all intermediate waypoints. This can be accomplished by clicking on waypoint #1 and dragging the cursor down to waypoint #16, effectively selecting (highlighting) these waypoints. Once selected, the waypoints can be deleted together by pressing the DELETE button. The waypoints table and the resulting image are shown in Figure 34.

The waypoints table in Figure 34 now shows only two waypoints and the missile trajectory is a straight line connecting the launch and destination points. The path length box shows a new path length of approximately 30-km.

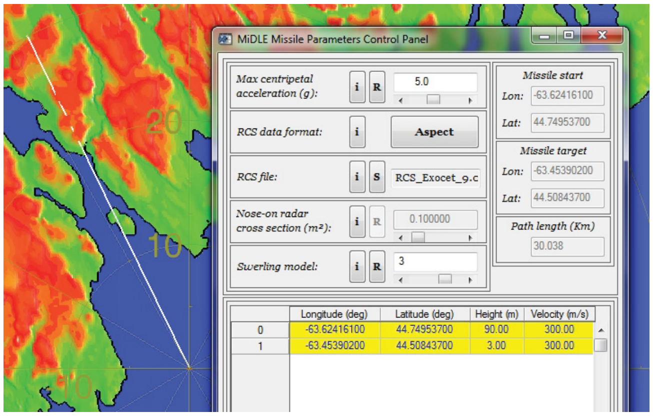


Figure 34: Deleting Intermediate Missile Waypoints

Coordinates of the missile launch or destination (target) positions can be changed by highlighting the waypoint, pressing the <Shift> key and clicking anywhere in the view. Note that neither of these waypoints can be deleted as the missile trajectory always requires a minimum of two waypoints.

In Figure 33 the missile launches from a height of 90-meters and descends to 3-meters on its way to the target. The white trajectory line is not visible at certain points because of the intervening terrain. The missile's trajectory must therefore be adjusted to so that the missile either flies around obstacles and elevated land features or flies over them. The terrain elevation is colour-coded so that green areas are of lower elevation than red regions.

Insert a new waypoint by clicking on the waypoint after which the new waypoint will appear. In this example we select waypoint #0 (the missile launch position) and click on the INSERT button. A new waypoint is added with the same parameters as waypoint #0 as illustrated in Figure 35.

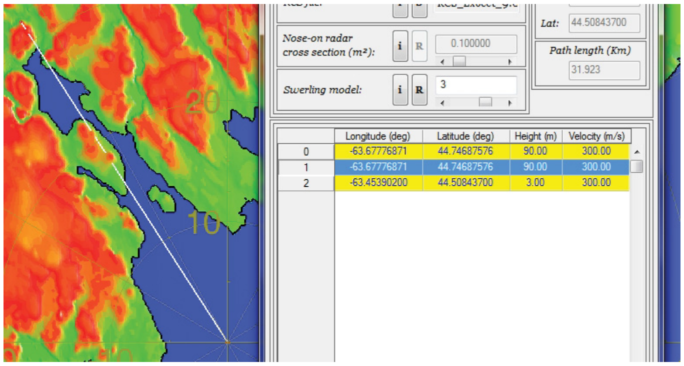


Figure 35: Adding Intermediate Missile Waypoints

Select new waypoint #1 in the view using the left mouse-button while holding down the <Shift> key. The view changes to show the location of the new waypoint and the waypoints table shows the waypoint's latitude/longitude position. The height and velocity field values remain unchanged. If the position of the new #1 waypoint needs to be adjusted slightly, repeat the procedure by holding the <Shift> key and clicking on the view.

For a finer adjustment of the new waypoint position, the view can be zoomed and rotated and the waypoint latitude/longitude values can be edited manually. The underlying terrain elevation grid uses level 2 data arranged in a 3601x3601 array. As each cell covers approximately 1° of latitude and longitude the resolution is therefore limited to approximately 0.0003 degrees using this method. If fine-tuning of the waypoint's position is required it must be done manually by modifying the table values.

Figure 36 below shows the resulting plot with two waypoints added after the missile launch waypoint #0. The view has been zoomed and rotated for clarity.

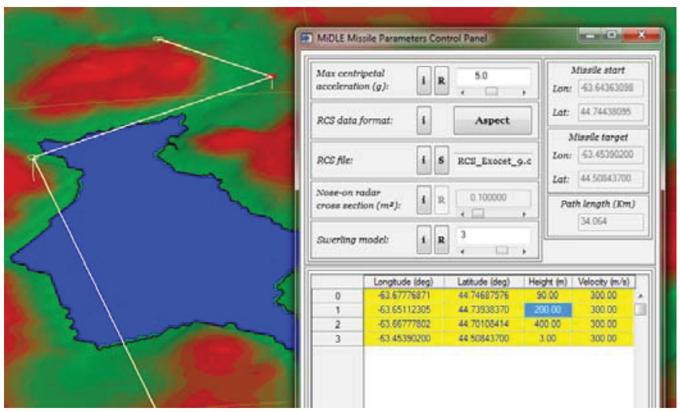


Figure 36: Example With Two New Missile Waypoints Added

The default waypoints can be reconfigured by pressing the RESET button. When all new missile waypoints have been defined, the configuration can be saved for the current session by pressing the APPLY button. Once APPLY is pressed the RESET button will no longer return the waypoint values to the default (start-up) values since the new configuration applied now becomes the default setting. To reset the original configuration click on *Program->Reset*.

The DISPLAY button toggles the waypoint designator circles on and off as well as the projection lines extending from the waypoint to the ground surface. This feature allows for de-cluttering of the display if required.

The SAVE and LOAD buttons open a file dialog box for saving and restoring a set of defined waypoints. The data is saved/loaded as **.wpt* files. The CLOSE button closes the MPC panel.

When new missile waypoints are defined and applied for the current session, MiDLE will automatically configure the Program Execution Control panel discussed in Section 6.2.1. The program will set the EXECUTE command for the following functions:

- Trajectory,
- Missile Propagation,
- Missile Range Weights,

- Surface Clutter,
- Detection Thresholds and Probabilities,

The above quantities, as a minimum, must be recalculated each time a new set of missile waypoints is defined.

6.2.3.5 Projectile Parameters Control Panel

The Projectile Parameters Control (PPC) panel only becomes selectable when the Target Type is set to 'Projectile' in the Control Parameters Control (CPC) panel discussed in Section 6.2.3.2. The PPC panel is shown in Figure 37.

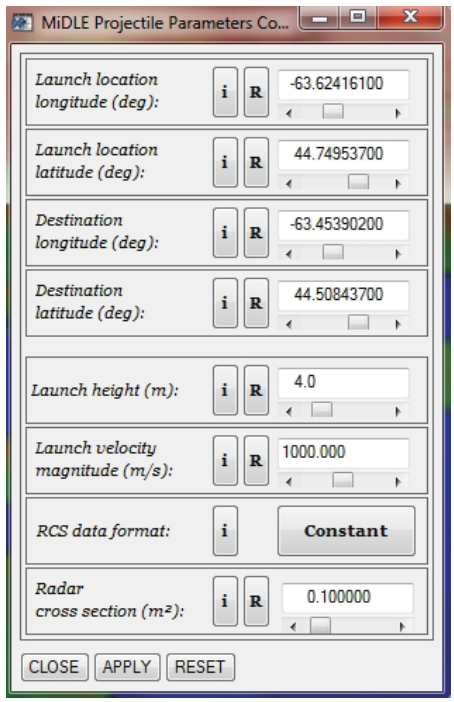


Figure 37: Projectile Parameters Control Panel

The PPC panel contains the following parameter controls:

- *Launch location longitude* .... range: -180.0 to 180.0 degrees
- *Launch location latitude* .... range: -90.0 to 90.0 degrees
- *Destination longitude* .... range: -180.0 to 180.0 degrees
- *Destination latitude* .... range: -90.0 to 90.0 degrees
- *Launch height* .... range: 0.0 to 30.0 meters
- *Launch velocity magnitude* .... range: 10.0 to 2000.0 m/sec
- *RCS format data* .... Constant or Aspect
- *Radar cross section* .... range: 0.01 to 2.0 m^2

The PPC panel contains only two 'waypoints', namely the projectile launch and destination latitude/longitude positions. The projectile destination (target) position coincides with the position of the radar by default. The main view area changes to show a single line connecting these positions. This line is shown for reference only and does not represent the projectile flight path. MiDLE will generate the projectile flight path from the input parameters (e.g. launch height and velocity, etc.) as it executes and display it in the view. Figure 38 shows the calculated projectile trajectory.

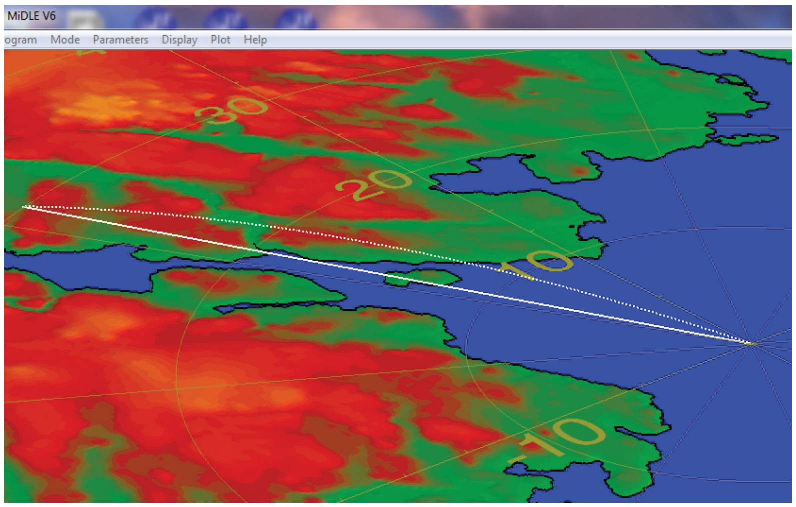


Figure 38: Projectile Trajectory View

6.2.3.6 Signal Processing Parameters Control Panel

The signal processing parameters control is used to display the Signal Processing Parameters Control (SPPC) panel shown in Figure 39.

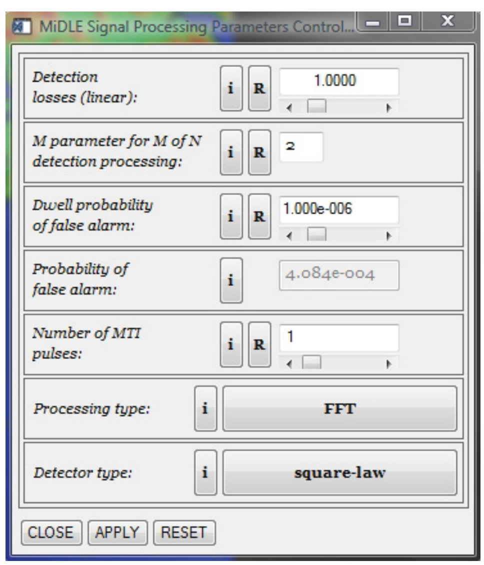


Figure 39: Signal Processing Parameters Control Panel

The SSPC panel contains the following parameter controls:

- *Detection losses* ……………………………………………… range: 0.0 to 10.0
- *M parameter for M of N detection processing* … text field
- *Dwell probability of false alarm* ……………………… *1.0e-7 to 1.0e-5*
- *Probability of false alarm* ……………………………… reference field
- *Number of MTI pulses* …………………………………… range: 1 to 30
- *Processing type* ……………………………………………… FFT, Coherent or Non-coherent integration
- *Detector type* ………………………………………………… Square-law or Envelope

6.2.3.7 Jammer Parameters Control Panel

The jammer parameters control is used to display the Jammer Parameters Control (JPC) panel shown in Figure 40.

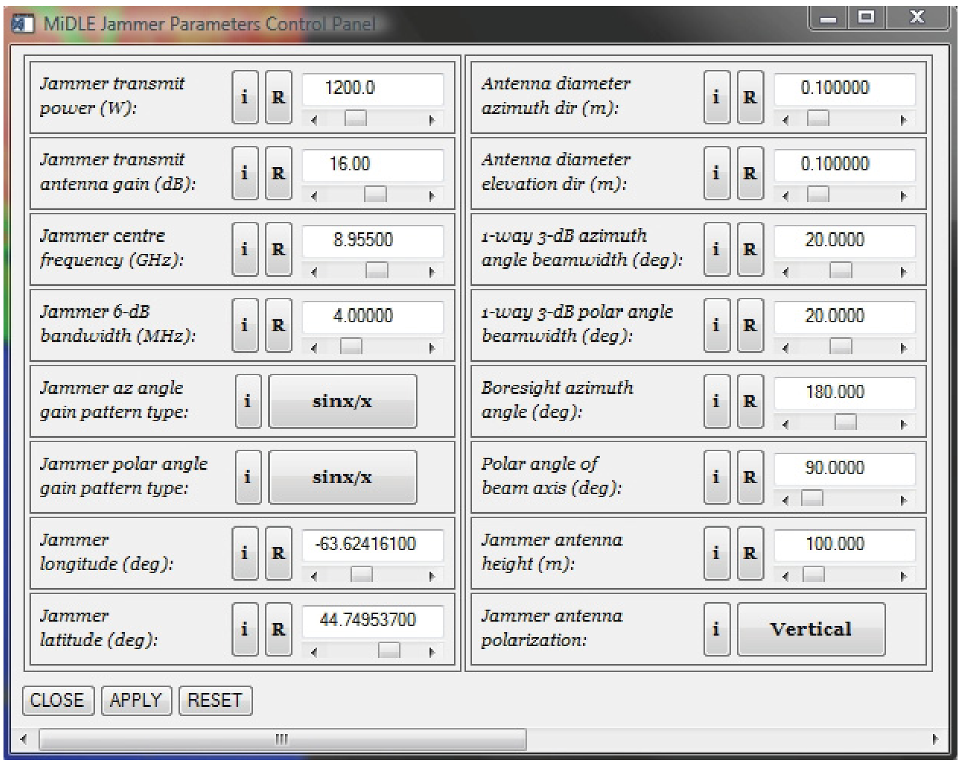


Figure 40: Jammer Parameters Control Panel

The JPC panel contains the following parameter controls:

- *Jammer transmit power* ……………………………………… range: 100.0 to 5000.0 W
- *Jammer transmit antenna gain* ………………………… range: 0.0 to 30.0 dB
- *Jammer centre frequency* ………………………………… range: 1.0 to 15.0 GHz
- *Jammer 6-dB bandwidth* …………………………………… range: 1.0 to 20.0 MHz
- *Jammer azimuth angle gain pattern type* …………… sinx/x or Gaussian

- *Jammer polar angle gain pattern type* .... sinx/x, Gaussian or User
- *Jammer longitude* .... range: -180.0 to 180.0 degrees
- *Jammer latitude* .... range: -90.0 to 90.0 degrees

- *Antenna diameter in the azimuth direction* .... range: 0.0 to 1.0 meter
- *Antenna diameter in the elevation direction* .... range: 0.0 to 1.0 meter
- *1-way 3-dB azimuth angle beamwidth* .... range: 1.0 to 45.0 degrees
- *1-way 3-dB polar angle beamwidth* .... range: 1.0 to 45.0 degrees
- *Boresight azimuth angle* .... range: 0.0 to 360.0 degrees
- *Polar angle of beam axis* .... range: 90.0 to 0.0 degrees
- *Jammer antenna height* .... range: 0.0 to 3000.0 meters
- *Jammer antenna polarization* .... Vertical or Horizontal

The Jammer Parameters Control panel can only be selected if the jammer is enabled in the Program Execution Control panel. When enabled, the jammer is represented by a black diamond symbol. The jammer symbol contains a pointer indicating the antenna boresight azimuth angle. In the default scenario the jammer's position is the same as the missile launch position. The antenna height is 100-meters and the jammer antenna points south.

The jammer location can be changed via the JPC panel GUI or by holding down the <Shift> key and clicking anywhere within the view. In this case however changes only becomes effective after the APPLY button is pressed. Figure 41 shows the resulting view with the jammer antenna boresight azimuth angle changed to 270° and the height set at 500-meters. As with the missile waypoints, a projection line to the ground surface is used to preserve the spatial orientation of the jammer.

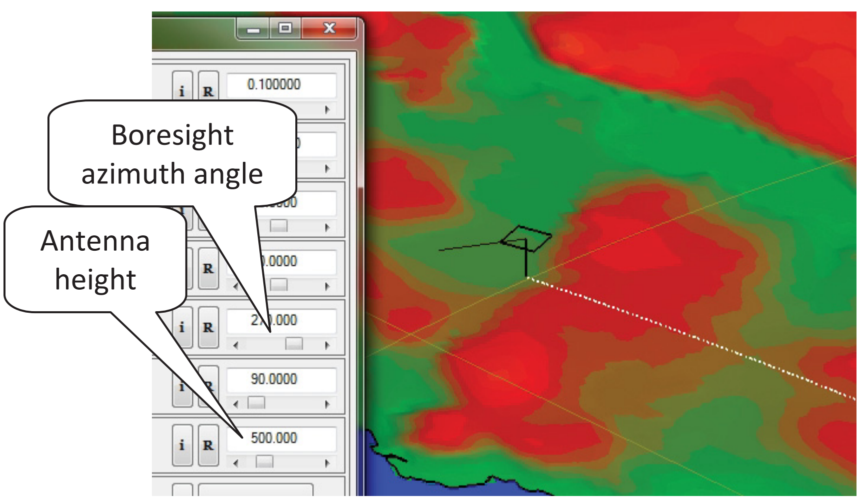


Figure 41: The Jammer Symbol

6.2.3.8 Expert Parameters Control Panel

The expert parameters control is used to display the Expert Parameters Control (EXPC) panel shown in Figure 42.

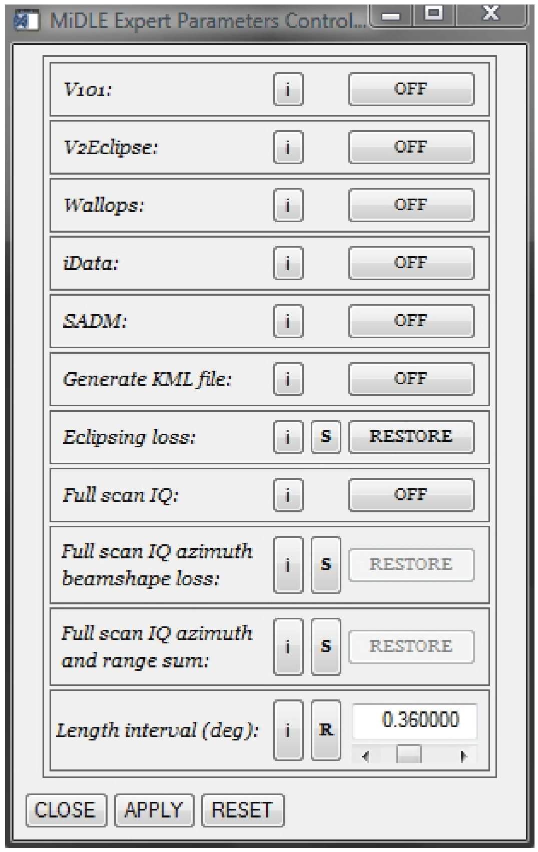


Figure 42: Expert Parameters Control Panel

The EXPC panel contains the following parameter controls:

- *V101* ………………………………………………………… On or Off
- *V2Eclipse* …………………………………………………. On or Off
- *Wallops* ……………………………………………………. On or Off
- *iData* ……………………………………………………… On or Off
- *SADM* ………………………………………………………. On or Off
- *Generate KML file* …………………………………. On or Off
- *Eclipsing loss* ……………………………………………. Restore or Execute
- *Full scan IQ* ………………………………………………. On or Off
- *Full scan IQ azimuth beamshape loss* ………. Restore or Execute
- *Full scan IQ azimuth and range sum* ………… Restore or Execute
- *Length interval* ………………………………………… range: 0.0 to 1.0 degrees

6.2.4 The Display Menu

The display menu controls the various graphic objects presented in the main view area and contains the following selections:

- Threat
- Radar
- Terrain
- Ocean
- Symbols
- Background
- Visibility
- Platform
- Detection
- Overlay

6.2.4.1 Threat Display Control

The threat display control is used to control how the threat (either missile or projectile) trajectory is displayed in the view. By selecting *Threat->Trajectory* the following options are available:

- Enable
- Color
- Style

When MiDLE is first started the user can select the ‘Enable’ button to display the default missile trajectory as MiDLE initially always loads the default scenario. When the ‘Enable’ button is clicked it becomes checked. Clicking the button again turns the trajectory display off. The colour and style of the missile/projectile trajectory can be changed using the controls provided.

If the MPC panel is opened and new waypoints are defined and saved for the current session, MiDLE is ready to calculate the trajectory for the new scenario. Clicking on *Trajectory->Enable* is no longer possible as the new trajectory data has not yet been calculated. When MiDLE is executed it will automatically display the new trajectory after which *Trajectory->Enable* button will become re-sensitized.

6.2.4.2 Radar Display Control

The radar display control is used to toggle the following quantities in the view:

- Azimuth scan region
  - Enable
  - Colour
- Antenna boresight
  - Enable
  - Colour

Both of these menu buttons become checked when selected and the display will be updated with the corresponding objects. Figure 43 shows the MiDLE view with the azimuth scan region and antenna boresight displays enabled.

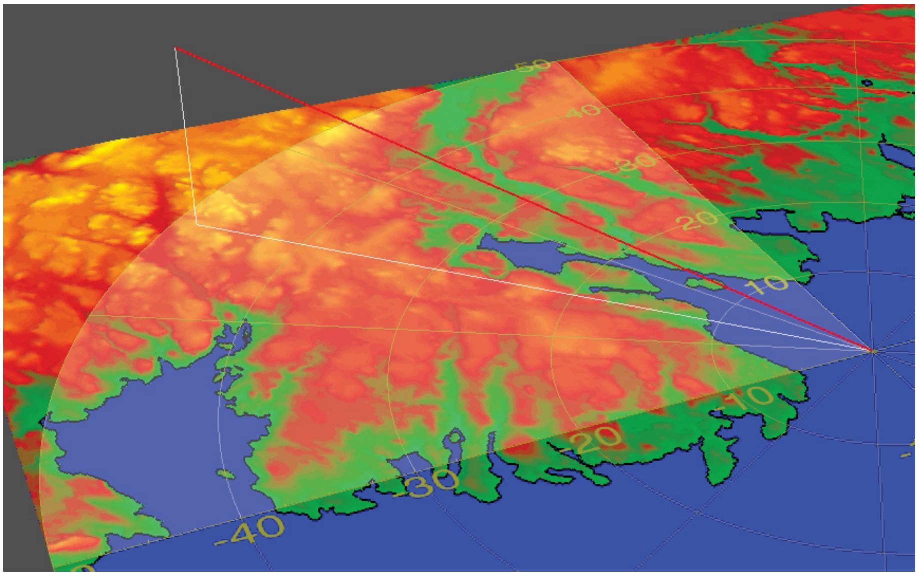


Figure 43: Azimuth Scan Region and Antenna Boresight Display

The image shown in Figure 43 corresponds to the default azimuth scan and antenna boresight values in the RPC panel. The initial azimuth angle is 270° and the azimuth extent of scan is 90°. The antenna boresight azimuth angle is 315° and the boresight elevation angle is 75°. These values agree with the image shown in the above figure.

MiDLE will update the view when these values are changed in the Radar Parameters Control panel and the APPLY button is pressed.

It is important to define these parameters accurately as currently MiDLE does not do extensive error checking. For example, when a new set of waypoints is defined, the user must make sure that the missile trajectory lies within the region scanned by the radar. It is also important to set the antenna boresight closer to the middle of the scan region. The graphic presentation of data by MiDLE helps to assure that these conditions are avoided.

6.2.4.3 Terrain Display Control

The terrain display control is used to manipulate the following quantities in the view:

- Elevation
  - Enable
  - Colours
  - Type (Filled or Lined)
  - Exaggeration (None, 2x, 5x, 10x)
- Coastline

  - Enable
- Landcover
  - Enable

MiDLE displays terrain elevation data when it is launched. By default IDL colour table #4 (Blue-Green-Red-Yellow) is used to contour elevation data to 30 different levels. The user can change the colour table used and the colour mapping by clicking on the 'Colours' button. This opens the Contour Colours Selection (CCS) panel shown in Figure 44.

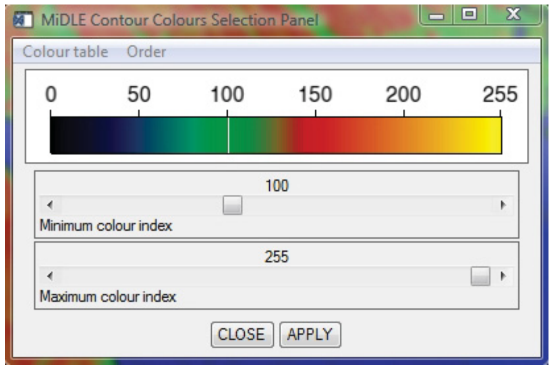


Figure 44: Contour Colours Selection Panel

Colour indices 100 (green) to yellow (255) are mapped to 30 different elevation levels. The colour spectrum can be increased to map the entire colour range (blue to yellow) by moving the Minimum Colour Index slider all the way to the left. The Minimum Colour Index slider can however be moved only to index 226 towards the right because there has to be a minimum of 30 contour colours.
Clicking on the 'Colour table' menu button offers the following colour selections:

0:	Black-White Linear	11:	Blue-Red
1:	Blue-White Linear	13:	Rainbow
2:	Green-Red-Blue-White	16:	Haze
3:	Red Temperature	17:	Blue-Paste-Red
4:	Blue-Green-Red-Yellow (default)	25:	Mac Style
5:	Standard Gamma-II	29:	Nature
6:	Prism	33:	Blue-Red 2
7:	Red-Purple	34:	Rainbow 2
8:	Green-White Linear	36:	Volcano
9:	Green-White Exponential		
10:	Green-Pink		

The list above are standard IDL colour table numbers and names. The image shown in Figure 45 was generated using colour table #16 (Haze) with indices 100 to 255. The order of the indices was also reversed using the 'Order' menu.

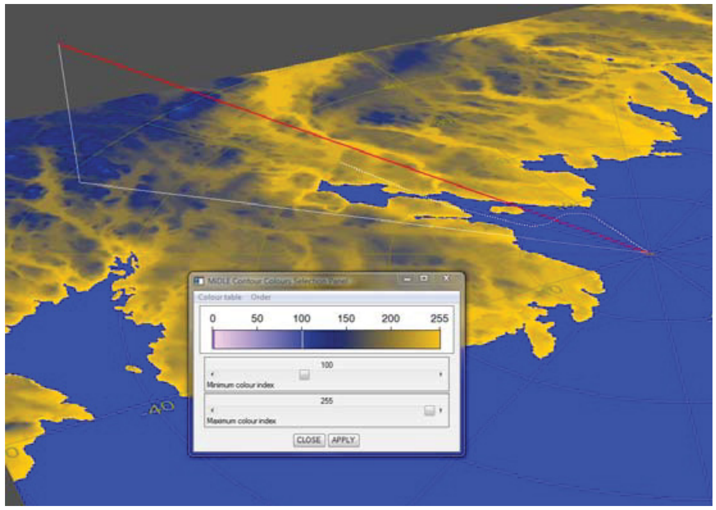


Figure 45: Filled Terrain Elevation Contour Using Colour Table 16

The terrain elevation contour shown by default is a 'filled' type, however this can be changed to a 'lined' contour. This is shown in the next Figure 46. Displaying a lined elevation contour is useful in certain applications, for example when the view needs to be de-cluttered but still show terrain elevation information.

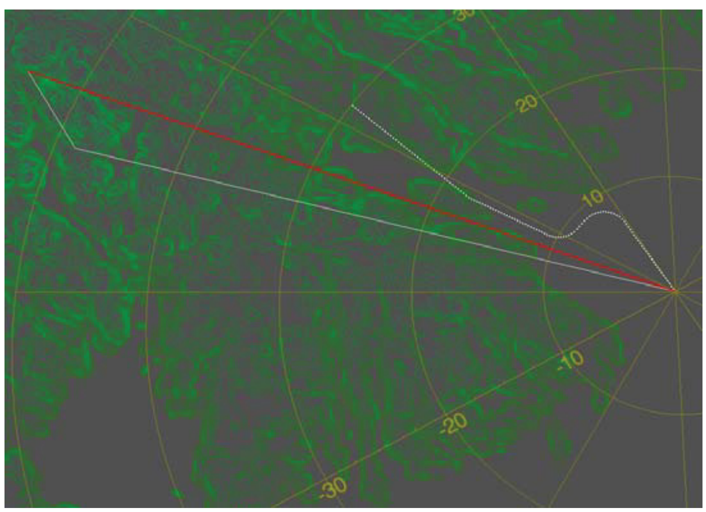


Figure 46: Lined Terrain Elevation Contour

MiDLE displays colour-coded terrain elevation data as shown in the previous figures. The terrain elevation data can be exaggerated (multiplied) by factors of 2, 5 and 10 by selecting *Display->Terrain->Elevation->Exaggeration*. This feature is for visually emphasizing terrain elevation and is useful in certain applications. Figure 47 below shows an example of a 10x exaggerated view with the coastline disabled.

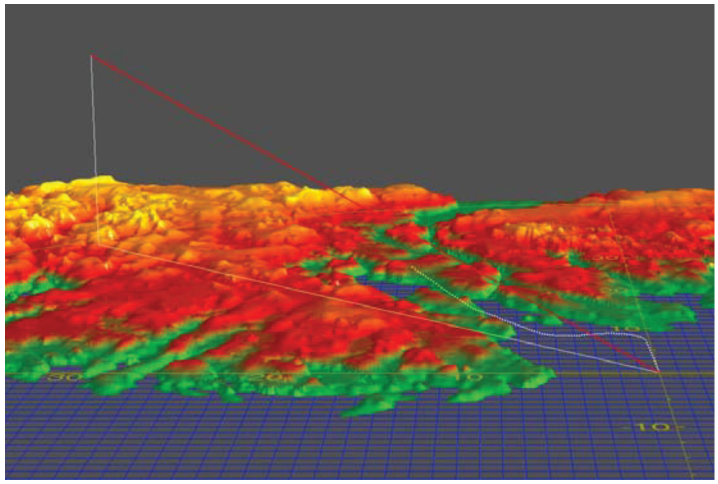


Figure 47: View with Exaggerated Terrain Elevation

Normally MiDLE displays terrain elevation in the view. If the user selects *Display->Terrain->Landcover->Enable* the terrain type data is displayed for the geographical region covered. The terrain type graphics layer is located 'below' the elevation data layer therefore the terrain elevation data should be deselected. Figure 48 is a plan view of the missile trajectory showing land cover data.

If the user clicks anywhere within the view, the system message window displays the following information:

- Landcover type,
- GeoBase landcover code,
- Colour code.

where the landcover type describes the terrain type (e.g. water, developed, forest, etc), the GeoBase landcover code (0 to 233), and the actual red, green and blue primary colour values.

Note that Figure 48 shows the Halifax, Nova Scotia area with the purple colour (code 34) representing built-up or non-vegetated regions.

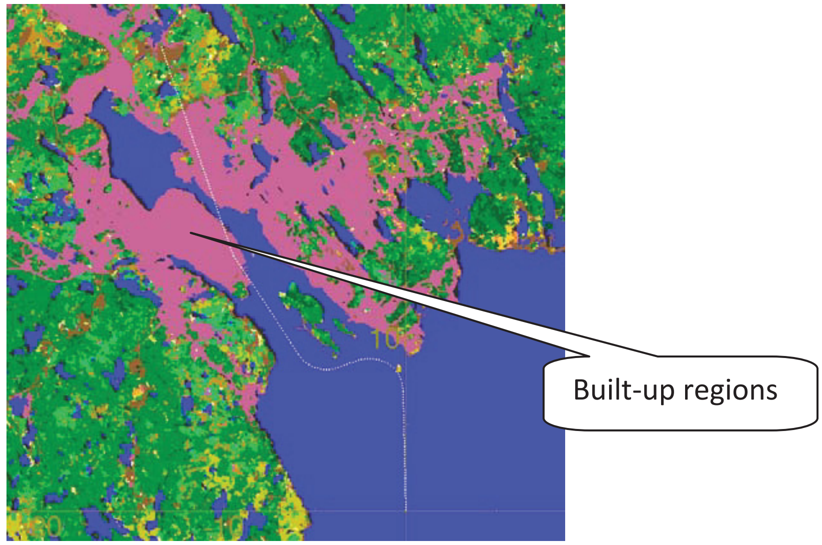


Figure 48: Terrain Landcover Display

Figure 49 shows how both terrain landcover data and terrain elevation data may be visualized. First enable both elevation and landcover displays, select the black-white linear colour table #0 and select lined contour. The view will change as shown below.

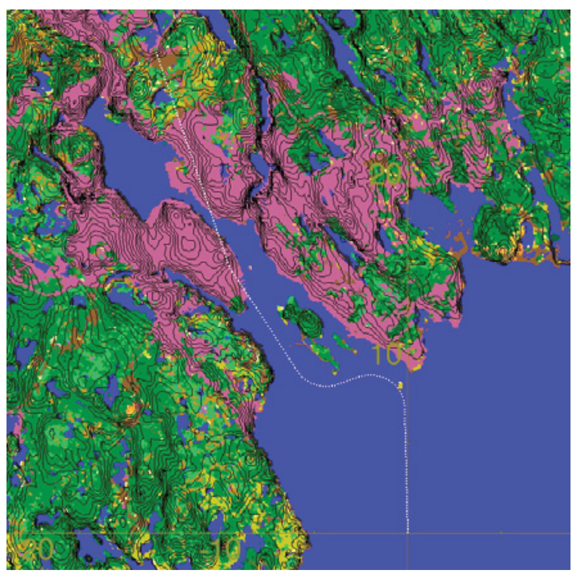


Figure 49: Terrain Landcover with Elevation Contour Lines

6.2.4.4 Ocean Display Control

The lowest graphics layer of the MiDLE GUI is the 'ocean' layer. For certain applications this layer can be disabled by selecting *Display->Ocean->Enable* which toggles this layer on and off. When enabled the 'ocean' surface may be changed to a gridded surface as shown in Figure 50.

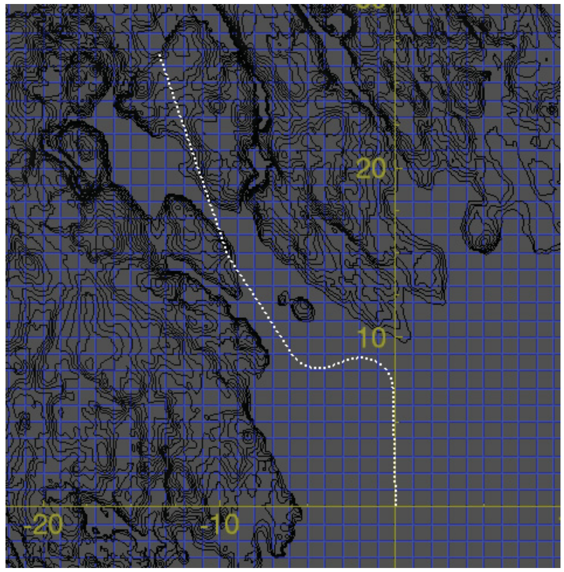


Figure 50: View with Gridded Ocean Surface

In Figure 50 the terrain elevation was set to a lined contour and the range circles and azimuth lines were removed.

6.2.4.5 Symbology Display Control

The MiDLE top-level 'Display' menu contains the 'Symbols' menu which can be used to control how symbology in presented in the view. It consists of the following selections:

- Axis
  - Text
  - Colour
- Grid
  - Lines
  - Circles
  - Colour
- Cursor
  - Colour

The purpose of these controls is essentially to de-clutter the display by removing the axis text, the grid lines and circles or changing their colours.

The cursor cannot be removed and only its colour may be changed. Clicking anywhere within the view region displays the elevation of the point in meters, its range from the radar in kilometers, its bearing from the radar in degrees, and its longitude and latitude position as shown in Figure 51.

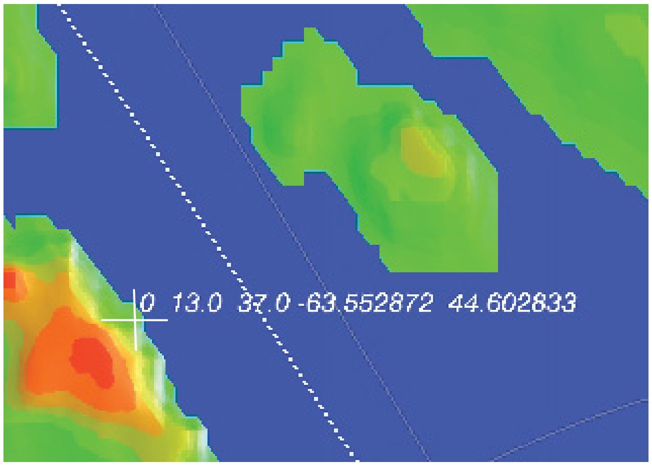


Figure 51: The Cursor Display

Clicking anywhere within the view then holding down the <Ctrl> key and clicking again at a different location displays the distance separating the two points in meters, as illustrated in Figure 52.

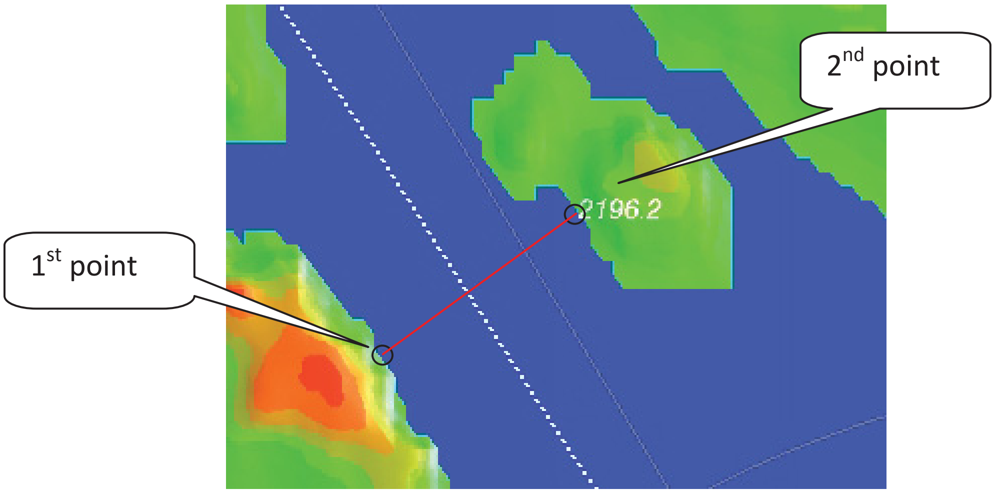


Figure 52: Displaying Distance Between Two Points

6.2.4.6 Background Display Control

The background display controls enables changing the view background colour from the default gray to either black, white or blue to create a different visual effect.

6.2.4.7 Visibility Display Control

The visibility display control setting is 'Unlimited' by default. To create different visual effects, the visibility can be decreased to 75, 50, 25 or 0 percent. In Figure 52 a white background was selected with 25% visibility. Range circles and azimuth lines were removed for clarity. The missile path from its launch position to the target is clearly visible.

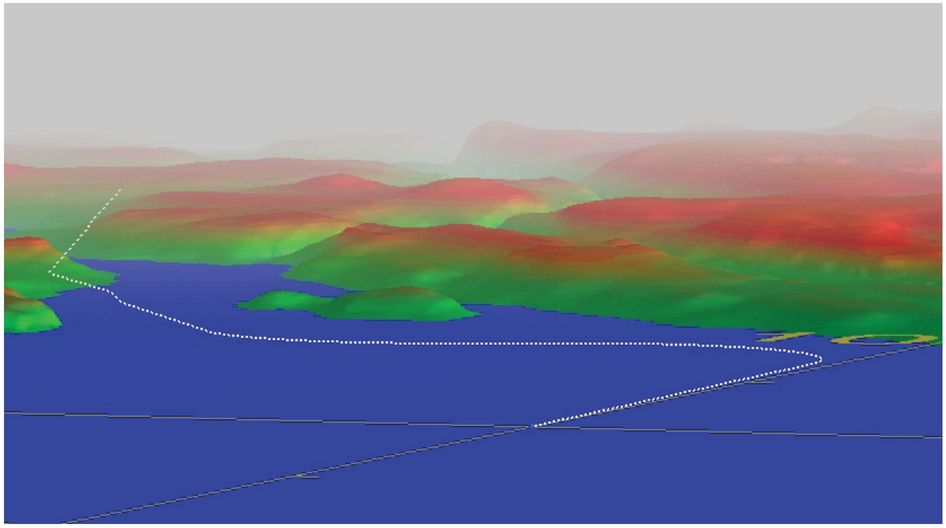


Figure 53: Background Colour and Visibility Use Example

6.2.4.8 Platform Display Control

The default radar platform used by MiDLE is the Halifax-class Canadian Patrol Frigate (CPF) equipped with the Sea Giraffe and AN/SPS-49 radars. Using the GUI zoom controls (right mouse button click in the upper view area or '+' on the numerical keypad) the ship is displayed as shown in Figures 54 and 55. The radar azimuth scan region is visible.

MiDLE is able to display models of other platforms but these have been disabled. The radar platform used is always the Canadian Patrol Frigate.

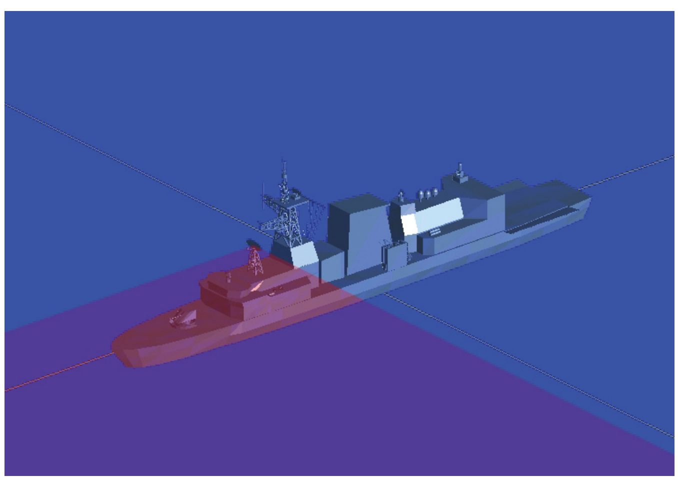


Figure 54: The CPF Radar Platform

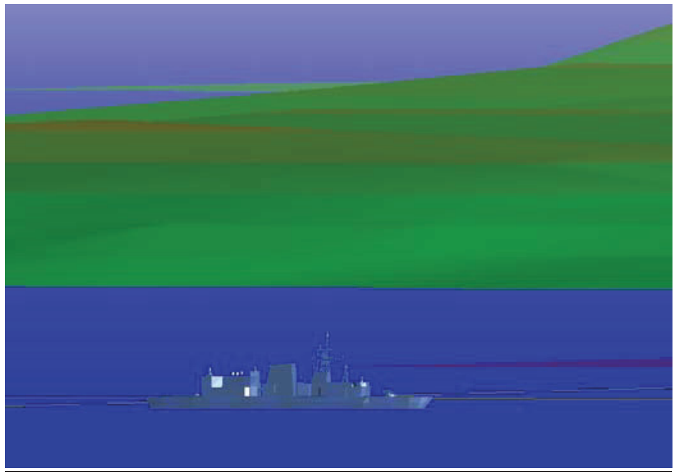


Figure 55: Radar Platform Showing Azimuth Scan Region

6.2.4.9 Detection Display Control

MiDLE calculates the probability of detecting a threat in the littoral environment and displays this data in the view after execution is complete. The visual display of the probability of detection is only to give the user qualitative information. More precise, quantitative data can be generated in the form of plots as shown later.

In the example shown in Figure 56 the dwell probability of detection is superimposed on the missile trajectory as detection lines. These lines are proportional in height to the probability of detection at a given point along the missile trajectory. Lines which exceed the detection threshold are coloured red. (The detection threshold is specified in the CPC panel). Selecting *Display->Detection->Enable* toggles the detection lines on and off. This control is only enabled after MiDLE runs and the probability of detection values have been calculated for a given scenario.

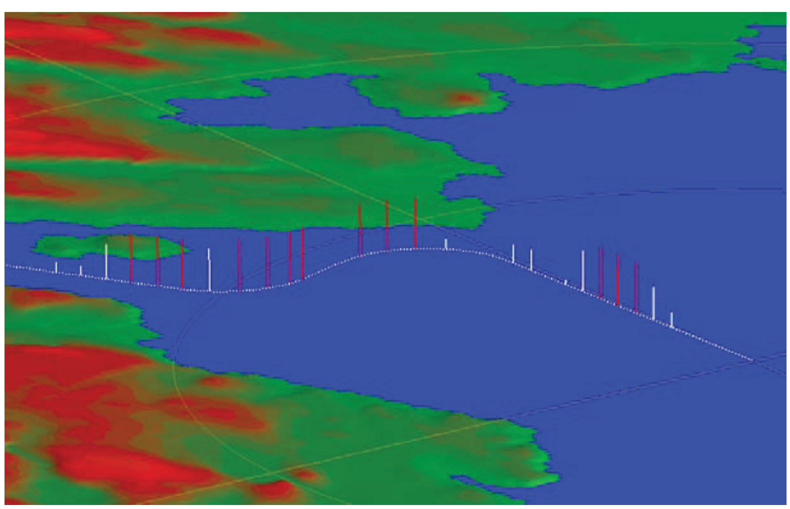


Figure 56: Missile Trajectory with Superimposed Detection Lines

6.2.4.10 Overlay Display Control

MiDLE can overlay the following quantities on the view:

- Surface clutter power,
- Weather clutter power,
- Surface reflectivity,
- Reflectivity factor,
- Wave height,
- Duct height.

The graphics surfaces of these quantities can be overlaid on the MiDLE view by selecting *Display->Overlay*, whereby the selected quantity's button becomes checked. Selecting the same quantity again removes it from the view and the button is un-checked. Only a single quantity can be viewed at any given time. Selecting another quantity removes the existing one and displays the one specified.

6.2.4.10.1 Surface Clutter Power Overlay

Figure 57 shows the surface clutter power overlay and its corresponding colourbar. The program requests the burst number from the user before the overlay is generated. The surface clutter power overlay is not completely opaque and gives a hint of the underlying terrain features. If the underlying terrain elevation is not required it can be disabled by selecting
Display->Terrain->Elevation->Enable which toggles it on and off.

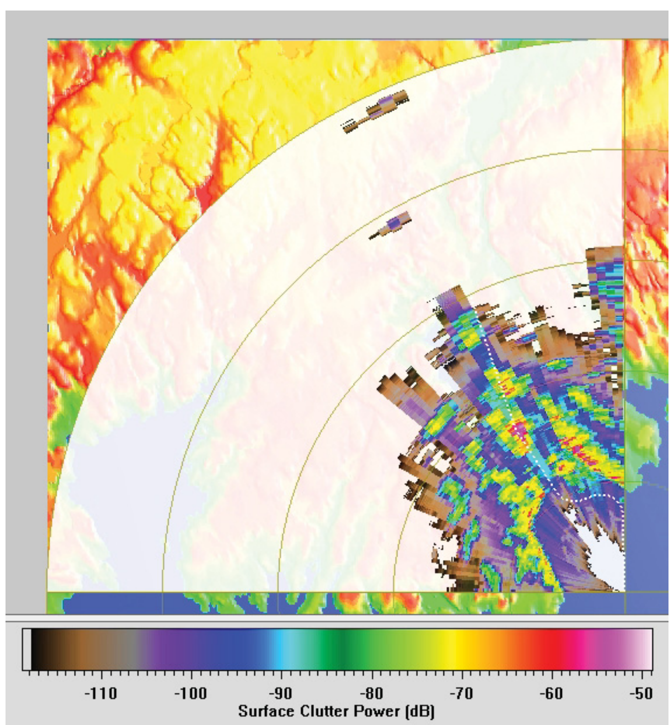


Figure 57: Surface Clutter Power Overlay

6.2.4.10.2 Weather Clutter Power Overlay

MiDLE only calculates the weather clutter power if it is explicitly specified in the Program Execution Control panel. When the user requests the weather clutter power overlay the program informs the user of this and can optionally generate the overlay using existing data (e.g. from the *WeatherClutter_nC_default.dat* file). The burst number for which the overlay is to be generated is obtained from the user.

Figure 58 shows an example weather clutter power overlay and its corresponding colourbar. In this figure the terrain elevation data has been deliberately disabled to clarify the image.

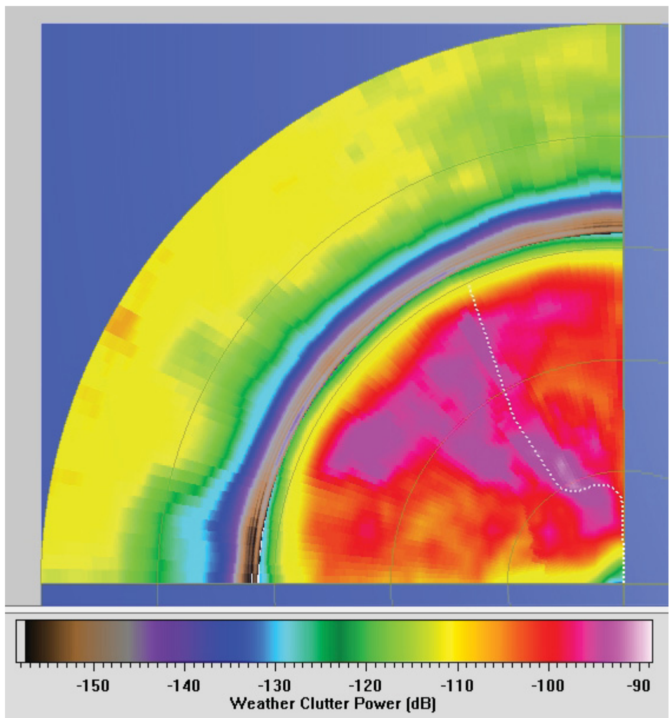


Figure 58: Weather Clutter Power Overlay

6.2.4.10.3 Surface Reflectivity Overlay

For the surface reflectivity overlay the program first obtains the burst number from the user as for the surface and weather clutter power overlays. Figure 59 shows an example surface reflectivity overlay for burst #0 with its corresponding colourbar. In this image the ground elevation details have been disabled to clarify the view. Note that in this case the region covered extends past the radar scan region.

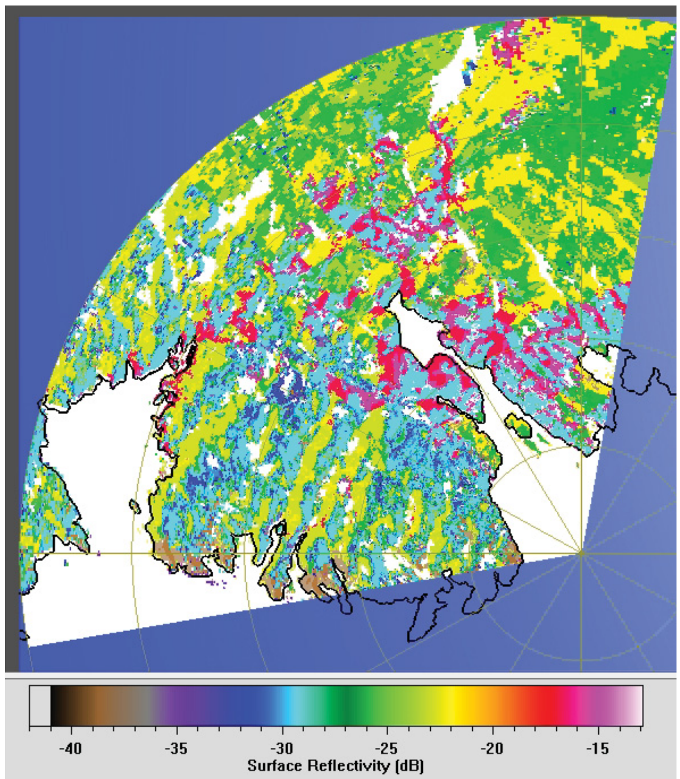


Figure 59: Surface Reflectivity Overlay

6.2.4.10.4 Reflectivity Factor Overlay

Clicking on *Display->Overlay->Reflectivity factor* opens a file dialog box showing the contents of the DATA directory. The following metafiles can be selected:

- *CAPPI1,
- *CAPPI4,
- *ECHOTOP,
- *PRECIP

Figure 60 shows the overlay generated for the *PRECIP file and its corresponding colourbar. The ground elevation details have been disabled to clarify the view.

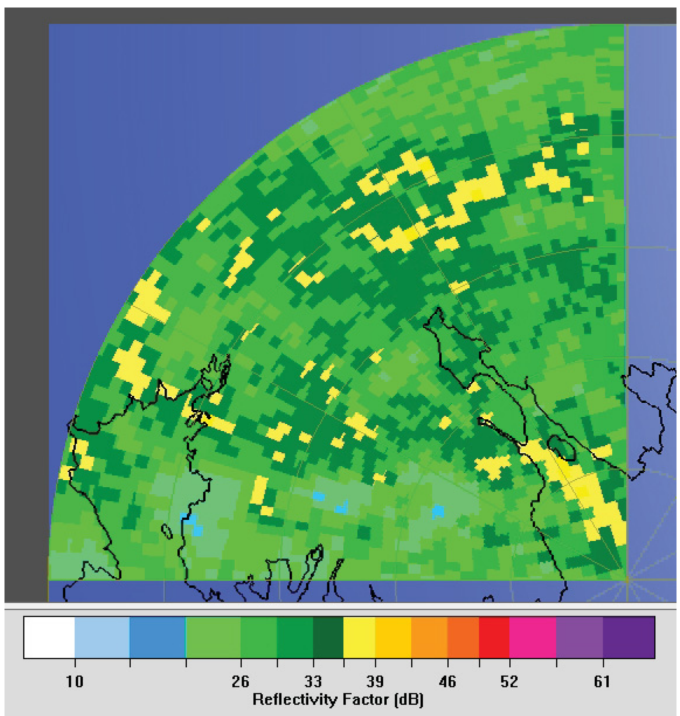


Figure 60: Reflectivity Factor Overlay

6.2.4.10.5 Wave Height Overlay

The wave height overlay is shown in Figure 61. In this figure the view was zoomed in to show more detail of the area of interest. The terrain elevation, coastline and ocean features have been disabled for clarity.

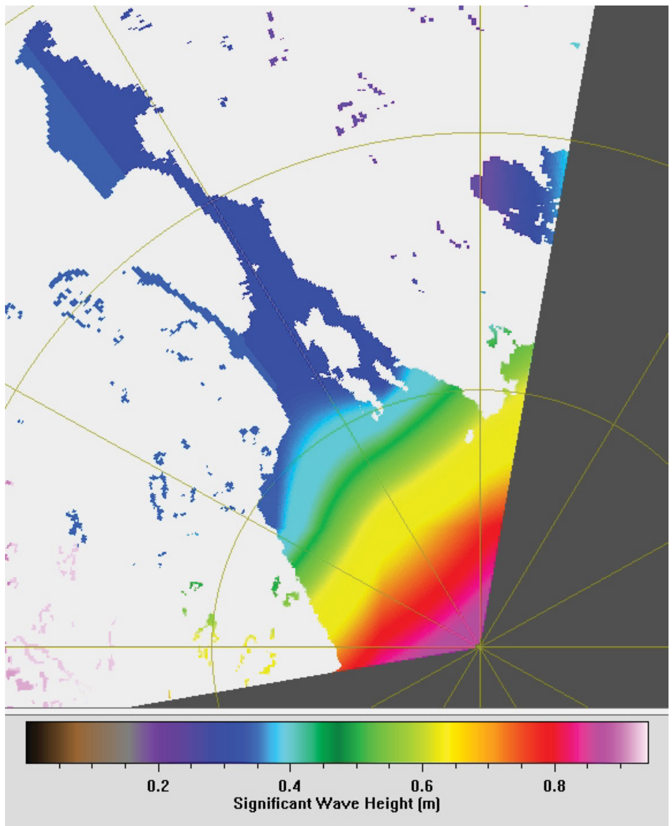


Figure 61: Wave Height Overlay

6.2.4.10.6 Duct Height Overlay

The duct height overlay is shown in Figure 62. As for the wave height overlay, the view was zoomed in to show more detail of the area of interest. The terrain elevation, coastline and ocean features have been disabled for clarity.

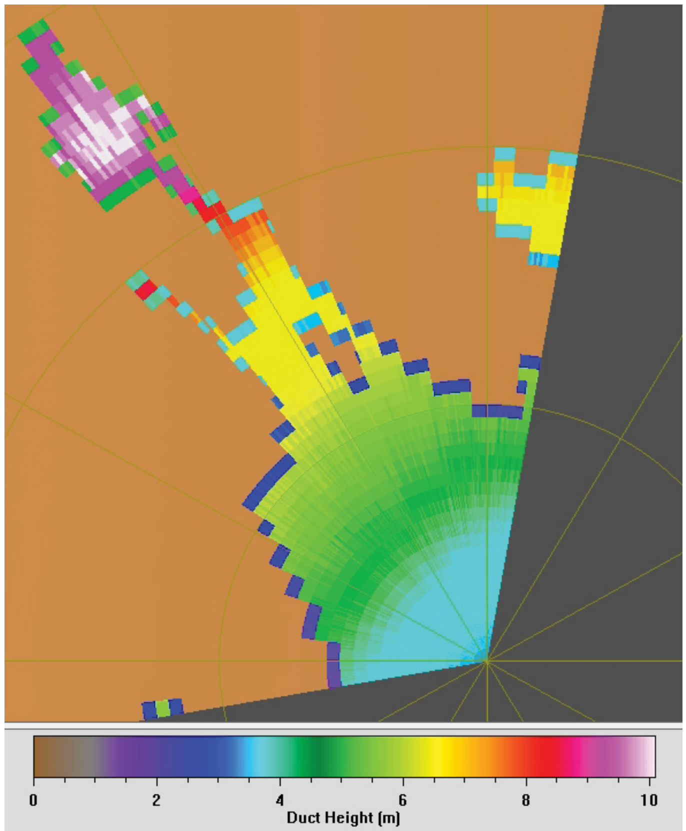


Figure 62: Duct Height Overlay

6.2.5 The Plot Menu

The top level 'Plot' menu is for the generation of plots (graphs) of various quantities calculated by MiDLE. These include:

- Missile properties,
- Missile propagation factor,
- Power received from missile,
- Surface propagation factor,
- Surface clutter,
- Probability of detection,
- Wave direction,
- Wind velocity,
- Swell direction.

MiDLE always uses as input the results of the latest calculations when generating plots. These results are stored in the *MissilePath_<mod>_PlotQty.dat* file, where 'mod' is a filename modifier. This file contains all necessary quantities to generate the plots. The following sections feature example plots generated using data from the *MissilePath_default_PlotQty.dat* file.

6.2.5.1 Missile Properties Plot

The example missile properties plot is shown in Figure 63. This plot is actually a compound plot containing five distinct missile properties:

- Range (kilometers),
- Azimuth (degrees),
- Height (meters),
- Radial velocity (ms^{-1}),
- RCS (dB).

The missile properties plot first appears minimized when opened but can be expanded to show individual plots. The 'Control' menu offers various choices to view the plots including changing the background colour. Plots of previous results can be plotted using the 'Load' button. The plot image can be saved as an encapsulated PostScript file using the 'Save' button for importing into documents. The 'Save' button opens a file dialog box where the file path and name can be specified. By default the image is saved to the OUTPUT directory as a type **.eps* file.

Figure 63 shows an example missile properties plot. The missile properties plots are always generated as property vs. time plots.

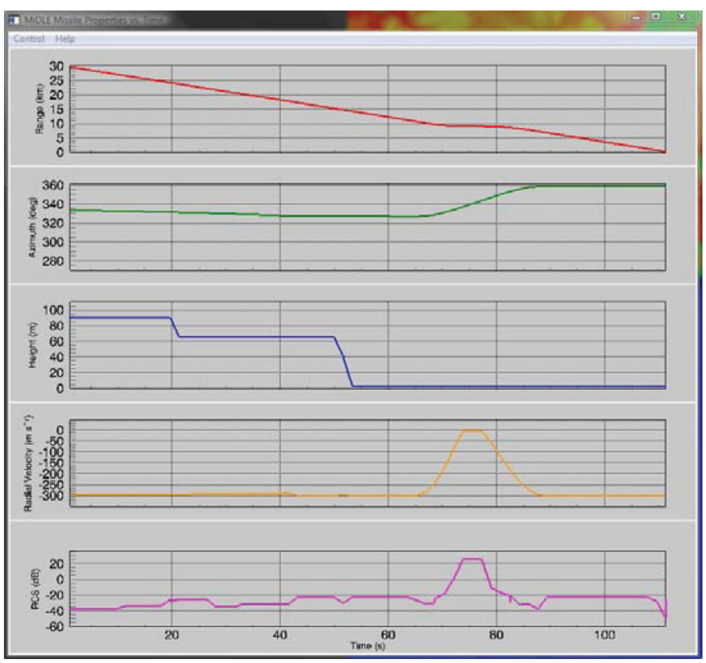


Figure 63: Missile Properties Plot

6.2.5.2 Missile Propagation Factor Plot

The plot of the missile propagation factor (PF) is shown in Figure 64. For the default case the radar uses four bursts. The propagation factor calculated by MiDLE for each burst are shown. Up to a maximum of 20-bursts can be plotted.

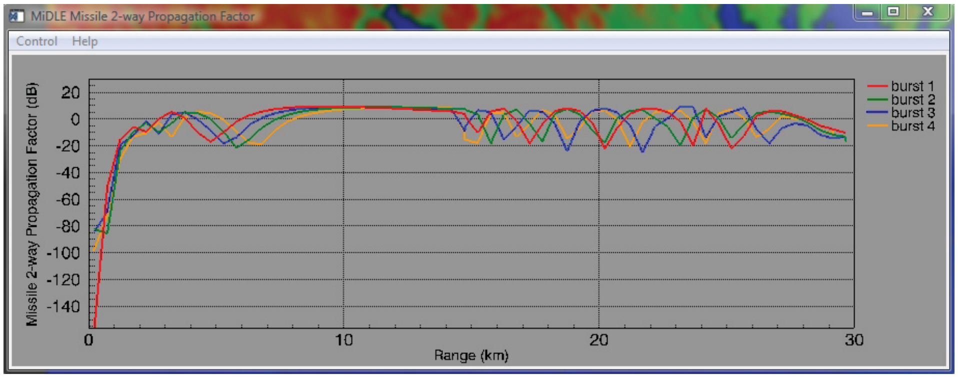


Figure 64: Missile Propagation Factor vs. Range Plot

The missile propagation factor 'Control' menu contains the following buttons to control how the data is plotted:

- Exit,
- Clear,
- Reset,
- Burst,
- Abscissa,
- Background,
- Axes,
- Load,
- Save.

The 'Exit' button simply closes the plot window and the 'Clear' button clears it. The 'Reset' button re-loads the initial plots when the window was first opened. The 'Burst' button allows individual bursts to be plotted at-a-time. The 'Abscissa' button enables selection between missile PF vs. range and missile PF vs. time plots. The 'Background' button offers a choice of three different background colours. The 'Axes' button is used to control the range of the x and y axes.

Figure 65 shows an example missile PF plot vs. time plot. In this plot the x and y axes were adjusted to view the data in the 0 to 60 second range.

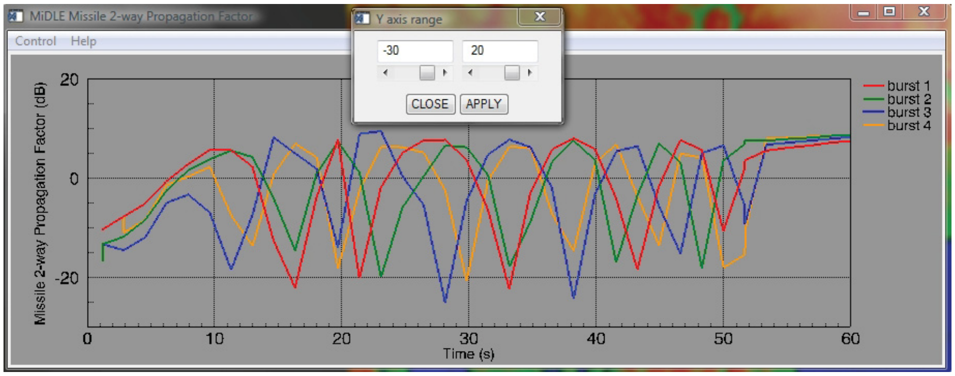


Figure 65: Missile Propagation Factor vs. Time Plot

Missile PF values from previous calculation results can be plotted using the 'Load' button. This opens a file dialog box where the file path and name can be specified. The 'Reset' button must be pressed after new data is loaded.

The plot can be saved to an encapsulated PostScript file using the 'Save' button.

6.2.5.3 Power Received From Missile Plot

The plot of the power received from missile (PRM) is shown in Figure 66. For the default case the radar uses four bursts. The received missile power calculated by MiDLE for each burst are shown. Up to a maximum of 20-bursts can be plotted.

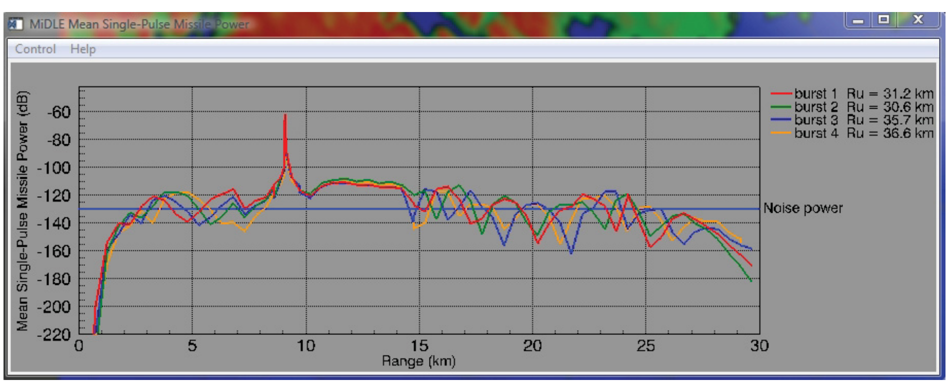


Figure 66: Received Missile Power vs. Range Plot

The power received from missile 'Control' menu contains the following buttons to control how the data is plotted:

- Exit,
- Clear,
- Reset,
- Burst,
- Abscissa,

- Background,
- Axes,
- Load,
- Save.

The 'Exit' button simply closes the plot window and the 'Clear' button clears it. The 'Reset' button re-loads the initial plots when the window was first opened. The 'Burst' button allows individual bursts to be plotted at-a-time. The 'Abscissa' button enables selection between received missile power vs. range and received missile power vs. time plots. The 'Background' button offers a choice of three background colours. The 'Axes' button is used to control the range of the x and y axes.

Figure 67 shows an example received missile power plot vs. time plot. In this plot the x and y axes were adjusted to view the data in the 60 to 110 second range.

Received missile power values from previous calculation results can be plotted using the 'Load' button. This opens a file dialog box where the path and filename can be specified. The 'Reset' button must be pressed after new data is loaded.

The plot can be saved to an encapsulated PostScript file using the 'Save' button.

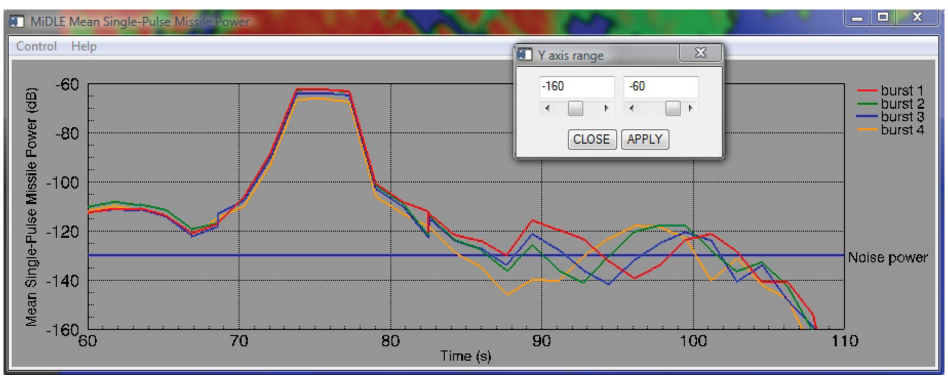


Figure 67: Received Missile Power vs. Time Plot

6.2.5.4 Surface Propagation Factor Plot

The plot of the surface propagation factor (SF4) vs. range is shown in Figure 68. For the default case the radar uses four bursts and 295 beams. The SF4 calculated by MiDLE for each burst are shown for beam #0. Up to a maximum of 20-bursts can be plotted.

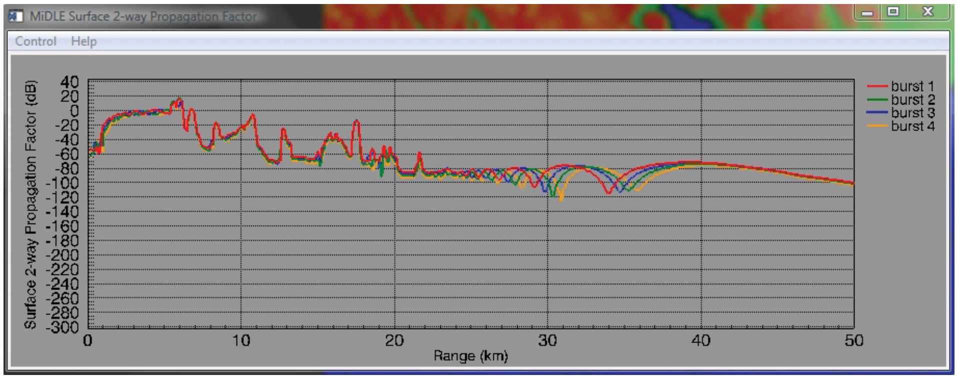


Figure 68: Surface Propagation Factor vs. Range Plot

The surface propagation factor 'Control' menu contains the following buttons to control how the data is plotted:

- Exit,
- Clear,
- Reset,
- Burst,
- Beam,
- Abscissa,
- Background,
- Axes,
- Load,
- Save.

The 'Exit' button simply closes the plot window and the 'Clear' button clears it. The 'Reset' button re-loads the initial plots when the window was first opened. The 'Burst' button allows individual bursts to be plotted at-a-time. The 'Abscissa' button enables selection between surface propagation factor vs. range and surface propagation factor vs. time plots. The 'Background' button offers a choice of three background colours. The 'Axes' button is used to control the range of the x and y axes.

For the SF4 vs. range case the 'Beam' button is sensitized and the user can generate plots for individual beams. A total of 296 beams can be plotted for the default scenario. For the surface PF vs. time case however this button is desensitized as the PF values are plotted with respect to the missile.

Figure 69 below shows the SF4 vs. time plot.

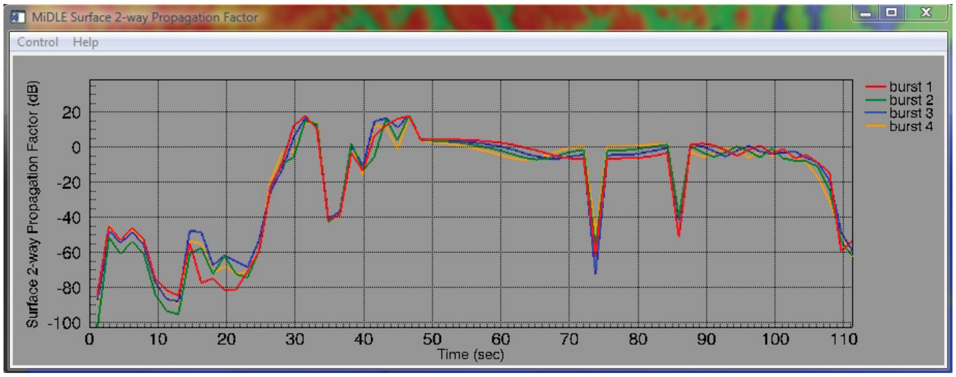


Figure 69: Surface Propagation Factor vs. Time Plot

Surface propagation factor values from previous calculation results can be plotted using the 'Load' button. This opens a file dialog box where the file path and name can be specified. The 'Reset' button must be pressed after new data is loaded.

The plot can be saved to an encapsulated PostScript file using the 'Save' button.

6.2.5.5 Surface Clutter Power Plot

The plot of the surface clutter power (SCP) vs. range is shown in Figure 70. For the default case the radar uses four bursts and 61 missile illuminating beams within the azimuth scan. The SCP calculated by MiDLE for each burst is shown for beam #0. Up to a maximum of 20-bursts can be plotted. The plot also displays the saturation and noise power levels as reference.

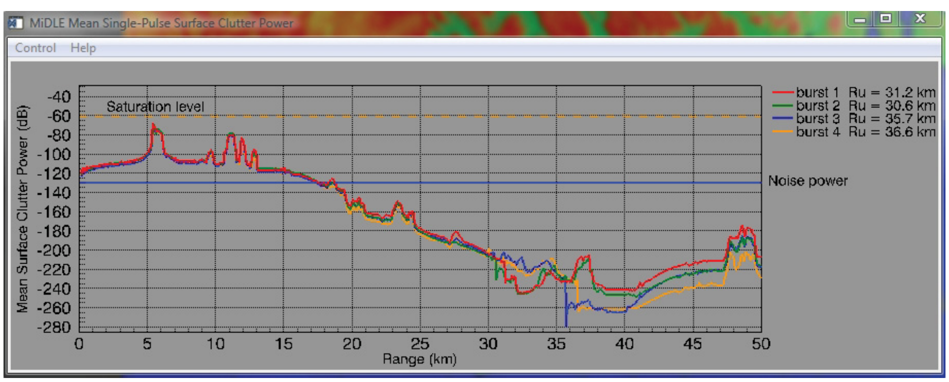


Figure 70: Surface Clutter Power vs. Range Plot

The surface clutter power 'Control' menu contains the following buttons to control how the data is plotted:

- Exit,
- Clear,
- Reset,
- Burst,

- Beam,
- Missile path,
- Abscissa,
- Background,
- Axes,
- Load,
- Save.

The 'Exit' button simply closes the plot window and the 'Clear' button clears it except for the saturation and noise power levels. The 'Reset' button re-loads the initial plots when the window was first opened. The 'Burst' button allows individual bursts to be plotted at-a-time. The 'Abscissa' button enables selection between surface clutter power vs. range and surface clutter power vs. time plots. If the 'Abscissa' button is changed to 'Time', the 'Missile path' button becomes checked as the SCP vs. time is plotted with respect to the missile along all beams.

The 'Background' button offers a choice of three different background colours. The 'Axes' button is used to control the range of the x and y axes.

If the 'Beam' button is selected, the display reverts back to the SCP vs. range plot. Selecting 'Missile path' allows for the generation of either SCP vs. range or SCP vs. time plots along the missile path. Figures 71 and 72 show example plots of each of these quantities.

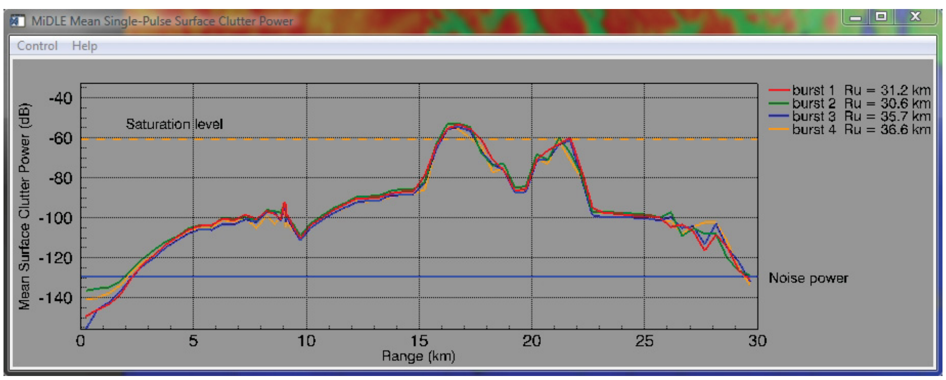


Figure 71: Surface Clutter Power Along Missile Path vs. Range Plot

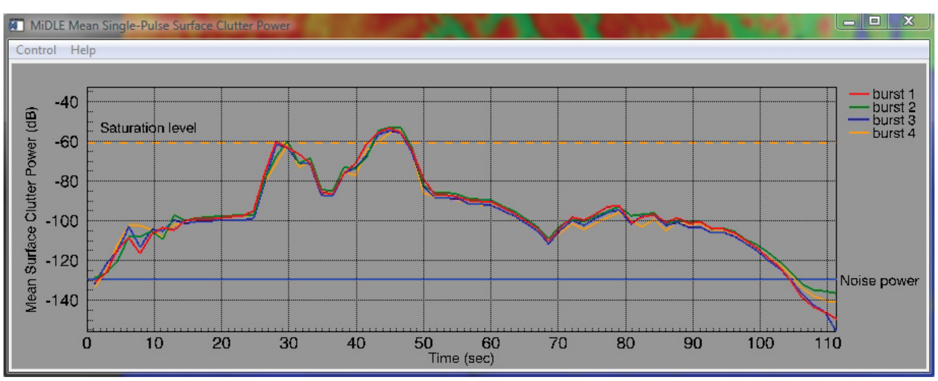


Figure 72: Surface Clutter Power Along Missile Path vs. Time Plot

Surface clutter power values from previous calculation results can be plotted using the 'Load' button. This opens a file dialog box where the file path and name can be specified. The 'Reset' button must be pressed after new data is loaded.

The plot can be saved to an encapsulated PostScript file using the 'Save' button.

6.2.5.6 Probability of Detection Plot

The plot of probability of detection (PD) vs. range is shown in Figure 73. The plot shows the PD values for each of the four colour coded bursts plus the dwell probability of detection (shown in black).

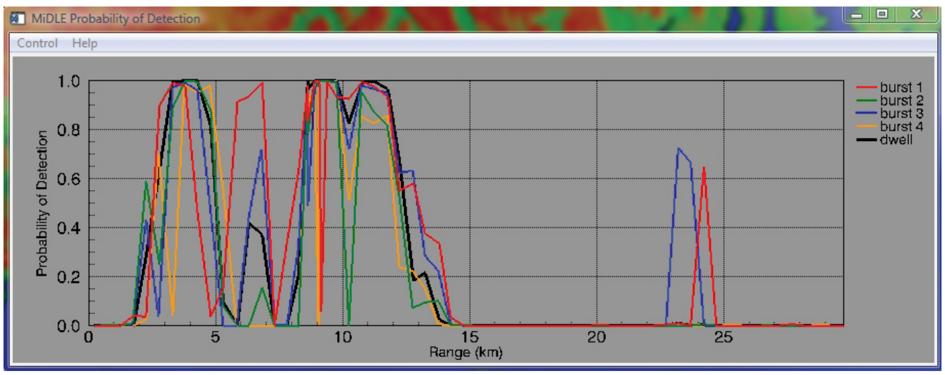


Figure 73: Probability of Detection vs. Range Plot

The probability of detection 'Control' menu contains the following buttons to control how the data is plotted:

- Exit,
- Clear,
- Reset,
- Burst,
- Abscissa,
- Background,
- Axes,
- Load,
- Save.

The 'Exit' button simply closes the plot window and the 'Clear' button clears it. The 'Reset' button re-loads the initial plots when the window was first opened. The 'Burst' button allows individual bursts to be plotted at-a-time as well as the dwell. The 'Abscissa' button enables selection between PD vs. range and PD vs. time plots. The 'Background' button offers a choice of three different background colours. The 'Axes' button is used to control the range of the x and y axes.

Probability of detection values from previous calculation results can be plotted using the 'Load' button. This opens a file dialog box where the file path and name can be specified. The 'Reset' button must be pressed after new data is loaded.

The plot can be saved to an encapsulated PostScript file using the 'Save' button. The dwell probability of detection vs. time plot is shown in Figure 74. When this figure is compared to Figure 56 (missile trajectory with superimposed detection lines) the correspondence between the quantitative and qualitative data can be observed.

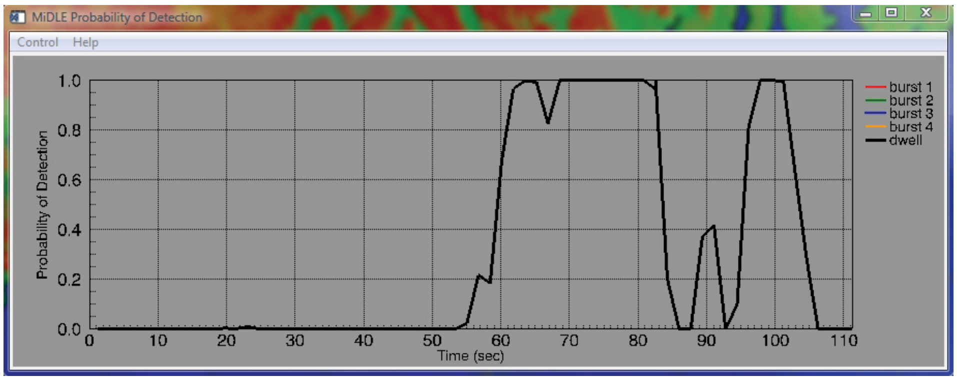


Figure 74: Dwell Probability of Detection vs. Time Plot

6.2.5.7 Wave Direction Plot

The plot of the wave direction is shown in Figure 75. The plot shows wave direction for both inland and ocean water regions. The 'Control' menu enables the image to be saved to an encapsulated PostScript file.

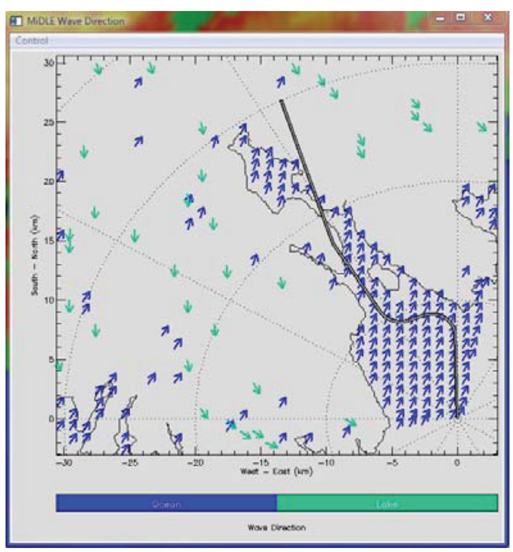


Figure 75: Wave Direction Plot

6.2.5.8 Wind Velocity Plot

The plot of the wind velocity is shown in Figure 76.

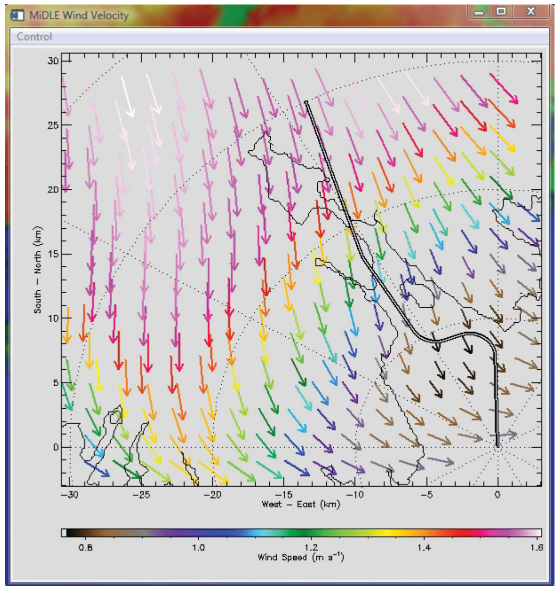


Figure 76: Wind Velocity Plot

6.2.5.9 Swell Direction Plot

The plot of the swell direction is shown in Figure 77.

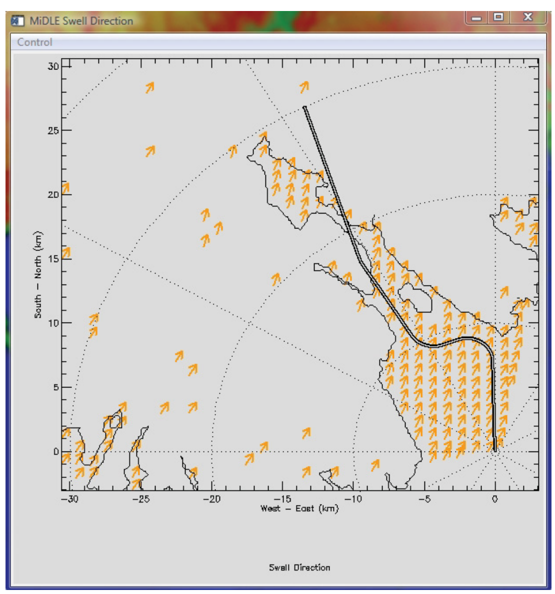


Figure 77: Swell Direction Plot

6.3 Program Execution Flow

When MiDLE is executed using *Program->Start*, its execution flow is determined by the user defined settings of the Program Execution Control panel. The flow diagram shown on the next few pages charts the sequence of program execution.

MiDLE first executes the *define.pro* procedure where all of the default parameters are set. These parameters are stored into structures (e.g. rad, env con, etc.) that are accessed by the program on a continuous basis. These structures are used by the various algorithms that perform calculations. MiDLE also executes the *common_defs.pro* procedure where all of the global variables are defined. These global variables are used mainly to control the GUI.

The main program is *MiDLE.pro*. If MiDLE was set to diagnostic mode it calls the *DiagnosticDisplay* procedure. This opens a window that blocks program execution until the user closes it. The window displays the contents of the various structures used. In diagnostic mode MiDLE updates the *diagnostic.log* file which can be inspected later.

6.3.1 Missile / Projectile Trajectory Calculation

Next the target type is determined. If the target type is 'Missile' and 'restore' was set for the trajectory then the program looks for the *MissilePath_<mod>.dat* file where 'mod' is the file modifier. If this file is not found then the program will restore the trajectory data from the *MissilePath_default.dat* file. The default trajectory file should always exist in the OUTPUT directory unless it was accidentally deleted. In this case the program will issue a warning and stop processing. Note that MiDLE still remains active and the user can access all of the program controls. If 'execute' was set for the missile trajectory, the program calls the *CircleSmooth* procedure to calculate the trajectory data. The trajectory data is saved in the *MissilePath_<mod>.dat* file.

The 'Projectile' target type case is treated similarly. If 'execute' was specified the program calls the *Ballistic* procedure to calculate the projectile trajectory. The output variables generated by both *CircleSmooth* and *Ballistic* are:

- rpath,
- phpath,
- thpath,
- vpath,
- max_tta.

At this point MiDLE displays the missile or projectile trajectory which appears in the view as a white dotted line.

If the 'Generate KML' switch was set in the Expert Parameters Control panel, the program will convert the trajectory data into a *.*kml* file for importing into Google Earth. This file is located in the OUTPUT directory.

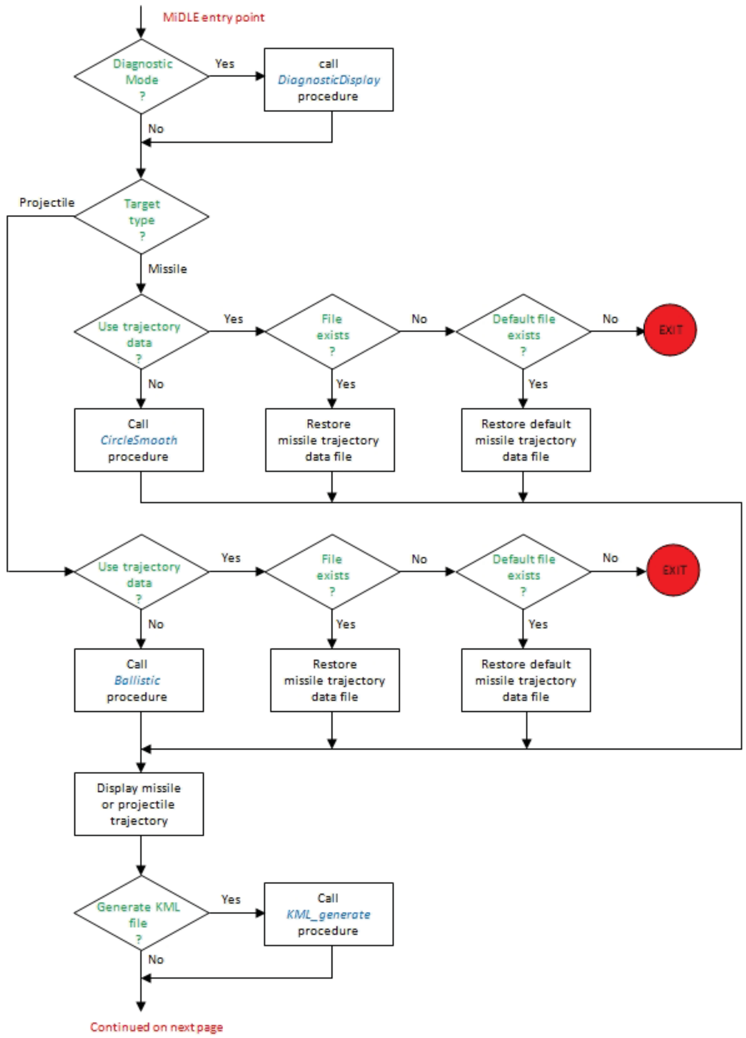


Figure 78a: MiDLE Program Flow Chart

6.3.2 Scanning Characteristics Determination

MiDLE calls the *DefineScan* procedure next to calculate the scanning characteristics. The input variable is:

- phpath.

Output variables generated by *DefineScan* are:

- phba,
- nbeam,
- rcmin,
- rcint,
- kph,
- th3s,
- gfac,

- ph3s,
- APM_antenna_pattern,
- rc,
- nUniqMisbeams,
- UniqMisbeams,
- nq,
- phq,
- nqint,
- MaxBinRange,
- nUniqMisq,
- UniqMisq,
- phASS,
- SLmaxPh,
- kth,
- thASS,
- SLmaxTh,
- ph_antenna_pattern,
- th_antenna_pattern.

6.3.3 Refractivity Profile Calculation

If no HPAC data is available (e.g. HPAC data is zero in the EPC panel), MiDLE uses a single refractivity profile throughout. If HPAC data is available and 'restore' was set in the Program Execution Control panel then the program searches for the *M_<mod>.dat* file where 'mod' is the file modifier. If this file is not found then the program will restore refractivity data from the *M_default.dat* file. The default refractivity file should always exist in the OUTPUT directory unless it was accidentally deleted. In this case the program issues a warning and stops processing. Note that MiDLE remains active and the user can access all of the program controls. If 'execute' was set for refractivity profile calculations, the program calls the *readHPAC_SM* procedure to calculate the data. The output data is saved in the *M_<mod>.dat* file.

The input variables to *readHPAC_SM* are:

- MaxBinRange,
- phq,
- rcint,
- phba,
- th3s,
- hh3s.

Output variables generated by *readHPAC_SM* are:

- GEMnx,
- GEMny,
- WindData,
- Mdata.

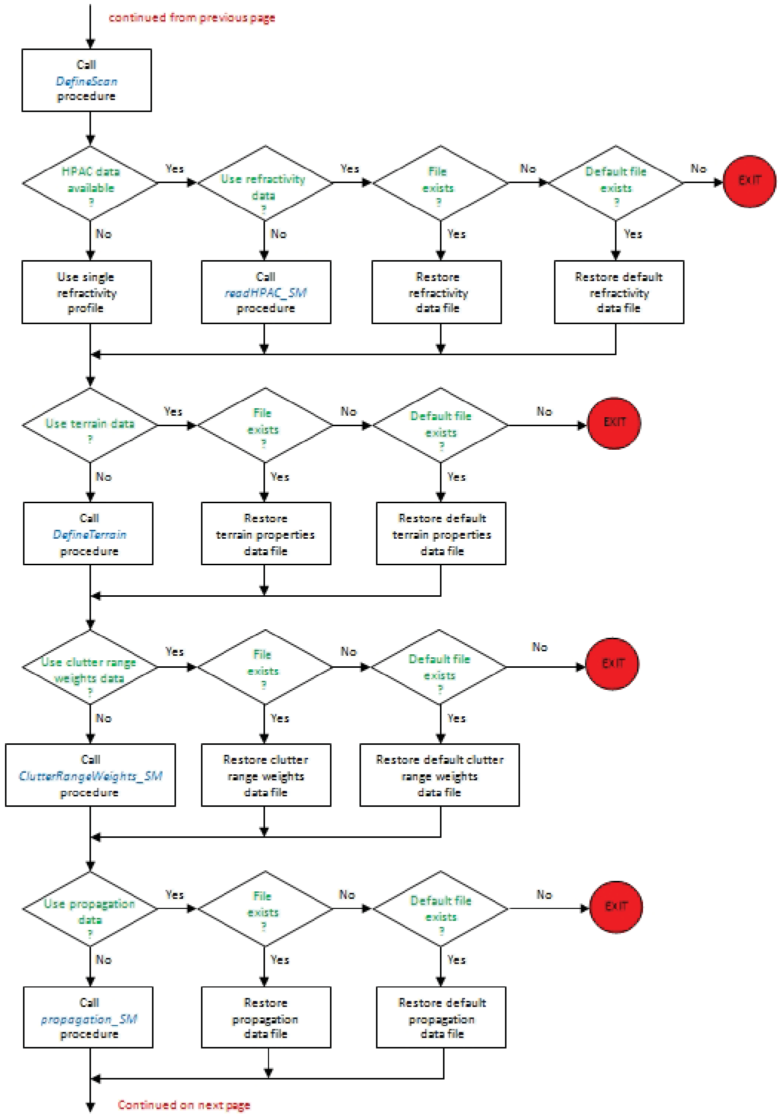


Figure 78b: MiDLE Program Flow Chart (cont'd)

6.3.4 Terrain Properties Determination

The terrain properties are determined next. If 'restore' was set for the terrain in the Program Execution Control panel then the program looks for the *Terrain_<mod>.dat* file where 'mod' is the file modifier. If this file is not found then the program will restore the terrain data from the *Terrain_default.dat* file. The default terrain data file should always exist in the OUTPUT directory unless it was accidentally deleted. In this case the program will issue a warning and stop processing. Note that MiDLE still remains active and the user can access all of the program controls. If 'execute' was set for the terrain properties, the program calls the *DefineTerrain* procedure to calculate the data. The output data is saved in the *Terrain_<mod>.dat* file.

The input variables to *DefineTerrain* are:

- nq,
- phq,
- MaxBinRange,
- WindData,
- rcint.

Output variables generated by *DefineTerrain* are:

- terr,
- hsig.

6.3.4.1 Terrain Elevation Data Processing

The *DefineTerrain* procedure inputs terrain elevation data generated by MiDLE. This data is read from files of type **.el1* or **.el2* contained in the ELDATA subdirectory. MiDLE can process raw DTED or CDED terrain elevation files placed in the ELDATA folder into a format that can be used directly and more efficiently.

The file conversion is performed by the *process_dem* and *process_dtd* procedures. The **.el1* and **.el2* files contain elevation arrays that are joined together by the *read_all_CDED* function as needed to cover the specified range. These procedures automatically compensate for the number of longitudes covered by each raw elevation data file. For example, CDED cells above 68° latitude cover 2° of longitude and above 80° latitude cover 4° of longitude. The conversion procedures therefore generate 2 output files for each input file above 68° latitude and 4 output files above 80° latitude.

Terrain elevation files do not always exist in certain situations. This can happen if a new location is specified for the radar platform and the user has not loaded elevation data files for the region covered. It can also happen if the radar is positioned as shown in Figure 79.

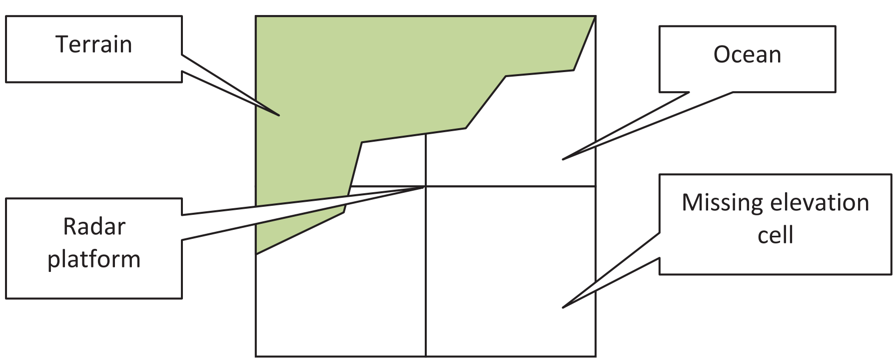


Figure 79: Terrain Elevation Data Processing

The elevation data cell in the bottom right corner of Figure 79 is entirely over water and therefore there is no corresponding elevation data file. MiDLE will detect the missing cell and issue the following message:

```
Terrain elevation data file <filename> was not found.
Zero elevation values will be used assuming that
the cell covers an area that is entirely over water.

Proceed?
```

The user can optionally terminate execution at this point, load the required elevation data files and run MiDLE again. The user can also choose to proceed whereby an elevation value of zero is used throughout for the cell in question.

6.3.4.2 Landcover Type Data Processing

The *DefineTerrain* procedure inputs landcover type data generated by MiDLE. This data is read from files of type **.lc1* or **.lc2* contained in the LCDATA subdirectory. MiDLE can process raw landcover files (shapefiles) placed in the LCDATA folder into a format that can be used directly and more efficiently.

The file conversion is performed by the *process_shapefile3* procedure. The **lc1* and **.lc2* files contain terrain type arrays that are joined together by the program as needed to cover the specified range.

As with terrain elevation data files, in certain situations landcover type files may not exist. This can occur if a new location is specified for the radar platform and the user has not loaded terrain type data files for the region covered. The *read_all_LANDC* function will detect the missing terrain type data cell and issue the following message:

```
Land cover data file <filename> was not found.
Index 20 will be used assuming that
the cell covers an area that is entirely over water.

Proceed?
```

The user can optionally terminate execution at this point, load the required landcover data files and run MiDLE again. The user can also choose to proceed whereby a landcover value of 20 (water) is used throughout for the cell in question.

6.3.5 Clutter Range Weights Calculation

The clutter range weight data is restored or calculated next depending on the setting of the corresponding control in the Program Execution Control panel. If 'restore' was set for the clutter range weights then the program looks for the *ClutterRangeWeights_<mod>.dat* file where 'mod' is the file modifier. If this file is not found then the program will restore the terrain data from the *ClutterRangeWeights_default.dat* file. The default data file should always exist in the OUTPUT directory unless it was accidentally deleted. In this case the program will issue a warning and stop processing. Note that MiDLE still remains active and the user can access all program controls. If 'execute' was set for the terrain properties, the program calls the *ClutterRangeWeights_SM* procedure to calculate the data. The output data is saved in the *ClutterRangeWeights_<mod>.dat* file.

The input variable to *ClutterRangeWeights* is:

- rc,

Output variables generated by *ClutterRangeWeights* are:
- rcRangeFold,
- W2q.

Note that all **_SM* procedures use parallel processing to reduce program execution time and use shared memory (SM) for inter-process communications.

6.3.6 Propagation Factor Calculation

The 2-way surface propagation data is calculated (or restored) next depending on the control settings in the Program Execution Control panel.

If 'restore' was set for the propagation factor, then the program looks for the *ExtractedSurfaceF4_<mod>.dat* file where 'mod' is the file modifier. If this file is not found then the program will restore the terrain data from the *ExtractedSurfaceF4_default.dat* file. The default data file should always exist in the OUTPUT directory unless it was accidentally deleted. In this case the program will issue a warning and stop processing. MiDLE still continues to run and the user can access program controls. If 'execute' was set for the terrain properties, the program calls the *propagation_SM* procedure to calculate the data. The output data is saved in the *ExtractedSurfaceF4_<mod>.dat* file.

The *propagation_SM* procedure spawns child (slave) processes depending on the number of CPUs available on the platform. MiDLE will always use the maximum number of cores available unless this number is changed in the Control Parameters Control panel. The slave processes call the APM DLL to calculate the surface and missile propagation factors and grazing angles. The master process communicates with the slave processes using shared memory. The master will wait (block processing) until all slave processes have successfully completed.

The input variables to *propagation_SM* are:

- th3s,
- ph3s,
- nq,
- APM_antenna_pattern,
- Mdata,
- MaxBinRange,
- rcint,
- max_tta.

Output variables generated by *propagation_SM* are:

- F4th,
- psigr,
- F4th_SO,
- logpsigr_SO.

The propagation calculation results are saved as files in the APM/OUTPUT directory.

6.3.7 Reflectivity Factor Field Calculation

If the precipitation field is '3D' in the EPC panel, and if the 'Precipitation' control is enabled in the Program Execution Control panel, and if weather clutter power calculations are commanded, then MiDLE will call the *DefineZ* procedure to calculate the reflectivity factor field.

The input variables to *DefineZ* are:

- MaxBinRange,
- th3s.

Output variables generated by *DefineZ* are:

- dbzX,
- dbzY,
- dbzH,
- dbz,
- lonr,
- latr,
- Hmax.

6.3.8 Missile Trajectory Limiting

If the radar scan type is 'EE' (electronic in azimuth and electronic in elevation) in the RPC panel then MiDLE will call the *MissileTrajectoryE* procedure to calculate the position of the target for each transmitted pulse. If the scan type is not 'EE' then the *MissileTrajectoryM* procedure is called.

The input variables to *MissileTrajectoryE* and *MissileTrajectoryM* are:

- rpath,
- phpath,
- vpath,
- nbeam,
- phq.

Output variables generated by *MissileTrajectoryE* and *MissileTrajectoryM* are:

- tpath,
- rm,
- tpath,
- thm,
- phm,
- vrm,
- timem,
- nscan,

- misbeams,
- nIllBeams,
- misburst,
- misq,
- misGroupBeams,
- HeadingAz,
- HeadingTh,
- misScans,
- BurstStartTime.

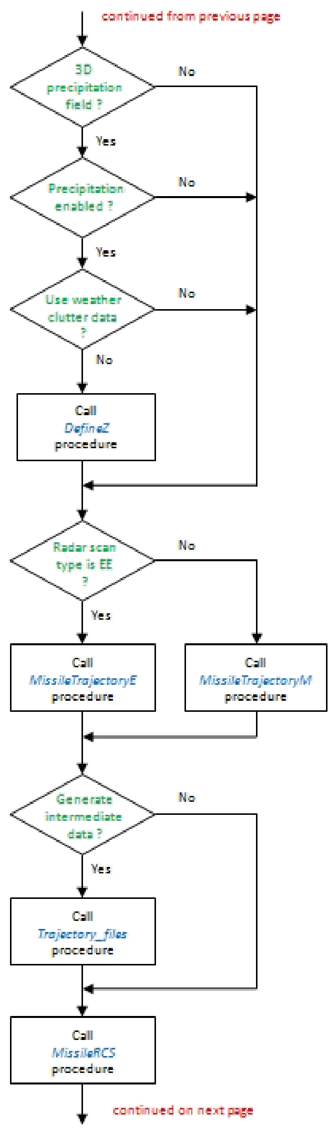


Figure 78c: MiDLE Program Flow Chart (cont'd)

6.3.9 Intermediate Data Generation

If the 'iData' flag is set in the Expert Parameters Control panel to generate intermediate data then the program next calls the *Trajectory_files* procedure.

The input variables to *Trajectory_files* are:

- rpath,
- phpath,
- thpath,
- vpath,
- tpath.

No output variables are generated by *Trajectory_files*. The intermediate data files are placed in the OUTPUT directory.

6.3.10 Radar Cross Section Calculation

The program calls the *MissileRCS* procedure next to create an array of radar cross sections corresponding to each missile position.

The input variables to *MissileRCS* are:

- rm,
- phm,
- thm,
- HeadingAz,
- HeadingTh.

The output variable generated by *MissileRCS* is:

- rcs.

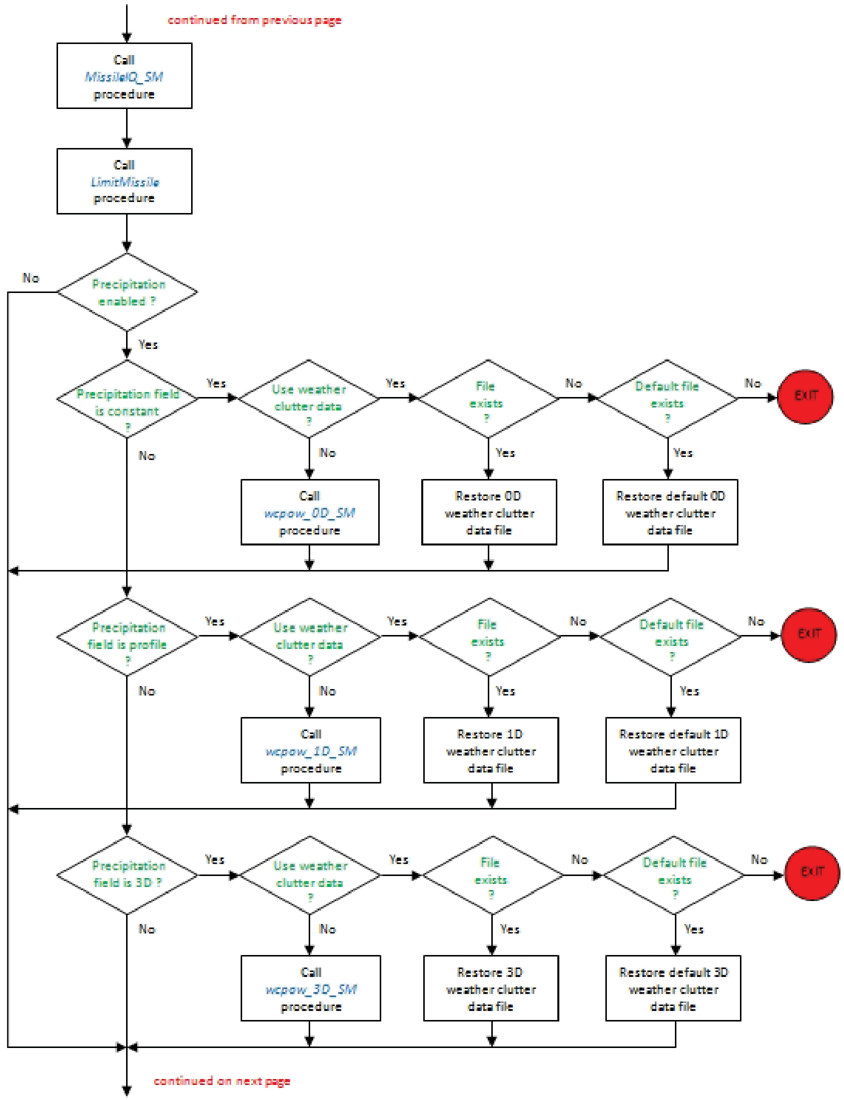


Figure 78d: MiDLE Program Flow Chart (cont'd)

6.3.11 Missile I/Q Data Calculation

The *MissileIQ_SM* procedure is called next to determine the I and Q signals corresponding to the target. This procedure is also parallelized to take advantage of multiple CPUs available on the platform and uses shared memory for inter-process communications.

The input variables to *MissileIQ_SM* are:

- kph,
- ph3s,
- misbeams,
- misScans,

- misburst,
- nUniqMisq,
- UniqMisq,
- Misq,
- misGroupBeams,
- nscan,
- nq,
- nIllBeams,
- rm,
- thm,
- gfac,
- rc,
- vrm,
- phba,
- phm,
- rcs,
- Rcint.

Output variables generated by *MissileIQ_SM* are:

- bigrc,
- bigI,
- bigQ,
- bigMisbeams,
- bigMisScans,
- bigMisBurst,
- bigMisGroupBeams,
- bigrm,
- mF4th.

6.3.12 Missile Power Limiting

The *LimitMissile* procedure limits the missile data to the beams and range bins that correspond to the maximum target signal strength for each burst. The calculated missile powers are then reduced to arrays corresponding only to these limited ranges.

The input variables to *LimitMissile* are:

- nIllBeams,
- bigrc,
- bigI,
- bigQ,
- bigMisbeams,
- bigrm,
- bigMisGroupBeams.

Output variables generated by *LimitMissile* are:

- trimrc,
- trimI,
- trimQ,
- trimMisbeams,
- trimMisGroupBeams,
- rIllindex.

6.3.13 Weather Clutter Power Calculation

The weather clutter power calculations are performed next if this control is enabled in the Program Execution Control panel.

If the precipitation field is set to ‘Constant’ in the EPC panel then the ‘0D’ case is in effect. If ‘restore’ was set for the weather clutter power, then the program looks for the *wcpow_0D_<mod>.dat* file where ‘mod’ is the file modifier. If this file is not found then the program will restore the terrain data from the *wcpow_0D_default.dat* file. The default data file should always exist in the OUTPUT directory unless it was accidentally deleted. In this case the program will issue a warning and stop processing. MiDLE still continues to run and the user can access all program controls. If ‘execute’ was set for the terrain properties, the program calls the *wcpow_0D_SM* procedure to calculate the data. The output data is saved in the *wcpow_0D_<mod>.dat* file.

If the precipitation field is set to ‘Profile’ in the EPC panel then the ‘1D’ case is in effect. If ‘restore’ was set for the weather clutter power, then the program looks for the *wcpow_1D_<mod>.dat* file where ‘mod’ is the file modifier. If this file is not found then the program will restore the terrain data from the *wcpow_1D_default.dat* file. The default data file should always exist in the OUTPUT directory unless it was accidentally deleted. In this case the program will issue a warning and stop processing. MiDLE still continues to run and the user can access all program controls. If ‘execute’ was set for the terrain properties, the program calls the *wcpow_1D_SM* procedure to calculate the data. The output data is saved in the *wcpow_1D_<mod>.dat* file.

The ‘3D’ case is treated similarly as for the ‘0D’ and ‘1D’ cases described above. MiDLE either restores the *wcpow_3D_default.dat* or executes the *wcpow_3D_SM* procedure.

The input variables to *wcpow_3D_SM* are:

- th3s,
- th_antenna_pattern,
- rcint,
- nq,
- phba,
- nbeam,
- rc,
- ph3s,
- kph,
- phq,
- W2q,

- gfac,
- phASS,
- SLmaxPh,
- thASS,
- SLmaxTh,
- rcRangeFold.

Output variables generated by *wcpow_3D_SM* are:

- PWc,
- La,
- Laq,
- Zeint,
- WCDopplerSpec.

6.3.14 Weather Clutter Power Limiting

The program next calls the *LimitWeatherClutter* procedure if 'Precipitation' is set in the Program Execution Control panel. This limits the weather clutter power data to the beams and range bins that correspond to the maximum target signal strength for each burst.

The input variables to *LimitWeatherClutter* are:

- trimrc,
- trimMisbeams,
- PWc.

The output variable generated by *LimitWeatherClutter* is:

- trimPWc.

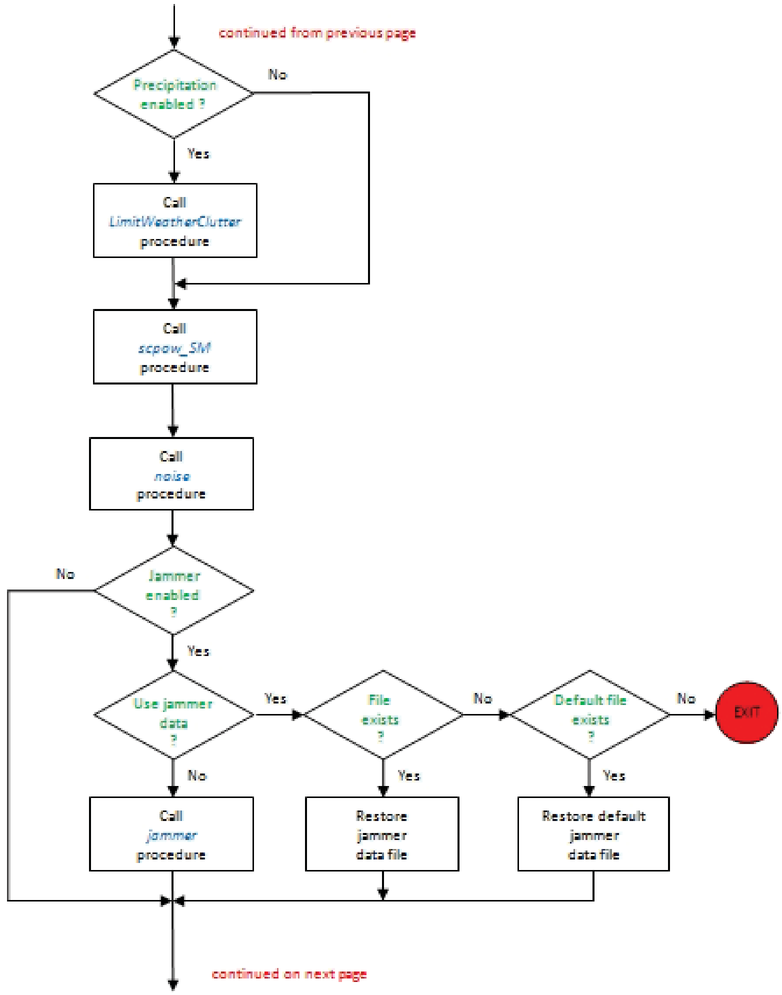


Figure 78e: MiDLE Program Flow Chart (cont'd)

6.3.15 Surface Clutter Power Calculation

MiDLE next calls the *scpow_SM* procedure to calculate the surface clutter power.

The input variables to *scpow_SM* are:

- kph,
- gfac,
- ph3s,
- nq,
- nqint,
- nbeam,
- rcint,
- phq,
- phba,
- rc,

- UniqMisbeams,
- Trimrc,
- trimMisbeams,
- rcRangeFold,
- phASS,
- SLmaxPh,
- La,
- Laq.

Output variables generated by *scpow_SM* are:

- PrSC,
- trimPrSC,
- trimstat,
- SCDopplerSpec,
- trimF4th,
- ref.

6.3.16 Noise Power Calculation

The *noise* procedure is called next to calculate the receiver system mean noise power. The output variable is 'Pn'.

6.3.17 Jammer Power Calculation

If the 'Jammer' control is enabled in the Program Execution Control panel and 'Jammer power' is set to 'execute', MiDLE calls the *jammer* procedure. Else if 'restore' is set then the *Jammer_<mod>.dat* file is restored from the OUTPUT directory where 'mod' is the filename modifier. If this file does not exist then MiDLE will restore the *Jammer_default.dat* file. The default data file should always exist in the OUTPUT directory unless it was accidentally deleted. In this case the program will issue a warning and stop processing. MiDLE still continues to run and the user can access all of the program controls.

The input variables to *jammer* are:

- gfac,
- rc,
- trimrc,
- trimMisbeams,
- nbeam,
- phba,
- ph3s,
- kph,
- phq,
- MaxBinRange,
- Max_tta,
- Rcint,
- Mdata.

Output variables generated by *jammer* are:

- Pjam,
- trimPjam.

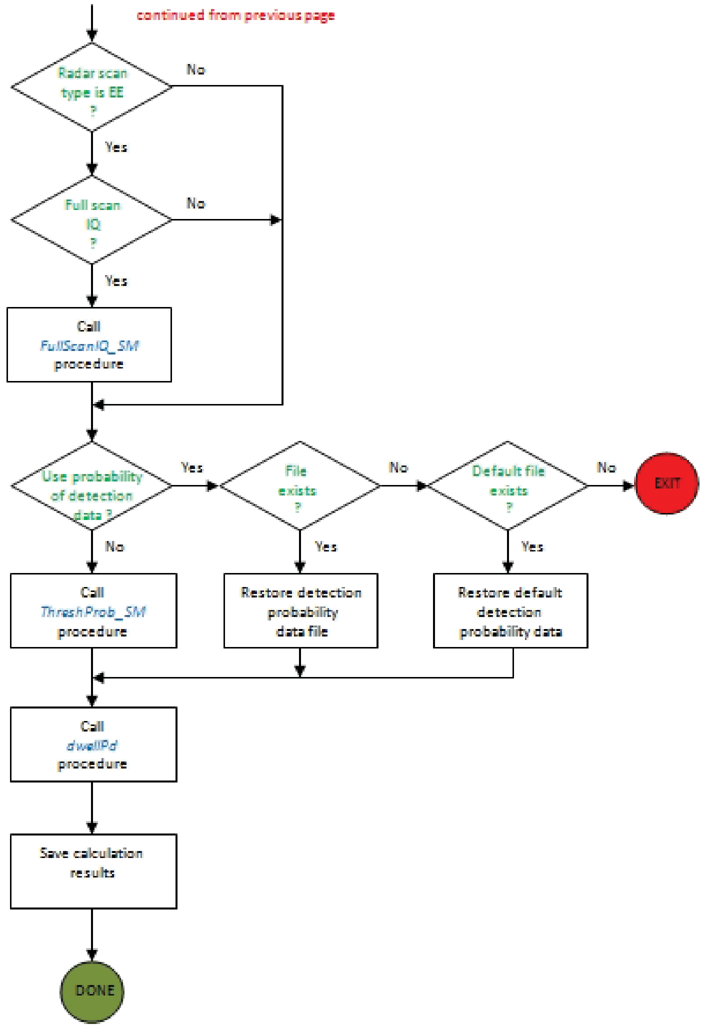


Figure 78f: MiDLE Program Flow Chart (cont'd)

6.3.18 Full Scan I/Q Data Calculation

If the radar scan type specified in the RPC panel is 'EE' and the 'Full scan IQ' switch is set in the Expert Parameters Control panel, MiDLE will execute the *FullScanIQ_SM* procedure. Note that these calculations are very time consuming even with the use of parallel processing techniques.

The input variables to *FullScanIQ_SM* are:

- kph,
- gfac,
- ph3s,

- nq,
- nqint,
- nbeam,
- rcint,
- phq,
- phba,
- phASS,
- SLmaxPh,
- rc,
- Pn,
- PrSC,
- Pjam,
- bigI,
- bigQ,
- bigMisbeams,
- bigrc,
- bigMisScans,
- bigMisBurst,
- nscan,
- BurstStartTime,
- La,
- Laq.

The output results from *FullScanIQ_SM* are saved in files.

6.3.19 Detection Thresholds and Probability of Detection Calculation

At this point calculations are nearly complete and MiDLE calls the *ThreshProb_SM* procedure to calculate the detection thresholds and probabilities for each relevant range bin. This procedure is called if 'execute' was specified in the Program Execution Control panel, else the file *ThreshProb_<mod>.dat* is restored. If this file does not exist the MiDLE will restore the *ThreshProb_default.dat* file from the OUTPUT directory. Again, if the default file was accidentally deleted case the program will issue a warning and stop processing. MiDLE still continues to run and the user can access all program controls.

The input variables to *ThreshProb_SM* are:

- np,
- ph3s,
- phba,
- trimPrSC,
- trimstat,
- Pn,
- trimI,
- trimQ,
- trimMisbeams,
- SCDopplerSpec,
- trimPWc,

- WCDopplerSpec,
- trimPjam.

Output variables generated by *ThreshProb_SM* are:

- threshold,
- Pd_intlim,
- SatFlag,
- MDP,
- Fdindex.

6.3.20 Dwell Probability of Detection and Data Limiting

As the final step MiDLE calls the *dwellPd* procedure to calculate the probability of detection for the dwell.

The input variables to *dwellPd* are:

- np,
- ranges_intlim,
- Pd_intlim.

Output variables generated by *dwellPd* are:

- Pdd_intlim,
- Pddu_intlim.

The output probability of detection data is limited for each missile illumination to the range bin of the output response function that achieves the highest probability of detection.

Results of the detection thresholds and probability of detection calculations are saved in a structure. Calculation results that are needed by the various plot generation routines are saved in the *MissilePath_<mod>_PlotQty.dat* file where 'mod' is the filename modifier for the current scenario. The overlay and plot generation functions discussed in sections 6.2.4.10 and 6.2.5 use the data contained in this file.

6.4 Building the APM DLL and Executable Modules

6.4.1 Background

MiDLE uses the *Advanced Propagation Model* to perform propagation calculations. The APM dynamically linked modules and executable modules are contained in the APM subdirectory. MiDLE calls these programs based on the 'APM Calling Method' selected in the Control Parameters Control panel. Currently two APM versions (APM 2.3.03 and APM 2.3.05) are available.

APM version 2.3.05 FORTRAN source file names are listed in Appendix B. The source files are contained on the MiDLE distribution CD. In order to compile these files, *Microsoft Visual Studio 2010 Professional* and *Intel Visual Fortran Composer XE 2011* must first be installed on a computer platform and licensed.

6.4.2 Visual Fortran Project Setup

First create a folder on your computer where the Visual Studio project and the APM source files will reside. For example, create the directory *C:\APM_TST_2305* and copy all FORTRAN source files (both *.f90 and *.F90 files) to it.

Open MS Visual Studio and create a new project. The project type depends on whether a library or console application is being created. Click on *File->New->Project* in the MS Visual Studio menu and select the appropriate project type. A console application will build an executable image whereas a library project will create a DLL module. Select a project name and specify the location as shown in the following Figure 80. The solution name is entered automatically and defaults to the project name. The project and solution names can be specified at the user's discretion. In this example a DLL is created and the project name APM_TST_2305 is used. Click on the OK button. MS Visual Studio creates new folders in C:\APM_TST_2305 and inserts the corresponding **.sln* and **.vproj* files.

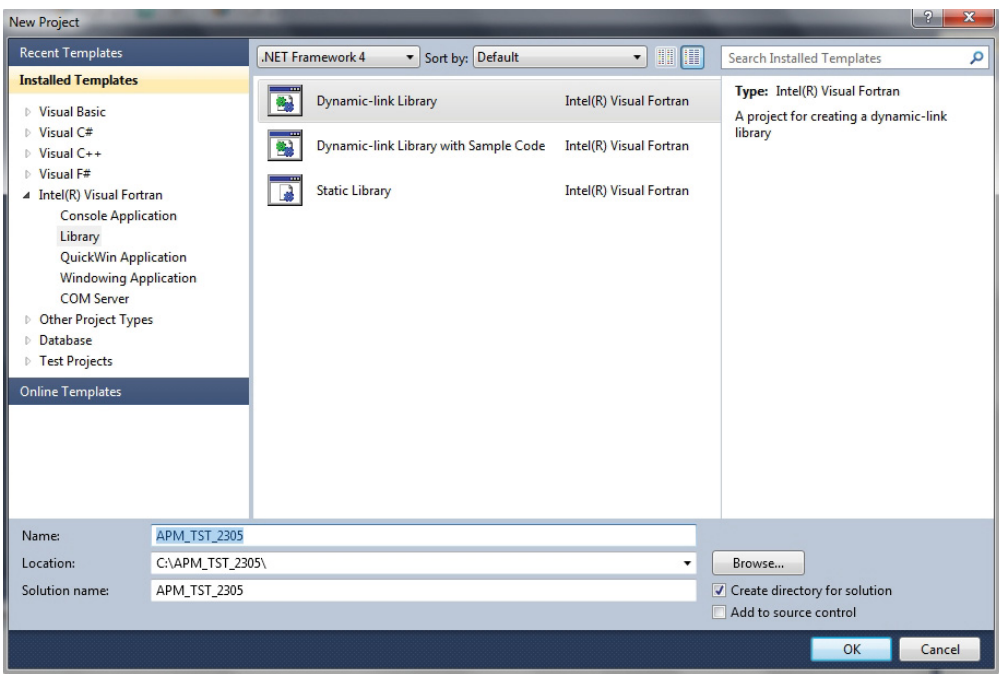


Figure 80: Visual Studio Project Setup Window

The right-hand side Solution Explorer window now shows the following configuration:

- Solution 'APM_TST_2305' (1 project)
  - **APM_TST_2305**

- Header Files
- Resource Files
- Source Files

The above header files, resource files and source files folders are initially all empty. In this example only source files are added. Right click on ‘Source Files’ and select *Add->Existing Item*. This opens up the window shown in Figure 81. Navigate to the top-level directory and select all FORTRAN source files. Click the Add button.

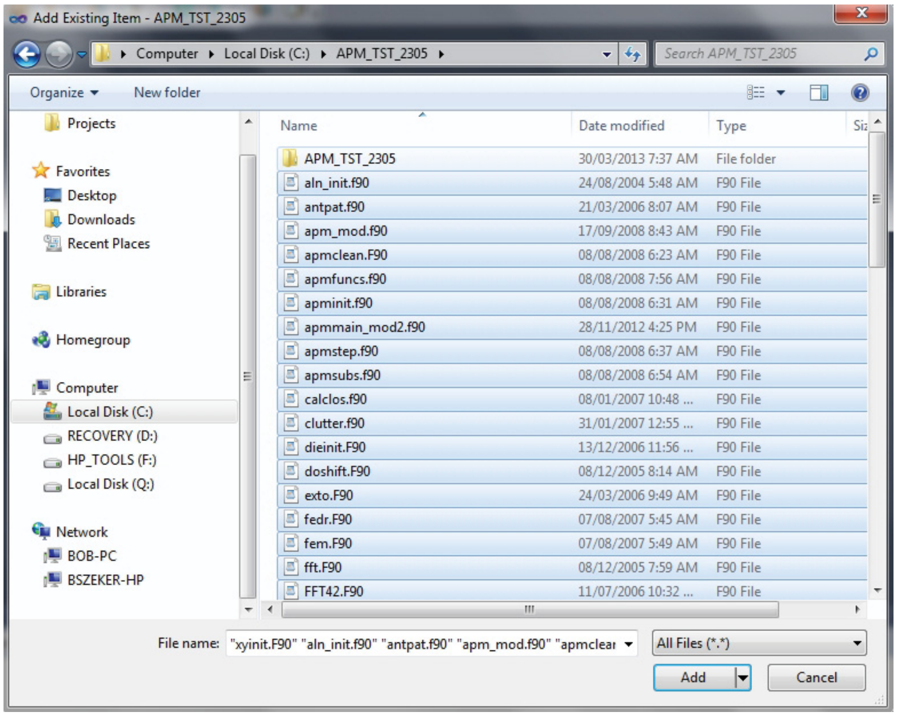


Figure 81: Adding APM Source Files in Visual Studio Project

The Visual Studio Solution Explorer window now shows the APM FORTRAN source files that will be compiled into the DLL. (The preprocessor is automatically invoked for files with types **.F90*). At this point a source file can be opened in the editor window by double-clicking on it.

In this example a ‘release’ version (as opposed to the ‘debug’ version) of the APM DLL is being built on a platform running a 64-bit operating system (Windows 7). The DLL generated will also be for a 64-bit system. Make the necessary changes by right-clicking on the project in Solution Explorer and select ‘Properties’. The solution Property Pages window is opened as shown in Figure 82.

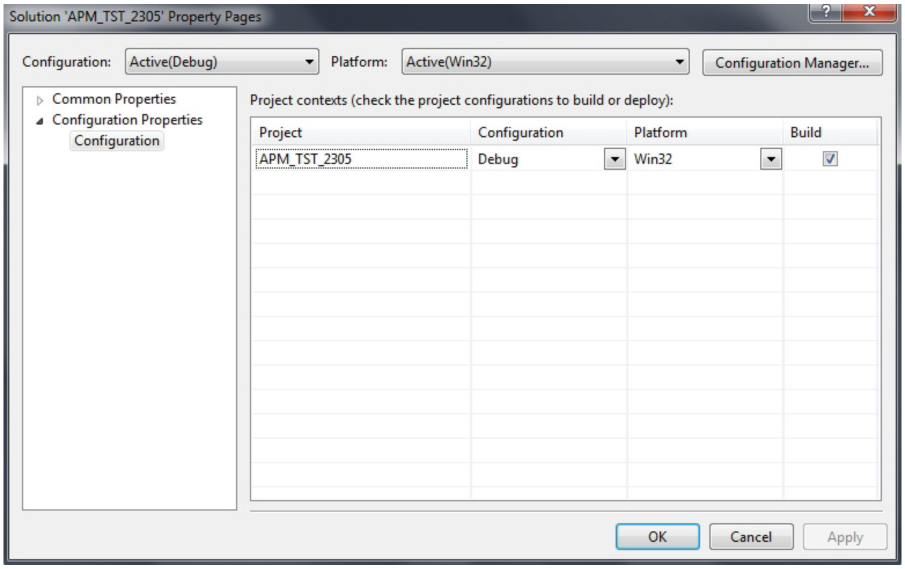


Figure 82: Visual Studio Property Pages Window

Click on the 'Configuration Manager' which opens the configuration manager window. Change 'Active solution configuration' to 'Release' and 'Active solution platform' to 'x64'. If the 'x64' option is not available, select <New> and specify 'Copy settings from Win32'. The final configuration is shown in Figure 83.

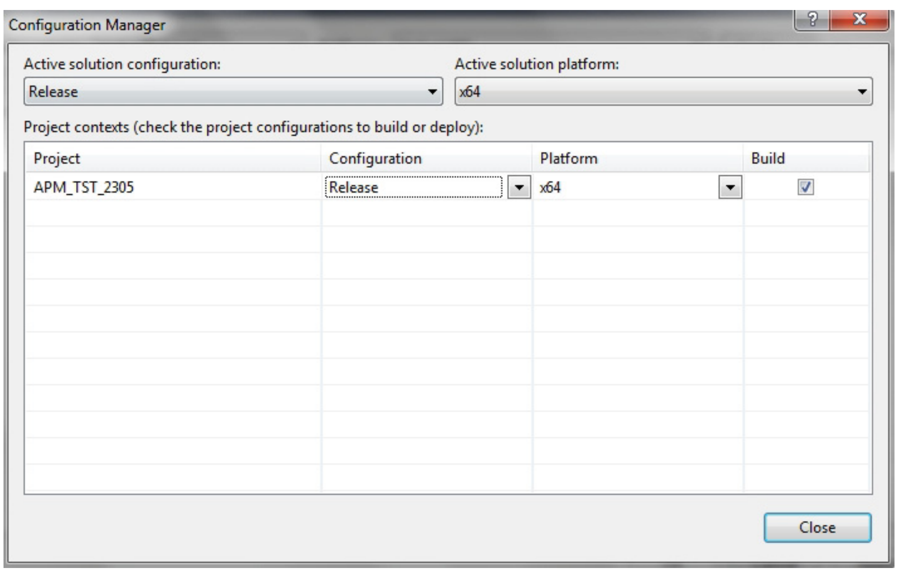


Figure 83: Visual Studio Configuration Manager Window

Click on the 'Close' button in the Configuration Manager. The Property Pages shown in Figure 82 now reflect the specified configuration:

- Configuration: Active(Release)
- Platform: Active(x64)

- Project: AMP_TST_2305
- Configuration: Release
- Platform: x64
- Build: checked

Click on the 'Apply' button in the Property Pages window the click on 'OK'. The project is now nearly ready to build. Before building the APM DLL, the solution properties such as the specific compiler and linker properties need to be set. This is covered in the following section.

6.4.3 Visual Fortran Solution Properties

Right-click on the APM_TST_2305 solution folder in the Solution Explorer window. This opens the solution Property Pages window shown in Figure 84.

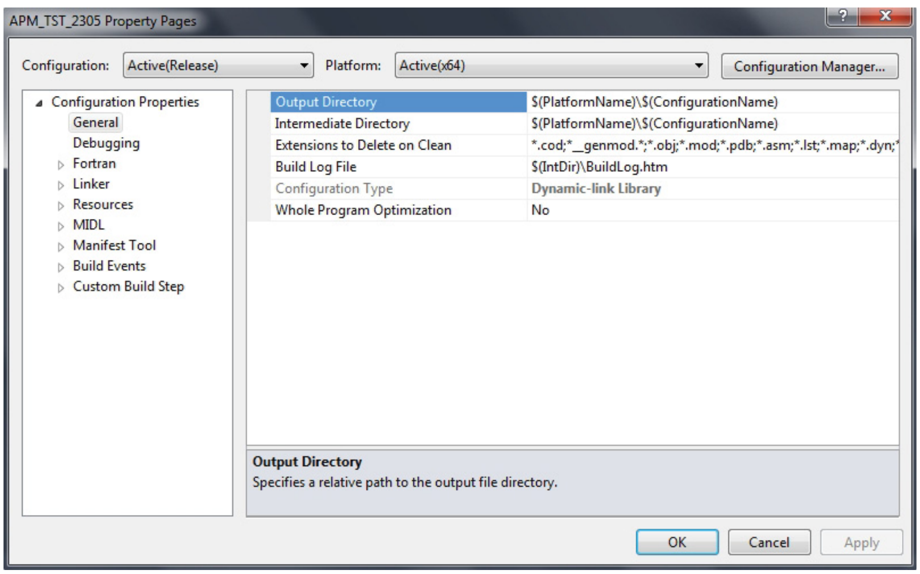


Figure 84: Visual Studio Solution Property Pages Window

The 'General' configuration properties tab in Figure 84 shows that the configuration type is a *Dynamic-link library* and this setting cannot be changed. Most of the solution property settings can be left in their default settings. For this demonstration example only the specific compiler and linker settings are changed.

6.4.3.1 Compiler Settings

Expand the 'Fortran' compiler properties and set the various options as described below. Empty fields are designated as *< empty >.*

General

- Suppress Startup Banner .... Yes(/nologo)
- Additional Include Directories .... *< empty >*
- Debug Information Format .... None
- Optimization .... Maximize Speed
- Preprocessor Definitions .... *< empty >*
- Compile Time Diagnostics .... Custom

Optimization

- Optimization .... Maximize Speed
- Inline Function Expansion .... Any Suitable
- Favor Size or Speed .... Favor Fast Code
- Loop Unroll Count .... *< empty >*
- Parallelization: .... No
- Threshold for Auto-Parallelization 100
- Threshold for Vectorization 100
- Prefetch Insertion .... Disable
- I/O Buffering .... No
- Heap Arrays .... *< empty >*
- Interprocedural Optimization .... No
- Enable Matrix Multiply Library Call .... Default

Debugging

- Debug Information Format .... None
- Enable Parallel Debug Checks .... No
- Information for PARAMETER Constants .... None (not selectable)

Preprocessor

- Preprocessor Source File .... No
- Additional Include Directories .... *< empty >*
- Add Dependent Outputs to INCLUDE Path .... Yes
- Ignore Standard Include Path .... No
- Default Include and Use Path .... Source File Directory
- Preprocessor Definitions .... *< empty >*
- Undefine Preprocessor Definitions .... *< empty >*
- Undefine All Preprocessor Definitions .... No
- Preprocessor Definitions to FPP Only .... No
- OpenMP Conditional Compilation .... Yes

Code Generation

- Enable Recursive Routines .... No
- Generate Reentrant Code .... Default
- Object Text String .... *< empty >*

- Enable Enhanced Instruction Set .... Not Set
- Add Processor-Optimized Code Path .... None
- Intel Processor-Specific Optimization .... None

Language

- Source File Format .... Use File Extension
- Fixed Form Line Length .... 72 Columns
- Pad Fixed Form Source Lines .... No
- Enable Alternate PARAMETER Syntax .... Yes
- Enable FORTRAN 66 Semantics .... No
- Compile Lines With D in Column 1 .... No
- Process OpenMP Directives .... Disable
- Enable F2003 Semantics .... No
- Enable Coarrays .... No
- MPI Configuration File .... *< empty >*
- Coarray Images 0

Compatibility

- Unformatted File Conversion .... None
- Enable VMS Compatibility .... No
- Enable F77 Run-time Compatibility .... No
- Use F77 Integer Constants .... No
- Treat Backslash as Normal Character in Strings .... Yes
- Use Filenames from Command Line .... No (PowerStation)
- Use PowerStation I/O Format .... No
- Use PowerStation Portability Library .... Yes
- Use PowerStation List Directed I/O Spacing .... No
- Use PowerStation Logical Values .... No
- Use Other PowerStation Run-time Behavior .... No

Diagnostics

- General
    - Error Limit 30
    - Treat Warnings As Errors .... No
    - Warn For Non-standard Fortran .... No
    - Treat Fortran Standard Warnings As Errors .... No
    - OpenMP Diagnostic Level .... Default
    - Auto-Parallelizer Diagnostic Level .... Default
    - Vectorizer Diagnostic Level .... Default
    - Disable Specific Diagnostics .... *< empty >*
    - Emit Diagnostics to File .... No
    - Diagnostics File .... *$(IntDir)\$(TargetName).diag*
- Guided Auto Parallelism
    - Guided Auto Parallelism Analysis .... Disable
    - Emit Guided Auto Parallelism Diagnostics to File .... No
    - Guided Auto Parallelism Diagnostic File .... *$(IntDir)\$(TargetName).gap*
    - Guided Auto Parallelism Code Selection Options .... *< empty >*

- Language Usage Warnings
  - Compile Time Diagnostics .... Custom
  - Warn For Undeclared Symbols .... No
  - Warn For Unused Variables .... No
  - Warn When Removing %LOC .... No
  - Warn When Truncating Source Line .... No
  - Warn For Unaligned Data .... Yes
  - Warn For Uncalled Statement Function .... No
  - Suppress Usage Messages .... No
  - Check Routine Interfaces .... No
- Optimization Diagnostics
  - Optimization Diagnostic Level .... Disable
  - Emit Optimization Diagnostics to File .... No
  - Optimization Diagnostic File .... *< empty >*
  - Optimization Diagnostic Phase .... All optimizer phases
  - Optimization Diagnostic Routine .... *< empty >*
- Static Analysis
  - Level of Static Security Analysis .... None
  - Analyze Include Files .... No
  - Static Security Analysis Results Directory .... *XE Results - $(ProjectName)*

Data

- Default Integer KIND 4
- Default Real KIND 4
- Default Double Precision KIND 8
- Local Variable Storage .... Default Local Storage
- Initialize Local Saved Scalars to Zero .... No
- Dynamic Common Blocks .... *< empty >*
- Structure Member Alignment .... Default
- Common Element Alignment .... None
- SEQUENCE Types Obey Alignment Rules .... No
- Assume Dummy Arguments Share Memory Locations .... No
- Assume CRAY Pointers Do Not Share Memory Locations .... No
- Constant Actual Arguments Can Be Changed .... No
- Use Bytes As RECL=Unit for Unformatted Files .... No
- Initialize Stack Variables to an Unusual Value .... No

Floating Point

- Floating-Point Exception Handling .... Produce NaN, signed quantities
- Floating-Point Model .... Fast
- Reliable Floating Point Exceptions Model .... Default
- Extend Precision of Single-Precision Constants .... No
- Enable IEEE Minus Zero Support .... No
- Limit COMPLEX Range .... No
- Check Floating-Point Stack .... No
- Floating-Point Speculation .... Fast

External Procedures

- Calling Convention ………………………………………………………………. Default
- Name Case Interpretation …………………………………………………….. Default
- String Length Argument Passing ……………………………………………. After All Arguments
- Append Underscore to External Names ………………………………… No

Output Files

- Module Path ……………………………………………………………………….. *$(IntDir)*
- Object File Name ………………………………………………………………… *$(IntDir)*
- Program Database File Name ………………………………………………. *$(IntDir)\vc100.pdb*
- Assembler Output ……………………………………………………………….. No Listing
- ASM Listing Name ……………………………………………………………….. $(IntDir)\ (not selectable)
- Source Listing ……………………………………………………………………… No
- Source Listing File ……………………………………………………………….. *$(IntDir)\$(InputName).lst*
- Build Dependencies ……………………………………………………………… No
- Emit Build Dependencies to File …………………………………………… No
- Build Dependencies File ……………………………………………………….. *$(IntDir)\$(InputName).dep*

Run-time

- Generate Traceback Information …………………………………………… No
- Default Output Carriage Control …………………………………………… Default
- Runtime Error Checking ………………………………………………………. Custom
- Check For Null Pointers and Allocatable Array References ………. No
- Check for Array and String Bounds ……………………………………….. No
- Check Uninitialized Variables ……………………………………………….. No
- Check Edit Descriptor Data Type …………………………………………… No
- Check Edit Descriptor Data Size …………………………………………….. No
- Check for Actual Arguments Using Temporary Storage …………… No

Libraries

- Runtime library …………………………………………………………………… Multithread DLL (libs:dll /threads)
- Use Common Windows Libraries …………………………………………… No
- Use Portlib Library ………………………………………………………………. No
- Use Intel Math Kernel Library ……………………………………………….. No
- Disable Default Library Search Rules …………………………………….. No
- Disable OBJCOMMENT Library Names in Object ……………………… No

Command Line

/nologo /module:"x64\Release\\" /object:"x64\Release\\" /Fd"x64\Release\vc100.pdb"
/libs:dll /threads /c

6.4.3.2 Linker Settings

Expand the 'Linker' properties and set the various options as described below. Empty fields are designated as < *empty* >. In this example the DLL is assigned a 100-MByte stack size.

General

- Output File .... *$(OutDir)\$(ProjectName).dll*
- Show Progress .... Not Set
- Version .... < *empty* >
- Enable Incremental Linking .... Default
- Suppress Startup Banner .... Yes (/NOLOGO)
- Ignore Input Library .... No
- Register Output .... No
- Per-user Redirection .... No
- Additional Library Directories .... < *empty* >
- Link Library Dependencies .... Yes

Input

- Additional Dependencies .... < *empty* >
- Ignore All Default Libraries .... No
- Ignore Specific Library .... < *empty* >
- Module Definition File .... < *empty* >
- Add Module to Assembly .... < *empty* >
- Embed Managed Resource File .... < *empty* >
- Force Symbol References .... < *empty* >
- Delay Loaded DLLs .... < *empty* >

Manifest File

- Generate Manifest .... Yes
- Manifest File .... *$(TargetPath).intermediate.manifest*
- Additional Manifest Dependencies .... < *empty* >
- Allow Isolation .... Yes
- Enable User Account Control (UAC) .... Yes
- UAC Execution Level .... asInvoker
- UAC Bypass UI Protection .... No

Debugging

- Generate Debug Info .... No
- Generate Program Database File .... *$(TargetDir)$(TargetName).pdb*
- Strip Private Symbols .... < *empty* >
- Generate Map File .... No
- Map File Name .... < *empty* >
- Map Exports .... No
- Debuggable Assembly .... No Debuggable attribute emitted

System

- SubSystem .... Windows (/SUBSYSTEM:WINDOWS)
- Heap Reserve Size 0

- Heap Commit Size 0
- Stack Reserve Size 104857600
- Stack Commit Size 104857600
- Enable Large Addresses .... Default
- Terminal Server .... Default
- Swap Run from CD .... No
- Swap Run from Network .... No

100-Mbyte stack reserve and commit size specified as decimal value.

Optimization
- General
  - References .... Default
  - Enable COMDAT Folding .... Default
  - Optimize for Windows98 .... Default
  - Function Order .... *< empty >*
- Whole Program Optimization
  - Interprocedural Optimization .... Yes
  - Assembler Output .... No Listing
  - Assembler Output Listing Name/Location .... *< empty >*
  - Object File Name .... *< empty >*

Embedded IDL
- MIDL Command File .... *< empty >*
- Ignore Embedded IDL .... No
- Merged IDL Base File Name .... *< empty >*
- Type Library .... *< empty >*
- Typelib Resource ID 1

Advanced
- Entry Point .... *< empty >*
- Resource Only DLL .... No
- Set Checksum .... No
- Base Address .... *< empty >*
- Fixed Base Address .... Default
- Turn Off Assembly Generation .... No
- Support Unload of Delay Loaded DLLs .... No
- Import Library .... *$(TargetDir)$(TargetName).lib*
- Merge Sections .... *< empty >*
- Target Machine .... Not Set

Command Line

/OUT:”x64\Release\APM_TST_2305.dll” /NOLOGO /MANIFEST /MANIFESTFILE:”C:\APM_TST_2305\ APM_TST_2305\APM_TST_2305\x64\Release\APM_TST_2305.dll.intermediate.manifest” /MANIFESTUAC:”level=’asInvoker’ uiAccess=’false’” /SUBSYSTEM:WINDOWS /STACK:104857600,104857600 /IMPLIB:”C:\APM_TSTS_2305\APM_TST_2305\APM_TST_2305\x64\Release\ APM_TST_2305.lib” /DLL

6.4.4 Building the Solution

To build the APM DLL, click on *Build->Build Solution* in Visual Studio. The output window displays messages as each source file is compiled. The DLL module *APM_TST_2305.dll* is generated in the x64/Release directory which also contains various other output files. At this point the DLL file can be renamed as required (e.g. *APM2305_100MB_x64.dll*) to give it a more descriptive name and copied to the MiDLE APM folder.

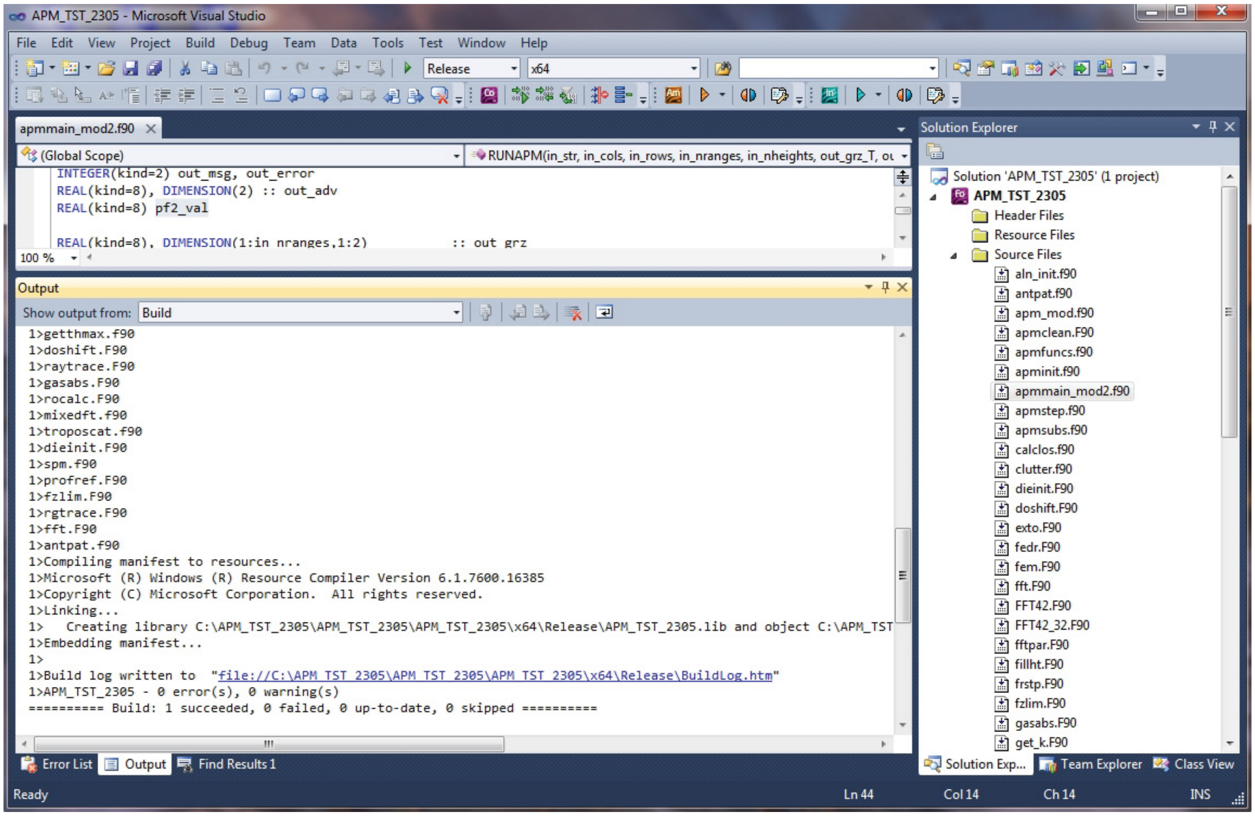


Figure 85: Building the Solution in Visual Studio

6.5 An Example Scenario

The following sections provide a step-by-step example in which MiDLE is used to execute a new scenario. In this example the radar platform's location is changed to a new location and a new missile launch position is designated. The missile follows a new trajectory to the target performing a single radius turn. MiDLE then executes the required calculations and displays the probability of detection information.

This example assumes that the software was successfully configured and installed on a computer platform as explained in Section 5.

6.5.1 Launching MiDLE

First launch MiDLE in either the IDL development environment or run-time environment. The view appears as shown in Figure 86.

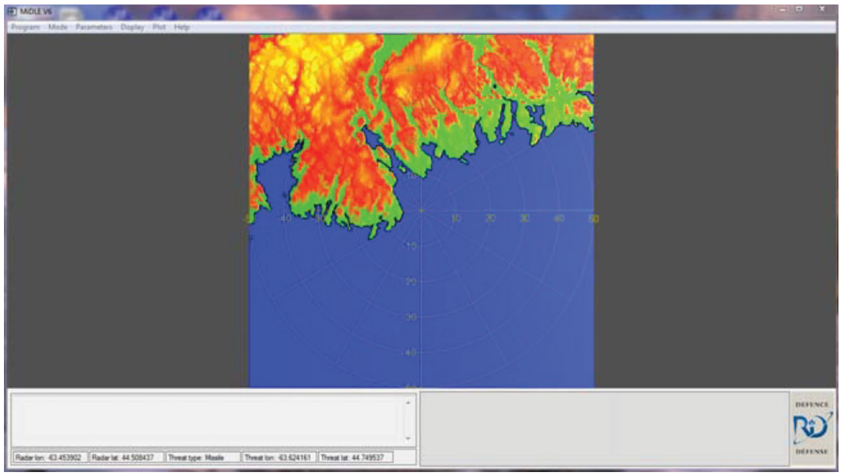


Figure 86: Example Scenario – The MiDLE Display

MiDLE can be started from the IDL DE by typing 'midle_init' at the command line. In the RT environment it can be started by double-clicking the 'MiDLE_V6.exe' program then clicking on the IDL splash screen.

6.5.2 Repositioning the Radar Platform

Reposition the radar platform by clicking on *Parameters->Radar* in the top-level menu. This opens the Radar Parameters Control (RPC) panel. Click the cursor at the approximate position of -63.988 longitude and 44.603 latitude (west of the default location) while holding down the <Alt> key. The RPC panel will update showing the new position selected as shown in Figure 87.

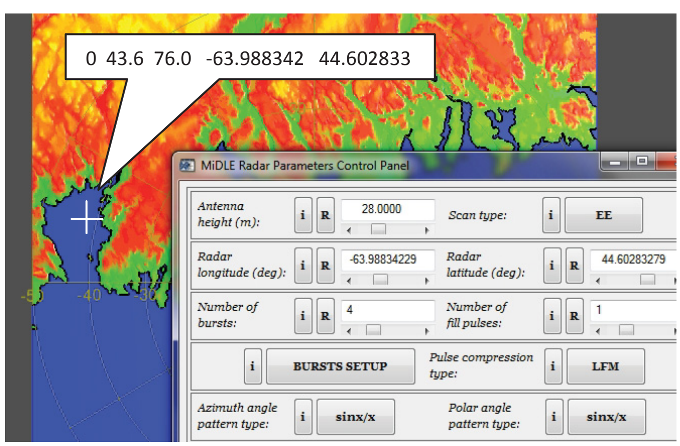


Figure 87: Example Scenario – Repositioning the Radar Platform

Click the APPLY button in the RPC panel. The view takes a few seconds to update as new elevation data files are loaded and will appear as shown in Figure 88. Close the RPC panel and zoom in on the view to display a range of about 30-km.

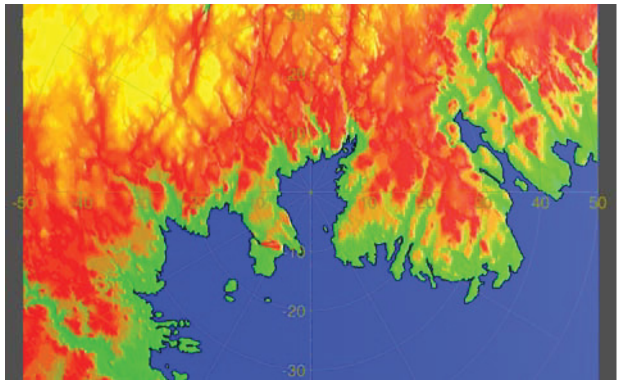


Figure 88: Example Scenario – View of New Radar Location

6.5.3 Specifying New Missile Waypoints

From the top-level menu select *Parameters-Missile*. The Missile Parameters Control panel appears containing two waypoints showing the missile launch location and the target location. The program sets the target location by default to that of the radar platform, however the missile launch location is unknown at this time and the default launch location is used. The view appears as shown in Figure 89. (The MPC panel was moved to the left hand side).

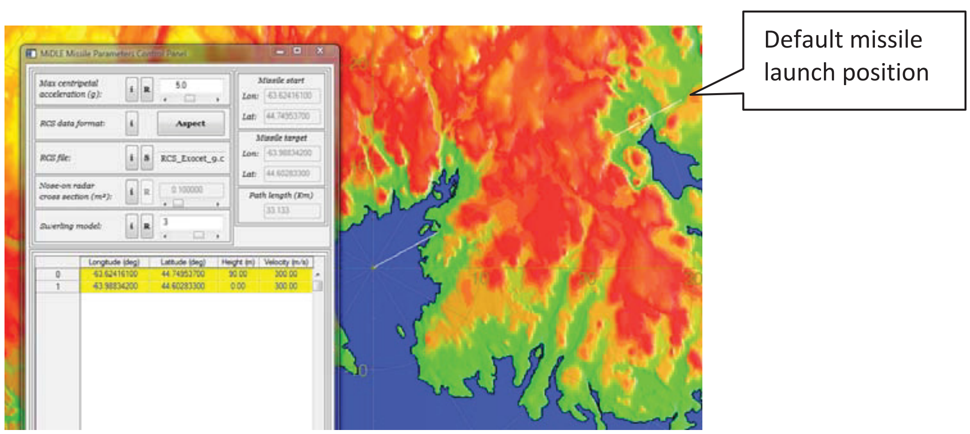


Figure 89: Example Scenario – Default Missile Waypoints

Click on waypoint #0 in the waypoint table and specify a new missile launch position. Hold down the <Shift> key and click anywhere in the view and the lat/lon values automatically updated in the table. Recall that the current radar scan is from 270° to 0° so make sure the waypoints are located in this quadrant. (The radar scan region can be modified using the RCP panel). Figure 90 shows the view with the new missile launch position designated. The height above sea level of the new waypoint is shown by the cursor.

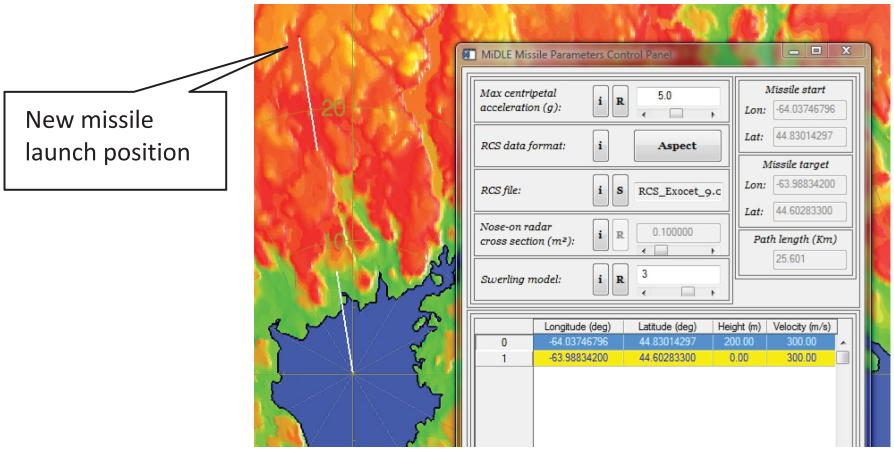


Figure 90: Example Scenario – New Missile Launch Point

Modify the corresponding entry in the table so that the missile height is 'above' this elevation.

The line connecting the launch and destination (target) waypoints is not entirely visible, indicating that at certain points there is intervening terrain. Additional waypoints have to be added so that the missile either flies over land features or around them.

To add a new waypoint, select the waypoint after which a new one is to be inserted and click on the INSERT button. Hold down the <Shift> key and click in the view to designate its location. This procedure can be repeated until a satisfactory waypoint is found. To add another waypoint after the new one, select the new one and click INSERT again, etc. Figure 91 shows the final waypoint configuration.

While designating the waypoints, the MiDLE view can be zoomed, translated or rotated for a better perspective. The MPC panel is a floating widget that will always stay above the view.

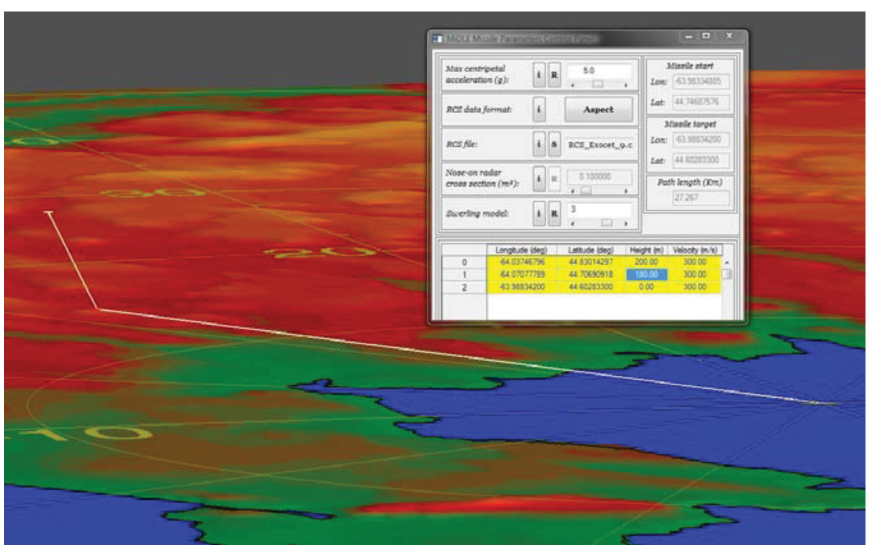


Figure 91: Example Scenario – Final Waypoint Configuration

Press APPLY after the missile waypoints have been successfully configured to apply them to the current session. At this point the *Display->Threat->Trajectory* is disabled as the new trajectory has not yet been calculated. Close the MPC panel. The missile waypoints and the lines connecting them are removed from the view.

6.5.4 Setting the Program Execution Control Parameters

Select *Program->Control* to open the Program Execution Control panel. The panel appears as shown in Figure 92.

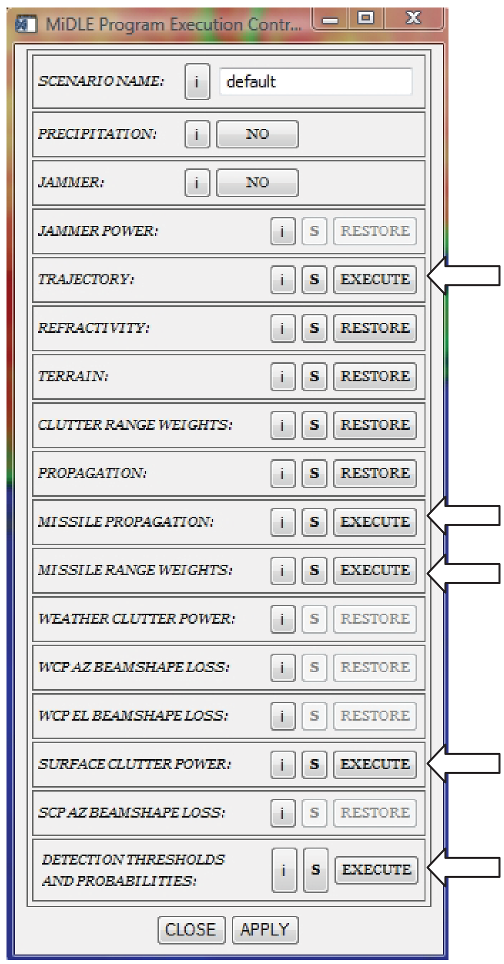


Figure 92: Example Scenario – Program Execution Control Panel

The scenario name entry is 'default' as it has not yet been specified. Enter 'example' and press <Return> which updates all filenames used by the program. Note that MiDLE automatically selects the trajectory, missile propagation, missile range weights, surface clutter power and detection thresholds and probability calculations (indicated in Figure 92 by arrows) to be executed. These quantities, as a minimum, must be calculated when new missile/projectile waypoints are specified. The other quantities used are taken from the defaults. The user can of course opt to execute the refractivity profile, terrain and other calculations as well.

Click on APPLY to apply the selections to the current scenario. Clicking on the 'S' button adjacent to each quantity opens a file dialog box where the user can specify a different filename to be saved or restored. Close the Program Execution panel.

6.5.5 Running MiDLE

Click on Program->Start. MiDLE will start and open the popup dialog box shown in Figure 93.

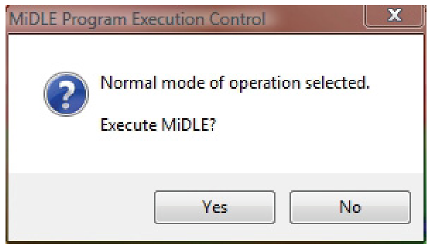


Figure 93: Example Scenario – MiDLE Execution Dialog Box

The dialog box show that MiDLE is operating in 'normal' mode as opposed to batch processing mode. Click on 'Yes' to start program execution.

The program displays various messages in the system message window while it is running. When parallelized procedures are executed MiDLE spawns slave processes whose status windows appear on the upper left portion of the screen. The following Figure 94 shows the slave process status windows for the missile range weights calculations.

The user can optionally kill slave processes, for example if the program needs to be terminated for some reason. If a slave process is killed, MiDLE will terminate all other slave processes automatically and issue a warning message. MiDLE will continue to run and the user can access all program controls from the menus.

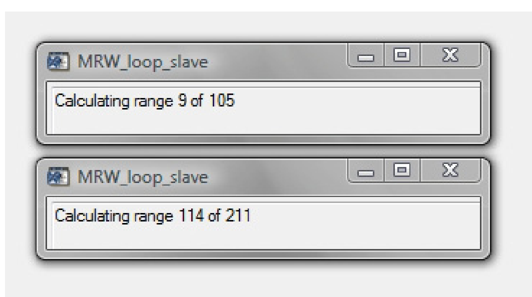


Figure 94: Example Scenario – Slave Process Status Windows

6.5.6 Calculation Results

When MiDLE finishes calculations, the main view is updated with probability of detection information. Figure 95 shows the results.

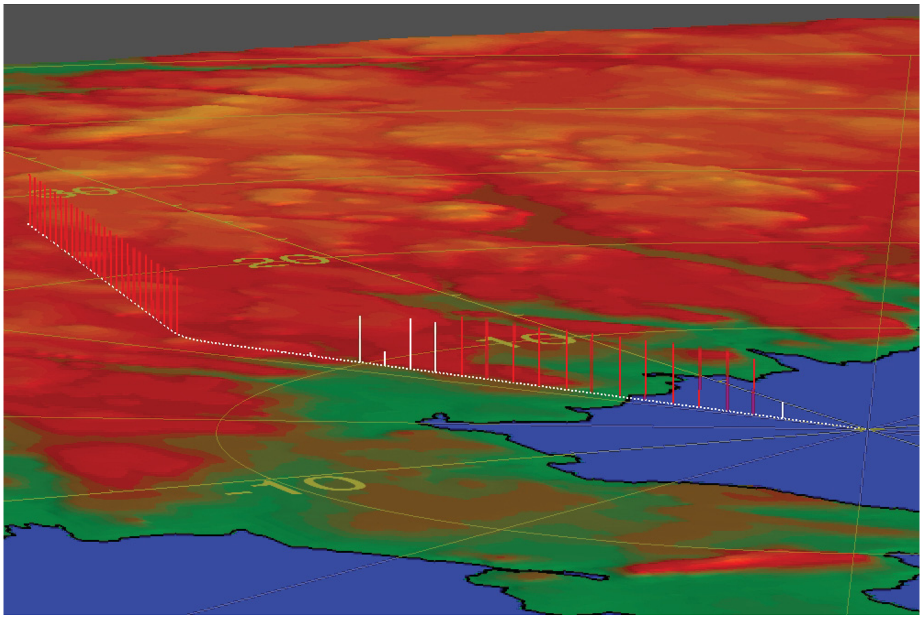


Figure 95: Example Scenario – Calculation Results

From the above figure it can be seen that the missile will be detected with a high probability immediately after it is launched. The probability of detection drops to zero for a brief period then increases again.

Taking a look at the probability of detection plot using *Plot->Probability of detection,* it can be seen that there is good agreement with the visual presentation of the data.

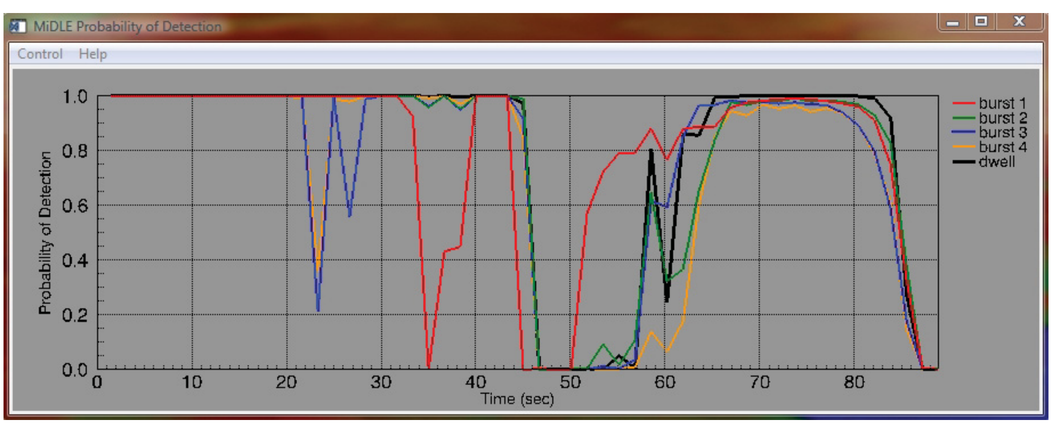


Figure 96: Example Scenario – Probability of Detection Plot

Appendix A - Diagnostic File Example

```
*******************************************************************************************
*** MiDLE Runtime Diagnostics Output ***
    Date: Tue Mar 12 21:12:08 2013
    Operating mode:  Normal

PARAMETERS:
                    rad.SCANAZ          scalar            1.57080     float
                      rad.BSAZ          scalar        0.026087436    double
                     rad.PHBAI          scalar            4.71239     float
                       rad.THC          scalar            1.57080     float
                      rad.THBS          scalar          1.3089969    double
                      rad.PHBS          scalar          5.4977871    double
                       rad.GBS        [1 x 20]                       double
                    rad.NBURST          scalar                  4      long
                       rad.TH3        [1 x 20]                       double
                       rad.PH3        [1 x 20]                       double
                     rad.BURST        [1 x 20]                       struct
                 rad.ANTDIAMPH          scalar            1.00000     float
                 rad.ANTDIAMTH          scalar            1.00000     float
                        rad.HA          scalar          28.000000    double
                      rad.RRES          scalar          37.474998    double
                       rad.TAU          scalar       5.00000e-005     float
                      rad.LONR          scalar         -63.988342    double
                      rad.LATR          scalar          44.602833    double
                       rad.POL          scalar                  V    string
                         rad.N          scalar            200.000     float
                        rad.PT          scalar            13000.0     float
                        rad.LS          scalar            1.00000     float
                        rad.FN          scalar            5.62341     float
                        rad.BR          scalar          4000000.0    double
                        rad.BN          scalar          5000000.0    double
       rad.FREQUENCYWEIGHTING          scalar             Taylor    string
                       rad.DSL          scalar           -40.0000     float
                      rad.NBAR          scalar                  6   integer
                        rad.GS          scalar           0.000000     float
                    rad.STCEXP          scalar                  3   integer
                 rad.STCOFFSET          scalar           0.000000     float
               rad.STCMAXRANGE        [1 x 20]                       double
                        rad.TO          scalar            290.000     float
                    rad.SATLEV          scalar            69.0000     float
      rad.TIMEDOMAINWEIGHTING          scalar            Hanning    string
                     rad.NFILL          scalar                  1      long
                  rad.SCANTYPE          scalar                 EE    string
        rad.THGAINPATTERNTYPE          scalar             sinx/x    string
                      rad.ARPM          scalar            30.0000     float
     rad.PULSECOMPRESSIONTYPE          scalar                LFM    string
        rad.PHGAINPATTERNTYPE          scalar             sinx/x    string
rad.ANTENNASIDELOBESUPPRESSION         [1 x 2]                       string
     rad.ANTENNASIDELOBELEVEL         [1 x 2]                        float
                rad.PHASECODE       [1 x 150]                      integer
            rad.PHASECODE_LEN          scalar                 35   integer
                    rad.FSAMP          scalar          4000000.0    double
            rad.THUSERPATTERN    [20 x 2 x 7]                        float
                    con.RSTEP          scalar          37.474999    double
                 con.MAXRANGE          scalar            50000.0     float
                 con.NPERPEAK          scalar                 11   integer
             con.MAXPROPANGLE          scalar            10.0000     float
                     con.DRF2          scalar            100.000     float
                     con.DHF2          scalar            1.00000     float
               con.DPATHANGLE          scalar       0.0062831853    double
               con.HPACLEVELS          scalar                 10   integer
                   con.REFRDR          scalar            1000.00     float
          con.LWKDMEASHEIGHTU          scalar            1.50000     float
         con.LWKDMEASHEIGHTWS          scalar            10.0000     float
              con.TEST2THRESH          scalar         0.00500000     float
                       con.H2          scalar            30.0000     float
                  con.MAXITER          scalar                200   integer
```

con.AZBEAMSHAPELOSS	scalar	0	integer
con.DPHINT	scalar	0.0065217390	double
con.AZPERBEAMWIDTH	scalar	4.00000	float
con.DPL	scalar	0.990000	float
con.RANGEFOLD	scalar	2	integer
con.NUMPOINTSINBEAMWIDTH	scalar	5	integer
con.THMIN4INT	scalar	0.0174533	float
con.NSPG	scalar	1000	integer
con.SAMPLELIMITVALUE	scalar	2500000.0	double
con.W2POINTS	scalar	101	integer
con.APM_MAX_NH	scalar	1000	integer
con.NCPU	scalar	2	long
con.CALLPATH	scalar	C:\MiDLE\MiDLEV6\V6\	string
con.TARGETTYPE	scalar	Missile	string
con.PROPMODEL	scalar	APM	string
con.APMMETHOD	scalar	dll	string
con.BLENDMETHOD	scalar	DRDC	string
con.DBLEND	scalar	0.250000	float
con.LWKDMAXHEIGHT	scalar	50.0000	float
con.PDTHRESH	scalar	0.900000	float
env.SOL	scalar	2.9980000e+008	double
env.RE	scalar	6371000.0	double
env.SS	scalar	5	integer
env.TERRAINELEVATIONFILE	scalar	TerrainElevationFile.dat	string
env.LCTYPE	[2 x 28]		string
env.VWS	scalar	11.4401	float
env.TS	scalar	15.0000	float
env.RHS	scalar	90.0000	float
env.PS	scalar	1013.25	float
env.RV	scalar	461.500	float
env.REFRACTIVITYPROFILE	[3 x 155]		float
env.REFRACTIVITYPROFILE_NOHPAC	[3 x 9]		float
env.PHIWIND	scalar	3.66519	float
env.REFTABLE	[2 x 5 x 30 x 12]		float
env.KB	scalar	1.3800000e-023	double
env.LOGATABLE	[2 x 30 x 12]		float
env.AWTABLE	[2 x 30 x 12]		float
env.THSW	scalar	3.66519	float
env.RDCACFACTOR	[1 x 12]		float
env.VWS_LAND	scalar	3.15686	float
env.HPACFILE	scalar	hpac2005091612_000_011.txt	string
env.HPACFLAG	scalar	12	integer
env.HPACTIME	scalar	Fri Sep 16 14:04:05 2005	string
env.RRCONSTANT	scalar	20.0000	float
env.HMAX	scalar	10000.0	float
env.ZEPROFILE	[2 x 7]		float
env.ZESOURCE	scalar	3D	string
env.SRCAPPI	scalar	200509171450PRECIP	string
env.CAPPI1	scalar	200509171450CAPPI1	string
env.CAPPI4	scalar	200509171450CAPPI4	string
env.ECHOTOPS	scalar	200509171450ECHOTOP	string
env.HRESZ	scalar	500.000	float
env.ETZ	scalar	18.0000	float
env.DZDH	scalar	-0.00700000	float
env.KE	scalar	1.33333	float
env.PW	scalar	1.00000e+006	float
env.AA	scalar	200.000	float
env.BB	scalar	1.60000	float
env.KW2	scalar	0.920000	float
env.EULER	scalar	0.557216	float
env.SIGT	scalar	1.00000	float
env.VWCONSTANT	scalar	11.4400	float
env.PHIWINDCONSTANT	scalar	3.66519	float
env.VWPROFILE	[3 x 4]		float
env.WINDSOURCE	scalar	3D	string
env.G	scalar	-9.80665	float
env.WAVESOURCE	scalar	2D	string
env.WAVEFILE	scalar	2005091612_000.grib1	string
env.HAV	scalar	2.00000	float
env.SAL	scalar	30.0000	float
env.WAVEFORECASTHOUR	scalar	2	integer

env.LANDCOVERFLAG	scalar	1	integer
env.LANDCOVERALL	scalar	25	integer
env.PROFILEMERGE	scalar	1	integer
env.MOPROFILE	scalar	0	integer
env.UPPERHEIGHT	scalar	20.0000	float
env.UPPERP	scalar	996.700	float
env.UPPERT	scalar	31.1000	float
env.UPPERRH	scalar	77.0000	float
env.WSHEIGHT	scalar	20.0000	float
env.WSPD	scalar	5.20000	float
env.WDIR	scalar	320.000	float
env.TSEA	scalar	33.9000	float
env.LOWERHEIGHT	scalar	0.000000	float
env.LOWERRH	scalar	98.2000	float
env.GROUNDELEVATION	scalar	0.000000	float
env.UPPERAIR	[4 x 24]		float
env.DEDLEVEL	scalar	1	string
env.VONKARMON	scalar	0.400000	float
env.PO	scalar	1000.00	float
env.RD	scalar	287.000	float
env.CP	scalar	1004.67	float
env.ALPHA	scalar	0.0110000	float
env.FCP	scalar	1.25000	float
env.RHWS	scalar	100.000	float
mis.START_LONLAT	[1 x 2]		double
mis.LONMI	[1 x 200]		double
mis.LATMI	[1 x 200]		double
mis.HMI	[1 x 200]		double
mis.VMI	[1 x 200]		double
mis.MCA	scalar	48.999996	double
mis.RCSSOURCE	scalar	Aspect	string
mis.RCSFILE	scalar	RCS_Exocet_9.0GHz_vv.dat	string
mis.RCSI	scalar	0.100000	float
mis.SWERLING	scalar	3	integer
mis.MTLON	scalar	-63.988342	double
mis.MTLAT	scalar	44.602833	double
mis.LONMI_P	[1 x 200]		double
mis.LATMI_P	[1 x 200]		double
prj.PL_LON	scalar	-63.624161	double
prj.PL_LAT	scalar	44.749537	double
prj.PL_HEIGHT_AGL	scalar	4	integer
prj.PL_V	scalar	1000.00	float
prj.PD_LON	scalar	-63.453902	double
prj.PD_LAT	scalar	44.508437	double
prj.RCSSOURCE	scalar	Constant	string
prj.RCSI	scalar	0.100000	float
sig.LD	scalar	1.00000	float
sig.DWELLPFA	scalar	1.0000000e-006	double
sig.PFA	scalar	0.00040835946	double
sig.M	scalar	2	integer
sig.MTI	scalar	1	integer
sig.PROCESSINGTYPE	scalar	FFT	string
sig.DETECTORTYPE	scalar	square-law	string
jam.PTJ	scalar	1200.00	float
jam.GTJ	scalar	39.8107	float
jam.FTJ	scalar	8.9550000e+009	double
jam.BJ	scalar	4000000.0	double
jam.PHGAINPATTERNTYPEJ	scalar	sinx/x	string
jam.THGAINPATTERNTYPEJ	scalar	sinx/x	string
jam.LONJ	scalar	-63.624161	double
jam.LATJ	scalar	44.749537	double
jam.PH3J	scalar	0.349066	float
jam.TH3J	scalar	0.349066	float
jam.ANTDIAMPHJ	scalar	0.100000	float
jam.ANTDIAMTHJ	scalar	0.100000	float
jam.PHBSJ	scalar	3.1415926	double
jam.THCJ	scalar	1.57080	float
jam.HAJ	scalar	100.000	float
jam.POLJ	scalar	V	string
ext.V101	scalar	0	integer
ext.V2ECLIPSE	scalar	0	integer

```
                  ext.WALLOPS              scalar                           0    integer
                    ext.IDATA              scalar                           0    integer
                     ext.SADM              scalar                           0    integer
               ext.ANGLELIMIT              scalar                           1    integer
                   ext.GENKML              scalar                           0    integer
                   ext.OLDLEC              scalar                           1    integer
                   ext.SAVEIQ              scalar                           0    integer
                ext.IQ_OLDLPH              scalar                           1    integer
                ext.IQ_OLDSUM              scalar                           1    integer

PROGRAM EXECUTION CONTROL FLAGS:
              gOldMissilePath             0
             gOldRefractivity             1
             gNoPrecipitation             1
                  gOldTerrain             1
                        gV101             0
      gOldClutterRangeWeights             1
                   gV2eclipse             0
              gOldPropagation             1
                     gWallops             0
                       gOldWC             1
                    gOldLphWC             1
                    gOldLthWC             1
                       giData             0
       gOldMissilePropagation             0
                gOldMissileW2             0
                      gOldLec             1
                    gOldLphSC             1
                      gOldSum             0
                        gSADM             0
                    gNoJammer             1
                   gOldJammer             1
                   gOldThProb             0
                      gSaveIQ             0
                   gIQ_OldSum             1
                   gIQ_OldLph             1

PROGRAM DATA FILES:
           gTrajectoryDataFile                 MissilePath_example.dat
         gRefractivityDataFile                           M_example.dat
              gTerrainDataFile                     Terrain_example.dat
    gClutterRngWeightsDataFile         ClutterRangeWeights_example.dat
          gPropagationDataFile          ExtractedSurfaceF4_example.dat
         gReflectivityDataFile                         dbz_example.dat
         gMissilePropDataFile                  MissileF4th_example.dat
    gMissileRngWeightsDataFile         MissileRangeWeights_example.dat
       gEclipsingLossDataFile                          Lec_example.dat
           gWC3DPowerDataFile               WeatherClutter_example.dat
           gWC1DPowerDataFile               WeatherClutter_example.dat
           gWC0DPowerDataFile               WeatherClutter_example.dat
    gWCAzBeamshapeLossDataFile       WCAzBeamshapeLossData_example.dat
    gWCElBeamshapeLossDataFile       WCElBeamshapeLossData_example.dat
              gSCAzRngSumFile                          Sum_example.dat
    gSCAzBeamshapeLossDataFile       SCAzBeamshapeLossData_example.dat
         gJammerPowerDataFile                       Jammer_example.dat
              gIQAzRngSumFile                          Sum_example.dat
    gIQAzBeamshapeLossDataFile       IQAzBeamshapeLossData_example.dat
          gThreshProbDataFile                   ThreshProb_example.dat

PROGRAM EXECUTION LOG:
Starting MiDLE..
Calculating missile flight path..
Duration: 26.95 seconds.
Saving file C:\MiDLE\MiDLEV6\V6\OUTPUT\MissilePath_example.dat..
       variables:  rpath phpath thpath vpath max_tta lonr latr
Displaying threat trajectory..
Calculating scanning characteristics..
Duration: 0.69 seconds.
Restoring refractivity profiles file..
File "C:\MiDLE\MiDLEV6\V6\OUTPUT\M_example.dat" was not found.  Using default..
Restoring terrain properties file..
```

```
File "C:\MiDLE\MiDLEV6\V6\OUTPUT\Terrain_example.dat" was not found.  Using default..
Restoring range weighting functions file..
File "C:\MiDLE\MiDLEV6\V6\OUTPUT\ClutterRangeWeights_example.dat" was not found.  Using default..
Restoring propagation file..
File "C:\MiDLE\MiDLEV6\V6\OUTPUT\ExtractedSurfaceF4_example.dat" was not found.  Using default..
Calculating missile trajectory..
Duration: 0.51 seconds.
Calculating missile RCS for each missile position..
Duration: 0.02 seconds.
Saving file C:\MiDLE\MiDLEV6\V6\OUTPUT\MissileRCS.dat..
       variable:  rcs
Processing missile I and Q signals..
Duration: 165.88 seconds.
Performing missile power limiting..
Duration: 0.12 seconds.
Calculating surface clutter power..
File C:\MiDLE\MiDLEV6\V6\OUTPUT\ExtractedSurfaceF4_example.dat was not found.  Using default..
File C:\MiDLE\MiDLEV6\V6\OUTPUT\ClutterRangeWeights_example.dat was not found.  Using default..
Duration: 172.03 seconds.
Calculating receiver system mean noise power..
Duration: 0.00 seconds.
Calculating detection thresholds and probabilities..
Duration: 430.58 seconds.
Saving file C:\MiDLE\MiDLEV6\V6\OUTPUT\ThreshProb_example.dat..
       variables:  np threshold Pd_intlim MDP fdindex
Calculating dwell probability of detection..
Duration: 0.00 seconds.
Limiting output data for each illumination..
Saving file C:\MiDLE\MiDLEV6\V6\OUTPUT\MissilePath_example_PlotQty.dat
       variables:  env rad con rm thm phm vrm timem rcs mF4th Pdd
                   trimI trimQ Pn Pd_maxindex rcint F4th trimF4th
                   rc PrSC phba trimPrSC rpath thpath phpath ranges
                   Pd Pddu PWc phq ref hsig Mdata MaxBinRange terr WindData
MiDLE completed!  Total elapsed time: 811.50 seconds  (13.5 minutes).
```

Appendix B – APM Version 2.3.05 Fortran Source Files

APM filename	Date modified	Size (KB)
aln_init.f90	24/08/2004	2
antpat.f90	21/03/2006	6
apm_mod.f90	17/09/2008	58
apmclean.F90	08/08/2008	9
apmfuncs.f90	08/08/2008	20
apminit.f90	08/08/2008	29
apmmain_mod2.f90	28/11/2012	32
apmstep.f90	08/08/2008	9
apmsubs.f90	08/08/2008	18
calclos.f90	08/01/2007	15
clutter.f90	31/01/2007	12
dieinit.F90	13/12/2006	11
doshift.F90	08/12/2005	2
exto.F90	24/03/2006	11
fedr.F90	07/08/2007	7
fem.F90	07/08/2007	9
fft.F90	08/12/2005	2
FFT42.F90	11/07/2006	4
FFT42_32.F90	07/02/2012	4
fftpar.F90	05/12/2006	3
fillht.F90	27/03/2006	5
frstp.F90	08/12/2005	2
fzlim.F90	08/08/2008	4
gas abs.F90	08/12/2005	2
get_k.F90	19/12/2005	6
getaln.f90	26/08/2004	5
getangles.f90	08/08/2008	8
getrefcoef.f90	02/12/2005	5
gettheta.F90	08/12/2005	2
getthmax.f90	08/08/2008	13
graze_int.F90	24/08/2007	9
htcheck.F90	24/08/2007	4
intprof.F90	08/12/2005	2
meanfilt.F90	19/07/2006	2
mixedft.f90	03/11/2005	5
peinit.f90	08/08/2008	7
pestep.f90	25/11/2012	12
process_ang.F90	20/08/2007	15
profref.F90	08/12/2005	4
raytrace.F90	08/12/2005	9
refinit.F90	08/08/2007	14
refinter.F90	08/12/2005	4
remdup.F90	02/02/2006	2

APM filename	Date modified	Size (KB)
ret_graze.F90	05/06/2006	4
rgtace.F90	14/08/2007	7
rocalc.F90	08/08/2008	10
roloss.F90	08/08/2007	14
savepro.F90	08/12/2005	2
sort2.F90	08/08/2007	2
specest.F90	08/12/2005	4
spm.f90	08/08/2008	18
surfimp.f90	26/08/2004	6
terinit.F90	12/12/2006	7
trace_rout.F90	08/08/2008	5
trace_step.F90	20/08/2007	6
tropoinit.f90	19/12/2005	4
troposcat.f90	02/11/2005	5
xoinit.F90	30/01/2007	4
xostep.F90	14/12/2006	7
xyinit.F90	08/12/2005	3

Appendix C – Acronyms and Abbreviations

APM	-	Advanced Propagation Model
BMP	-	Bulk Meteorological Parameters
CAPPI	-	Constant Altitude Plan Position Indicator
CCS	-	Contour Colours Selection
CD	-	Compact Disk
CDED	-	Canadian Digital Elevation Data
CPC	-	Control Parameters Control
CPF	-	Canadian Patrol Frigate
CPU	-	Central Processing Unit
DE	-	Development Environment
DLL	-	Dynamically Linked Library
DRDC	-	Defence Research and Development Canada
DTED	-	Digital Terrain Elevation Data
EPC	-	Environment Parameters Control
EXPC	-	Expert Parameters Control
FFT	-	Fast Fourier Transform
GEM	-	Global Environment Multiscale
GUI	-	Graphical User Interface
HPAC	-	Hazard Prediction Assessment Capability
IDL	-	Interactive Design Language
JPC	-	Jammer Parameters Control
KML	-	Keyhole Markup Language
MiDLE	-	Missile Detection in the Littoral Environment
MPC	-	Missile Parameters Control
MPI	-	Message Passing Interface
MS	-	Microsoft
MTI	-	Moving Target Indicator
NSWC	-	Naval Software Weapons Center
PD	-	Probability of Detection
PEC	-	Program Execution Control
PF	-	Propagation Factor
PRM	-	Power Received from Missile
PPC	-	Projectile Parameters Control
RPC	-	Radar Parameters Control
RCS	-	Radar Cross Section
RT	-	Run Time
SCP	-	Surface Clutter Power
SM	-	Shared Memory
SPF	-	Save Parameters File
SPPC	-	Signal Processing Parameters Control
STC	-	Sensitivity Time Control
SUM	-	Software User Manual
WCP	-	Weather Clutter Power

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This document is a software user manual for the MiDLE (Missile Detection in the Littoral Environment) software. MiDLE, developed by DRDC over the last ten years, is a flexible, high-fidelity model designed to predict the detection performance of naval radar systems operating against anti-ship missiles in a littoral environment. This version of the software was developed under contract to include a graphical user interface designed to make the software more accessible to non-expert users and some additional features. The main features of the software are described. Instructions for the installation and execution of the software are also provided.

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