APPENDIX 1 TO ANNEX A

CANADIAN ARMY

MEDIUM RANGE RADAR ACQUISITION (MRR-A)

SYSTEM PERFORMANCE SPECIFICATION (SPS)

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1. INTRODUCTION

1.1 Purpose

1.1.1 This System Performance Specification describes the key performance requirements for a Medium Range Radar (MRR); referred to henceforth as the “MRR System”, for the Land Force Intelligence Surveillance, Target Acquisition and Reconnaissance (LF-ISTAR) Omnibus project support for the force generation and deployment of Canadian Armed Forces (CAF) units.

1.2 Identification / Overview.

1.2.1 The Medium Range Radar (MRR) System specified in this document includes the sensor system and the other ancillary equipment. A complete system consisting of all the equipment required such as Canadian communication equipment will be specifically referenced as applicable.

2. APPLICABLE DOCUMENTS

2.1 General. A complete list of documents that form part of this specification to the extent specified herein, and are supportive of the specification when referenced in section 3 and beyond can be found in Annex D (Applicable Documents) to the MRR System RFP.

3. REQUIREMENTS

3.1 System Performance.

3.1.1 General System Capability.

3.1.1.1 Radar Modes

3.1.1.1.1 The MRR System shall have the necessary capacity to simultaneously host software for all modes. Simultaneous hosting shall enable the system to switch between weapon locating and air surveillance modes without rebooting the system.

3.1.1.1.2 The MRR System should perform the weapon locating mission and the air surveillance mission concurrently.

3.1.1.2 System Integration, Transmit and Record Data.

3.1.1.2.1 The MRR System shall digitally record and transmit target data.

3.1.1.3 Command Post Equipment.

3.1.1.3.1 The ruggedized equipment/workstation that would be installed in a command post to operate the radar shall be provided in transit cases in accordance with IP 65, IEC 60529.

3.1.1.4 Remote Operation.

3.1.1.4.1 The MRR System shall have a remote operation capability allowing the operator to be a minimum distance of 100 meters from the MRR System.

3.1.1.5 Into and Out of Action Time.

3.1.1.5.1 The set-up time is defined as the amount of time required to have the MRR system deployed and in action from a road move configuration.

3.1.1.5.2 Set-up times do not include set-up of communication masts / antennae, camouflage, additional grounding beyond the minimum safe grounding, cable payout due to a remote location for the power generator, manual survey in the case of INS failure, automatic terrain following initialization after the system start-up, manual levelling if the automatic levelling has failed, installation of the DTED files, installation of communication devices beyond the operators workstation.

3.1.1.5.3 Set-up times make the assumption that the soil is suitable for the easy installation of safe grounding for the MRR System operation. Set up time also includes all activities required for the safe operation of the MRR System in the operational environmental conditions as defined in paragraphs 3.3.10 and 3.3.11 Wind and Sand Dust.

3.1.1.5.4 The MRR System shall be set-up and operational in no more than 20 minutes in temperatures from 5° C to 49° C.

3.1.1.5.5 The MRR System shall be set-up and operational in no more than 30 minutes in temperatures from -40° C to 5° C.

3.1.1.5.6 For temperatures from -15 degrees C to 49 degrees C, the MRR System shall be packed up and out of action in no longer than 5 minutes (displacement time). Displacement time starts when the system is powered off and ends when the system is ready for movement. The times to remove and stow communication masts / antennae, camouflage, additional grounding beyond the minimum safe grounding, cable payout due to a remote location for the power generator, and manual levelling if the automatic levelling has failed, are excluded from the displacement time.

3.1.1.5.7 Setup and pack-up times of the MRR System shall be achievable with no more than four persons.

3.1.2 General Weapon Locating Capability.

3.1.2.1 Mode. The MRR System shall have stand-by (non-radiating but ready to radiate on command) and operating (radiating) modes.

3.1.2.2 Extrapolation. The MRR System shall automatically extrapolate the trajectory of a projectile to the correct location of the weapon and to the correct altitude of the weapon within the accuracy limits of the Location Accuracy paragraph 3.1.3.6 as determined by Digital Terrain and Elevation Data (DTED).

3.1.2.3 Automatic Altitude Correction. The MRR System shall automatically correct for differences in altitude between the MRR System and the location of the weapon using DTED.

3.1.2.4 Minimum Radial Velocity. The minimum radial velocity of a projectile, with respect to the position of the MRR System, from a weapon that can be located, shall be automatically adaptive to the clutter conditions.

3.1.2.5 Target Location Capacity

3.1.2.5.1 The MRR System shall acquire, process, record and transmit to an external destination a minimum of 40 targets per minute.

3.1.2.5.2 The MRR System shall record and store target records to internal storage devices.

3.1.2.5.3 The amount of internal recording capability shall be 24 hrs.

3.1.2.5.4 All applicable recorded data shall be accessible through a USB interface.

3.1.2.6 Site Reconnaissance Survey and Navigation

3.1.2.6.1 The MRR System shall have an automated navigation system providing accurate pointing/orientation data.

3.1.2.6.2 The navigation system of the MRR System shall operate with or without access to military GPS signals.

3.1.2.6.3 The MRR System shall manually accept external position information in the absence of GPS signals.

3.1.2.6.4 The MRR System shall manually accept orientation information.

3.1.2.7 Weapon Locating Man Machine Interface

3.1.2.7.1 As a minimum the MRR System shall display the following:

a. Ground tracks of the projectile;

b. Point of Origin (POO);

c. Point of Impact (POI);

d. Radar position;

e. Table with projectile details;

f. Individual detections of the projectile;

g. BIT;

h. Jamming strobe indicator;

i. Ground tracks of other non-ballistic tracks (the detections of other objects/clutter is not suppressed);

j. An error estimation in ellipse format of the POO;

k. An error estimate in ellipse format of the POI; and

l. A tool to show the view-shed information (shows terrain viewable by the radar in 3 dimensions).

3.1.2.7.2 As a minimum the MRR System display shall have the following controls:

a. Zone creation capability;

b. Frequency selection;

c. Map controls;

d. Communication controls (to be refined with interface to CAF C2)

e. Radiation control;

f. Mission planning tools;

g. Sector radiation control; and

h. Control of the applicable color codes on the display screen.

3.1.3 Hostile Weapon Locating Capability.

3.1.3.1 Search Sector Capability.

3.1.3.1.1 The MRR System in the 360 degree weapon location mode shall continuously search and locate in a full 360 degree sector in azimuth.

3.1.3.1.2 The MRR System should search and locate in a 90 degree sector in azimuth, to obtain better location accuracy and longer range capability.

3.1.3.2 Location Range

3.1.3.2.1 The MRR System shall locate mortar, gun, and rocket weapon systems positioned anywhere out to a mandatory range of 15 km from the MRR System's location, in a 360 degree sector in azimuth.

3.1.3.2.2 In a 360 degree sector in azimuth, the minimum location range for mortars and guns shall be 5 km or less.

3.1.3.2.3 In a 360 degree sector in azimuth, the minimum location range for rockets shall be 8 km or less.

3.1.3.2.4 The MRR System shall determine the Point of Impact (POI) for projectiles which land within 15 km radius of the MRR System when the firing weapon is up to 15km from the MRR System.

3.1.3.2.5 The MRR System should be able to locate guns and rockets to a range greater than 15 km in a 360 degree sector in azimuth.

3.1.3.2.6 The MRR System should be able to locate guns and rockets to a range greater than 15 km in a 90 degree sector in azimuth.

3.1.3.3 Minimum Calibre.

3.1.3.3.1 The minimum calibre mortar weapon that the MRR System shall locate is 60mm.

3.1.3.3.2 The minimum calibre gun weapon that the MRR System shall locate is 105 mm.

3.1.3.3.3 The minimum calibre rocket weapon that the MRR System shall locate is 107 mm.

3.1.3.4 Weapon Types.

3.1.3.4.1 At a minimum, the weapon systems that shall be located by the MRR System are in the following table:

Type	**Calibre**	**Muzzle Velocity (m/s)**	**Quadrant Elevation (mils)**
Gun	105 mm	205-494	200-1100
Gun	155 mm	208-807	200-1100
Mortar	60 mm	152-306	800-1500
Mortar	81 mm	66-268	800-1425
Mortar	120 mm	100-316	800-1350
Rocket	107 mm	375	400-733
Rocket	122 mm	687	400-853

3.1.3.5 False Location Rate (Weapon Locating).

3.1.3.5.1 The MRR System shall have a maximum False Location Rate (FLR) of one (1) false location reported per six (6) hour period under nominal environmental conditions with terrain clutter and 4 mm/hour rainfall. The clutter model for terrain clutter and 4 mm/hour rainfall is specified at paragraph 3.5.12 of this document.

3.1.3.6 Location Accuracy.

3.1.3.6.1 The MRR System shall have an accuracy of location for mortars equal to or better than a Circular Error Probable of 50% CEP(50%) of 50 meters or 0.5% of range from the MRR System while locating in a 360-degree sector in azimuth.

3.1.3.6.2 The MRR System shall have an accuracy of location for guns (105mm and larger) and rockets (107mm and 122mm) equal to or better than a CEP(50%) of 75 meters or 1.0% of range from the MRR System while locating in a 360-degree sector in azimuth.

3.1.3.6.3 The MRR System should locate mortars and guns out to a range of 15 km or more in a pre-defined azimuth sector of 90 degrees, with a minimum accuracy of CEP(50%) of 50 m or 0.5% of range. The minimum location range for mortars in this predefined sector should be no more than 1 km. The minimum location range for guns in this predefined sector should be no more than 3 km.

3.1.3.6.4 The MRR System should locate rockets out to a range of 15 km or more in a pre-defined azimuth sector of 90 degrees, with a minimum accuracy of CEP(50%) of 60m or 1.0% of range. The minimum location range for rockets in this predefined sector should be no more than 5 km.

3.1.3.6.5 The MRR System should locate mortars and guns out to a range of 15 km or more in 360 degree mode, with a minimum accuracy of CEP(50%) of 50 m or 0.5% of range. The minimum location range for mortars in 360 degree mode should be no more than 1 km. The minimum location range for guns in 360 degree mode should be no more than 3 km.

3.1.3.6.6 The MRR System should locate rockets out to a range of 15 km or more in 360 degree mode with a minimum accuracy of CEP(50%) of 60m or 1.0% of range. The minimum location range for rockets in 360 degree mode should be no more than 5 km.

3.1.3.7 Probability of Location

3.1.3.7.1 The probability of location for mortars, guns and rockets shall be a minimum of 80%.

3.1.3.8 Specific Location Accuracy of Guns. The MRR System while operating in a 360 degree mode shall locate a 105mm gun with 85% probability of location and 150m Circular Error Probable of 50% (CEP(50%)) when:

a. firing at a 15 km range from the MRR System;

b. the direction from the MRR System that the gun is firing from, is not known a priori;

c. the weapon is fired towards the MRR System with aspect angles of: 0°, +40°, -40°;

d. the gun is firing a minimum of 1,100 mils elevation;

e. the gun round is not base bleed;

f. the impact location is not known a priori and may be anywhere along the described ground path but at least 6 km from the gun and no further than 15 km from the MRR System; and

g. the projectile is 30 mil above the terrain mask for at least 6 seconds.

3.1.3.9 Specific Location Accuracy of Rockets. The MRR System while operating in a 360 degree mode shall locate a 107mm rocket launcher with 85% probability of location and 150m CEP(50%) when:

a. firing at a 15 km range from the MRR System;

b. the direction from the MRR System that the rocket is firing from, is not known a priori;

c. the weapon is fired towards the MRR System with aspect angles of: 0°, +40°, -40°;

d. the rocket is firing a minimum of 600 mils elevation;

e. the impact location is not known a priori and may be anywhere along the described ground path but at least 6 km from the weapon and no further than 15 km from the MRR System; and

f. the projectile is 30 mil above the terrain mask for at least 6 seconds.

3.1.3.10 Specific Location Accuracy of Mortars. The MRR System while operating in a 360 degree mode shall locate an 81mm mortar with 85% probability of location and 75m CEP(50%) when:

a. firing at a 15 km range from the MRR System;

b. the direction from the MRR System that the mortar is firing from, is not known a priori;

c. the weapon is fired towards the MRR System with aspect angles of: 0°, +40°, -40°;

d. the mortar is firing at 1,400 mils elevation and reaches a height of at least 800m;

e. the impact location is not known a priori and may be anywhere along the described ground path inside the 15 km radius from the MRR System; and

f. the projectile is 30 mil above the terrain mask for at least 6 seconds.

3.1.3.11 Volley Fire.

3.1.3.11.1 The MRR System shall locate volley fire from mortars and guns within the essential CEP limits in the Location Accuracy paragraph 3.1.3.6 of this document, from at least 5 or more different weapons, in a 360 degree sector in azimuth, at a maximum of 15 km from the MRR System.

3.1.3.12 Hostile Impact Prediction.

3.1.3.12.1 The MRR System shall predict the impact point of a located hostile projectile to within 500m, CEP (50%) when the projectile impact point remains inside the 360°, 15 km distance from the MRR System.

3.1.3.12.2 The MRR System shall predict the impact point of a located hostile projectile if it lands outside the 360°, 15 km distance from the MRR System.

3.1.3.12.3 The MRR System should predict the impact point of a located hostile projectile to less than 500m, CEP(50%) when the projectile remains inside the 360°, 15 km distance from the MRR System.

3.1.3.12.4 The point of impact or the point of origin for any detected and tracked hostile projectile which is outside the specified range shall be recorded if there are a series of detections considered to be a non-ambiguous valid trajectory track for that projectile.

3.1.3.13 Ballistic/Non-Ballistic Delivery System Classification.

3.1.3.13.1 The MRR System shall be able to classify each located weapon, either as a mortar, gun or rocket.

3.1.3.13.2 The MRR System shall be able to classify ballistic and non-ballistic projectiles.

3.1.4 Friendly Fire Locating Capability.

3.1.4.1 Friendly Fire Registration.

3.1.4.1.1 The MRR System shall perform friendly fire registration missions with a CEP(50%) of 50 meters or 0.5% of range or better out to a range of 15 km.

3.1.4.1.2 The MRR System should perform friendly fire registration missions with a CEP(50%) of 50 meters or 0.5% of range or better out to a range of up to 30 km in a predefined azimuth sector of 90 degrees.

3.1.5 Air Surveillance Capability

3.1.5.1 General. The MRR System shall have an airspace surveillance mission, 360 degrees in azimuth. The clutter model at paragraph 3.5.12 of this document shall apply.

3.1.5.2 Range for $1m^2$ Targets.

3.1.5.2.1 The MRR System shall detect and track a 1 $meter^2$ RCS uncooperative target at a range from 1 km to 75 km. A one m^2 target consists of either fixed wing high speed aircraft or low speed rotary wing aircraft in clutter.

3.1.5.2.2 The MRR System should detect and track a 1 $meter^2$ RCS uncooperative target at a range from 1 km to distances greater than 75 km.

3.1.5.3 Range for $0.1m^2$ Targets.

3.1.5.3.1 The MRR System shall detect and track a 0.1 $meter^2$ RCS uncooperative target at a minimum range from 1 km to 25 km. Aircraft with 0.1 m^2 RCS may consist of high speed cruise missiles and low speed UAVs in ground clutter.

3.1.5.3.2 The MRR System should detect and track a 0.1 meter^2 RCS uncooperative target at a minimum range from 1 km to distances greater than 25 km.

3.1.5.4 Altitude. The MRR System shall detect uncooperative targets at altitudes from 100 meters or less to 10,000 meters or more.

3.1.5.5 Elevation.

3.1.5.5.1 The MRR System shall detect uncooperative targets from -10 degrees to a minimum of 30 degrees in elevation in search. The minimum elevation angle of -10° is subject to a terrain imposed limit, such that it is applicable to sites where the local topology and MRR system position supports a Line of Sight (LOS) to targets below the nominal horizon beyond the minimum detection range of the radar.

3.1.5.5.2 The MRR System shall track uncooperative targets from -10 degrees to a minimum of 45 degrees in elevation.

3.1.5.6 Accuracy. The MRR System shall have a one-sigma accuracy for 1 meter^2 RCS targets of 20 meters in range, 0.6 degrees in azimuth and 600 meters in altitude at a range of 75 km.

3.1.5.7 Target Characteristics. The fluctuation of the radar cross-section of airborne targets is expected to best be modeled by a Swerling I type target. See P.Swerling, Probability of Detection for Fluctuating Targets, Rand Research Memo RM-1217, 17 March 1954.

3.1.5.7.1 The MRR System shall detect fixed wing high speed aircraft and cruise missiles to a maximum velocity of 825 m/sec or more.

3.1.5.7.2 The MRR System shall detect UAV and rotary aircraft to a minimum velocity of 20 m/sec or less.

3.1.5.8 Detection in Rainfall. The MRR System shall have a minimum probability of detection of 50% per scan in rain fall of 4mm per hour at the maximum range specified in paragraph 3.1.5.2.1 and paragraph 3.1.5.3.1. Refer to the clutter model at paragraph 3.5.12.

3.1.5.9 Detection in Clear Weather. The MRR System shall have a minimum probability of detection of 80% per scan in clear weather at the maximum range (specified in paragraph 3.1.5.2.1 and paragraph 3.1.5.3.1) with a minimum of 24 detection opportunities per target per minute. In clear weather, the ground clutter model at paragraph 3.5.12 in this document still applies.

3.1.5.10 Detection Rate.

3.1.5.10.1 The MRR System shall have a minimum possible detection rate of 24 detections per target per minute, which assumes one detection per target per antenna rotation.

3.1.5.10.2 The probability of detection of 80% in clear conditions at maximum range results in 19.2 detections per target per minute. Similarly, the probability of detection of 50% in rain results in 12 detections per target per minute.

3.1.5.10.3 The MRR System should have a detection rate of over 24 detections per target per minute.

3.1.5.11 Air Surveillance False Track Rate. The MRR System shall have a maximum false track rate of 20 false tracks per hour. See definition of False Track Rate in Acronyms and Definitions, Annex E.

3.1.5.12 New Track Latency.

3.1.5.12.1 The MRR System shall establish a track in 10 seconds or less following the first detection of a target with a 90% probability of track initiation.

3.1.5.12.2 The MRR System should establish a track in less than 10 seconds following the first detection of a target with a 90% probability of track initiation.

3.1.5.13 Tracking.

3.1.5.13.1 The MRR System shall be able to keep track of a minimum of 200 tracks simultaneously.

3.1.5.14 Classification of Targets. The MRR System shall be able to classify the following targets:

a. Fixed wing aircraft;

b. Hovering rotary wing aircraft;

c. Moving rotary wing aircraft;

d. UAVs;

e. Cruise missiles;

f. Airborne jammers; and

g. Ground based jammers.

3.1.5.15 Identification Friend or Foe (IFF) / Secondary Surveillance Radar (SSR).

3.1.5.15.1 The MRR System shall have an IFF interrogator that as a minimum has modes 1, 2, 3/A, 4, C, S and is “mode 5 ready” and contains all of the latest features of a modern IFF / secondary surveillance radar (SSR)suitable for use with the specified function of the air surveillance radar specified herein.

3.1.5.15.2 The IFF interrogator in modes that require crypto shall be operable with at least one of the following crypto devices:

a. KIV-77;

b. KIV-78;

c. Embedded crypto in accordance with US DoD AIMS 04-900A; or

d. Other US NSA or NATO Security and Evaluation Agency (SECAN) approved mode 4/5 cryptographic device.

3.1.5.15.3 The IFF/SSR shall have a minimum target report load of 200 airborne targets per scan.

3.1.5.15.4 The primary surveillance radar (PSR) to IFF/SSR correlation percentage shall be a minimum of 98%.

3.1.5.15.5 The IFF/SSR shall be compliant with US DOD AIMS 03-1000, ICAO Annex 10, and STANAG 4193. The Mode S capabilities shall be limited to the Mode S selective interrogation feature.

3.1.5.15.6 The IFF/SSR shall have a Selective Identification Feature (SIF).

3.1.5.16 Air Surveillance Man Machine Interface / Display Presentation.

3.1.5.16.1 Controls. The MRR System shall have a Primary Surveillance Radar (PSR) RF inhibit function in all azimuth and selectable by specific sectors. The MRR System shall have a Secondary Surveillance Radar (SSR) RF inhibit function in all azimuth and selectable by specific sectors.

3.1.5.16.2 Air Surveillance Display Presentation.

3.1.5.16.2.1 The MRR System display shall show correlated returns from the Primary Surveillance Radar and the Secondary Surveillance Radar.

3.1.5.16.2.2 The MRR System display shall show sources of active RF interference from a Jam Strobe function.

3.1.5.16.2.3 The MRR System display shall have data blocks with the minimum data consisting of the transponder mode, the IFF/SSR altitude, the PSR altitude, the PSR range and the PSR bearing. The data block may also contain a target identification number that refers to a table with the same data.

3.1.5.16.2.4 The MRR System display shall have a "hooked" capability that will follow an airborne target with a data block.

3.1.5.16.2.5 The MRR System display shall have the capability of displaying the range and bearing between any two points chosen by the operator.

3.1.5.16.2.6 The MRR System display shall have the capability to zoom in on a portion of the display or to offset/pan the display.

3.1.5.16.2.7 The MRR System display shall have the capability to allow the operator to map points of interest and zones onto the background map.

3.1.5.16.2.8 The MRR System display shall display emergency beacons, urgency modes, safety related alerts and warnings received from aircraft IFF transponders.

3.1.5.16.2.9 The MRR System display shall have the capability to display maps.

3.1.5.16.2.10 The MRR System display presentation shall be clear and concise, and continuously updated in a manner that precludes erroneous identification or confusion on the part of the operator.

3.1.5.16.2.11 The MRR System display shall present to the operator the following additional information:

a. Distinct symbols for unintentional duplicated SSR codes and aircraft identification;

b. Predicted positions for non updated track;

c. Display the reserved SSR codes including 7500, 7600 and 7700, operation of IDENT and display the SSR code 1000 used as a non discrete code for ADS-B use as well as other uses in Canada and the USA;

d. Bearing to the airborne target;

e. Range to the airborne target;

f. Absolute Altitude, height above terrain of the airborne target;

g. True Altitude, height above mean sea level of the airborne target;

h. The operator's choice of UTM or MGRS grid reference or Latitude and Longitude of the airborne target;

i. Individual position blips such as PSR, SSR symbols and combined symbols;

j. SSR responses which include SSR code of the aircraft, aircraft identity and pressure altitude derived level information;

k. Plot and track data (historical); and

l. The operator’s choice of imperial or metric measurements where applicable.

3.1.5.17 Air Surveillance Modes

3.1.5.17.1 A second air surveillance mode may be used to meet the hovering helicopter requirement for the air surveillance capability.

3.1.6 External Communication Interfaces.

3.1.6.1 The air surveillance part of the MRR System shall be integrated using the ASTERIX standard interface protocol by EUROCONTROL.

3.1.6.2 The weapon locating part of the MRR System shall use a non-proprietary Application Programming Interface. The weapon locating part of the MRR shall transmit a comprehensive set of messages to the LCSS.

3.1.6.3 The communication link between the MRR operator’s station and the Canadian Armed Forces Land Command Support System (LCSS) shall be based on Ethernet technology, capable of a minimum 100Base-T.

3.2 Electronic Protection Measures.

3.2.1 General.

3.2.1.1 The MRR System shall have Emissions Control (EMCON) capabilities.

3.2.1.2 In a non-interference environment, electronic protection (EP) features shall not degrade the MRR System performance.

3.2.1.3 All MRR system equipment shall incorporate all necessary Electronic Protection Measures (EPM) which allows it to operate in an interference environment.

3.2.1.4 The MRR System shall use modes and techniques which allow the radar to operate in an environment with sources of both intentional and unintentional RF interference.

3.2.1.5 The MRR System shall incorporate operating modes and techniques which allow the radar to minimize RF interference to other systems.

3.2.2 Threat Environment. The expected MRR System electronic threat consists of friendly emissions, stand-off jammers, expendable jammers, repeat jammers in the side-lobes, and chaff.

3.2.3 Degradation. In the presence of a broadband jammer covering the entire operational band of the MRR System with an effective radiated power (ERP) of 25 W/MHz, located at 15 km from the radar, performance of the radar in both range and accuracy shall not be degraded by more than 20% over the azimuth search sector except within ± five (5) degrees of the jammer's azimuth or in the immediate proximity (range gates/Doppler cells) of a chaff cloud.

3.2.4 False Track Rate. The MRR System’s average per scan False Track Rate in the Air Surveillance Mode shall not be degraded by more than 20% in an interference environment as defined by the broad band jammer in paragraph 3.2.3. See definition of False Track Rate in Acronyms and Definitions, Annex E.

3.2.5 Chaff. The MRR System shall incorporate electronic protection measures to minimize detection performance degradation when a target is in the vicinity of a chaff cloud.

3.2.5.1 The nominal characteristics of the chaff cloud are:

a. Chaff radar cross section within resolution cell of the radar: 10 m^2;

b. Wind speed (average speed of chaff cloud): 20 m/sec;

c. Velocity distribution of cloud: Gaussian;

d. Altitude distribution: 0 to 6,000 m;

e. Range distribution: 10 to 80 nm; and

f. Single cloud diameter on release: 30 m.

3.3 Environmental.

3.3.1 All MRR System components required to operate the system remotely shall be IP65 certified.

3.3.2 Temperature.

3.3.2.1 All MRR System external components shall operate in accordance with the specifications herein in temperatures between -40 degrees C and +49 degrees C.

3.3.2.2 All MRR System components shall survive storage in temperatures from -46 degrees C to + 63 degrees C.

3.3.2.3 The low temperature operational test shall be in accordance with MIL-STD-810G, Method 502.5, Procedure II (operation) for -40 degrees C temperature or -25 degrees C temperature as applicable.

3.3.2.4 The high temperature storage test shall be in accordance with MIL-STD-810G, Method 501.5, Procedure I (storage) using the cyclic temperatures in Table 501.5-II High Temperature Cycles, Climatic Category - Basic Hot, for a maximum temperature exposure of +63 degrees C and the MRR System is in a transport configuration.

3.3.2.5 The low temperature storage test shall be in accordance with MIL-STD-810G, Method 502.5, Procedure I (storage) for a -46 degrees C temperature for 8 hours and the MRR System is in a transport configuration.

3.3.3 Solar Radiation.

3.3.3.1 The MRR System shall operate in accordance with the specifications herein with solar radiation of 1120 W/square meter at the maximum required operation temperature.

3.3.3.2 The solar radiation test shall be in accordance with MIL-STD-810G, Method 505.5, Procedure I (cycling - heating effects) using the cyclic temperatures in Figure 505.5-1 Procedure I - Cycling Test, for a maximum temperature of 49 degrees C and a maximum solar radiation of 1120 W/square meter.

3.3.4 Humidity.

3.3.4.1 The MRR System shall operate in accordance with the specifications herein at humidity levels of 95% RH at a temperature of 27 degrees C.

3.3.4.2 The humidity test shall be in accordance with MIL-STD-810G, Method 507.5, Procedure II using a minimum of ten 24 hour humidity cycles as per Figure 507.5-7 Aggravated Temperature-Humidity Cycle.

3.3.5 Fungus.

3.3.5.1 The materials which make up the MRR System shall be fungus resistant and shall not support the growth of fungus.

3.3.5.2 The fungus test shall be in accordance with MIL-STD-810G, Method 508.6. The fungus test shall be done using representative materials or coupons rather than testing the full MRR system.

3.3.6 Precipitation.

3.3.6.1 The MRR System shall be able to withstand rainfall of 45 mm/hr for extended periods without damage due to water penetration.

3.3.6.2 The MRR System shall be able to withstand the effects of blowing rain without water penetration except where the design allows for water penetration without damage as part of normal operations as follows; 45mm/hr rainfall rate; 9 m/s wind speed.

3.3.6.3 The operational, non-operational and transport configuration rain test shall be in accordance with MIL-STD-810G, Method 506.5, Procedure I, using 45 mm/hr as the rainfall rate and 9 m/s as the wind speed.

3.3.7 Freezing Rain and Icing.

3.3.7.1 The MRR System shall survive exposure to freezing rain conditions found in MIL HDBK 310. Manual removal of ice prior to operation is permitted.

3.3.7.2 The MRR System shall be resistant to damage from reasonable and normal ice removal procedures.

3.3.7.3 The MRR System shall be able to withstand build up of glaze ice, specific gravity of 0.9, up to 50 mm thick due to icing or freezing rain.

3.3.7.4 The MRR System shall be able to withstand the build up of hard rime ice, specific gravity of 0.6, up to 75 mm thick due to icing or freezing rain.

3.3.7.5 The MRR System shall be able to withstand the build up of soft rime ice, specific gravity of 0.2, up to 150 mm thick due to icing or freezing rain.

3.3.8 Snow Loading.

3.3.8.1 The MRR System shall be able to withstand the snow load of 100 kg/square meter.

3.3.8.2 For the snow loading specification, verification shall be done by analysis.

3.3.9 Altitude.

3.3.9.1 The MRR System shall operate in accordance with the specifications herein at altitudes of up to 10,000 feet above sea level.

3.3.9.2 The MRR System shall be able to withstand storage at altitudes of 15,000 feet.

3.3.9.3 The operational altitude test shall be in accordance with MIL-STD-810G, Method 500.5, Procedure II, using the equivalent air pressure found at 10,000 feet.

3.3.9.4 The storage altitude test shall be in accordance with MIL-STD-810G, Method 500.5, Procedure I, using the equivalent air pressure found at 15,000 feet.

3.3.10 Wind.

3.3.10.1 The MRR System shall be able to operate in accordance with the specifications herein in winds of 20m/s with the antenna deployed.

3.3.10.2 The MRR System shall be able to withstand winds of 29m/s while in any non operating configuration including with the antenna in a deployed position.

3.3.10.3 With antenna stowed the MRR System shall survive winds of 40 m/s.

3.3.10.4 For the wind specification, verification shall be done by analysis.

3.3.11 Sand and Dust.

3.3.11.1 The MRR System shall operate during and survive exposure to blowing sand and dust.

3.3.11.2 The MRR System shall use air filters or filtering systems or sand and dust removal systems for all air inlets into the system to combat the effects of sand and dust.

3.3.11.3 Air filter systems or sand and dust removal systems shall withstand daily removal, cleaning or filter replacement without damage.

3.3.11.4 The MRR System shall employ seals for all bearings and sliding surfaces.

3.3.11.5 The MRR System shall deploy and operate as specified in a sand concentration of 1.0 g/m3 with wind speeds of up to 18 m/s.

3.3.11.6 The MRR System shall deploy and operate as specified in a dust concentration of 1.0 g/m3 with wind speeds of up to 1.5 m/s.

3.3.11.7 The dust test while in operation shall be in accordance with MIL-STD-810G, Method 510.5, Procedure I, using a wind speed of 1.5 m/s and a dust concentration of 1.0 g/cubic meter.

3.3.11.8 For the sand specification, verification shall be done by analysis. If testing has been done previously, the record of the test with a third party can be used as proof of compliance. Use MIL-STD-810G, Method 510.5, Procedure II, using a wind speed of 18 m/s and a sand concentration of 1.0 g/cubic meter.

3.3.12 Shock.

3.3.12.1 The MRR System shall withstand shocks due to transportation by rail with a maximum impact speed of 12.9 km/hr.

3.3.12.2 For the shock specification, the MRR System is in a transport configuration and the test specification shall be in accordance with MIL-STD-810G, Method 526 Rail Impact. Loaded cars may be used with prior approval of the Technical Authority. A test railcar, equipped with chain tie-downs and end-of-car cushioned draft gear are to be used unless other railcar types are approved by the Technical Authority. Substitute test items are not be used unless approved by the Technical Authority.

3.3.13 Vibration.

3.3.13.1 The MRR System shall withstand the vibration caused by highway and cross-country transportation, in accordance with MIL-STD-810G, Method 514.6, Procedure III; Category 6 of Annex C, in a transport configuration.

3.3.13.2 The road test shall consist of 300 km paved surface at a minimum speed of 80 km/hr, 64 km of secondary gravel roads at 45 km/hr, 15 km of trails at 15 km /hr, 6 km cross country at 10 km /hr, 0.5 km of driving on Belgian block at a maximum speed of 10 km /hr and 0.5 km of driving on 6 inch washboard at a maximum speed of 10 km/hr.

3.3.14 Salt Fog and Corrosion Resistance.

3.3.14.1 The MRR System shall be resistant to the corrosive effects of exposure to road salt or salt fog while being transported either by road or sea.

3.3.14.2 For the salt fog specification, the exterior of the MRR System is in a transport configuration and the test specification shall be in accordance with MIL-STD-810G, Method 509.5.

3.3.15 Temperature Shock.

3.3.15.1 The MRR System shall not be physically damaged or suffer a deterioration in performance after being exposed to temperature shock such as may be experienced when the MRR System is moved from a heated storage area when the outside temperature is at the minimum operating temperature.

3.3.15.2 For the temperature shock test, the MRR System shall be in a transport configuration and the test specification shall be in accordance with MIL-STD-810G, Method 503.5, Procedure I-D from room temperature to minimum operating temperature.

3.4 Mobility.

3.4.1 General.

3.4.1.1 The MRR Sensor System shall be mounted on a single trailer. Ancillary equipment may be transported on the GFE prime mover or a second trailer.

3.4.1.2 The trailer(s) shall be supplied by the contractor and is part of the MRR System.

3.4.1.3 The trailer(s) shall be towed by Canadian in-service vehicles. Canadian in-service vehicles are equipped with pintle hooks for towing. The lunette height shall be adjustable. The lunette shall measure 76.2 mm x 41.2 mm. The vehicle maximum vertical load of the pintle hook shall be 2250 kg.

3.4.1.4 The gross vehicle weight of any trailer fully equipped shall not exceed 13,500kg.

3.4.1.5 The trailer(s) shall meet the required standards as set out by Transport Canada in the Motor Vehicle Safety Regulations at the transport Canada web site www.tc.gc.ca.

3.4.1.6 The trailer(s) brakes shall be power assisted.

3.4.1.7 The trailer(s) shall have an emergency brake and a parking brake.

3.4.1.8 The receptacle for the trailer electrical connector shall be in accordance with STANAG 4007.

3.4.1.9 Trailer(s) shall be designed such that the MRR System meets the reliability specifications.

3.4.1.10 The trailer(s) shall be equipped with a suspension system of sufficient capacity to absorb the high impact loading experienced when traveling over rough terrain.

3.4.1.11 High frequency vibrations and noise shall be attenuated by the suspension system to minimize the detrimental effects on the payload.

3.4.1.12 Standard Military Pattern (SMP) blackout lights shall be provided in accordance with STANAG 4381.

3.4.1.13 The MRR System shall operate when emplaced in any orientation on slopes of up to 5 degrees without excavation.

3.4.2 Transportability and Deployability.

3.4.2.1 The location of the Centre of Gravity (CG) of the fully loaded trailer in all three axes shall be determined and printed on the trailer nameplate.

3.4.2.2 The trailer shall have a landing gear with a pad or suitable device to prevent undue sinking of the front end in moderately soft soil. The pressure exerted on the soil shall be no greater than 28 pounds per square inch (psi).

3.4.2.3 The trailer landing gear shall either be fully retractable or fold towards the trailer when the trailer is hooked to a prime mover.

3.4.2.4 The trailer wheels and tires shall be interchangeable from one side to the other and front to rear, if applicable.

3.4.2.5 The trailer shall have a spare wheel with tire. Changing tools shall be provided in a locked compartment. Tools in the locked compartment shall be required to remove the spare tire from its storage position.

3.4.2.6 Gladhand air hose connectors shall be provided at the front of the trailer.

3.4.2.7 Stowage for wheel chocks (4) and a single steel plate 40 cm by 40 cm by 6 mm shall be provided either in a securable container or space.

3.4.2.8 Provision for mounting a rear license plate shall be provided.

3.4.2.9 The trailer Mean Kilometres Between Mission Failures (MKBMF) shall not be less than 16,000 km. See paragraph 3.5.7.5 for Mission Failure definition.

3.4.3 Strategic Mobility.

3.4.3.1 The MRR System, on trailers, shall be transportable by a C-17 Globemaster III aircraft.

3.4.3.2 The MRR System shall be lifted by crane or fork lift using standard lifting frames, straps, shackles, and spreaders bars. Any specialized equipment required shall be supplied by the contractor.

3.4.3.3 All transport configurations or assemblies shall have sufficient slinging and tie-down points that meet the requirements of MIL-STD-209K.

3.4.3.4 Suitable tie-down points shall be provided so that the trailer, with full payload (MRR System), may be lifted or tied down for transport by rail, air or sea.

3.4.3.5 The lifting and tie-down points of the MRR System shall meet the strength requirements of STANAG 4062.

3.4.4 Rail Transportability.

3.4.4.1 The MRR System, on trailers, shall meet the requirement for unrestricted rail transportation using the Gabarit International de Chargement (GIC) loading gauge from MIL-STD 1366

3.4.5 Air Transportability.

3.4.5.1 The MRR System shall survive pressures and pressure changes associated with air transportation.

3.4.6 Sea Transportability. The MRR System shall be transportable by sea.

3.4.7 Highway Operation.

3.4.7.1 The MRR System shall be towed at a speed of up to 90 km/hr on highways in good condition under all climatic conditions.

3.4.8 Tactical Mobility.

3.4.8.1 The MRR System shall be towed up slopes of up to 40% on a hard surface.

3.4.8.2 The MRR System shall be towed down slopes of up to 40% on a hard surface.

3.4.8.3 The MRR System shall be towed while traversing slopes of up to 20% on a hard surface.

3.4.8.4 The addition of the MRR System onto the contractor selected trailer shall not affect the centre of gravity of the trailer sufficiently to cause the trailer to become unstable. The trailer shall not sway at highway speeds. The stability of the trailer shall be tested using the steady state circular and double lane change tests per

NATO Allied Vehicle Testing Publication AVTP-1, publication # 03-160W – Dynamic Stability.

3.4.8.5 The primary trailer brake system shall be able to stop, hold, and control the trailer ascent and descent on a 20% grade.

3.4.8.6 The parking brake shall hold the trailer on a 20% grade facing up or down the grade.

3.4.8.7 The trailer shall be driven through light vegetation and of being backed into wood lines of light vegetation without damaging any exterior component. Light vegetation is defined as small trees/brush with a stem diameter less than or equal to 25 mm in diameter at breast height.

3.4.8.8 The ground clearance shall be the maximum possible but not less than 350 mm.

3.4.8.9 The trailer angle of departure shall not be less than 30 degrees. A retractable under ride bumper may be used to meet this requirement.

3.4.8.10 The MRR System shall be able to ford a water obstacle up to 750mm deep.

3.5 Miscellaneous Specifications.

3.5.1 Electrical Power.

3.5.1.1 The electrical power source shall be part of the MRR System.

3.5.1.2 The electrical power source shall be a state of the art, mature technology, of conservative and proven design with a proven high reliability.

3.5.1.3 The generator engine shall be a state of the art, mature technology, of conservative and proven design with a proven high reliability.

3.5.1.4 The MRR System shall permit connection to an external independent power source of adequate power capacity that matches the generator voltage and frequency.

3.5.1.5 The MRR System generator shall be a multi-fuel system that uses the fuel as required by STANAG 4362.

3.5.1.6 The connector to the outside source shall allow the direct connection of an appropriate cable onto CSA approved connectors.

3.5.1.7 The generator audio signature shall not exceed 70 dBA at 7 meters.

3.5.1.8 The fuel tank on the generator shall be of sufficient size to run the generator for 8 hours at full power without refuelling.

3.5.2 Cables. All portable cables that are part of the MRR System shall bend at the minimum temperature requirements without the insulation cracking.

3.5.3 Electrical Standards. The electrical installation on the MRR System shall meet the requirements of the Canadian Electrical Code Part 1, C22.1-02.

3.5.4 Marking. Caution, warning, danger and instructional markings on the MRR System shall be in a bilingual format in both the English and French languages.

3.5.5 Nomenclature. Military nomenclature shall be assigned to the MRR System in accordance with Canadian Armed Forces Standard D-01-000-200/SF-001 and MIL-STD 196.

3.5.6 Identification

3.5.6.1 Identification marking shall be applied to major assemblies and loose assemblies of the MRR System in accordance with Canadian Armed Forces Standard D-02-002-001/SG-001.

3.5.6.2 In addition to the mandatory marking information, the system weight and dimensions shall be included. Note: Weight and dimension information is for transportation.

3.5.7 Reliability.

3.5.7.1 The MRR System shall have a minimum Mean Time Between Critical Failure (MTBCF) of 500 hours not including any Government Furnished Equipment (GFE).

3.5.7.2 The MRR System should have a MTBCF of greater than 500 hours not including any GFE.

3.5.7.3 The electrical generator system including the engine shall have a minimum MTBCF of 600 hours.

3.5.7.4 The electrical generator system including the engine should have a MTBCF of greater than 600 hours.

3.5.7.5 Mission Failure or Critical Failure shall be defined in accordance with STANAG 4158. Mission essential functions are all mandatory requirements as specified in the SPS specification in paragraph 3.1 and paragraph 3.2 including all the subordinate paragraphs. Any other failures that prevent the MRR System from performing the mission essential functions shall also be defined as mission essential functions.

3.5.7.6 Reliability predictions shall be determined by mathematical derivation and calculation as described in MIL-HDBK-217F and MIL-STD 1629A.

3.5.8 Durability. The MRR System shall be able to perform at least 30 battlefield days per year over the expected lifetime of the MRR System.

3.5.9 Supportability. The MRR shall be supportable without major redevelopment associated with obsolescence for an initial period of 5 years.

3.5.10 Battlefield Day.

3.5.10.1 During a battlefield day of a medium intensity scenario, each MRR System shall be expected to perform the following:

a. 18 hours operational;

b. 4.0 hours mobile (four moves per day) including the time to deploy and tear down for a daily total of:

i. 50 km on paved roads;

ii. 14 km on rough tracks; and

iii. 6 km cross-country; and

c. Remaining time non-operational (non-continuous, maintenance can be carried out during this time).

3.5.11 Geospatial Data Requirements.

3.5.11.1 The MRR System shall use Digital Terrain Elevation Data (DTED), MIL-PRF-89020, to compute locations automatically in accordance to the Performance Specification.

3.5.11.2 The MRR System shall use all applicable levels of DTED data to achieve the accuracy requirements set herein.

3.5.11.3 The MRR System shall have a digital graphical map display capability.

3.5.11.4 The following are the mapping products that shall be used for the MRR System display:

a. Compressed ARC Digitized Raster Graphics (CADRG);

b. Digital Terrain Elevation Data (DTED);

c. Controlled Image Base (CIB); and

d. Shape Files (.shp).

3.5.11.5 The graphical map display shall displaying grid lines identified by UTM, MGRS and Latitude and Longitude data.

3.5.11.6 The graphical map display shall have the capability to display all graphical map data using the World Geodetic System 1984 (WGS 84) horizontal datum.

3.5.12 Clutter Model.

3.5.12.1 Rain Clutter Characteristics. The MRR System in all modes shall operate in accordance with all the specifications during rain fall at 4mm/ hr. The range extent for rain is 30 km cross range and 30 km down range with respect to the radar coverage and extends uniformly to a 4km height. Specified radar performance in 4mm/hr rain is required over the entire down range extent of the radar coverage. In addition, the rain clutter in the context of the Medium Range Radar has the characteristics as defined in the following paragraphs:

The velocity distribution due to wind is Gaussian and is defined as follows:

V_m (m/s)= (2.53h + 7.7) where,

h is the height in kilometres
V_m is the mean velocity in meters per second

In stagnant air, limits on the falling speed of rain droplets at a particular temperature and pressure is shown in Tables 1 and 2 of The Terminal Velocity of Fall for Water Droplets in Stagnant Air by Ross Gunn and Gilbert D. Kinzer.

The standard deviation of wind velocity distribution σ_r is given by:

$\sigma^2_r = \sigma^2_{turb} + \sigma^2_{shear}$ where,

$\sigma_{turb} = 1.0$ m/s and $\sigma_{shear} = 0.42kR\theta_{el}$ where,

k = shear constant with a value of 4.0 m/s/km
R = slant range to clutter in km
θ_{el} = two way half power antenna elevation beamwidth (radians)

The formula for wind velocity distribution of the wind shear can be found in Radar Design Principles: Processing and the Environment by Fred E. Nathanson, J. Patrick Reilly and Marvin N. Cohen, Chapter 6, pages 242, formula 6.12.
The wind shear was calculated as between 5 to 10 m/s/km in the Naval Research Laboratory report Rain Clutter Statistics by William B. Gordon and Jon D. Wilson, 30 Sept 1982, page 8-9.
Wind shear is further discussed in The Shape of Doppler Spectra from Precipitation by Louis H. Janssen and Gerard A. Van Der Spek, Physics and Electronics Laboratory TNO, The Netherlands, 7 Dec 1984, IEEE AES-21 No 2, March1985.
The book Radar Design Principles: Processing and the Environment by Fred E. Nathanson, J. Patrick Reilly and Marvin N. Cohen, Chapter 6, pages 231-236 contains a discussion on the calculation of backscatter coefficients. The following equation on reflectivity η (m^2/m^3) of rain is defined as follows:

$\eta = (5.7x10^{-14})\ r^{1.6}\lambda^{-4}$ where,

r = rainfall rate in mm/hr
λ = wavelength in meters

Radar performance in the presence of clutter is also discussed in the Radar Handbook edited by Merrill I. Skolnik, Second Edition, pages 2.56-2.60 where the instantaneous illuminated volume or volumetric clutter cell Vc, is defined as follows:

$V_c = R^2\theta_{az}\theta_{el}(c*\tau/2)$ where,

R = slant range to clutter cell in meters
θ_{az} = two-way half power antenna azimuth beamwidth
θ_{el} = two-way half power antenna elevation beamwidth
c = speed of light in m/s
τ = processed received pulse width

Clear Air Attenuation. Atmospheric attenuation strictly due to air is defined by:

Frequency Band	Attenuation (dB/km two-way)
L	0.012
S	0.015
C	0.018
X	0.024

See figures 2.19, 2.21, 2.22, and 2.23 from Radar Handbook, edited by Merrill Skolnik, Second Edition. Choose the 0 degree elevation angle in each figure out to 100nm and convert to db/km.

Rain Attenuation. Rain attenuation does not include atmospheric attenuation and is defined as follows:

$\alpha = ar^b$ (dB/km) where,

α = rain attenuation in dB/km (one way)

r = rainfall in mm/hr

a and b are a function of frequency and polarization as listed in the table below.

Values of a and b for Rain Attenuation

Frequency (GHz)	**a*H***	**a*V***	**b*H***	**b*V***
1	0.0000387	0.000035	0.912	0.880
2	0.000154	0.000138	0.963	0.923

3	0.00065	0.00059	1.121	1.075
6	0.00175	0.00155	1.308	1.265
7	0.0030	0.00265	1.332	1.312
8	0.0045	0.00395	1.327	1.31
10	0.010	0.00887	1.276	1.264

Note that values for ‘**a**’ and ‘**b**’ at other frequencies can be derived by interpolation using a logarithmic scale for ‘**a**’ and a linear scale for ‘**b**’.

The formula for attenuation due to rain can be found in Radar Design Principles: Processing and the Environment by Fred E. Nathanson, J. Patrick Reilly and Marvin N. Cohen, Chapter 6, pages 226 – 228.

3.5.12.2 Land Terrain Clutter Characteristics.

The MRR System in all modes shall operate in accordance with all the specification in the presence of land terrain surface clutter. The surface clutter model is defined in the book Low-Angle Radar Land Clutter: Measurements and Empirical Models by J. Barrie Billingsley. See chapter 4 for the Clutter Model.

See Table 4.2 Multi-Frequency Weibull Parameters of Land Clutter Amplitude Distributions page 295 of Low-Angle Radar Land Clutter: Measurements and Empirical Models by J. Barrie Billingsley. Table 4.2 reproduced below, gives the Weibull parameters of the land clutter that the MRR System shall be able to operate in the present of. With respect to the MRR System, the land terrain clutter characteristics can best be described by the rural terrain as shown in Table 4.2, for example, agricultural, forest, shrub land, grassland, wetland, and desert regions.

Multi-Frequency Weibull Parameters of Land Clutter Amplitude Distributions

Terrain Type	Depression Angle (deg)	$\overline{\sigma^{\circ}_{w}}$ (db)					a_w	
		Frequency Band					Resolution(m^2)	
		VHF	UHF	L-	S-	X-Band	10^3	10^6
Rural/ Low-Relief a) General rural	0.00 to 0.25	-33	-33	-33	-33	-33	3.8	2.5

Terrain Type	Depression Angle (deg)	$\overline{\sigma°_w}$ (db)					a_w	
		Frequency Band					Resolution(m^2)	
		VHF	UHF	L-	S-	X-Band	10^3	10^6
	0.25 to 0.75	-32	-32	-32	-32	-32	3.5	2.2
	0.75 to 1.50	-30	-30	-30	-30	-30	3.0	1.8
	1.50 to 4.00	-27	-27	-27	-27	-27	2.7	1.6
	> 4.00	-25	-25	-25	-25	-25	2.6	1.5
b) Continuous forest	0.00 to 0.30	-45	-42	-40	-39	-37	3.2	1.8
	0.30 to 1.00	-30	-30	-30	-30	-30	2.7	1.6
	>1.00	-15	-19	-22	-24	-26	2.0	1.3
c) Open farmland	0.00 to 0.40	-51	-39	-30	-30	-30	5.4	2.8
	0.40 to 0.75	-30	-30	-30	-30	-30	4.0	2.6
	0.75 to 1.50	-30	-30	-30	-30	-30	3.3	2.4
d) Desert, marsh, or grassland (few discretes)	0.00 to 0.25	-68	-74	-68	-51	-42	3.8	1.8
	0.25 to 0.75	-56	-58	-46	-41	-36	2.7	1.6
	>0.75	-38	-40	-40	-38	-26	2.0	1.3
Rural/ High-Relief								
a) General rural	0 to 2	-27	-27	-27	-27	-27	2.2	1.4

Terrain Type	Depression Angle (deg)	$\overline{\quad}$ $\sigma°_w$ (db)					a_w	
		Frequency Band					Resolution(m^2)	
		VHF	UHF	L-	S-	X-Band	10^3	10^6
	2 to 4	-24	-24	-24	-24	-24	1.8	1.3
	4 to 6	-21	-21	-21	-21	-21	1.6	1.2
	>6	-19	-19	-19	-19	-19	1.5	1.1
b) Continuous forest	any	-15	-19	-22	-22	-22	1.8	1.3
c) Mountains								
	any	-8	-11	-18	-20	-20	2.8	1.6
Urban								
a) General urban	0.00 to 0.25	-20	-20	-20	-20	-20	4.3	2.8
	0.25 to 0.75	-20	-20	-20	-20	-20	3.7	2.4
	>0.75	-20	-20	-20	-20	-20	3.0	2.0
b) Urban, observed on open low-relief terrain	0.00 to 0.25	-32	-24	-15	-10	-10	4.3	2.8
Negative Depression Angle								

Terrain Type	Depression Angle (deg)	$\overline{\sigma^\circ_w}$ (db)					a_w	
		Frequency Band					Resolution(m^2)	
		VHF	UHF	L-	S-	X-Band	10^3	10^6
a) All, except mountains and high-relief continuous forest	0.00 to -0.25	-31	-31	-31	-31	-31	3.4	2.0
	-0.25 to -0.75	-27	-27	-27	-27	-27	3.3	1.9
	<-0.75	-26	-26	-26	-26	-26	2.3	1.7

See Appendix 2.B.3, page 133 of Low-Angle Radar Land Clutter: Measurements and Empirical Models by J. Barrie Billingsley for the definition of the Weibull probability density function. As well, see Appendix 5.A.2, page 549 for further information on the Weibull probability distribution function. As well, see section 5.2 Derivation of Clutter Modeling Information, page 416.

The Weibull probability density function may be written as:

$p(x) = b \cdot c \cdot x^{b-1} \cdot e^{-cx^b}$, where $a_w = {}^1/_b$, $x = \sigma^\circ_w$ (db) , $c = \ln2 / x^b_{50}$

The Weilbull cumulative distribution function follows from the definition of P(x) as:

$P(x) = 1 - e^{-cx^b}$

The ratio of the mean to median in a Weibull distribution is given by:

$\bar{x} / x_{50} = \Gamma (1 + a_w) / (\ln2)^{a_w}$, where Γ is the Gamma function.