3.0 SUMMARY OF ASSUMPTIONS, LIMITATIONS, AND ERRORS (SALE)

This section of ASP-I summarizes assumptions, limitations, and known errors of the model. This information is useful in helping a user to determine if the model adequately addresses all the phenomena and environmental conditions that are important to the intended application. These assumptions, limitations, and errors are derived from any and all applicable sources (including model documentation and V&V reports), and addresses the implications of these for model use or application.

RADGUNS is limited to one-on-one engagements (AAA threat vs. airborne target). The models are deterministic, or transfer function type, rather than stochastic (probabilistic). Threat components are modeled at either the subsystem or circuit level. In stand-alone mode, terrain modeling is limited to analytic terrain models (DMA terrain is available under DIME). No reactive maneuvers are simulated. Chaff and flares are not modeled. The global coordinate frame originates at the center of the threat radar antenna (typically a few meters above the earth's surface). Positive x points north, positive y points west, and positive z points up. Azimuth is measured in radians clockwise from the positive X-axis. Elevation is $\pi/2$ on the positive Z-axis and 0 toward the horizon. The target coordinate frame originates at the target centroid. The positive X-axis points out the nose, positive y points out the left wing, and positive z points out the top of the fuselage. Roll is defined as the rotation of the Y-axis into the Z-axis, pitch is the rotation of the X-axis into the Z-axis, and yaw is the rotation of the X-axis into the –Y-axis.

3.1 ASSUMPTIONS

Table 3-1 contains known model assumptions, conditions of their applicability, and a brief assessment of their impact. Assumptions are discussed in greater detail in Section 2 of ASP-II. As verification efforts continue, this listing will be updated. The conditions of applicability may not be all encompassing; future activities may uncover new or modify existing conditions.

TABLE 3-1. Model Assumptions by Functional Element.

No.	FE	Assumptions	Conditions of Applicability	Impact
All	Model Level	1v1 engagements	At all times	M-on-N effects not addressed
4	Signature Fluctuations	Glint modeled as sinusoidal rather than random process	During autotrack	Unknown; assumed to be minimal
		Glint model assumes average target speed of 200 m/s and 10 Hz frequency of fluctuation	During autotrack	Minimal effect on typical engagements, glint return from slow targets (i.e., helicopters) at close range may be inaccurate

TABLE 3-1. Model Assumptions by Functional Element. (Contd.)

No.	FE	Assumptions	Conditions of Applicability	Impact
5	ECM Noise On-board	Jammer antenna boresight is assumed to be aimed at the threat radar	When ECM is selected	Maximum gain always applied to jammer signal
		Jammer bandwidth is centered at threat radar receiver's bandwidth	When ECM is selected	Frequency agility not addressed
11	Masking	Simulation terminates if system enters reacquisition mode while target is masked	When hill selected and mask time is > 10 s	None
12	Clutter	No clutter return beyond the radar horizon	When clutter is selected	Unknown
		Uniform land form and cover	When clutter is selected	Minimal for short range engagements
13	Multipath	Flat earth	When multipath is selected and target is at low altitude (< ~200 m)	Minimal for short range engagements
		Uniform land form and cover	When multipath is selected and target is at low altitude (< ~200 m)	Minimal for short range engagements
		For horizontally polarized antenna, 180∞ phase shift on reflection	When multipath selected with horizontally polarized antenna and target is at low altitude	Small variation in phase shift (2%) over all grazing angles does not significantly affect return
		Surface reflection for water assumes smooth sea	When multipath over water is selected and target is at low altitude (< ~200 m)	Sea state does not affect multipath return
20	Antenna Gain	Uniform illumination, rotationally symmetric	At all times	None (RADGUNS models a family of systems)
25	Integration	Post-detection noncoherent integration by operator implicit in probability of detection model	During acquisition	None

TABLE 3-1. Model Assumptions by Functional Element. (Contd.)

No.	FE	Assumptions	Conditions of Applicability	Impact
27	Angle Track	Time domain solution approximated by Taylor Series expansion	During autotrack	Accurate to eleven decimal places
		The FCC and operator do not introduce errors in memory or manual modes	In memory (coast) mode or in optical tracking with cross hairs	Unknown
28	Range Track	Time domain solution approximated by Taylor Series expansion	During autotrack	Accurate to eleven decimal places
		The FCC and operator do not introduce errors in memory or manual modes	In memory (coast) mode or in optical tracking with cross hairs	Unknown
31	Gun Movement	Type Two servos assumed for all systems	When guns are enabled	Unknown

3.2 LIMITATIONS

Table 3-2 lists known model limitations, conditions of their applicability, and a brief assessment of their impact on typical engagements. Model limitations are discussed in greater detail in Section 2 of ASP-II. Depending on the user's specific objectives, any or all limitations may restrict model usefulness to varying degrees. These limitations are subject to modification as further analysis is conducted. Similarly, as enhancements are added to new model versions, this list will change.

TABLE 3-2. Model Limitations by Functional Element.

No.	FE	Limitations	Conditions of Applicability	Impact
All	Model Level	Simulation is not real time	At all times	Not suitable for MIL/HWIL use
All	Model Level	Tabular output options limited by page size and format	At all times	Code must be inserted to generate additional outputs, or additional runs must be made
1	Flight Path	No reactive maneuvering	At all times	Effects not modeled
		Helicopter and Harrier flight paths not specifically modeled (takeoff, hover, approach, landing, etc.)	At all times	BLUMAX flight paths may be used

TABLE 3-2. Model Limitations by Functional Element. (Contd.)

No.	FE	Limitations	Conditions of Applicability	Impact
5	ECM	Effects modeled for track radar only	When ECM is selected	Jammer effects on detection range not modeled
		Limited to four jammer classes (on-board, towed, expendable, and escort) and six techniques (noise, inverse gain, RGWO, simple repeater, passive reflector, and swept audio)	When ECM is selected	Chaff, flares and other techniques not modeled; specific jammers not modeled
11	Masking	Single, billboard type hill	When masking is used	No detailed terrain model
12	Clutter	Volume clutter not modeled	When clutter is used	Under clear (non-rainy) conditions, effects are minimal
13	Multipath	Specular reflection only	When multipath is used and target below ~200 m	Diffraction not modeled; effects assumed to be minimal
36	Probability of Kill	Targets modeled by singly-vulnerable areas	When guns enabled	Cannot model multiple component vulnerability

3.3 ERRORS

Table 3-3 lists known errors in RADGUNS v.2.0 along with implications for model use. These errors were identified through verification and are reported in greater detail in the sections listed in ASP-III. MDRs generated as a result of verification findings are also listed.

TABLE 3-3. Model Errors by Functional Element.

No.	FE	Errors/Deficiencies	Implication	Source/MDR
4	Signature Fluctuations	Number of pulses integrated not consistent with S/N ratio used in calculation of probability of detection	May lead to early detections when probability of detection option is selected	ASP-III, 2.4 MDR 95-01
		FE not documented	User cannot easily quantify detection results with PDET option	ASP-III, 2.4 MDR 95-02
22	Detection Threshold	FE not documented.	User cannot easily quantify detection results	ASP-III, 2.22

TABLE 3-3. Model Errors by Functional Element. (Contd.)

No.	FE	Errors/Deficiencies	Implication	Source/MDR
27	Angle Track	Variable L implicitly declared as an integer but used as a real (Taylor series)	Poor programming practice (FORTRAN performs this conversion automatically)	ASP-III, 2.26
		Second derivative not adjusted when slew-rate limits applied	Accelerations will be incorrect for one time step (scan)	ASP-III, 2.26
31	Gun Movement	If the gun is limited in elevation, the elevation slew rate should also be limited; slew-rate limits should affect azimuth and elevation position	Incorrect elevation slew rate, or gun azimuth or elevation for one time step (scan)	ASP-III, 2.31 MDR 94-007

Table 3-4 lists errors reported on previous model versions that were approved for change and are reported by the developer as being corrected in the current version. Reverification has not yet been performed, however, preliminary validation assessments of the antenna gain and 57-mm ballistics functions show improved correlation with test data. Errors identified in Section 2 of ASP-III were uncovered during verification. Errors identified in Sections 3 and 4 of ASP-III were uncovered during FE and model level validation respectively.

TABLE 3-4. Errors Corrected in RADGUNS v.2.0.

No.	FE	Errors/Deficiencies	Implication	Source/MDR
5	ECM	Beam nutation not included in calculation of antenna gain on incoming jammer signals (CONSCAN systems only)	Received jammer signals were slightly in error for CONSCAN radars	MDR 95-10
12	Clutter	Incorrect calculation of clutter patch areas for both pulse- and beamwidth-limited cases in Descriptive Model	With DESC option, power returned in pulse-limited case was half its correct value; one-fourth in beamwidth-limited case	ASP-III, 2.12 MDR 95-03
		Numerical Model did not include beamwidth-limited case. A factor of 0.75 was missing as the multiplier to the half-power beamwidth in the clutter patch RCS calculation (pulse-length limited case)	Beamwidth-limited case was not modeled; returns from clutter patches at large grazing angles with NUME option were slightly larger than they should have been	ASP-III, 2.12 MDR 95-04
13	Multipath	User-defined integers for land form and cover were not checked for range of values	User could enter inappropriate values which would have lead to incorrect data initialization with DESC option	ASP-III, 2.13

TABLE 3-4. Errors Corrected in RADGUNS v.2.0. (Contd.)

No.	FE	Errors/Deficiencies	Implication	Source/MDR
20	Antenna Gain	Antenna pattern did not match intelligence for ZSU-23-4	Narrower beamwidth decreased tracking errors in some scenarios resulting in improved shooting performance	ASP-III, 3.20 MDR 95-08
25	Signal Integration	Constants used in NPULSE calculation not traceable ($\theta_B \cdot f_p$).	Algorithm could not be verified without additional information	ASP-III, 2.25
		NPI set to number of pulses in target return if target range > range to horizon, else set to one for land	Algorithm could not be verified without additional information	ASP-III, 2.25
		PRIA not initialized prior to PDET call	Detection ranges may have been inaccurate when using probability of detection model (PDET option)	ASP-III, 2.25
27	Angle Track	Static RCS target model unrealistic	Modeled tracking errors were smaller than measured errors	ASP-III, 4.2
28	Range Track			
31	Gun Movement	Minimum gun elevation limit did not match intel, maximum azimuth and elevation slew rates did not match intel	Limits slightly in error	ASP-III, 2.31 MDR 94-008
34	Ballistics	57-mm drag function did not match intelligence	Trajectory of 57-mm projectiles in error by ~200 m after 10 s TOF at 33.75 deg firing angle	ASP-III, 3.34 MDR 95-11

3.4 IMPLICATIONS FOR MODEL USE

RADGUNS is not suitable for many-on-many assessments or MIL/HWIL use. Reactive maneuvering is not modeled, although the user may input predefined maneuvers with the BLUMAX input option. The ECM model is generic; specific jammers (e.g., an ALQ-161) are not modeled. The effect of jamming on target acquisition is not modeled. Jamming is limited to six techniques in four configurations. The jammer antenna boresight is aimed at the threat radar, thus the maximum gain is always applied to the jammer's transmitted signal (the worst case scenario is modeled). Target vulnerability is based on a single area. Neither redundant nor distributed components are addressed, thus assessments against some targets (e.g., a large target with several vulnerable systems located at various offsets from the target centroid and/or with redundant components) may be unrealistic. Volume clutter, and thus weather effects, are not modeled. RADGUNS uses a flat earth model which is valid for the short engagement ranges of the systems modeled.