

NTIA REPORT 79-25

**SPECTRUM RESOURCE
ASSESSMENT
IN THE 2.7-2.9 GHz BAND
PHASE II: RADAR
SIGNAL PROCESSING
(REPORT NO.2)**

Robert L. Hinkle
Robert M. Pratt
Jay S. Levy



U.S. DEPARTMENT OF COMMERCE
Juanita M. Kreps, Secretary

Henry Geller, Assistant Secretary
for Communications and Information

AUGUST 1979

ACKNOWLEDGEMENT

The completion of this general investigation into the signal processing properties of the primary radars in the 2.7 to 2.9 GHz band and the Automated Radar Terminal System (ARTS-III A) required the contributions of many individuals. In particular, the ASR-8 measurements made at Stapleton Airport, Denver, Colorado, were coordinated by Gerald J. Markey, Chief Frequency Engineering Branch, Federal Aviation Administration; and Larry Scofield, Supervisory Electronic Technician, Federal Aviation Administration. In addition, Robert B. Steves, Air Traffic Control (ATC) Systems Engineer, Texas Instruments Incorporated, contributed extensively to the completion of this investigation by providing both analytical and hardware experience in the signal processing properties of the ASR-7 and ASR-8 radars. Also, the generosity of Dr. Gerard V. Trunk, Naval Research Laboratory, Department of Defense, in technically reviewing the report was greatly appreciated.

TABLE OF CONTENTS

ACKNOWLEDGEMENTiii
ABSTRACTxxv

SECTION 1

INTRODUCTION

BACKGROUND.1-1
Phase I1-2
Phase II.1-2
OBJECTIVE1-3
APPROACH.1-3

SECTION 2

CONCLUSIONS AND RECOMMENDATIONS

GENERAL2-1
GENERAL CONCLUSIONS2-1
PRIMARY RADAR CONCLUSIONS2-2
ARTS-IIIA POST PROCESSING CONCLUSIONS2-2
GENERAL RECOMMENDATIONS2-4
PRIMARY RADAR RECOMMENDATIONS2-4
ARTS-IIIA POST PROCESSING RECOMMENDATIONS2-5

SECTION 3

PRIMARY RADAR SIGNAL PROCESSING

INTRODUCTION. 3-1

GENERAL SYSTEM DESCRIPTION. 3-2

Antenna and RF Waveguide. 3-2

Receiver Unit 3-2

Processor Unit. 3-5

ANTENNA AND RF WAVEGUIDE SYSTEM 3-5

RECEIVER UNIT 3-7

Receiver Front End. 3-9

TR Limiter. 3-9

Sensitivity Time Control (STC) Attenuators. 3-9

Antenna Pattern Switch. 3-11

Passive Channel 3-11

Parametric Amplifier. 3-11

Preselector Filter. 3-13

Phase Shifter 3-13

Mixer 3-13

Preamplifier. 3-14

Normal Channel. 3-14

IF Amplifiers 3-14

Envelope Detector 3-16

Log-Normal Channel. 3-22

Log IF Bandpass Filter. 3-22

Log IF Amplifier-Video Detector 3-24

Moving Target Indicator (MTI) Channel 3-26

IF Filter 3-27

Linear-Limiting Amplifier 3-29

MTI Quadrature Phase Detector 3-29

Low Pass Filter 3-30

PROCESSOR UNIT. 3-33

Processor Unit Normal Channel 3-33

Subtractor Anti-Log 3-35

Noise 3-35

Desired Signal. 3-35

Interference. 3-35

Normal Enhancer 3-37

Feedback Integrator 3-38

Binary Integrator 3-43

Normal Channel Weather Background 3-52

Processor Unit MTI Channel . . . . .	.3-54
MTI Cancellers . . . . .	.3-54
Noise . . . . .	.3-57
Desired Signal . . . . .	.3-60
Interfering Signal . . . . .	.3-60
Rectifier . . . . .	.3-61
Combiner . . . . .	.3-61
MTI Log-FTC . . . . .	.3-63
MTI Enhancer . . . . .	.3-65
Noise . . . . .	.3-65
Desired Signal . . . . .	.3-66
Interference . . . . .	.3-66
Processor Unit Alignment/Diversity Combiner . . . . .	.3-69
MTI/Normal Alignment . . . . .	.3-69
Output D/A Converter . . . . .	.3-69
Weather Background Diversity Combiner . . . . .	.3-71

SECTION 4

ARTS-IIIA SIGNAL PROCESSING

INTRODUCTION . . . . .	.4-1
RADAR DATA ACQUISITION SUBSYSTEM DESCRIPTION . . . . .	.4-1
Radar Extractor . . . . .	.4-3
Video Multiplexer Converter . . . . .	.4-3
Rank Order Detection Process . . . . .	.4-3
Rank Quantizer . . . . .	.4-3
Hit Processor . . . . .	.4-5
Target Detection . . . . .	.4-8
Clutter Monitor Logic . . . . .	.4-8
Radar Micro Controller . . . . .	.4-8
ARTS-IIIA RDAS INTERFERENCE ANALYSIS . . . . .	.4-11
Effect of Interference on the Probability of a Hit . . . . .	.4-13
Effect of Interference on Probability of False Alarm . . . . .	.4-15
Probability of False Target Hit Caused by Noise . . . . .	.4-15
Probability of False Target Hits Caused by Interference . . . . .	.4-16
Probability of False Alarm Caused by Interference . . . . .	.4-26
Interpretation of Interference Effects on False Alarms . . . . .	.4-34
Effect of Interference on Probability of Target Detection . . . . .	.4-36
Probability of Target Hit Caused by a Target . . . . .	.4-36
Normal Channel . . . . .	.4-37
MTI Channel . . . . .	.4-38
Interference Effect on Target Hit . . . . .	.4-40
Interference Effect on Target Detection . . . . .	.4-51
Interpretation of Interference Effects on Target Detection . . . . .	.4-61

Trade-Off Between Interference Suppression and ARTS-III A/RDAS	
Performance . . . . .	.4-62
Rank Quantizer Threshold Trade-Off . . . . .	.4-62
Hit and Miss Count Threshold Trade-Off . . . . .	.4-67
Second Order Interference Effects . . . . .	.4-69
Interference Effect on Clutter Hit Probability . . . . .	.4-69
Interference Effect on Video Selection Control . . . . .	.4-70
Interference Effect on MTI Channel Hit Count Threshold Control . . . . .	.4-75

APPENDIX A

MIXER TRANSFER PROPERTIES

INTRODUCTION.	A-1
MIXER TRANSFER PROPERTIES	A-1
Noise	A-1
Desired/Interfering Signal.	A-3
SNR Transfer Properties	A-5
IMAGE RESPONSE.	A-5

APPENDIX B

IF FILTER TRANSFER PROPERTIES

INTRODUCTION	B-1
IF SELECTIVITY.	B-1
IF Selectivity Modeling	B-2
RECEIVER FREQUENCY-DEPENDENT-REJECTION CHARACTERISTICS.	B-7
IF OUTPUT TIME WAVEFORM	B-9
IF OUTPUT NOISE LEVEL	B-18
IF FILTER INR TRANSFER PROPERTIES	B-24

APPENDIX C

MTI CHANNEL TRANSFER PROPERTIES

INTRODUCTION. . . . .	.C-1
PHASE DETECTOR TRANSFER PROPERTIES. . . . .	.C-1
Noise . . . . .	.C-1
Desired/Interfering Signal. . . . .	.C-6
Signal-Plus-Noise Distribution. . . . .	.C-8
MTI LOW PASS FILTER TRANSFER PROPERTIES . . . . .	.C-9
Noise . . . . .	.C-11
Desired/Interfering Signal. . . . .	.C-11
MTI CANCELLER TRANSFER PROPERTIES . . . . .	.C-13
Single Stage Canceller Transfer Properties. . . . .	.C-13
Noise . . . . .	.C-17
Desired Signal. . . . .	.C-17
Interfering Signal. . . . .	.C-18
Double Stage Canceller Transfer Properties. . . . .	.C-18
Noise . . . . .	.C-23
Desired Signal. . . . .	.C-23
Interfering Signal. . . . .	.C-24
RECTIFIER . . . . .	.C-28
DUAL MTI CHANNEL TRANSFER PROPERTIES. . . . .	.C-31

APPENDIX D

INTEGRATOR TRANSFER PROPERTIES

INTRODUCTION. . . . .	.D-1
FEEDBACK INTEGRATOR . . . . .	.D-2
Input Limiter Transfer Properties . . . . .	.D-2
Feedback Integrator Loop Transfer Properties. . . . .	.D-4
Noise . . . . .	.D-4
Desired Signal. . . . .	.D-6
Interference. . . . .	.D-20

BINARY INTEGRATOR . . . . .	.D-32
FAA Integrator Modification . . . . .	.D-32
Noise . . . . .	.D-34
Desired Signal . . . . .	.D-41
Interference . . . . .	.D-58

APPENDIX E

RADAR SIMULATION

INTRODUCTION. . . . .	.E-1
PROCESSOR UNIT DESCRIPTION. . . . .	.E-1
DESIRED SIGNAL. . . . .	.E-4
INTERFERING SIGNALS . . . . .	.E-6
NOISE . . . . .	.E-6
NORMAL CHANNEL SIMULATION . . . . .	.E-6
Noise Distribution. . . . .	.E-6
Signal-Plus-Noise Distribution. . . . .	.E-6
Normal Channel Enhancer . . . . .	.E-8
Normal Channel Alignment. . . . .	.E-11
MTI CHANNEL SIMULATION. . . . .	.E-11
Noise Distribution. . . . .	.E-11
Signal-Plus-Noise Distribution. . . . .	.E-11
MTI Cancellers. . . . .	.E-12
MTI Channel Enhancer. . . . .	.E-15
MTI Channel Alignment . . . . .	.E-15
FEEDBACK ENHANCER . . . . .	.E-15
OUTPUT DISPLAY. . . . .	.E-15

APPENDIX F

INTRODUCTION. . . . .	.F-1
DERIVATION OF EQUATIONS . . . . .	.F-1
Effect of Interference on Hit Probability . . . . .	.F-1
Probability of False Target Hit . . . . .	.F-5

Probability of Target HitF-8
COMPUTER PROGRAM DESCRIPTIONS.. . . .F-9
Probability of False Alarm Program.F-9
Probability of Target Detection ProgramF-11

APPENDIX G
SYSTEM CHARACTERISTICS

INTRODUCTION.G-1

APPENDIX H

REFERENCES

LIST OF ILLUSTRATIONS

<u>FIGURE</u>	<u>PAGE</u>
3-1 Block Diagram of Non-Diversity Radar Receivers	3-3
3-2 Block Diagram of Frequency Diversity Radar Receivers	3-4
3-3 ASR-8 RF System Simplified Block Diagram	3-6
3-4 ASR-8 Diplexer Filter Characteristics.	3-8
3-5 ASR-8 Receiver Unit Block Diagram.	3-10
3-6 STC Waveform Generation.	3-12
3-7 Typical IF Output Time Wavefore Responses for On-Tune and Off-Tune Pulses	3-17
3-8 Signal-to-Noise Ratio Transfer Properties of a Linear Detector .	3-19
3-9 Signal-to-Noise Ratio Transfer Properties of a Square-Law Detector	3-20
3-10 Probability-Density Function for Noise Only and for Signal-Plus- Noise at the Normal Channel Envelope Detector Output	3-21
3-11 Logarithmic Amplifier-Detector Block Diagram	3-23
3-12 Log Amplifier Transfer Characteristics	3-25
3-13 Receiver Unit MTI I and MTI Q Channel.	3-28
3-14 Probability Density Function for Noise Only and for Signal- Plus-Noise at the MTI Phase Detector Output.	3-31
3-15 Processor Unit Normal Channel Block Diagram.	3-34
3-16 Log-FTC Block Diagram.	3-36
3-17 Feedback Integrator Block Diagram.	3-39
3-18 Simulated Normal Channel Unintegrated Target Return Pulse Train for a SNR = 15 dB.	3-41
3-19 Simulated Normal Channel Integrated Target Return Pulse Train for the Input Limiter Set at 1.0 Volts and a SNR = 15 dB	3-41

3-20	Simulated Normal Channel Integrated Target Return Pulse Train for the Input Limiter Set at 0.5 Volts and a SNR = 15 dB	3-42
3-21	Simulated Normal Channel Integrated Target Return Pulse Train for the Input Limiter Set at 0.34 Volts and a SNR = 15 dB.	3-42
3-22	Simulated Normal Channel Unintegrated Radar Output with Interference	3-44
3-23	Simulated Normal Channel Integrated Radar Output with Interference	3-44
3-24	ASR-7 (AN/GPN-12) Binary Integrator Block Diagram.	3-45
3-25	Hit/Miss Characteristic Curve for FAA Modified ASR-7 Enhancer.	3-47
3-26	Simulated Binary Integrator Output for Target Return Pulse Train (ASR-7, AN/GPN-12)	3-50
3-27	Simulated FAA Modified Binary Integrator Output for Target Return Pulse Train (ASR-7).	3-50
3-28	Simulated Normal Channel Unintegrated Target Return Pulse Train for a SNR = 15 dB.	3-51
3-29	Simulated Normal Channel Integrated Target Return Pulse Train for a SNR = 15 dB.	3-51
3-30	Simulated Normal Channel Unintegrated Radar Output with Interference	3-53
3-31	Simulated Normal Channel Integrated Radar Output with Interference	3-53
3-32	Weather Background Modes	3-55
3-33	Processor Unit MTI Channel Block Diagram	3-56
3-34	Canonical Form of Simulated ASR-7 MTI Canceller.	3-58
3-35	Probability Density Function for Noise Only and for Signal-Plus-Noise at the MTI Canceller Output for a single Channel Double Stage Canceller.	3-62
3-36	Probability Density Function for Noise Only and for Signal-Plus-Noise at the MTI Canceller Output for a Dual Channel Double Stage Canceller (Simulated).	3-64
3-37	Simulated MTI Channel (Mode 1 and 2 CASC) Unintegrated Radar Output with Interference	3-67

3-38	Simulated MTI Channel (Mode 1 and 2 CASC) Radar Feedback Integrator Output with Interference for the Input Limiter Set at 2.0 Volts. . . . .	.3-67
3-39	Simulated MTI Channel (Mode 1 and 2 CASC) Radar Feedback Integrator Output with Interference for the Input Limiter Set at 0.34 Volts . . . . .	.3-68
3-40	Simulated MTI Channel (Mode 1 and 2 CASC) Radar Binary Integrator Output with Interference . . . . .	.3-68
3-41	Processor Unit Alignment/Diversity Combiner Block Diagram. . . . .	.3-70
4-1	Block Diagram of Radar Data Acquisition Subsystem. . . . .	.4-2
4-2	Block Diagram of Radar Extractor . . . . .	.4-4
4-3	Block Diagram of Rank Quantizer Logic. . . . .	.4-6
4-4	Block Diagram of Hit Processing Logic. . . . .	.4-7
4-5	Block Diagram of Target Detection. . . . .	.4-9
4-6	Block Diagram of Clutter Monitor Logic . . . . .	.4-10
4-7	ARTS-IIIA/RDAS MTI Channel Hit Count Threshold Control for Maintaining a Constant False Alarm Rate. . . . .	.4-12
4-8	ARTS-IIIA/RDAS Probability of False Target Hit Versus Rate of Received Interference (ASR-7 Victim Radar, Normal Channel, Rank Quantizer Threshold 23). . . . .	.4-18
4-9	ARTS-IIIA/RDAS Probability of False Target Hit Versus Rate of Received Interference (ASR-7 Victim Radar, Normal Channel, Rank Quantizer Threshold 24). . . . .	.4-19
4-10	ARTS-IIIA/RDAS Probability of False Target Hit Versus Rate of Received Interference (ASR-7 Victim Radar, MTI Channel, Rank Quantizer Threshold 23). . . . .	.4-20
4-11	ARTS-IIIA/RDAS Probability of False Target Hit Versus Rate of Received Interference (ASR-7 Victim Radar, MTI Channel, Rank Quantizer Threshold 24). . . . .	.4-21
4-12	ARTS-IIIA/RDAS Probability of False Target Hit Versus Rate of Received Interference (ASR-8 Victim Radar, Normal Channel, Rank Quantizer Threshold 23). . . . .	.4-22

4-13	ARTS-III/RDAS Probability of False Target Hit Versus Rate of Received Interference (ASR-8 Victim Radar, Normal Channel, Rank Quantizer Threshold 24)	. . . . .	4-23
4-14	ARTS-IIIA/RDAS Probability of False Target Hit Versus Rate of Received Interference (ASR-8 Victim Radar, MTI Channel, Rank Quantizer Threshold 23)	. . . . .	4-24
4-15	ARTS-IIIA/RDAS Probability of False Target Hit Versus Rate of Received Interference (ASR-8 Victim Radar, MTI Channel, Rank Quantizer Threshold 24)	. . . . .	4-25
4-16	ARTS-IIIA/RDAS Probability of False Alarm Versus Probability of False Target Hit for Various Hit/Miss Count Threshold Parameter Combinations	. . . . .	4-31
4-17	Probability of Target Hit Versus Signal-to-Noise Ratio for the ARTS-IIIA/RDAS connected to the ASR-7 or ASR-8 Radar Normal Channel (Rank Quantizer Thresholds 23 and 24)	. . . . .	4-39
4-18	Probability of Target Hit Versus Signal-to-Noise Ratio for the ARTS-IIIA/RDAS Connected to the ASR-7 Radar MTI channel (Rank Quantizer Thresholds 23 and 24)	. . . . .	4-41
4-19	Probability of Target Hit Versus Signal-to-Noise Ratio for the ARTS-IIIA/RDAS Connected to the ASR-8 Radar MTI Channel (Rank Quantizer Threshold 23 and 24)	. . . . .	4-42
4-20	ARTS-IIIA/RDAS Probability of Target Hit Versus Rate of Received Interference (ASR-7 Victim Radar, Normal Channel, Rank Quantizer Threshold 23)	. . . . .	4-43
4-21	ARTS-IIIA/RDAS Probability of Target Hit Versus Rate of Received Interference (ASR-7 Victim Radar, Normal Channel, Rank Quantizer Threshold 24)	. . . . .	4-44
4-22	ARTS-IIIA/RDAS Probability of Target Hit Versus Rate of Received Interference (ASR-7 Victim Radar, MTI Channel, Rank Quantizer Threshold 23)	. . . . .	4-45
4-23	ARTS-III/RDAS Probability of Target Hit Versus Rate of Received Interference (ASR-7 Victim Radar, MTI Channel, Rank Quantizer Threshold 24)	. . . . .	4-46
4-24	ARTS-IIIA/RDAS Probability of Target Hit Versus Rate of Received Interference (ASR-8 Victim Radar, Normal Channel, Rank Quantizer Threshold 23)	. . . . .	4-47
4-25	ARTS-IIIA/RDAS Probability of Target Hit Versus Rate of Received Interference (ASR-8 Victim Radar, Normal Channel, Rank Quantizer Threshold 24)	. . . . .	4-48

4-26	ARTS-IIIA/RDAS Probability of Target Hit Versus Rate of Received Interference (ARS-8 Victim Radar, MTI Channel, Rank Quantizer Threshold 23).	4-49
4-27	ARTS-IIIA/RDAS Probability of Target Hit Versus Rate of Received Interference (ASR-8 Victim Radar, MTI Channel, Rank Quantizer Threshold 24).	4-50
4-28	ARTS-IIIA/RDAS Probability of Target Detection Versus Probability of Target Hit for Rank Quantizer Threshold 23 and Various Hit/Miss Count Threshold Parameters Combinations (Probability Scale)	4-57
4-29	ARTS-IIIA/RDAS Probability of Target Detection Versus Probability of Target Hit for Rank Quantizer Threshold 24 and Various Hit/Miss Count Threshold Parameter Combinations (Probability Scale).	4-58
4-30	ARTS-IIIA/RDAS Probability of Target Detection Versus Probability of Target Hit for Rank Quantizer Threshold 23 and Various Hit/Miss Count Threshold Parameter Combinations (Linear Scale)	4-61
A-1	Radar Mixer Block Diagram.	A-2
B-1	ASR-8 Normal IF Bandpass Filter Schematic.	B-3
B-2	"Y" Parameter Equivalent Circuit for One IF Amplifier Stage Shown in Figure B-1.	B-4
B-3	Simulated IF Output Time Waveform Envelope	B-12
B-4	Simulated IF Output Time Waveform Envelope	B-13
B-5	Simulated IF Output Time Waveform Envelope	B-14
B-6	Simulated IF Output Time Waveform Envelope	B-15
B-7	Simulated IF Output Time Waveform Envelope	B-16
B-8	Simulated IF Output Time Waveform Envelope	B-17
B-9	Simulated IF Output Time Waveform Envelope	B-19
B-10	Simulated IF Output Time Waveform Envelope	B-20
B-11	Simulated IF Output Time Waveform Envelope	B-21
B-12	Measured IF Output Time Waveform	B-22
B-13	Measured IF Output Time Waveform	B-22
B-14	Measured IF Output Time Waveform	B-22

B-15	Simulated IF Output Phase Modulation for an Off-Tuned Pulse Signal . . . . .	.B-23
C-1	Digital MTI Channel Block Diagram. . . . .	.C-2
C-2	Inphase and Quadrature Digital MTI Channel Block Diagram . . . .	.C-3
C-3	Radar Coherent MTI Phase Detector. . . . .	.C-4
C-4	Probability Density Function for Noise Only and for Signal-Plus- Noise at the MTI Phase Detector Output . . . . .	.C-10
C-5	Measured MTI Low Pass Filter Output Time Waveform. . . . .	.C-12
C-6	Measured MTI Low Pass Filter Output Time Waveform. . . . .	.C-12
C-7	Measured MTI Low Pass Filter Output Time Waveform. . . . .	.C-12
C-8	First-Order Nonrecursive Filter. . . . .	.C-14
C-9	Canonical Form of First-Order Nonrecursive Filter. . . . .	.C-14
C-10	Frequency Response for a Single Stage MTI Canceller. . . . .	.C-16
C-11	Measured Single Stage MTI Canceller Output Time Waveform. . . .	.C-16
C-12	Second-Order MTI Filter with Feedback for Velocity Shaping . . .	.C-19
C-13	Canonical Form of Second-Order Recursive Filter. . . . .	.C-19
C-14	Frequency Response for a Double Stage Canceller with Feedback. .	.C-22
C-15	Measured Double Stage MTI Canceller Response to an Interfering Pulse (1 and 2 CASC Mode). . . . .	.C-25
C-16	Simulated Double Stage MTI Canceller Response to an Interfering Pulse (1 and 2 CASC Mode). . . . .	.C-25
C-17	Simulated Double Stage MTI Canceller Response to an Interfering Pulse (SCV-25 Mode). . . . .	.C-26
C-18	Simulated Double Stage MTI Canceller Response to an Interfering Pulse (SCV-30 Mode). . . . .	.C-26
C-19	Simulated Double Stage MTI Canceller Response to an Interfering Pulse (SCV-35 Mode). . . . .	.C-27
C-20	Simulated Double Stage MTI Canceller Response to an Interfering Pulse (SCV-40 Mode). . . . .	.C-27

C-21	Probability Density Function for Noise Only and for Signal-Plus Noise at the MTI Canceller Output for a Single Channel Double Stage Canceller.	C-29
C-22	Probability Density Function of One-Sided Gaussian Distribution (Equation C-41).	C-30
C-23	Probability Density Function for Noise Only and for Signal-Plus-Noise at the MTI Canceller Output for a Dual Channel Double Stage Canceller (Simulated).	C-32
C-24	Probability Density Function of Rayleigh Distribution (Equation C-44).	C-34
D-1	Feedback Integrator Block Diagram.	D-3
D-2	Canonical Form of Second-Order MTI Canceller Filter Showing Noise Correlation at MTI Channel Output.	D-7
D-3a	Simulated Normal Channel Unintegrated Target Return Pulse Train for a SNR = 3 dB	D-11
D-3b	Simulated Normal Channel Integrated Target Return Pulse Train For a SNR = 3 dB ($V = 2.0$).	D-11
D-4a	Simulated Normal Channel Unintegrated Target Return Pulse Train for a SNR = 5 dB	D-12
D-4b	Simulated Normal Channel Integrated Target Return Pulse Train for a SNR = 5 dB ($V = 2.0$).	D-12
D-5a	Simulated Normal Channel Unintegrated Target Return Pulse Train for a SNR = 10 dB.	D-13
D-5b	Simulated Normal Channel Integrated Target Return Pulse Train for a SNR = 10 dB ($V = 2.0$)	D-13
D-6a	Simulated Normal Channel Unintegrated Target Return Pulse Train for a SNR = 15 dB.	D-14
D-6b	Simulated Normal Channel Integrated Target Return Pulse Train for a SNR = 15 dB ($V = 2.0$)	D-14
D-7	Simulated Normal Channel Integrated Target Return Pulse Train for a SNR = 15 ($V = 1.0$).	D-15
D-8	Simulated Normal Channel Integrated Target Return Pulse Train for a SNR = 15 ($V = 0.7$).	D-15
D-9	Simulated Normal Channel Integrated Target Return Pulse Train for a SNR = 15 ($V = 0.5$).	D-16

D-10	Simulated Normal Channel Integrated Target Return Pulse Train for a SNR = 15 ($V = 0.34$)	D-16
D-11	Measured ASR-8 Normal Channel Integrated Output.	D-17
D-12	Measured ASR-8 Normal Channel Integrated Output.	D-17
D-13	Measured ASR-8 Normal Channel Integrated Output.	D-17
D-14	ASR-7 Six Stagger Sequence	D-22
D-15	ASR-8 Four Stagger Sequence.	D-22
D-16	Simulated Feedback Integrator Output for Asynchronous Normal Channel Interference ($V = 2.0$, INR = 30 dB)	D-23
D-17	Simulated Feedback Integrator Output for Asynchronous Normal Channel Interference ($V = 1.0$, INR = 30 dB)	D-23
D-18	Simulated Feedback Integrator Output for Asynchronous Normal Channel Interference ($V = 0.34$, INR = 30 dB).	D-24
D-19	Measured ASR-8 Integrator Output for Asynchronous Normal Channel Interference	D-25
D-20	Measured ASR-8 Integrator Output for Asynchronous Normal Channel Interference	D-25
D-21	Measured ASR-8 Integrator Output for Asynchronous Normal Channel Interference	D-25
D-22	Simulated Normal Channel Unintegrated Radar Output with Interference	D-26
D-23	Simulated Normal Channel Integrated Radar Output with Interference	D-26
D-24	Simulated Feedback Integrator Output for Asynchronous MTI Channel Interference ($V = 2.0$, INR = 30 dB)	D-28
D-25	Simulated Feedback Integrator Output for Asynchronous MTI Channel Interference ($V = 1.0$, INR = 30 dB)	D-28
D-26	Simulated Feedback Integrator Output for Asynchronous MTI Channel Interference ($V = 1.0$, INR 30.0 dB)	D-29
D-27	Measured ASR-8 Integrator Output for Asynchronous MTI Channel Interference	D-30

D-28	Measured ASR-8 Integrator Output for Asynchronous MTI Channel Interference	D-30
D-29	Measured ASR-8 Integrator Output for Asynchronous MTI Channel Interference	D-30
D-30	Simulated MTI Channel (Mode 1 and 2 CASC) Unintegrated Radar Output with Interference	D-31
D-31	Simulated MTI Channel (Mode 1 and 2 CASC) Integrated Radar Output with Interference	D-31
D-32	ASR-7 (AN/GPN-12) Binary Integrator Block Diagram.	D-33
D-33	FAA Modified ASR-7 Enhancer Block Diagram.	D-35
D-34	Hit/Miss Characteristic Curve for FAA Modified ASR-7 Enhancer.	D-36
D-35	Probability of Noise Causing a Binary 1 at the Threshold Comparator Output.	D-38
D-36	Probability of 1 at the Threshold Comparator Output as a Function of the Signal-to-Noise Ratio at the Threshold Comparator Input for the Normal Channel	D-44
D-37	Probability of 1 at the Threshold Comparator Output as a Function of the Signal-to-Noise Ratio at the Threshold Comparator Input for a Single Channel MTI Canceller	D-46
D-38	Simulated Binary Integrator Output for Target Return Pulse Train (ASR-7, AN/GPN-12)	D-50
D-39	Simulated FAA Modified Binary Integrator Output for Target Return Pulse Train (ASR-7).	D-50
D-40a	Simulated Normal Channel Unintegrated Target Return Pulse Train for a SNR = 3 dB.	D-51
D-40b	Simulated Normal Channel Integrated Target Return Pulse Train for a SNR = 3 dB.	D-51
D-41a	Simulated Normal Channel Unintegrated Target Return Pulse Train for a SNR = 5 dB.	D-52
D-41b	Simulated Normal Channel Integrated Target Return Pulse Train for a SNR = 5 dB.	D-52
D-42a	Simulated Normal Channel Unintegrated Target Return Pulse Train for a SNR = 10 dB	D-53

D-42b	Simulated Normal Channel Integrated Target Return Pulse Train for a SNR = 10 dB . . . . .	.D-53
D-43a	Simulated Normal Channel Unintegrated Target Return Pulse Train for a SNR = 15 dB . . . . .	.D-54
D-43b	Simulated Normal Channel Integrated Target Return Pulse Train for a SNR = 15 dB . . . . .	.D-54
D-44a	Simulated MTI Channel (Mode 1 and 2 CASC) Unintegrated Target Return Pulse Train for a SNR = 3 dB . . . . .	.D-55
D-44b	Simulated MTI Channel (Mode 1 and 2 CASC) Integrated Target Return Pulse Train for a SNR = 3 dB . . . . .	.D-55
D-45a	Simulated MTI Channel (Mode 1 and 2 CASC) Unintegrated Target Return Pulse for a SNR = 10 dB . . . . .	.D-56
D-45b	Simulated MTI Channel (Mode 1 and 2 CASC) Integrated Target Return Pulse Train for a SNR = 10 dB. . . . .	.D-56
D-46a	Simulated MTI Channel (Mode 1 and 2 CASC) Unintegrated Target Return Pulse Train for a SNR = 20 dB. . . . .	.D-57
D-46b	Simulated MTI Channel (Mode 1 and 2 CASC) Integrated Target Return Pulse Train for a SNR = 20 dB. . . . .	.D-57
D-47a	Simulated Normal Channel Unintegrated Radar Output with Interference. . . . .	.D-59
D-47b	Simulated Normal Channel Integrated Radar Output with Interference. . . . .	.D-59
D-48a	Simulated MTI Channel (mode 1 & 2 CASC) Unintegrated Radar Output with Interference. . . . .	.D-61
D-48b	Simulated MTI Channel (mode 1 & 2 CASC) Integrated Radar Output with Interference . . . . .	.D-61
E-1	Block Diagram of Simulated ASR-7 Processor Unit. . . . .	.E-2
E-2	Clock Timing and Desired Signal Characteristics for ASR-7 Radar. .E-3	
E-3	ASR-5 Interfering Signal Characteristics . . . . .	.E-7
E-4	ASR-8 Interfering Signal Characteristics . . . . .	.E-7
E-5	AN/FPS-90 Interfering Signal Characteristics . . . . .	.E-7

E-6	Probability Density Function for Noise Only and for Signal-Plus-Noise at the Normal Channel Envelope Detector Output	E-9
E-7	ASR-7 (AN/GPN-12) Binary Integrator Block Diagram.	E-10
E-8	Probability Density function for Noise Only and for Signal-Plus-Noise at the MTI Phase Detector Output	E-13
E-9	Canonical Form of Simulated ASR-7 MTI Canceller.	E-14
E-10	Feedback Integrator Block Diagram.	E-16
E-11	Simulated PPI Display of Interference.	E-17
F-1	Modified Cumulative Distribution of Signal-Plus-Noise at ASR-7 Radar MTI Channel Output for Various Signal-to-Noise Voltage Ratios	F-6

LIST OF TABLES

<u>TABLE</u>	<u>PAGE</u>
3-1 MTI Canceller Transfer Properties	3-59
4-1 Time Intervals That Interfering Radar Pulses Overlap The Rank Quantizer Range Bin Sample Times For Various Combinations Of Interfering And Victim Radars	4-17
4-2 ARTS-IIIA/RDAS Probability Of False Target Hit When Connected To ASR-7 Radar That Is Receiving Interference From One Radar.	4-27
4-3 ARTS-IIIA/RDAS Probability Of False Target Hit When Connected To ASR-7 Radar That Is Receiving Interference From One Radar.	4-28
4-4 ARTS-IIIA/RDAS Probability Of False Target Hit When Connected To ASR-8 Radar That Is Receiving Interference From One Radar.	4-29
4-5 ARTS-IIIA/RDAS Probability Of False Target Hit When Connected To ASR-8 Radar That Is Receiving Interference From Three Radars Of The Same Type.	4-30
4-6 ARTS-IIIA/RDAS Probability Of False Alarm For Typical Detection Parameters And Various Combinations Of Interfering And Victim Radars	4-33
4-7 Average Number Of Azimuth Change Pulse Since Initial Hit For A False Alarm To Occur	4-35
4-8 ARTS-IIIA/RDAS Probability Of Target Hit When Connected To ASR-7 Radar That Is Receiving Interference From One Radar	4-52
4-9 ARTS-IIIA/RDAS Probability Of Target Hit When Connected To ASR-7 Radar That Is Receiving Interference From Three Radars Of The Same Type	4-53
4-10 ARTS-IIIA/RDAS Probability Of Target Hit When Connected To ASR-8 Radar That Is Receiving Interference From One Radar.	4-54
4-11 ARTS-IIIA/RDAS Probability Of Target Hit When Connected To ASR-8 Radar That Is Receiving Interference From Three Radars Of The Same Type	4-55

4-12	ARTS-IIIA/RDAS Probability Of Target Detection For Typical Detection Parameters And Various Combinations Of Interfering And Victim Radars	4-59
4-13	ARTS-IIIA/RDAS Probability Of False Alarm When Connected To ASR-7 Radar (MTI Channel) That Is Receiving Interference From Three Radars Of The Same Type	4-63
4-14	ARTS-IIIA/RDAS Probability Of False Alarm When Connected To ASR-8 Radar (MTI Channel) That Is Receiving Interference From Three Radars Of The Same Type	4-64
4-15	ARTS-IIIA/RDAS Probability Of Target Detection When Connected To ASR-7 Radar (MTI Channel) That Is Receiving Interference From Three Radars	4-65
4-16	ARTS-IIIA/RDAS Probability Of Target Detection When Connected To ASR-8 Radar (MTI Channel) That Is Receiving Interference From Three Radars Of The Same Type	4-66
4-17	ARTS-IIIA/RDAS Probability Of Clutter Hit When Connected To Victim Radr That Is Receiving Interference From Three Radars Of The Same Type	4-71
4-18	ARTS-IIIA/RDAS Probability Of Clutter Parameter Decrement And Increment Due To Interference Effect On Normal Channel Clutter Hits	4-74
4-19	ARTS-IIIA/RDAS Probability Of MTI Hit Count Threshold And Sliding Window Isolated Hit Sum Change Due To Interference.	4-74
C-1	MTI Canceller Transfer Properties	C-20
C-2	Signal-To-Noise Improvement (In Decibels) Relative To Detection Of $I^2 + Q^2$ (Fluctuating Signal), Single Pulse	C-35
D-1	Feedback Integrator Peak Signal-To-Noise Enhancement For Normal Channel	D-9
D-2	Target Azimuth Shift Caused By Feedback Integration	D-19
D-3	Probability Of Noise Causing The Integrator To Be In State E_j	D-40
D-4	Probability Of Noise Causing The Modified FAA Integrator To Be In State E_j	D-42

D-5	Probability Of Noise Causing The Integrator To Be In State E (Simulated)	D-43
D-6	Probability Of Desired Signal Target Return Pulse Train Of 20 Pulses Causing The FAA Modified Integrator To Be In State E	D-48
G-1	ASR-5 System Characteristics	G-2
G-2	ASR-7 System Characteristics	G-3
G-3	ASR-8 System Characteristics	G-4
G-4	WSR-57 System Characteristics	G-5
G-5	WSR-74S System Characteristics	G-6
G-6	AN/FPS-6 System Parameters	G-7
G-7	AN/GPN-20 System Characteristics	G-8
G-8	AN/CPN-4 System Characteristics	G-9
G-9	AN/MPN-13 System Characteristics	G-10
G-10	AN-TPN-24 System Characteristics	G-11