Mission Research Corporation

MRC/COS-R-1326

Analysis of Radiation Effects on Sensors (ARES)
Final Summary Report

October 30, 1992

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SECTION 1

INTRODUCTION

This report documents the accomplishments obtained by Mission Research Corporation on the Analysis of Radiation Effects on Sensors (ARES) program. The period of performance of the referenced contract was from July 1, 1989 through July 24, 1992.

The ARES program is part of the U.S. Army Strategic Defense Command's (USASDC) on-going program to develop the technologies needed to field infrared (IR) sensor systems capable of meeting the requirements of current and future ballistic defense missions. The mission requirements include the range of threat environments expected under the current Global Protection Against Limited Strikes (GPALS) scenario.

Restructuring of the program in early-1991 led to a considerable down-sizing in the overall scope of the ARES effort at Mission Research. De-emphasis of the nuclear survivability of IR sensors reoriented the goals of the program to emphasize sensor functionality in benign environments.

SECTION 2

SUMMARY OF ACCOMPLISHMENTS

This section contains a brief summary of all technical efforts accomplished by Mission Research under the ARES contract. Each section is labeled with the title of a technical document that was submitted under the ARES contract. A complete copy of any of the referenced documents can be found in MRC/COS-91-102, "Draft, Analysis of Radiation Effects on Sensors (ARES) - Annual Report", Volumes 2 and 3, dated 31 July 1991.

2.1. "Advanced Nuclear Hardened Focal Plane Program Review at Rockwell, Anaheim on 7 June 1989 and Nuclear Hardened Mosaic Technology Program Review at Aerojet, Azusa on 8 June 1989", MRC/COS-L-1204, 13 July 1989.

One of many program reviews supported where many valuable comments, critiques, and recommendations were given in support of the ARES contract. This letter discusses the design goal for acceptor concentrations of IBC detectors.

2.2. "An Experimental Investigation of Intrinsic Event Discrimination in IBC SiAs Detectors", MRC/COS-R-947, MRC/COS-B-502, 19 July 1989.

This task was conducted in order to explore intrinsic event discrimination (IED) mechanisms in IBC Si:As detectors and determine whether any high-quality IBC Si:As detector arrays can be made to operate in an IED mode. The goal was to further develop the understanding of IED behavior in the hopes that fully predictable, working arrays can be produced. In particular, it was attempted to see if IED behavior can be produced in standard arrays which are not specially designed. A PATHS Si:As detector array and SFD readout fabricated by Hughes Aircraft was tested at MRC. Clear and radiation (gamma) environment experimental data were obtained. The results indicate that definitive proof of IED behavior in standard IBC Si:As detectors remains elusive.

2.3. "Recommendation for Mirror Test at Spire Corporation", MRC/COS-L-1231, 22 August 1989.

This mirror test was identified, defined, and recommended as being crucial to the Passive Sensors project. This test would help in understanding the response of mirrors to multiple x-ray exposures in tactical scenarios.

2.4. "Trip Report - Advanced Infrared Sensor MODIL Workshop", MRC/COS-L-1238, 28 August 1989.

One of many workshops supported where many valuable comments, critiques, and recommendations were given in support of the ARES contract. This letter summarizes the Advanced Infrared Sensors Manufacturing Operational Development and Integration Laboratory (MODIL) workshop. The ground rules under which the MODIL is to operate were presented and several conclusions and recommendations for future directions were given.

2.5. "Possible Radiation Test of IED Detectors at MRC/COS", MRC/COS-L-1233, 29 August 1989.

This letter reports on the possibility of performing e-beam (simulated debris gamma) tests of IED detectors at Mission Research using the MRC e-beam facility.

2.6. "Use of High Explosive (HE) Tests to Support BOAST", MRC/COS-L-1235, 5 September 1989.

This HE test was identified, defined, and recommended as being crucial to the Passive Sensors project and to BOAST so that the impact from nuclear-induced dust clouds can be assessed.

2.7. "SDS Interceptor", MRC/COS-L-1251, 6 September 1989.

This letter report suggests that Passive Sensors give consideration to expanding its role so that it can serve as the repository of expertise for SDS interceptors at USASDC.

2.8. "Passive Survivability Program Review", MRC/COS-L-1254, 11 September 1989.

One of many program reviews supported where many valuable comments, critiques, and recommendations were given in support of the ARES contract. This letter provides a preliminary report of the WL Passive Survivability Program Review held at Sandia on 22-24 August, 1989.

2.9. "A Concept for a Baffle Blow Off Measurement System", MRC/COS-L-1256, 20 September 1989.

This effort identifies the need for experimental test equipment for evaluating the hardened baffle technologies in development. Specifically, for the ejecta, the number of particles ejected (per unit area), their optical scatter cross sections, and their velocities are needed as inputs to sensor performance predictions. The lack of

adequate test equipment for obtaining particle velocities in tests of hardened baffles is identified. The effort then proceeds to define a concept for an experimental apparatus capable of obtaining the needed data to the level of precision and with the accuracy required.

2.10. "HYWAYS Program Reviews, 7-8 September 1989", MRC/COS-L-1264, 25 September 1989.

One of many program reviews supported where many valuable comments, critiques, and recommendations were given in support of the ARES contract. This letter discusses the possible sensor performance problems due to large detector thicknesses. It also addresses preliminary radiation test data for the low-background AHD hybrid.

2.11. "Comment on AESC Report No. 8313-11, dated 3 September 1989", MRC/COS-L-1259, 26 September 1989.

One of many documents reviewed and critiqued in support of the ARES contract. It was recommended that IR sensor outages be assessed on the tracker loop performance simulation from Strapdown Associates.

2.12. "Priority of Indium Bump Activation Issue", MRC/COS Internal Memo, 29 September 1989.

This memo gives MRC's recommendation on the issue of the importance of neutron activation of indium bumps. It was recommended that the indium-activation issue be given low priority for several reasons. First, most scoping calculations have indicated that indium activation is neglibible for exoatmospheric systems. Second, the neutron environment is not well established and the uncertainty in prediction of indium activation is dominated by this. Third, the development of alternative bump technologies to indium will probably not be required, even if indium activation turns out to be a problem because there is an easy solution.

2.13. "Effects of X-Ray Exposure on Candidate Mirrors for Endoatmospheric Seekers (U)", MRC/COS-89-154, MRC/COS-L-1281, 10 October 1989.

This report contains a first-look at the system effect of thermal distortion of the primary mirror in a generic endoatmospheric seeker. It is pointed out that even a small differential thermal expansion of the mirror as a result of the x-ray induced thermal gradients will change the focal length of the sensor optical train and could cause serious defocus of the image at the focal plane array.

2.14. "Comments on Rockwell International Document, Unnumbered, Intial Draft, Dated 19 September 1989, 'Technology Advancement Plan (TAP) for Advanced Technology for Nuclear Hardness Enhancement of (Focal Plane) Detector Subarrays (HEEDS) Program'", MRC/COS-L-1293, 18 October 1989.

One of many documents reviewed and critiqued in support of the ARES contract. Several comments concerning Rockwell's plan for technology advancement are given.

2.15. "IRFPA Hardening Concepts Program Meeting 11-12 October 1989 at Air Force Weapons Lab, Kirtland AFB, NM", MRC/COS-L-1292, 19 October 1989.

One of many program reviews supported where many valuable comments, critiques, and recommendations were given in support of the ARES contract. This letter summarizes the material presented on the four hardware subtasks.

2.16. "Test Plan for Radiation Testing of Rockwell IBC Detectors in IED Mode", MRC/COS-R-996, 21 November 1989.

This test plan describes a test program intended to evaluate the impact of weapon-induced debris gamma environments on the performance of Si:As IBC detectors when operated in IED mode. The purpose of this infrared detector test is to determine the radiation response at operating conditions, and the effectiveness of operation in IED mode.

2.17. "HEEDS Comments and Responses", MRC/COS-L-1312, 28 November 1989.

One of many program reviews supported where many valuable comments, critiques, and recommendations were given in support of the ARES contract.

2.18. "Evaluation of Microlense Concepts", MRC/COS-L-1347, 2 January 1990.

The microlense test was identified, defined, and recommended as being crucial to the Passive Sensors project. Microlenses and condensing cones have been identified as a means of reducing the physical size of detector pixels while maintaining optical collection efficiency. However, most programs are largely analytical.

2.19. "LMSC Mirror Replication Effort", MRC/COS-L-1356, 8 January 1990.

One of many documents reviewed and critiqued in support of the ARES contract. It was advised that qualitative and quantitative results be given in LMSC monthly reports.

2.20. "Comments on AESC Report 9526, Technology Advancement Plan, Dated 7 November 1990", MRC/COS-L-1370, 19 January 1990.

One of many documents reviewed and critiqued in support of the ARES contract. This letter provides several responses/comments about AESC Report 9526.

2.21. "Comment on Boeing 'Program Plan for HEEDS Noise ... etc.', Appendix B in AESC Report No. 9518-06, dated 10 January 1990", MRC/COS-L-1374, 25 January 1990.

One of many documents reviewed and critiqued in support of the ARES contract. It was recommended that an experimental evaluation be done of the performance of the noise suppression concepts.

2.22. "Comments on the January HEEDS IPRS", MRC/COS-L-1379, 6 February 1990.

One of many program reviews supported where many valuable comments, critiques, and recommendations were given in support of the ARES contract. Numerous comments and recommendations were made concerning the Rockwell, Hughes, and AESC HEEDS IPRs.

2.23. "WRDC Program Reviews held on 30-31 January 1990", MRC/COS-L-1381a, 8 February 1990.

One of many program reviews supported where many valuable comments, critiques, and recommendations were given in support of the ARES contract. This letter discusses the Advanced HYMOSS Focal Plane Optimization, SSPM Technology Development, and Photoconductive (PC) Heterojunction Interface Trap (HIT) HgCdTe Detectors Program Reviews.

2.24. "ARES Program Analysis Results Technology Program Needs (U)", MRC/COS-90-049, MRC/COS-B-591, 21 February 1990.

This effort was conducted in order to assess the thermal recovery of IR focal plane arrays (FPAs). Both IBC Silicon and PV HgCdTe arrays were assessed. This effort also predicts the performance, and identifies and evaluates hardening concepts, of sensors operating in RFI (radio frequency interference), HPM (high power microwave),

and EMP (electro-magnetic pulse) environments. The results show that hardening techniques are required for sensors operating in the expected levels of these environments.

2.25. "Condensing Cone Arrays for Application in Large Aperture Sensors", MRC/COS-L-1407, 12 March 1990.

This effort was conducted in order to assess the utility of condensing optics as a method for reducing detector sizes, thereby providing a hardening concept for persistent betas and gammas for exoatmospheric surveillance sensors. The methodology consisted of using SENSIM to perform optical raytracing in order to compute the optical transfer efficiency of the condensing cones. The optical transfer efficiency was then used as a figure-of-merit to assess the performance of the optical condensing cones. The results of the investigations show that optical condensing cones exhibit considerable potential as a hardening technique for persistent betas and gammas and that experimental investigations are warranted.

2.26. "Condensing Cone Arrays for Application in Small Aperture Sensors", MRC/COS-L-1408, 12 March 1990.

This effort was conducted in order to assess the utility of condensing optics as a method for reducing detector sizes, thereby providing a hardening concept for persistent betas and gammas for exoatmospheric interceptors. The methodology and results are the same as those reported in Section 2.25.

2.27. "Analysis of Radiation Effects on Sensors Briefing Presented to the Project 5 Review at NOSC on 28 February 1990", MRC/COS-L-1410, 14 March 1990.

This briefing provides a top-level view of the activities performed under the ARES contract at MRC from July, 1989 through January, 1990.

2.28. "SDIO Passive Sensors Program Review (Project 5 Meeting)", MRC/COS-L-1417

One of many program reviews supported where many valuable comments, critiques, and recommendations were given in support of the ARES contract. A critique is provided that summarizes the SDIO Passive Sensors Program Review.

2.29. "Need for Tests of Knife Edges", MRC/COS-L-1427, 3 April 1990.

Tests of baffle knife edges were identified, defined, and recommended as being crucial to the Passive Sensors project. Analysis has shown that knife edges are critical to the performance of baffles and have been ignored in many programs.

2.30. "Proposed Program for Demonstration of Hardened FPA Module Design Technology (Draft) (U)", MRC/COS-90-099, MRC/COS-L-1424, 12 April 1990.

This effort identifies data needs for SDI/SDC surveillance and homing IR sensors. Specifically, it is noted that present test programs are not structured to obtain data for complete focal plane modules which incorporate state-of-the-art TREE, EMP, and IEMP suppression techniques. Data inadequacies are identified and a test program for obtaining the necessary data is recommended.

2.31. "Comments on 'LWIR HgCdTe Hybrid Arrays for Seekers', dated 18 December 1989, by Jamieson Science and Engineering (U)", MRC/COS-90-083, MRC/COS-L-1429, 12 April 1990.

One of many documents reviewed and critiqued in support of the ARES contract. It provides many detailed comments after a telephone conversation with Dr. Jamieson.

2.32. "Focal Plane Array-Signal/Data Processor Target Discrimination Demonstration Program", MRC/COS-L-1446, 12 April 1990.

This report identifies a discrepancy between analytical and computer simulation modeling of the performance of IR sensors as regards target signal amplitude estimation. It is further noted that highly accurate target signal amplitude estimation is required in order for these sensors to meet mission requirements regarding target discrimination. It is then noted that computer simulation modeling predicts significantly less accurate target signal amplitude estimation than does analytical techniques. The effort then defines and recommends a program to resolve these differences and obtain a definitive resolution as regards the performance prediction of sensor estimates of target signal amplitude.

2.33. "Negative Polarity Gamma Pulse Rate and Amplitude Analysis for the GSTS Sensor (U)", MRC/COS-90-106, MRC/COS-L-1409, 13 April 1990.

This effort was conducted in order to quantify the tolerable pulse rates and pulse amplitudes for negative-polarity gamma pulses in the GSTS sensor. The methodology consisted of using SENSIM in a Monte Carlo fashion to predict the RMS error in the sensor estimate of target angular position and target temperature. The results show the operable and inoperable regions in the two-dimensional trade space of pulse rate and pulse amplitude. The results can be used to assess the utility of focal plane array technology, from the standpoint of negative-polarity gamma pulses, being developed in the HEEDS and HYWAYS programs.

2.34. "Hardened Surveillance Sensor Development and Demonstration Program (U)", MRC/COS-90-093, MRC/COS-L-1430, 18 April 1990.

This effort identifies the need for radiation test data for an integrated surveillance sensor. It is noted that the only availbale data of this type is that obtained in the SPIRE Program and that the test item was 1973 technology so that the data is only partially relevant to present needs. It is noted that considerable data are (or will be) available concerning component response and that predictions based on these data suggest that quite useful mission capability should be possible, but that new (for LWIR sensors) engineering features will have to be incorporated. The successful integration of these features must be demonstrated if the hardened design is to be credible. This implies that a tactical sensor will need to be exposed in an underground test and that the test will need to be supported by above and underground tests of components and subsystems, along with aboveground tests of the sensor and its test system. The effort then defines and recommends a program to accomplish these goals.

2.35. "Development of Hardened Superlattice IR Detectors as an Alternative to HgCdTe", MRC/COS-L-1447, 18 April 1990.

The mainstream focal plane array (FPA) technology for many SDI infrared (IR) sensors is photovoltaic (PV) or metal-insulator-semiconductor (MIS) HgCdTe. This task identifies that this technology has producibility and radiation hardness problems, and that it is not clear that these problems can be solved adequately or in a timely fashion to meet SDI system requirements and time lines. The task then identifies LWIR detectors using superlattice/quantum well (SL/QW) technology as an alternative high-payoff path to a producible and hardened IR FPA technology. The task then continues by defining and recommending a program for SL/QW detector development which would be appropriate to address USASDC LWIR interceptor needs.

2.36. "Neutron Activation in Indium Bumps Used for Bonding Detector and Readout Arrays", MRC/COS-L-1452, 25 April 1990.

This effort was conducted in order to investigate neutron activation in Indium bumps used in the mating of detector and readout arrays for the GSTS sensor. The methodology consisted of computing the neutron-induced beta and gamma event rates in the detectors and readouts due to the neutrons from a nuclear detonation. Both direct and "albedo" (thermalized and reflected from the atmosphere) neutrons were utilized. The results show that neutron activation is not an issue so that an alternative to Indium bump technology is not required. The results have a direct impact on the HEEDS Program.

2.37. "Trip Report - Attend IRIS Specialty Group Meeting on Passive Sensors, March 13-15, 1990, John-Hopkins Applied Physics Laboratory, Laurel, Maryland", MRC/COS-L-1456, 25 April 1990.

One of many meetings supported where many valuable comments, critiques, and recommendations were given in support of the ARES contract. This letter summarizes papers of interest to the ARES program.

2.38. "Mirror Scatter Requirement for Exoatmospheric Interceptors (U)", MRC/COS-90-100, MRC/COS-L-1438, 26 April 1990.

This effort was conducted in order to quantify the mirror scatter requirement for exoatmospheric interceptors. The methodology consisted of using analytical bounding calculations in quantifying the mirror scatter requirement, using standard signal-to-noise ratio equations based on a required value for the signal-to-noise ratio. The results of the analysis have a degree of uncertainty in the value for the scatter requirement such that the mirror scatter that can be obtained by current hardened mirror technology falls within the error bounds of the analysis. Consequently, a definitive answer as to whether current hardened mirror technology can meet the mirror scatter requirement was not obtained.

2.39. "Mirror Scatter Requirement for Exoatmospheric Surveillance Sensors (U)", MRC/COS-90-101, MRC/COS-L-1439, 4 May 1990.

This effort was conducted in order to quantify the mirror scatter requirement for exoatmospheric surveillance sensors. The methodology and results are the same as those in Section 2.38.

2.40. "Trip Report: Wide-Field-of-View (WFOV) Status Review at Nichols Research Corp., Huntsville, AL on 25 April, 1990", MRC/COS-L-1462, 10 May 1990.

One of many reviews supported where many valuable comments, critiques, and recommendations were given in support of the ARES contract. The following conclusions were made: data from mirror experiments is of limited value because initial BRDF levels on samples were two orders of magnitude larger than those of interest, data from baffle experiments is of limited value because blow off cannot be inferred from the reflectivity measurements made, stability of the telescope design must be considered carefully because of the use of different materials and x-ray heating issues, and high power microwave threats must be considered.

2.41. "Be Mirror Scatter, Possible Benefits of Coating (U)", MRC/COS-90-117, MRC/COS-L-1469, 14 May 1990.

This effort reports that the use of a thin Al coating on a Be mirror may be used to reduce the overall mirror BRDF.

2.42. "Fast Interferometer at SPIRE", MRC/COS-L-1478, 24 May 1990.

This letter report comments on how taking a single instantaneous interferogram may not be adequate if vibrational motions cause a change in the mirror figure.

2.43. "Operability/Survivability Technologies for Brilliant Pebbles (U)", MRC/COS-90-132, MRC/COS-B-658, 31 May 1990.

This briefing discusses the attack strategies and threat scenarios for the Brilliant Pebbles concept.

2.44. "Comments of HEEDS IPRs Held at TBE on 5-7 June", MRC/COS-L-1493, 15 June 1990.

One of many program reviews supported where many valuable comments, critiques, and recommendations were given in support of the ARES contract. Specifically, this letter report contains comments on the problems with the HEEDS filter design and the progress of each of the three HEEDS contractors (Rockwell, AESC, and Hughes).

2.45. "Problems With Use of HgCdTe Detector Arrays in an Infrared Sensor System", MRC/COS-L-1496, 19 June 1990.

The AGT/UGT Program has experienced continued problems with the use of HgCdTe detectors in its tests. These problems are typical of what others have experienced with HgCdTe, and raise the question of how viable this technology is for use in sensor systems. This report includes comments on current technology, impact on sensor systems, and recommendations to program offices.

2.46. "Trip Report: Solid State Photomultiplier (SSPM) Workshop", MRC/COS-L-1502, 3 July 1990.

One of many workshops supported where many valuable comments, critiques, and recommendations were given in support of the ARES contract. The purpose of the workshop was to gather users of the SSPM to exchange information about potential applications and experience people have gained in operation of the devices.

2.47. "Operating Temperature of Detectors at High Optical Background", MRC/COS-L-1510, 18 July 1990.

At the HEEDS IPRs in Huntsville on 5-7 June 1990, it was pointed out that operation at higher optical backgrounds (due to microlens focusing) would permit operation of Silicon IBC detectors at higher temperatures. This report discusses the significance of operating at higher temperatures in terms of which technologies may benefit. In particular, the IBC Si:Ga detectors that were dropped from consideration for interceptor and surveillance sensor designs are discussed.

2.48. "Optical Filter Vulnerability and Test Issues", MRC/COS-L-1511, 30 July 1990.

At the HEEDS IPRs in Huntsville on 5-7 June 1990, it became apparent that the filter task is presenting the program with some confusion. The approaches being taken by the three contractors are significantly different, but it is not clear that any will produce what is needed. This report discusses optical filter vulnerability and reports on the comments made by Jerry Gurtman of S-Cubed and Mike Treadaway of JAYCOR at a meeting with Arne Kalma.

2.49. "Off-Axis Rejection Requirement for Exoatmospheric Interceptors (U)", MRC/COS-90-102, MRC/COS-L-1440, 7 August 1990.

This effort was conducted in order to quantify the off-axis rejection requirement for exoatmospheric interceptors. The methodology consisted of using analytical bounding calculations in quantifying the off-axis rejection requirement, using standard signal-to-noise ratio equations based on a required value for the signal-to-noise ratio. The results of the analysis have a degree of uncertainty in the value for the off-axis rejection requirement.

2.50. "Off-Axis Rejection Requirement for Exoatmospheric Surveillance Sensors (U)", MRC/COS-90-103, MRC/COS-L-1441, 10 August 1990.

This effort was conducted in order to quantify the off-axis rejection requirement for exoatmospheric surveillance sensors. The methodology and results are the same as those described in Section 2.49.

2.51. "Revised Letter Report: Mirror Scatter Requirement for Exoatmospheric Surveillance Sensors (U)", MRC/COS-90-101/R1, MRC/COS-L-1439/R1, 10 August 1990.

This effort was conducted in order to quantify the mirror scatter requirement for exoatmospheric surveillance sensors. The methodology and results are the same as those detailed in Section 2.39.

2.52. **"SDIO Passive Sensors Program (Project 5) Review: Report of Significant Technical Accomplishments and Upcoming Milestones", MRC/COS-L-1543, 23 August 1990.**

This letter provides a top-level view of the activities performed under the ARES contract at MRC from February, 1990 through August, 1990.

2.53. **"Performance of the GRIS Gamma Circumvention Algorithm", MRC/COS-B-715, 14 February 1990.**

This briefing contains plots comparing the performance of Harris' GRIS gamma circumvention algorithm with other circumvention algorithms (e.g. LOBALL, THRESHOLD LOBALL, etc.).

2.54. **"Comments on: Advanced Technology for Nuclear Hardness Enhancement and Evaluation of Focal Plane Detector Subarrays (HEEDS): Test Plan Covering AMCIDERO E-Beam Experiment at Mission Research Corporation, Colorado Springs, CO", MRC/COS-L-1561, 10 September 1990.**

Experiments at Aerojet Electronics Systems Division (AESD), Naval Ocean Systems Center (NOSC), and Jet Propulsion Laboratory (JPL) have indicated that the ability of the AMCIDERO to read out IR or ionizing radiation-induced charge depends on the temporal generation of this charge (i.e., the time in the integration period of AMCIDERO when charge is generated determining how much can be subsequently read out). Data for IR-generated charge are quite clear on this dependency, but data for ionizing radiation-induced charge are sketchy and confusing. This report presents a plan for testing AMCIDERO detectors so that the confusion can be eliminated.

2.55. **"Support for Beam Blanking Modifications to MRC's Electron Beam", MRC/COS-L-1565, 14 September 1990.**

This letter discusses possible support for modifying MRC's electron beam machine to operate in beam blanking mode.

2.56. **"Relative Advantages of Staring and Scanning IR Sensors for Interceptor Guidance Applications, and Implications for FPA Technology Development (U)", MRC/COS-90-191, MRC/COS-R-1107, 14 September 1990.**

A study was completed some years ago that concluded that staring IR sensors offered significant advantages over scanning ones for a number of applications, including interceptor guidance. A more recent study (by LMSC/Palo Alto) has concluded that staring presents serious practical difficulties, and that some scanning, even if of

limited amplitude ("dithered starers"), will probably be needed. This report reviews some of the technical considerations involved in comparing the two kinds of systems and the implications for IR sensors of SDC (and SDI) interest.

2.57. "Test Plan for Radiation Testing of Hughes Aircraft Reduced Area Detectors", MRC/COS-R-1105, 2 October 1990.

This test plan describes a test program intended to evaluate the impact of weapon-induced debris gamma environments on the performance of Si:As detectors of various sizes which utilize specialized readout techniques. The effects to be measured are signal and noise in a gamma-flux environment. The purpose of the infrared detector test is to determine the radiation response under normal operating conditions, and the effectiveness of using detectors of very small sizes, along with readout oversampling techniques, to circumvent noise due to gamma radiation.

2.58. "Comparison of HCT and Si Technologies for Exoseeker Applications (U)", MRC/COS-90-187, MRC/COS-R-1114, 15 November 1990.

This paper discusses and compares the producibility of LWIR doped Silicon and photovoltaic HgCdTe (PVHCT) focal plane assemblies. The hostile environments which are of concern for many systems impact the producibility in several important ways. The presently available data base for the technologies is reviewed in this context. The inadequacies of the data base for both technologies are identified, and recommended improvements are described. It is concluded that the decisions to baseline PVHCT for several DOD systems may well have been somewhat premature, and that doped Silicon should probably be kept under consideration as an alternate. This may be especially prudent if a need for early deployment should become desirable.

2.59. "Trip Report: IRIS Passive Sensors Conference 5-7 March 1991 at John Hopkins University Applied Physics Laboratory", MRC/COS-L-1685, 15 March 1991.

One of many conferences supported where many valuable comments, critiques, and recommendations were given in support of the ARES contract. This letter points out the possible similarities between structured nuclear clutter and clutter seen by FLIRs on F-14 platforms.

2.60. **"Sensor Performance Impact of Increasing the Gap Between Detectors on HYWAYS FPAs (U)", MRC/COS-91-075, MRC/COS-L-1710, 19 April 1991.**

This effort was conducted in order to determine the significance of increased detector gap size on sensor performance. It provides several conclusions to aid in the HYWAYS FPA development program.

SECTION 3

FINAL TECHNICAL STATUS

Mission Research Corporation completed several very valuable analyses during the period of performance of the ARES contract. Sixty technical documents are summarized in Section 2 above. MRC was directly involved in deciding the course for several programs such as BOAST, HYWAYS, and HEEDS. By utilizing technical expertise in areas such as signal processing, sensor performance, hardened sensor technology, survivability, focal plane detectors/readouts, experimental testing, and physics, MRC has been able to shape the future of the ARES Program with regards to IR sensor design.

Although numerous accomplishments were achieved, several analyses were initiated that were never finished due to budget constraints. These analyses include quantifying the mirror scatter requirement for exoatmospheric interceptors and surveillance sensors, quantifying the off-axis rejection requirement for exoatmospheric interceptors and surveillance sensors, quantifying the requirement on the density of baffle blow-off particles in the sensor field-of-view for exoatmospheric interceptors and surveillance sensors, a GSTS parametric trade study, and an investigation of the FPA hardening implications associated with detector thickness for low-noise FPAs being developed on the HYWAYS Program. Furthermore, laboratory radiation testing of on-chip gamma circumvention using novel concepts was planned but also was not completed.

SECTION 4

HOW ACCOMPLISHMENTS AND FINAL TECHNICAL STATUS WERE REACHED

The accomplishments and final technical status at Mission Research were reached by following several different approaches. Key technical personnel supported program reviews, planning meetings, coordination meetings, technical interchange meetings, conferences, and workshops. At these assemblies, MRC personnel were instrumental in providing comments, critiques, and recommendations. These meetings also allowed for MRC to sharpen technical skills and to keep up-to-date with state-of-the-art technology. Another approach used by MRC personnel was to provide critiques of technical reports from organizations such as AESC, Rockwell, and Boeing. This method allowed for MRC personnel to be informed of analyses taking place at other organizations. Additionally, by using the MRC Colorado Springs Radiation Test Facility, several radiation tests were conducted. In particular, tests were performed on a Hughes PATHS Si:As detector array and SFD readout and on a Rockwell Si:As IBC detector array. These tests allowed for MRC to evaluate critical sensor components. Finally, MRC's analytical tool, the SENsor SIMulation code SENSIM, was modified to analyze and predict the performance of current and conceptual IR sensor designs in SDI missions and hostile environments. SENSIM was used to calculate performance parameters such as signal-to-noise ratio, radiometric precision, target position estimation, probability of detection, probability of false alarm, and target temperature discrimination.

APPENDIX A

SUPPORTING ANALYSES

MRC Doc. No.	Title
86-232	Annual Report for Period 31 May 1985 through 31 May 1986, Nuclear Effects Analysis and Test Definition, Vol. I and Vol. II subtitled, Performance Predictions for SDC Infrared Sensors in 1986 and 1991 Time Frames (U), November 1986.
87-206	Annual Report for Period 18 June 1986 through 31 May 1987, Nuclear Effects Analysis and Test Definition, Vol. I and Vol. II subtitled, Performance Predictions for SDC Infrared Sensors in 1990 and 1995 Time Frames (U), September 1987.
88-313	Annual Report for Period 18 June 1987 through 31 May 1988, Nuclear Effects Analysis and Test Definition, Vol. I through Vol. III subtitled, Vol. I - Executive Summary of the Effort, Vol. II - Recommended Maximum Goal Levels of Nuclear Environments for SDC IR Sensor Technology Development - 1988, Vol. III - Performance Predictions for SDC Infrared Sensors in 1994 and 1998 Time Frames (U), July 1988.
89-085	Final Report for Period 31 May 1985 through 31 May 1989, Nuclear Effects Analysis and Test Definition, Vol. I through Vol. IV subtitled, Vol. I - Review of MRC Efforts on Nuclear Effects Analysis and Test Definition and Other Tasks Related to Hardened IR Sensor Technology (U), Vol. II - Recommended Maximum Goal Levels of Nuclear Environments for SDC IR Sensor Technology Development - 1989 (U), Vol. III - Performance Predictions for SDC Infrared Sensors in 1995 and 1999 Time Frames (U), Vol. IV - Appendices (U), May 1989.
90-138	Draft Annual Report for Period 1 July 1989 through 30 April 1990, Analysis of Radiation Effects on Sensors (ARES), Vol. I through Vol. III subtitled, Vol. I - Summary of the Effort for the Period 1 July 1989 through 30 April 1990, Vol. II - Recommended Maximum Goal Levels of Nuclear Environments for SDC IR Sensor Technology Development - 1990 (U), Vol. III - Performance Predictions for SDC Infrared Sensors in 1992 and 1995 Time Frames (U), April 1990.

APPENDIX A (Continued)

MRC Doc. No.	Title
91-102	Draft Analysis of Radiation Effects on Sensors (ARES) Annual Report (U), Vol. 1 through Vol. 3 subtitled, Vol. 1 - Summary, Predictions, and Recommendations (U), Vol. 2 - Appendix A (U), Vol. 3 - Appendix B (U), July 1991.