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**PROCEEDINGS OF THE FIRST SPACE
SYSTEMS SURVIVABILITY WORKSHOP**

**PUBLISHED BY
THE SPACE SYSTEMS SURVIVABILITY DIVISION (SSTDs)**

14 & 15 APRIL 1966

NOTICES

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4. If more detailed information on the subject matter of the workshop is desired, classified recorded tapes of the entire conference are on file in the Survivability Division (SSTDS). These classified tapes are available to qualified requestors on a loan basis. For further information, contact Lt M. R. Pierce (SSTDS/AC 213, 643-0778).

PREFACE

The First Space Systems Survivability Workshop was sponsored by the Advanced Development Directorate (SSTD) for the purpose of stimulating the exchange of information and promoting progress in the technical problem areas of space systems survivability. The meeting was conducted by the Advanced Development Directorate in the Auditorium of Building A-1, Aerospace Corporation (El Segundo Operations), on 14 and 15 April 1966.

There were 20 presentations made at this conference which are summarized in these proceedings.

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**SSD
SURVIVABILITY WORKSHOP
REVISED AGENDA**

FIRST DAY

0800 - 0900 REGISTRATION

0900 - 0910 INTRODUCTION - Col G.W. Scott (SSTD)

0910 - 1000 AFSC Survivability Considerations -
 Col W.P. Wood, AFSC (SCS-7)

1000 - 1030 Threat to U.S. Satellites in the Near Future
 Time Period - Lt R.J. Rudmann (SSF)

1030 - 1100 COFFEE BREAK

1100 - 1145 Space Systems Division Survivability Program -
 Col G.W. Scott (SSTD)

1145 - 1300 LUNCH

1300 - 1400 Technical Aspects of Space Systems Survivability -
 Dr. V. Josephson (Aerospace Corp.)

1400 - 1515 Current Efforts in Nuclear Weapons Effects & Testing

1. Air Force Weapons Laboratory (AFWL) 55 min.

a. ARGUS Effects - Capt Reenthaler

b. Techniques for Weapon Systems Analysis -
 Major P. Daily

c. TREES Effects - Capt S.O. Kennedy

d. X-Ray Effects - Capt R. Hansen

2. Nuclear Weapons Effects Testing & Research;
 20 min., Mr. J.D. McClelland (Aerospace Corp.)

1515 - 1545 COFFEE BREAK

1545 - 1615 ASTRO DEFENSE - Commander D.D. Heerwagen
 (Navy - Buweps)

1615 ADJOURN

INDEX OF PRESENTATIONS

1. AFSC Survivability Considerations - Col W.P. Wood, AFSC (SCS-7)
2. Threat to U.S. Satellites in the Near Future Time Period -
Lt R.J. Rudmann (SSD/SSF)
3. Space Systems Division Survivability Program - Col G.W. Scott
SSD (SSTD)
4. Technical Aspects of Space Systems Survivability - Dr. V.
Josephson (Aerospace Corp.)
5. ARGUS Effects - Capt D. Rekenhaller (AFWL)
6. Techniques for Weapon Systems Analysis - Major P. Daily (AFWL)
7. TREES Effects - Capt S.O. Kennedy (AFWL)
8. X-Ray Effects - Capt R. Hansen (AFWL)
9. Nuclear Weapons Effects Testing and Research - Mr. J. D.
McClelland (Aerospace Corp.)
10. ASTRO Defense - Cmdr D. D. Heerwagen (Navy)
11. Minuteman Guidance Hardening Approach - Mr. N. Skinker (BSD)
12. ABRES Survivability Efforts - Mr. R. Egermeier (Aerospace Corp.)
13. Hypervelocity Weapons Effects and Shielding - Mr. W. Dittrich
(AFATL)
14. RATSCAT - Mr. D. Montana (RADC)
15. Space Surveillance Sensors - Mr. R. McMillan (RADC)
16. ECM Techniques - Lt M. Cannon (AFAL)
17. Radar Reflectors and Dispensing Techniques - Miss M.P. Gauvey
(AFAL)
18. Radar Camouflage Techniques - Mr. C. H. Krueger (AFAL)
19. Active Defense of Spacecraft - Mr. L. W. Krautman (AFAL)
20. Ground Radar Capability for Satellite Identification - Mr. E. Fowle
(Mitre Corp.)

TITLE OF PRESENTATION: AFSC Survivability Considerations

PRESENTOR: Colonel W. P. Wood

**DUTY STATION: Hq AFSC (SCS-7)
Andrews AFB
Wash DC 20331**

SYNOPSIS:

An overview of the AFSC survivability/vulnerability management program and a review of the scope of the subject was presented. Both nuclear and non-nuclear implications on weapon systems from the time of alert to the target intercept modes were discussed. The AFSC master plan for survivability/vulnerability management was described and the progress on its implementation throughout the Systems Command was summarized. Objectives of the survivability/vulnerability program, its management structure, how it interfaces with the scientific community and the various regulatory documents connected with the program were presented.

TITLE OF PRESENTATION: Threat to U.S. Satellites in the
Near Future Time Period

PRESENTOR: Lt R. J. Rudmann

DUTY STATION: Hq SSD (SSFTT)
Los Angeles Air Force Station
Air Force Unit Post Office
Los Angeles, California 90045

SYNOPSIS:

With the advancement of manned and unmanned military space missions, an unrelenting effort in evaluating the threat to these U.S. space systems must be conducted. An assessment of the Soviet's capability and potential for the negation of U.S. space systems was presented. The assessment considered the following three basic threat elements: Electromagnetic Countermeasures, Ground Complex Vulnerability and Direct Satellite Attack, with primary emphasis devoted to the problem of the attack on satellites. Present and near-future Soviet systems which pose a threat to U.S. satellites, were discussed in a presentation of Soviet military space strength.

TITLE OF PRESENTATION: Survivability Improvement Program

PRESENTOR: Colonel G. W. Scott

DUTY STATION: Hq SSD (SSTD)
Los Angeles Air Force Station
Air Force Unit Post Office
Los Angeles, California 90045

SYNOPSIS:

The background of the formation of the Space Systems Survivability Division and its current program, Advanced Survival Techniques and Analysis Program, was provided. Future plans for the Division, which include the publication of an Advanced Development Plan to get survivability approved on a continuing level of effort in the DOD budget, was described. The objectives of the Division and all related activities performed by the Division were presented. The scope of the funded portion of the Program (ASTAP), was described and contracts in various areas were discussed. The overall goals of space systems survivability and their vital effects on military space missions were emphasized.

TITLE OF PRESENTATION: Technical Aspects of Space
Systems Survivability

PRESENTOR: Dr. V. Josephson

DUTY STATION: Aerospace Corporation
El Segundo

SYNOPSIS:

An analysis was presented showing the relative vulnerability of satellite systems as they are presently designed, and the design and survivability measures available to enhance their survivability.

The analysis included a description of the systems, and their operational characteristics which affected the credibility of the posed threat. The enemy threat was considered in terms of electromagnetic jamming of the communications links, and destructive attacks against both satellites and ground elements to indicate the enemy capability for system degradation.

A brief discussion was given of nuclear weapon effects on subsystems to illustrate how the system vulnerability is dependent not only on individual components but also on how they are integrated into a subsystem and the subsystems mode of operation. Shielding and hardening criteria were discussed which, if adhered to in system design, would prevent long range kill effects.

A review was made of conventional auxiliary survival aids to illustrate how their utility is strongly dependent on system design and

mission constraints, and to indicate possible areas of application.

Finally, recommendations were made regarding future research activities in terms of hardening and shielding, and in overall system and mission design factors having the most effect on satellite system survivability.

TITLE OF PRESENTATION: ARGUS Effects

PRESENTOR: Capt D. Rekenhaler

**DUTY STATION: AFWL (WLRP)
Kirtland AFB
New Mexico 87118**

SYNOPSIS:

The Air Force Weapons Laboratory's capability to determine the magnitude, extent and persistence of data trapping that results from a high altitude nuclear detonation was presented. The capability to determine the amount of electron flux incident to an orbital vehicle was also discussed. Through the benefit of the knowledge of the above techniques, the determination of the ability of a space vehicle to perform its mission in that nuclear environment is made possible. The effect of this knowledge is beneficial to systems designers in the fabrication of resistant materials and advances the state of the art of space systems survivability.

TITLE OF PRESENTATION: Techniques for Weapon System
Analysis (Nuclear)

PRESENTOR: Major P. J. Dally

DUTY STATION: AFWL (WLAA)
Kirtland AFB
New Mexico 87118

SYNOPSIS:

The mission of the Analysis Branch of the Air Force Weapons Laboratory and the objectives of Project 8809 were presented. Existing analysis efforts which have possible space systems implications were discussed. The main elements covered were the HIGH ENERGY LASER SYSTEMS ANALYSIS (HELSEA), THE FUNDAMENTAL SPACE OPERATIONS STUDY (PHASE II), of which WLAA is the AFWL RTD Office of Primary Responsibility (OPR), The MID-COURSE OFFENSE/DEFENSE ENGAGEMENT SIMULATION (M-CODES), and the technical liaison activities which have been conducted by Weapons Lab personnel between SSD, other Weapons Lab offices and contractors. A brief explanation of the weapons systems analysis interpretation of philosophy and methods associated with the development of techniques for analysis were presented. General areas of possible information exchange between AFWL analysis activities and SSD vulnerability/survivability programs were identified.

TITLE OF PRESENTATION: TREE Vulnerability and Hardening

PRESENTOR: Capt S. O. Kennedy

DUTY STATION: AFWL (WLAA)
Kirtland AFB
New Mexico 87118

SYNOPSIS:

Nuclear phenomenology and its interactions with SSD systems were discussed. Recommended hardening effects and TREE vulnerability were presented. A brief review of the various kill mechanisms associated with the exposure of electronics to transient radiation was accomplished. This review treated the effects resulting from gamma rays, x-rays and neutrons. The relationship of kill mechanisms to systems exposed and typical environments was considered. Areas in which component selection can be successfully utilized to reduce circuit vulnerability were discussed. The concepts of circumvention and direct hardening through circuit design were compared and the areas of applicability of each of the concepts were explained. Current TREE programs for research of the basic physics of interactions, for prediction of circuit response, and for the development of hardening techniques were summarized and the present state of the art of each area was related to space systems survivability. The direct and expected contributions of future efforts were related to future space systems survivability requirements.

TITLE OF PRESENTATION: X-RAY EFFECTS

PRESENTER: Capt R. Hansen

**DUTY STATION: AFV/L
Kirtland AFB
NMex**

SYNOPSIS:

Capt Hansen discussed the phenomenology of X radiation and its interaction with satellites. He presented AFWL future plans in underground nuclear testing and associated nuclear research. Highlights of the plan for NATIVE MIST and DRAGON MIST were presented.

TITLE OF PRESENTATION: Nuclear Weapons Effects Testing
and Research

PRESENTOR: Mr. J. D. McClelland

DUTY STATION: Aerospace Corporation

SYNOPSIS:

The current status of the In-house SSD/AFWL/Aerospace experimental program on the behavior of materials in a nuclear weapon environment was reviewed. The damage threshold levels for surface effects which have been established, as a result of an underground test program were presented. Specific results on metals, glasses, inorganics and organic materials were described and correlated with existing codes. New damage mechanisms were postulated for several observed phenomena. Future research programs including underground testing were discussed.

TITLE OF PRESENTATION: Astro Defense

PRESENTOR: Commander D. D. Heerwagen

DUTY STATION: Department of the Navy
Bureau of Naval Weapons (Code RTAD)
Washington, D.C. 20331

SYNOPSIS:

Navy technical efforts in Astro Defense are directed towards analyzing potential threats from space and their impact on traditional warfare missions. Prospective work and development covers the entire scope of the problem from detection of a space object to either active nullification of a satellite or use of passive fleet countermeasures. Future work will include analysis to provide a better understanding of satellite survivability techniques and satellite design (materials and selected components used for specified space missions of interest to the Navy). In particular, survivability techniques will provide the most essential input to technical approaches for seeker/tracker warheads and choosing for the anti-satellite problem. In addition a brief resume was provided of the basic level research efforts which directly contribute to satellite design criteria for a radiation environment in space.

TITLE OF PRESENTATION: Minuteman Guidance Hardening
Approach

PRESENTOR: Mr. N. Skinker

DUTY STATION: BSD
Norton AFB
San Bernardino, Calif.

SYNOPSIS:

A vehicle description of the difference between Minuteman 1, 2 and 3 and the applicable airborne hardness requirements was provided. A derivation under the requirements was also addressed. The system mechanization provided to meet the hardness requirements was discussed, as well as the simulation and underground test program being performed to provide design verification. The inherent design limitation/capabilities of systems of this type were discussed.

TITLE OF PRESENTATION: ABRES Survivability Efforts

PRESENTOR: Mr. R. Egermeler

**DUTY STATION: Aerospace Corporation
San Bernardino, Calif.**

SYNOPSIS:

Penetration aids influence ballistic warhead survivability indirectly by forcing exhaustion of defense interceptors. The function is approached by providing masking, false targets, or by a combination of the two. Specifically: Decoys provide false targets, with a degree of credibility which may be traded off against decoy weight and against desired penetration altitude.

Chaff provides noise masking by incoherent scattering from large numbers of particles, but is stripped away by a slowdown during reentry.

Electronic countermeasures can conceptually provide either noise masking or false targets by choice of signal generated. Present ABRES efforts are concentrated into noise generators, because of the high degree of sophistication required from credible false target generators.

In hardening studies, advantage is taken of related work in reentry vehicle and electronics hardening to cover decoy and ECM studies. Specific operational configurations will be tested.

TITLE OF PRESENTATION: Hypervelocity Weapon Effects
& Shielding

PRESENTOR: Mr. W. Dittrich

DUTY STATION: AFATL (ATWR)
Eglin AFB
Fla

SYNOPSIS:

The AFATL activities in the area of hypervelocity penetration on single and multiple plate structures were discussed. Certain pellet warhead configurations which could be used in hypervelocity encounters were described. The results of lethality studies on candidate projectiles for these warheads were shown together with indications of the shielding requirements. Initial test results were presented on two typical satellite components previously subjected to hypervelocity penetration. The results of hypervelocity testing aids the system designer in the determination of the least vulnerable vehicle design and thereby tends to allow the system to be more survivable.

TITLE OF PRESENTATION: RATSCAT

PRESENTOR: Mr. D. Montana

**DUTY STATION: RADC (EMASP)
Griffiss AFB
New York 13442**

SYNOPSIS:

A review of current radar tracking scattering sites followed by the (RATSCAT) measurement capabilities provide a description of the facility conversion which resulted from the initial contract effort in this area. The plans for the updating of this facility to satisfy the recently established BSD and SSD needs were described in detail. This effort includes an extension of the range frequency measurements down to 30 megahertz and an improved capability for measuring full scale vehicles having maximum dimensions on the order of 60' in length and 6" in diameter. This range capability should allow for the simulation and testing of radar returns on postulated space systems to determine the effect of various survivability techniques upon the radar signature of the satellite.

TITLE OF PRESENTATION: Space Surveillance Sensors and Tracking

PRESENTOR: Mr. R. McMillan

**DUTY STATION: RADC (EMASS)
Griffiss AFB
NY 13442**

SYNOPSIS:

The near future U.S. capabilities and space surveillance sensors were described with representative examples to indicate the present trends in satellite detection and tracking. These examples include the AN/FPS - 85 radar, the AM/FPS - 80 radar, the Active Swept Frequency Interferometer Radar (ASFIR) and the Lincoln Haystack Facilities. The possibility of satellite survival with regard to the capability of these sensors was discussed. Information relative to expected Soviet capabilities in the radar sensor area was presented.

TITLE OF PRESENTATION: Electronic Countermeasures
Techniques

PRESENTOR: Lt M. L. Cannon

DUTY STATION: AFAL (AVWW)
Wright-Patterson AFB Ohio 45433

SYNOPSIS:

Since 1959 the Air Force Avionics Laboratory has been actively engaged in the development of electronic countermeasures techniques for satellite defense. This presentation described the results obtained to date from these investigations. Specifically, the electronic countermeasures technique "detection denial" was described and the results of tests run against the Navy SPASUR system were given. Additional work in the areas of trajectory denial and optical surveillance systems was identified and described. Future lab plans for expanding research efforts in the area of ECM for satellite survivability were disclosed. These efforts are to include investigation of rendezvous radar countermeasures and signature degradation.

**TITLE OF PRESENTATION: Radar Reflectors and Dispensing
Techniques**

PRESENTOR: Miss M. P. Gauvey

**DUTY STATION: AFAL (AVWW)
Wright-Patterson AFB Ohio 45433**

SYNOPSIS:

Past, present and future exploratory development efforts under AFSC Project 4025, Radar Reflectors and Dispensing Techniques, which have applicability to satellite survivability were reviewed. Futuristic goals to provide a technical base for ways and means of increasing the probability of survival of advanced aerospace vehicles operating in a hostile electromagnetic environment were established about 10 years ago. Though the limitations of passive type countermeasures are recognized, it is expected that these types of deceptions and screening devices will be among the first generation of Space Electromagnetic Warfare subsystems, while necessary development is pursued to provide more sophisticated orbital vehicle countermeasures.

TITLE OF PRESENTATION: Radar Camouflage Techniques

PRESENTOR: Mr. C. H. Krueger

**DUTY STATION: AFAL (AVWE)
Wright-Patterson AFB Ohio 45433**

SYNOPSIS:

Several effects of the Air Force Avionics Laboratory's activities in the area of camouflage programs were discussed. The radar absorbing materials development effort presented included circuit analog ferrite and graded dielectric types. Typical performance data of these techniques was shown. Computed scattering patterns from the calibration of radar cross section efforts were presented together with comparable results derived by measurement or other numerical methods. Antenna camouflage concepts being investigated by The Ohio State University and reactive loading techniques under investigation by the University of Michigan were presented. The in-house radar signature alteration program presently being conducted by the Air Force Avionics Laboratory and its relationship and possible benefit to the Space Systems Survivability Division were demonstrated.

TITLE OF PRESENTATION: Active Defense of Spacecraft

PRESENTER: Mr. L. W. Krautman

**DUTY STATION: AFAL (AVNS)
Wright-Patterson AFB Ohio 45433**

SYNOPSIS:

All Air Force Avionics Laboratory sponsored vehicle defense program activities which pertain to space systems were presented. At present there are three main areas of active defense work in progress through the AFAL: 1) Lethal defense - a study by industry to define feasible concepts of lethal defense applicable for space vehicle use; 2) active and passive shielding techniques effective for use in defense against the effects of hypervelocity pellet attack; 3) active shielding techniques for use in the defense against the effects of certain advanced weapons. Knowledge gained from the results of studies such as these further the state of the art of space systems survivability.

TITLE OF PRESENTATION: Ground Radar Capability for
Satellite Identification

PRESENTOR: Mr. E. N. Fowle

DUTY STATION: The Mitre Corporation
P.O. Box 208
Bedford, Mass.

SYNOPSIS:

The various types of measurements which ground based radars are capable of obtaining were briefly reviewed. The resulting information which is deduced from these measurements of space vehicles and its impact on future military space systems were discussed. The special capabilities of present operational radars was summarized. Current R&D programs which appear relative to the area of satellite identification and the possible results obtained from the implementation of these efforts were analyzed. Future objectives and the forecasted capabilities of near future ground radars were postulated.