THE DISPENSING AND BEHAVIOR OF CHAFF IN SPACE

Authors: Richard P. Fray; AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB OH SCHOOL OF ENGINEERING

... made to determine some possible methods of dispensing chaff at very high altitudes. Secondly, the behavior ... separating dipoles in a space-like environment, (2) when dispensing fluid-saturated chaff in a low-pressure environment, the dipole velocity is approximately linear with the square root of the fluid vapor pressure, (3) chaff dispensed omnidirectionally from a vehicle in a circular geocentric orbit will form a belt around the earth, and (4) chaff given a uniform dispensing velocity perpendicular to the original circular orbital velocity will produce a chaff cloud which grows and changes ...

Optimal Estimation of Target in Clutter (CHAFF) from Radar

Authors: J. H. Henson; J. W. Craig; TEXAS UNIV AT AUSTIN DEFENSE RESEARCH LAB

This work produced a simulation capable of giving the effectiveness of chaff used in the self-protective mode. Signal processing techniques were studied in chaff discrimination in crucial missile conditions. A missile-ship ... chaff model will be constructed to provide the optimum confusion of the missile. The radar included in this simulation is a tracking radar with conical-scan modulation. Results of simulation runs illustrate the effects of varying chaff radar cross section when ship and chaff are in the same resolution cell.

Jamming Performance of Infrared Bait/Chaff

Authors: Gongpei Pan; NATIONAL AIR INTELLIGENCE CENTER WRIGHT-PATTERSON AFB OH

... of infrared guidance and radar guidance jamming with infrared bait and chaff has been proven in modern high-tech warfare. Their jamming ... and of anti-chaff techniques and then examining the characteristics tactical chaff defense problem in the light of these technical characteristics. (Author)
In this thesis time-varying radar cross sections of chaff clouds are generated for use in radar/ECM computer simulations, under the assumption that scattering from chaff clouds is a wide sense stationary random process. For a jointly gaussian random ... also derived from gaussian variables to present an alternative way of describing the probability distributions of chaff cloud cross sections. Topics for further study are suggested. Keywords: Chaff simulation, Correlation techniques, Electronic countermeasures, Radar confusion reflectors, and Radar cross sections. ...

Environmental Effects of RF Chaff. A Select Panel Report to the Undersecretary of Defense for Environmental Security

Aug 31, 1999 85 pages

Authors: Barry J. Spargo; NAVAL RESEARCH LAB WASHINGTON DC

This report presents the assessment of the environmental effects of radio-frequency (RF) chaff as determined by a Select Panel of university-based research scientists, each with published expertise in ... "upper bounds" (or worst-case) estimates based on the amounts and areas of chaff use, analysis of known lecture data related to the effects of RF chaff, and reasonable, prudent extrapolations and derivations from these data. The Panel concludes that environmental, human, and agricultural impacts of RF chaff as currently used are minimal to be based on all the data, analyses, estimations, and ...

Chaff Radar Cross Section Studies and Calculations

May 1978 42 pages

Authors: R. J. Garbacz; OHIO STATE UNIV COLUMBUS ELECTROSCIENCE LAB

The objective of Contract F33815-C-1024 has been to analytically and experimentally investigate chaff scattering and the reduction of antenna-related radar cross section. This final report summarizes results obtained during the interim 1 January 1976 through 30 June 1977 on the chaff aspect of the effort. Included are summaries of (1) an investigation of scattering by a long wire excited by either a plane wave or by a nearby short dipole with sinusoidal current distribution and (2) an experimental study of small foam shapes very densely coated with chaff filaments. (Author)

Chaff Theoretical/Analytical Characterization and Validation Program

Sep 30, 1981 124 pages

Authors: E. F. Knott; D. J. Lewinski; S. D. Hunt; GEORGIA INST OF TECH ATLANTA ENGINEERING EXPERIMENT STATION

This report describes the modeling of radar returns from chaff. The dipoles are allowed to follow helical paths as they fall, and the signal scintillation characteristics of the entire chaff cloud are assumed to be the same as those of a small collection of up to 1000 dipoles. The dipole motion ... computed assuming a bivariate Gaussian distribution for the dipole number density in a plane transverse to the axis of a plume of chaff. The computation of the amplitude requires a numerical integration of the product of the radar antenna radiation pattern ...

Bistatic Radar Cross Sections of Chaff

Jun 1983 40 pages

Authors: Peyton Z. Peebles Jr.; Barry Stam; FLORIDA UNIV GAINESVILLE ELECTRONIC COMMUNICATIONS LAB

Bistatic cross sections applicable to scattering from a cloud of randomly positioned and randomly oriented resonant dipoles, or chaff, are found. The chaff cloud can have an arbitrary location relative to an illuminating radar and the radar antenna can have an arbitrarily specified polarization. The receiver can be located arbitrarily in relation to the radar and chaff cloud and can also have arbitrary polarization (different from transmitter antenna). Average cross sections are found a preferred receiver polarization, and the ...

Errors Inherent in Chaff Centroid Tracking.

Jul 1970 38 pages

Authors: C. R. Mullin; GENERAL RESEARCH CORP SANTA BARBARA CA

An analysis of the errors inherent in tracking the radar-cross-section centroid of a chaff cloud shows the centroid to have a random motion in addition to its long-term motion with the chaff cloud. This random motion can lead to errors in cloud trajectory estimation. There is a further error caused by the fact that the centroid does not exactly follow a Keplerian orbit. The deviation is slight, however, and can be neglected. (Author)

Statistics of Electromagnetic Scattering from Chaff Clouds

Apr 1975 58 pages

Authors: Vittal P. Pyati; AIR FORCE AVIONICS LAB WRIGHT-PATTERSON AFB OH

Starting from first principles, the first and second order probability densities of the scattered field from chaff clouds are derived. Auto-correlation functions and power spectra of the received voltage, radar cross section and phase are obtained. All the ... that an integral relation exists between the speed distribution function and the intensity auto- correlation function. The utility of second order statistics in studying the effects of chaff clutter fluctuations on advanced radars such as moving target indicator is demonstrated. Finally, numerical results are included both from an actual ...

A Time Domain Simulation of the Pulsed Radar Return from a Chaff Cloud

May 1992 50 pages

Authors: Thoman A. Winchester; ELECTRONICS RESEARCH LAB ADELAIDE (AUSTRALIA)

A numerical technique for the time domain simulation of the radar return from a chaff cloud is developed. This technique is suitable for pulsed radars. A Monte-Carlo analysis of the effect of this return upon the range discriminant of typical pulsed radar systems is then carried out. Chaff, Radar signals, Time domain, Pulse radar, Monte carlo method, Ship defense systems.

Chaff Aerodynamics

Nov 1975 166 pages

Authors: James Brunk; Dennis Mihora; Peter Jaffe; ALPHA RESEARCH INC SANTA BARBARA CA
The aerodynamic characteristics of thirteen distinct chaff dipole configurations were determined from drop tests of individual elements in a special enclosed test chamber. The dipole motion and trajectory were recorded by multi-image photographs taken by orthogonal still cameras equipped with specially designed synchronized rotating shutters. The dynamic behavior and descent rate of the dipoles was found to depend greatly upon the principal cross-section dimensions of the filaments. Aerodynamic forces and moment coefficients for each dipole configuration were computed from the photographic ...
This document reports the results from an investigation of the impact of aluminized glass chaff countermeasures on environmental aluminum levels in the Chesapeake Bay. This study was ... over the potential environmental hazards that might be associated with the release of aluminized glass chaff fibers during training exercises by Naval aviators. Chaff used to provide protection against radar based attack on aircraft and other military vehicles is ... in the Chesapeake Beach region of the Chesapeake Bay, an area over which chaff countermeasure flight training operations have been conducted for nearly ...

Final Environmental Assessment for the Defensive Training Initiative, Cannon Air Force Base, New Mexico
Authors: John K. Austin; G. M. Brown; Maureen Cunningham; Linda DeVine; Dave DISchner; Bill Doering; Jerry Dougherty; Claudia Druss; Michele Fikel; Kimberly Freeman; AIR COMBAT COMMAND LANGLEY AFB VA

Characterization of the Ecotoxicity of Five Biodegradable Polymers Under Consideration by NAVAIR for Use in Chaff-Dispensing Systems
Authors: Darrell P. Arfsten; Cody A. Wilson; Kenneth R. Still; Barry J. Spargo; John Callahan; NAVAL HEALTH RESEARCH CENTER WRIGHT-PATTERSON AFB OH TOXICOLOGY DETACHMENT

Robust Detection of Stepping-Stone Attacks
Authors: Ting He; Lang Tong; CORNELL UNIV ITHACA NY SCHOOL OF ELECTRICAL AND COMPUTER ENGINEERING

Performance Characteristics of Meteorological Rocket Wind and Temperature Sensors
Authors: NORMAN J BEYERS; OTTO W THELE; Norman J Wagner; WHITE SANDS MISSILE RANGE NM

APPLICATION OF METEOROLOGICAL ROCKET SYSTEMS
Authors: Willis L Webb; Kenneth R Jenkins; ARMY ELECTRONICS RESEARCH AND DEVELOPMENT ACTIVITY WHITE SANDS MISSILE RANGE NM

Polarization Processing Techniques Study
Authors: Albert Klein; David Hammers; Masaaki Fujita; George Ioannidis; Nhan Levan; ITT GILFILLAN VAN NUYS CA

Signal-Filter Design and System Performance for Polarimetric Radar
Authors: Richard A. Altes; Stephen F. Connelly; James R. Miller; Kishan G. Mehrotra; H. Liu; ORINCON CORP LA JOLLA CA
have resulted in the design of a new polarimetric clutter canceller which theoretically allows a polarimetric radar to see through chaff. Signal-to-interference ratio (SIR) maximization has been used to obtain an optimum signal-filter pair for polarimetric radar when targets and/or clutter exhibit ...

**The Shootdown of Trigger 4**

**Authors:** Todd P. Harmer; C. R. Anderregg  
DEPARTMENT OF THE AIR FORCE WASHINGTON DC

... North Vietnam on 29 July 1972, engaged and shot down a MiG-21, a kill credited to Cadillac 1. Shortly thereafter, a flight of four F-4s, escorting a chaff mission, engaged and shot down a second MiG-21. Almost immediately thereafter, a third MiG-21 shot down Trigger 4, one of a flight of four that was also escorting the chaff mission. However, research conducted at Air University over the past few years challenged the official record by suggesting that Trigger 4 was mistakenly shot down by ...

**Secure Learning and Learning for Security: Research in the Intersection**

**Authors:** Benjamin I Rubinstein  
CALIFORNIA UNIV DAVIS DEPT OF ELECTRICAL ENGINEERING AND COMPUTER SCIENCE

... up of 99% regular legitimate and spam messages, and 1% dictionary attack spam messages containing legitimate words. By increasing the FPR the adversary a defects a Denial of Service attack on the filter. In the second case-study, the False Negative Rate of a popular network-wide anomaly detector based on Principal Components Analysis is increased 7-fold (increasing the attacker's chance of subsequent evasion by the same amount) by a variance injection attack of chaff traffic inserted into the network at training time. This high-variance chaff traffic increases the traffic volume by only 10%.

**FRAGMENTATION TEST OF ROD-EXPPELLING WARHEAD NO. 143**

**Authors:** J. Gorman  
NAVAL WEAPONS LAB DAHLGREN VA

... mass distribution of 4.74-in.-diam Composition C-3 loaded rodexpelling warheads was determined. The warheads were internally slotted to produce 26 rodlike fragments, each weighing 350 g and 12 in. long. In tests war head no. 143-2, employing a full-length 1/16-in.-thick liner, produced fragments averaging 320 g each. Twenty-four fragments were full length and the other 2 were 11.75 and 10.0 in., respectively. The amount of chaff obtained in the war head was reduced by the full-length cork liner. A 316-in.-cork liner 6 in. long was used in war head no. 143-1, but was not as successful.

**STUDY AND MODIFICATION OF CONVECTION STORMS**

**Authors:** T. B. Smith; C. J. Todd; Chen-Wu Chien; Betsy Woodward  
METEOROLOGY RESEARCH INC PASADENA CA

... cumulus clouds of all sizes were investigated using a coordinated system of two instrumented aircraft, two ground radars, and a ground network. There were cases of small and large cloud seeding by dry ice drops and by silver iodide from ground and from an additional aircraft. The investigations were coordinated with the studies of USAERDL, which used three aircraft, a limited ground network, and several lightning study stations, for probing lightning development and characteristics, IR measured ground temperatures, condensation nuclei and seeding with condensation nucle apparatus and chaff.

**REVIEW OF THE HIGH ALTITUDE RESEARCH PROGRAM (HARP)**

**Authors:** C. H. Murphy; G. V. Bull  
ARMY BALLISTIC RESEARCH LAB ABERDEEN PROVING GROUND MD

... from 20 pound, 5-inch projectiles reaching 240,000 feet to 185-pound, 16-inch projectiles reaching 470,000 feet. Single and multiple stage rockets launched from the 16-inch gun have very promising predicted performance and are under development. Scientific results to date are primarily wind profiles measured by radar chaff, aluminized balloons and parachutes, and tri-methyl-aluminum trails, although a number of successful 250 MHz and 1750 MHz telemetry flights were made. Sun sensors, magnetometers, and temperature sensors were flown and an electron density sensor was fired in early June.

**TEST FIRING SERIES, PROJECT HARP**

**Authors:** H. J. Luckert  
MCGILL UNIV MONTREAL (QUEBEC) SPACE RESEARCH INST

... firings during three nights. In three of these rounds a 250 MHz telemetry package was carried with a temperature gauge and a magnetometer for temperature and magnetic field measurements. Modified Martlet 2C vehicles were instrumented with 1750 MHz telemetry and Langmuir probes, as well as with a magnetometer and temperature gauges, for electron density measurements in the upper atmosphere. Ejection tests with 8-band chaff and parachute-suspended telemetry were also included in this series, and the structural performance of rocket grain at high launch accelerations was tested in two rounds.

**WIND MEASUREMENTS IN THE SUBPOLAR MESOPAUSE REGION**

**Authors:** James E. Morris  
ARMY ELECTRONICS COMMAND WHITE SANDS MISSILE RANGE NM ATMOSPHERIC SCIENCES LAB

Mesospheric wind data obtained with a new high altitude Loki system during the summer of 1966 over Fort Greely, Alaska, are presented. Soundings, utilizing very light chaff as a wind sensor, were scheduled near noon and midnight for a 24-hour period. These data are from a sparsely sampled region of the atmosphere. The diurnal variations and the high velocities observed give valuable information regarding noctilucent clouds, atmospheric tidal oscillations, and the mean summer flow near the subpolar mesopause.

**AEROSPACE APPLICATION OF GUN LAUNCHED PROJECTILES AND ROCKETS**

**Authors:** Charles H. Murphy; Gerald V. Bull  
MCGILL UNIV MONTREAL (QUEBEC) SPACE RESEARCH INST
... an approach lies in the very high accelerations experienced by gun-launched payloads. The guns used in Project HARP vary in size from 5-inch and 7-inch extended guns on mobile mounts to transportable fixed 16-inch guns. Altitude performance varies from 20 pound, 5-inch projectiles reaching 240,000 feet to 185-pound, 16-inch projectiles reaching 590,000 feet. Scientific results to date are primarily wind profiles measured by radar chaff, aluminized balloons and parachutes, and tri-methyl aluminum trails, although a number of successful 250 MHz and 1750 MHz telemetry flights have been made.

Adaptive Cancellation of Scattered Interference

Authors: L. E. Brennan; W. L. Doyle; L. S. Reed; ADAPTIVE SENSORS INC SANTA MONICA CA

This is the final report on a 1 year study of methods of adaptively cancelling scattered jamming. The results contained in this report are relevant to interference scattered into the main beam of a radar or communication system from terrain or chaff illuminated by a jammer. These same techniques can be applied to jamming scattered into the sideloabs or main beam of a receiving antenna from scatterers near the antenna, i.e., the multipath problem, which is an important limitation in some adaptive nulling systems.

Airworthiness and Flight Characteristics Test of a Sixth Year Production UH-60A

Authors: Robert M. Buckenthin; Michael K. Herbst; Roy A. Lockwood; Gary L. Skinner; Patrick J. Sullivan; ARMY AVIATION ENGINEERING FLIGHT ACTIVITY EDWARDS AFB CA

... at a referred rotor speed (N sub R/square root theta) of 288 revolutions per minute. Of this increase, 2.5 was attributed to the External Stores Support System fixed provision fairings, 1.5 sq ft to the external mounting brackets of the AN/ALQ-144(V) infrared countermeasures set and M130 chaff dispenser, and 1.0 sq ft to numerous other minor external changes. However, throughout the N sub R/square root theta range, the difference in power required between the first and sixth year production aircraft does not equate to a constant Fe. A limited investigated did not completely account for the ...

Doppler Radar Analysis of Coastal Marine Atmospheric Boundary Layer Structure during a Cold Air Outbreak

Authors: Michael N. Jones; AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB OH

... . Time-height plots of horizontal wind spread, vertical velocity, horizontal divergence and deformation were constructed to depict the temporal variation of the MABL. Horizontal wind speed and direction versus altitude were plotted for each VAD analysis in order that anomalies in the MABL wind profiles may be identified and explained. The VAD analysis radius was varied between 5 and 15 kilometers so that spatial distribution of the wind field could also be observed. Chaff was dispersed by aircraft at a distance equivalent to 40 minutes travel distance upwind from the radar network. (R.H.)

Preliminary Airworthiness Evaluation of the AH-64A Equipped with the Air to Air Stinger (ATAS)

Authors: John S. Lawrence; Joseph A. Lyle; Gerald J. Hopkins; ARMY AVIATION ENGINEERING FLIGHT ACTIVITY EDWARDS AFB CA

... sighting symbology, which does not provide the copilot/gunner with accurate missile seeker line of sight relative to the selected sight line of sight except in FLIR wide field of view; reduction in storage space imposed by the ATAS installation in the aft storage bay; location of the repositioned chaff fire switch on the cyclic hand grip; and the manual reset feature of the ATAS missile sequencing logic. The absence of an altitude encoding feature in the installation of the AN/AEX-100(V) transponder was a shortcoming not associated with the ATAS modification. Seven recommendations specific to ...

A Simulation of a Combined Active and Electronic Warfare System for the Defense of a Naval Ship Against Multiple Low-Altitude Missiles Threat

Authors: Hua K. Chia; NAVAL POSTGRADUATE SCHOOL MONTEREY CA

A computer simulation model was developed (Interactive Simulation of System Performance, or ISSP) simulating the integrated performance of hard-kill (surface-to-air missile, and close-in weapon system) and soft-kill (defensive jammer, or ECM, and chaff) systems in the defense of a single naval ship against attack threat by four anti-ship missiles. The quantitative contribution of each system to ship survivability is evaluated. The hard-kill and soft-kill weapon systems are the focus of the two major anti-air warfare (AAW) improvement plans assessed in this simulation. Based on these plans, ...

Electronic Warfare Technology - Trends and Visions

Authors: Kenneth Helberg; Tony White; Kevin Geiger; Joseph Koesters; David Wilkes; WRIGHT RESEARCH AND DEVELOPMENT CENTER WRIGHT-PATTERSON AFB OH

... mean time, threat density and sophistication make the basic problem of finding, identifying, and countering all types of threat signals very difficult. The operational choices, as a result, have expanded to include ‘smart jamming’, support jamming in several different forms (stand-off, UAV), expendables (chaff, decoys) and a greater dependence on threat awareness and avoidance. These choices make it imperative to exploit technology to its fullest and in turn they provide an opportunity whereby technologies can be shown to impact the real capability needed operationally. As a result, trends of ...

Wald Sequential Detection with Non-Gaussian Pulsed Radar Data Using the Zakai Equation

Authors: S. P. Rodriquez; NAVAL RESEARCH LAB WASHINGTON DC

... signals is presented. The result is a threshold test with explicitly computable thresholds. Five possible schemes for a numerical implementation of the test are given. A comparison of the different implementations and
analysis of the detectors performance is done for the radar problem of ship versus chaff target discrimination using lognormal and Rayleigh models respectively. Parameter estimation for the lognormal and Rayleigh cases is also studied. Finally, a signal estimation scheme is presented utilizing the conditional expectation of the signal computed from the conditional density of the ...

Off-Board Expendables: An Aid to Aircraft Survivability

Authors: Jeffrey N. Knieriemen; AIR WAR COLL MAXWELL AFB AL

During World War II, off-board expendables in the form of chaff, significantly reduced Allied bomber losses to radar guided anti-aircraft artillery. From World War II on, the United States has employed Electronic Counter-Measure (ECM) techniques on various bomber, fighter, cargo and special mission aircraft to enhance their survivability. The primary threats to aircraft today are the highly sophisticated radar and infrared guided air-to-air and surface-to-air missiles. Advances in computer hardware and data/signal processing techniques have enabled these missiles to increasingly distinguish ...

Stealth Technology in Surface Warships: How This Concept Affects the Execution of the Maritime Strategy

Authors: John W. McGillivray; NAVAL WAR COLL NEWPORT RI DEPT OF OPERATIONS

... and discusses how a warship with a much reduced RCS might better execute various naval missions. It was found that actual stealth performance data is highly classified, but much open source literature is available which addresses the technical concepts of stealth. In theory stealth, when employed with chaff decoys, has the potential to enhance surface warship defenses against present generation ASCMs. With the proliferation of modern ASCMs to the Third World, stealth warships with an 'improved' soft kill capability are better suited to conduct various sea control, power projection and crisis ...

On the Integrated Scheduling of Hardkill and Softkill Assets Using Dynamic Programming

Authors: Douglas W. Oard; Sheldon I. Wolk; Anthony Ephremides; NAVAL RESEARCH LAB WASHINGTON DC

The problem of integrated employment of cruise missile defenses by a single ship is considered in this report. Two defensive systems, surface to air missiles and chaff, are examined, and a mathematical model of their performance is developed. An optimal scheduling problem is posed using this model, and a dynamic programming solution is developed. The computational complexity of this solution is beyond the capability of current computer facilities, therefore several simplifications are proposed. The study concludes with a discussion of the potential for application of heuristic techniques to ...

A Systems Engineering Approach to Aircraft Kinetic Kill Countermeasures Technology:
Development of an Active Aircraft Defense System for the C/KC-135 Aircraft, Volume 1

Authors: Mark C. Cherry; Bruce R. Dewitt; Christopher G. Dusseault; Joel J. Hagan; Brian S. Peterson; AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB OH

Modern Surface to Air Missiles (SAMs) present a significant threat to today's military and civilian aircraft. Current countermeasure systems such as flares and chaff rely on decoying the missile threat and do not provide adequate protection against advanced computerized missiles (Schaffer, 1993:1). An aircraft defense system that actively seeks out and defeats an incoming missile by placing a physical barrier in the missile's path offers a promising alternative to current countermeasures technology. This thesis reports the preliminary design of an active aircraft defense system for the ...

Joint Suppression of Enemy Air Defenses (J-SEAD) Developing a Realistic Strategy for Today's Operational Artist

Authors: David B. Woods; NAVAL WAR COLL NEWPORT RI

... enemy air defenses (SEAD) was the answer to this air power counter History shows the leap frog effect that technology advancements in enemy air defense and SEAD have had on each other. Defense radio detection and ranging (RADAR) equipment facilitated the development of RADAR jamming and chaff. RADAR guided surface-to-air missiles (SAM) and antiaircraft artillery (AAA) created the requirement for antiradiation missiles (ARM), drones, and decoys. Linking early warning and acquisition RADARS to SAM sites with radios and data links hastened the development of communication and data link jamming. ...