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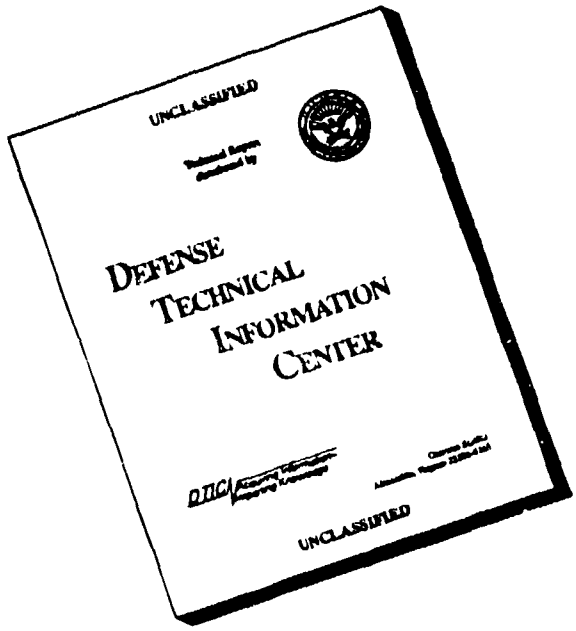

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SECRET

ANALYSIS OF STRATEGIC ANTI-CROP WEAPONS SYSTEMS (U)

PREPARED FOR:

U. S. ARMY CHEMICAL CORPS BIOLOGICAL LABORATORIES
FORT DETRICK, FREDERICK, MARYLAND

SECRET

Copy No. 1 of 20 copies

Proposal Number P62-90

Technical Proposal in response to:
Army Study Requirement 37

ANALYSIS OF STRATEGIC ANTI-CROP WEAPONS SYSTEMS (U)

Prepared for:

U. S. Army Chemical Corps Biological Laboratories
Fort Detrick, Frederick, Maryland

29 June 1962

Prepared by:

Dunlap and Associates, Inc.,
429 Atlantic Street
Stamford, Connecticut

PROPRIETARY NOTICE

The data furnished herein shall not be disclosed outside the Government or be duplicated, used or disclosed in whole or in part for any purpose other than to evaluate this proposal, provided that if a contract is awarded to this offeror as a result of or in connection with the submission of such data, the Government shall have the right to duplicate, use, or disclose this data to the extent provided in the contract. This restriction does not limit the Government's right to use information contained in such data if it is obtained from another source.

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SUMMARY

A study of weapons systems for strategic destruction of crops is proposed. The study is divided into three parts:

(1) A critical examination of the context in which anti-crop warfare may be used, resulting in a rationale for such warfare.

(2) An analysis of the rationale to formulate requirements for strategic anti-crop weapons systems.

(3) An analysis of the cost and effectiveness of selected weapons systems to identify the most advantageous system and to indicate the needs for anti-crop weapon system improvement.

ANALYSIS OF STRATEGIC ANTI-CROP WEAPONS SYSTEMS (U)

INTRODUCTION

This proposal has been prepared in response to Army Study Requirement Number 37, which requests that a study of strategic anti-crop weapons systems be conducted for the Army Chemical Corps Biological Laboratories.

The introduction contains a statement of the nature of the problem, and a summarized description of the approach toward achieving a solution as proposed herein. The technical discussion describes the approach in detail, and last sections describe the organization of the effort, the schedule, and the relevant corporate experience and personnel resumes.

It will be noted that the proposed study is analytical in nature and scope, and excludes the development or fabrication of any hardware. Although the construction and testing of prototype hardware is essential to successful development of weapons systems, the forte of Dunlap and Associates, Inc., lies in the application of skilled professional research to analyze complex problems which must be solved to give proper direction, with assurance, to weapons systems development. It is emphasized that the exclusion of capability and intent to construct any hardware in this study serves as a distinct advantage, for it represents a freedom from bias in the conduct of an objective evaluation of alternative weapons systems.

The Nature of the Problem

The advent of modern biological and chemical agents which can effectively attack and destroy a variety of crops now makes it possible to consider the delivery of such agents on a strategic scale to wipe out entire crops of a region or country, thus leaving the target nation in a state of famine and subsequent starvation.

The Army Chemical Corps, having the responsibility of developing the agents necessary for such warfare, has in fact arrived at certain solutions to the technical problem of crop destruction; there are today some half dozen or more agents, of which at least two have been standardized, which can destroy

crops of potatoes, rye, rice, and wheat. Moreover, in view of the successes attained from the relatively modest level of research heretofore supported, there is little reason to doubt that the increased levels of effort in the Chemical Corps anti-crop program will yield even more potent and versatile anti-crop agents.

Other branches of the Army and the sister services are presently studying and developing various concepts and systems for the effective delivery of such agents. The state of the art today is such that we no longer question whether crops can be destroyed on a large scale. We are concerned with

a) improving the marriage between the destructive agents and the mechanical devices which can spray them at the proper flow rates under a wide variety of environmental conditions, and

b) determining which of several possible weapons systems for use against crop targets is the most attractive in terms of cost and effectiveness.

To date no comprehensive, objective analysis of the various known methods of delivery of anti-crop agents has been conducted to identify the most advantageous system. The primary objective of the proposed study shall be to close this gap.

However, to select one weapon system, or a particular family of systems, as the most advantageous of a set of possible systems implies that a rationale exists for the practice of anti-crop warfare, and that associated standards have been established whereby the cost and effectiveness of alternative weapons systems can be compared. A search of the literature suggests that such a rationale does not, in fact, exist. We know, then, of effective agents to destroy a variety of crops, and there are a number of feasible methods of delivery, but there is no guidance, no policy, no directives or requirements which explain why anti-crop warfare would every be gainfully exercised against a foe, and it it were what it would be expected to accomplish.

The Approach to the Problem

Accordingly, it is believed that a useful purpose would be served by beginning a cost-effectiveness analysis of anti-crop weapons systems with an investigation of the generic qualities of anti-crop warfare itself, so as to answer certain questions basic to the decision to support further development

of anti-crop weapons systems in general and a most advantageous system in particular. Primarily, this introductory phase of the study will be addressed to the following sorts of questions:

1) Against which countries of the Sino-Soviet communist bloc or which neutralist nations could anti-crop warfare be employed?

2) What would be the immediate and the long-term consequences of engaging in such warfare?

3) What factors are fundamental to the application of anti-crop warfare in preference to, support of, or exclusion of nuclear or conventional warfare?

4) Given that more than one possible advantageous application of anti-crop warfare can be identified, what is the spectrum of operational conditions under which strategic anti-crop weapons systems might have to perform?

5) Under what circumstances and against which potentially aggressive nations could anti-crop warfare have particular value as a form of deterrence? If such value exists or might exist in the foreseeable future, what trade-offs and considerations arise in the deployment of a strategic deterrent system based upon anti-crop weapons?

The conduct of this preliminary part of the study will presuppose the availability of an efficacious anti-crop weapon system, and as indicated previously, would deal with the fundamental problem of what specific applications appear advantageous for such a capability, given that it is available.

It is conceivable that the initial phase of the study may conclude that no situation can be envisioned in which anti-crop warfare will prove to be advantageous. For example, it may be found that in no case could anti-crop warfare accomplish any result which could not be accomplished in superior fashion by lethal or incapacitating anti-personnel agents, or by the use of nuclear weapons, or conventional weapons. It is very unlikely that no advantageous applications can be postulated at all; however, careful analysis may weed out several disadvantageous target situations hitherto considered favorable for anti-crop warfare. Such findings could be valuable in providing justification for eliminating anti-crop research and development in some directions while strengthening it in others, thus permitting more effort to be placed on the more promising avenues of research and development.

It is believed that this initial phase of the study will indeed identify several situations in which strategic attack against crops could make a powerful contribution to our deterrent posture or to achieve victory in an armed conflict. Such identification will serve the very useful purpose of bringing into sharper focus than has been heretofore available a logical basis for the employment of anti-crop weapons and the manner in which their use would contribute to an over-all effort and relate to other elements of warfare.

At the same time the introductory research would determine the important parameters of anti-crop warfare and would thus establish criteria upon which to evaluate selected alternative weapons systems.

Having determined a meaningful basis for the use of anti-crop weapons, the spectrum of situations in which anti-crop attack can be gainfully employed will be analyzed to delineate the parameters of importance in such attacks and the range of values to be assigned in covering an acceptable variety of conditions which might obtain in operational situations of the future.

The final phase of the study will consist of a review of the presently conceived weapons systems to select those which appear to hold promise for future application. These systems will then be evaluated in terms of their costs and performance. If it is possible to demonstrate that a particular weapon system is superior in these terms to the others, such a system will be identified; on the other hand, if it is difficult to describe any single system as an optimum one, the consequences of employing the several most advantageous systems will be shown.

TECHNICAL DISCUSSION

The proposed research comprises three phases:

1. The Value of Strategic Anti-Crop Warfare
2. The Requirements for Strategic Anti-Crop Weapons Systems
3. A Comparison of Alternative Strategic Anti-Crop Weapons Systems

1. The Value of Strategic Anti-Crop Warfare

This phase forms the basis for the study. It consists of an analysis of the applications, consequences, and value of conducting strategic anti-crop

warfare. As far as is known, no recent, comprehensive treatment of this subject is available today.

One of the most obvious nations against which anti-crop warfare might be successful is China; this is generally considered an excellent target because

a. The people are ostensibly always on the verge of starvation.
b. The economy of the country is fundamentally agrarian and therefore more susceptible to crop destruction than a highly industrial country.
c. Rice and wheat are the main crops and agents are available to destroy both.

Apparently there is little doubt that China has suffered from a lack of adequate basic nutritional crops. Since 1960 the Communist regime has reported at least one serious invasion of locusts in the wheat regions of Hopei Province in North China, and a serious combination of drought, floods, and pestilence which affected two successive harvests. An estimate of the Peiping reports at the time by Nationalist sources on Taiwan surmised that over half of the approximately 240,000,000 acres of farmland had been affected. If it were supposed for a moment that these data were correct, one could infer that despite a growing population and various internal problems other than those connected with food, a loss of produce from about 50% of the farmland in two successive years did little permanent damage to the nation as a whole. The Peiping government admitted sending thousands of soldiers and city workers to the fields to help the farmers, but no national crisis evolved sufficient to shake the Communist regime. We know very little about the short and long term effects of those famines; doubtless some discontent among the peasants who are forced to work in militarized communes grew and spread; on the other hand, perhaps a spirit of cooperation was fostered when the troops and urban dwellers came to the farmlands.

Although Russia contains millions of acres of wheat, rye, barley and rice, one seldom reads of proposals to destroy the crops of this communist country. One may immediately list several reasons why anti-crop warfare against Russia receives little attention:

1) It would be difficult in the extreme to conduct strategic anti-crop warfare clandestinely; thus any attack would be detected and interpreted as an act of war and we would thus run the risk of starting a major conflict.

2) If we wanted to subjugate the Russians it would be quicker and deadlier to employ nuclear weapons or strategic anti-personnel biological agents than anti-crop agents.
3) Russia is highly industrialized and maintains commerce with her satellite countries, from which she imports many foodstuffs already. Any large-scale destruction of her own crops, although doubtless capable of causing considerable concern to the Soviet regime, would in all likelihood not bring that people to their knees.

The brief foregoing discussion of two possible target countries was included herein only to illustrate some of the many different aspects of anti-crop warfare which must be studied carefully in assessing the ultimate value of this form of war. The first phase of the proposed study would be concerned with a detailed examination of a host of factors pertinent to anti-crop warfare. The examination would list in addition to Russia and China the various possible target countries* in Eastern Europe, the Middle East, Africa, and Asia, and for each country would review such factors as:

1) The political and economic structure of the country.
2) The principal crops.
3) The reliance on imported foodstuffs.
4) Food reserves.
5) General health levels.
6) Transportation systems, degree of mechanization, communications and sophistication of defense.
7) The over-all vulnerability to anti-crop attack.
8) The conceivable conditions under which anti-crop warfare could be waged against the nation; in particular, the possible actions available to the nation which we might want to deter, and the state of relations (cold war, limited war, etc.) which could prevail when such warfare would be advantageous.
9) The possible consequences, both immediate and delayed, which could be expected to follow anti-crop attack.

In short, this phase of the effort would identify that set of nations which could be vulnerable to anti-crop warfare, and the specific conditions which

*A tentative listing would include Bulgaria, Yugoslavia, Hungary, Roumania, Czechoslovakia, Poland, Iraq, Syria, Indonesia, Vietnam, Laos, Burma, Afghanistan, Thailand, Malaya, Sumatra, Borneo, Korea, Egypt, and Algeria, as well as China and the U.S.S.R.

would lend special emphasis to the employment of anti-crop weapons systems, as opposed to, in place of, or in conjunction with other methods of attack. The analysis would clarify, for example, how much value such a capability might have as a deterrent against Chinese aggression in various forms; why and when it would be advantageous to strike with anti-crop weapons against China; and what possible responses would most likely result from actual attack. The study of the consequences of attack would estimate insofar as possible what proportion of the population would probably die of starvation; what segments of the population would be most affected; what effect there would be on the military forces; what reduction in food stores and emergency measures would take place; what diversion of manpower could be expected; what reasons there might be to expect a significant internal reaction such as a revolt; and what retaliatory moves the Communist regime could take, both in terms of dealing with possible revolt and in terms of mobilizing the country against the forces which dealt the anti-crop blow.

A final and most important area for investigation in this initial phase of research is that of negotiations subsequent to anti-crop attack. The critical question to be answered here is: given that an effective attack has been delivered, how does one impress the enemy with the seriousness of his situation, and how does one proceed from that point to impose sufficient pressure on the enemy to cause him to accept surrender or armistice or control; in short, how does one negotiate with an enemy country which is faced with starvation?

The foregoing phase represents a most important part of the proposed study, and could conceivably be of sufficient importance to be justified in its own right; that is, funded independent of the rest of the proposed study. As we interpret the problem, however, it forms an essential basis for the evaluation of alternative strategic anti-crop systems.

2. The Requirements for Strategic Anti-Crop Weapons Systems

The second phase of the study will deal with the operational and support requirements for strategic anti-crop weapons systems. These requirements would be drawn from the findings of the preceding phase.

It is believed that the key to the intelligent selection of a worthwhile anti-crop weapon system is flexibility. Not only must a system chosen for subsequent development be capable of operation in the spring against one country's crop of rice, but perhaps also in the fall against a different crop in another part of the world. The first phase of research would identify which countries

might be the most likely targets of such warfare, and in each of these countries, which specific crops. It would then remain to define in this second phase of research such factors as:

1) The prevailing environmental conditions in the target countries.
2) Variations in environmental conditions; particularly the temperature, humidity, precipitation, winds, and pressure.
3) The topographic characteristics of the croplands; in particular, their locations, size; the variation in altitude, roughness; the most suitable avenues of aerial approach and runs for delivery, and the length of such runs.
4) The defenses which the country is likely to have.
5) The bases which could probably be used by our forces in mounting attacks, and thus the ranges from bases to targets, and the environmental conditions at the bases.
6) The levels of destruction in terms of the degree of damage required over the given cropland areas.
7) The delays (in terms of their nature and extent) which might be an unavoidably operational aspect of mounting attacks, and hence the necessary ability to remain in standby, collect intelligence, resupply, replace munitions which have lost virulance, etc.
8) The most likely supporting forces which would be necessary to coordinate with the weapons systems delivering the anti-crop attack; e. g., the need for BW-CW protection at bases known to the enemy, in view of his probably retaliating in that manner; the need for photo-reconnaissance to evaluate the effects of the attack; the need for meteorological reconnaissance prior to attack.
9) The surveillance of munitions at advanced bases, and the safety measures required to guard operational personnel from ill effects (e. g., protective measures for personnel maintaining aircraft).
10) The required transportation of virulent munitions to the theater of operations to back up the attack.
11) The stockpiling required in ZI to support the operation.
12) The production required to support anti-crop warfare on such strategic scales.

This phase of the study, then, will draw data from the first phase to determine the general specifications for a strategic anti-crop capability sufficiently powerful and flexible to deal with the most important and most likely cases which could arise in the future. The specifications will reflect the weighting assigned to various conflicts through skilled judgment; that is, if it appeared

very likely that anti-crop warfare would be highly advantageous in Laos, and further that there could well be a conflict there, but that anti-crop warfare would not appear very advantageous or would not likely find application in Poland, then the system would tend to be designed more for the conditions prevailing in Laos, and less for the conditions prevailing in Poland.

The performance specifications would be kept as general as possible consistent with the findings of Phase 1, since it is impossible to foresee just where a conflict would actually arise in which we would want to employ anti-crop warfare. On the other hand, it is believed possible to postulate a credible deterrent posture based upon anti-crop capability, at least in part; and thus there might be more assurance in setting forth the requirements for a weapon system primarily designed for a deterrent role against a particular aggressor, but with the capability of serving in other situations and areas if required.

In this phase we will match known agents to their applicable types of targets. The following list of agents may need revision in the light of research since 1960-1961:

Biological Agents:

LO	Potatoe Blight
LX	Rice Blast (std.)
SX	Rye Rust
TX	Wheat Rust (std.)

Chemical Agents:

LNA - 2, 4-D
LNF
LNB - 2, 4, 5-T

Pests:

Beetles
Locusts
Worms

Insofar as possible the variation within the anti-crop arsenal will be reduced for logistic reasons, consistent with the necessary degree of flexibility.

3. Evaluation of Alternative Weapons Systems

The final phase of the study will involve a comparison of the cost and effectiveness of selected weapons systems designed for strategic anti-crop warfare. The comparison would be based upon the criteria and performance specifications determined in Phase 2 of the study.

Several weapons systems capable of large area coverage have been proposed; at least one of these has been developed to the point of demonstrating the feasibility of the system concept through flight tests of prototype equipment. It is proposed that the analysis in this phase of the study would include all those possible systems which are believed to have any promise at all, regardless of their state of development. Whereas the list of candidate systems would be determined after initiation of the study, it is possible to indicate now what weapons systems might be included for consideration:

a) Airplanes:
   - B-58
   - B-52
   - A4D

b) Airplanes and drone airplanes

c) Cruise missiles
   - Regulus
   - Snark or other

d) Missiles
   - Polaris
   - Land-based IRBM
   - Land-based ICBM

e) Airplane-launched missiles
   - IRBM
   - Cruise missile

The comparison between alternative vehicles would involve scrutiny of a number of complex problems, such as:

1) What is the trade-off between large and small airplanes? (Consider payload, operating costs, capability to reach target area)
2) Can surplus or outmoded airplanes be converted into drones that could be remotely controlled in close formations by a co-pilot in a master plane?
3) With regard to unmanned vehicles, can they be programmed to make the required delivery runs over the target areas?

4) If programming is possible, what investment is worthwhile in complex guidance or automatic programming equipment?
5) If programming is impossible, what remote control systems can be used for delivery phase guidance (e.g., radar guidance from a mother plane at high altitude)?

For each selected weapons system, the analysis will estimate:

a) The system performance in terms of certain probabilities of reaching the target areas and effectively delivering the agent over the target areas, and
b) The total annual systems cost, including initial investment, operating costs, and support costs.

A final and significant product of this analysis will be the identification of specific shortcomings of the selected weapons systems, including the agents, delivery mechanisms, vehicles, supporting systems, and concepts of operation and support. Such identification is believed to be of considerable value in providing direction for further research and development of anti-crop weapons systems and system components.

Information Sources and Travel

In addition to the facilities of the Army Chemical Corps at Fort Dietrick and Camp Edgewood, it is anticipated that the following facilities should be visited:

Headquarters, STRIKE
Headquarters, STRAC
Headquarters, TAC, Langley Field, Va.

The above three headquarters will be visited to obtain data on current systems and operational and support concepts.

Headquarters, SUBRON 1, U.S. Naval Base, Groton, Conn.

This headquarters will be visited to review a recent study by the Submarine Squadron of the feasibility of submarine-launched BW-CW weapons.

In addition, the following facility is an excellent source of basic information and may be visited to obtain agricultural data for selected countries:

Human Relations Area Files
Yale University
New Haven, Conn.

Other sources of information may be regarded as valuable as the study proceeds. In each case, all visits will be cleared through the cognizant project officer of the Chemical Corps Biological Laboratories.

PROJECT ORGANIZATION, SCHEDULE AND COST

Research Team

It is proposed that the study be conducted by a team based in the main offices of Dunlap and Associates, Inc., in Stamford, Connecticut, with support during the first and second phases of the study as indicated below. The work will be under the over-all direction of Mr. Kenneth W. Yarnold, Vice President and Head of the Systems Division. The research team under his direction will consist of the following staff members whose experience resumes are included in a subsequent section of this proposal.

Mr. Charles P. E. von Wrangell, Senior Systems Analyst, who will be in direct charge of the technical effort
Mr. Charles E. Van Albert
Mr. Arthur S. Cosler, Jr.
Dr. Phil S. Eckert (Agri Research, Inc.)
Mr. John T. Gorby
Dr. Robert C. Suggs

The above team will receive strong support during the first phase of work from the services of Dr. Paul M.A. Linebarger, Professor of Asiatic Politics, School of Advanced International Studies of the Johns Hopkins University, Washington, D.C. Dr. Linebarger will analyze the applications, consequences, and value of anti-crop warfare in Asiatic countries.

During Phase 1 and Phase 2 it is planned to augment the team with support from Agri Research, Inc., a subsidiary of the corporation located in Manhattan, Kansas. The primary contribution of Agri Research will be to analyze the agricultural economic structure of target countries and the physical characteristics of target croplands in terms which permit the formulation of system requirements. Access to classified information for this aspect of the study will not be required.

Schedule

The following schedule is tentatively suggested. It should be emphasized that whereas the three phases of the study should follow each other sequentially, the over-all duration of the effort may be compressed or extended, depending on the requirements of the Chemical Corps.

Phase	Month 1	2	3	4	5	6	7	8	9	10	11	12
1. Rationale	———	———	———	———	———	———						
2. Requirements						———	———	———				
3. Cost-Effectiveness							———	———	———	———	———	———

Security

The offices of Dunlap and Associates, Inc., enjoy the privilege of a Top Secret facility clearance, granted by the Office of Naval Research, 207 West 24th Street, New York 11, New York.

Each staff member of the Dunlap and Associates, Inc., team has a personal clearance of Secret or Top Secret.

COSTS

The cost of the proposed study is estimated below, based upon a twelve-month effort. It is emphasized that our research capability is sufficiently flexible to permit lengthening or shortening the over-all period to accommodate any schedule requirements of the Chemical Corps.

The Costs are estimated on the basis of a cost-plus-fixed fee contractual structure approved and in use by the company with other Department of Defense agencies. Should a different contractual structure, such as one based upon time and materials, be specifically desired by the Chemical Corps, we will be pleased to submit alternative cost estimates upon request.

Direct Labor	Hours	Rate	Total
Responsible Officer	185	$ 11.06	$ 2,046.00
Chief Scientist	925	8.65	8,001.00
Senior Scientist, Level D	1,110	7.07	7,848.00
Associate Scientist, Level A	1,390	6.20	8,618.00
Staff Scientist, Level B	1,850	3.85	7,123.00
Technical Assistant, Level B	370	2.99	1,106.00
Salary Adjustment at Jan. 1, 1963			1,042.00
TOTAL DIRECT LABOR			$ 35,784.00
Overhead (110% of Direct Labor)			39,362.00
Travel (estimated)			7,150.00
Materials (Report production)			500.00
Consultants			
Dr. P. M. A. Linebarger, Consulting Services (100 days @ $100/day)			10,000.00
Total Estimated Cost			$ 92,796.00
Fixed Fee			6,496.00
TOTAL ESTIMATED COST PLUS FIXED FEE			$ 99,292.00

COMPANY EXPERIENCE

The brochure entitled "Military, Space and Nuclear Project Experience" describes various projects which have been completed by Dunlap and Associates, Inc., under contract to governmental agencies and to industry. A copy of this brochure is enclosed with the forwarding of this proposal. Attention is drawn to the following projects which have particular relevance to the proposed research effort:

CINC-Level CBR Decision Making

AF 30(602)-2309

A study was conducted for Rome Air Development Center to determine the information inputs and decision processes involved in the event of chemical, biological, radiological and weather warfare in the period 1965-1975. Three categories of missions were analyzed: offensive use of CBR&W weapons by the U.S.; defense of the U.S. against CBR&W attack; and resource management of CBR&W weapons. A thorough study of the state of the art in CBR&W weapons was made and the future objectives of SAC, TAC and NORAD in various conceivable situations were determined. The decision processes and necessary information inputs for a matrix of possible situations were defined, assuming an operational capability in CBR&W warfare. The results of this study are designed to serve as a basis for the design and development of equipment in future CINC-level control centers.

Envanal

DA 19-129-QM-390

This project was concerned with the development of an index of environmental factors vs. Army equipment, particularly terrain and climatological factors. Under contract to the U.S. Army Quartermaster Corps, we conducted the research to define the factors required, and the data processing requirements. We tested the system during Arctic exercises and made recommendations for directions of future development.

473L, USAF Headquarters Control System

AF 19(626)-1

In the course of our systems analytic and human factors work on this system, Dunlap and Associates, Inc., has amassed a large amount of

experience in the area of military planning and the methods and procedures used for planning purposes. During these studies it was necessary to become familiar with both strategic and tactical planning and plan generation and modification in order to provide for mechanization of techniques for performing these operations in short periods of time. Detailed analyses of the decisions required of personnel echelons in the Air Force from Command Post personnel through the Joint Chiefs of Staff and the National Security Council were studied in order to arrive at optimum techniques, methods and procedures for plan modification in the face of impending situations requiring Air Force response.

Weapons Systems

DA 19-020-ORD-2335
DA 19-020-ORD-4687
DA 19-020-ORD-5335

In the development of several weapon systems, it was necessary for Dunlap and Associates, Inc., to conduct studies involving nuclear effects. For some weapons such as the HAWK missile system, the weapon itself could have a nuclear warhead. In such cases, detailed analyses of the various techniques for controlling nuclear-tipped missiles and their effects on intercept were studied. Recommendations for control mechanization in order to provide for safe operation were made. In other cases, as with the Field Army Ballistic Missile Defense System, it was necessary to consider the environmental effects of nuclear detonation. In such situations the control of the environment in which personnel operated was of paramount importance. Methods for shielding personnel from the effects of fallout blast, noise and other effects of nuclear weapons were developed and recommended to appropriate personnel.

Drone Systems

DA 36-039-SC-73253, T.O. 09, 12

For the U.S. Army Signal Corps, a review was made under prime contract of the operator tasks, the facilities provided to accomplish these tasks, and the suitability of the equipment-operator team to perform its mission in complete systems of the SD-1, 2 and 3 surveillance drones. Special attention was given to the feasibility of integrating these three subsystems into the AN/UPW-1 Control and Guidance system. This Control and Guidance system itself was also the subject of a separate study and recommendations designed to improve its operational effectiveness.

REFERENCES

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2. Ch'u Chai and Winberg Chai, The changing society of China. New American Library, 1962.

3. J. P. Cole, Geography of world affairs. Penguin Books, Ltd., 1959.

4. Theodore Shabad, Geography of the Soviet Union. Columbia University Press, 1951.

KENNETH W. YARNOLD

Title: Vice President
Director, Systems Division

Date of Birth: 6/19/13

Education:

Ph. D. *	Oxford University	1937
B. A.	Oxford University	1935

Professional History:

1950 - present	Dunlap and Associates, Inc.
1949 - 1950	Operations Research Office, Department of the Army, Washington, D. C.
1947 - 1949	(British) Army Operations Research Group
1940 - 1947	Ministry of Supply (Tanks and Chemical Warfare)
1937 - 1940	Gas, Light and Coke Company

Pertinent Experience:

1. Currently directing Dunlap and Associates efforts on CNO ASW Study Program. In twelve years with Dunlap and Associates, Inc., supervising systems studies for Office of Naval Research, Signal Corps, etc., studies on training, morale, predicted artillery fire, rumor as a psychological warfare tool, accidents, and effects of climate on operations. Operations research on mid-range logistic planning, the design of air traffic control systems, airborne early warning systems, antiaircraft systems, transportation problems. Design of Combat Operations Center for NORAD, design of Tactical Operations Center for Army, and other combat operations centers. Systems studies of BMEWS. Development of training requirements for POLARIS, TALOS, etc. Economic analysis of ASW systems, including passive systems; range instrumentation studies, design and management of fallout shelters. Studies to develop data processing requirements.

2. One year as first exchange officer between Army Operations Research Group, England, and Operations Research Office, Department of the Army, Washington, D. C. Chairman of Project POWOW, dealing with Army psychological warfare.

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* Completed requirements

Chairman of ORO Project Board, charged with general supervision of all projects. General consultant to other projects, dealing with antiaircraft defense, body armor, artillery fire, tank design, transportation, etc., 1949-1950.

3. Two years as head of Training Section while Principal Scientific Officer of Army Operations Research Group, England. Directed and/or carried out about ten training and morale research projects for the British Army, covering such topics as small arms training, construction of syllabi, instructor training, map reading, morale surveys. Made a study of fear in guerrilla warfare conditions in Palestine during the disturbances following Partition, 1947-1949.

4. Four years as head of Trials Planning Section, Tank Armament Research Establishment, Ministry of Supply, England, 1943-1947. Responsible for:

   a. Planning, conduct, evaluation and reporting of all development trials of all tank armament, fire control and vision devices.

   b. Systems analysis of new proposed weapon systems.

5. Three years in charge of field investigations of chemical projectiles, Ministry of Supply, England. Wrote relevant Army training manuals, 1940-1943. Extensive experience with chemical warfare agents.

6. Three years in Research Department, Gas, Light and Coke Company, London, England. Research and development in domestic appliance design. Basic research in human warmth, comfort, and ventilation, 1937-1940.

CHARLES P. E.. VON WRANGELL Date of Birth: 8/8/26

Title: Senior Systems Analyst

Education:

M.S. in M.E.	Princeton University	1953
B.M.E.	Cornell University	1948

Professional History:

1956 - present	Dunlap and Associates, Inc.
1953 - 1956	Sikorsky Aircraft
1951 - 1953	Sperry Gyroscope Company

Pertinent Experience:

At Dunlap and Associates, Inc.. he participated in studies to determine the most advantageous system for air traffic control for Army aircraft in the Combat Zone in two future time periods; to evaluate the Talos land-based weapon system; to determine the instrumentation requirements and design the displays and controls for helicopters powered by free gas turbines, and to design an improved method for obtaining mid-range logistical planning estimates.

Mr. von Wrangell has directed research in the following areas:

Design and development of a tactical operations center for the Field Army Commander and his staff for use in 1965-70.

Studies to recommend advantageous equipment types, layout, and operational procedures for technical control centers for the future U.S. Air Force world-wide communication system (480L).

Analysis of the Navy FBM management system, PERT, resulting in recommendations for increasing its usefulness to both the Navy and its contractors.

Specification of guidance accuracy requirements, methods of command control, and design of launch crew's equipment for an advanced surface-to-surface missile.

Specification of system requirements for the operations central of the Pacific Missile Range.

The design of an information receiving, processing, storing, and display system for the Space Surveillance Center (496L) for the Air Force.

The determination of the decision processes required of CINC-level personnel with regard to the use of, and defense against, CBR and weather producing weapons.

Determination of the most advantageous courses of action for the Special Projects Office to follow with respect to the application of digital computers on future FBM submarines.

Prior to joining Dunlap and Associates, Inc., Mr. von Wrangell was a senior dynamics engineer at Sikorsky Aircraft, where he participated in the design, development and flight test of a Sikorsky-furnished automatic stabilization system. As an assistant project engineer in the Flight Controls Department of Sperry Gyroscope Company, he developed electro-mechanical components of the A-14 automatic pilot and an electric boost link for the HUP-2 helicopter.

Mr. von Wrangell has supplemented his mechanical engineering background with courses on digital computer programming, systems simulation using digital computers, and engineering mathematics.

Mr. von Wrangell is currently engaged in operations analyses of ASW problems, serving as an analyst in support of the CNO-ASW Study Group.

Professional Affiliations:

Operations Research Society of America

ARTHUR S. COSLER, JR. Date of Birth: 10/5/13

Title: Senior Scientist

Education:

B.Sc.	Ohio State University	1940

Professional Experience:

January 1962	Dunlap and Associates, Inc.
1961	Geonautics, Inc.
1960 - 1961	Broadview Research Corp.
1959 - 1960	Melpar, Inc.
1954 - 1959	Ohio State University
1950 - 1954	Steri-Seal Co., Inc.
1944 - 1950	Battelle Memorial Institute
1944	Duke University
1940 - 1944	Columbia University

Experience:

1. Broadview Research Corp. Director of Intelligence Systems Division. Responsibilities included: over-all management of the division, customer relations and project sales, preparation of proposals. Projects included: photogrammetry, geodesy, reconnaissance and intelligence systems analysis, photo interpreter training programs and keys, applications of satellites to reconnaissance and survey, targeting studies, spectrophotometry and its application to special military problems. Major work was as subcontractor on Subsystem I of Samos program.

2. Melpar, Inc. Project manager. As senior member of Reconnaissance Systems Analysis Group, was responsible for preparation of proposal on topographic mapping system. Project leader on a Fix-Location Techniques Study, part of the Elint work.

3. Ohio State University. Executive Director of Mapping and Charting Research Laboratory, working mainly for the USAF and the Army. Main fields were: geodesy, gravimetry, photogrammetry, navigation, radar mapping and charting, cartographic studies, photo-interpretation.

ARTHUR S. COSLER, JR. (Cont'd.)

4. Battelle Memorial Institute. Research Engineer, working on a variety of problems: acoustic, thermodynamic, electronic, instrumentation, new methods of machining being the principal ones. Assisted in formulating research projects in various fields of applied physics.

5. Duke University. Research Physicist at OSRD lab which was set up to develop a very small, portable sound ranging apparatus for use by amphibious forces, after landing, to locate enemy guns.

6. Columbia University. Staff member in Division of War Research, involved in development of the Magnetic Anomaly Detector.

JOHN T. GORBY

Title: Staff Industrial Engineer

Date of Birth: 12/29/36

Education:

B.S.	Yale University	1959
Graduate work toward M.S.	Yale University	1960 - present

Professional History:

1959 - present	Dunlap and Associates, Inc.
1957 - 1959	Laboratory of Marine Physics

Pertinent Experience:

1. Participated in a study with the Yale High Energy Physics Department at the Brookhaven National Laboratories to investigate various characteristics of nuclear particles.

2. Participated in a research study for the Navy to determine the acoustical patterns of unique shock waves in water and heavier media.

3. Participation in study for Bureau of Aeronautics to determine instrumentation systems for Pacific Missile Range during 1960-75. Analyzed functions of various key personnel to determine most advantageous control equipment. Observed and analyzed operation of present downrange communications at Atlantic Missile Range.

4. Participation in study for USAF to determine design of future Space Surveillance System Center. Analyzed functions within center in evaluating control equipment techniques.

5. Participated in a study which analyzed decision alternatives available to CINC level personnel, relative to the use of, and defense against chemical, biological, and radiological weapons.

6. Participated in a study for the Navy Special Projects Office to determine the most advantageous type of computer selection for the Polaris submarine. This study included an analysis of cost, maintenance, logistics, reliability, etc., of various EDP systems.

7. Participated in a study for United States Coast Guard to design an optimum materials handling system for a new class of buoy tenders which will be responsible for servicing coastal aids to navigation.

8. Participated in a study for the Navy to evaluate and recommend a maintenance procedure which would fully utilize a new module test set to be used aboard future Polaris submarines.

9. Participated in a study for Naval Training Devices Center which developed a methodology for estimating an increase in system effectiveness as a result of training in individual areas or activities.

Dunlap and Associates, Inc.

ROBERT C. SUGGS

Title: Associate Anthropologist

Date of Birth: 2/24/32

Education:

Ph. D.	Dept. of Anthropology Columbia University	1959
A. M.	Dept. of Anthropology Columbia University	1956
A. B.	Columbia College	1955

Pertinent Experience:

1. Author of manual on design and use of home fallout shelters, designed radiation rate meter, investigated ecological effects of nuclear attacks, developed design for personnel capsule to be used during nuclear attacks, and conducted preliminary investigation of radiobiology problems in space flight. Conducted studies of personnel protection and general life support problems for operators in missile systems. Carried out preliminary investigations in field of isolation and confinement studies and Communist psychological warfare and thought reform techniques.

2. The Martin Company, Baltimore, Senior Engineer, Human Factors, Advanced Design. Conducted anthropometric studies of mobility in restricting garments, specifically pressure suits for space flights. Developed a system for rating these garments on a scale of relative efficiency for varied types of work.

3. Participated as human factors consultant in Lunar Base Study (SR 192) contributing recommendations for interior configurations of manned vehicles and lunar surface shelters. Outlined human life support requirements for mission. Made a general evaluation of human functions in the entire lunar base system, leading to an estimate of personnel strength required for the operation.

4. Consultant in Human Engineering, McLaughlin Research Corp., of Washington. Research in anthropometry in connection with maintainability studies of advanced weapons systems and design of control centers and work spaces. Participated in work on publication presentation techniques.

CHARLES E. VAN ALBERT Date of Birth: 6/19/21

Title: Senior Operations Research Analyst

Education:

A.B.	University of Pennsylvania (Physics, Mathematics)	1949
Graduate Study	Universities of Pennsylvania Delaware, Maryland, and U.S. Department of Agriculture	1949-53

Professional History:

1956 - present	Dunlap and Associates, Inc.
1952 - 1956	Westinghouse Air Brake Co. (Senior Staff Engineer)
1951 - 1952	U.S. Bureau of Standards (Physicist)
1949 - 1951	Hobart College (Instructor of Physics)

Experience:

1. Five years experience as an operations research analyst at Dunlap and Associates, Inc., where he conducted research on a wide variety of industrial management and military systems problems, such as:

   - Hawk surface-to-air missile system. Conducted analysis of a number of problems associated with the control-display subsystem. These investigations were concerned with: a) the usefulness of rate-aided tracking in the system, b) the range scales for the principal radar displays, c) the ability of a human operator to evaluate target threat utilizing data measured by a CW radar, and d) several additional problems of progressively greater detail.

   - Naval supply costing problems. Participated in the study of costs at three Naval supply activities. The object of this study was to develop functional relationships capable of predicting the marginal and total costs to receive, issue, and store material at each activity. Duties included directing the research project, developing cost models and preparing reports.

- Mining-processing. Participated in an analysis of a large mining-processing operation. Developed cost models designed to show the results of each of a number of management decision alternatives such as plant expansion, construction, modernization, relocation, etc. Required identification and measurement of profit influencing factors and the relationship between such factors and the throughput of the system.

- Inventory-production control system. Defined the cost controlling factors and developed models which illustrated the sensitivity and influence of the control variables on the total cost of the operation. Included as variables were uncertainty in product usage rates and manufacturing lead times.

- Ballistic Missile Early Warning System. Participated in human factors effort applied to the checkout and monitoring subsystem. Duties required close working cooperation with design engineers and responsibilities included an analysis of subsystem tasks leading to the division of tasks between man and machine, the information that was required by the human operator to optimally perform his function, and the preliminary design of information displays for the subsystem.

- Maintenance of Air Force ground electronic equipment. This study was concerned with the kinds of information that could be coded on electronic equipment to simplify the preventive and corrective maintenance required by the equipment. Duties included field observation and experimentation, developing hypothesis, and the experimental exploration of the hypothesis.

2. At Westinghouse Air Brake Company he worked on an analysis of various problems associated with railroad supply industry among which are:

   - Design and development of an automated test rack for railroad air brakes.

   - Utilization of statistical quality control in the production of air brakes and related parts.

   - Analysis of the problem of destination costing railroad freight cars which led to a design of an automated classification yard.

3. Presented series of ten lectures entitled "Mathematical Techniques of Decision Making," under the sponsorship of the Metropolitan New York Chapter of the American Institute of Industrial Engineers, the Institute of Management Sciences, and The Society for the Advancement of Management. Lecture series was given in the Fall of 1957 and was repeated in the Spring and Fall of 1958. Topics discussed included probability theory, statistics, queuing theory, linear programming, monte carlo, inventory control theory, etc.

Professional Affiliations:

- Operations Research Society of America.
- Scientific Research Society of America.

PHIL S. ECKERT

Title: Executive Vice President, Agri Research, Inc.

Education:

B. S.	Agriculture	Ohio State University
M. S.	Agriculture	Ohio State University
Ph. D.	Agricultural Economics	Ohio State University

Experience:

Began professional career as an agricultural economist with the Cleveland Federal Reserve Bank. Was head of the departments of agricultural economics and rural sociology and economics and sociology at Montana State College.

Served as agricultural commissioner for the Economic Cooperation Administration (Marshall Plan) in Paris following World War II.

Dean of the College of Agriculture and director of the Agricultural Experiment Station, University of Arizona.

Agricultural Attache, Foreign Agricultural Service, at the American Embassy, Bonn, Germany.

Executive Vice President of Agri Research, Inc., in Manhattan, Kansas.

Publications:

Author of many articles and studies in the field of agricultural finance, agricultural marketing, farm organization and management, and foreign agriculture.

Membership:

Gamma Sigma Delta (Honor Society of Agriculture); Alpha Zeta (honorary agriculture); Sigma Xi (honorary science); Phi Kappa Phi (honorary scholastic); honorary State Farmer, Future Farmers of America.

Award:

Received the U. S. Department of Agriculture's Award for Superior Service while representing U. S. agriculture in Germany, 1960.

PAUL M. LINEBARGER

Title: Consultant

Education:

A. B.	George Washington University	1931
Ph. D.	Johns Hopkins University	1934

Experience:

Began his professional career as Private Secretary to Legal Advisor, National Government of China (Nanking and Washington)

At Harvard University was an Instructor in Government and tutor in the Division of History, Government and Economics.

At Duke University served as political science instructor and associate professor in charge of Far East courses.

Participated in formation of O. W. I. as Far Eastern specialist, Operation Planning and Intelligence Board

At Johns Hopkins University was lecturer at School of Advanced International Studies and Acting Dean of the school in 1959. Since 1946 he is the professor for Asiatic politics

Currently he is a consultant to numerous agencies of the Federal Government.

Publications:

Numerous works on China, Sun Yat Sen and related items. Governments and Politics of Far East and also in field of Psychological Warfare.