NAVAL RESEARCH

REVIEWS

AUGUST 1977

PROFILES IN SCIENCE

Dr. Forrest Mozer

Dr. Forrest Mozer is a Professor in the Physics Department at the University of California, Berkeley. His research interests involve, primarily, experiments on and theories of electric fields in the earth's magnetosphere, and the acceleration of charged particles by such fields to produce auroras and the radiation belts. With ONR funding since 1966, his group has pioneered in measuring ionospheric electric fields with small balloons carrying more than 100 payloads from sites in the United States, Canada, Alaska, South America, Antarctica, Greenland, Iceland, and Europe. This balloon data has provided the first and most complete understanding of electric field variations during substorms and the radial diffusion of charged particles due to such variations.

With ONR support, he has also flown electric field experiments on three piggyback satellites launched by the Air Force. The most recent of these, the S3-3 satellite, observed electric fields that are a factor of 30 larger than expected from extrapolations of lower altitude data. These electric fields exist in confined spatial regions along high latitude magnetic field lines. The discovery of these electric fields and the experimental and theoretical understanding of the electrostatic shocks that contain them allow the first quantitative explanation of the origin of discrete auroral arcs.

Small Ballooning Serves the Navy

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Background

On September 25, 1947 a small, shimmering plastic balloon, with a total volume of less than 35,000 cubic feet climbed with its 65 lb. cloud chamber experiment to a height of 100,000 ft. where it floated for a few hours above southwestern Minnesota. Project SKYHOOK thus registered the first of several thousands of successful scientific balloon flights. This small balloon flight represented not only the birth of Project SKYHOOK but a significant technological milestone in a young post-World War II technology, where failures far outnumbered successes. In the years to follow, both balloon and electronics technology would provide systems nearly incomprehensible to SKYHOOK "pioneers." Balloons would grow more than three orders of magnitude in size and scientific payloads would be measured in metric tons. Experiments would gather data for days, even months, on a single flight. Thousands of probes would be lofted into the space-like upper atmosphere in support of diverse scientific and engineering efforts. Basic atmosphere and near-space observations, research in physical, astrophysical, chemical, biological and life sciences, test and evaluation of prospective space systems, and development of communications and surveillance systems, all would come to be well and economically served by the descendents of that first successful SKYHOOK balloon (1).

Media coverage of scientific balloons has been substantial, particularly during the era of manned stratospheric flights, which extended into the early 1960's, and again in the late 1960's and on into this decade, when balloon size and payload weight began to increase to truly dramatic dimensions. During the times that the gigantic balloon systems commanded so much public attention and wonder, an important segment of the ballooning community remained unnoticed. This is the group of scientists and engineers sometimes termed the "small balloon community," who are busily engaged in experiments using balloons which have an extremely impressive record of success. These small balloons are similar in size to the original SKYHOOK aerostat. SKYHOOK

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is one of the oldest continuing projects supported by ONR, going back 30 years. All of the balloon projects described here are part of ONR's SKYHOOK project.

Small Balloons

What is a "small balloon?" Technically speaking this classification of aerostat includes those lighter-than-air free balloons having a maximum inflation or displacement of air at ground level of up to about 150 lbs. Within this range of buoyancies, balloon systems may be safely handled by one or two persons during the final stages of the launch operation. The definition of the small balloon is confined to gross lift only. There is no limitation of achievable altitude and duration, sophistication of airborne experiment or absolute balloon volume. Small balloons have continued to perform in the same scientific leagues with their larger cousins due to the burgeoning revolution in microelectronics and innovations in manufacturing and operating techniques.

The practical differences between present-day "small" and "large" balloons are low cost, ease of operation, and flexibility. With low gross inflations and no heavy specialized equipment with attendent crew, no logistics and support problems are required for handling inflation, launch, and recovery. The balloons themselves are relatively inexpensive (Figure 1) and require a minimum of easily transported equipment. The operations "crew" usually consists of a launch supervisor, the principal scientific investigator, students, and laboratory technicians. The crew pay careful attention to good operating procedures and safety precautions, such as those outlined in the small balloon handbook (2). Recovery of the scientific experiment is usually desired, and many investigators have relegated the recovery of small compact payloads to a reward-tag procedure with excellent success. Another advantage with small balloons is that they permit flexibility in choice of site for the launch. A location may be chosen for optimum scientific considerations with a minimum of concern for prepared surfaces, access by heavy equipment, or billeting for a large group of people. As shown by Figure 2, SKYHOOK small balloons have been flown from sites the world over, including ships at sea. Many groups, both U.S. and foreign have exploited the flexibility of the small balloon in countless observation, test and evaluation programs.

Current Projects

Some of the small balloon programs of the past and some of the plans for the future will show what these balloons can do. Since the early 1950's when Dr. James VanAllen's group began the ROCKOON

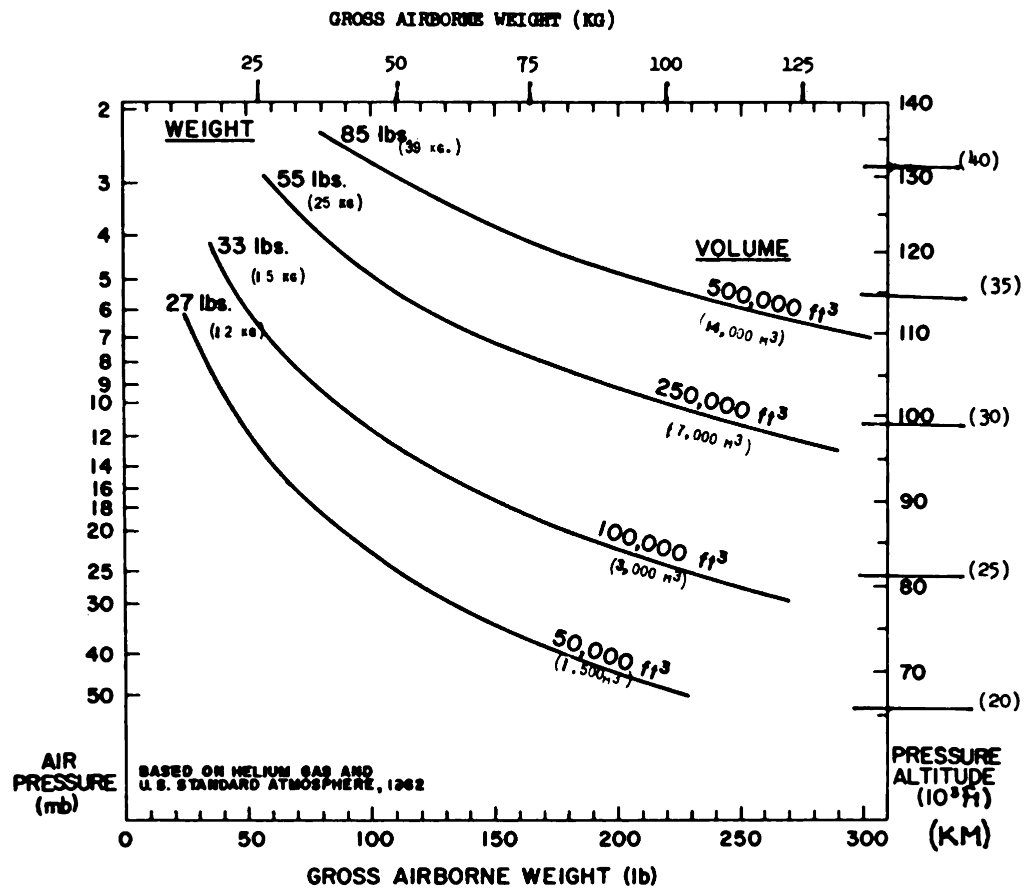

Figure 1 — Typical small balloon performance characteristics. For very rough estimate of balloon cost it may be considered, that price ranges from about $20-$25 per pound ($45-$55 per kg.) of balloon weight.

program of balloon-borne rockets launched in the Arctic (Figure 3), small balloons have contributed to many scientific programs which have required data at remote locations, or have required data to be taken simultaneously at multiple locations, or a combination of both.

Beginning in 1969, three separate Arctic expeditions entitled Project SKYHOOK "Buckshot," have netted nearly 1000 hours of electric field data at balloon altitudes (3,4). For these expeditions experiment packages were designed by a group under the leadership Dr. F. S. Mozer of the University of California, Berkeley. These packages, (Figure 4), weighing approximately 44 lbs. were flown simultaneously from Canadian sites at Cambridge Bay, Fort Churchill, Yellow knife, Uranium City, Fort McMurray and Penhold in 1969; and in 1971 from canadian sites at Cambridge Bay, and Resolute Bay and Thule, Greenland. During Buckshot III, in 1974, the California group launched flights at Fort Simpson, Thompson, and Poste de la Baleine (formerly Great Whale River) in Canada, and Narssarssuaq, Greenland. For this

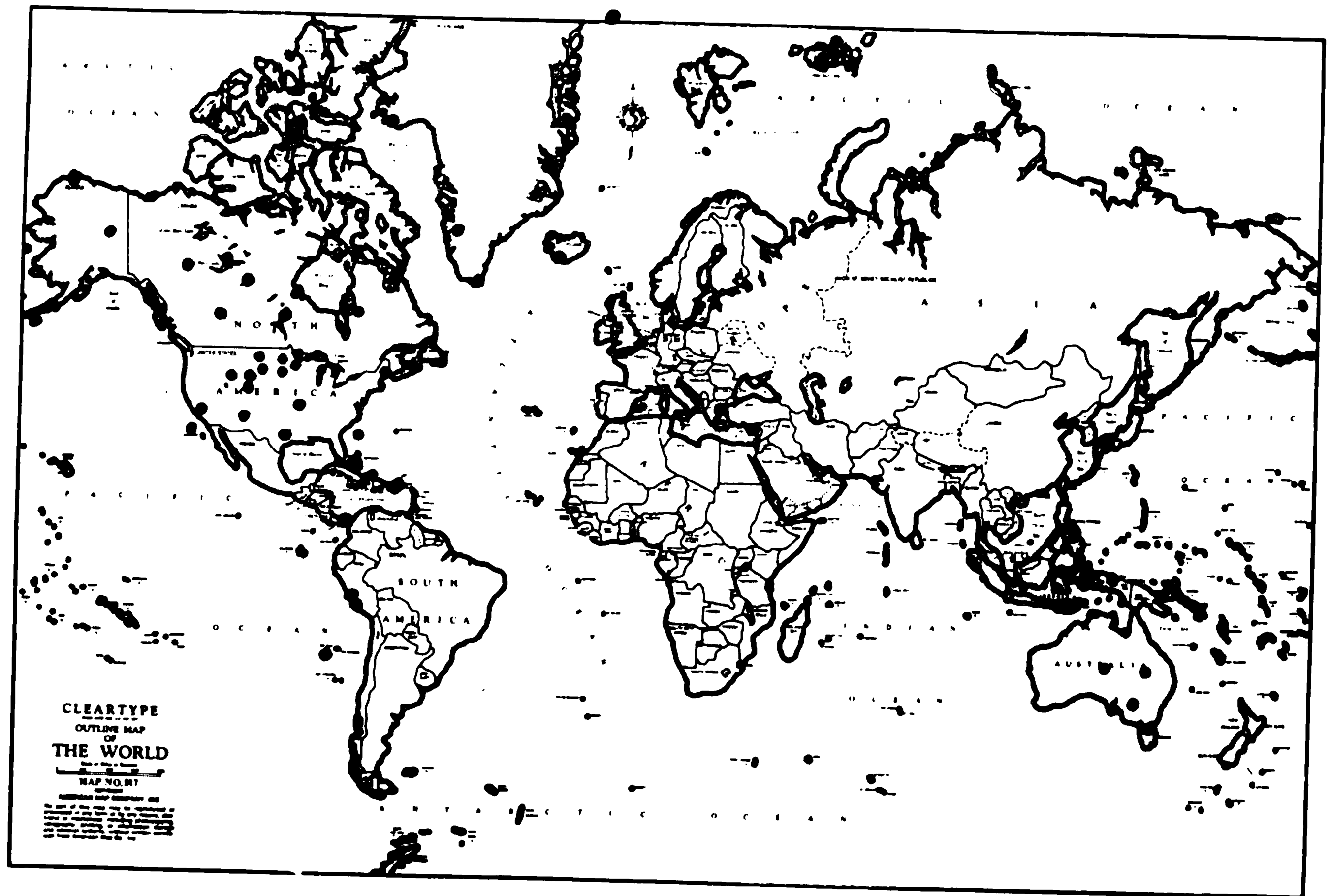

Figure 2 – Launch Sites of SKYHOOK small balloons.

Figure 3 – Project ROCKOON in the early 1950's involved the launch of sounding rockets from small balloon platforms at an altitude of about 20 km.

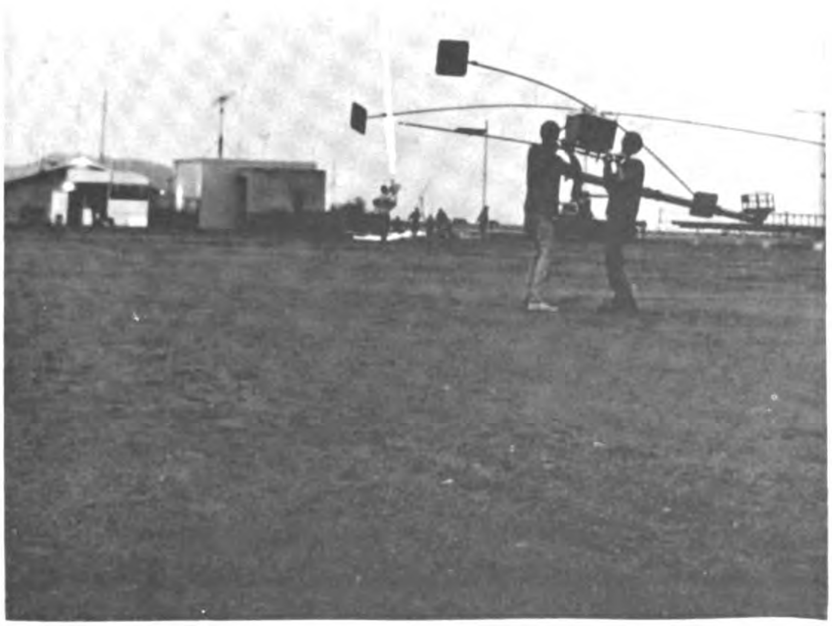

Figure 4 – Launch of a small balloon with electric field experiment poised for pickup.

latter campaign, French and Russian groups also conducted balloon-borne electric field experiments in Iceland and the USSR respectively. Future flights of this experiment will be made simultaneously from Thompson, Manitoba, Canada in the fall of 1977, using small balloon techniques in an attempt to obtain vertical resolution of the electric field.

The Department of Transportation's Climatic Impact Assessment Program (CIAP), included substantial balloon sampling activity. A group from the University of Wyoming, headed by Dr. D. J. Hofmann, conducted small balloon flights from numerous sites, ranging from the Arctic Ice Island T-3 to a South Pole station in Antartica, during 1971 through 1974. This program included Australian collaborators from the University of Melbourne, who took data from two sites on that continent during the same period. The data results included measurements of stratospheric aerosols, H_2O, O_3, and temperatures using miniaturized sensors carried by balloons of 35,000 to 106,000 cubic feet in volume (5). This group continues to conduct balloon sampling (6) both as a primary source of data and to provide ground varification for similar instrumentation aboard satellites.

Since 1976 work has been conducted under Navy contract to Raven Industries, Inc., Sioux Falls, SD. to develop a small balloon capable of inflation and launch in winds of up to 45 knots. Several candidate configurations were recently tested at the full scale low speed wind tunnel at NASA Langly with good success (Figure 5). Full flight test of this small balloon system is scheduled to begin in the summer of 1977.

Figure 5 – Natural Shape prototype balloon for NonSat Relay System during inflation tests at NASA Langley. Inflation is approximately 70% complete in measured wind speed of 45 kts.

The Technique

Until recently, the "hand-launched" method was made possible by the "Huch-Clutch", named after its inventor, W. Huch, formerly of the University of Minnesota. The clutch provides a means of restraining the balloon and payload while it is being inflated and allows a positive check on buoyancy not possible with other techniques (Figure 6). Restraint of the inflated bubble is difficult to accomplish without damaging the polyethylene balloon material, and the Huch Clutch succeeds well in this respect. However, immediately prior to launch, the clutch must be removed and the balloon held by the hand for release (Figure 7). As stated in the definition of the small balloon, these latter stages of the techniques impose a practical maximum buoyancy or gross inflation of about 140 lbs. Recent work done by small balloonists at University of Wyoming (Figure 8), ONR the field Office Twin Cites, Minnesota (Figure 9), and National Center for Atmospheric Research (NCAR), Boulder, Colorado, has resulted in bubble restraint techniques which retains the weigh-off capability, while extending the upper limit of gross inflation to about 500 lbs., in addition to providing mechanical restraint and release. The ONR developed technique will be used for launch of a 650 lbs. system at Thompson, Manitoba during the Fall of 1977.

Figure 6 – Weighing off using the Huch Clutch technique. The inflation proceeds until the entire system weight, including free lift for ascent is just neutrally buoyant. The dark sleeve at upper center is the clutch, which is removed prior to launch by hand.

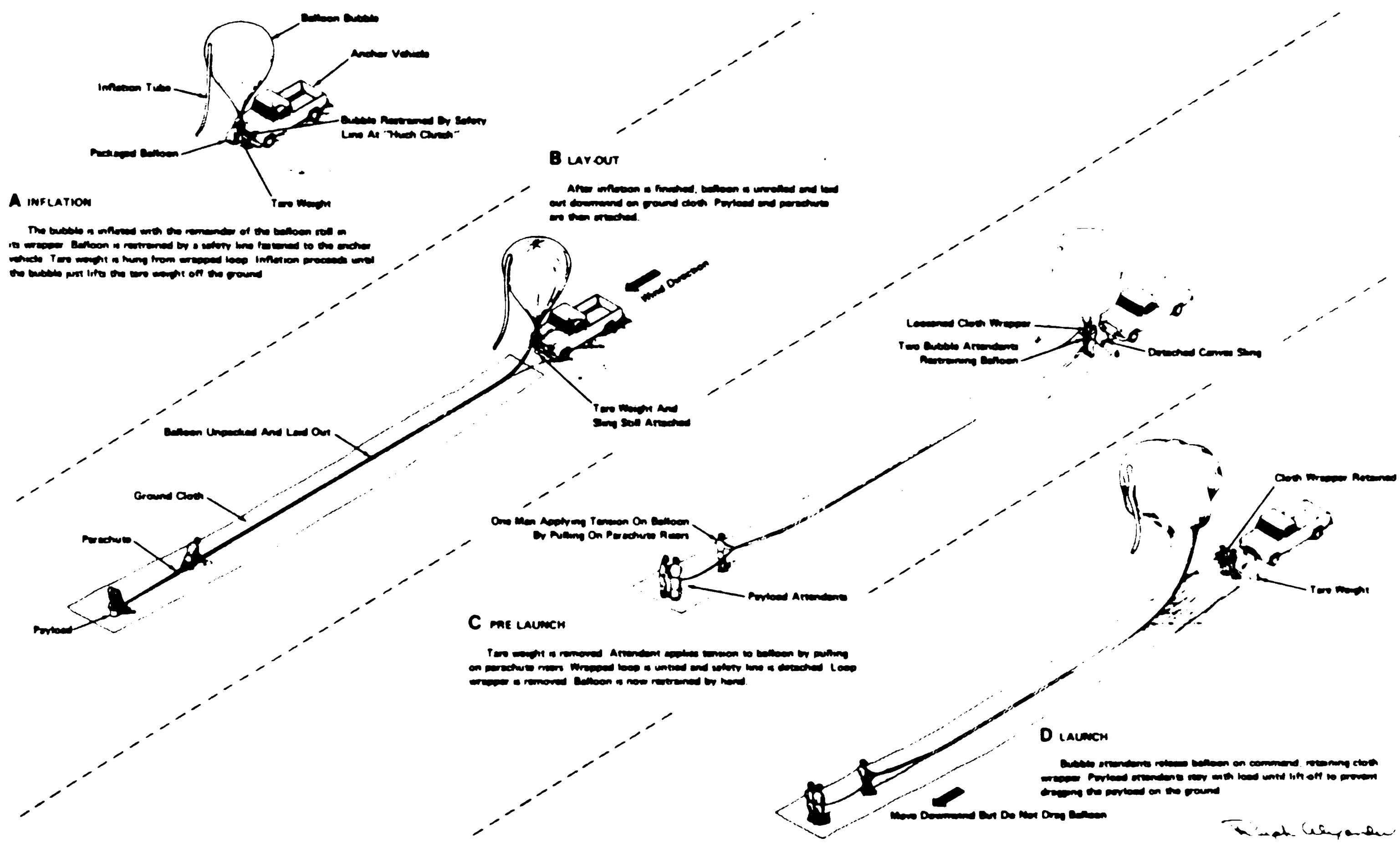

Figure 7 – Typical Sequence of Events in launching a small balloon. In step 3, balloon must be restrained by hand just prior to release, placing an upper safe inflation of about 150 lbs.

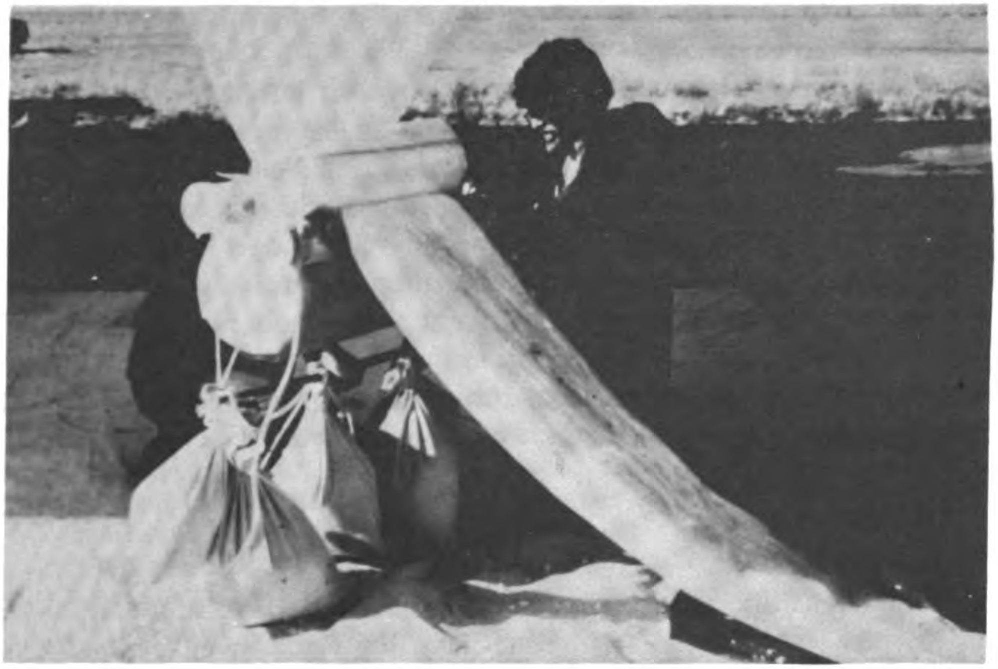

Figure 8 — Bubble restraint mechanism developed by University of Wyoming group. This device has been successfully employed in launching gross inflations of up to 260 lbs.

Figure 9 — Bubble restraint device developed by M. O. Evanick of ONR has been used to launch systems with 330 lbs. gross inflations. Pending further tests, the technique will be used for a 650 lbs. launch in early fall, 1977

This technique has been successfully used in systems with gross inflations of 350 lbs. (7).

Concern for improved safety together with interest in recovering certain payloads has spurred development of inexpensive, lightweight radio command and ranging equipment for small balloons use, which until recently had traditionally been operated with pre-set timers for flight termination. A system developed by Dr. Roger Williamson of Utah State University provides termination control and slant range. The system has been successfully flight tested and is scheduled for deployment for a full flight program in the summer of 1977 (8), (Figure 10). The airborne components of this system weigh less than 6.5 lbs including power for flight durations of up to 24 hours.

Outlook

Indications are strong that the small balloon will continue to have a high level of utilization during the next few years, even beyond the advent of the space shuttle. Its utility for primary data acquisition, which is due to versatility with respect to launch site and relatively low personnel and equipment costs, will be enhanced by increased capacity brought about by new launch techniques. It will continue to be a cost effective platform for science, training, calibration of satellite borne

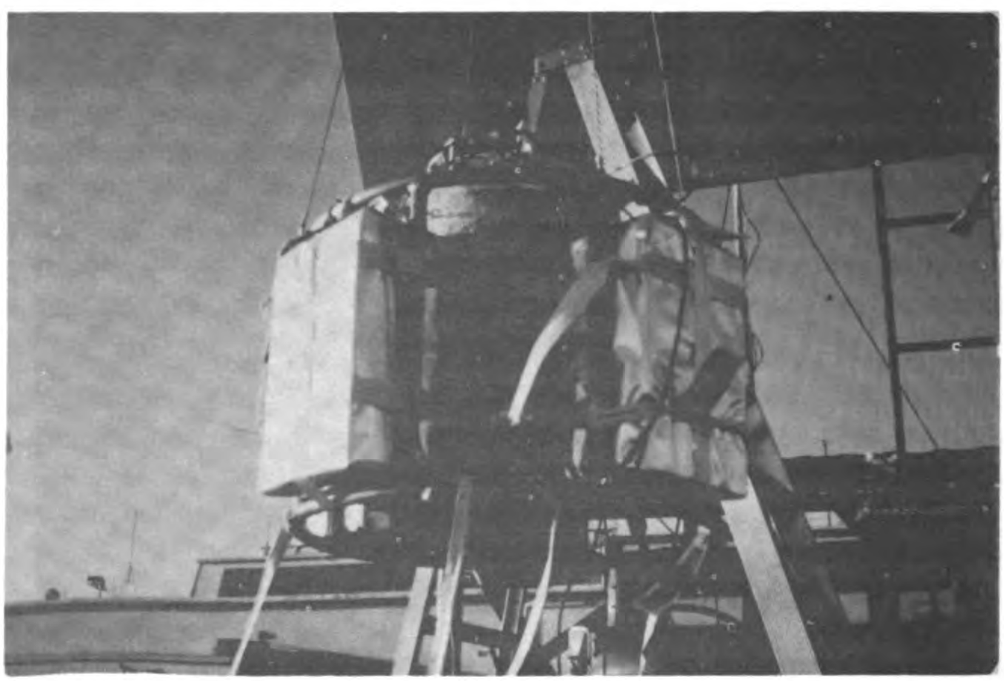

Figure 10 – Two light-weight command and ranging units awaiting launch for flight test. Each unit weighs under 6.5 lbs. including power for a duration of 24 hours.

remote sensors, and for the development of instrumentation ultimately destined for space flight (9). The balloon, including our small version, is uniquely capable of in-situ sampling of stratospheric trace constituents in regions above aircraft altitudes, and with scale definition not presently achievable by remote satellite observation (10,11).

References

1. Cdr. E. Melton, "Twenty Five Years of SKYHOOK," Naval Research Review *XXVIII*-12, 1-11 (1973).
2. J. Smalley, et al. "Basic Procedures for Small Balloon Flights." 131 pp. Office of Naval Research, Arlington, Va. 1976.
3. F. S. Mozer and R. H. Manka, "Magnetospheric Electric Field Properties Deduced from Simultaneous Balloon Flights." Space Sciences Laboratory Report, 39 pp. University of California, Berkeley, CA. 1970.
4. F. S. Mozer and W. D. Gonzalez, "Response of Polar Cap Convection to the Interplanetary Magnetic Field." J. Geophys. Res. **78**, 6784-6786, 1973.
5. D. J. Hofmann, et. al. "Global Measurements of the Time Variations and Marphology of the Stratospheric Aerosol." Proceedings of the Third CIAP Conference, Department of Transportation Report DOT-TSC-OST 74-15 pp. 284-297, 1974.
6. D. J. Hofmann and J. M. Rosen, "In-situ Measurements at Laramie, Wyoming of the Recent Increase in Stratospheric Aerosol." Proceedings of the Fourth CIAP Conference. Department of Transportation Report DOT-TSC-OST 75-38, pp. 527-529, 1976.
7. M.O. Evanick, "Semi-automatic Huch-Clutch Balloon Launch System." Patent Disclosure. Office of Naval Research. 1977.
8. P. R. Williamson, "Final Report," ONR Contract N00014-76-C-0258, 1977.
9. *The Use of Balloons for Physics and Astronomy*. Report of the Balloon Study Committees, Geophysics Research Board, 150 pp. National Academy of Sciences 1976. Chapter 3 "Comparison of Ballooning and Alternative Techniques.
10. Ibid. Appendix G, G. K. Parks, "Particles and Fields in the Magnetosphere" pp. 121-127.
11. Ibid. Appendix H, D. J. Hofmann, "Stratospheric Chemistry" pp. 128-150.

Perspectives—The Operational Link*

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Many Perspectives

Navy Research and Development Projects are viewed from several separate and sometimes mutually exclusive perspectives. You, the Principal Investigators, could be more aware of this and be prepared to act accordingly. Some persons or agencies viewing your project may have little understanding of its technical or scientific detail, and they may assess it and/or influence it negatively, without any appreciation of its true value.

Most people recognize that different perspectives exist; however, is the Navy missing opportunities because some projects aren't readily viewed and appreciated by the operator? For example, can the naval officer – an operator – who is a surface warfare specialist see the true relationship between your R&D project and the resultant change in naval capability? If the relationship is other than a direct one such as the F-18 fighter development, it is probably difficult for him to properly relate to it. In this case, can you help him develop an alternative means of assessing the relative worth of the project; that is, can you help him appreciate its scientific or technical worth, or to understand its importance for other valid reasons?

We must all recognize that these different perspectives exist and be ready to discuss the work from different viewpoints, according to the needs of the viewer. At the same time, the principal investigator must be able to keep the true relationships among a project's various facets in mind at all times.

I will discuss some of these different perspectives, and then dwell in more detail upon the operational perspective. I will summarize how naval programs are currently being evaluated, illustrate some of the difficulties the operator may have in evaluating (or viewing) R&D projects and illustrate some current opportunities which may be open to you. Although my focus will be primarily on those projects which are in the "technology base" area, the discussion is not necessarily limited to this area.

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*Extracted from a presentation made at the Tribology Workshop sponsored by ONR and NRL, October 14–16, 1975

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Many of you already understand and put into practice the idea that any written report, paper, or presentation describing a project should be put in a form that allows your intended audience to gain the most benefit from the material. Consequently, you convey project information (purpose, objectives, results, etc.) tailored toward a particular perspective. For example, you have learned that comptrollers and sponsors may need different presentations. You must translate your project information to accommodate them, so that they can better assess your project's relative worth to them.

The purpose of R&D is to provide for future capability. To assure ready naval forces in the future, we need to be technically alert and to sharpen our ability not only to put project detail into the appropriate operational perspective, but also to be able to identify and follow good ideas through from any of the six DoD Research, Development, Test and Evaluation (RDT&E) categories to fleet introduction. We must also understand from the outset that even though the project may be extremely difficult for the operator to appreciate from his current viewpoint, the project may still be a crucial part of the total R&D program.

Because of the way the Navy's R&D community is organized, the principal investigator of a "technology base" project may well face the most diverse set of perspectives of any in the system. "Technology base" is that area of the total RDT&E program which is composed of the categories: Research (6.1); Exploratory Development (6.2); and part of Advanced Developments (6.3A). These, plus the remaining part of 6.3 and the other three categories, Engineering Developments (6.4); Management and Support (6.5); and Operational Systems Development (6.6), comprise the somewhat arbitrary set of categories in the overall RDT&E appropriation. Results from "tech base" projects have for the most part application to a wide variety of our forces, and provide a critical foundation for many of our future technical options. A principal investigator of a "tech base" project must ask, "How many links with the outside world do I have, and what are their correpsondign perspectives?"

Management

The manager's perspective is most apt to stress the facilities, the allocation of personnel, and just how the project fits in with the overall program of the Laboratory or Center for which he is responsible. While there may be similarities between Naval Laboratories and their Industrial or Academic counterparts, their managment relationships are not *fully* comparable. There are differences in corporate purpose, rewards, and scope of work. Therefore, the influences that management may exert on the projects vary widely. Because of the Navy's structure, for example, the immediate superior of the Navy Laboratory's Commanding

Officer can have a pronounced influence on the way the project is viewed by others. Therefore in this case, to fully understand the manager's perspective, you must be sensitive to his immediate supervisor's perspective.

The Sponsor's Perspective

The sponsor's perspective is crucial for the project. His primary emphasis frequently is: where can I get the most return from my investment? One should not make generalizations of sponsors. They differ in many ways; the task orders of some may be very general statements of work to be done, while others will give detailed and lengthy specifications. But in most cases, the sponsor must subject your project to a review chain. By the time your project has been molded into higher aggregates of RDT&E activity, you may find it hard to recognize your original input, or even, in some cases, your project. In a few cases the review chain for a Navy Laboratory project could culminate or and possibly terminate with a presentation to a Congressional committee. You, therefore, are challenged to tailor your initial inputs so that the *true* relationships can be preserved throughout this sequence of events; a sequence that may have a bearing on how or *if* the project is to be supported.

Intra/Interdisciplinary Perspectives

As a scientists you are likely to be most deeply involved in and supportive of persons and organizations in your own discipline. It is the approval of these peers which constitutes much of your psychic wage. From them come the panels of referees who review your work for publication in scientific journals. You and they share so much and are so important to each other that you are strongly pulled to present your work in ways that you know will be best understood and be most impressive to them. In fact, the scientists frequently feels himself more strongly attached to his professional community than to the organization in which he is employed.

But in your RDT&E area, it is not only the scientific peers to whom you must speak and to whom you must be heard, but also to managers, comptrollers, sponsors, and operators. You share with members of your own discipline a common language and a common perspective; but, the people to whom you *must* speak, such as managers and sponsors, may not share that language or perspective. Suppose you have written a superb article for a scientific journal on statistical applications which support a model of an intricate air-to-air encounter, the naval officer who is an air warfare specialist may not easily understand what you have written, even though he may have years of practical experience in exactly the subject of your article.

In fact, members of another scientific discipline may not wholly understand or appreciate your insights unless you are capable of "translating" your work to them in the requisite jargon. But members of other disciplines are important to the development of your own project, for they can offer valuable insights and collaborative areas of interest. They can do this only if they can understand your notations, your acronyms – in short, your language or jargon.

Talking to the Operator

Naval officers who are operating existing equipment, assessing current capabilities, acquiring new systems, and developing tactics look at your project from a "Fleet perspective". Their perspective of a "tech base" project may be misty. This is partly due to development or "lead" time. The average development time for the results of a "tech base" project to influence Fleet capability is from 7 to 14 years. The typical naval officer may have trouble getting excited about anything that far downstream.

Another factor may be risk; a factor which frequently may be taken out of context. Terms suitable for describing the developmental risk of a software modification to the Navy Tactical Data System may not apply to the risk associated with the application of a new polymer or the confidence of success in some exploration of a space frontier. Basic research is a very risky business, and an all inclusive risk statement for a "tech base" project can be very difficult to frame. The principal investigator may be called upon to demonstrate, perhaps repeatedly, that a project which produces negative results may be just as important (or more so) than one which produces positive results. That is, the demonstration of what probably will not happen may be as useful as showing what probably can happen in determining the shape of things to come.

A third factor is the project's apparent worth to a Fleet system. It is frequently difficult to show how the results of projects which significantly alter a component or subsystem of a major weapons system change the war-fighting capability of the major platform. The current methods used to assess or estimate force capability are frequently not sufficiently sensitive to show the differences at the subsystem level. For example, two different turbine gear box greases may indeed be two very different breeds of cat. The discussion and eventual decision as to which grease to use, and the preferred characteristics may never be obvious to the operator. Thus, the visibility and relative worth of this project may not be as easy to portray as others. To be visible, it must be made apparent to the operator.

The Link to an Operational Capability

The essential path to the development of an operational perspective and an effective two way link with him lies in how well you understand his operating environment and he yours. You both must have some appreciation foreach other's current capabilities, and limitations. If this path is not established, then you will not be able to relate your project to present and future Fleet capability. Additionally, there is a need for people involved in "tech base" activities to follow ideas and experimental results through to a logical conclusion, and not to assume that others, including the operator, will pick up the ball and run with it. The importance of this following through to effect efficient transfer of technology seems to be well understood by industrialists.

The Key Operator

The key operator in the Fleet is the Chief of Naval Operations (CNO). From his experience and from his perspective at the pinnacle of the operating naval forces, he provides a view of the Navy relative not only to the other uniformed forces but also to the other agencies of the Executive Department such as Departments of State, Commerce, Transportation. His view must also include provisions to convey the idea of Navy to the public through congressional liaison, the press and community programs. True, CNO has many advisors. True, also, that persons commanding units afloat may have a slightly different perspective of your research project than that of the CNO. However, it is useful to be aware of how these two points of view (the CNO and the afloat commander) bear on you, the principal investigator.

The CNO's view is based on an indepth, professional understanding of how naval requirements are derived frm national strategy. In several different ways he has, for the record, explained his understanding of these complex relationships.

The most recent statement of record is his 1977 Report to Congress (1). In this posture statement he builds the case for maritime superiority as a requisite element of the national military strategy. That strategy is a *forward* strategy, driven by geopolitical considerations. He notes that 40 of our 42 allies lie overseas, and that the increasingly interdependent free-world economy depends on the continued use of ocean shipping. Out of these understandings, the CNO interprets the Congressional Statement of the Navy's mission (2), defines its functions, and determines the employment of our naval forces. These factors in turn drive our naval requirements; they shape the military characteristics of our ships and aircraft; and they determine how we size our forces.

Thus from understanding our force capabilities and from an understanding of the capabilities of potential adversaries, the CNO advises the Congress of the risks involved and the advantages to be served in authorizing and appropriating national resources for naval programs.

Further, the CNO heavily stresses the importance of relating the objectives of current Navy programs and projects to their contribution to naval capability. This is the ultimate scale on which each and every project, including your project, must be weighed: what does it contribute to naval capability?

Competition for resources is keen, so every idea about how capability can be enhanced by better use of existing resources, or about what radical departures from present programs may be necessary, must be put to the test of *Fleet perspective*, the combined viewpoint of the naval officer on the ship today and the Chief of Naval Operations. For all its attendant complexity, the test is brutally simple – or simply brutal.

With an understanding of this perspective and how it has been derived, you are in a better position to do two very important things:

- Sharpen your long-range research objectives, and/or to better understand the CNO's Scientific and Technical Objectives (STOs).
- Appreciate how interim results may supply short-range solutions for current problems.

The Commander Afloat

Let us consider now how you can describe the importance of your project to the commander afloat. Your description, language and format, depend on the *degree of relevance* the commander afloat can be made to comprehend. To illustrate, let us look at four different projects; one of them is clearly relevant, and three have more technically based roots which makes relevance somewhat more difficult to demonstrate.

A Clearly Relevant Project

The afloat commander can easily visualize how the introduction of a new carrier-based fighter aircraft—say the F-18 – can enhance his combat capability. With clearly defined improvements over the F-4 aircraft that it is intended to replace, the F-18 will complement the F-14 and provide a much needed contribution to the Navy's air warfare capability. Both the fighter and the planned attack version of the same aircraft will incorporate proven and low risk technical advancements with the result that logistic support will be simplified and effective fire-power will be available using a wide range of air-to-air and air-to-ground weaponry.

He can also see easily how this new capability can be introduced, for within their own experience most senior officers have seen one or more new systems introduced. His perspectives, therefore, allow him to understand readily the efforts and end product of the project manager and/or principal investigator. The chief challenge here may not only be to successfully introduce the F-18, but to develop effective feedback to the "tech base" activity in order to help improve the product and maximize the possibility that it can lead to future answers to future needs.

Projects With Less Immediately Perceptible Relevance.

a. *Chemistry*. From the field of chemistry we can draw two examples whose relevance to his needs the afloat commander may need more help in seeing.

(1) Let us say that your project is the development and introduction of a better way to sample and analyze air quality. The submarine afloat commander immediately understands the relevance of your work, but does the air warfare specialist? For him, and for the surface warfare specialist, you may have to work harder to show the value of your project.

(2) Our knowledge of the mechanics of corrosion is still far from complete. Our afloat commander, regardless of his warfare specialty, will easily see how answers to corrosion problems are relevant to him. But where he may have trouble and, therefore, where your challenge lies, is in being made to see that although work on these questions seems to be perpetually continuing, the development time (or result) is not predictable, and yet the questions are far too important to be abandoned, i.e., not funded. Conversely, by cultivating and strengthening a dialogue with him, you may be able to help him make some feasible near-term applications of your short-term results. To put it another way, you may be able to give him some help today, and he can give you some support for the many tomorrows. But none of that will happen unless you are able to appreciate his perspectives and you are able to help him to understand yours.

b. *Space*. Naval interests in space are clearly relevant and the CNO refers in the cited report to some of the current uses of space technology. He mentions specifically the contributions of satellites. How this far-from-well-understood frontier of space including astronomy will affect our future naval capability has only begun to emerge.

In his book titled *Amazing Universe* (3), Dr. Herbert Friedman evoked the lure of the heavens. "How does it feel to find a star that winks on and off thirty times a second, or to hear what may be the whispering echo of explosive creation 16 billion years ago, or to discover an X-Ray star a hundred thousand times as bright as the sun?" Note that in this straightforward layman's language, Dr. Friedman immediately engages the reader, regardless of his particular perspective. Once engaged, the reader can be introduced to more sophisticated concepts, such as neutron star densities on the order of a billion tons per cubic inch. Dr. Friedman gradually expands the complexity of his vocabulary until the lay reader is eventually led to understand something about quasars, pulsars, and black holes. This is a useful example of addressing oneself to other people's perspectives.

How does the afloat commander view these astronomical findings? He will probably feel that they have absolutely no relevance to his day-to-day Fleet realities. But space *is* relevant, and it is in this very area of astronomical research that the Navy may find radically different and useful ways of executing its mission. Here, therefore, is an example of the greatest challenge to a principal investigator. If you are working in a project in this area or one with a similar appearance of nonrelevance, *you must be persistent* and *imaginative* at communicating your true progress to the afloat commander. Frame your present results where possible in terms that relate to his immediate needs and capabilities. Challenge and provoke him to bring his own operational experience and wisdom to bear on the problems you are encountering. Ask for his observations, perceptions, even his intuitions. Your efforts may well bear fruit and provide him and the Navy with an extraordinary capability.

Suppose the project is non relevant? Credibility is a much-discussed term these days. In talking to the naval operator, you must remain credible if you are to receive his support. This means candor, even when it hurts. If and when you see that your project appears to have little or no relevance to future naval capability, you need the courage to say so, even though you know that in that event the chances are good that support for your project will cease.

But take heart. There are very few areas in the scientific domain in which the Navy does not have either an active or a latent interest. If you can candidly admit that your present project appears to have little relevance, it is possible, even likely, that you will then be freed to work on something of greater or more easily demonstrable relevance. But if you succumb to the temptation to mask or alter your own research perspective, you may win short-term victory at too high a price.

It is your unique responsibility to develop within the Navy the understanding that there is a need to support a wide diversity of research. Further, you are uniquely responsible to educate the naval planners that the criteria for essentiality may not have anything to do with the current set of naval forces. True, the lack of a clear operational perspective for any given project may complicate the resource allocation procedure, but it does not necessarily mean that a project not clearly related to such a perspective should not continue to be actively pursued. Your task is to look beyond the here-and-now, beyond the horrendous problems of the program managers and to visualize, cleary or dimly, the problems of the future and continue to seek an understanding.

Opportunities for Application of Interim Results

We have already touched upon the value to both the Fleet and to the principal investigator of finding applications for interim results. We also note that the Navy's top priority for the allocation of resources is Fleet readiness. Fleet readiness and interim results have a significant relationship.

Fleet readiness is defined as the current capability of naval forces to carry out their roles in prompt response to the orders of the Commander-in-Chief. It is composed of three factors—personnel readiness, material readiness, and operational readiness.

Material readiness, that is, the material condition of our ships and aircraft should be of great interest to a principal investigator in the fields of materials or electronics. Material readiness is a matter of acute concern to naval operators. Many equipments are not working as advertised; also there is a crying need for better coatings to apply to ships' interior and exterior surfaces.

Fundamental investigations are needed to determine how the material condition of systems can be better evaluated, how this condition can be described in terms that each of us can understand, and finally how they can properly be maintained.

Do you know the functions of various equipments? Only when you do can you design better equipment. Or, you may be able to eliminate their function and develop a way of performing a segment of the larger task so that this particular function is no longer necessary. For example, if the need for high pressure air aboard ships could be eliminated, then the requirement for a more reliable high pressure air compressor could be by-passed.

Another example, the direct relation of environment to operational capability is obvious to most people, but the *marginal* changes in capability due to environment factors is less obvious. If you can show a naval operator why his widget works like a charm at 60°F water temperature but sulks at 65°F, and how to cope with this variation, he'll be your friend and supporter for life.

Summary

There are many different ways of looking at an RDT&E project. The principal investigator needs to be aware of the differences, and to structure the project information in order to permit his work to be viewed from the various perspectives and still keep the *true* relationships intact. Of the perspectives discussed, the role and significance of the perspective of the final user, in this case, the naval warfare specialist needs to be strengthened, particularly for projects in the "technology base" which represent the source of future capability. There are clear and relatively straightforward ways to establish this perspective. With some effort, the relationships to naval capability can in most instances be traced. The determination of the relative worth may not be easily amenable to standard analytic techniques for determining the change in naval capability. In this case, decisions regarding relative worth must be made on a subjective basis. Because of this fact, the principal investigator needs to maintain appropriate communications with all who have an interest in the work, to be alert to the need to clarify and recognize the importance of continually educating the user community, and to seize every opportunity in this area. Finally, the opportunity for the application of interim results to solve current fleet problems can be enhanced by strengthening the operator's view of the principal investigator's project, and by establishing an effective two-way link between investigator and operator.

References

1. James L. Holloway, Chief of Naval Operations, CNO Report on the Posture of the U.S. Navy, April 1977.
2. Navy Mission Statements: Title 10, U.S. Code; JCS Publications and DoD INST 5100.1.
3. Herbert Friedman, *Amazing Universe*, published by National Geographic Society, Washington, D.C., 1975.

AUTO SCALPS MAN

Microsurgical techniques recently developed under an ONR Biophysics Program project enabled doctors at the Ralph K. Davies Hospital in San Francisco to successfully replace the scalp torn from the head of a Santa Cruz man.

James Homer, a long-haired chef, crawled under his truck to investigate some engine noise. His long hair, blowing in the wind, became caught in the universal joint of the spinning drive shaft. His 10 X 16-inch scalp was ripped off, separating just above his eyebrows and ears, exposing the bald skull.

The patient was rushed to a Santa Cruz hospital by friends and then transported by ambulance to San Francisco where the necessary microsurgical techniques were available. Apparently there were three full rotations of the drive shaft before the scalp was fully separated, as three distinct U-joint cuts were found in the scalp. In addition, a 2 X 3-inch avulsive skull fracture was found. The 17-hour-long operation, under the direction of Dr. Harry J. Buncke, involved matching and suturing of millimeter-diameter blood vessels and nerve sheaths from the temple area of the skull to the torn scalp before the two could be joined.

The operation appears to be a complete success and the first ever done in America. A similar operation was performed in Australia–last year by a student of Dr. Buncke's.

Research Notes

RADIATIVE COLLISIONS

Professor John Weiner, Dartmouth College, has been studying with ONR support the nature of single collisions processes occuring in the presence of an intense laser radiation field. Using mass spectrometric analysis he has positively identified the NaK^+ molecular ion, and believes this to arise from a laser-induced associative ionization process Na(3p) plus K(4s) plus $h\nu$ to give NaK^+ plus an electron.

This work is potentially very important because it represents the first direct observation of an associative ionization occurring under a single collision conditions, and, in addition, it is the first example of a radiative collision or a "laser induced inelastic collision" producing two chemically distinct products. The radiative collision, which was first discovered last year under ONR support is an especially important process because energy transfer can occur between two different atoms whose levels have large energy separation. In this process the energy defect associated with this event is overcome by the presence of a radiation field applied during the time of the collision at a frequency close to the difference between the transition frequencies.

The present experiment uses crossed atomic beams of Na and K, and a single tunable dye laser is focused on the beam crossing region. This laser is used to pump the sodium resonance transition to saturation; and the same wavelength probes the NaK^+ vibronic levels by inducing a transition between the time-dependent Na(3p) K(4s) collision complex and a sationary vibronic state of NaK^+ plus an electron. With the addition of a second dye laser, now being interfaced into this experiment, this work has the potential for providing a definitive study of radiative collisions, because, unlike the previous studies, it is done under single collision conditions, and the detection of molecular ions is intrinsically more efficient (higher signal to noise ratio) than detecting photons in the presence of a large background. In these new experiments the first dye laser will be tuned to the sodium resonance line while the second laser will be used to scan all possible vibronic states of NaK^+.

A NEW NUCLEAR DOUBLE RESONANCE TECHNIQUE

Dr. Robert W. Vaughan of Caltech under ONR contract has perfected, over the past two years, a multiple-pulse double resonance scheme which permits nuclear magnetic resonance (NMR) studies of solids. Vaughan's scheme is the most elaborate, and apparently the most successful, of the many attempts made to obtain NMR spectra of solids. The scheme involves looking at the influence which two spin-1/2 nuclei, rather than only one spin-1/2 nucleus as in ordinary NMR, have on microwave absorption by the compound or system being studied. Of these nuclei, one is dilute and the other one is abundant. In compounds studied by Vaughan so far, such as benzene, calcium formate, and trichloracetic acid, the dilute nucleus is ^{13}C and the abundant nucleus is ^{1}H. The result of such studies is geometrical, orientational, and motional information not otherwise available for polycrystalline solids.

This kind of intimate information is precisely what is sought for the first molecules which sorb on a solid surface. It is suspected that geometrical, orientational, and motional characteristics of adsorbed molecules are changed drastically by their binding with the surface. Indeed, some of the characteristics of the surface are also changed by the adsorption of molecules. Few "hard" data on such changes are available, however. Correlation of such changes with the processes mediated by sorption on a surface, such as catalysis, has only barely stated. Vaughan's instrumental technique appears ideally suited to this purpose. Preliminary experiments show that high-resolution solid state ^{13}C chemical shift powder patterns of formic acid adsorbed on a zeolite can be obtained. Vaughan expects to use a series of simple adsorbates, and catalytically important adsorbents, in further studies with this technique.

SHARK BEHAVIOR STUDIES

Dr. Donald R. Nelson, Professor of Biology at California State University, Long Beach, and principal investigator on an Oceanic Biology project, for the Office of Naval Research has been concerned with behavioral patterns of several species of sharks. They have been studied in their natural habitats, utilizing telemetric tracking to locate and follow tagged specimens, and employing underwater photography to record normal swimming movements as well as agonistic postures (aggressive displays). A more complete understanding of the latter should provide clues which would enable a diver to predict how a shark might react to his approach.

Observations were carried out on four species. The feeding behavior of the Blue Shark (*Prionace glauca*), which often reaches lengths of four feet or more, was observed during scuba dives several months ago in the ocean off Catalina Island. Most of the observations and film records on swimming aggregations of sharks, however, were made on three other species last year during expeditions to Rangiroa Atoll in French Polynesia, and to Eniwetok Atoll in the Marshall Islands. The three species whose behavior and movements were studied in the mid-Pacific included the Reef Whitetip (*Triaenodon obesus*), the Blacktip Reef Shark (*Carcharinus melanopterus*), and the Gray Reef Shark (*C. menisorrah*). The latter species is considered to be the most dangerous.

Nelson has designed and constructed a prototype of a battery-power submersible vehicle, which will enable a scuba diver-observer and camera operator to approach groups of sharks safely at close range. This will help him to collect much more data on the species, age, and sex makeup of the swimming groups, as well as on the characteristic behavior of individual types.

Nelson has also continued work on the development of improved ultrasonic telemetry instruments (originally described in an article in Naval Research Reviews, December 1974, pp. 1-21). He has recently fabricated a transponding transmitter that permits extended observation, and a sensor module that provides up to eight channels of information, e.g., compass bearings, depth, speed, temperature, and ambient light. The analog data from the sensors will be recorded on magnetic tape. He has developed a digital distance gauge, employing synchronized quartz clocks, that permits precise monitoring of a tagged shark's location by a swimmer. These instruments provide a wide range of flexibility to locate subjects for observation.

Recently, a microcomputer was purchased to acquire and process data. The real-time analog data from tapes is replayed at high speed, digitized, and punched out on paper tape. Data on paper tape are subsequently analyzed using the University's large computer, and is printed out as eight parallel graphs of sensor state vs. time. These graphs provide detailed information on the tagged shark's behavior.

Nelson and several of his graduate students are now in Eniwetok to continue their research. They will utilize their new submersible and telemetry equipment. During the coming year, they also expect to initiate tagging and behavioral studies on the Mako or Bonito Shark (*Isurus oxyrinchus*), a pelagic shark often reaching a length of ten feet, found off the shores of Catalina Island.

SUPER CORRODING ALLOYS

A family of supercorroding magnesium alloys that react spontaneously and vigorously with seawater to produce heat and hydrogen gas has been developed by the Civil Engineering Laboratory (CEL), Naval Construction Battalion Center, Port Hueneme, Calif.

The original research was focused on adapting the magnesium seawater reaction for the development of a self-contained Navy diver heat source. As the result of this basic research, the new technology of supercorroding alloys (so named because of their extremely high corrosion rate) was created. Investigations revealed that the reaction was so vigorous that the alloys could be adapted to equally important applications such as the generation of hydrogen for buoyancy, thermodynamic engines and fuels cells, and the development of corroding links to retrieve oceanographic equipment.

Supercorroding alloys are formed by a mechanical process which bonds anodic metals to cathodic materials. The alloys are produced by repeated flattening, fracturing, and cold welding of the powdered constituents within a high-energy ball mill.

Various cathodic materials in different proportions were alloyed with magnesium and tested to determine corrosion characteristics. For four years, engineers at CEL have been considering methods for manufacturing powdered metals that would produce high reaction rates for an improved heat source for divers. Efforts were hindered by the inability to achieve intimate bonding of cathodic and anodic materials

Learning of a new alloying process developed by the International Nickel Co. which forms unconventional alloys, the engineers concluded that the same procedure appeared applicable to CEL's attempts to overcome poor bond strength which had previously hindered rapid corrosion. By cooperating with company metallurgists, the first family of supercorroding alloys was created.

Most of the research has been directed at producing alloys with magnesium as the principle element. Magnesium alloys of iron, copper, nickel, and other cathodic materials have been developed and tested. Studies have found that corrosion/reaction rates escalated with increased cathode content, up to approximately 10 atomic percent cathode content. Higher percentages showed decreased reaction rates. Reaction rates also vary with different cathode materials with iron and nickel being the most active. One of the slowest reacting cathodes tested was titanium.

The corrosion reaction rates also are dependent upon environmental factors such as temperature, pressure, and to a lesser degree, salinity. It is possible to alloy a salt as a third constituent to further increase the reaction rate or make the allowy react in fresh water.

In developing supercorroding alloys as a heat source for military divers, it was essential to provide both rapid generation of heat and high reaction efficiencies. Magnesium-iron alloys apparently meet these requirements.

In one fuel-type heater system proposed by CEL, the alloy is slurried with inert ingredients to facilitate pumping. Approximately equal volumes of seawater and slurry are injected into the open-ended reaction tube. The produced heat is removed by the counterflow fluid that surrounds the reaction tube. The heated fluid is then circulated through a water circulation garment worn by the diver. Fresh seawater is preheated by the expelled reactants and products in order to conserve energy. CEL will test this type of heat reactor in the near future.

The production of hydrogen is a second application for supercorroding alloys. Hydrogen is especially suited for ocean buoyancy because of its low molecular weight. The gas can be used in a safe, simple, reliable and compact mode wherein approximately two pounds of the alloys would produce a ton of buoyancy at the surface in less than five minutes.

There are many ways in which supercorroding alloys could be used to produce hydrogen. If a totally controlled production rate is desired, a slurry metering system, similar to the diver heater application, could be used. For small buoyancy generators, gas could be generated by rupturing a plastic pouch containing the alloys. The pouch could be located beneath the container that collects the gas. The container would be attached to the object to be lifted.

Hydrogen can also be used to power hydrogen-type fuel cells which produce electrical energy.

The third application for supercorroding alloys in the construction of sintered self-destructing corroding links. In many ocean engineering projects, a timed release device is needed to shed temporary hydrodynamic drag reduction shrouds and/or to assist in recovering various instrumentation packages. The majority of devices presently used are either not totally reliable or are extremely expensive. Their corroding links require two separate parts (anode and cathode) that must be electrically connected to promote link destruction. The connections often break down and are unreliable.

Since supercorroding alloys are inherently self-destructive, there is no need for electrical connections. Release times could be controlled by sizing the dimensions of the supercorroding link or by selecting the alloy composition.

CEL would like to develop a family of corroding links that predictably would release an underwater instrument packet in a matter of minutes or hours.

Tentative plans also call for development of an experimental model of a totally self-contained buoyancy lift device for diver and submersible use.

TOWARDS A NEW CLASS OF BLUE-GREEN LASERS

Laboratory experiments at the Naval Ocean Systems Center, San Diego, have produced the first known laser action in the visible spectrum between two molecular electronic states in which the higher energy state is the direct product of photodissociation.

Laser action was achieved by the photodissociation of mercuric bromide which produced output in the 502 nanometer to 505 nanometer spectral ranges. This is within the "ocean window" which is of interest to the Navy since it constitutes a wavelength region which permits the transmission of light energy in ocean waters.

Mercuiric bromide maintained in its vapor state was pumped with 193 nanometer energy produced by an argon flouride excimer laser, raising triatomic mercuric bromide molecules to a higher energy level where they dissociate into electronically excited diatomic mercurous bromide and bromine, producing laser energy in the visible blue-green spectral region. The laser has operated in the laboratory for extended periods of time without noticeable deterioration of the lasing material. This indicates that the mercurous bromide radical recombines with the free bromine after lasing to form the original mercuric bromide.

The very small amount of mercuric bromide needed is hermetically sealed in a quartz cell heated to $200^{C^{\circ}}$. The handling is completely safe and no problems with environmental contamination are encountered.

The new development is important because it opens a generic class of new, potentially highly efficient lasing materials suitable for excitation by photodissociation including, among others, the dihalides of zinc, cadmium and lead.

Although the mercuric halides have been listed among numerous other materials as potential candidates for excitation by photodissociation, no experimental results seem to have been reported. This might be explained in part by a lack of suitable pump sources.

Excitation via photodissociation is the first step toward the development of a new class of efficient blue-green lasers for naval systems applications. Excitation is also possible by direct electron impact in a pulsed discharge configuration. Experiments are now underway at NOSC to achieve laser action under those conditions.

BIOREGENERATION OF ORGANIC CONTAMINATED ACTIVATED CARBON

The Environmental Protection Agency (EPA) requirement that oil content of water pumped into harbors not exceed 2 to 5 ppm has caused the Navy to abandon its long-standing practice of pumping bilge water into harbors. Instead, it has often been pumped into local sewer systems. However, these systems often become saturated, so an alternative method of removing the oil from the bilge water prior to discharge from the ship is required.

The Navy utilizes a three-step separation method. The bilge water is first passed through a mechanical separator which skims off the large globules of oil. The second step involves passage through a coalescing filter in which the smaller droplets are removed. The water is finally passed through an activated carbon bed to remove residual amounts of oil.

After a period of operation, however, the activated carbon pore spaces become saturated and the carbon bed must be regenerated. This requires removal and thermal treatment to remove the oil by evaporation. The method is inconvenient and costly.

Mr. Ernest E. Lory, of the Civil Engineering Laboratory, Port Hueneme, is conducting ONR-funded research to investigate the feasibility of using microorganisms for both off-line and on-line filter regeneration. The underlying concept is that oil-degrading bacteria secrete enzymes that penetrate the pores of the carbon bed (which are of the order of 100 Å in diameter), where they digest the oil into nonpolluting products to a degree sufficient to meet EPA standards.

Research is directed toward establishing optimal environmental conditions for bacterial action. During normal use, the carbon bed tends to become acidic. If the reaction of the fluid in the carbon bed is maintained near neutral (pH 7.0), however, regeneration of the bed through bacterial action is favored. It is also essential to supply critical nutrients, especially phosphate, to facilitate bacterial growth.

Both pure and mixed cultures of bacteria have been tested for their efficacy in regenerating the carbon bed. The cultures of bacteria tested were obtained from a collection of oil-degrading strains that Dr. T. B. O'Neill had isolated under an earlier ONR Microbiology-funded project at the Civil Engineering Laboratory. Tests with mixed cultures have produced the best results, probably because one or another of its component species has the capacity to respond favorably (produce oil-degrading enzymes) to each new environmental change that develops as the "carbon bed culture" ages. Lory uses an infrared spectrophotometry technique to measure the amount of oil biodegraded at periodic intervals.

Additional experiments will seek to determine whether various combinations of bacteria can achieve more effective results. Identification of limiting nutrients and the addition of these should upgrade the efficiency of the bioregeneration process. Further research should reveal whether the use of bacteria proves to be a cost-effective method for regenerating the active carbon bed.

COCKPIT COMPUTATION

Because of the LSI "revolution," it will be possible, in a few years, to install the equivalent of a present-day large scientific computer on aircraft. Once powerful LSI machines are available on the ground, it will be an easy and brief step to militarize them. A few packaging changes is all that is required. This will make essentially unlimited logical processing power available in the cockpit. It will be possible to compute almost anything. The question then becomes what to compute in order to best augment the pilots' abilities.

Recently Dr. Dan Cohen of the Information Sciences Institute made a compelling case that the time to investigate these questions is now. He cited the precedent of computer graphics, where great sophistication has been achieved on the ground in the past ten years. However, when it came time to fly sophisticated graphics, the cockpit designers found that inadequate research had been done in airborne applications. The result is a "seat-of-the-pants," first generation cockpit graphics design.

Cohen is doing a small study for the Office of Naval Research and OP-098 to define a research program in cockpit computation. His thinking centers around techniques to aid the pilot's functioning as decision maker by reducing the amount of pilot attention required for the relatively mechanical aspects of flying. Any number of ideas suggest themselves. Both instruments (which can be displayed in any format on a CRT) and controls could be customized with a specific task in mind, e.g., different instrument displays are appropriate for low-level, terrain-following flight and for aerial refueling. Instrument displays could also be customized for individual pilots.

The computer could help the pilot with his instrument scan. It could be particularly helpful in monitoring combinations of instruments for trends which suggest trouble. It could also suggest the most likely diagnoses.

The inhuman speed of the machine could probably be effectively harnessed to aid the pilot in those emergency situations where fast action is essential. For example, by monitoring speed, attitude, ground proximity, and engine performance, the computer might be able to give better advice about when to eject or when not to eject than the stressed pilot could generate for himself. It can happen that in certain airplanes an engine failure must be responded to (by shutting down) within two seconds in order to avoid losing the plane. The pilot usually cannot read the instruments and make the diagnosis that quickly. The computer could flash a message on the CRT in milliseconds. Depending on the probable consequences, it might be desirable to actually close the loop in this case and have the computer shut the engine down–this feature could have an override for low altitudes.

There are any number of useful tasks that a computer can perform to aid in aerial combat. Two obvious examples are energy management guidance and the real-time computation of missile launch envelopes.

The possibilities for cockpit computation are almost endless. A research program to sort out the most attractive alternatives seems to be indicated. Even though raw processing power will decrease in cost almost to zero, the cost of the software to implement sophisticated systems will remain high. A set of priorities will be required.

STORM STUDY PLANE

Flying into thunderstorms, with lightning flashing near their single engine research plane, scientists from the New Mexico Institute of Mining and Technology conducted a study of electrical storms in the Key West area. This Naval research sailplane, piloted by J. William Bullock, flew into active thunderstorms in the area to study cumulus clouds.

This project at Key West is part of an international thunderstorm research program involving many of the world's leading atmospheric scientists. These scientists are seeking to understand the details of how clouds make rain and produce lightning. Researchers for the project are Professors Charles Moore of New Mexico Institute and John Latham of the University of Manchester.

Investigation of activities in storm clouds will help us understand nature and give us a reference for future use. Some of the questions the scientists are trying to answer are:

U. S. GOVERNMENT PRINTING OFFICE: 1977 O - 247-019

1. Does rain cause static electricity, thus producing lightning, or does static electricity cause the rain?

2. What element of a cloud carries the electrical charge?

3. Would a missile launched from a submarine under the sea trigger static electricity in the clouds, causing an electrical storm?

Much of the instrumentation on the airplane was designed by Dr. Hugh Christian of New Mexico Institute and Dr. Anthony Illingworth of the University of Manchester.

The Schwieizer sailplane is specially equipped with instruments that record atmospheric, electrical and cloud physics measurements, and it has a 60-foot fuel-filled wing. The former Air Force drone was converted to a piloted vehicle by Mr. Bullock, when he added 22 inches to the overall length of the craft to support the cockpit. As a drone, a pilotless aircraft, the plane flew to altitudes of up to 39,000 feet and achieved 29 hours of flying time. Piloted, this turbo-charged sailplane has been to 36,000 feet and has flown a total of 250 hours in storms.

This project is part of the Office of Naval Research Program of atmospheric research.

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Editor: WILLIAM J. LESCURE

NAVSO P-510

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Cover Caption

Shown here is the release at Byrd Station, Antarctica, in January 1967 of an 80,000 cu. ft. balloon of 3/4 mil. polyethylene carrying an x-ray detector payload. *(See page 1).*

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