EPILOGUE

R. Ray, R. R. Brownlee, H. M. Peek, and D. R. Westervelt

As Ogle might have put it, we had to fuss a bit with the question: What should we do about Chapter V? The decision to proceed as we have was not casually taken. It was clear that the author's concept of that unwritten chapter involved "Lessons Learned," but to the further questions: From what? About what? and By whom?, we were not certain of answers in spite of our close association with the project. Eventually we realized that the best evidence on which to base a decision could be found in Bill's own record of concerns and actions during the 20-odd years following the events of this account. Those years brought their own lessons, and Ogle played a vital role in bringing them to the nation's attention.

Thus, instead of a Chapter V we offer an Epilogue. It is in the nature of epilogues to summarize related events that occur after the conclusion of a story, and we believe that this is appropriate here. The text, as Bill left it, certainly contains many lessons specifically for those who may be called upon in the future to respond to a similar national need. We will summarize those that seem most important to us, but also will leave many more for the reader to discover. It was Ogle's style to provide leadership by making the system* think. We offer our own observations in the same spirit, and must assume full responsibility for the result while acknowledging our debt to the author as leader, tutor, colleague, and friend.

It is our belief that, strictly speaking, the period of test resumption in 1961-62 ended before the most important moratorium-related lessons for the nation had emerged. These lessons, the most important of which we have tried to state below, were not self-evident, but had to be learned as evidence accumulated.

Without knowledge of certain events that followed the history presented here, even a thoughtful reader might be excused for reaching conclusions that are erroneous. It would be possible, for example, to read this account carefully and note that, after all, it was possible for the United States to resume useful testing underground only two weeks after the first Soviet explosion; and that although the Christmas Island phase was delayed for a number of months, most if not all of the weapons tested there performed admirably. At this point, a reader might be tempted to ask "What is the problem?" The problem is that these facts, by themselves, are incomplete and misleading. Ogle, who was very much involved in the events that followed, never hesitated to point this out; we therefore see it as our duty to attempt here to do so.

*Several times in the text, and now here, "the system" is referred to. It is a term of art that we think deserves definition. Usually when Ogle referred to "the system" he meant the entire community of doers: politicians, executive decision makers, scientists, military players, and other operators who make things happen. One of the characteristics of the system is that it is seldom static for long (at one time the McMillan Panel was not an active part of the system, but it soon became one). Another is that it consists of subsystems and interrelationships, understanding of which can sometimes prove useful (the President is unlikely to overrule the Joint Chiefs on a crucial issue). Outsiders sometimes try to enter the system by offering "every assistance short of actual help." They usually fail.

Test Readiness

With regard to its ability promptly to resume underground testing, the nation actually was somewhat better off late in 1961 than it would have been if the Soviets had ended the moratorium a year or more earlier. As is noted in Chapter II, after an initially severe slump in test-related activities, and a dispersion of test personnel, the laboratories had regrouped their test cadres and had begun to acquire physical assets such as those assembled by Livermore with future Plowshare activities in mind. Los Alamos followed a somewhat different path, but the result was the same. Consequently, the most essential laboratory personnel were available for duty in September 1961, as were many key personnel of the technical support contractors. Construction and operational support was a major problem, as Ogle makes clear, because those assets were almost entirely dispersed or put in mothballs, and the actual methodology of underground testing remained troublesome for some time after resumption because little homework on this had been tried or accomplished during the moratorium. The availability of a technical cadre proved to be crucial when the President decided on a quick response to the Soviets, but this came about not from contingency planning, but as a fortuitous result of other influences.

The lesson here was that a quick response to national testing needs is likely to be available only if essential people and physical assets are kept active during a testing hiatus, by engagement in closely related and clearly useful activities. Evidence that this lesson was easily forgotten emerged a decade and a half later during intragovernmental negotiations sparked by the Carter Administration's efforts to achieve a comprehensive test ban. A chain of events that need not be recounted here, but in which William Ogle played a central role, finally led to a Presidential decision that any CTB negotiated with the Soviets must be of limited duration (comparable, as it turned out, to the moratorium), and that during that period experiments at the NTS involving small nuclear yields must be permitted. It was believed that a program of this kind would benefit both the weapons design technology base, on which stockpile confidence depends, and also the readiness of the nation to resume full-scale underground testing when the CTB expired.

This was a conclusion of great importance, but it was reached in 1978 only after protracted and often heated internal debate. The permitted-experiment activity that finally was sanctioned would have had some of the same effects as the Rover, Pluto, Plowshare and other activities did in 1958-61. The lesson, though it was recalled only with the greatest difficulty, was in part that such activities are essential unless testing is permanently renounced.

In retrospect, it is clear that the events chronicled in Chapter IV were far more traumatic than those in Chapter III, precisely because no comparable programmatic protection of cadre and assets existed in the area of atmospheric and high altitude testing. Perhaps because it was more dramatic, the nation more easily remembered this experience for a while after the moratorium. In particular, it had not yet been forgotten in 1963, the year when the U.S. and the U.S.S.R. reached agreement on a partial or limited test ban treaty (LTBT) that prohibited all but underground tests.

During Senate hearings on the LTBT, the Joint Chiefs of Staff, who were more sensitive to this piece of history than most, insisted on (and the Kennedy Administration promised to establish) four so-called Safeguards. The third of these, Safeguard C, required that the nation maintain readiness promptly to resume testing in the atmosphere and other prohibited environments, should this be required for national security. In effect, this Safeguard was a concrete reflection of the lesson learned from the moratorium.

The LTBT was ratified, and the country at first supported the readiness

Safeguard with funding and effort; two of us (RRB, DRW) became deeply involved in the resulting activity at Ogle's request. As a result of experience gained during the latter part of Operation Dominic, the Air Force was tasked in a joint memorandum of understanding to provide several NC-135 aircraft, to be developed, modified, and maintained as improved diagnostic platforms; dedicated and modified B-52 drop aircraft and a fleet of samplers were activated as well. A special Wing at the Kirtland Air Force Base maintained an ability to perform test missions, reinforced periodically by realistic readiness exercises that involved many of the laboratory personnel who had participated in Dominic. Ogle continued to involve himself in this activity, at first directly and later in an advisory capacity, even after, for practical purposes, the readiness program expired in 1975 with the loss of Air Force support and deletion by President Ford of the word "promptly" from the Safeguard.

Thus, the immediate lesson of the moratorium, that the nation should expend money and effort to maintain readiness to test in the atmosphere (and at high altitudes), was overtaken by a second lesson based on the post-moratorium experience. As the apparent likelihood of test resumption in the prohibited environments receded, it became progressively more difficult and eventually impossible to maintain readiness to do so. Even staunch supporters of the original four Safeguards, such as the late Senator Henry M. Jackson, eventually turned their attention to more pressing matters, and competition with other programs for funding became impossible. Control of much of the real estate was transferred to other agencies, many of the physical assets became obsolete or fell victim to neglect, and the personnel with relevant experience became scarce and now have all but disappeared. Even the tenuous hold on Johnston Island as a base for test operations was and is in jeopardy. Military expertise in test operation procedures quickly began to disappear and now is nonexistent.

Two other LTBT Safeguards (strong weapons laboratories and a vigorous underground test program) have more or less survived, although both are threatened by recurring attempts to eliminate testing entirely. Safeguard D, the ability to monitor testing by other nations, currently (1985) is enjoying something of a resurgence after years of neglect. As Dr. Foster observes in his Foreword, the future as regards atmospheric test resumption is clouded. Should the requirement once again arise, the account provided by Ogle may prove to be the nation's most important readiness asset.

Stockpile Considerations

The evident success of the weapons tests performed during the Christmas Island phase of this account carries its own danger of misinterpretation. It would be easy to conclude from these results that testing was really unnecessary because the validation of moratorium designs demonstrated that it was possible to design weapons during a testing hiatus and confidently put them into the nation's stockpile. Only during the following sustained period of underground testing was it learned how wrong that conclusion would have been.

The lesson here has been restated many times, most recently in a September 1985 statement by Robert N. Thorn, Los Alamos National Laboratory Deputy Director, before the Special Panel on Arms Control and Disarmament of the House Committee on Armed Services:

> With resumed U.S. testing in the aftermath of the Moratorium, we discovered technical problems with several weapons systems. As a result of the Moratorium, we lost many people from the weapon program. If it had not ended when it did, we would have remained ignorant of stockpile problems and suffered further personnel attrition.

The experience of the moratorium and the surprises immediately after it ended, but most especially the dismaying results obtained later as underground testing continued into the 1960s (in all of which Ogle was personally involved), led him in August 1977 at a meeting of a senior scientific advisory panel, to express surprise at the apparent indifference of the military about the Carter Administration's CTB proposal. The remark, offered in the usual Ogle style, was instrumental in prompting the subsequent recognition by the Joint Chiefs of Staff, and eventually by the President himself, that a protracted CTB was not in the national interest. The conclusion reached at that time has survived, although the design laboratories, Los Alamos and Livermore, increasingly have compromised their position by agreeing to the adequacy of partial-yield tests both for primaries (during the Carter Administration) and for high-yield weapons (under the restrictions of the Nixon TTBT).

Had the moratorium not ended, it is now clear that by the mid-1960s a large fraction of the U.S. stockpile would have been in serious trouble, and without recourse to testing there would have been a major loss of confidence in some weapon systems and false confidence in the performance of others. The problem was stated clearly by Thorn:

> Our calculation of risks and benefits [from the Moratorium] was affected by our overconfidence, perhaps one could say arrogance, in the state of our knowledge of the weapon R&D program and weapon tests before and leading up to the Moratorium. Looking back, this is astounding.... The Moratorium would amply demonstrate that there was much we did not know, and experience later showed that we totally failed to recognize our ignorance at the time.... Ultimately we did certify some weapons that had not been tested, in the belief that our understanding and design codes were satisfactory. In some cases the weapons proved out in testing after the Moratorium, in others they did not. The key point here is that we went ahead and made these decisions, under the pressures of the time and our excessive belief in our theoretical understanding and design codes . . . I can only say now, with the benefit of considerable hindsight, that such reliance was (and probably would again be) an almost irresistible temptation in the absence of nuclear tests to prove out our theories and validate our design calculations.

The implied lesson apparently was learned better by Ogle than by many of his colleagues, who only recently came very close to repeating the errors of the distant past. Again, Thorn explains:

> A very recent experience shows that we still can make mistakes in spite of the great advances in our computers and experimental techniques. The case involved one of our most important new strategic systems. Safety requirements for this weapon were especially tight, as were the constraints placed on the delivery system for which it was being designed, and there were still other considerations that made this a particularly challenging assignment. In spite of these sometimes conflicting priorities, we were entirely confident that the weapon we designed would perform as required.
>
> After the design was completed and certified for production, another contingency was brought up that had not been duplicated in the test program up to that time. Most of the key participants judged that no further test was required in order to have high confidence in the weapon under all circumstances, but a few, mindful of past misadventures, convinced us we should do another test simulating the new conditions. When this test was done (after production had started) it failed dramatically. The weapon would fail under certain conditions that it very likely would encounter. Because we were able to do additional nuclear tests, we could confirm the performance of a replacement design expeditiously, and production was interrupted only briefly.

It was, in fact, William Ogle who first raised the question of the neccessity for an additional test of this weapon.

A most important conclusion, then, reinforced by the events of recent years, is that a nation that depends in a fundamental way on nuclear weapons for its security cannot safely dispense with nuclear weapon testing. This conclusion depends on another: that a competent nuclear weapon technology cannot be preserved indefinitely without a test program. We know now that nuclear weapon design was, and to a large degree still is, an empirical rather than an exact science. Weapons are not designed from "first principles." Although both calculational and laboratory techniques have improved dramatically since 1961, those responsible for certification of the performance of the weapons in the U.S. stockpile believe that they require the ultimate proof of a successful nuclear explosion. Thorn concludes his statement of his Laboratory's position in 1985 as follows:

> [Under a CTB] If a problem were detected with a stockpiled weapon. . .we would again be unable to determine its seriousness or validate proposed solutions with nuclear tests. . . .With a relatively small number of designs in the stockpile, usually intended to remain there for many years, a problem with a single design could have a serious impact on our nuclear deterrent. This problem is worsened, in my view, by the unforgiving nature of current nuclear weapon designs. . . .
>
> Despite this fact, the risk that we would come to rely too much on theory, codes, and non-nuclear tests during a moratorium is probably even greater today. Fewer of our designers remember the chastening experience of the Moratorium, and the years that followed, and because our calculational tools are more elaborate and refined, it is easier to believe that they truly simulate nature. Thus, we could again be led seriously astray without the ability to validate our calculations and designs from time to time. As time went by, we would probably be tempted to develop, certify, and stockpile untested weapons again.

The immediate post-moratorium period is replete with illustrations of the vital importance of testing the weapons on which the national security depends. The active role of William Ogle in making the system think about the issue and reach this conclusion leaves little room for doubt that he would wish this major lesson from the moratorium period and its sequelae to be repeated here.

Systems Testing and Realism

Two questions were repeatedly posed by Ogle: (1) Is the U.S. doing all it reasonably can do to achieve maximum confidence that operational nuclear weapon systems will perform as planned, if they have to be used? and (2) If not, shouldn't we change the procedures to do so?

No one U.S. organization is responsible for ensuring the performance of an entire nuclear weapon system. Instead, many organizations, including the DOE, the Military Services, the Joint Chiefs of Staff, and other DOD elements, separately contribute information about their functions that is used in formulating and developing policy and war plans. This approach makes it likely that not every aspect of a system will ever be fully understood until the entire system is actually used. Nuclear testing history includes several examples of such "interface" problems which were not found until either planning or execution of some end-to-end test of the entire operational system was accomplished.

Another aspect of current systems testing practice that Ogle considered a weakness is our inability or failure to comprehend and simulate the hostile effects of the system environment which may influence system performance.

Illustrative of his concern about such problems, we have become aware of a private communication upon which Ogle was working just a few days before his death. On the one hand, he wrote: "There is a tendency to try to think of what might be wrong with a system and then to argue that the test should be worked in some way to look for that problem. To me that illustrates a basic philosophical error. We are looking for the problems that we cannot imagine!" He also wrote: "All of these items have of course been considered in going into stockpile, and in general, the judgment made that they cannot produce serious effects. But, can any of them lead to minor glitches that nevertheless will affect overall system performance?"

Ogle believed, and so do we, that an understanding of these problems should be an urgent task for those responsibile for nuclear weapons systems lest estimates of system performance are revealed, in a time of crisis, to be dangerously optimistic.

Safety in Testing

In these discussions of specific lessons for those who may have to repeat the 1961 experience, we take the position, as Bill Ogle did, that everything we talk about we talk about in the context of peacetime. In war much higher risks are accepted than when nations are at peace, because war is an incredibly high risk business. But in peacetime, although we are developing and testing the tools of war, the entire system must accept the values and the constraints of a society at peace.

Over the years, the Department of Energy and the national nuclear weapons laboratories, in concert with the Department of Defense, have evolved methods of testing and proving physics principles, design concepts, and weapon configurations in a field laboratory setting which has also provided a high degree of safety for the (world) public and for the members of the test organization.

In the later years of atmospheric testing, there were efforts made to conduct tests of military systems under realistic operational conditions. In fact, however, as the author makes clear in several places in Chapter IV, no nuclear weapon system in its standard military configuration provides adequate built-in safety for realistic, full-scale testing in peacetime. This assertion, which we are willing to state as fact, should provide ample challenge for test program and military planners, some of whom recognize the need for realistic operational systems tests.

Operational Trade-Offs

Each test operation, and in fact, each test involves a number of compromises. We have already alluded to the need for compromise in the testing of operational systems. Public health and safety, and the safety of test participants, have invariably led to hardware or procedural modifications that have just as invariably been resisted by the sponsors of the test. The author has given us several examples. We have discussed also the matter of political compromise. (Some would say scientific and technical compromise for political reasons.) In addition, though, we have important experience with compromise within the scientific organization itself.

A first category of compromise has to do with what we shall call test configuration. Each test event is conceived and justified to examine and investigate one or a few principles, concepts, or hypotheses. But once the individual test is approved for planning, it is viewed, properly, as an experimental opportunity. This may lead to modifications of the original test plan, and even of the test device itself, to accommodate additional experiments, and thus to make the test event more productive of useful data. The author has discussed a classic example of this process in the high-altitude series of the Dominic operation, when the McMillan Panel, for cogent scientific reasons, prevailed upon the test organization to make several important configuration changes at quite late times in the preparation for the series. The lesson here is that the technical managers of the program must be prepared for such eventuality, but must develop and enforce a discipline of their own, to assure that the primary test objectives are not unduly compromised and that accommodation of the needs of one test participant does not inadvertently harm the interests of another.

A related category of compromise comes during the operational or test execution phase. Not all test participants will have achieved the required high state of readiness at the same time. Nor will all find the same set of operational conditions optimum. Yet, typically, a delay in favor of one experimenter will lead to deteriorating readiness of another. The test organization management (read Scientific Deputy) must be thoroughly conversant with the purpose, experimental requirements and relative importance of each of the primary and add-on experiments, and must have the perception and courage to choose among them when that is called for.

Several aspects of these compromises are well illustrated by Ogle's account of the ASROC and Polaris systems tests of Dominic.

The DOE/Laboratory Role

Under current United States law, it is inconceivable that a full-scale nuclear weapons test program might be carried out except as a joint venture of the national laboratories and their federal sponsors (today DOE) and the military services (the DOD). Looking back over this history of some of the momentous years of the nuclear test program, it is well to consider the unique position of the Scientific Deputy Commander of the Joint Task Force (Ogle was the last incumbent of that position during atmospheric testing). In some future situation, the titles may be different, and the organization may have a different outward appearance, but the functional relationships are likely to be similar. It seems reasonable that if full-scale testing should again go outside the currently established test sites, the Secretary of Energy--with all of the technical and scientific resources of his department--will be expected to regenerate the equivalent of a scientific task group, a principal scientific advisor, and a technical support organization. The authorities, functions, and responsibilities of the Department of Energy relating to weapons testing derive from the Atomic Energy Act--the same act that established the AEC many years ago. The DOE is required "as a matter of continuing responsibility" to participate in the development of special safety studies, including those pertaining to nuclear detonations of whatever nature.

With history as our guide, we would expect to see weapons scientists of the DOE laboratories as advisors at all levels from the White House on down, and as active responsible agents in the execution of test plans. In years past, using our Pacific test experience as detailed in this work, this has been facilitated by the establishment of a Joint Task Force, reporting jointly to the AEC and the Joint Chiefs of Staff. The Task Force staff was integrated, with a senior AEC scientist serving as the Deputy Commander. This Deputy Commander had a direct reporting channel to the Atomic Energy Commission. We should note the political, operational, and scientific roles of the Scientific Deputy, and understand the importance of a good match between that person and the one who may be named as Task Force Commander.

The Political Environment

At the national political level, too, we should consider the vital roles of the Scientific Deputy and other scientists of the test community, for the political imperatives and the scientific realities are often if not on a collision course, at least on divergent paths. Timely and substantive interaction between responsible scientists and responsible politicians is both essential and inevitable; yet neither is entirely comfortable in the other's domain (or at least, if he is, he is probably suspect in his own house).

Perhaps the classic example of this imperative has to do with the timing of a resumption of testing after a moratorium, or even after a simple lapse in test activity. Historically, on each such occasion, there have been influences thought by the scientists to be extraneous, but considered by the national leadership to be compelling. On occasion, a test or a resumption of testing has been delayed to allow a political process to proceed without distraction. This can be frustrating to the test organization; but when the reverse occurs, that is, when overriding political imperatives influence the test organization to proceed ahead of its own schedule, the price may be very high indeed, not just in the morale of the scientific organization, but in the quality and validity of urgently needed test results. It is idle to lament this conflict, and dangerous to pretend that it does not exist. The key scientists in the test community must actively seek to inform the decision makers in Washington of the realities of testing, and must seek also to understand and find accommodation with the political world in which they live.

In a time of urgency approaching national emergency, regardless of the scientific imperatives, that which is inconsistent with the then-current national political initiatives *probably will not occur.* The corollary--just as true--is that political imperatives can give sufficient impetus to unsound technical initiatives to bring them to life even over the objections of responsible scientists.

In our time, perhaps no other scientific activity has had such an immediate and volatile interaction with national politics. For the knowledgeable scientist to participate in the political process without himself becoming politicized, or being viewed as a special interest lobbyist, is difficult; but it must be done.

Conclusion

We conclude this Epilogue with a final quote from the recent statement by the Los Alamos Deputy Director:

> In early 1962 President Kennedy, reflecting on the experience of the Moratorium, . . . said that in the future the US would find acceptable only written agreements which provided for an adequate inspection system in regard to preparations as well as testing. He emphasized that "this must be a fully effective treaty. We know enough now about broken negotiations, secret preparations and the advantages gained from a long test series never to offer again an uninspected moratorium. Some may urge us to try it again, keeping our preparations to test in a constant state of readiness. But in actual practice, particularly in a society of free choice, we cannot keep top flight scientists concentrating on the preparation of an experiment which may or may not take place on an uncertain date in the undefined future. Nor can large technical laboratories be kept fully alert on a standby basis waiting for some other nation to break an agreement. This is not merely difficult or inconvenient--we have explored this alternative thoroughly, and found it impossible of execution."

It appears that this fundamental lesson must be relearned often by the nation's ever-changing leadership. If it is forgotten, the other lessons become meaningless. It is our hope and belief that Ogle's account will serve the nation well. Certainly that was his intention.

APPENDIX A

A QUICK AND CURSORY SUMMARY OF THE CHRISTMAS ISLAND PORTION OF OPERATION DOMINIC 1962

SUMMARY

The Christmas Island portion of Operation Dominic consisted of the firing by air drop of twenty-four nuclear devices to satisfy the large yield weapon development testing needs of the Atomic Energy Commission. Twelve LRL and twelve LASL devices were fired.

The total yield of each device was deduced from fireball diameter vs. time and from bhangmeter data, and the fission yield by radiochemical analysis of bomb debris. The time intervals between stages were measured by electromagnetic and optical detectors. To check on the feasibility of an all-airborne measurement system, fireball cameras, time interval detectors, and distance measuring equipment were also operated from aircraft.

The Department of Defense conducted a number of effects measurements in conjunction with the AEC tests. Eyeburn studies, radar transmission studies, and close-in thermal radiation measurements were among the more prominent.

Weapons put into the stockpile during the test moratorium were tested and operated as designed. Ex.(b)(3) [redacted]

There was no appreciable fallout detected either on Christmas Island or any of the surrounding islands, and there was no damage from water waves. Damage from thermal radiation was very slight, and blast damage was generally minor, being limited for the most part to broken glass and studding and loosened panels.

I. INTRODUCTION

During Operation Dominic some twenty-four devices were air dropped over the ocean near the southeast arm of Christmas Island. The main objectives of the tests were:

Ex.(b)(3) [redacted]

Ex.(b)(3) [redacted]

SECRET

Ex.(b)(3)

[redacted]

SECRET

Ex.(b)(3)

[redacted]

[redacted]

Ex.(b)(3)

[redacted]

[redacted]

Ex.(b)(3)

[redacted]

[redacted]

Ex.(b)(3)

[redacted]

[redacted]

Ex.(b)(3)

[redacted]

Ex.(b)(3)

[redacted]

APPENDIX B

STARFISH

General Summary of Results

Unfortunately, difficulties in pod stabilization and positioning seriously degraded the acquisition of data on the direct effects of x-rays on materials. Some of the material samples and indenter gauges were subject to the direct x-ray flux and the data are being analyzed; these should yield some useful x-ray effects information.

Rocketborne detectors did successfully measure the x-ray yield, the black body temperature of the weapon, and the neutron flux; in addition, foils carried on the pods yielded useful neutron flux data. [redacted]

Ex.(b)(1)

Ex.(b)(3)

Ex.(b)(1)

Ex.(b)(3)

[redacted]

An interesting side effect was that the Royal New Zealand Air Force was aided in antisubmarine maneuvers by the light from the bomb. The next paragraph is an eyewitness report of the detonation by Major C. X. McHugh, who was on Kwajalein; the paragraph following that is an eyewitness report from Johnston Island.

[redacted]

At Kwajalein, 1400 miles to the west, a dense overcast extended the length of the eastern horizon to a height of 5 to 8 degrees. At 0900 GMT, a brilliant white flash burned through the clouds, rapidly changing to an expanding green ball of irradiance extending into the clear sky above the overcast. From its surface extruded great white fingers, resembling cirro-stratus clouds, which rose to 40 degrees above the horizon in sweeping arcs turning downward toward the poles and disappearing in seconds to be replaced by spectacular concentric cirrus-like rings moving out from the blast at tremendous initial velocity, finally stopping when the outermost ring was 50 degrees overhead. They did not disappear, but persisted in a state of frozen stillness. All this occurred, I would judge, within 45 seconds. As the greenish light turned to purple and began to fade at the point of burst, a bright red glow began to develop on the horizon at a direction 50 degrees north of east and simultaneously 50 degrees south of east expanding inward and upward until the whole eastern sky was a dull, burning red semicircle 100 degrees north to south and halfway to the zenith obliterating some of the lesser stars. This condition, interspersed with tremendous white rainbows, (Ed. note: meaning unclear) persisted no less than seven minutes.

At zero time at Johnston, a white flash occurred, but as soon as one could remove his goggles, no intense light was present. A second after shot time, a mottled red disc was observed directly overhead and covered the sky down to about 45 degrees from the zenith. Generally, the red mottled region was more intense on the eastern portions. Along the magnetic north-south line through the burst, a white-yellow streak extended and grew to the north from near zenith. The width of the white-streaked region grew from a few degrees at a few seconds to about 5-10 degrees in 30 seconds. Growth of the auroral region to the north was by addition of new lines developing from west to east. The white-yellow auroral streamers receded upward from the horizon to the north and grew to the south and at about two minutes, the white-yellow bands were still about 10 degrees wide and extended mainly from near zenith to the south. By about two minutes, the red disc region had completed disappearance in the west and was rapidly fading on the eastern portion of the overhead disc. At 400 seconds, essentially all major visible phenomena had disappeared except for possibly some faint red glow along the north-south line and on the horizon to the north. No sounds were heard at Johnston Island that could be definitely attributed to the detonation.

Ex.(b)(1)

[redacted]

[redacted]

Ex.(b)(1) [redacted]

APPENDIX C

CHECKMATE

General Summary of Results

At Johnston Island, Checkmate observers first saw a green and blue circular region with spikelike protrusions from its outer edge. This region was surrounded by a blood-red ring which faded in less than a minute. Streamers oriented magnetic north-south formed almost immediately and gradually straightened out the initial circular patch. The blue-green streamers and numerous pink striations eventually extended to about a 50-degree elevation to the north and 10 degrees away from the burst to the south. The blue-green streamers faded out at about plus three minutes, leaving pink streamers which gradually faded, but were still visible at plus 30 minutes. A faint red patch was seen for a few minutes to the north, below and beyond the streamers.

At Samoa, observers saw a conical-shaped bright white flash originating some 45 degrees above the horizon and terminating at the southern magnetic conjugate point. The white color faded in a few seconds leaving an orange glow at the conjugate point which then faded completely by about H plus 1 minute.

Ex.(b)(1) [redacted]

Ex.(b)(1)

[redacted]

Ex.(b)(1)

[redacted]

APPENDIX D

BLUEGILL

General Summary of Results

Observers at Johnston noted a brilliant white flash and a noticeable thermal pulse that was readily felt on the bare skin. At +10 seconds the burst appeared to be a slightly distorted, bright, moonlike-sphere with a clouded inner portion. As the sphere expanded its outer edges resembled a transparent shock wave. Inside was a denser, irregular, luminescent core which first appeared bright yellow and gradually became colored with subdued hues of green, pink, and violet. The central material moved to the surface of the sphere, forming a toroid whose center glowed with a purple fluorescence. Blue-purple streamers formed with the evolution of the toroid, extending about 15-20 degrees from the toroid, north and south along the magnetic field. The streamers, which appeared to come to a focal point in the south and to form a fan toward the north, lasted about three minutes, gradually disappearing. The toroid filled with luminescent wispy material and took on the form of a large, fairly uniform, glowing cloud. At +10 minutes, the cloud was about 120 degrees in diameter and its glow easily permitted resolving the dial of a watch. The cloud glow slowly died away, being still visible at +30 minutes, but no longer apparent by about +1 hour.

From Samoa, observers reported a narrow band whose color changed from bright pink at the northern magnetic horizon to green about 30 degrees above the horizon. The width of the band was about one finger at an arms length (Ed. note: about 1 1/2 degrees), spreading to three fingers, or about 5 degrees, after 3 minutes. The band faded to a dull pink with the green disappearing. By +10 minutes the width was constant at about 5 degrees, but the color had faded. The band was still visible at +20 minutes.

From high-speed photographic records, the following more detailed picture of the fireball and debris motion can be built up.

Ex.(b)(1)

[redacted]

[redacted]

Ex.(b)(1)

[redacted]

[redacted]

Ex.(b)(1) [redacted]

The 2,500-foot and 6,000-foot range pods carried aloft on the Thor have been recovered in good condition. The middle pod impacted abnormally and suffered moderate structural damage; its instrumentation was in fair condition. Good tracks were obtained and orientations appear to have been correct on all pods. Quantitative data from the pod experiments are not yet available; however, it appears that the pod experiments on Bluegill were more successful than those on either Starfish or Kingfish.

Ex.(b)(1) [redacted]

Monkey and rabbit eyeburn data were obtained in the four C-118 aircraft and on Johnston as part of the DASA retinal burn study. Two inadvertent human eye exposures occurred, resulting in bilateral foveal burns. Neither person suffered any discomfort, but both have lost significant amounts of their central vision. These case histories are being followed by project personnel.

APPENDIX E

KINGFISH

General Summary of Results

As seen from Johnston Island, a few seconds after burst there was a ring with a nearly transparent outer edge and an inner luminous circular region containing an irregular cloud-like mass. The outer edge quickly disappeared, leaving a luminous white-yellow region. Observers on the ground then saw what appeared to be two nonconcentric, circular areas moving rapidly northward. The two circles seemed identical in size, with one displaced magnetic north of the other. The north edge of the northern circle became increasingly irregular as spikes grew northward from it. At about +60 seconds, intense purple streamers had grown to the north, with several early green streaks. At times, there appeared to be rapid, twisting motion in the northward purple streamers. A purple glow region about 10 degrees above the northern horizon was separated by about 20 degrees elevation from the purple-green streamers and persisted until +10 minutes. The luminous circular regions straightened out into purplish, magnetic north-south striations by about a minute. To the magnetic south of the burst an oval, pale-green patch appeared early, persisted, and grew. This large pale-green patch south of, but near the burst point, was the dominant visible area after +5 minutes. This green area grew into an elliptical region with the long axis oriented east-west, and appeared to grow westward. At +10 minutes the oval extended about 30 degrees east-west and 20 degrees north-south. At about +20 minutes stars became visible through the green oval region. At +60 minutes the green area had lost its color, but had grown to be 120 degrees east-west and about 80 degrees north-south. At this time most of the light was emanating from areas close to the burst location. The dull gray region persisted for at least 30 hours after burst.

The event was first visible from Oahu as a bright flash of light on the southwest horizon. About 10 seconds later a great white to pink ball appeared to rise slowly out of the sea, preceded by a surrounding ring of red light. As the fireball rose above the horizon it appeared as a white sphere, somewhat egg-shaped, completely surrounded by a well-defined red ring. As it continued to rise the red ring diminished in brightness and the white ball elongated vertically, being asymmetric at the bottom. The cloud stablized at an elevation about 20 degrees above the horizon and flattened out as the red ring disappeared and the cloud faded. Eventually, the debris separated into two platters, one above the other, with their centers canted 15 degrees to the horizon, the lower end to the observers' left. The cloud was still easily visible at +7 minutes, but was no longer visible after about 9 minutes.

Ex.(b)(1)

[redacted]

Ex.(b)(1)

[redacted]

Pod release and pod tracking appear to be satisfactory. The near pod was recovered in excellent condition, and superficial examination indicated that all instruments functioned and recorded data. Pod orientation appeared satisfactory. The middle pod was recovered, with the backplate and major portion of the flare and tracking antenna portion of the nose missing. The indenter gauge on this pod was recovered. The pod appeared to have been within 20 degrees of its desired orientation at burst. The third pod was recovered, but the backplate and almost all experiments were lost.

Ex.(b)(1)

[redacted]

Ex.(b)(1) [redacted]

Ex.(b)(3) [redacted]

APPENDIX F

TIGHTROPE

General Summary of Results

On Johnston Island, the Tightrope detonation was accompanied by an intense bright flash. Even with high-density goggles, the fireball was too bright for direct observation during the first few seconds. A distinct prompt thermal pulse was noticable on bare skin. The initial bright yellow-orange disc rapidly evolved into a doughnut shape with purple tinges. By about 60 seconds the torus was well-formed, had sharp edges, and was purple in color. The torus soon became purple throughout. By about 200 seconds, the torus had become crownlike in appearance and had fringes extending outward from the outside edge. The inner edge remained uniform and circular. By 240 seconds, the purple color of the torus became less intense and the slowly deforming torus was cloudlike in appearance. In a few minutes the residue appeared as a glowing purple cloud that was still faintly visible at +10 minutes. The cloud slowly moved north until it was no longer visible.

From Hawaii, a short sharp flash of white light was visible on the horizon, lasting less than 2 seconds. No other evidence of the detonation was detectable.

No observable effects were seen at Tutuila, although the weather was reported clear.

The experimental effort on the Tightrope event was greatly reduced from that on previous high-altitude events. The lower altitude of the detonation, as predicted, did not provide the widespread disturbances and effects seen in earlier Dominic events.

In general, the phenomena noted and the effects measured were in accord with predictions. Visible effects were confined generally to the Johnston Island danger area, some 320 miles in diameter.

Ex.(b)(1)

[redacted]

[redacted]

Ex.(b)(1)

[redacted]

[redacted]