The Air Force Aeronautical Systems Division finally managed to do the B-57 thermal experiment mentioned earlier. In order to get the proper flux, the aircraft had to be very close to the detonation point at zero time. The aircraft was moving quite rapidly, and there was a long series of arguments between the project people on the one hand and Starbird and Ogle on the other hand concerning the placement of the aircraft. (The aircraft was controlled from radar on the ground.) However, eventually the debate was resolved and the aircraft participated, with good results.

The last shot at Christmas was the LRL Pamlico event on July 11, 1962. While Americans did not completely leave Christmas Island until late 1963, by midnight of July 11 the technical organization had rolled up to such an extent that it would have taken a month to get ready again. However, several steps to preserve the capability had already been taken. By late May the budget cycle had progressed such that the Laboratories were making proposals for future test operations. Ogle argued to try to keep Christmas Island as well as to develop the capability for completely airborne diagnostics, implying that new aircraft such as Boeing 707s should be obtained and that a satisfactory DME capability should be developed. AFSWC also argued to maintain the airborne capability but suggested three C-130 aircraft.

However, by early July Air Force Headquarters was requesting that the aircraft be returned after the end of the Christmas Island portion of the operation. Samuel objected and pointed out that, considering the high quality of data obtained from the aircraft after a very short time of preparation, the probability was high that given another 11 months (to the next operation), the aircraft would become quite satisfactory data-collection platforms. He went on to argue that if the C-130s had to be lost, then at least one more C-135 should be added to the Task Force resources of test aircraft. The Air Force suggested a modified C-97 and Samuel objected, pointing out the high record of reliability of the C-130s which would not be likely with C-97s. (C-97 is a piston engine aircraft, whereas a C-130 is a turboprop.) The Laboratories saved the day by requesting early in July that the C-130s be kept for use against the high-altitude shots in order to make electromagnetic and optical time interval measurements. After some discussion, the Air Force agreed.

Meanwhile, Ogle had pointed out to Bradbury, Foster, Betts, and Reeves that there now appeared to be no political resistance to using Christmas Island as part of Dominic, but the high-altitude shots were causing great political flurry; therefore, he suggested that one solution was not to stop testing at Christmas at all (as of July 8), but try to continue to do a shot every couple of weeks or perhaps as little as once a month, fitting in with the development plan for the Laboratories, and hence keeping alive and nourishing the atmospheric test program at Christmas. Senior representatives of both Laboratories, who happened to be in Los Alamos, discussed the question. Their reaction was that the Laboratories jointly could not provide that many shots in the near future, and that they would prefer to prepare an orderly, well-planned, atmospheric test series for the fall of 1963, feeling that by that time a very satisfactory open sea operation could be developed, and, hence, we would not be dependent on Christmas Island. They suggested that the outer space capability be developed and perhaps demonstrated the following year. Perhaps more pertinently, they asked, "What do we use for money to operate Christmas Island and still operate NTS?" Betts advised Ogle to go ahead and roll up the island.

It is to be pointed out that the failures that had by then occurred at Johnston Island in a way helped the Christmas operation. Kennedy had authorized several of the later tests only if they were ready by the end of the high-altitude operation. Since that operation stretched on in July, two shots, Sunset and Pamlico, were approved and fired at Christmas.

A summary of the Christmas Island technical results, given in Appendix A, is a somewhat edited version of the "quick look" report prepared by Al Embry of LASL

immediately after the operation. (Ed. note: Because the author had not completed his editing of the Embry report by the time of his death, we have chosen to include as Appendix A only an abstract of the general results part of the Embry report. The complete report will be a part of the William Ogle Collection of papers maintained in the archives of the Los Alamos National Laboratory.)

Follow-on Air Drops

During the evening of July 25, 1962, a Thor was destroyed and burned on the pad on Johnston Island. There came then an approximate two-month interval of no testing at Johnston Island, which allowed the Laboratories to think a little bit more about their problems in developing high-yield devices.

In mid-July 1962 Air Force Headquarters had initiated attempts to get the B-57 samplers back, but AFSWC resisted, arguing their need for the upcoming 1963 operation. AFSWC also argued that by now the C-130s had been altered so much that to remodify them for normal use and then reconfigure for a later operation would be an unreasonable cost. However, by the early part of August the Air Staff had judged that Air Defense Command need for the B-57 aircraft as high-altitude vehicles had priority and four of the B models were returned, leaving six in sampler configuration.

The break in the operation due to the July 25 accident on the pad at Johnston Island apparently induced Betts to think about continued atmospheric testing. On July 27 he asked Reeves to estimate the AEC costs and DOD effort to support continual atmospheric testing at a rate of one or two shots per month, using either completely airborne, or airborne plus supplemental surface, diagnostic measurements. He assumed the continued availibility of the airborne diagnostic system and asked that various areas of operation be considered. He discussed the question informally with Bradbury and Foster and requested their reactions.

On August 2 Foster advised Betts of the LRL desire to conduct further atmospheric detonations during Dominic. [redacted] Ex.(b)(3) [redacted] He went on to note that the Russians had announced their intention to conduct further atmospheric tests during August, September, and October and said, "The Laboratory should make every effort to prepare to test their most useful and urgent experiments." He added that LRL was starting the design and construction of Ex.(b)(3) devices. Bradbury replied to Betts on August 8 that:

> LASL has considered with care your informal request concerning our possible interest in additional experimental shots in the Dominic program in a time scale of the next two or three months corresponding with the resumption of activities at Johnston Island. We remain of the opinion that a preferable course of action would be to inform the Laboratories from a suitably high level that definite planning and preparation should be carried for atmospheric test operation in approximately one year. It appears to us that the only real arguments for additional Dominic tests at this time arise out of a fear that atmospheric testing will soon be discontinued. You will recall the many discussions in Washington last fall in which the difference between the U.S. course of action after August 1958 and the presumed U.S.S.R. course of action during this same time were kicked around. You will also recall that it was fairly obvious that the U.S.S.R. scientists had been told to plan on an operation and we

had been told the exact opposite. It seems to us extremely important that we not forget this lesson and that it is more important that we get a general long-range policy decision than that we add a few hasty and inevitably not very well considered experiments in a rush-rush time scale on the basis of a fear of what might not happen. Ex.(b)(3) [redacted] . Any device we could possibly prepare in the prescribed time scale would be a very ragged affair, far from optimized, and of problematical behavior. We would not recommend its testing at this time, but could regard an initial version as a very appropriate candidate a year from now following adequate calculational study. . . . It would appear to us that the only justification for trying to get bits and pieces together in the suggested time scale would be on the basis of early word from you that we should act on the assumption that further atmospheric testing in the next year or two is quite unlikely.

Bradbury went on to discuss other difficulties, finally remarking that if an operation were turned on, he would propose to repeat as an atmospheric test [redacted] Ex.(b)(3) [redacted] His message ended with the following:

. . . being old, tired, and sour, and the writer cannot forebear to notice that LASL is shooting about 25 shots per year at Nevada, has just shot 12 at Christmas, and presumably expects to shoot a similar number in the Pacific in a year's time. Livermore's program is comparable. . . . Whither are we drifting when a jaundiced observer looking at the overall behavior of U.S. missiles might easily conclude that nuclear weapons were about 10 years ahead of their corresponding delivery systems. In any event, LASL does not feel that the world will come to an end if we do not do other than spend a year studying what happened in Dominic, experimenting in Nevada, and preparing as good designs as we can in the light of the nation's needs for testing in the Pacific a year from now.

Ex.(b)(3) [redacted]

The test system moved rapidly. Livermore had informed the Air Task Group at Kirtland of their intentions even before they sent the message to Betts, and on August 3 TG 8.4 knew what airplanes they needed; these were virtually the same as those used at Christmas Island, including the two C-130s, eight B-57 Bs, two KC-135s for sample return, B-52s, etc. TG 8.4 notified Air Force Headquarters that the C-130s and B-57s were absolutely critical to the success of the renewed test operation and said, "In view of the compressed time schedule for the proposed operation and to prevent their unrecoverable loss, CJTG 8.4 is retaining control of these aircraft and assets." On the same day JTF-8 Headquarters in Washington considered the need for WB-50 weather reconnaissance aircraft and concluded that they would be required.

On August 4 TG 8.4 requested the return of the C-130s to Kirtland for modification of the currently installed diagnostic gear. The modification would take some time and the crews would not have to remain with the aircraft during the modification period.

Planning moved rapidly and as a result Ogle sent the following TWX on August 17:

As a result of a meeting on August 15 in Albuquerque with representatives of LRL, LASL, DOD, and EG&G Task Units, as well as PMR and TG 8.4 and 8.5, and further discussions at LASL and Kirtland, the following concept for the airdrop operation was agreed to:

1. Ex.(b)(3) [redacted]

2. Nuclear devices will be assembled and loaded on the B-52s under the supervision of Lee Hollingsworth. Loading will take place at Travis or Kirtland, depending upon the Laboratory involved. 8.4 will investigate the advantage of doing all loading at Kirtland. The device checks will go down to about 5-hour readiness, after which the B-52 will proceed to Barbers Point where the final telemetry checks will be made and the DME units in the other array aircraft calibrated with the device. The key will be put in at Barbers Point. The check at Barbers Point will require a minimum of personnel and equipment, eliminating the necessity to reestablish the entire Barbers Point mechanical and electronic setup. It will be necessary to have the C-130s at Barbers Point for the calibration of the DME, but they need not be based there. The B-52s would be based in the Hawaiian area. 8.4 and Hollingsworth will arrange for the necessary facilities at Barbers Point and Hickam.

3. The Command Post for the air operation would be in an RC-121-type aircraft in the air array. This aircraft would serve as the Command Post for the senior Task Force Officer and the senior laboratory representative from the sponsoring Laboratory. It appears logical that the airborne AOC also be in this aircraft. From this aircraft, then, the Commander and the senior scientific representative would be able to control the air array and determine the readiness of the instrumented aircraft. The results of the prerelease checks and the bomb functions as obtained from telemetry would be funneled into this control point from the C-130s and B-52s by voice relay.

4. In order to obtain the best EM signals from the device, the B-52 would fly in a north-south path so that the C-130s can fly either east or west (magnetic) from the drop aircraft. As the instrumentation of the C-130s is on the left side of the planes, it will be necessary to either have the 130s on opposite racetrack patterns or else stack them and have them on the same racetrack. (LRL has requested another camera platform for their shots. If there is another aircraft in the array, then stacking the 130s is an acceptable solution. If this other camera platform is a B-52, then it would be preferable to have the 130s on either side of the burst.) It is proposed to detonate the devices somewhere between 8,000 and 14,000 feet. This altitude was selected because of altitude restrictions on the 130s and predicted weather conditions during September and October. Ex.(b)(3) [redacted] would be detonated in the vicinity of 19.5° north, 164.5° west, approximately 400 nautical miles southwest of Hawaii and within the Bluegill danger area. Flying in this area would permit the B-57s to return to Barbers Point directly without having to land at Johnston Island. It also permits the use of a B-57D as a controller. Even with a surface burst, this area is safe in all respects for the LASL device. LRL devices should be detonated in the vicinity of 12.75° north, 171.5° west. This area is approximately 250 miles southwest of Johnston and would require the B-57s to land at Johnston upon completion of their sampling missions. Because of the distance from Johnston, it is possible to use a B-57D as a controller by staging the plane through Johnston prior to the mission. The drop areas selected are not to be considered exact; the array will be able to move about to some degree to take advantage of favorable weather conditions. If 8.4 prefers, the last shot could also be fired in the latter area.

5. Control of the array will be accomplished using radars in RC-121 and Task Group 8.4 aircraft controllers. All aircraft will be positioned using clock time zero positions and the predicted burst point. The necessity of target rafts will be settled by discussion between 8.4 and JTF-8. Difficulties of mooring would be encountered because of the depths in the target areas. Further, the flexibility of an all airborne operation would be lost if tied to a specific target in a single area. The concept outlined here allows the array commander to shift to some degree, taking advantage of clear areas. Insofar as all airdrop operations are expected to be nighttime operations, all positioning will be accomplished by radar, and Task Group 8.4 is capable of providing this positioning control without the use of target rafts. Provisions for additional aircraft participation must be made. It is possible that the LASL and AFTAC KC-135s may participate.

6. Additional effort will be necessary to provide adequate communications to the entire air array, as well as communications to Headquarters, JTF-8, on Johnston Island and a scientific net within the air array. This latter net will be necessary in order to pass certain information of readiness and bomb functioning to the scientific representative in the command aircraft. In addition, some sort of countdown net will have to operate to assist aircraft outside the immediate array in positioning themselves. A Motorola-type VHF or UHF net might satisfy the scientific communication requirement. Johnston-Barbers Point communications must be provided. 8.4 will arrange for the inter-aircraft communications. The drop plane countdown should be available in all experimental aircraft. This is to be arranged by 8.4.

7. The C-130s in the array will be equipped almost as they were in the Christmas Island operation with the exception of the DME. Time interval measurements and bhangmeter recordings will be taken as before. Certain modifications to improve the fireball photography are being planned, and in order to take advantage of this photography, certain major changes are being made in the DME systems within the array. Mutual agreement was reached at the Albuquerque meeting to eliminate all so-called slave stations in the DME system, and to provide direct measurements between the device and the various aircraft only. This system is contingent on the ability of Sandia to install the necessary transponders in the device cases. DME systems will be provided as follows: from device to 298 (LASL C-130), Sandia and AFSWC; from device to 299 (LRL C-130), AFSWC and LRL; from device to third camera station, Sandia. The LRL DME system is a development item and utilizes a microwave pulse technique rather than the phase shift system used by Sandia and AFSWC. The installation of additional DME systems is necessary to ensure adequate distance measurements, although it will require considerable effort on the part of the AFSWC test division to modify the aircraft. AFSWC presently has a C-54 modified for aerial photography of this type and efforts are being made by Task Group 8.4 to obtain the use of this aircraft. The modification of the B-52 camera station in the tail to accept more suitable cameras and to provide surer functioning may involve more effort than time will allow but is preferable to the use of the C-54. EG&G and SWC are investigating this now.

8. Sandia has agreed to furnish to each C-130 release and arm baro signals. In addition, Sandia will provide a real-time presentation of the bomb functioning in aircraft 298, using the standard telemetry system from the device. This information will also be relayed verbally as needed over the scientific net to the command aircraft, using a simple, prearranged voice code. An FM/AM fiducial marker will be provided to the aircraft 299 to satisfy LRL requirements. EG&G will install the proper timing systems in the aircraft to provide the necessary timing signals to the various instrument stations, as has been done in the past. It is assumed that EG&G will have facilities in Honolulu to process the necessary photography records resulting from the airdrop operations.

9. The danger area for the airdrop operation is assumed to be the same as announced for Bluegill. This should cover the problems of eyeburn to transient aircraft in the normal commercial airlines and should provide adequate protection from fallout for ships. This will be studied further. It is assumed that the major weather functions will take place on Johnston, using already established procedures and facilities. The hazards evaluation group will operate from Johnston. It is felt that these groups should be where they can advise CJTF-8 directly as to the feasibility of a given operation.

10. With this concept of operations, certain personnel will have to be deployed forward to provide for both normal and emergency functions. Some personnel will have to be stationed for short periods on Johnston to remove samples from the B-57s after the LRL shots, as well as to provide personnel decontamination and perhaps area decontamination in the aircraft parking area. Provisions will have to be made by CJTF-8 for EOD personnel at Barbers Point as well as adequate fire-fighting personnel and equipment.

11. Because of the parachute retardation system being used by LRL in their events, information concerning rates of fall and drift must be provided to Task Group 8.4 and other interested groups by Sandia so that safety studies can be initiated. It is contemplated that the drop aircraft will fly as low as possible consistent with safety so as to minimize the drift of the LRL devices. 8.4 will determine the safe separation distance for experimental aircraft. Both LASL and LRL will determine optimum heights of burst for their devices early and disseminate this information widely.

12. Rehearsals for the airdrop operation are planned as follows: 30 August, off the coast of California with the B-52, 130s, and the command aircraft only (date may change to allow aircraft modification); 10 September, same aircraft, with DRM 4 drop; 14 September, complete array using a Mark 36 case (retarded), conducted at the LASL drop area, and staging from Barbers Point. The first airdrop is being planned for 16 September. Ex.(b)(3)

13. Comments to this concept and schedule are invited. I propose that Walt Dumas will assist me in coordinating the airdrop operations. Send comments to either of us at LASL. Warmest regards.

Further agreements as to responsibilities were quickly made. Austin McGuire would be in charge of the LASL portion of the airdrop operations, Robert Goeckermann in charge of the LRL portion of the operation, John Eckhart in charge of the Sandia portion of the operation, and Lee Hollingsworth would coordinate device check-out and loading for all airdrops.

Meanwhile, the airdrop system had dispersed and 8.4 had lost a great number of their people. On August 20 they asked Samuel to arrange for the recall of a large number of Air Force people by name in order to ensure success in the operation. By August 20 the approving system had written letters to the President requesting authority for the extended airdrop operation Ex.(b)(3) Ex.(b)(3)

On August 27 the population of Los Alamos personnel in the Pacific was two.

Changes in the plan were worked out over the next six weeks. On August 24 Betts authorized preparations toward the airdrop operation and on August 30 expanded that to include procurement actions, laboratory effort, construction orders, and aircraft modifications.

During the last week in August and the first week in September, CTG 8.3 and CTG 8.4 (Mustin and Samuel) agreed that they needed a target for proper array positioning. Parts were available to put together target rafts such as were used at Christmas and deep sea mooring equipment was available. However, it then was necessary to decide where the targets should be. .. Ex.(b)(3) That put it a little further away from Johnston than was convenient to Samuel for aircraft operation, and it made the B-57 job harder, since these aircraft would have to stage out of Johnston. Also, it introduced possible scheduling trouble with the RC-121 control aircraft which were staged out of Hawaii, since they also had to be used on dry runs for the forthcoming return to high-altitude testing. The point was eventually settled in favor of the safety arguments. Ex.(b)(3) ..

While the AEC Task Units worked hard during August and the early part of September to rebuild the gear in the C-130s and, in particular (between themselves and AFSWC), to get the DME gear working properly, they and Hollingsworth also had a great deal of trouble because the program kept changing. LRL's original proposals of variations Ex.(b)(3) seemed to be acceptable, but Bradbury's oralloy shot to improve the understanding of underground testing could not be sold permanently. He complained, with tongue in cheek, that apparently one had to have a previous failure on a given device to be allowed to get it in the fall operation.

By the end of August the system was tentatively planning, at the request of the AEC, on Androscoggin; .. Ex.(b)(3) The

difficulty was very clear. The President wanted the operation over by November 1 and the DOD had proposed some more high-altitude shots. Consequently, approval of the airdrops had to be mixed in with the high-altitude problem, taking into account Washington's idea of the Task Force capability to do them all, and worrying about total overall radioactivity produced. Ex.(b)(3)

These concerns led to an early September meeting during which the question of drogue parachutes was discussed by Samuel, Ogle, Goeckermann, and the rest of 8.4, the final conclusion being that a reefed drogue would be satisfactory.

Bradbury kept arguing for Tocito, but the Commission itself would not buy the shot, largely because it was too small to be included in the overseas operation. However, the test organization kept it in the schedule right up to the end, just in case Bradbury should win. By mid-September the air array was ready to go again and a first dry run was held on the 13th near Clovis, New Mexico. It looked promising. However, the second dry run the next day was aborted due to difficulties with both the AFSWC and Sandia DME systems. A third dry run on the 17th, off the coast of California, was more satisfactory and it was agreed that the aircraft would be deployed to the forward area on the 20th.

By then the array and the various responsibilities had been settled. Samuel would be in the control RC-121 with the appropriate Task Unit Commander, and Starbird and Ogle would be on an aircraft carrier in communication with Samuel and close to the target area.

In late September two more rehearsals for Androscoggin were held in the target area. On the first one the Sandia DME was questionable, the AFSWC DME gave nothing, and the LRL DME was quoted as being "no good." However, on the next dry run the system worked appreciably better, and, working around the high-altitude schedule, Androscoggin was finally fired on October 2. The Sandia and AFSWC DMEs worked properly,

Ex.(b)(3)

10 p.m.

On October 11 McGuire, for LASL, conducted the rehearsal for Chama. It was rough but satisfactory, and Chama itself was in the B-52 bomb bay ready to go by noon on the 13th in order to be fired on the 14th if Bluegill Double Prime should slip because of weather. Bluegill was slipped, but too late to try Chama. (The next day, Bluegill Double Prime failed.) Chama was tried again on the 17th, but one of the radar systems in the C-130 was out and Chama had to be delayed until the 18th, when it was fired.

Ex.(b)(3)

Ex.(b)(3)

Ex.(b)(3)

Ex.(b)(3)

[redacted] (On October 26, Rear Admiral Lloyd M. Mustin replaced General Starbird as Senior Atomic Energy Commission Representative for the operation and as JTF-8 Commander. Starbird was called back to Washington to head the Defense Communications Agency.) [redacted]

Ex.(b)(3)

[redacted]

Thus, in about three months, an airdrop system that had been largely torn apart was put back together again and managed to fire five more shots: the Everready concept had finally come to fruition.

The results of those five shots are given in the following table.

TABLE XXXVIII
RESULTS OF DOMINIC II AIRDROPS

Event	Yield (kt)
Androscoggin	63.0
Bumping	11.9
Chama	1700.0
Calamity	780.0
Housatonic	9960.0

Outcome of Systems Tests

Angel Fire/Dial Right (Atlas/Air Force)

Among other people and organizations considering the safety of the Atlas systems test just before test resumption there was a "Special Ad Hoc Safety Group" who wrote a "Special Safety Study Report of the SM-65D (Atlas)/Mark III R/V," published in April 1962. Chaired by Air Force Colonel Edwin Miller of the Directorate of Nuclear Surety (other members included Bob Hilty of the AEC Albuquerque Office and Lee Hightower of Sandia), the group concluded this test could be conducted safely "provided that action is taken to reduce the probability of premature application of the prearm signals to the arming and fusing system." They also concluded that there might be RF interference between the General Electric Range Safety System (GERSYS) and the Mod 3 Guidance System. Furthermore, they recommended the alternative impact area to provide better protection for the Hawaii and Johnston areas. After making the brief recommendations to eliminate the noted problem areas, they seemed to be approving the conduct of the test.

Consideration of how to modify the system to allow carrying out the Atlas systems test, as well as to permit the scientific community of the Task Force to get the minimum data on the shot, continued through a fair part of the month of May. Roswell Gilpatric, Deputy Secretary of Defense, sent a memo on May 9 to the Chairman of the Joint Chiefs of Staff reporting decisions made by the President on May 8, including a reaffirmation of his disapproval of an Atlas operational test. Either the JCS did not communicate this fact to the operational force, or the Air Force didn't believe it was a final no, or they interpreted it as withholding approval until later. In any case, the Air Force still requested readiness preparations, and

the test was pursued for some time before it was firmly canceled.

Ogle, as Task Force Scientific Deputy, tried to support the military systems tests by arranging for measurements ordinarily made by the various scientific Task Units, but the task was difficult because the military systems tests did not yield information of significant importance to these Task Units, e.g., weapons development or effects information. As a result he spent a fair amount of time during May trying to work out ways to obtain good yield, location, and performance data as well as coaxing the scientists to provide adequate support for the tests even though it was not their primary interest. On May 15 Dial Right was scheduled for June 6, if it was approved.

The Air Force sponsor for the test, Strategic Air Command, made a broad effort to meet the recommendations of those judging the safety of the test and to have the test approved. Their outlook was included in a message from SAC to the Air Force Chief of Staff on May 16. One safety feature that had been recommended was a device to prearm the warhead in flight. Such a device, consisting of an explosive switch and acceptable means for its activation, was engineered and was being installed in the three Dial Right missiles as of May 16. An installation similar to this had been successfully flight tested on May 11 "using the appropriate Dial Right prearm boundaries." Modifications to the General Electric ground guidance system to assist the PMR instantaneous impact predictor (IIP) plotting system had shown satisfactory coverage of the Dial Right target area, and the appropriate maps had been prepared. In addition, the Atlas system had been modified to include the General Electric Range Safety System (GERSYS) and this package had been successfully flight tested on both the Atlas and the Titan. Another improvement to the system was attempted as part of a calibration flight on May 11, but the performance of the system was erratic in its coordination with the PMR radars, and it was not considered satisfactory for the Dial Right test. The lack of time left to improve and check out an acceptable system led SAC to recommend that the Dial Right missiles be equipped with the prearm safety device and the GERSYS systems but not the C-band beacon. SAC felt that this configuration would satisfy the redundant IIP requirements and that the absence of the C-band beacon was not a safety hazard. Additional concern had been voiced about radioactive contamination of the Vandenberg local area resulting from accidental burning or single-point detonation of the warhead. A special safety study of these problems indicated that the effects of the worst possible accident could be minimized and contained within acceptable limits. SAC Headquarters had reviewed the disaster control plans in detail to ensure their adequacy. Based on all of these activities and their continual coordination with the Commander of JTF-8, SAC strongly urged final approval of the Dial Right systems test.

In spite of this effort the end came for this Air Force systems test on May 25. On that day Starbird was informed by the JCS that the test was canceled. He immediately expressed to SAC and the numerous other units associated with the test his regrets that the event could not be carried through and his appreciation to all of those involved in preparations.

There is a most important lesson here for the consideration of any potential systems test sponsor during any time period prior to nuclear testing. That is, no matter how important the execution of a national strategic or tactical systems test is considered to be to the so-called national defense or national security, the safety considerations to protect the people and property of the United States certainly carry a tremendous weight. Thus, the judgments, conclusions, and recommendations of those most familiar with the hazards must be taken seriously and met point by point, or repeats of the futile exercise carried out by the Air Force and SAC with the Atlas systems test will be experienced.

Frigate Bird (Polaris/Navy)

On the day after the U.S. resumed atmospheric testing, Ogle distributed the tentative shot list which showed two approved DOD systems tests. The first of these, a test of the Navy Polaris missile Ex.(b)(3) was scheduled for May 5. The target danger area, a 240- by 120-nautical-mile box added to the northeast corner of the Christmas Island danger area, was in effect from April 30 through May 10. In line with the projected schedule and previous decision that the JFT-8 Navy Deputy Commander would also serve as Commander of the Task Group for the Polaris systems test, Rear Admiral Lloyd Mustin left Christmas Island on April 28 to serve as Commander of Task Group 8.8 in execution of the Polaris systems test. The missile was to be launched in an operational mode from a submerged submarine, the U.S.S. Ethan Allen, commanded by Captain P. L. Lacy. For the Frigate Bird event two arrays of ships were involved, located 1,020 miles apart. The launch area array was composed of the Ethan Allen, a guided missile ship (AVM), a support carrier (CVS) with an embarked air group, and four destroyers. The purpose of all of this was to execute the launch properly and safely with precise ship positioning. In the impact area the array consisted of two submarines operating at periscope depth 25 miles from the impact point and positioned 45 degrees on each side of the flight path of the Polaris. Each submarine was equipped to provide scientific and documentary data, and, in addition, there was a small air array with diagnostic functions. The air array was composed of an RC-121 AOC, a C-130 diagnostic aircraft (the Livermore aircraft, number 299), a C-135 sampler controller, and B-57 D samplers. Admiral Mustin established the JTF-8 control point aboard the AVM, the U.S.S. Norton Sound. He was advised by Rear Admiral Levering Smith, Technical Director of the Navy Special Projects Office in Washington, whom he had requested be present for the systems test.

The test date was slipped from the planned date of May 5 to May 6 because of inability to maintain required communications between the deployed launch array and the Commander of JTF-8 at Christmas Island. This problem was overcome by various measures, principally through CINCPACFLT, who exercised control of frequency usage by assigning a series of frequencies exclusively to this function and silencing all other users of these frequencies throughout the Pacific. Special safety features aboard the Polaris missiles included range safety tracking beacons, destruct systems, and a separate battery power source. Additional safety measures required that the destruct safe-arm switches be moved to the arm position in a prelaunch sequence before the first stage missile ignition system could be enabled. Many rehearsals of the launch sequence were conducted, simulating the beacon aboard the missile by flying a beacon aboard some aircraft. The Ethan Allen crew could acquire the C-band beacons within six seconds after a simulated launch, giving them confidence that their radar would be locked on the missile soon after it broached the surface and before it reached the expected altitude of the usual low clouds. (If lock-on were not achieved the missile would be destroyed by range safety.) The Ethan Allen arrived in the launch area on May 2. Rehearsals on May 3 and 4 uncovered long-distance communication problems which led to a delay until May 6.

On launch day the weather in the launch and impact areas was predicted to be marginal but worth trying. Holds due to adverse weather conditions in the impact area caused delays of about two hours on the morning of the test. These holds came after switching the missile safety systems to internal power (beginning the drain on the internal batteries). At long last the countdown proceeded, but at 30 seconds before launch of the primary missile the fire order to that tube was automatically bypassed by the control system and the backup missile was selected, and then that tube was also automatically bypassed. Analysis quickly showed that the first bypass happened because the "muzzle hatch open" limit switch failed to close and the second

bypass was caused by a false "safe/ready" indication. Only a few minutes were needed to correct the situation, after which the standard firing crew procedures were used to achieve proper indications. However, by this time Admiral Mustin thought the delay in the detonation time might be a safety problem for the observation aircraft in the burst area, and he ordered a range-safety hold in order to choose a new burst time. In the Task Group report on the test, the following was stated about the missile bypasses:

> It should be emphasized here that these missiles would have been fired in a true tactical situation, since there would have been time to analyze and correct these casualties with very little delay in a tactical countdown, where "burst time" is not such a restrictive consideration.

Thus, a new detonation time was established which still would be within the useful operating time of the activated internal batteries. However, just before the new launch time Admiral Mustin ordered another hold for launch area weather conditions. This hold led to the further complication of replacing the beacon and destruct batteries in the two missiles previously counted down, since their remaining operating times were now too short. During the several minutes required to effect the battery changes, the local weather reconnaissance aircraft indicated a favorable cloud situation approaching, and a new missile tube was selected, simultaneously cutting short the battery exchange procedure and precluding the possibility of utilizing either of the two original missiles. Finally, this third missile was successfully launched 18.5 seconds after the nominal launch time, the delay being "associated with the relatively slow hydraulic pressure buildup shown in the history of this missile and experienced in the final seconds of its terminal count." Following launch the range safety observations showed a nominal trajectory and nominal time of flight. Diagnostics were limited, data coming from three sources. The two submerged submarines in the burst area observed the burst with bhangmeters mounted to see through their periscopes. Secondly, the B-57 D sampler aircraft controlled by the KC-135 (all under Task Group 8.4) successfully sampled the burst cloud at a location about 525 nautical miles (near their maximum range) from their Christmas Island base. Thirdly, the Livermore C-130 diagnostic aircraft positioned by the RC-121 attempted to acquire diagnostic data from the test, but this attempt was essentially fruitless, primarily because of inappropriate positioning in this all-airborne configuration.

Rough estimates of the burst height and location based on the observations in the impact area indicated that the burst was at about 8,300 feet altitude and 1.25 miles from the nominal aim point. [redacted]

Ex.(b)(3)

The report on the Frigate Bird test from the Commander of JTF-8 to AEC Headquarters stated the following:

> Three holds were imposed because of weather and one for technical reasons prior to launch . . . one tube experienced a failure of the launch hatch interlock and another tube lost the 800-cycle conference voltage during a simultaneous countdown of two missiles. Countdown continued on Tube No. 9. A slow hydraulic system buildup indicated a no-go condition that required recycling. This accounted for the additional 20 seconds on launch.

An illustration of "filtering" of information to minimize what might be considered failures is found in a letter from Chairman Seaborg to President Kennedy on May 18, which discussed the progress of the test series. As for the systems tests, Seaborg simply reported that they both "functioned reliably on the first firing."

Swordfish (ASROC/Navy)

This test of the Navy's antisubmarine rocket system was, as mentioned before, both a system test and an underwater nuclear weapons effects test. Just as for the Polaris test, a separate Task Group, TG 8.9, was temporarily established within JTF-8 to execute the Swordfish event. By May 3 two full dress-rehearsals had been conducted in the San Diego area, with full participation except for the carrier surveillance group that was engaged in the Polaris test at the time. One ASROC weapon was fired by each of two destroyers in a nonnuclear mode during these rehearsals. One of these destroyers, the U.S.S. Agerholm, was the primary firing ship on the Swordfish test, and the other destroyer, the U.S.S. Anderson, was the standby firing ship.

The units supporting the test in the San Diego area departed for their stations beginning on May 4, the majority departing on May 7. After the Frigate Bird Polaris test on May 6 Admiral Mustin sailed aboard the carrier Yorktown to the Swordfish test area. Following the May 8 authorization to perform the test, Mustin and the Yorktown reached the array of all other Swordfish units in their assigned area on May 9, and Admiral Mustin shifted to the LSD Monticello, which was his flagship for the test. The ship array to conduct and observe the test consisted of three destroyers, a submarine, the landing ship dock (LSD) on which the Task Group Commander established his command center, and the support aircraft carrier. As on the Polaris test, the overall command was from the JTF-8 Commander at Christmas Island, but it was exercised through the TG 8.9 Commander in the ASROC area.

The towed instrumentation array, which included the target raft, the unmanned destroyer to measure effects (U.S.S. Bausell), and ten instrumental platforms, was over six miles long. The numerous pieces of instrumentation in this towed array were all assembled as one string on a polypropylene tow line. The target raft carried a radar target for the radar systems on the launch ship and a sonar reflector suspended underneath to simulate a submarine target for the sonar systems of the launch ships. The instrumented array was towed into place as planned by an ocean-going tug, the rest of the ships took their assigned positions, and the countdown commenced early on the morning of May 10 in anticipation of a noon event time. However, as noon approached, low cumulus clouds in the burst area threatened to obscure the view of the A3D aircraft responsible for critical photography from above the burst. The photo aircraft were moved into a new pattern in the hope of achieving zero time coincident with holes in the clouds. What transpired is best related by quoting from the Task Group report:

> During this process, there then occurred a succession of further interruptions from individually minor items. First, the lead A3D had an electrical power failure. The standby plane was slow in the planned takeover, mainly because of the considerable communication confusion which attended this casualty. Then Agerholm momentarily lost power on the switchboard providing primary power to the ASROC system, through faulty procedure in the engineering department. This lost the "green board" system indication on the bridge, which was misinterpreted to indicate a masked battery, and led to clearing maneuvers which put the ship in poor position relative to the planned test firing conditions. Finally came a report (later found erroneous) that the start-camera had been sent on a nonfiring run, which would have disabled critical technical photography for the actual run. At this point, with the A3Ds nearing the end of endurance on station and cloud cover progressively worsening, the event was canceled for the day and rescheduled to May 11.

The initial feeling was that achieving readiness for May 11 would be an impossible task because of necessary reorientation of the instrumentation array and other coordinated requirements, but owing to "magnificent seamanship with the array and extraordinary efforts by the instrumentation technical groups," all was made ready for a repeat attempt one day later. The ASROC test was conducted successfully on May

11 at 1 p.m. The time of flight of the ASROC was about 40 seconds from the Agerholm to the burst point about 4,000 yards down range, and the actual burst occurred about 350 yards beyond the nominal aim point. Measurements indicated that the burst depth was Ex.(b)(3)

The test yielded a wealth of effects information, but only a small part of the planned system test diagnostic data were recorded. Included in the data gathered were information on the base surge, the water contamination, effects on ship sonar, damage to a variety of ships in various positions, and off-site hydroacoustic effects. Some of the data gathered resulted in significant recommendations on tactical employment range concepts and on the need to investigate the premature detonation probabilities of the ASROC fuse.

The High-Altitude Series

The President directed the AEC on April 24, 1962, to resume testing, just two days before the first rehearsal for Tiger Fish, which was to be the certification launch of the Thor missile from Johnston Island. As with any good rehearsal, the intention was to have a complete array of aircraft and ships and to have all experimenters on the dry run, but not to fire the small rockets, or at least not very many of them. The LASL C-135 aircraft did participate in the dry run, as did most of the air array and all of the ships. However, the DASA aircraft were not yet ready, needing those last few days to prepare.

Trouble with the pod orientation continued, and the certification shot which would carry pods was delayed until May 2. On April 25 or 26 Douglas and SSD concluded from analytical and wind tunnel data that they could reconfigure the ballast in the Mark 5 RVs to provide the capability of carrying two RVs and one pod on Starfish. Additional wind restrictions for the launch were involved, but they did not seem to be particularly difficult.

Tiger Fish was fired on the morning of May 2. The missile itself and all the warhead certification features operated properly. Range tracking was satisfactory. The pods were recovered satisfactorily. Unfortunately, the flywheel drive motors used to establish pod orientation burned out, but one pod had one flywheel running slowly at launch time. As a result, two of the pods tumbled almost immediately after release from the missile and the third showed a 20 percent wobble at what would have been burst time. The long-range communication was unsatisfactory and some "go, no-go" information was not relayed to Johnston in time to be acted upon.*

Between Tiger Fish and the first attempt at Bluegill, long-range communication was improved and a proper size motor was put on the pods. Several dry runs were conducted between the two shots, as were a couple of air array rehearsals.

Shortly before Bluegill Norman Thomas, in a telegram to Seaborg, suggested:

> In view of opinions of British scientists and others, is there not grave danger in sudden unilateral American decision to explode three "rainbow" bombs possibly affecting seriously the Van Allen belt? Is not the mere fact of these protests sufficient reason for indefinite delay at least until international consultation?

The problem was to grow during the operation.

*The center of the communications net in Honolulu lost voice and teletype transmission from Johnston Island shortly before launch. They continued, however, to transmit "blind" to Johnston, and most of the critical information was received at Johnston, including the status of Haleakala, Kauai, Point Arguello, etc.

The AEC and DOD Task Units had established joint technical operation centers at both Johnston Island and Hawaii. These operation centers coordinated their actions more and more in the time between Tiger Fish and Bluegill in order to present to the Task Force Commander a moderately unified view of the situation. "Go, no-go" criteria established included such items as (a) excellent seeing conditions between the ground optical stations and the burst, (b) appropriate launch winds for the Thor and the small missiles, both from operating and safety points of view, (c) conditions of solar magnetic storms, (d) the requirement that at least two pods be stabilized and capable of recovery, (e) communications to the far-out stations being in operating order, and (f) an appropriate fraction of the observational aircraft operating. These criteria varied from shot to shot, depending upon the requirements for the particular shot.

While the remaining Bluegill experimenters were moving to the field, setting up their equipment, establishing communications, etc., and while Shuster, Ray, and others on Johnston Island were establishing the control system and agreeing on safety and other no-go conditions, etc., the AEC and DOD in Washington continued their pressure on the President to add tests. At the May 8 NSC meeting the President agreed to include Urraca in the series. However, the system could not leave the program alone. A query concerning the effects of a high-altitude nuclear detonation on the Van Allen belt and the possibility of satellite damage reached high levels very quickly. In response to a question from Colonel Anderson of DMA, Conrad Longmire stated:

> It is expected that the high nuclear shots, Urraca and Starfish, will have some small, but possibly measurable, effects in the region of the inner Van Allen belt. The effects fall into the following two types: (1) injection of energetic bomb-produced electrons and protons into the belt . . . . In summary, it is my strong belief that the perturbations produced on the inner belt will be minor, if detectable at all. Furthermore, if detectable perturbations are produced, a measurement of the relaxation time of the perturbation would add a positive contribution to our scientific understanding of the belt.

Three days later Longmire and Taschek expanded the point for Commissioner Haworth.

Ex.(b)(3)

[redacted] They noted that the measurements would be made mostly from rockets launched from Kauai and Vandenberg Air Force Base and that there would be extensive photography coverage. They again commented that the perturbations to the inner Van Allen belt were expected to be small. On May 15 Seaborg briefed PSAC on the problem. After thinking about it, J. Wiesner (the President's Scientific Advisor) inquired whether the yield of the device could be reduced and still allow a good experiment.

Ex.(b)(3)

[redacted] On May 24 Seaborg, as previously requested, reviewed the discussions of the last few weeks for the President. After again giving all of the reasons for its inclusion and the

reasons for not changing the yield, and further stating that it was too late to modify the booster to utilize a lower-yield warhead, he concluded that another look would be taken on the subject of reducing the yield.

On May 24 Seaborg, Haworth, Harold Brown, J. Wiesner, McGeorge Bundy, Carl Kaysen (Bundy's Deputy), Spurgeon Keeny, and General Betts met to address the problem. Wiesner did not believe that a demonstration was necessary in order to convince ourselves that we could carry out deep space tests. Seaborg took a firm position that there would be definite technical value in carrying out the experiment Ex.(b)(3) in the proper medium. It was concluded that there was no eyeburn hazard. The group finally decided to leave the shot in the program, apparently because of the argument (presented by Bundy) that the President probably would not wish to be accused of giving in to British scientific pressure.

Preparations for Bluegill proceded. On May 8 Gilpatric notified Betts of his intention to appoint a Joint Board of Investigation which could be convened immediately by the Commander of JTF-8 in the event of a major nuclear accident or incident involving loss of life, damage to public property, or serious public reaction. The Board membership would consist of two representatives from the AEC and a Field Grade officer from each service and DASA, with retired Vice Admiral E. M. Parker as chairman.

DASA began to move on the McMillan Committee suggestions for additional shots. On May 11 they proposed "Red Snapper," Ex.(b)(3) at 20 kilometers altitude. Associated with the burst would be powered pods positioned above and below the device during reentry to observe the effects on the pods. DASA also reentered Kingfish into the plan in mid-May.

The addition of these shots would only be sensible if more Thor boosters could be obtained. On May 16 the Director of Materiel Management at Norton Air Force base (SBAMA) explained to the Chief of Staff of the Air Force:

> SBAMA literally scraped the bottom of the barrel in providing a total of four SM-75 (Thor) missiles for Project Fishbowl launch operations. The two additional SM-75 missiles provided Fishbowl are emergency backup missiles which were assigned to Fishbowl with a definite and agreed understanding that they would be returned to SBAMA at the conclusion of Fishbowl to meet commitments to USAF/RAF operation program in accordance with existing country-to-country agreement signed by U.S. and U.K. governments. As a consequence, the emergency backup missiles are not surplus which are available for other projects at the conclusion of Fishbowl operations.

They also noted that one missile might be obtained without involving the U.K. by using a missile allocated to SAC at Vandenberg for display purposes. That missile (No. 150) was then being used by Douglas to assist in engineering testing for Fishbowl. They recommended immediate authorization for rework of missile No. 150, to be used either for Red Snapper or Kingfish, and urged that only one of the two projects be done. SSD commented that Kingfish could be no sooner than July 21-24 and Red Snapper no earlier than August 15-18. By May 25 Kingfish was approved for planning as the last shot in the series: presumably it would be fired only if appropriate materiel and time were left for it.

On May 11 the Commission approved Starfish and Bluegill for execution. Schlesinger wrote,* concerning the effort to build the international machinery of peace in mid-May 1962:

*Schlesinger, *A Thousand Days*, page 503.

The President, therefore, maintained a steady pressure on the executive branch to keep the negotiating effort alive. Wiesner and Kaysen flourished the White House mandate, were tireless in needling the bureaucracy and forcing disarmament issues; and Bundy intervened valuably at critical moments. Wiesner often carried the brunt of the argument against the Pentagon in meetings before the President. After one contentious session, he told me that he was afraid that he had talked too much and might be wearing out Kennedy's patience. Later the President asked me about the meeting. I said it had filled me with gloom, that only Wiesner had made much sense, and that he was afraid he had done more than his share of speaking. Kennedy smiled and said, "Sometimes, I think Jerry talks too much, but I didn't think so yesterday. Tell him that I thought he made a series of excellent points and that I want him to keep it up." Next to the President, McNamara, with the able backing of John McNaughton probably did more than anyone else to sustain the disarmament drive. With his sense of the horror of nuclear conflict, his understanding of the adequacy of existing stockpiles, his fear of nuclear proliferation, his analytic command of the weapons problem, and his managerial instinct to do something about an irrational situation, he forever sought new ways of controlling the arms race. His contribution was especially crucial in dealing with the Joint Chiefs of Staff, possessed as they were by the conviction that they alone understood the requirements of American safety. Nor was the invocation of national security confined to the JCS. Once, at a meeting of the Committee of Principals, someone from ACDA objected to a proposed arms control measure on the ground that it might imperil the nation. McNamara said sharply, "If I'm not afraid of it, I don't see why you should be. You take care of disarmament. Let me worry about the national security of the United States."

On May 20 the Chief of DASA concurred with Kiley on the recommendations for two RVs and one pod on Starfish. Kiley would keep the capability of using three pods in case new problems came up.

By mid-May LASL had loaded up their C-135 with so much instrumentation that when fueled for the rather long-range mission they planned, the weight of the plane approached the maximum operating capability utilized by SAC. The result of discussions between the scientists and the Air Force was a clear recognition and understanding by both SAC and LASL that aircraft safety was the responsibility of the Air Force. While there were occasionally some tense situations on takeoff from Hickam, flights operated as planned and Air Force judgment was validated.

The problem of possible eyeburn in Hawaii was raised by introduction of Kingfish, which was planned to be Ex.(b)(3) altitude over Johnston Island. The initial calculations indicated that a danger area 600 miles in radius would be required at sea level and a greater radius at aircraft altitudes.

Late in May, as the date for Bluegill approached, other operational decisions were made. Betts issued a statement to all Labs that there would be no message traffic from Johnston Island to those organizations in the period from 24 hours before to 24 hours after Bluegill because of the heavy communications traffic needed for operational reasons. In the last two weeks of May, under Shuster and Ray, several Bluegill dry runs were conducted in a very realistic fashion. There were communication troubles, aborts because of weather, aircraft trouble, etc. The Johnston Island system was doing a fine job of making the rehearsals as realistic as they could. In the middle of all this, Salet got his second star, but the party that night at the Point House didn't slow down the operation very much. Starbird and Ogle moved to Johnston Island a few days before the Bluegill event, which was scheduled for June 2.

Bluegill was counted down for the first time on the night of June 2, 1962. At minus 45 minutes the Range Tracker (the PMR range safety ship) computer failed and there was a two-hour hold, but the test was then cancelled for that day. The cancellation arose from the requirement to know the burst-time position of the RV to within two miles because of the positioning of effects ships. The Range Tracker computer was essential because it computed predicted positions from data on the missile position acquired from launch through main engine cut-off time. PMR worked desperately all day on June 3 to repair the computer, managing to get some computer experts from

Los Angeles to the island at 3 a.m. on the 4th, just after PMR got the computer fixed. Bradbury was on the same 3 a.m. flight.

The first launch of the Bluegill Thor Ex.(b)(3) Ex.(b)(3) occurred just after midnight on June 4. Earlier in the evening the weather had been cloudy, but Dan Rex had predicted it would clear and it did by about midnight. After a few holds for minor reasons the Thor missile was launched, apparently achieving a perfect trajectory. However, in the last stages of propulsion, just before main engine cutoff, PMR lost track from the beacon-tracking radar used to calculate the predicted burst position. There was some chance that a second radar, which was skin-tracking the missile, might have acquired sufficient data to validate the impact prediction. Therefore, attempts were made between about minus 10 and minus 5 minutes to use the skin-track data for burst-point prediction, while also attempting to reacquire the beacon, but neither was successful. Consequently, at minus 5 minutes Ogle suggested, and Starbird agreed, that the warhead should be destroyed, and that was done.

In a discussion of predicted impact computations following the end of the test the path of the predicted impact point appeared normal through main engine cutoff. However, during the vernier engine phase the predicted impact position shown on the plotboards seemed to change excessively, based on the beacon-tracking FPS-16 radar. But data from the skin-tracking MPS-26 radar indicated a smooth and nominal path. Which radar, if either, was telling the truth is, unfortunately, unknown.

Years later Frank Strabala of EG&G pointed out to Ogle that the timing system run by EG&G, which provided signals to all of the cameras and other missiles, etc., had failed appreciably earlier in the flight. However, EG&G had seen no point in bringing up the subject since the flight already had troubles. In addition to the problems already mentioned, telemetry data discussed in the postmortem showed that two of the three pods failed to separate. The JTF-8 control room voice tape record shows that a few moments after "destruct," as the pieces were falling down, Ogle commented, "Best damn dry run we ever had."

On the Honolulu beaches the many people who had turned out to watch the flash in the sky were disappointed. The next morning, the Honolulu Star Bulletin quoted a JTF-8 spokesman: "There was no nuclear detonation and there is no likelihood that the fragments of the device will explode in the ocean. Nor is it considered that it will cause hazardous levels of radioactivity in the water, and they will not constitute a hazard to human health."

An appreciable number of the small rockets (and the equipment they were to carry) had been saved on Bluegill, either because they had been cancelled before the Thor launch because of improper winds or because the launch countdown timer had been stopped before they were launched. There was a spare Bluegill RV and nuclear explosive device on Johnston Island. On the other hand, the pod-orienting system had to be rebuilt. The Starfish shot had all of its parts coming down the pipeline and had been planned as the next shot. Furthermore, Starfish was a somewhat more important shot. Thus, for these and various other reasons, the decision was to do Starfish next.

However, something had to be done about the tracking systems. The Range Tracker radars and computer were the first problem. After some discussions it was arranged that the two radars would operate separately, one on beacon track and one on skin track. Each radar would feed its information into the computer memory separately. Because of limitations on the computer, only one set of data would be used in real time to compute the refined impact point, but it was arranged that if that tracking system failed, then the computer could use the data from the other radar track, recomputing the track in about three minutes.

The Range Tracker also had a real-time presentation of the missile horizontal

range versus altitude, obtained from its primary radar. Since the intended trajectory was known, these data were sufficient for safety purposes if they were available after main engine cutoff. However, it took a trained man watching that data to derive that information. PMR had such a trained man, and it was arranged that he would watch that data specifically, advising the Task Force Command Post 200 seconds after lift-off whether everything was all right or not (via a specially arranged hot line).

Field Command had arranged for the Cubic Corporation to be responsible for tracking all of the DASA instrument packages, including one of the pods. Cubic Corp. used a very accurate microwave interferometer system known as angle measuring equipment, distance measuring equipment, or AME/DME. On the first attempt at Bluegill the AME/DME data had not been presented in real time. Arrangements were quickly made to use it to get a nearly real-time plot of the surface range and azimuth, which, if compared with predicted values, could also be used for safety purposes.

Sandia operated a similar system using the transponder on one of the RVs, but this system would give only a slant range in real time. It was therefore arranged to have a real-time presentation of the slant range that could be compared with the record from Tiger Fish, since the two trajectories were supposed to be identical. Lastly, even after the missile range exceeded the Range Tracker capability, that radar could give the angular elevation of the RV to within about 2^{o}. In addition, the Cubic Corporation microwave interferometer could give the angles to within about 1^{o}. The combination of these angles and the slant range would give an approximate position, which then could be compared with the expected position at a given time. The proper arithmetic had to be done by hand calculation, and a team of people in the control room were given the job. The prime calculators were Dan Rex and Vay Shelton. They could give the position about one minute later than real-time.

It took about two weeks to institute all the new tracking procedures, and then several days were used feeding in data from old tapes (Tiger Fish), etc., so that by June 19 there were a number of independent systems which would give RV position within a minute or two after it passed through a given point.

On June 7 JTF-8 planned to do Starfish on June 18 and Urraca two weeks after that (approximately July 3), with a repeat of Bluegill not scheduled precisely. The problem in scheduling a repeat of Bluegill was not only the mechanical one of rockets and pods, but the political one, since the President had indicated the series should be done by the end of June. However, the next day, the JCS sent a message to Starbird and Bradbury stating their desire that Bluegill Prime, the second try of Bluegill, be fired during the current series and giving their opinion that the Urraca shot "must not interfere in any way." The JCS suggested that the next shot should be Starfish, then Bluegill Prime, and after that could come either Urraca or Kingfish if Urraca should not be fired. Harold Brown and Gerry Johnson concurred with this opinion. However, it soon became clear that all of the equipment for a repeat of Bluegill could not be constructed soon enough to do Bluegill two weeks after Starfish, and, therefore, on June 15 the Task Force reiterated the schedule, according to which Starfish would be done about June 19, with Urraca as soon as possible after that, but not earlier than July 3. Bluegill would be attempted after Urraca. However, the Washington debate persisted, and Betts asked Starbird to consider other schedules that would include Kingfish. Knowing the President's desire to keep the operation as short as possible and recognizing the weight that could be exerted by the Department of Defense, Hoerlin promptly asked Taschek to go to Washington and join the argument in defense of Urraca. Hoerlin commented to Haworth on the strong need for the AEC scientific side to get the data in the regime which Urraca would investigate and noted with respect to the proposed Kingfish shot that "My colleagues and I would like to state that after a successful Starfish and in view of the

similarity with Teak, it should pose no problem to compute both the phenomenology and the effects of such an event."

The picture was clouded even further on June 19 with the first attempt at Starfish (1.45 megatons at 400 kilometers altitude). For that shot, the missile carried one pod and two RVs externally. The weather was acceptable and the Thor was launched a little before 11 p.m. in order to have an 11 p.m. burst time. However, 59 seconds after launch the missile flared and exploded. The warhead destruct signal was sent 64 seconds after launch. Debris rained on the island, fortunately doing no serious damage. Investigation of the pieces and the telemetry data made it clear very soon that the mock RVs carried up with the missile had disturbed the flow of gases from the turbine exhaust, sucking the hot gas back against the boat tail and weakening the structure. The engine had torn itself loose and flown right through the fuel tanks.

In the meantime, Hoerlin, Longmire, Ogle, etc., had been considering the eyeburn problem in the Hawaiian Islands presented by the proposed Kingfish shot Ex.(b)(3) Ex.(b)(3) That same problem had led to an odd-shaped danger area for Starfish, circular at sea level and at aircraft altitudes, but increasing in radius with altitude. Since this danger area would require rerouting of commercial air flights, the Commission requested information on the subject. The information was provided by Hoerlin and Ogle, who explained the problem to the Commission during a meeting on June 7. The Commission agreed with the proposed danger area, as did Jerry Wiesner later in the day. Samuel, Mustin, and Ogle visited President Kennedy in the afternoon to brief him on the operation. The President expressed a desire to hurry the tests (Ogle said we could not) and got one more view on the reasons for the high-altitude shots.

However, according to calculations, Kingfish would present an eyeburn problem in some parts of Hawaii. Even though the shot might be fired late at night or early in the morning, experience had already shown that there would be a number of Hawaiians in the mountains trying to observe the detonation.

The scheduling problem became very difficult. In the first half of June DASA and JCS reviewed the priority of the DOD shots and decided that Starfish was their most important test. Field Command DASA stated that there were sufficient pods, including ones that were being refurbished, to provide three pods each for another attempt at Starfish and Bluegill and three additional pods in the event Starfish needed to be repeated a second time. They concluded that there should be no further attempt to fly RVs, and Douglas concurred. Thus, from their June 20 meeting the JCS concluded that (a) the next shots should be Starfish and Bluegill and (b) Urraca after those was uncertain depending upon the situation at that time. Betts transmitted that information to the Laboratories and the Task Force, stating that he had sufficient information on Urraca and did not need any further arguments. (On the 19th Hoerlin had reiterated in a very strong message all of the reasons for doing Urraca and the reason for the AEC insisting on the shot, pointing out the tremendous effort that Los Alamos and Sandia had put into the shot so far.)

However, the argument did not stop. On the 21st Schwartz of Sandia echoed Hoerlin's sentiments to Haworth and Betts, and Ogle was in Washington to explain the operational problems again at high levels. The argument did result in the cancellation of Kingfish, but the order of shots was not Starfish, Bluegill, and Urraca, as the President had agreed to on June 20.

President Kennedy, upset at the series of failures, asked the Department of Defense why the Thor had been chosen rather than some other missile such as Redstone. Gerry Johnson reviewed the reasons for the missiles (see missile selection section earlier), pointed out that there were three Thors left at Vandenberg, with one scheduled to be shipped within the next two days, and added that the Air Force had

seven additional boosters which could be configured in a minimum of two months. [redacted] Ex.(b)(3) [redacted] Accordingly, the next attempt was to be Starfish, and rumors circulated that July 9 would be the end of the atmospheric testing. LASL continued to argue for Urraca right after Starfish, claiming that it was more important than Bluegill. On June 24 Starbird requested that another Starfish RV and warhead be delivered by July 9 in case the proposed July 4 Starfish repeat should also fail.

On June 25 Hoerlin sent a message to Wiesner, Starbird, Ogle, Johnson, et al. concerning Urraca. In addition to previous arguments, he debated what he called the principle of noninterference, which was interpreted as meaning that Urraca must wait until the DOD was absolutely finished with its program, regardless of how many repeat shots were necessary. He did not see how the AEC could agree to do its work only when it did not interfere with the DOD's schedules without being derelict in the duty assigned to it by law. However, he went on to argue the military importance of Urraca, commenting that each of the three shots (Starfish, Bluegill, and Urraca) would occur in completely different atmospheric regimes and that our lack of understanding of the dominant mechanisms controlling the explosions was such that any of the shots would produce important information, but that Starfish seemed most likely to do so. On the other hand, he argued that Bluegill phenomena would be most closely related to low-altitude detonation phenomena, and it was, therefore, more likely to be predictable by calculations. Consequently, the order of firing should be Starfish, Urraca, Bluegill. He also brought up the point that Urraca was important as a test of our space detection system, and the lessons to be learned could prevent the Russians stealing another march on us by preparing to test in deep space.

The McMillan Committee met in Hawaii on July 13 en route to observe the Starfish Prime shot, again re-examining the priority of the three remaining high-altitude shots. They found no reason to alter the previously recommended order of priority, recommending that Starfish be tried until it was successful, followed by Bluegill until it was successful, and then, finally, to do Urraca. However, they did comment:

> The effects associated with Urraca have sufficient interest and potential to merit DOD support. Weapons effects cannot be reliably extrapolated in the new altitude regimes. The Urraca could contribute significantly to the understanding of high-altitude effects and thus, indirectly, answer many questions now in a speculative stage.

At the beginning of July McGeorge Bundy reviewed the problem [redacted] Ex.(b)(1) [redacted] if Urraca were included it could not be carried out before August 3 and might slip as much as a week due to weather requirements. Against the test was the argument that there was no serious military interest that far out into space, that neither space testing nor space test detection were of current urgency, and that the United States was running overtime on high-altitude tests and should stop before August. On the other hand, Bundy commented that Urraca was the most interesting shot in strictly scientific terms as compared to Starfish and Bluegill, and that knowledge about space testing and test detection in outer space would make it more practicable to propose an atmospheric test ban. He pointed out the great amount of effort that had gone into the Urraca shot so far and noted the morale difficulty, stating:

> But it will not be easy for them to understand why one third of their eight months of effort should be rubbed out for a gain of two weeks in the end point of the series.

Finally he stated:

Technically, Urraca is probably the most failureproof of the three high-altitude space shots. Its missile does not have the special gear of Starfish, and it does not have to follow the close track of Bluegill. It is in the hands of the Los Alamos Scientific Laboratory, which is, on the whole, the most experienced and most reliable testing agency we have. (It is one of the most abrasive aspects of possible cancellation that it would appear to penalize Los Alamos for the failure of its friendly rivals in Defense.)

On July 4 Starfish Prime was ready. The early steps of the experimental preparation had begun. The area had been swept. The FAA had been notified and the first aircraft were leaving Hawaii. However, at minus three hours, Douglas and SSD informed Starbird that the wind shear was too high, and the launch was canceled. In later discussion between the Douglas people on Johnston and those at home, new wind shear limits were adopted which would have allowed the launch early on July 5. The next few nights were unacceptable because of clouds. On the night of the 8th the weather was not perfect, but it was good enough. After the earlier failures, the test organization was nervous. Starbird wouldn't watch the TV pictures of the missile. Starfish Prime was launched on July 8. The Thor flew properly, the small rockets worked properly, and tracking went properly. In fact, essentially everything worked properly. The nose cones from the Kauai rockets were recovered. The pods were recovered. There were no eyeburns. The only problems were some cloud cover at Tonga, one pod flywheel that apparently ran slow and allowed the pod to tumble, and two instrument rockets from Point Arguello that failed. The shot was an outstanding success.

While the results of Starfish Prime would be subject to study for many years after the shot, some points were known fairly quickly. It appeared that about half of the debris was distributed in the southern magnetic conjugate area, and there was also an appreciable amount in the northern conjugate area. Some debris did fall below the burst, giving a maximum density at about 300 kilometers and some density as low as about 150 kilometers. There was evidence that an appreciable fraction of the debris must have risen to several thousand kilometers above Johnston Island, but there was no indication that a significant quantity had actually escaped from the earth's atmosphere. An artificial belt of electrons was trapped in the earth's magnetic field, some 25 percent of those electrons drifting at least once around the world, and some passing around the world as many as four times.

The AFSWC people were especially happy with the results, as is shown in a message to their Headquarters: "Success of experiments is extremely gratifying to AFSWC personnel who have pointed space physics research to this achievement for several years. Suggest you pass congratulations to Research and Test Directorates and other AFSWC nuclear testing programs." Hoerlin was also happy, but in reporting the success to Bradbury at LASL, he noted the failure of the Arguello rockets and commented that the motives for conducting Urraca had been strengthened rather than weakened.

The successful firing of Starfish Prime therefore left two shots to be fired and two missiles available. Curtis LeMay, then Air Force Chief of Staff, noted in mid-July to Gerry Johnson that the Air Force was preparing an additional Thor in case the next Bluegill should fail. The missile was to come from those committed to the United Kingdom Air Force Training Launch Program. He also stated, "In view of the above, it is recommended that the additional Thor missile now being readied for shipment not be considered for any use other than backup for those high-priority DOD tests currently scheduled." (The fact that LeMay talked of "tests" probably reflects the Air Force's continued interest in Kingfish.)

Bluegill Prime was scheduled for July 25. LASL reported to Betts that the results of Starfish "go a long way toward proving out the feasibility of getting good bomb diagnostics from instrumented rockets in a space testing program." It appeared

that the worst problems had been solved. On July 23 things looked smooth enough that the Task Force planned to fire Urraca 11 days after Bluegill, assuming Washington agreed. However, on that same day Ogle noted to Luedecke, "I've become aware that there is still consideration in Washington of proposed Ex.(b)(3) Ex.(b)(3) Kingfish as a possible detonation of Operation Dominic after Urraca." He went on to note that the proposed shot would be quite bright and would produce an image on the retina of the human eye at the distance of Hawaii, roughly two thirds the size of the sun's image. He pointed out that for such a shot Kauai would possibly be within the danger area and that, certainly, people in the mountains at Kauai would have to wear dark glasses or turn away. Precautionary actions would have to be taken on Nihoa and Niihau. Small boating and fishing within the area would have to be stopped during the hazardous period. He noted that this situation could be improved by changing the missile trajectory to fire Kingfish some 200 to 250 miles south of Johnston, but that it would take two months after notification to change the Thor trajectory in that way. He also pointed out that lowering the burst altitude could solve the problem.

The next day SSD was busy calculating the additional costs of a seventh Thor to be used for the tentative Kingfish event and discussing the question of which kinds of pods could go on the missiles.

However, the picture changed rapidly. On July 24 the Bluegill Prime launch was delayed by weather, but the decision was made to go ahead on the night of the 25th. Shortly after 11 p.m. the Thor launch was attempted.

The missile ignited 20 to 30 seconds early and was burning in the boat tail and around the missile before lift-off time. The range safety officer therefore destroyed the missile and warhead within a few seconds after receipt of the lift-off signal, in order to prevent a large fuel explosion on the pad. In fact the Thor rose just a fraction of an inch and then settled back on the pad and began to burn. The fuel continued to burn for some time; at midnight personnel had still not been allowed outside because of the possibility of nearby fuel tank explosions, but by 12:30 a.m. it seemed safe. Inspection showed that the launch pad was badly damaged and was seriously contaminated with plutonium.

At 5 a.m. on July 26 JTF-8 issued the following statement in Hawaii:

> A check with Johnston Island discloses no injuries to personnel and no hazard from any radioactivity as a result of the deliberate destruction and burning of a Thor booster and nuclear device on the launch pad last night. All missile fires have been extinguished.

Assessment of the damage and the situation for future shots started immediately, the first concern being proper procedures for plutonium cleanup and radiological protection. Ex.(b)(3)

A very early estimate of the repair time was approximately one month, but after discussions with Douglas and SSD personnel it was apparent that it would be appreciably longer than one month. While estimates were being refined Starbird and Ogle left for Washington to promulgate further decisions. On the way through Hawaii Ogle requested that LASL prepare another Ex.(b)(3)

The controlling factor in preparing for another high-altitude shot seemed to be the Thor pad. By July 28 it was fairly clear that an extremely optimistic schedule for repairing the present pad would have the pad ready in approximately eight weeks. Some two weeks of this was for cleaning and decontaminating the pad, about three weeks would be needed for procuring, inspecting, shipping, and installing all replacement items, and check-out of the rebuilt pad and support equipment would take another three weeks. By the time Starbird reached Washington, SSD and Douglas had

determined that, given the proper priority, a second pad could be obtained in 13 to 15 weeks. Many other items were also critical, not the least of which was scheduling the USAS American Mariner (DAMP ship) which was necessary for some of the radar measurements.

Although rumors were rampant that the President would call an end to the operation, this was really very improbable. On July 22, 1962, the U.S.S.R. had announced their intention to begin a new series of atmospheric tests. Kennedy was still trying to pressure the Russians about a test ban. Furthermore, in the game of international strength it was bad enough for the U.S. to have such publicly miserable failures; it would be even worse to stop the tests, admitting that we could not finish the job. Furthermore, both the AEC and the Department of Defense had solidified their reasons for the experiments yet to be done. Thus, within a day or so after Starbird reached Washington the decision clearly was to finish the series, but the President was still in a hurry and urged a "crash" effort.

Upon his arrival in Washington at the end of July, Rod Ray started investigating backup systems that might be available. While Ray searched, Starbird notified the system that it should proceed with the second Thor pad with the understanding that Thor work could be stopped if other systems appeared more reasonable. H&N received AEC authorization to begin the pad on August 1. In the midst of this flurry the DOD requested that Kingfish be put back into the schedule, so the search for new launch systems also included that shot. A first alternative seemed to be a Polaris fired from a submarine near Johnston Island, using the same command destruct system that had been used for Frigate Bird. Other possibilities were the Hercules, Pershing, and Redstone.

Two other problems arose late in July and early in August 1962. The McMillan Committee observed that there were three shots left, that is, Bluegill, Urraca, and Kingfish, and that the Thor turnaround time was two weeks. They therefore inquired through DDR&E whether it would be possible to insert into the schedule a couple of fairly small high-altitude shots (with simple delivery systems, such as the Hercules) at two-week intervals, and the Task Force system promptly starting working on this. At the same time PMR decided that they could no longer afford to have the Range Tracker at Johnston Island and informed Starbird of their intent to take it back to California. The problem was solved rather quickly by Starbird and Mustin who dealt with the appropriate authorities in Washington: the Range Tracker stayed.

While the Johnston Island pad was being cleaned up during the first two weeks of August, a continual series of meetings and discussions gradually resolved the other carrier possibilities. It appeared that Sandia could put an RV with appropriate fusing and firing on a Polaris missile, and there was the possibility of launching either from a submarine or from the ship Observation Island. However, the Polaris allowed only a very short time for detonation decision after main engine burnout, and any hesitation would allow the possibility of the warhead getting to any of many inhabited areas. Furthermore, a certification shot would be required with such a system. This seemed to be a tremendous amount of work for a backup and it wasn't at all clear that the Polaris system would be any less trouble than the Thor. The Polaris proposal was eventually turned down. The equipment at Vandenberg AFB Thor Pad 8 could be moved to Johnston, but would require approximately eight weeks of construction and then six weeks of installation, at a minimum. However, this option also involved moving an appreciable number of experimental installations on Johnston Island, and finding a suitable place for all of those seemed very difficult. Furthermore, Douglas and SSD pointed out that if there were another accident on the first pad, it too could probably be cleaned up in about eight weeks; thus, putting in a second launch pad would not really save much time. The Army discussed their systems. The Pershing could reach the altitudes for either Bluegill or Kingfish,

carrying nuclear devices Ex.(b)(3) They preferred only their standard trajectory, but they could modify it with some degradation in confidence. Command arm, fire, and destruct signals could be provided. The Pershing could be available in five to nine weeks, depending on the trajectory, and would cost $5,000,000 to $10,000,000, excluding transportation. The Army preferred not to use the Pershing because of the effect on their in-house Pershing program. The Redstone could lift Ex.(b)(3) to 92 kilometers altitude on the tactical trajectory. It would not have a warhead destruct capability, but command arm and fire could be provided. It could be ready in approximately seven weeks after authorization to proceed, and there would be very little impact on Army programs. The Hercules could lift Ex.(b)(3) to altitudes as high as 95 kilometers with high accuracy, and it could be ready to fire within a month. It did not have a command arm signal, but did have command fire and destruct. In parallel with these considerations, Sandia started down the path of what eventually became known as the Strypi, a ballistic (unguided) missile that could lift Ex.(b)(3) or smaller systems to some of the lower altitudes being considered. The Strypi used an XM-33 rocket engine that had already been used for some of the instrument packages during the operation.

The Kingfish argument now became real. It was quickly determined that it was feasible to change the trajectory of the Thor and that most of the experiments could be performed with a detonation point some 250 miles southwest of Johnston Island. However, such a change increased the operational problems greatly. The McMillan Committee eventually compromised on the trajectory, selecting a Ex.(b)(1) burst altitude and thereby avoiding the possible eyeburn hazard in Hawaii. Sandia started down the path of preparing nearly every possible warhead for every practical missile. While all of this was going on a large part of the testing organization had scattered to the four winds, since there was no definite plan for future high-altitude shots and no possibility of any shots soon.

On August 1 Kennedy accepted a Russian proposal for test ban monitoring by national means in all environments, but noted that this would require international supervision and on-site inspection. His discussion of the meaning of international supervision made it difficult to distinguish between that and international systems for monitoring. On August 6 the Soviets rejected his terms, having resumed testing on August 5.

By mid-August appropriate decisions had been made, and the system had started to settle down. Major reliance would still be on the Thors launched from two pads, but the Nike-Hercules and the Strypi would serve as backup systems for Bluegill. The Hercules and Strypi were also possible delivery systems for the small shots still being discussed. Starbird notified the testing organization to be prepared to test on one month's notice.

In the second half of August the tentative agreement on the burst altitude of Kingfish came unstuck. The McMillan Committee did not wish to accept Ex.(b)(1) for the altitude Ex.(b)(3) shot because the air density was still too high to allow the desired x-ray propagation. However, the trajectory had to be picked soon or Douglas could not put it into the Thor missile in time for the shot. Other questions arose for the small shots. The first two of these at Ex.(b)(1) .. altitude presented no problem; however, the third, proposed at posed a potential eyeburn problem in Hawaii, but it was not clear that the very small fireball to be produced would create a serious eyeburn hazard. By mid-August two Thor pads were being prepared for the larger shots, construction of two Hercules pads was underway as backup for Bluegill (the pads being equipped so that if one missile did not operate, the second could be launched immediately), and the XM-33 missile (Strypi) was in the final stages of development. Between the Hercules and the Strypi the small shots could be taken care of, but DASA had not yet decided that those shots

should be done. It appeared that the Bluegill Thor could be ready September 20; the Bluegill Hercules by September 25; the Urraca Thor on October 2; a second Hercules or first Strypi by October 5; a third low-yield shot by October 15; and then the Kingfish Thor on October 17.

In late August, recognizing the problems with satellites, the DDR&E had changed the proposed Kingfish yield Ex.(b)(3) and added some small shots, namely Sideshow, Ex.(b)(3), Tightrope, at the highest altitude available to the Hercules, and Checkmate, Ex.(b)(3) at the highest altitude available to the Strypi Ex.(b)(1)

However, the effects of Starfish on satellites and the Van Allen belts were now becoming well known. Scoville told Gerry Johnson that he thought the DOD was irresponsible in proposing any more high-altitude detonations. The problem came to a head at an NSC meeting on September 5. By now the Soviets were well into their second atmospheric test operation since the 1958-1961 moratorium, and some of the results were available. The McMillan Committee had done their job well in outlining the technical needs for Bluegill and Starfish and the kind of problems that could be answered by the small-yield detonations. Starfish Prime had raised a number of questions that could be investigated using data from these small shots. Furthermore, the shots could be interspersed with the Thor shots without prolonging the series. At the NSC meeting one of the small shots was deleted, but, perhaps more important, Urraca was thrown out by the President, both because of its possible effect on satellites and because the President really did not wish to develop another method of testing. His objective was to prevent testing, not to help it. In addition to these decisions, Kingfish was left floating because of the worry that at such a large yield, it too, would cause satellite difficulties. Thus, of the old high-altitude schedule there was only Bluegill to finish, but there were three new shots.

During September the argument about Kingfish continued. To make some progress, a tentative burst position Ex.(b)(1) at 180 kilometers range on a bearing of 210 degrees from Johnston was chosen by WET with the concurrence of Ogle. However, this position was still not satisfactory to the McMillan Committee. In mid-September the situation was that if the intended yield was changed after September 25 there was no time to rebuild the pod instrumentation before the end of the series. The possible positions for Ex.(b)(3) Ex.(b)(3) altitude on the old Thor trajectory, or 115 kilometers on the new trajectory mentioned above, or Ex.(b)(1) altitude at 80 kilometers range on a bearing of 190 degrees. The first possibility, Ex.(b)(1) could be done earliest, was satisfactory from the point of view of instrumentation, and presented no eyeburn hazard, but it was the least desirable experiment from the point of view of the McMillan Committee. The second position involved flying the Thor on a trajectory not previously used, but Douglas thought it would probably work. However, detonation at that altitude might lead to satellite damage. Ogle simply would not agree to the third possibility Ex.(b)(1) because of the possible eyeburn problem in Hawaii.

During the third week of August Ogle went to Washington and settled the problem with the McMillan Committee. Kingfish would be at Ex.(b)(1) altitude. Of course, later in the week the decision came unstuck again. On September 20 McNamara agreed that preparations would continue for the Ex.(b)(1) but he also requested that work be carried forward in parallel to allow the Ex.(b)(1) Ex.(b)(1) shot. Starbird requested still another review of this possibility. Ogle's answer was that "There's a limit beyond which human flesh cannot endure," but he went on to point out that the latest date at which the Field Command Test Unit could adjust the small rocket trajectory's instrumentation and pod instrumentation for Kingfish was the previous Monday, September 17, and that any changes from now on

would degrade the quality of the experimental results until there was finally a point of minimum return. He further stated that we could not retain the full dual capability; all that could be done was to plan on one trajectory and suffer the very serious loss of data if a late switch were required. He also pointed out that any further studies on the eyeburn problem were a complete waste of effort.

By September 1 the Thor pad construction, the Hercules preparations, and the Strypi preparations were sufficiently advanced to plan resumption of high-altitude testing, starting with Bluegill on September 23. However, the September 5 NSC meeting changed that. The third U.S. manned orbital space flight with astronaut Walter Schirra aboard was planned for September. Starfish results indicated some possible hazard, and, furthermore, the DAMP ship was required for his recovery. Thus, the NSC decided that no high-altitude shot would be fired before the next Mercury shot (MA-8, scheduled for September 25), and the last Dominic event would be November 1 or earlier. As a result of these decisions, the September high-altitude schedule showed Bluegill on October 1, Tightrope on October 9, Checkmate on October 15, and Kingfish on October 27. Various certification shots of the Strypi and the Hercules would also have to be done. Kiley immediately requested that Bluegill be slipped to October 4, since his optically instrumented KC-135 aircraft could not arrive until then, but the schedule held for the time being. By mid-September there were already rumors that the Mercury launch would be delayed.

On September 10 Tightrope was planned Ex.(b)(3) altitude and Checkmate Ex.(b)(3) By September 18 DASA had convinced the Task Force that the DAMP ship was absolutely essential to their Bluegill experiments. However, as was noted before, the DAMP ship was also required for the MA-8 recovery exercise, which was to be done some 1,600 miles from Johnston Island. Consequently, in order to avoid repeated short delays, Bluegill Double Prime was rescheduled to be MA-8 plus 11 days, with the high probability that MA-8 would meet its scheduled September 28 date. This decision allowed the pace to slow a little on the island, and by September 24 the Mercury 8 schedule had slipped to October 3.

With the inclusion of the Nike-Hercules in the series as a weapon carrier, safety studies of its fusing and firing systems promptly began. After a safety meeting on September 11 Starbird asked for information on a number of other subjects, including the probabilities of certain types of malfunctions such as burning on the pad when launch is attempted, malfunction during the booster thrust, malfunction after separation, probability of success of the barometer backup, probability of firing without the fire signal being sent, etc. He was also somewhat unhappy at the concept of launching a second Nike immediately if the first one failed. Mustin immediately discussed the problems with Bill Carter of Redstone Arsenal, who offered a number of possible changes, but recommended none. The Hercules was designed for comparatively small warheads; Ex.(b)(3) Starbird therefore asked Rod Ray to work out with Carter some positive guarantee that the Bluegill alternate could not fire below an altitude of 60,000 feet. Eventually a command arm circuit was installed to take care of this problem.

The Strypi's firing system was the same as used on the Thor, and there was no particular question about its characteristics; however, certification was still necessary. The first Strypi certification occurred on Johnston Island on September 22. The mock warhead reached an apogee of Ex.(b)(1) and impacted downrange at 225 kilometers. The flight was fully acceptable for the Checkmate shot.

The finality of Urraca being deleted from the schedule had so discouraged LASL that Hoerlin had concluded not to fly his highly instrumented KC-135. Furthermore, Kiley was having problems getting his KC-135s back to the shot and was thinking very

carefully about the necessary optical coverage. On September 14 he discussed this problem with the Chief of DASA, who then formally requested that LASL operate its optical aircraft on all subsequent high-altitude shots, noting that it had some unique instrumentation and that it provided backup in the event a DOD aircraft should abort. After some discussion Hoerlin agreed.

The MA-8 mission on October 3 was a success, and by October 5 the Bluegill Thor launch was scheduled for the night of October 14, assuming arrival of the DAMP ship at Johnston. (That ship had had to turn back to Midway to off-load a seriously ill individual and was scheduled to arrive at Johnston on the 14th.)

On September 30 another Strypi certification was fired successfully, and on October 1 the second try of the Nike-Hercules Bluegill certification round was fired successfuly. (On the first try a manually operated switch had not been turned on to allow the EG&G timer signal to initiate launch.)

The DAMP ship arrived as planned, and on October 14 the Task Force was ready to do Bluegill. However, unfavorable weather forced a delay to the night of the 15th. Shortly after launch on the night of the 15th the Thor again failed in flight, and the warhead and missile were destroyed. This failure was apparently due to troubles in the guidance system. The Thor crews and, for that matter, everyone else were tremendously dejected. Starbird effectively gave up on the Thor, suggesting that the Douglas representative sit to one side for a little while and contemplate the situation. However, there was no choice: the Task Force had to make the Bluegill attempt with a Hercules. The system stalled a little and then scheduled the next attempt for the night of the 22nd or 23rd, depending upon whether the Hercules or the Thor was picked.

In the meantime, Checkmate, Ex.(b)(3) had been scheduled for the 19th. There was a complete and successful dry run the day of the 19th, and that night the Strypi lifted the device to the proper altitude and the shot was fired successfully, cheering up the organization appreciably.

Checkmate was beautiful. It was first a green and blue ring with spikelike protrusions at the edge, surrounded by a blood-red auroral ring which faded in less than a minute. Auroral streamers to the north and south formed immediately. Pink streamers were still visible 30 minutes after the explosion.

Ex.(b)(1)

After Checkmate the system began preparing for Bluegill using the Hercules. In the meantime the Thor situation was reviewed, and Starbird proposed that the pods might be causing some of the problems, since, of the nine pods flown, only five had been within the acceptable range. He also noted that if the Hercules was used, almost half of the instrumentation rockets would have to be fired prior to the launch; if the Hercules launch failed, these instrumentation rockets would be wasted, precluding some measurements on yet a later Bluegill. He also noted that Sandia had been asked to prepare a Strypi missile as the primary carrier for Kingfish. In spite of these problems the remaining shots would use Hercules and Strypi as the primary missiles, with the Thor as backup.

The confusion about carriers caused the experimental system great difficulty because the timing of the equipment depended upon the carrier used. However, alternate plans were made and the timing system was set up to handle any of the proposed carriers.

On October 21 a second Nike-Hercules Bluegill certification was fired, but it self-destructed nine seconds after lift-off. The failure apparently resulted from

loss of beacon return signal to the missile track radar 2.9 seconds after launch. (The October 1 Bluegill Nike-Hercules certification had been satisfactory, as had the Tightrope Nike-Hercules certification on October 6.) There was some hope that this difficulty was caused by high RF background noise on the island, so plans were made to do a Tightrope Nike-Hercules certification the next day to gain assurance that the Hercules was actually all right. Starbird argued to delay Bluegill until the Ex.(b)(3) device could be put on the Strypi. (The Strypi had worked successfully every time it had been fired.)

The next day, October 22, 1962, at 4:45 p.m., the Nike-Hercules certification failed again in exactly the same fashion. The Strypi was not ready to use for Bluegill and its basic position inaccuracy made it a very undesirable missile for that shot, so the decision was made to try the Thor again.

For the next two days the Hercules people worked on their problems while Sandia tried to prepare for all variations of shots with the Strypi. Because of all of the options, failures, and backups, Ogle asked LASL how long it would take to prepare another one or two Ex.(b)(3) warheads. On October 25 Max Roy replied that one or two additional warheads could be available 21 to 25 days after a firm requirement was given.

November 1 was getting close. The fourth attempt at Bluegill using a Thor took place just after midnight on October 26: it was finally successful. Starbird left Johnston at 4 a.m., and that afternoon the airdrop test Calamity was fired. The decision was immediately made to switch back to Thor for the Kingfish shot. By October 29 it appeared too difficult to do Tightrope on a Strypi. The tentative suggestion was to try a Hercules again the next day, and if it failed, request that Tightrope be canceled. After several days of study, there was a tentative conclusion that the RF environment was disturbing the Hercules tracking system required for control. Consequently, for the dry run all environmental RF was cut down to the absolute minimum necessary for the test.

On October 30, following the Housatonic airdrop in the morning, the Hercules Tightrope certification was tried again and it worked properly.

Kingfish was attempted in the evening of October 31, but the weather was bad and there were problems in the Thor engine-position monitoring circuit. Weather window after weather window went by and finally, on the last opportunity of the evening, a little past 2 a.m., the Kingfish device was lifted to altitude and fired, using up our last Thor, our last RV, and the last pods. The rest of the night was spent in celebration.

The Kingfish success left one shot to be fired, namely, Tightrope, which had been relegated to the Hercules. On November 1 the Task Force gave the Army Hercules personnel one more day to be ready for certification, but there were still troubles. On November 2, by turning off most of the RF on the island and putting in a new amplifier decoder in the missile track radar, a successful Hercules certification shot was fired. The Tightrope shot itself followed on the next evening at 9:30 p.m. with complete success, ending the operation at Johnston Island.

The summaries of the results of the high-altitude detonations of Operation Dominic as given in the "Quicklook" reports are contained as Appendices B through F. (Ed. note: As noted at the end of the Christmas Island airdrop section, we have chosen to include here only an abstract of the document referred to because the author had not completed editing at the time of his death.)