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RADIATION LABORATORY
AT
LIVERMORE

From NMB-9

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The following proposal is an attempt to draw a comparison of the advantages and disadvantages of the geographical areas concerned in connection with the field testing programs of the University of California Radiation Laboratory at Livermore. Although it is written primarily from this point of view, it is hoped that, if approved, this effort could serve another useful purpose and become a framework and guide for detailed support planning and the evolution of an operational plan for the localities involved.

Dr. Harry Keller and Dr. Vay Shelton have aided greatly in the preparation of the proposal.

Walter D. Gibbins

Walter D. Gibbins

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PROPOSAL

IT IS PROPOSED THAT TAONGI (POKAAKKU) ATOLL, MARSHALL ISLANDS, BE UTILIZED AS A NUCLEAR TEST SITE DURING OPERATION HARDTACK, 1958.

Factors Considered in Proposal

1. Scope of Operation Hardtack

The proposal for the use of Taongi Atoll is based on a scope of operation for Hardtack as stated in a meeting at Los Alamos Scientific Laboratory, 31 January 1957 (Ref - JDO 632, Graves to Distribution, Meeting Minutes). The assumption is made that the following scope is representative of the program as it will be approved with the exception of the possible deletion of two to six devices. Three agencies desire to field test a total of approximately 25 to 31 devices. The University of California Radiation Laboratory will fire 14, Los Alamos Scientific Laboratory will fire 12, and the Department of Defense is planning 5 shots according to preliminary maximum scope planning. The following table gives the approximate yield categories by agency:

	UCRL	DOD	LASL
A. Greater than 5 MT	3	0	1
B. 1-5 MT	3	2	3
C. 100 KT - 1 MT	3	0	2
D. Less than 20 KT	5	3	6

2. Concept of Operation

The concept of Operation Hardtack, as outlined and tentatively agreed to by representatives of UCRL, LASL, DOD, and Sandia Corporation in attendance at the above mentioned meeting on the 31st of January, is as follows:

A. UCRL shots will be fired at Bikini Atoll and Taongi Atoll, or Bikini Atoll only.

B. LASL shots will be fired at Eniwetok Atoll with the exception of their largest yield shot (approximately 7 MT) which will be fired at Bikini.

C. DOD will attempt to fire the three high altitude shots at Bikini Atoll and the underwater shots at Eniwetok.

D. The starting date of 1 May 1958 for Operation Hardtack will be maintained.

E. UCRL will fire five barge shots at Taongi, if available, with the first zero point chosen so as to broach the reef, probably toward the northern end on the leeward side.

F. The basic principles upon which the concept of operation was developed included dividing the real estate in the best manner possible to reduce mutual interactions between the programs of individual agencies. The assignment of testing areas by agency was also based on the assumption that no yield greater than 5 megatons should be fired at Eniwetok.

3. Weather and Geography

Taongi Atoll is located approximately at latitude 168°, 50'E, and longitude 14°, 40'N, 285 miles northeast of Bikini Atoll and 324 miles south-southeast of Wake Island. The surface winds at Taongi are slightly more northerly, five to six degrees, and their average velocity is higher in that there are fewer days during the year (as compared to Bikini or Eniwetok) when the surface winds drop below five knots.

The atoll is a lunar shaped crescent approximately ten miles long and four miles wide at its maximum width. A chord joining the tips of the crescent lies along a NNW-SSE direction and approximately normal to the wind. The lagoon is totally landlocked except for a very narrow channel in the leeward reef. Narrow, long sand islands lie along the southeastern side of the atoll, running in the approximate direction of northeast to southwest. These land masses span a distance of some eight miles.

4. Fallout

Because of the unique position of Taongi, situated northwest of Bikini, the useable firing sector from the fallout standpoint is much greater than at either Bikini or Eniwetok. This is only true if one accepts as a concept of operation at Taongi the basic principle of treating the Taongi islands as inaccessible due to fallout radiation levels after the first large shot, which would be the proposed plan of operation.

5. Cost of Developing Taongi Atoll

Another of the important factors bearing on the feasibility of the use of Taongi is the dollar cost for initial entry and establishment of whatever beachhead and minimal facilities are necessary to fire large yield shots in the area.

6. Logistics and Support

The magnitude of logistics support cost added to the costs of Item 5 above must be evaluated against those real savings of operational time which accrue through employment of triple atoll operations versus dual atoll operations.

7. [redacted] Test Consideration

Of the devices in Category A in the table under Item 1 above, one is a [redacted] which UCRL would like to test to full yield. This yield is 25-40 MT and, if approved for test, will present very major problems when included in the program. DOE

Discussions Bearing on Proposal

1. Scope of Operation

The full scope of Operation Hardtack represents an increase in effort over Operation Redwing of 75-100%. The figure of 25 to 30 shots total would offhand seem to indicate that Operation Hardtack will be 75-100% longer in the operational phase. From the UCRL point of view, this is not necessarily so as the schedules for firing at Bikini and Taongi will show. It is our opinion that the entire Hardtack Operation can be concluded within a period of time equal to, if not less than, that required for accomplishing Redwing, providing Taongi is employed.

Reasons for this difference are pointed out in the following discussions:

DOE

UCRL's program involves test firing a maximum total of 14 devices. One of the two stage test devices is expected to yield 300 KT and will be fired as a rather heavily diagnosed surface or short tower shot. This shot, plus two or three of the lower yield two-stage devices, and the five single stage devices will be committed to the Tare-Uncle Island complex for testing. Such a firing program can start with the beginning of the operational phase and be concluded as rapidly as possible. At the same time, preparations and firing of large devices can proceed on the northern side of the atoll. Also, concurrent with the Bikini phase of the testing, and if the proposal is approved, firing of the large yield barge shots can proceed routinely at Taongi.

2. Concept of Operation

The acceptance of the basic principle of dividing the programs of the two laboratories by locating their respective testing sites in separate atolls insures the maximum in flexibility insofar as maintenance of ready dates is concerned. Under this plan, each laboratory is free to change the order of its own firing with a minimum of interaction with other shots. LASL's occupation of Eniwetok and UCRL's occupation of Bikini (even without Taongi) affords dual large shot capability and dual small shot capability between the two atolls, but with a maximum of two shots on any one day.

The LASL 7 MT device yield should be tested at Bikini since it is somewhat larger in yield than the maximum it seems reasonable to fire at Eniwetok.

There is tentative agreement between the laboratories that either group finishing their shot program in a given atoll would immediately make that area available to the agency with shots remaining to be fired. The UCRL planning incorporates the use of Taongi in order to relieve both Bikini and Eniwetok of yields which would be difficult to interweave with smaller shots and which would necessitate being much more selective in choosing a safe shot day, especially at Eniwetok. Following are two schedules for UCRL shots with and without the proposed Taongi firing capability. These schedules are, of course, not firm at this time, but incorporate the basic thinking and are therefore not just examples, but typical of the final Hardtack schedules. These prospective schedules are the culmination of several planning conferences in our own organization at Livermore and reflect the UCRL point of view toward accomplishing the operation in the shortest time practical for each of the two cases:

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SCHEDULE I - BIKINI

EVENT NUMBER	DATE	FIRING FACILITY	YIELD	LOCATION
1	1 May	300' Tower	Less than 5 kilotons	West Tip - Tare
2	2 May	Barge	0.5 - 2.0 megatons	Northern Lagoon
3	10 May	50' Tower	Approx. 150 kilotons	South Side - Uncle
4	12 May	Barge	0.5 - 2.0 megatons	Northern Lagoon
5	20 May	300' Tower	Less than 5 kilotons	Southeast Tip - Tare
6	22 May	Barge	0.5 - 2.0 megatons	Northern Lagoon
7	30 May	50' Tower	Less than 20 kilotons	East Edge Tare Crater
8	2 June	Barge	Approx. 400 kilotons	Northern Lagoon
9	10 June	Barge	Less than 20 kilotons	In Tare Crater
10	20 June	Barge	Less than 20 kilotons	In Tare Crater
11	30 June	50' Tower	Approx. 30 kilotons	West Tip - Uncle
12	2 July	Barge	Approx. 7.0 megatons	Fox/George
13	11 July	Barge	Approx. 12.0 megatons	North Lagoon
14	20 July	Barge	Approx. 12.0 megatons	North Lagoon
15	30 July	Barge	25 - 40 megatons	Northwest Lagoon

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SCHEDULE II - BIKINI AND TAONGI

BIKINI ATOLL					TAONGI ATOLL		
EVENT NUMBER	DATE	YIELD	FIRING FACILITY	LOCATION	FIRING FACILITY	YIELD	LOCATION
1	1 May	Less than 5 kilotons	300' Tower	West Tip - Tare			
2	2 May				Barge	0.5 - 2.0 megatons	Northern Leeward reef
3	7 May	Approx. 150 kilotons	50' Tower	South Side - Uncle			
4	9 May				Barge	0.5 - 2.0 megatons	On Eastern Edge Crater
5	13 May	Less than 5 kilotons	300' Tower	Southeast Tip - Tare			
6	16 May				Barge	0.5 - 2.0 megatons	On Eastern Edge Crater
7	19 May	Less than 20 kilotons	50' Tower	East Edge - Tare Crater			
8	23 May				Barge	Approx. 12.0 megatons	On Eastern Edge Crater
9	25 May	Less than 20 kilotons	Barge	In Tare Crater			
10	30 May				Barge	Approx. 12.0 megatons	On Southern Edge Crater
11	31 May	Less than 20 kilotons	Barge	In Tare Crater			
12	2 June	Approx. 400 kilotons	Barge	Northern Lagoon			
13	6 June				Barge	25.0 - 40.0 megatons	Center of Lagoon
14	7 June	Approx. 300 kilotons	50' Tower	West Tip - Uncle			
15	8 June	Approx. 7.0 megatons	Barge-LASL	Fox/George			

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The following comments are pertinent in comparing the two schedules:

a. The interval between shots for a given test location; i.e., the Tare Complex, is the sum of the time required for re-entry, technical preparedness, design interaction, average weather delay (see discussions on weather following), and time lost, if any, for evacuation and re-entry for the firing of a shot somewhere else in the atoll. This is true for both Schedules I and II.

b. In Schedule I, the time interval between shots of the small weapons program at the Tare Island complex is nominally ten days, which is perhaps longer than one might expect. This interval is necessary for planning purposes because of interruptions in attaining technical preparedness while trying, at the same time, to continue firing large shots in the northern part of the lagoon. All installations at Tare, for example, must be protected from water wave damage. The concept of the use of 50 foot stub towers is aimed at circumventing damage from such an effect. As pertains also to Schedule I, the firing of Events 2, 4, 6, 12, 13, 14, and 15 in the northern Bikini Lagoon sector, as well as the Tare shots, necessitates the evacuation of all Tare personnel to Nan for protection from fallout. Shots greater than 5 MT, such as Schedule I Events 12, 13, 14, and 15 will make complete atoll evacuation necessary while firing.

c. Also in Schedule I, it is to be noted that the time interval between large shots in the northern lagoon is 10 days. The yields make the inclusion of the average Bikini weather delay for these shot intervals necessary.

d. The interwoven schedule of large and small shots at Bikini would preserve the dual large and small shot capability, but, in the case of one of each being in readiness, the large yield or most difficult shot would take precedence.

e. No insertion of DOD shots is shown in Schedule I. It is believed that Bikini Atoll is best adapted for these shots even if Taongi is unavailable and it becomes necessary to insert them into a schedule typical of Schedule I. The information available at the present time indicates that there may be considerable difficulty in getting either of the ultra high altitude rocket shots ready for a 1 May ready date. Both the 100,000 foot and 250,000 foot rocket shots require installation of manned diagnostic rocket launchers at several points around the atoll. Even though the scope of this program is not firm, the inclusion of such an effort in Schedule I between the indicated dates 1 May and 30 July will be difficult indeed if uncontaminated areas must be guaranteed for the manned diagnostic rocket stations which are more or less equally distributed around the atoll. It is felt that the high altitude nuclear device vehicles themselves can be guaranteed uncontaminated launching sites at How or Nan Islands during all of the period encompassed by Schedule I. The launching of the nuclear device carrying balloon from either of these islands seems feasible at any time between other shots during this period.

f. Schedule I affords high probability of maintaining a very necessary temporary camp on Oboe until Event No. 11 is ready for firing.

g. The inclusion in Schedule I or Schedule II of shots with yields greater than 5 MT at Bikini poses the problem, as at Eniwetok, of personnel safety in the atoll. This condition will exist on four events, 12, 13, 14, and 15 in Schedule I but on only one event in Schedule II.

h. It is the opinion here that the firing of the 25-40 MT device at Bikini in the northern lagoon at Charlie or Fox/George could result in the following damage: DOE

(1) Loss of the 300 foot communications tower on Nan. √

(2) Loss of the fireball photo towers on William and How. √

(3) Irreparable damage to Station 1512 and Station 1528 on George plus Station 1321 on Dog if fired at Fox/George.

(4) Undesirable, but reparable, damage to Station 1320 on Dog if the shot is fired in the Fox/George region.

(5) Loss of Station 1319 and Station 1200 on Charlie if the shot is fired in this region.

(6) Demolition of the Nan Camp buildings. √

i. Schedule II affords uninterrupted periods for technical readiness for the first six shots in the Tare island complex. These shots are small enough to warrant optimism as far as weather delays are concerned and the technical preparation period is not affected by simultaneous firing of large yield shots in the northern test areas.

j. The entire period from 1 May to 31 May under Schedule II can be utilized at Bikini for the inclusion of the DOD shots in the schedule with full assurance and reasonable guarantee of being able to conduct this program in uncontaminated areas as far as the proposed four diagnostic rocket launching sites to be manned during the UHA shots are concerned. This time can be extended to 8 June if one assumes that the possible fallout interference from Event 12 does not constitute a major delay risk.

From the UCRL viewpoint, the concept of operation at Taongi would be conducted in a manner involving an absolute minimum of installations ashore on the islands or reef. It is our opinion that all the data required for diagnosing these shots could be obtained from a diagnostics and firing ship operating over a range of 15 to 20 miles from zero on the first four shots, and a greater range on the 25-40 MT yield shot. Data which would be obtained from equipment, some of which would be mounted on stabilized platforms on this ship, could include:

a. Teller Time interval.

b. Electromagnetic time interval.

c. Fireball yield.

d. ENS timing and primary alpha by telemetering.

e. Such reaction history as feasible by the optical method being used and to be proved in Operation Plumbbob.

Considerable effort and thought have already gone into the planning for remote diagnostics and the same remote experiments will be performed from land based equipment on Tare in diagnosing shots in the northern test areas at Bikini. Remote diagnostics obtained at sea are not without precedent since time interval and fireball yield were obtained from the command ship on the Mike Shot, Operation Ivy. The five shots would be placed on barges moored in the lagoon, probably toward the northern end. The first of these shots would be placed near the leeward reef so as to broach an opening approximately equivalent to the crater diameter. Each succeeding shot barge would be moored on the edge of the previously formed crater in order to open a navigable deep water channel into the lagoon and to form, with the largest shot, a turning basin at its end. This stepwise strategic placement and encroachment into the lagoon would result in a man-made deep water anchorage for possible use in the future.

The sequence timer and radio firing racks would be placed aboard the shot barge. Such a method is very feasible and the reliability of the system has been proven in past operations. The firm of Edgerton, Germeshausen, and Grier, Inc., who normally provide the firing equipment, have considered this system for Hardtack and are able and willing to provide, install, and operate the necessary equipment.

3. Weather and Geography

One of the greatest gains to be netted in this use of Taongi Atoll is the opportunity of taking advantage of its isolated and unique position with respect to populated areas. The nearest populated area west of Taongi is Guam, some 1,300 miles distant. To the east, no populated area exists for at least 1,500 miles. To the north, the nearest population is on Wake bearing NNW 324 miles distant. The closest population of any is Utirik Atoll, 215 miles S by E of Taongi. One of the reasons for advocating minimal construction ashore at Taongi is to assure no need for reoccupation of the islands and since taking full advantage of being able to fire with the stable Taongi wind pattern is certain to produce heavy fallout on them.

Typical hodographs of shot time observed winds at Eniwetok and Bikini, with their usual inverted S shape to the north, are indicative of the desirability for southerly components in the levels from 20,000 feet to the tropopause. The stable winds above and below this middle layer very seldom change in direction, being mostly easterly in both the upper and lower layers.

Acceptable patterns at Bikini and Eniwetok are essentially only those which contain little northerly component at all levels and, for any substantial margin of safety in preventing contamination of inhabited islands to the east and southwest, must have some southerly component. Perturbations in the weather which provide these conditions at Bikini and Eniwetok are not long lived, and are not the dominant pattern.

Acceptable patterns at Taongi include the flat hodograph plus, in most cases, the inverted S to the north or south. In other words, it is possible to always fire at Taongi on the stable long lived weather pattern while at Eniwetok and Bikini, one can use essentially only the short lived perturbations.

The Joint Task Force SEVEN Meteorological Center at Pearl Harbor has recently published a report, under the direction of Commander Daniel A. Rex, USN., entitled "Climatology of Taongi". This report was prepared to compare, from a weather standpoint, the suitability of Taongi Atoll with the Eniwetok/Bikini area as an atomic nuclear test site. This report has been studied in detail at UCRL by Dr. A. Vay Shelton, and others, and although there is not full agreement on the interpretations of Commander Rex's determinations, there is no question that Taongi offers some advantages. Three 15 day periods were analysed by the JTF 7 Group:

14 April - 28 April 1956 inclusive
11 June - 25 June 1956 inclusive
9 July - 23 July 1956 inclusive

These 45 days embrace the period of firing activity at Bikini during Operation Redwing. Hodographs for Taongi on each of the above days were interpolated from analysed Redwing flow charts. Neglecting fallout computations and space/time variation studies has led Commander Rex's staff to state:

> "In summary, 32 days were judged to be satisfactory for shooting at Taongi although local fallout on the shot site would have been experienced on 19 of these 32 days. During the same period, 7 days were judged to be satisfactory for Bikini."

Page 6 of the Joint Task Force Meteorological Center report states the following conclusions:

"a. The local weather conditions at Taongi may be expected to be somewhat more favorable for air and test operations than at Eniwetok/Bikini; i.e., less rainfall, decreased shower activity, stronger and more constant surface tradewinds, etc.

"b. The upper wind regimes at the two locations may be expected to be essentially the same; i.e., predominately east-west. Because of its more northerly latitude, stronger northerly components will usually be observed in the upper westerlies at Taongi and the strength of these upper westerlies will prevail later into the summer season. Variations from year to year may be expected to affect both locations in the same sense and approximately the same extent.

"c. From a comparison of unweighted hodographs, it appears that a significantly greater number of acceptable (high-yield) shooting days occur at Taongi than at Eniwetok/Bikini. As can be seen from Figure 9, this results primarily from the geography of the area rather than from any marked climatological differences. At Taongi, and assuming fallout on the test site can be accepted, the normal wind structure produces east-west fallout patterns which do not interfere with populated areas; at Eniwetok/Bkini similar patterns cannot be accepted. Comparative danger areas are shown in Figure 9 for the two locations."

Dr. Vay Shelton has stated:

"The number of good weather days at Taongi for shots of the Hardtack class will, as indicated in Commander Rex's report, be substantially greater than at Bikini. A study of the 45 cases submitted in his report indicates that his estimated number of good days of 32 may be high by 9 or 10 because this many of the 32 "good" days are quite marginal and would probably not be acceptable to those responsible for firing. He considered a day as good if the fallout axis missed all of the inhabited Marshalls and Wake. There are still about three times as many good days at Taongi as at Bikini, however."

Taking the least optimistic viewpoint, as just expressed, and based on 22 good shooting days versus 7 for Bikini out of the total of 45, the probability of being able to fire the first shot at Taongi or Bikini on any day during the period analysed is respectively 50% and 15%. This merely states that whatever the average weather delay at Bikini is, the same average is 1/3 as large at Taongi.

In the above typical schedules, we have based the shot intervals between large shots at Bikini on a minimum of four days technical preparedness and six days average weather delay. At Taongi, we have based the shot intervals on five days technical preparedness and two days average weather delay. The 3:1 ratio is a conservative figure based on Dr. Shelton's interpretation of the accuracy of the determinations in the JTF 7 report and it is pertinent to mention that Commander Rex believes the interpolated hodograph data to be accurate to only 20% in wind velocities and 20° in direction.

There is general agreement between the JTF 7 Meteorological Center and UCRL in considering Taongi as a test site. The problem of checking the validity of the above data should also be considered. Establishment of weather observation capability early in the Taongi area to record data as long as possible prior to Operation Hardtack is deemed advisable. Such data would be valuable not only as a check on the interpolated data accuracy but would lend considerable help toward more accurate Taongi forecasts.

Weather information locally in the Taongi area can be well covered from the diagnostics ship. It is also deemed necessary to observe the weather further out from Taongi, probably from ships to the northwest and east. Late checks on the weather in such locations can likely be obtained from destroyers. It is not obvious that weather ships whose sole mission is weather observation are necessary for this purposes.

It should also be stated that the advantages of the Taongi weather conditions as compared to Bikini, of less rainfall and decreased shower activity are important in diagnostic experimental work as a greater assurance that optical lines of sight will remain open at shot time, especially over long distances. The possibility of transmission interlocks stopping a shot is less likely at Taongi by whatever margin of advantage exists in this regard.

4. Fallout

As discussed under Item 3 above, and as seen from the JTF 7 interpolated hodographs, the ever present northerly component in the upper westerly winds precludes the possibility of keeping the sand islands clear of contamination at Taongi after the first shot. Past operations have been very successful in being able to continue firing at Fox/George at Bikini and to re-enter scientific stations and to prepare the next shot. Many yards of concrete are required to provide adequate shielding for film data in such stations, in addition to assuring structural strength in close proximity to the blast. The contamination picture at Taongi would be even more discouraging if one had to guarantee re-entry into land stations. The diagnostic ship method rids a considerable portion of the operation of recovery and construction complications.

Another consideration at Taongi concerns contamination in the lagoon and the effects on barge mooring operations in case of no reef break-through on the first shot. Taongi lagoon has an average depth of only 50 feet and possesses an extremely small tidal prism volume. At the present time, it is estimated the half life of the lagoon water in exchange is 180 days. This figure, although large, is not so surprising when it is remembered that Taongi is totally land locked. The 8 knot current in the channel at low tide arises from the fact that the reef is continuous except for Pokaakku passage and this outflow is not enough to allow the lagoon level to equalize with that of the ocean. It is estimated that the minimum difference between the two is in the range of 8-10 inches.

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In the case of reef break-through on the first shot, the small lagoon volume becomes a beneficial factor since the exchange rate, once the tidal flow through the crater comes into action, would increase tremendously. It is felt that the crater proper from a 1 - 2 megaton first shot on the reef would clear itself for re-entry faster than either Eniwetok or Bikini.

The storage of radioactive contaminant in any flowless stagnant pot holes below an intermediate current return layer is being looked at very carefully. Measurements of the vertical mixing, and establishment of the surface and sub-surface current patterns will reveal any possibility of such storage. These are all factors bearing on the choice of zero points. The feasibility of building a model to aid in these determinations is being investigated.

The northerly component of the westerly layer in the wind structure at Taongi is a help actually in affording fallout patterns from Taongi which have little tendency to encompass Wake Island. An examination of the Bikini firing sector shows a usable fallout sector with an included angle of approximately 150°. At Taongi, neglecting Wake for the moment, the usable firing sector is 270° when laid out to miss populated areas by the same margin in the two cases. To be safe as far as Wake is concerned, and if a 30° sector, for example, is subtracted out to include Wake on its bisector, the total usable sector at Taongi is 240° and is 90° larger than at Bikini. This sector clears Wake on each side by a generous 190 miles.

5. Cost of Development

During the past few weeks, Task Group 7.1 has developed in conjunction with Task Group 7.5 a staff study on the costs involved, aside from those of operational logistic support, in developing Taongi Atoll to the stage which would allow the mooring and detonation of the first device barge. This study was requested earlier at a time when UCRL's planning was considerably less firm and when the laboratory was not in a position to evaluate the plan for shipboard remote diagnostics as feasible or not feasible. As a consequence, and without knowing whether or not major land stations would be required, two hypothetical situations were described to Task Group 7.5 and the architect engineers were then asked for dollar estimates of the cost of preparing for each of the two situations.

Situation No. 1 described a concept of operation along minimal lines which would involve the necessity of lagoon entry, establishment of the necessary minimal camp and the construction of facilities ashore comprising a firing and control station equivalent to the existing Station 70 on Enyu Island at Bikini. A second situation described a greater effort in which the construction of three major stations similar to Castle Stations 1210, 1342, 1550, and an airstrip were added to the minimal requirements. The costs of access and construction for each of these two situations are stated in a letter forwarded by the architect engineers, Holmes and Narver, Inc., to ALO (Howell to Sanders dated 30 January 1957) and are quoted below:

> For the minimum scope of work contemplated, it is estimated 65 construction and 35 operation personnel will be required for a period of six and one-half months prior to the first shot. The maximum scope of work will require 120 construction and 80 operation personnel for a period of seven and one-half months. These schedules cover on-site construction only; a minimum of four months must be added to these schedules for procurement and shipment of material and equipment. In estimating the time schedule, it has been assumed that the topography of the proposed airstrip site will be similar to that of Nan and that beaches for landing craft, coral deposits, trees, underbrush and other conditions will be similar to those of other atolls in which construction operations have been conducted.

Cost Estimates. The items of work contemplated and the cost estimates are summarized in the following tables:

Minimum Requirements

	ITEM	ESTIMATED COST
1.	Beachhead	12,000
2.	Camp (as Fox-Redwing)	325,000
3.	Access Channel - 20' Deep	686,000
4.	Concrete Station (As Station 70 - Redwing)	~~295,000~~
5.	300' Steel Tower (As Station 5- Redwing)	~~343,000~~
6.	Five (5) Barge Anchorages	222,000
7.	Inter-Atoll Communications	243,000
8.	Submarine Cable	~~900,000~~
9.	Seadrome	96,000
TOTAL MINIMAL CONSTRUCTION		2,422,000

1,362

RECAPITULATION

Construction Equipment	471,340
Operational Equipment	35,000
Construction Projects	2,422,000
TOTAL	2,928,340

1,948

Maximum Requirements

	ITEM	ESTIMATED COST
1.	Beachhead	12,000
2.	Camp - 200-Man	450,000
3.	Airstrip	560,000
4.	Access Channel - 20"	686,000
5.	3 Concrete Stations as Redwing	1,013,000
6.	Five (5) Barge Anchorages	222,000
7.	Seadrome Facility	96,000
8.	Inter-Atoll Communications	243,000
9.	Submarine Cable	613,000
10.	300' Steel Tower	343,000
11.	Concrete Station (Redwing - Station 70)	295,000
12.	Access Roads and Causeways	180,000
13.	Mole Type Pier	98,000
TOTAL CONSTRUCTION		4,811,000

RECAPITULATION

Construction Equipment	1,022,510
Operational Equipment	50,000
Construction Projects	4,811,000
TOTAL	5,883,510

(This is the end of the quotation from the Task Group 7.5 report.)

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At the outset, it must be stated that the optimum plan for Taongi operations is one in which an absolute minimum of construction is required. The basic UCRL viewpoint is that such an operation is totally sea and airborne. Taongi itself should be looked upon for Hardtack as only an area of quiet water in which to moor shot barges.

It is pertinent to any discussion of developmental cost, therefore, to state the tasks which need be performed prior to the first shot. These are:

a. Lagoon Access

Holmes and Narver, Inc., have considered in their cost estimates a channel 300 feet wide and a clear depth of 20 feet at mean low water. This channel would be approximately 500 feet long and would be blasted through the leeward reef at the extreme south end of the atoll near South Island. This is the $686,000 item shown above.

Conversations with the Commander, Underwater Demolition Unit No. 1, U. S. Navy, San Diego, have disclosed that a recent operation by this branch of the navy has opened a channel through the reef at Ebye Island, Kwajalein Atoll, whose dimensions are 100 feet wide, 1200 feet long, and 8 feet deep at mean low water. This task was accomplished with 70 tons of condemned U. S. Navy bulk explosive by 12 personnel in 14 days.

At Taongi, the UDT No. 1 has estimated that the present Pokaakku passage could be opened into a channel 210 feet wide, 300 feet long, and 30 feet deep with 70 tons of bulk explosive. 21 personnel working during only the daylight slack high water periods (± 2 hours) could accomplish this task in 30 days. It is assumed that condemned bulk explosive could be made available and utilized here also. The current at low tide through the present Pokaakku passage into the ocean is about 8 knots and is adequate to remove blasted debris with a self-cleaning action. Should an attempt be made to blast through the reef in a location other than Pokaakku passage, no self-cleaning action from a current would exist until the channel is opened over practically its full length and into the lagoon.

The cost of plastic bulk explosive to UCRL at Livermore is $1.65 per pound. If obsolete condemned explosive were not available for use in underwater demolition of the coral in the passage, an expenditure of $231,000.00 for explosive would be required. Using this figure to compare the cost per cubic yard in the above three cases gives:

Ebye Channel	Widening Pokaakku Passage	South Island Channel
$6.50 per cu. yd.	$3.30 per cu. yd.	$6.20 per cu. yd.

It is felt that the above comparison is fairly drawn, even though no overhead cost factors were included in the first two figures above, and since only military personnel are involved those costs would not be AEC funded. The figures then, represent the comparative cost per cubic yard if the explosive had to be purchased with AEC funds.

Either of the two prospective channels described above will be adequate for LCU access at high slack water when the lagoon outflow current is decreased. Either channel will be directly into the wind and the best direction for shallow draft craft. Once the reef is breached with the first large shot the current in Pokaakku passage will essentially be zero at all tide stages and small craft can enter at any time necessary during the daylight.

b. Triangulation Survey

It is probably advisable to execute a fairly precise survey at least to an extent which would allow establishment of bench marks and markers for barge positioning. It should be pointed out that the precision of the placement of zero points does not require any great accuracy since all diagnostics will be zeroed in visually from the ship to marker lights on the barges.

c. Estuarial Oceanographic Survey

No actual measurement data of currents exists for Taongi atoll. It is deemed necessary, for the reasons set forth in connection with the fallout discussion under Item 4 above, to accumulate data on the surface currents within the lagoon, their direction, the depths of any subsurface current return paths, a check on the accuracy of the soundings as shown presently on the U. S. Navy Hydrographic Survey charts, and the currents across the reef. At the present time two Scripps Institution of Oceanography personnel are attempting to accumulate what meager data can be obtained in a very short three day visit.

d. Channels Within Lagoon

Course lines for navigation within the lagoon must be surveyed and tied into the triangulation survey. A channel must be cleared to permit barge movement up the lagoon to the first zero point and buoys and range marks installed if necessary.

e. Beachhead and Living Facilities

The requirement for a beachhead and living facilities is mandatory to accomplish necessary work ashore prior to the first shot, but it should be remembered that the operations planning should take into account the fact that living facilities must be evacuated before firing and will not be required again ashore. Recent conversations with T. G. 7.5 representatives have indicated the possibility of an APL type barge being used for housing after a channel has been opened, and since the installations are so minimal this method of providing accommodations may prove the most economical.

f. Communications

Since no need exists for personnel to man stations or live ashore after the first shot it is indicated that a military communications link such as was used during the post Crossroads Bikini re-entry at Tare should be considered. Such a link would provide communications to Eniwetok and it is believed that no need would exist for the transmittal of classified information during the construction phase.

g. Logistics and Support

As a start, in a discussion of this subject, it is pertinent to first describe our concept of a list of operations events, which we feel could be typically utilized in placing the first barge in position.

Two things would be necessary in obtaining the optimum compromise of dollar expenditure versus operational time saving in an operation involving Taongi.

(1) Airstrip

We feel that an airstrip suitable at least for C-47 use is essential at Taongi. Experience has shown that the requirement for fast transportation often arises when trouble develops with equipment, or additional personnel are needed quickly, or a medical evacuation is necessary. The closer one approaches the shot date, the more important this consideration becomes. The freedom of being able to shuttle personnel and equipment is a great help in maintaining a fast firing schedule especially when keeping multiple firing capability. It is recognized that contamination and water borne debris can be problems in trying to maintain usefulness of an airstrip after the first shot. The Tare strip in Operation Castle was used considerably after Bravo and some of the other shots. It is felt that an airstrip, even with limited later use, will lend enough efficiency to the operation to warrant its installation. We feel that this is true in spite of the fact that no one agency, probably, could justify the total expenditure on its own necessity.

(2) Critical Device Handling Facilities

Critical storage, device assembly, and shot barge loading facilities located at Bikini on Nan will facilitate maintenance of the desired seven day firing capability at Taongi and the required firing capability according to Schedule I if Taongi is not occupied. It is felt, based on the number of shots alone, that the installation of such facilities at Bikini is justified for either schedule.

Assuming that the two above items have been acquired and the Taongi moorings are in, a firing of the first shot at Taongi would entail:

(a) Placement of the device aboard the shot barge in a barge slip or alongside the pier at Nan.

(b) Loading of the barge into an LSD in the Bikini Lagoon.

(c) Transporting of the shot barge to Taongi in the LSD.

(d) Unloading of the shot barge in deep water off the channel entrance at high slack water.

(e) Warping of the shot barge through the channel with LCM's and transporting it to the zero site.

(f) Mooring and orienting barge.

(g) Arrival of the diagnostics ship off shore in the lee of the atoll at the time of barge mooring or before.

(h) Two days of dry runs and equipment check-out of diagnostics ship.

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(i) Loading LCU which set moorings and LCM's which placed barge into LSD in the late afternoon before the shot, and after arming.

(j) Firing of the shot with the LSD standing by at sea.

(k) Returning the LSD into the proximity of channel entrance.

(l) Surveying lagoon contamination by probing from amphibious craft airborne from Bikini or Kwajalein.

(m) Discharge of the LCU and the LCM's from the LSD to set new moorings.

(n) Sailing of the LSD to Bikini for next shot barge return.

The above order of events can be accomplished in about the same length of time as now required at Bikini and Eniwetok in the staging of barge shots in the Bikini Lagoon.

There seems to be no reason that extra time would be required since the device would be staged from Bikini rather than Eniwetok, and the diagnostics equipment dry runs would be simpler.

Our Concept of the type and the operation of a diagnostics ship comprises the following:

(a) Procurement

The procurement of the ship should be funded for and obtained by the Atomic Energy Commission on a time base of 6 years for its continued use.

(b) Operation

The ship could be operated for the AEC by Task Group 7.3 or Task Group 7.5 with the primary mission of housing experimental personnel, obtaining experimental data, acting as the firing control ship. This ship, of course, can be used by other agencies, such as Task Group 7.5 in support of barge mooring facilities. UCRL would plan to place the diagnostics ship on berth in the San Francisco area prior to the operational phase of Hardtack. There, all diagnostic gear would be installed, checked, and operated prior to sailing for the forward area. The saving in time overseas for diagnostic personnel from this fact alone will be 3000 man days plus the fact that reliability of operation will be assured upon arrival overseas.

(c) Type of Ship

In our estimation, a ship such as an AV or an AGC is not required. The largest space allocation aboard would be living quarters to house an estimated 200 TG 7.1 and TG 7.5 personnel. No large cargo space is necessary, but the inclusion of shop space and laboratory space is required, though the shops do not need to be as large as those on the Curtiss. Heavy shipboard cranes are not required.

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It is thought that a ship of the hospital or small transport type fulfills the requirements.

(d) Configuration

In addition to small laboratory and shop space, a total area of clear deck space of some 10,000 square feet is required. This space can be several small areas in which stabilized radar or optically tracked armament mounts would be installed to support fireball cameras, mirror systems, fast cameras, and other diagnostic equipment.

(e) Communications

This ship should be equipped with communications adequate to provide voice and teletype links to Eniwetok and Bikini carrying secret restricted data classifications. During the operational phase the the ship would serve as the communications center for TG 7.1 and TG 7.5 and no communications would be installed ashore other than the temporary construction not mentioned previously. All communications ship to shore or ship to barge would be by radio.

(f) Cost

It is estimated that the cost of reestablishing sea worthiness upon removal from reserve fleet storage would be $100,000 to $200,000 depending on the present condition of the ship chosen.

The cost of reconfiguration and installation of stabilized platforms, shops, and communications would be in the range of $750,000 to $1,000,000.

In and out costs for storage between operations are estimated at $150,000.

If approval to this proposal is given, a decision to utilize a ship such as the Curtiss or Estes for this purpose may be the correct one and certainly these ships would be adequate. The same costs as shown above would apply, however, since some work would be necessary in providing quarters, and even though these ships are now in commission. Thus, the total cost for providing a diagnostic ship, exclusive of operating costs, is estimated at $1,000,000 to $1,250,000.

Another factor to be considered in a support discussion concerns the cloud sampling capability. Informal discussions indicate that the maintenance of dual firing capability between any two of the three atolls can be accomplished with the presently requested number of sampling aircraft. It is believed that Schedule II above does not conflict with this statement. If, however, it was deemed advisable to provide triple firing capability, in even a two day period, additional sampling aircraft would be required. In any case, the primary method of sampling at Teongi will be by aircraft, not rockets, and the present plans have included a review of the feasibility of sampling with the B-57's requested now.

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Conclusions

A review of the above information results in our desire to state the following conclusions:

1. In the concept of the operation as visualized without the use of Taongi it becomes immediately obvious that Operation Hardtack would be difficult, if not impossible, to accomplish in a period of time less than 12 weeks.

2. With Taongi in use as a test site, Schedule II is feasible, and far more assurance of being able to maintain the schedule is inherently associated due to less average delay risk from both weather and shot interaction.

3. Schedule I, without Taongi, is feasible but with less assurance as just stated.

4. Schedule II will guarantee completion of the DOD high altitude program on schedule and in safe areas, while Schedule I will not.

5. Schedule II represents a saving of 7 weeks over Schedule I.

6. Believing Schedule I to be typical timewise of what can be accomplished in firing the shots, now planned for Eniwetok, leads to the conclusion that the overall operation can be shortened by about one-half of the above saving or 3 to 4 weeks if firing of some Eniwetok shots is continued at Bikini after completion of Schedule II.

7. After review of the major requirements, and since no plans exist for the re-establishment of the Fox/George camp or the maintenance of the semi-permanent camp ashore at Taongi during the operational phase, leads to the conclusion that the total Hardtack logistic support required with Taongi is no greater than Redwing with the exception of the diagnostics ship and Taongi weather ships participation.

8. It is concluded that the cost of any additional support plus the developmental cost of Taongi is fairly estimated at $5,000,000 for Hardtack.

9. The use of a diagnostics ship not only constitutes the most important factor in making a Taongi firing site feasible but will provide a more economical means of accomplishing the diagnostics experiments in the future.

10. The Laboratory will greatly benefit in personnel efficiency by the shorter stay of personnel overseas as provided by Schedule II.

If the proposal is approved, we would make the following recommendations:

1. Perform the complete oceanographic survey as soon as possible incorporating representatives from agencies concerned in order to take the most advantage of the support required to place and maintain people ashore for this task. Agencies who might participate are Task Group 7.5; U.S. Navy UDT No. 1; NEC, and Task Group 7.1.

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2. Establish the capability at Taongi to accumulate weather information and data. This station should start as soon as possible and continue until just prior to the Hardtack Operational phase. This viewpoint has already been expressed in a letter dated 21 January 1957, Dr. G. W. Johnson to Captain K. Musick.

3. Immediately determine if an airstrip is justified since this would constitute the major effort ashore and fixes the scale of effort required from the contractor at Taongi.

4. Fix the method and responsibility for the opening of the channel as soon as possible after the completion of the preliminary inspection and oceanographic survey trip.

5. Accomplish the task of choosing and obtaining the diagnostics ship just as early as possible in order to begin the time consuming experimental outfitting and reconfiguration soon.