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Task II - Monitor the Fleet Ballistic
Missile Development Program
46th Meeting - 18, 19 November 1964

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TABLE OF CONTENTS

Introduction	1
Logistics Support Reports Discussion	
Missile, Mr. L. O. Kitchen	3
Navigation, Commander H.A.R. Peyton	27
Fire Control and Guidance, Mr. Wilford Lewis	39
Launching, Mr. Trevor Clark	48
Remarks of Captain Gooding	58
Systems Appraisal Committee Report Discussion	
Dr. J.P. Craven	61
Missile Committee Report Discussion	
Captain T.J. Christman	83
Admiral Galantin	131
Re-Entry Body Committee Report Discussion	
Commander A. Julian	141
Launching Committee Report Discussion	
Captain J.C. Lieber	171
Fire Control and Guidance Committee Report Discussion	
Captain J.A. O'Neil	195
Navigation Committee Report Discussion	
Commander H.A.R. Peyton	219
Submarine Design Committee Report Discussion	
Commander Clayton Adams	231
Command Communications Report Discussion	
Mr. B. Justice	241
Executive Session	253




INTRODUCTION

The following news was presented to the STG by Captain Gooding:
"I would like to read a telegram. This is addressed to Dr. Charles Stark Draper, 62 Bellview Street, Newton, Mass., and it says,

It gives me the greatest pleasure to designate you as one of the 1964 recipients of the National Medal of Science in recognition of your outstanding contributions in the engineering sciences. You have my warmest congratulations and gratitude for the service to science and to the Nation which have merited this award. Presentation of the award to the medalists will take place at the White House probably shortly after the first of the year. You will be informed later of the details regarding the ceremony.

"And this is signed by Lyndon B. Johnson. I guess that is anticlimactic, but SP adds its congratulations."

Dr. Draper acknowledged the applause and congratulations, and thanked those present.



SYSTEMS APPRAISAL COMMITTEE
REPORT DISCUSSION

"If you will recall, in the last, somewhat abbreviated, Systems Appraisal Committee Report," said Dr. Craven, "we noted some fluctuations and oscillating cycles with respect to the overhaul, repair, and construction in the POLARIS program. The burden of our last meeting was to see if we could not pin down the generic component, if there was one, in a particular fluctuating cycle, and to determine whether we might expect to see cycles of a similar type in other aspects of the system. Accordingly, we had a meeting in October whose subject was 'Systems Acquisition and Maintenance Cycles and Their Effect on the POLARIS FBM Program. For that meeting we went back to a rather famous treatise, The General Theory of Employment, Interest, and Money, written some thirty years ago by Lord John Maynard Keynes. In this work, Lord Keynes sheds insight into the causes of the business cycle; in particular, he points up and demonstrates the paradox that business cycles could be particularly disturbing if the business or venture had behaved prudently and had produced a highly reliable product which required little or no maintenance. To the extent that we in SP have indeed been prudent, have produced highly reliable products, and have developed systems requiring little maintenance, we should expect to be confronted with long term oscillations which have profound systems effect.

"To understand these processes in relationship to our program, let me first restate the basic cause for the cycle, and then cite five specific versions and variances of the cycle that we have. While I will use overly simplified cases as a background against which we will examine a few POLARIS situations, I am sure the POLARIS system examples will come up loud and clear, nonetheless.

SYSTEMS APPRAISAL COMMITTEE DISCUSSION

To begin with, the cycle is generally initiated by a transient associated with the rapid acquisition of a particular producible. Such transients are often associated with technological innovations like television, where they come after a period of denial of consumer demand-- for example, after the war. In the case of the POLARIS, the transient was also associated with high national need. When the basic need of the society has been fulfilled, the initial transient is completed, and there is a regression to a replacement and repair economy or to cycles associated with consumables in the program. Oscillations take place about this reduced level of activity until a time when block obsolescence occurs or a technological replacement appears which the society regards as necessary; this will serve to start the whole process over again.

"Let us now look at some of these overly simplified examples to point out the basic manifestations of the cycles and the problems associated therewith. Figure 1 describes what might essentially be called the one horse shay cycle. It is a simplified case in which all elements of the system have almost the same life span and near perfect reliability and maintainability until failure.

"During the one horse shay cycle, the acquisition of units is rapid, and I would like to relate to some things about our rapid acquisition. Recall that over a short period of time we acquired a number of almost-prototype submarines which started the rapid acquisition cycle. This chart is not exactly right in that we are re-building a good number of these submarines and putting them out as almost new items in this cycle. Thus, in point of fact, our POLARIS acquisition cycle is very close to full acquisition of the entire system over a three-year period. In our overly simplified model we will then show acquisition cycles that are about three years in nature for the major acquisition, and we will omit all sorts of details.

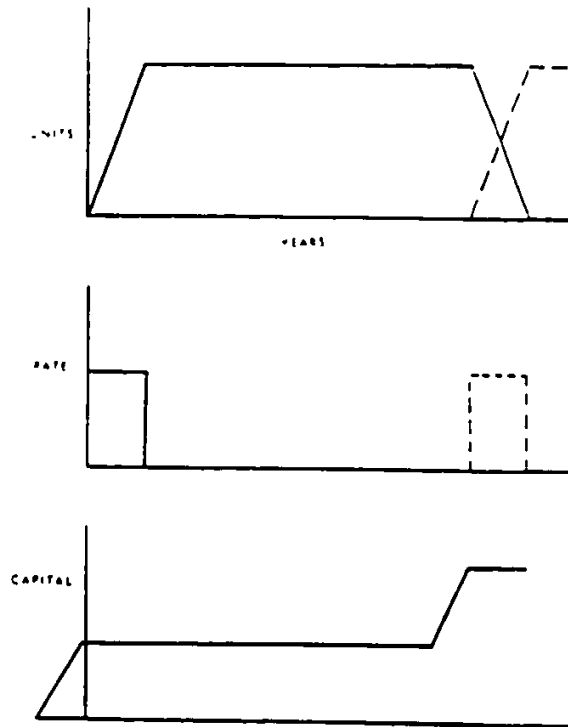


Figure 1

"So, figure 1 deals with our situation in that we are acquiring material within a 3-year period that will remain operationally good for 20 years, after which we 'de-acquire' it and begin a new cycle. The second graph on figure 1 covers the production rate which supports this acquisition program; we have shown the production rate as a step function which is constant during the acquisition period and then drops off to zero until the next acquisition period. The third graph on figure 1 deals with the capital investment. As you can see, the amount of investment builds up during the initial pre-production period and levels off as soon as the production rate is reached. This may be a high level of capital investment in order to get the first producible

items, but then there is a great reluctance to make any further capital investment of any kind in this enterprise during the 20-year period.

"As a matter of fact, there is a tendency to 'de-invest' capital during this use period. On the graph, we have shown the capital as quite static during the entire period. Only when the new cycle starts is there any investment activity, and then, of course, there is a flurry of activity with adequate investment capital available again. The important point in all three graphs is that they allow us to recognize and identify these cycles in our own program; later I will discuss the way in which these cycles introduce bad transients into the POLARIS program.

"I think we can agree that it is expensive to do as we did in the POLARIS program at its outset -- which was to get all the investment capital moving rapidly in an area confined by both time and scope. We need to flatten out the initial investment curve by spreading it over a longer time period; this can be done by earlier construction of submarines, thus spreading out the next cycle over a longer time period. This would tend to do away with the sharp rise in capital and production rate at the end of the first cycle.

"We have a number of items in the program that will fit into this effort: the submarine hull and a great many of its internal appurtenances will fit into this effort. I have been assured that there are some items in fire control, guidance and navigation that will also fit. There are also a good number of heavy items which do not see much use but which do suffer fatigue deterioration during this 20-year period; these also belong in this category. The point here is that we can expect a major 20-year cycle of oscillation and accordingly we can expect the first cluster of major transients in the program to occur around 1982.

"In figure 2, I have attempted to define a somewhat different kind of cycle. Here we have more rapid decay together with a steady

requirement for repair, maintenance and refurbishing. There are more consumables in this cycle and hence a steady requirement for replacement items. The propulsion reactor is a good example of material within this cycle, and there are many other items in the system that have a high rate of consumption. A good many of the consumables aboard the submarines are replenished only when the bin is empty -- the fact that the bin is empty is only learned by going to it for a replacement.

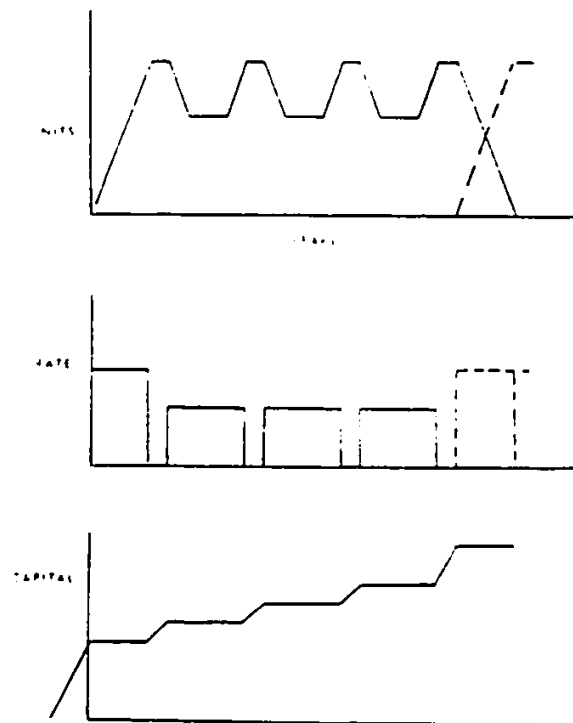


Figure 2

"In figure 2 we are showing acquisition over a three-year period and we also presume that the material will, at the end of a four-year use period, require replacement or refurbishment. As we set up this cycle, the refurbishment itself requires two years, after which the material returns into service again as a used consumable item.

"Comparing the production rate with the units, you can see periods of time when everything is out being consumed and nothing is being produced. Then, of course, items start coming off the production lines. There are periods when material is returning from use to the production line at the same rate as material is coming off the production line. There are periods when the only activity is return of material from use to refurbishment production.

"The rate, which is high during the period of initial production, is lower during the replenishment and refurbishment periods, and the rate runs in cycles much as shown except that the cycles are always sufficiently damped so that they would not appear in the square-wave form shown. Nonetheless, as a general thing, the production will run in feast-or-famine cycles. In figure 1, there was no stimulus to investment except at the 20-year cycle. In figure 2 you can see the effect of a small but continuing inducement for capital investment which can grow out of an awareness that there are better ways to overhaul, more effective methods for repair, and other similar improvements that might be made but which require a capital investment. Thus, the capital investment graph proceeds by small but more frequent increments: still, it proceeds by steps and we again get the cyclic process at work.

"In figure 3, we have a real life example drawn right from the POLARIS program. We are concerned with the number of SSB(N)s on the line during the 1967-1972 period, and I think the cyclic nature shows itself quite obviously. If we wish to resolve this cycle, we

SYSTEMS APPRAISAL COMMITTEE DISCUSSION

find that we must face some inefficient or uneconomic processes. One of the major problems lies with personnel in the start-and-stop production. When production stops, these people are laid off from their jobs. They do not, however, go into some kind of suspended animation while they wait for production to resume -- they get other jobs in other lines of work. They may be quite reluctant to return to their old jobs. Any attempt to restart a production function must face definite costs for re-education or retraining of earlier workers together with the larger chore of training a new group of workers right from scratch. This supports the theory that there would be an economic benefit realized -- though it is hard to define -- by eliminating the start-and-stop production. One way of doing that would be through returning submarines for overhaul and refit sooner than is necessary in terms of actual consumption. In other words, we would give away a portion of our consumable margin in order to smooth out the fluctuations in production and acquisition. I think this is a desirable thing to do in the long run.

"Thus far, these cyclic problems have been discussed with respect to the submarine and its internal equipment and appurtenances. Next we should consider these same problems as they may bear upon the missile itself. We have not thus far met this kind of problem with the missile because, possibly without being aware of it, we have made use of one of the classic solutions to the Keynesian dilemma -- early obsolescence. This is the solution of the American automobile industry, which prospers for one reason alone -- that they have forced the American public to believe that they must get a new car every five years, and they have further designed their cars with a built-in life expectancy that will force block obsolescence after five years. This has allowed the auto industry to keep the investment and employment cycle within reasonable rates of oscillation. While these rates may be somewhat discontinuous in this process, the rates are interrupted by the investment cycle; this tends to develop a balance between the production and investment process in terms of maintaining a fairly uniform allocation of the total resources in the society.

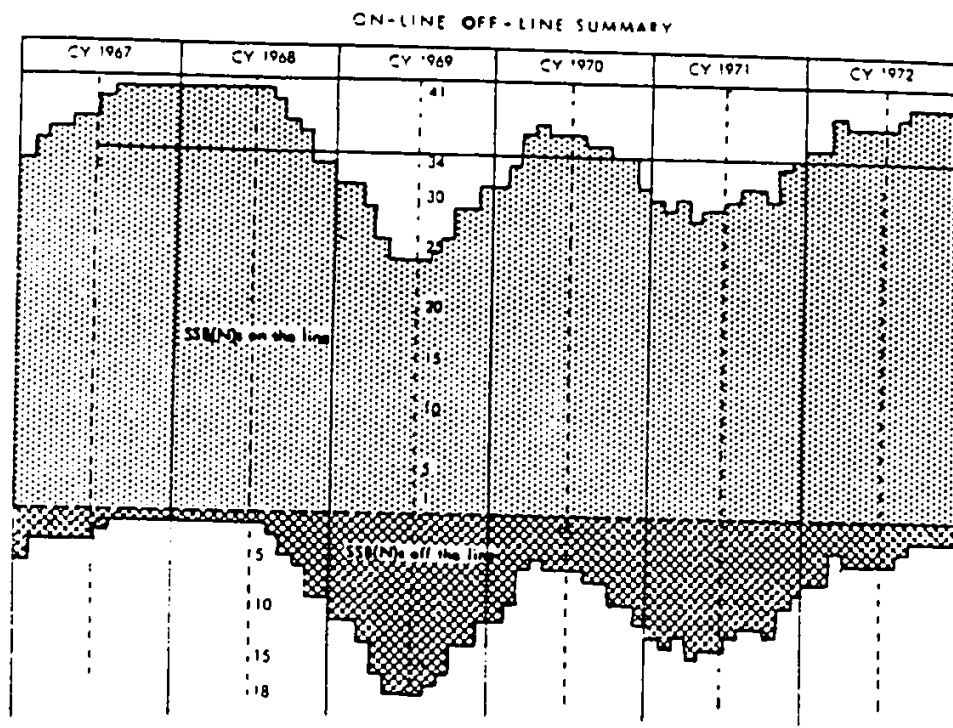


Figure 3

"Figure 4 is a consideration applicable to the missile itself. In terms of the units acquired, the initial acquisition was high enough to take care of consumption during the period of high consumption -- as we do consume missile in test firings, in DASO's, ORT's, and similar efforts. There is a high rate of consumption -- we have shown a peak on the graph of units to correspond with combined use and acquisition. Next, while we hope that such is not the case, we may be faced with a five-year missile life because of de-bonding or propellant depolarization; if this is true, then we will face a total replacement program.

SYSTEMS APPRAISAL COMMITTEE DISCUSSION

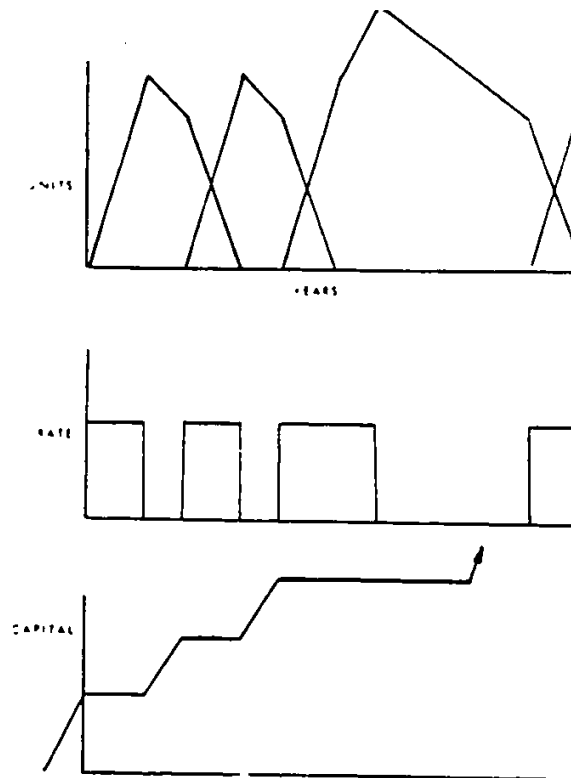


Figure 4

"Now if we had developed a new missile system to be phased in at the obsolescence of the original missile system, then we would have resolved the dilemma; we would also have resolved the problem of capital investment in things needed to keep the original missile system alive and going. We already know that investment is hard to come by, because no one feels that there is any profit in investing just to keep a short-term system alive. The businessman feels that it is not worth it.

SYSTEMS APPRAISAL COMMITTEE DISCUSSION

"Thus, the replacement system resolves the problem very neatly. We simply let the original system die. I believe that Captain Christman is going to talk to you about the problem of whether we should simply let the A1 system die; I need only remind you that if it is left to die, then we can expect its replacement will be on hand with its own set of cycles for the full 20 years.

"To go on to the next point, let us suppose that we are getting quite good at this business, and we decide that some missile is going to have a 10-year life span. Let us further assume that we find less and less reason for developing a new missile as a replacement at the end of the ten years. So we change the cycle by which the missile is developed.

"The first change would be a larger initial purchase because we must take care of consumption over a longer period of time. We would buy more initially and we would continue buying during the consumption period, as shown in figure 5. This markedly changes the procurement slope. Next, there will be bigger and bigger spaces in the procurement cycle, together with longer periods of procurement. Because of its length, the procurement cycle can satisfy us in terms of short-period needs. But while it is longer and runs past the first acquisition cycle, it is followed by a much longer period of no procurement, during which time there is a substantial difficulty in obtaining any investment capital.

"Considering investment in this cycle, recall that the rate of production is the factor that falls off. Now if we were dealing with an upcoming new missile, the resources would need to be augmented by re-investment of previous capital and the addition of new capital. What has been happening is the de-investment of the capital at about the same rate that it has been amortized. In other words, while that capital has utility in producing limited equipment, the investor feels that investment for that purpose is akin to investing in a junk yard.

So, during the production, there is no problem in maintaining the investment level. As you extend the lifetime of the system, however, you prolong the no-production period and you lose the possibility of re-invested capital. There is a loss of interest, a loss of capability, a loss of industrial capacity; then, whenever you decide to reopen production, the investment curve goes up steeply.

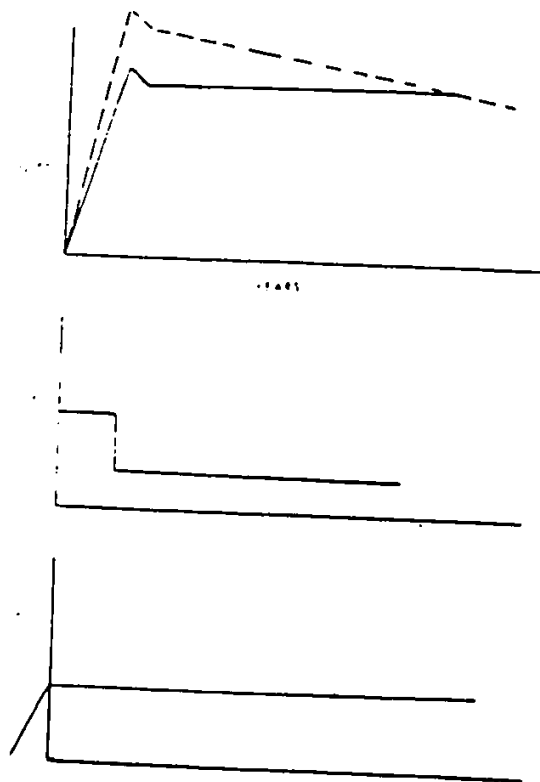


Figure 5

"I think you can see ample justification here as far as the development cycle is concerned beyond the elemental need for measures and countermeasures in this effort; we also must be able to recognize a

real danger in not moving from cycle to cycle in a development and losing, by our lack of movement, our ability to take full account of productive capacity and production level. I cite this example as being directly related to the missile problem -- after all, we do intend to maintain our system right down the line, and we must accept the fact that it will be extremely hard to maintain when it has a gap in it similar to the one shown.

"In figure 5 is a cyclic approach that looks ideal, but is not necessarily ideal at all. I might note that this cycle approximates our present circumstances as regards the fire control and guidance system. Here we had seen a large initial acquisition of an item which has a fairly high wear-life or rate of consumption. The fire control and guidance systems can, of course, wear out from the ORT's and DASO's. Thus, we have been fairly busy rebuilding these units on a continuing basis; in other words we will have continuous consumption coupled with a continuing building program. On the figure, we have indicated the case with no consumables by the solid line, and consumables are imposed above by the dashed line.

"While there is an initial over-buy, because of the consumables and the lag in the repair and return cycle, there is a long period of time during which the units and the rate of production remain quite constant. There would be no trouble in obtaining the initial capital investment, but there is very little inducement for any further capital investment and consequently very little new capital in the development during the stable period. Again, a certain amount of the capital would be de-invested as soon as it becomes amortized. The danger in this comes at the moment when block obsolescence occurs. Unless you have made contingent plans to take care of this problem you are in trouble. I think an example might lie in the equipment installed at some supplier's plant -- say a line of machine tools specially set up for this particular production. When they go out, they possibly will

SYSTEMS APPRAISAL COMMITTEE DISCUSSION

become obsolete or defunct at about the same time, provided they have seen approximately the same operational life. This obsolescence could deprive us of one supplier for a period of time. Then there will be further problems once the supply of the particular item is reassured-- if we use a different source, then there are qualification problems, and if we use the original source, we would have to wait on his re-tooling with replacement machines and re-establishing production according to the original specifications. Either way, we can expect a great deal of trouble.

"In figure 6, I have the fourth, and also the most paradoxical of all the examples. In this case, a majority of the items that we are covering within a development program decay and deteriorate with time. However, there is one thing that just continues to improve with age, at least up to a certain point, and that is the human beings concerned with the program. If we look at the crew situation in the light of these Keynesian economics, we can see that we do have and will have a cycle with the personnel of the program; we can also see that we will be in severe trouble if we do not prepare in advance to deal with this problem.

"To elaborate, we have already been faced with the extremely difficult task of getting the personnel together for the submarine crews, and then training them. I think we can admit that the Navy worked like blazes to get the initial crews together and trained-- and this we can call the personnel acquisition phase of the program.

"Once they are trained and given some experience, we can expect two things to happen with the personnel. Some of them will leave the service. This attrition can be equated with 'consumption' in terms of Keynesian theory. Other personnel in the program will become more educated by participation in the program, and will accordingly advance in their ratings or grades. We know already that we have a pyramidal structure here, and that as the individuals advance in their ratings,

SYSTEMS APPRAISAL COMMITTEE DISCUSSION

we will soon have a surplus of personnel within the higher grades and ratings unless the attrition occasioned by some of the higher ratings leaving the service equals the supply of incoming ratings. Further, the vacancies left by personnel as they become promoted to higher grades must be filled by a new supply of incoming personnel just joining the program.

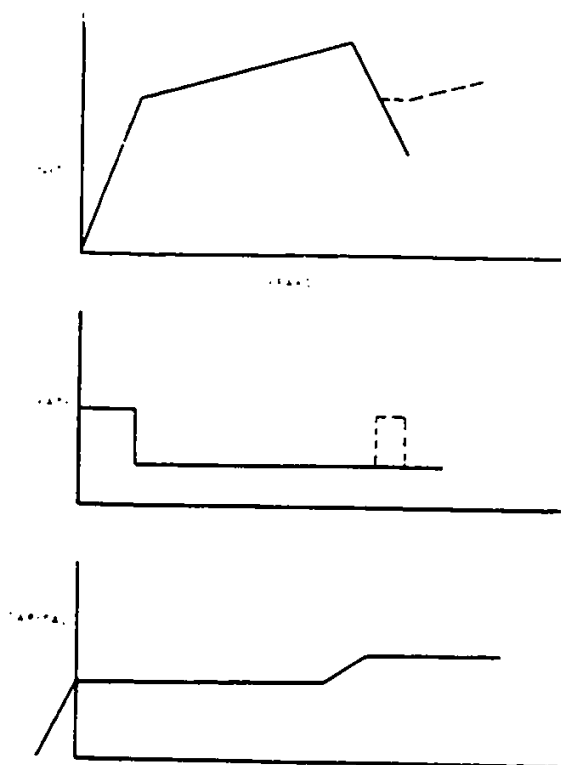


Figure 6

"At this time, the personnel attrition in the POLARIS program is not very large, and we are already moving into the position where

SYSTEMS APPRAISAL COMMITTEE DISCUSSION

we have, or soon will have, an excess of chiefs. At first glance, this looks like an extremely handsome situation to be in -- you start with common Indians who are somewhat better than we can normally expect. Then, with training and experience, the Indians become braves, and again this is a fine situation for the program. However, they soon develop skill and experience so that they are ready to become first-class or chiefs, but when this happens, we have no place to put them. For the moment, that situation may not be any problem; the man is extremely well-trained and skilled in his job, so we tend to leave him in it. However, at the same time we have to be developing more Indians in the lower categories, and these Indians will want to look ahead to becoming braves and eventually to become chiefs, also. If the possibility of this advancement is denied these incoming Indians, then there will be considerable attrition among them once they arrive at the status of braves.

"There is another feature to consider. Most of the personnel joining the program have come in with about six years of duty at the time they go to sea with the FBM submarines, which leaves them 14 years to go before the first consideration of retirement. If we look ahead to the time, about 14 years from the first patrol of the submarines, we can see the possibility of losing a tremendous number of chiefs within a very short time -- almost as though they left the Navy en masse. Unless we have a great surplus of high-quality replacement for them at that time, we can anticipate that the effectiveness of the Fleet will drop off sharply and that we will be caught up in one of the Keynesian oscillations. There are two things that we can do to offset this problem -- either develop and maintain a substantial pool of talent and ability among the younger personnel in the program (and this is hard to do in terms of the Navy's policy on promotion), or we can transfer well-qualified, experienced and highly skilled chiefs out of the program after they have served only a portion of their remaining service time as chiefs in the FBM program.

"This transfer-out has already occurred in the nuclear reactor program; they had the same problem having a great many excellent chiefs holding down all the available ratings in their program and almost eliminating the prospect of promotion for any upcoming talents. Their answer was a wholesale dumping of these chiefs onto the rest of the Navy in order to create an attrition which did not otherwise exist. Now, looking at the nuclear power plant development timescale, we can see immediately that a Keynesian cycle had taken place. Unless we do something about it, we can expect the exact same thing to happen within the POLARIS program; to our credit, we have already been working on some form of a program to give us a maximum attrition rate.

"The Bureau of Naval Personnel has been making some strides in this direction already. They have been developing a program called CAPRI that is designed to keep track of all personnel in the various ratings or grades. While it is not presently a predictive program, it can be easily altered into a predictive program and we can make good use of it when it is.

"In discussing personnel, we have an obvious investment factor. The training schools, their equipment, staffing and maintenance are an immediate high capital investment; there are others which are not shown in the investment line on figure 6. The rate is in agreement with the unit/years in that there will be cyclic increases in the need for men and accordingly in the rate of training. We can avoid sharp sudden increases in the rate, or at least flatten the increases out measurably, by taking certain precautionary measures -- by making certain that all personnel who like the POLARIS program but who are not qualified for it are moved out for the program as soon as possible. We can all take independent looks at our areas of the program and determine whether or not we might be getting some 20-year chiefs in our sections who are hanging on for the happy day when they retire.

SYSTEMS APPRAISAL COMMITTEE DISCUSSION

"This is the burden of what we wanted to present and to point out its problems. We warmly recommend that each group examine -- and this might be a thing for SPAN to look at -- its own program in great detail to locate and identify these cycles, and to bring them out in the open, not hide them under the rug. There has been a strong tendency to hide these cycles under the rug, because they are antithetical to short term prudence. However, we must point them out so that we can take the measures needed to prevent these sudden, sharp and surprising fluctuations that will otherwise occur only 10, 15 or 20 years from now. If anyone thinks that 15 years is a long time, remember this program is now eight years old.

"If you would wish to view the B3 in this context, check back to figure 3; in this graph you could identify the A2, A3, as well as the B3, if we accept that in the reasonable future lies the small ballistic missile recommended by Advanced Sea Based Deterrence or, for that matter, an advanced B3 missile. This graph is a boost for either idea, or for any other idea that would involve a development on an overall economic basis that will avoid this cyclic business.

"What this really says, in other words, is that the real advantage of the B3 is its ten-year lifespan. I do not mean that we should not build a full ten years of life into the B3. I do mean that if we accept the B3 program as pictured here, and if we do not have an improved B3 or an advanced model to turn to at the end of the ten years, then we will most likely have to face both a hole in the production rate and a hole in the investment capital.

"There is a natural two to four year gap in both the investment of capital and production. This would mean that industry's attention and concern with a sea-based missile system would be small or marginal during that time, and would inevitably be followed by a period of extremely rapid buildup and general acceleration of efforts. If

there are any budgetary advantages in the two or four year hiatus, these will rapidly vanish in the flurry of activity when the hiatus ends.

"In speaking about investment capital, I think a definition is in order. For our purposes, we should think of capital generally apart from the investment needed for the research and development of an item. However, development that occurs within the production process is most certainly covered by capital, as are all production costs -- the jigs, fixtures, buildings, tools, bricks, mortar, and, in fact, all items that you build which themselves are not part of the consumed items, which you build in order to have the consumed item. These items are hard to come by, are very essential, and yet are things which you would not build more of, if you could possibly avoid doing so. For example, we have a continuous-mix propellant plant; as far as I know, there is no intention of building another one in the near future.

"Now there is no effective way in which we can maintain capital constant in a non-producing program. This cannot even be thought of as depreciation. If you have capital in a fixed production program, it gradually becomes de-invested during that period of time. I really should have another plot of this graph to indicate the changes in the level of capital actually invested in the program. As the program runs out, the capital depreciates and the investment becomes de-invested: when you put in a new program, then you throw away the earlier program and put in a new capital investment.

"Finally, as a finishing touch, I should like to read a few lines from Lord Keynes' book as a simple means of returning our attention to the fundamental issues of the problem I have been discussing:

Take a house which continues to be habitable until it is demolished or abandoned. If a certain sum is written off

SYSTEMS APPRAISAL COMMITTEE DISCUSSION

its value out of the annual rent paid by the tenants, which the landlord neither spends on upkeep nor regards as net income available for consumption, this provision constitutes a drag on employment all through the life of the house suddenly made good in a lump when the house has to be rebuilt.

In a stationary economy all this might not be worth mentioning, since in each year the depreciation allowances in respect of old houses would be exactly offset by the new houses built in replacement of those reaching the end of their lives in that year. But such factors may be serious in a non-static economy, especially during a period which immediately succeeds a lively burst of investment in long-lived capital. For in such circumstances a very large proportion of the new items of investment may be absorbed by the larger financial provisions made by entrepreneurs in respect of existing capital equipment, upon the repairs and renewal of which, though it is wearing out with time, the date has not yet arrived for spending anything approaching the full financial provision which is being set aside: with the result that incomes cannot rise above a level which is low enough to correspond with a low aggregate net investment. Thus, sinking funds are apt to withdraw spending power from the consumer long before the demand for expenditure on replacements comes into play; i. e., they diminish the current effective demand and only increase it in the year in which the replacement is actually made. If the effect of this is aggravated by 'financial prudence' by its being thought advisable to 'write off' the initial cost more rapidly than the equipment actually wears out, the cumulative result may be very serious indeed.

"In other words, while you can write it off in five years, you had better throw it away at the end of five years. If you write it off

SYSTEMS APPRAISAL COMMITTEE DISCUSSION

in five years, and keep it going for 20 years. You have introduced a drag on investment and you have introduced a serious fluctuation in the cycle."

"Relative to Dr. Craven's talk," observed Mr. Barrow, "we should point out the peculiarities of the business we are in. We have only one customer, and he generates our entire demand; we cannot level this demand off and depress it as we must be responsive to the customer. As an example, we have a plant in Salt Lake City which was built as part of the SERGEANT Missile Program. If we do not, or cannot, build SERGEANT missiles in that plant, then we must either close it down completely or get rid of it. The same thing is true for the POLARIS complex built at Syosset, Long Island; we cannot keep that plant operating if it is not productive and productivity depends on the solitary customer. So all of these things are analytically interesting but they cannot lead to any action on the part of industry -- industry is pulled along in whatever way the Navy decides to carry out its programming."

"Granted," replied Dr. Craven, "and I admit that my lecture is more for the people in government than the people in industry who are, I suspect, more aware of the results of these cycles. However, industry has a function to point out to government these features about the basic nature of a program and the potentialities within these cycles. It is certainly not in the best interests of the government to support a facility or program just for the sake of supporting it; but it is definitely in the best interests of the government to maintain a specific military capability. The important thing right now is that the potential creation of these cycles and cyclic fluctuations is not now a criterion in advanced planning and budgeting nor a factor in choosing between ways of maintaining a military capability. Industry shares in the responsibility of incorporating its awareness of these problems in their planning."

SYSTEMS APPRAISAL COMMITTEE DISCUSSION

Dr. Kirchner observed that the fabric gets more complex when the government, in recognition of the problems and the need for a military capability, builds its own installations and activities, such as NOTS, which soon put industry in the position of competing with its only customer. Dr. Craven agreed that the use and continuance of such parallel facilities aggravates the problem for industry greatly.

"You cannot easily compete," continued Dr. Craven, "and conversely the government cannot solve these problems by doing things in-house. Either way, there is the problem of the capital investment, and no matter how you may regard it, this capital is invested usefully only when it is invested in the production of things which have utility. The fact that the physical investment can produce over a long period of time means little if there is no requirement for the items produced. It results in a bad balance of the books."

"Much of what you say," replied Dr. Barrow, "takes us to the edge of a large and completely political argument or issue. If we consider the Brooklyn Navy Yard, for example, we have a facility that is not productive for the moment. The problem is whether the Navy can divest itself of the yard. It is not an economic problem any longer."

"But it is an economic problem in one sense," countered Dr. Craven, "because the people in the Brooklyn Navy Yard are definitely a part of this cycle, and they are not going to suddenly die. There was a time when this yard was working as hard and as fast as possible to produce and repair ships. In a sense, they went through the cycles we have discussed and they have now come to a time when their capability is no longer needed. There will be another time when this capability will again be needed, when there will be an intensive production and repair program; when that occurs, we will have to re-establish or reacquire this capability."

SYSTEMS APPRAISAL COMMITTEE DISCUSSION

"When industry has this problem they turn their employees out into the streets. This cannot be done at a government installation; the employees cannot be fired so they continue on at the Navy Yard, creating both a political problem and an increased cost to the government."

Captain Gooding announced that the meeting would recess for lunch, and named Captain Christman to take over the rostrum after the meeting resumed.

MISSILE COMMITTEE REPORT DISCUSSION

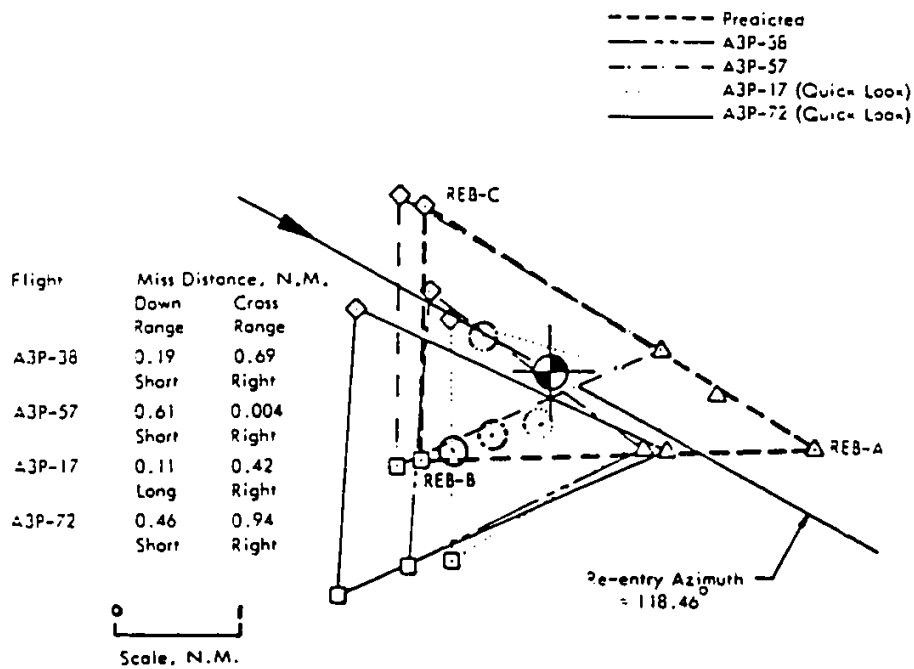
"Figure 1," said Captain Christman, "shows the status of the A3 DASO Program. We have fired 16 missiles, of which 15 were successful; our one failure has been the second stage and we attribute it to failure of the retaining ring. We had a failure in a STAS circuit on one of the early A3P's. We are now monitoring all three re-entry bodies and have actually observed STAS signal on 33 re-entry bodies. Aside from the one second stage nozzle failure, there have been no catastrophic failures.

<u>A3E DASO PROBLEMS</u>		
	<u>FAILURE RATES</u>	
	<u>JAN 1964</u>	<u>PRESENT</u>
1. ELECT. FAILURE (A3X-44) (CABLING)	1/33	
2. STUCK NOZZLE A3X-46	1/33	
3. S/S NOZZLE (A3X-58)	1/33	1/16
4. FRONT END REWORK	1/33	
5. MISCELLANEOUS	1/33	
A. STAS (A3P)		1/33
B. UMBILICAL		
C. AFD UNLOCK		
D. AFT SKIRT CORROSION F S		

Figure 1

MISSILE COMMITTEE DISCUSSION

"Four plots of actual impacts compared to predicted impacts are shown in figure 2. You can see that two of the four missiles landed almost on the predicted, or desired, target spacing.



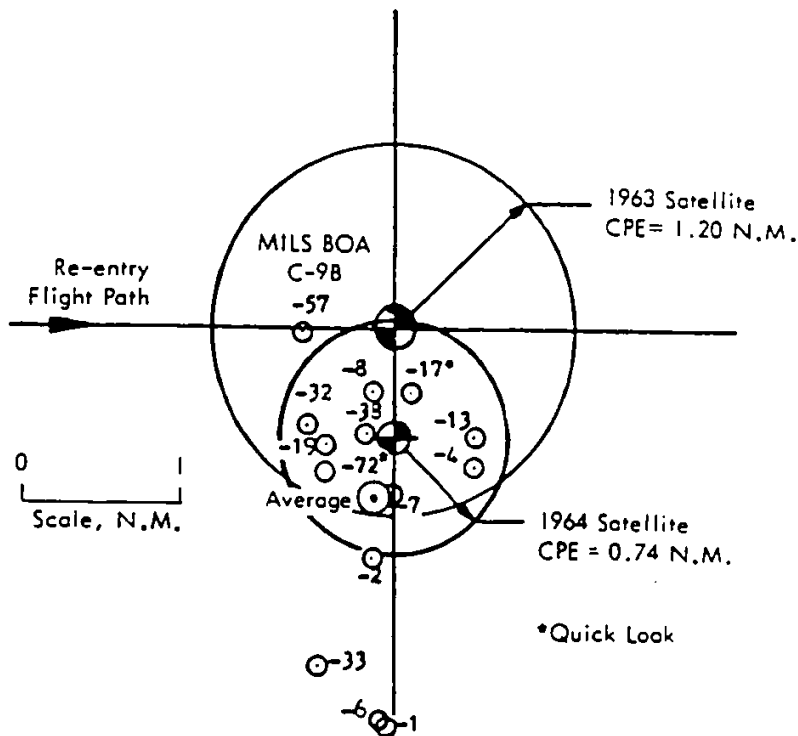
A3 DASO IMPACT PATTERNS

Figure 2

"You may remember that there have been many discussions about the calibration of the range. Although we do not have official confirmation that the 1964 satellite position has actually improved as shown in figure 3, this is the latest estimate of the difference in re-orientation between the 1963 and 1964 calibrations based on the

MISSILE COMMITTEE DISCUSSION

studies conducted this summer. Using the old calibration, we had a CPE of 1.20 n. m., and if the 1964 calibration is accepted, our CPE will be 0.74 n. m. You can see the path of three outliers towards the bottom of the figure, and the rest of them clustered in the middle. The two (A3P-6 and A3P-1) at the bottom were both shot from the same submarine, one by the blue crew and one by the gold crew."



A3P DASO

Figure 3

MISSILE COMMITTEE DISCUSSION

Dr. Kirchner inquired if any accuracy improvement was expected from the Mark 12 Re-entry Vehicle. Captain Christman replied, "There will be some improvement, but I do not know of any number that is comparable to the .74."

Further discussion of the Mark 12 test program indicated that POLARIS/Mark 12 interface demonstration would be satisfied by flying the Mark 12 on A1 missiles. LMSC is calling this configuration A1 prime, which, as an entity, has not yet been funded.

"The Air Force is being asked to provide us with the warhead gratis, which was a non-funded requirement," remarked Captain Christman.

"We refer to this as A3 prime," said Mr. Stevenson, "and even A3 prime as an entity is not funded so it will be difficult to run a test when the installation of Mark 12's on the front of A3 missiles has not yet been designed."

"We know we can do it from an interface standpoint," explained Captain Christman, "but the actual requirement for Mark 12's on the front of A3's has not yet been settled."

Dr. Kirchner said he thought this was the prime requisite for the authorization of the program, but Captain Gooding said that it was the prime requisite on a B3 alternative program in DOD. Mr. Stevenson commented that all the presentations on B3 have Mark 12's in front of them.

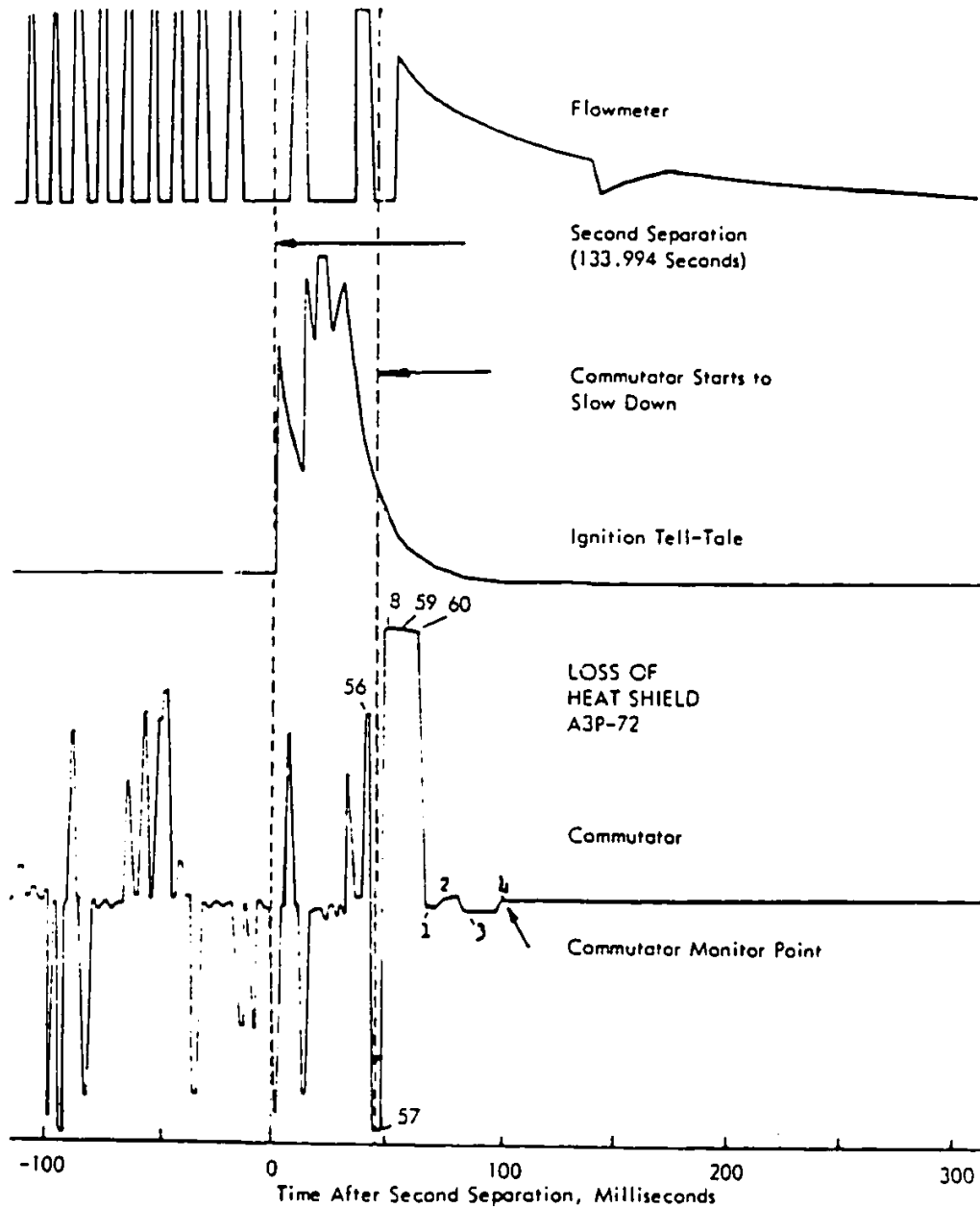
"Figure 4 illustrates the failure of the heat shield on the forward end of the equipment section on the A3P," resumed Captain Christman. "The failure did not affect the re-entry bodies as they had already left the missile at this point; however, the heat shield should stay on long enough to protect the control system so that the second stage will fly

through the re-entry bodies without striking any of them. In two flights we have observed that the heat shield has apparently lost its strength, crumpled, and permitted the control system to be destroyed. This is a case of not achieving what we had hoped to from the design of the heat shield, but the failure has not affected the separation process. The crumpling is apparently caused by the blast of the rocket motors as the three re-entry bodies leave the missile.

"The plot in the lower part of figure 4 is the commutator in the telemetering unit. At the center of the figure is a voltage trace which indicates what has happened to the ignition elements as a result of the charging and discharging of the firing units. At the top of the graph is the flowmeter whose ordinate indicates flow of gallons of fluid per minute. There are transformers between the battery and condensers which are fired when the rocket motors are fired. The illustration actually shows the recharging of those firing condensers. The significant point is that we have lost telemetry at about 50 or 60 milliseconds after re-entry body separation, which indicates that one feature of the missile is not actually performing as it should. If failure occurred soon enough, this could cause the second stage to strike a re-entry body and knock it off its course.

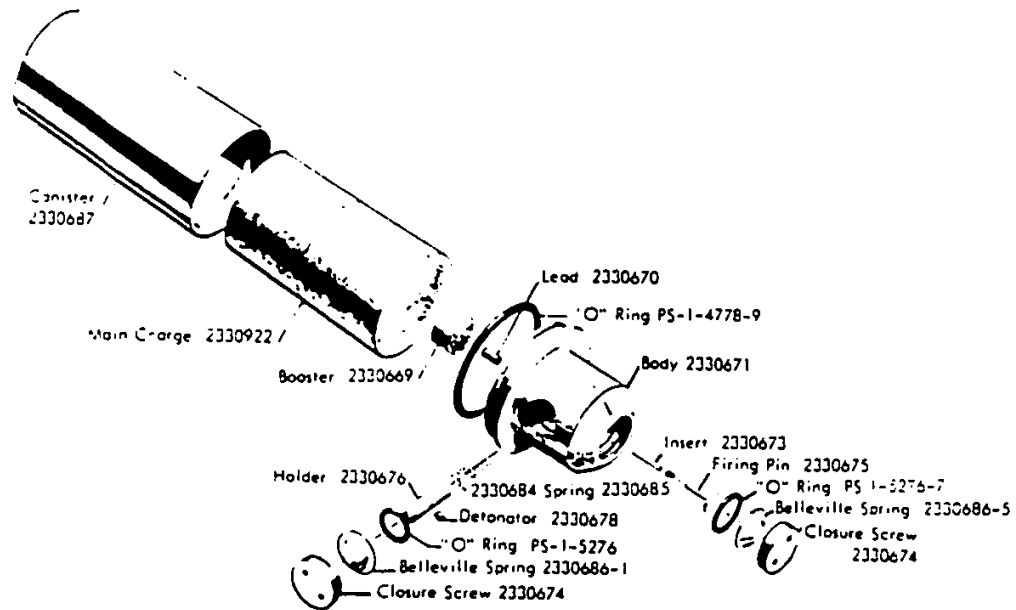
"In the A3E program we have experienced some failures of the SOFAR bomb. The bomb, shown in figure 5, has a safety element which arms it and places the detonator in line. At the appropriate depth to obtain the proper sound channel, it is closed by hydrostatic pressure, fired through one pellet, into the smaller lead pellet, into the booster and finally into the main charge.

"Figure 6 shows a cross-section of the bomb. Apparently, the booster has been firing but has not propagated across the interface. This main charge is PBXN-1."



FLOWMETER, IGNITION TELL-TALE, AND COMMUTATOR DATA AT SECOND SEPARATION

Figure 4



SOFAR BOMB P N 2330830 (2 pound)

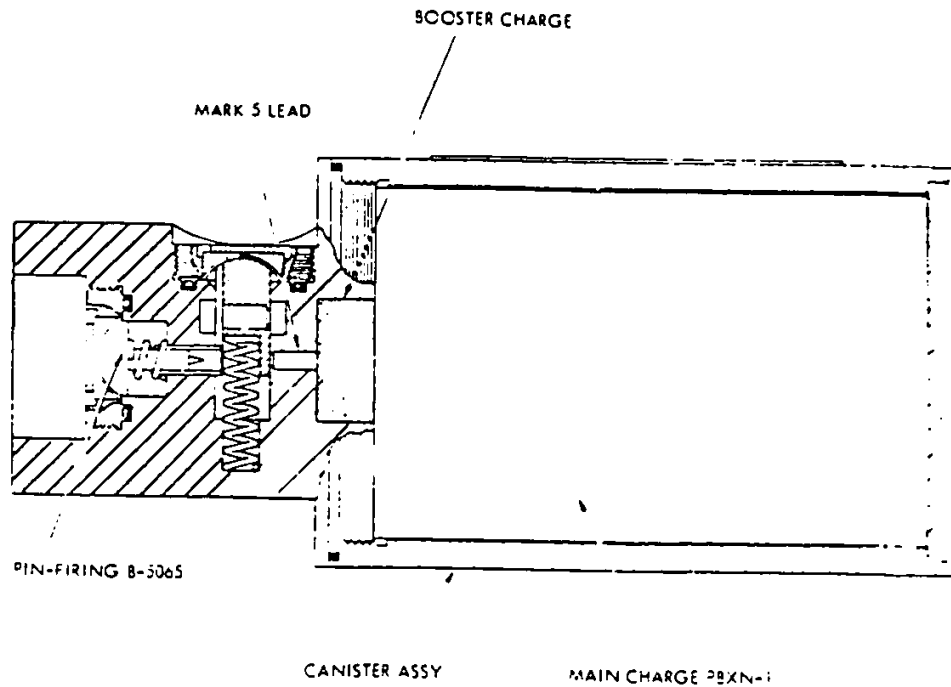
Figure 5

"A good practice," said Captain Gooding, "in using this type of booster is to sink it into the charge in little wells so that it has two dimensions to propagate across."

"We have had 40 successes out of 42 bombs, as shown in figure 7," said Captain Christman. "The real question is how much we are willing to pay for a change to try to recapture those two we lost on downstream tests. Independently of the two failures in flight tests, we have had two ground test failures. When we dismantled the bombs, the booster had detonated, but the main charge had not. We do not know if this happened in the two flight test bombs. At one of their best stations the Range claims to have heard the booster going off. We are going to use a bomb without a main charge but with a booster charge to see if it can be heard by that station. At the moment we

MISSILE COMMITTEE DISCUSSION

are not planning any drastic changes, but will study our data to see if we need any changes to get higher performance reliability."



SCFAR BOMB

Figure 6

"There seems to be a 'batch coincidence' here," remarked Mr. Stevenson. "One batch had 100 percent success, while all the failures have been localized in another batch."

"I came across a paper a couple of months ago that indicated that the density of the boosters is too high," added Captain Gooding.

MISSILE COMMITTEE DISCUSSION

"The shock wave refuses to propagate and puts itself out; things burn instead of blowing up."

A3 SOFAR BOMB FLIGHT PERFORMANCE

<u>A3X FLIGHTS</u> (26 Vehicles Considered)	<u>SUCCESSFUL</u>				<u>FAILURES (REPORTED)</u>			
	1/2#	1#	2#	4#	1/2#	1#	2#	4#
BOMB WEIGHT								
TOTAL	10	21	26	14	0	5	0	0
RESULTS	71 / 76							
	SUCCESSSES/BOMBS							
<u>A3P/E FLIGHTS</u> AS OF 11/2/64 (14 Vehicles Considered)	<u>SUCCESSFUL</u>			<u>FAILURES (REPORTED)</u>				
	1#	2#	4#	1#	2#	4#		
BOMB WEIGHT								
TOTAL		14	12	14	0	2	0	
RESULTS	40 / 42							
	SUCCESSSES/BOMBS							

Figure 7

"We are proposing," explained Captain Christman, "to fund NOTS to perform some measurements on the detonation velocity of the SOFAR bomb, seen in figure 8. Presumably if there is improper propagation across the interface we can measure the velocity of the detonation in the booster, and notice a drop as the wave is coming across the interface and a buildup of velocity as the primary charge gets under way."

"One of the important variables," said Dr. Kirchner, "is the temperature of the charge itself. If the temperature of the grain unit is reduced, the physical characteristics of the propellant change and it becomes a rather rigid material. The propagation of the detonation

wave in that material is greater than the propagation in a material which has, for example, a large elongation. When you are making these, be sure the temperatures of the units are being recorded. I can see that if you fire the unit at 110° you will get some burning, but if you fire it at -65° it will always detonate. Do you have any flight data taken when using thermocouples? I know we instrumented the entire re-entry body for other reasons."

SOFAR BOMB STUDY

DETONATION VELOCITY

PROBLEM:

Determination of Detonation Velocity of PBXN-1 Main Charge to Verify Stability of Explosive Transfer from Fuze to Main Charge.

DISCUSSION:

NOTS, China Lake Will Perform Test of 10 SOFAR Bomb Assemblies (Modified) to Provide Detonation Velocity Data (Including High-Speed Photography) for Approximately 53,680. Test Bombs to be Supplied to Laboratory.

RECOMMENDATION:

Perform the Detonation Velocity Test at NOTS, China Lake with Direct SP Funding GFE PBXN-1, and LMSC Supplied SOFAR Bombs.

Figure 8

"We do know the temperature of the SOFAR bombs all the time they are in flight," replied Mr. Stevenson, "so we can reproduce the actual temperature until loss of telemetry. We can predict quite closely the temperature the bomb should have when it reaches the depth at which it explodes. A good point to remember is that there are temperature gradients in an actual flight which might not be simulated during testing at one temperature."

"A second failure," resumed Captain Christman, "which is much more disturbing than failure of the heat shield, was observed on the A3P-57, and is shown in figure 9. When we light off the first stage motor, three conditions must be satisfied. The first is that the charging must occur between 0.6 and 0.98 second. To arm, which is to charge the firing condenser, we have a timing or a gate. The second condition is that the accelerometer measuring the travel of the missile to be sure we are out of the tube should have measured that we moved 40 feet and signaled this fact to the gate, at which point the first stage arms. Finally, the second accelerometer which is measuring 83 feet, presumes that the first stage is armed, and fires the missile at 83 feet of travel.

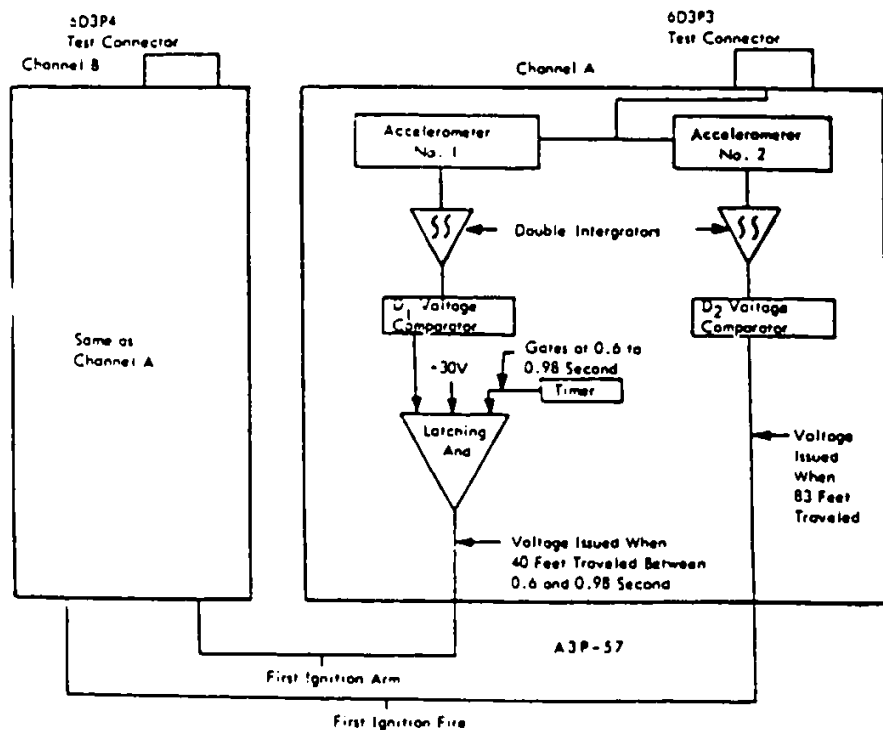


Figure 9

MISSILE COMMITTEE DISCUSSION

"On the A3P-57, as shown in figure 10, the first half of the team worked well. You can see the normal sequence where you would get the charging of the condenser at 40 feet and the firing at 83 feet when the first stage would go off. However, the second channel fired prematurely just after the charge had been placed on the condenser. The arming took place at 40 feet, but almost immediately thereafter the first stage lit off. This is obviously undesirable because when this happened, the missile had just left the tube; in fact, this is why we have a safety element.

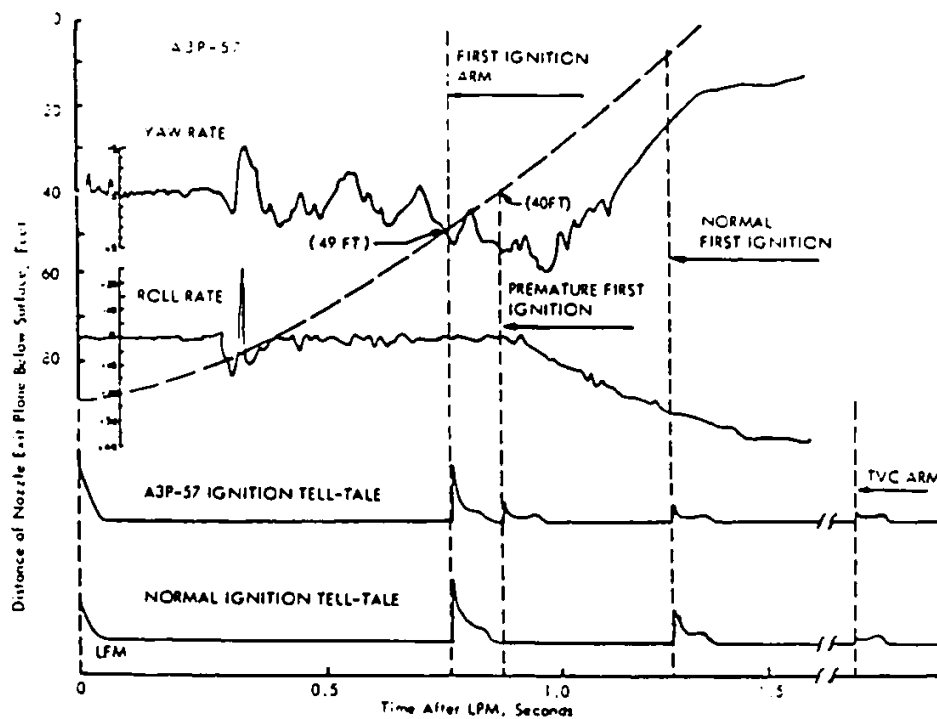


Figure 10

"We are now examining these packages to see if we can discover what caused the failure of this particular package. We also want to know if there is an inherent weakness in our safety links."

MISSILE COMMITTEE DISCUSSION

"I thought that both accelerometers in figure 9 were integrating devices in which you take both acceleration and time before the first stage ignition," said Dr. Kirchner.

"They are both measuring the travel," explained Captain Christman. "They are integrating the acceleration with time to give distance."

"Figure 9 is somewhat schematic," said Captain Gooding. "The end gate has to see acceleration between certain limits for a certain length of time. When this is the case, the gate is opened between 0.9 and 0.95 second, which has the effect of double integration."

"Why did the second accelerometer close up prematurely?" asked Dr. Kirchner. "You have the integrating acceleration which is within a time limit and this would give the assurance that you will be close to 90 feet from the tube before firing."

"The hypothesized mode of failure is leaky Hughes diodes which can put a false bias on the accelerometer, so it thought that it accelerated faster than it actually did," replied Captain Christman. "I do not know the actual integrating circuit, but if the voltage that is issued at 50 feet is higher than the corresponding actual acceleration, the accelerometer thinks it is doing the job faster than it really is."

"After the failure," remarked Mr. Stevenson, "it was fairly well determined that one channel went prematurely. In the laboratory another interlock was used to try to duplicate the failure. They found two ways this could be done: one of them concerned the umbilical or test plug. There is a test plug in the missile that has a rubber cap over it. If that cap is not there, salt water could enter and cause the failure. We discarded this idea because we did not see how the cap could be off and the salt water hit only one point; there would have to be a structure failure in the missile to get salt water in that area."

--

"The second method seems more likely and it concerns the leaky diodes. It happened that a batch of used diodes came in at the time this package went through. Although there had been a stock sweep and cleanout, apparently they did not catch this batch. This was further compounded by the test equipment at NWA where a recycling feature put a glitch into the test equipment so it would not record this condition in the unit. The unit at the factory is not the same and would have seen the condition. We have changed the test equipment so it is now visible; there is go/no-go on this."

"I always thought the acceleration device is responsible for closing the circuit, so that leaky diodes would not affect this," said Dr. Kirchner. "What is the mechanical outcome of the operation of the acceleration device?"

"Basically it is working on a pick-off of some kind that issues the voltage, proportional to the acceleration," replied Captain Christman. "This is then added as time elapses and is compared by the voltage comparator. When it integrates so that some of those voltages over time are greater than the voltage comparator, it fires the gap tube. It is transformed through voltage networks, so any shift in bias gets us into trouble."

"The missile," said Dr. Mechlin, "has to fly freely for 50 of the 83 feet before the ignition occurs. It does not have acceleration until then. There is a time limit in this -- there has to be a time delay between the time you acquire the final velocity and the time at which you have achieved the distance."

"There is a timer, shown in figure 9," said Captain Christman. "All that is needed is to get enough voltage from the accelerometer for this time so that it exceeds the voltage in the comparator. At that point when the match is made, it fires through the loop."

"We are trying to identify the mode of failure. If we decide the Hughes diode is faulty, we will propose a SPALT to remove all those diodes. We are also trying to discover if this has had any other bad effect on the circuit, possibly on the second stage INTERLOCKS. We will report to you about this at the next STG.

"At the last meeting we reported that we were painting the launcher support ring, the clamp ring, and the base skirt of the first stage motor, as shown in figure 11, to prevent corrosion of the aluminum by the bronze next to it. Since that time we have decided against wholesale replacement of the aluminum skirts, nor are we going to change this material in the downstream production. We are now waiting to see what the effect of the dehumidification on patrol and the protection of the paint will be. We have a team evaluating the amount of corrosion on the SSB(N)626 which has just arrived at Rota.

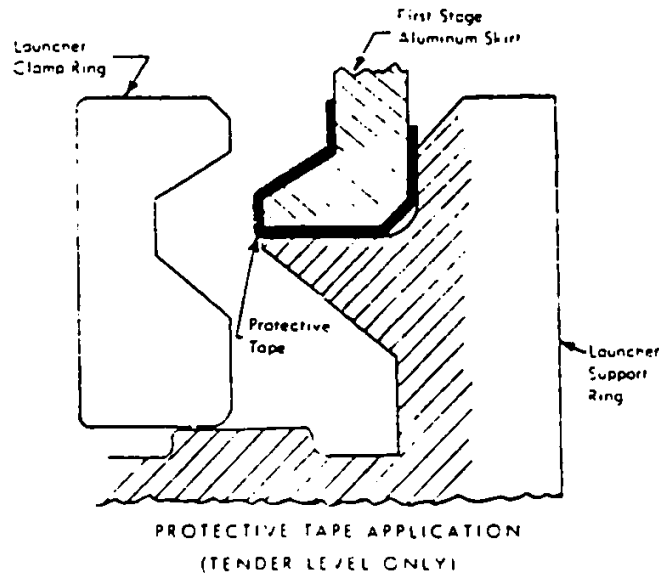


Figure 11

MISSILE COMMITTEE DISCUSSION

"We are collecting a significant amount of data about low density. Figure 12 summarizes the results to date. The next several figures deal with various aspects of what we have learned to date about these 330 motors.

A3P LOW DENSITY STATUS

330 MOTORS CAST TO DATE
 248 MOTORS THRU POST POT X-RAY
 47 MOTORS X-RAYED HAVING LOW DENSITY AT BACCHUS
 32 MOTORS SOLD (13 PET)
 16 MOTORS HAVING CBS
 205 MOTORS SOLD
 58 MOTORS WITH LOW DENSITY (13 PET)
 8 MOTORS WITH CBS (3 PET)
 154 MOTORS X-RAYED AT POMFLANT AND POMFPAC
 26 MOTORS HAVING LOW DENSITY DETECTED AT POMFLANT OR POMFPAC

Figure 12

"Figure 13 shows the number of flights we have had with clean motors, motors with low density and case bond separation, and motors with low density only. No failure as yet has been attributed to low density and case bond separation.

A3P FLIGHT & STATIC TEST RESULTS

	<u>CLEAN</u>			<u>LD+CBS</u>			<u>LD ONLY</u>			<u>TOTAL</u>		
	<u>S</u>	<u>F</u>	<u>NT</u>	<u>S</u>	<u>F</u>	<u>NT</u>	<u>S</u>	<u>F</u>	<u>NT</u>	<u>S</u>	<u>F</u>	<u>NT</u>
STATIC	0	0	1	3	0	1	11	0	1	14	0	3
FLIGHT	14	0	1	-	-	-	1	0	0	15	0	1
	<u>14</u>	<u>0</u>	<u>2</u>	<u>3</u>	<u>0</u>	<u>1</u>	<u>12</u>	<u>0</u>	<u>1</u>	<u>29</u>	<u>0</u>	<u>4</u>

Figure 13

MISSILE COMMITTEE DISCUSSION

"Figure 14 is a summary of low density firings and shows the various amounts of low density that we have tested with no anomalies noted. The way we measure amounts of low density is by taking X-rays of the motor; the amount of mottled area is the amount of low density. Low density perhaps is not the right term; variable density would be a better term. What is on the X-ray film is a mottled appearance as opposed to the clear appearance of the standard propellant. The measuring on the number of standard X-ray shots that we take of the motor is the total number of square inches of the mottled appearance, and you see this total number on figure 14.

L. D. FIRING EVALUATION

<u>MOTOR NO.</u>	<u>AMT. L.D.</u> <u>sq. in.</u>	<u>S</u>	<u>F</u>	<u>NT</u>	<u>REMARKS</u>
ZM-01/047	254	X			NO ANOMALIES
ZM-02/009	210	X			NO ANOMALIES
ZM-02/022	164	X			NO ANOMALIES
ZM-02/006	158	X			NO ANOMALIES
ZM-02/059	142	X			NO ANOMALIES
ZM-02/048	124	X			NO ANOMALIES
ZM-01/015	115	X			NO ANOMALIES
ZM 01/003	110	X			NO ANOMALIES
ZM-01/033	75			X	DOMES FAILURE
ZM-02/084	32	X			NO ANOMALIES
ZM-02/054	23	X			FLIGHT
ZM-02/109	7	X			NO ANOMALIES
RH-372	1			X	DOMES FAILURE

- NOTES: 1. There Were 13 Tests with 11 Success and 2 No Tests
 2. Maximum LD Experienced to Date is (292 sq. in.) on Motor No. ZM-02/019

Figure 14

MISSILE COMMITTEE DISCUSSION

"For the case bond separation, shown in figure 15, we actually use a projection where we observe case bond separation and it is in linear inches on an X-ray film. We extrapolate this, and wherever we notice separation we charge that separation with half the distance to the next X-ray film. With this method we arrive at an area.

<u>CBS FIRING EVALUATION</u>					
<u>MOTOR NO.</u>	<u>AMT CBS</u> Area Ratio -sq. in.	<u>PERFORM.</u> S F NT			<u>COMMENTS</u>
ZM-01.006	744/341	X			PRESSURE ANOMALY
RH-366	163/105		X		DOME FAILURE
ZM-01/034	90/33	X			NO ANOMALIES
ZM-01/007	44/44	X			NO ANOMALIES
ZM-01/029	30/33		X		DRIP FAILURE
BE 7-K05	6/6	X			NO ANOMALIES

NOTES: 1. There Were 6 Tests with 4 Success and 2 No Tests
 2. Maximum CBS Experienced to Date is 3173/795 in Unit ZM-01/049
 3. ZM-01/011 is Scheduled at NOTS for Static Firing and Has 802/577 sq. in. of Case Bond Separation.

Figure 15

"You may notice 'drip failure' under comments in the figure. A drip failure occurs because we are firing in a horizontal position during static firings and aluminum oxide is collecting on the igniter boss and dripping into the space between the two insulators in the forward boot area. The molten aluminum oxide burns a hole through the forward dome. During flight tests we do not notice this because we are firing vertically and gravity forces the molten material out through the nozzles.

MISSILE COMMITTEE DISCUSSION

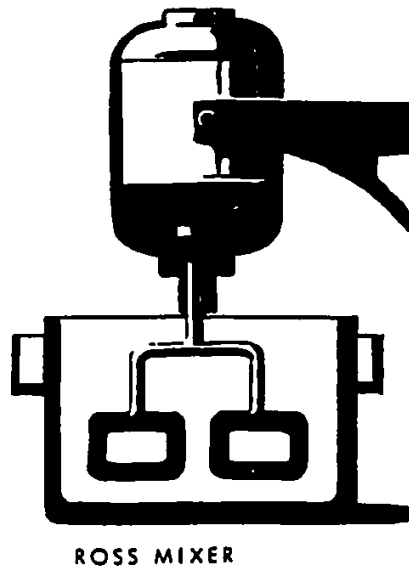
"We are looking for a failure at some point beyond our worst failure to date to give us an upper limit on how much case bond separation we can tolerate. We had precisely this situation in the AIP second stage, so we must now re-examine our criteria. If, for example, we decide that 600 inches is our upper limit and our predicted growth rate is 200 inches per year, do we use a motor with 400 inches on it for a year, and then examine it to see if it had gone to 600 inches?

"This is, of course, time dependent: we have to determine a rate of progression. At this point we do not have a valid number on the time dependence of the case bond separation, so we are not permitting any motors with case bond separation to be used by the service. We are observing them in storage which will be a key factor in our prediction of time dependence.

"Over the past several months we have made several changes in the processing at Bacchus. Figures 16 through 19 illustrate four of the most significant changes. The Epirez Epicure is a resin which is used to bond the little grains at the embedment layer, shown in figure 16, and forms the bond between the insulator and the first grains which are on the periphery of the case. We have changed the mixing so that we have a faster mixing in the first two minutes of stirring this resin.

"The second change is shown in figure 17. We have investigated very closely how ABL loaded powder, because we had no experience with low density or no evidence of it in the motors which were loaded at ABL. One of the changes that had been introduced at Bacchus was the level at which the motors were loaded. We are now returning to the 5100 pound load that ABL used, and we are also varying the shape of this load more in accordance with the method used at ABL.

EPIREZ -- EPICURE MIXING



PREVIOUS METHOD

FIRST MIX 2 MIN AT 30 RPM
SECOND MIX 5 MIN AT 30 RPM
AFTER SCRAPING

PRESENT METHOD

FIRST MIX 2 MIN AT 60 RPM
SECOND MIX 5 MIN AT 60 RPM
AFTER SCRAPING

ROSS MIXER

Figure 16

"The speed at which you get the casting solvent down into the grains to distribute the solvent throughout the entire mass is very important, since eventually it will jell. Figure 18 shows that we have enlarged the pipes and filters to get faster pressure on the casting solvent to distribute it more quickly and evenly throughout the casting powder.

"The most controversial change we have made is shown in figure 19. We changed the method by which the solvent pressure is held on motors during motor movement and application of the ram pressure. At ABL, motors were left to dwell in casting buildings so that although the motor was moved immediately, the casting pressure was never actually dropped; the motors were permitted to do their curing right

POWDER LOADING CHANGES

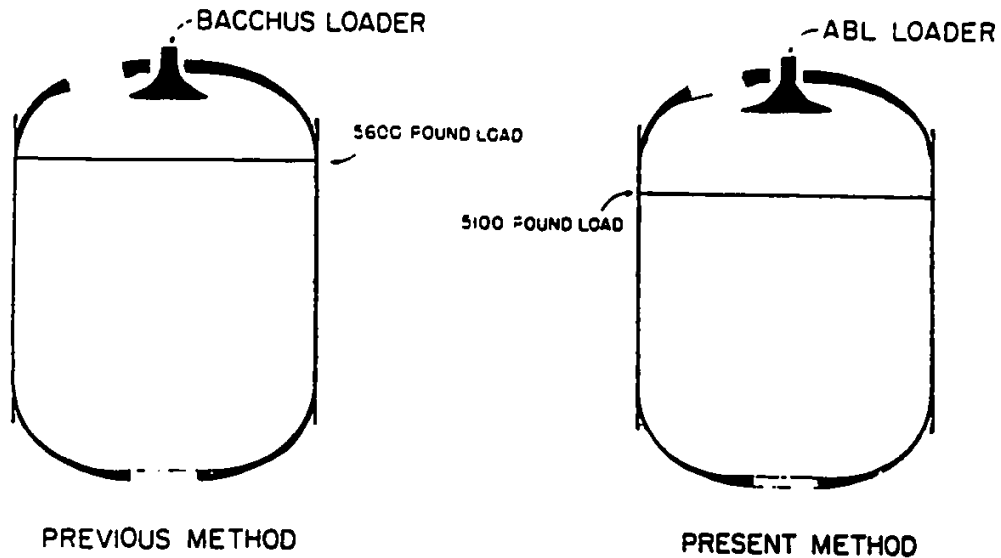


Figure 17

in the building in which there were cast. We felt when we went to the Bacchus method that, for reasons of safety, we should do the curing in a building apart from that used for casting. We would cast the motors and then remove the pressure, move the motor to another building, and then apply the pressure back on the motor.

"We do not now remove the motor from the building, but pull it out of the casting pit. We also retain pressure on the solvent head so that as nearly as possible we never drop this pressure until 16.5 hours after the motor has been cast.

SOLVENT ADDITION CHANGES

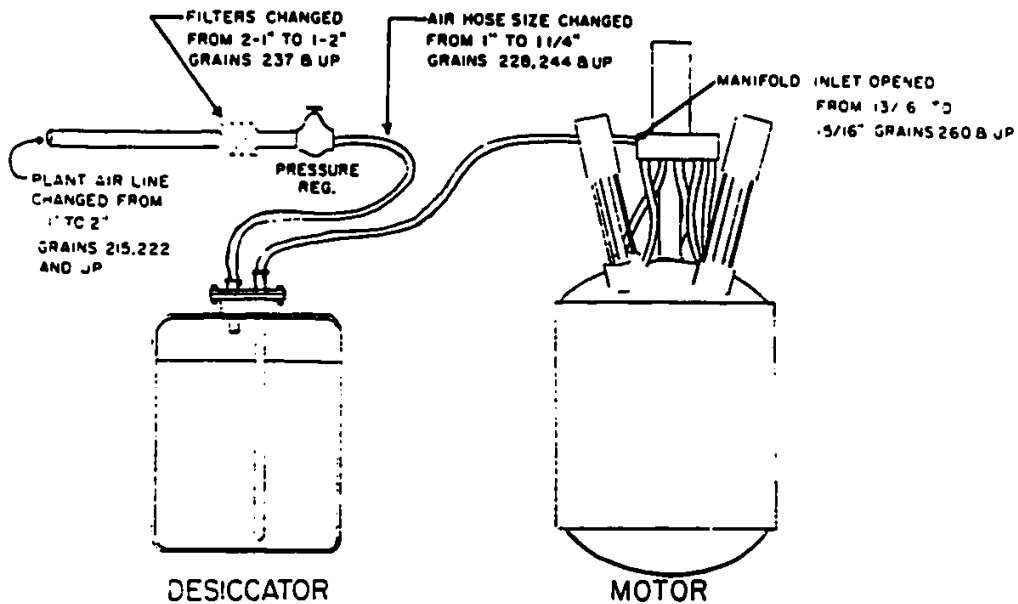


Figure 18

"Currently we have four low density motors on the USS TECUMSEH, two on the USS DANIEL WEBSTER, and four on the USS PROTEUS which has gone to Guam. The numbers shown in the right hand column of figure 20 are the totals of the missiles on board.

"Figure 21 is a summary of the incidence of L. D. units per lot since the start of production at Bacchus. The broken line is the low density that was actually detected at the factory; and the dark line shows the total cumulative number that we have observed from the lot either through additional examinations at the factory, or at the Naval Weapons Annex.

MISSILE COMMITTEE DISCUSSION

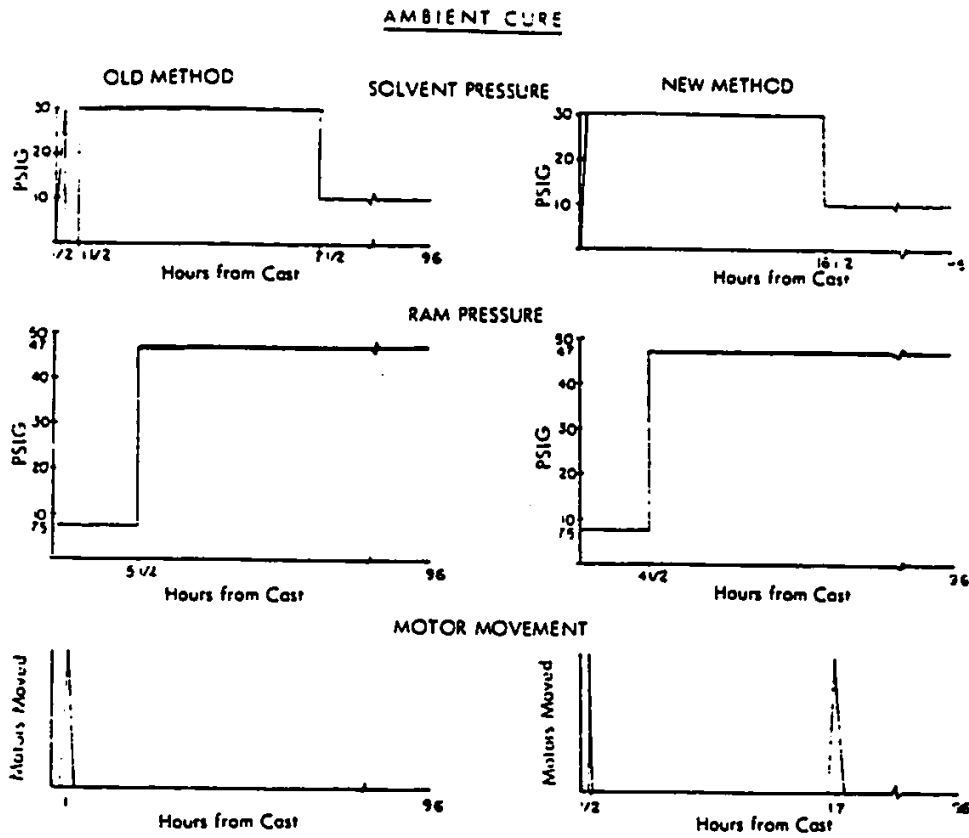


Figure 19

SSB(N) 628 TECUMSEH ----- 16	SSB(N) 626 DANIEL WEBSTER --16	AS 19 PROTEUS (TENDER) ----- 20
4 LOW DENSITY MOTORS	2 LOW DENSITY MOTORS	4 LOW DENSITY MOTORS
ZM-02/049	ZM-01/039	ZM-01/024
ZM-02/097	ZM-01/048	ZM-01/056
ZM-02/061		ZM-02/039
ZM-02/087		ZM-02/079

Figure 20

MISSILE COMMITTEE DISCUSSION

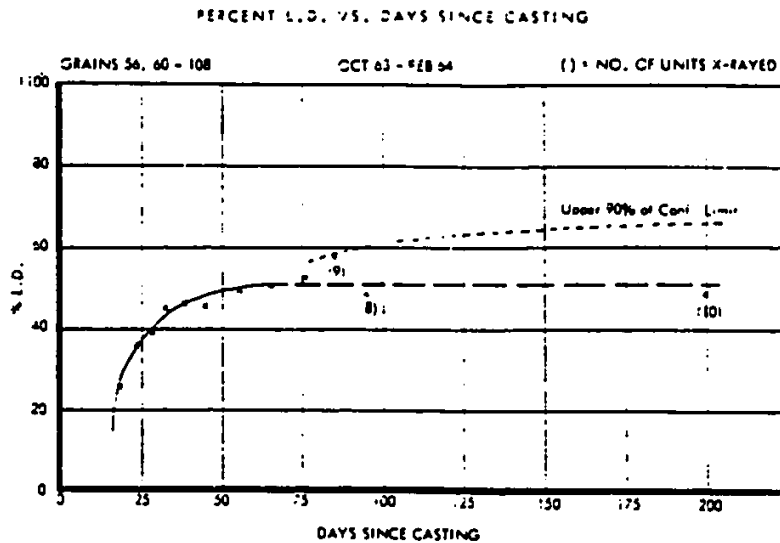


Figure 22

motors in a lot, so two-thirds of them have been X-rayed. The chart also shows that even on the very early motors it has settled out so that even after 200 days of aging, there is no additional low density.

"The next group were cast during the period from February 1964 to April 1964, and figure 23 shows the L. D. is slightly less, but again levelling out. so that no new motors are showing up with low density.

"Figure 24 is the chart for May 1964 to June 1964. Of course, we are much closer now to casting time so you do not see times going out further, but even here we have evidence that the levelling off has taken place.

MISSILE COMMITTEE DISCUSSION

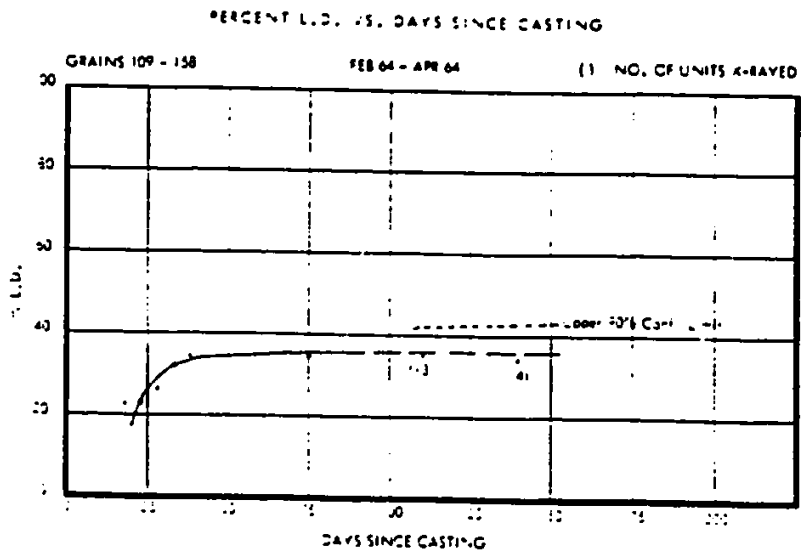


Figure 23

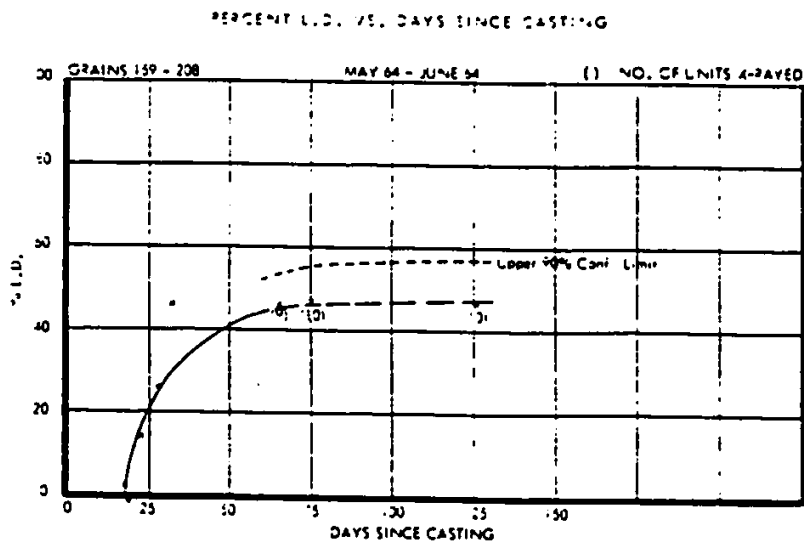


Figure 24

MISSILE COMMITTEE DISCUSSION

"For motors from June 1964 to August 1964, we have levelled off and you can notice in figure 25 that the percentage has gone down from fifty to twenty percent.

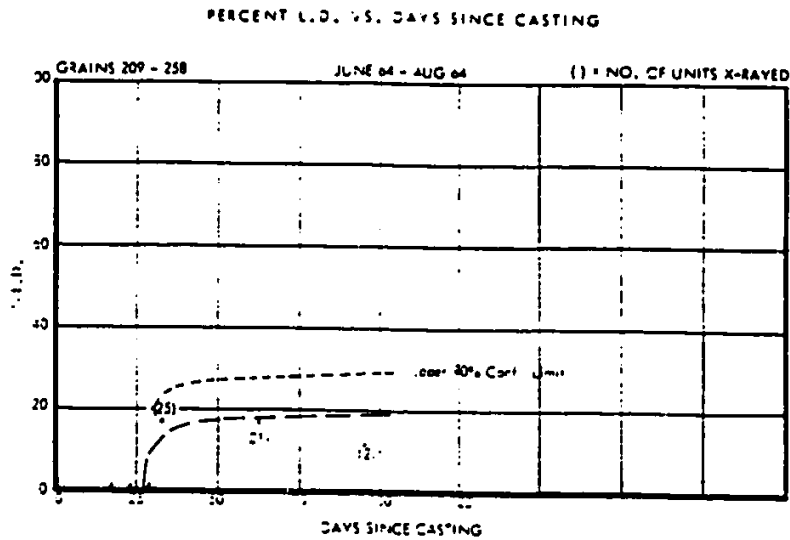


Figure 25

"Figure 26 does not represent an occurrence of low density; at least at the time the chart was made, there had not been any. I think there has been one subsequently.

"Figure 27 superimposes the first four and simply shows how all the grains have levelled off. Based on the data we have out to 200 days, there does not appear to be any tendency for the grains which have not exhibited low density at about 75 days to develop it beyond that point.

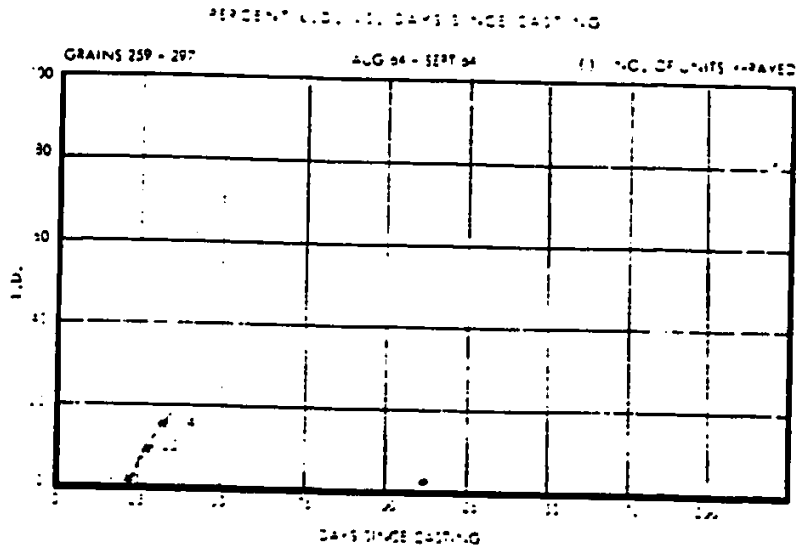


Figure 26

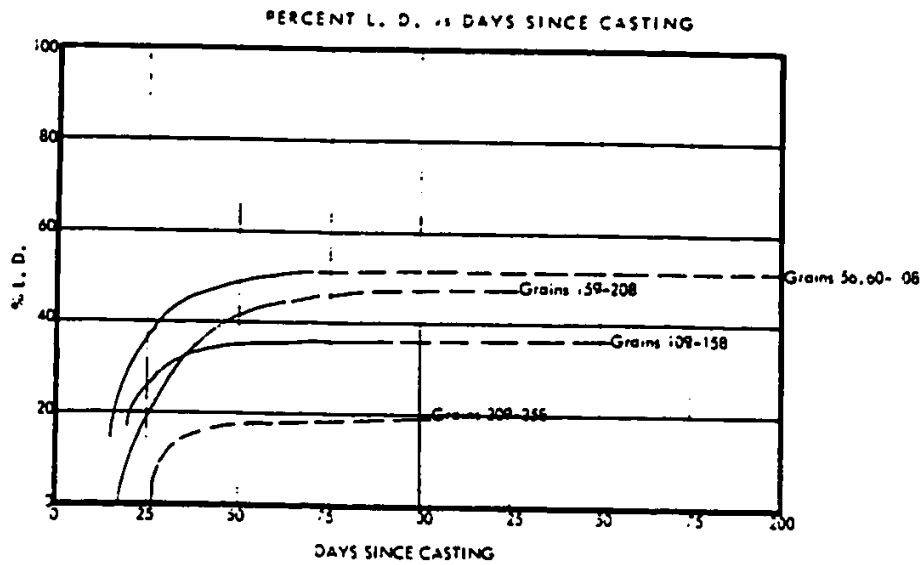


Figure 27

"Figure 28 shows the percent of L. D. developing into case bond separation in the early motors from grain one, the first motor cast at Bacchus to about 50 grains into the production base. At the last Missile Working Group, the prediction at this point was that 88 percent, or essentially all, of the motors showing low density would develop case bond separation. We now have examined ten out to 250 days and on the basis of analysis of these data we now show a prediction of 58 percent, which means that rather than driving upward in this direction as it appeared two months ago, the data appear to be turning.

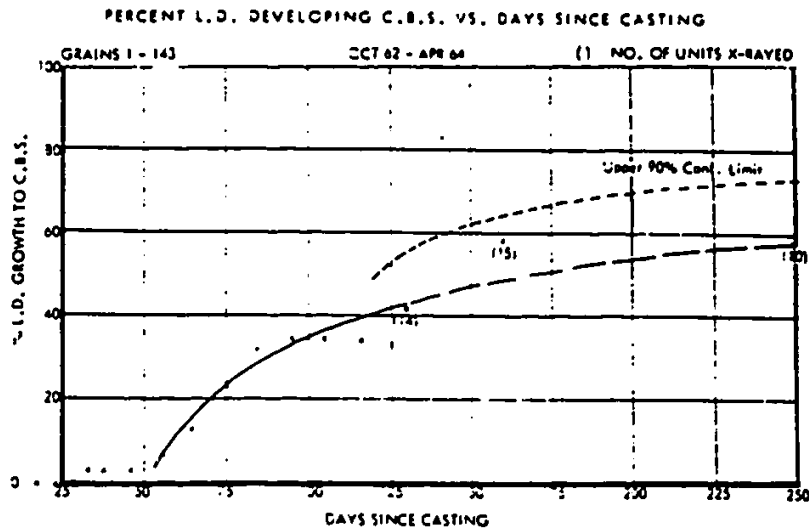


Figure 28

"Figure 29 shows the percentage of case bond separation in the first block of tactical motors; the first ones were used in A3X and were part of the prototype production line plus these motors. The chart shows the same sort of a curve based on 15 motors examined at 175 days and here we have about 30 percent of them developing case bond separation if they had low density. The significance of

these factors, if they continue to be validated, is that it does appear that after a certain time those motors that are left will not show case bond separation.

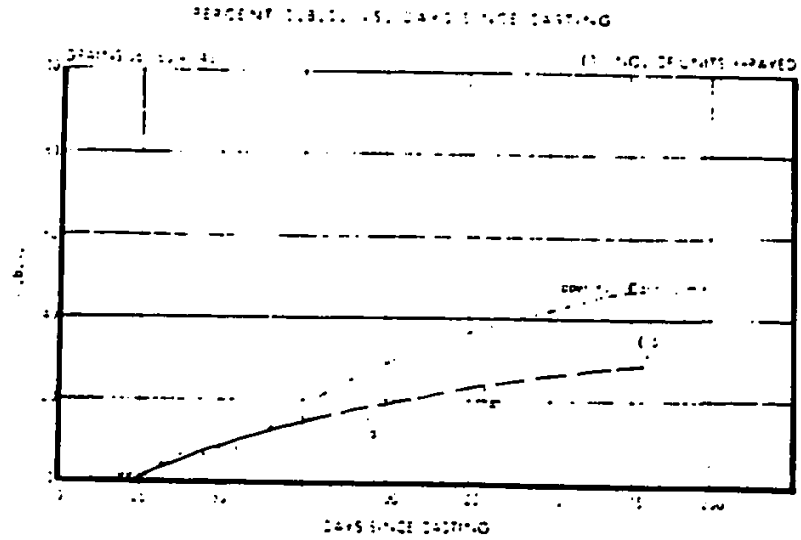


Figure 29

"Figure 30 is another plot of the same chart. It shows that on a cumulative basis, we seem to be levelling off. It is another way of presenting the data from those six curves that we looked at before, and it shows the number of motors that were processed in that particular time span.

"I think, in summary, we seem to have more optimistic data than we have ever presented before. This is the first time that we seem to have a levelling off after about 75 days. If a motor has been examined and low density has not been indicated up to that time there seems to be good evidence that the motors will not develop low density

thereafter. Similarly on the motors which do have low density there does seem to be an upper limit to the percentage of those that will develop case bond separation, and that will occur within a certain finite time.

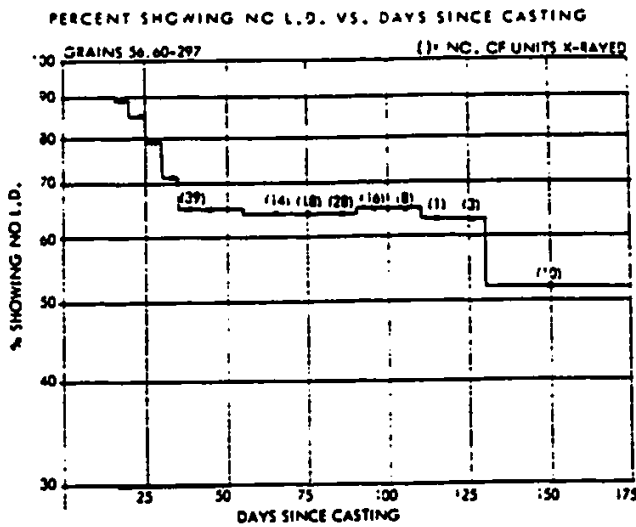


Figure 30

"Both of these factors will help our production people predict which motors will have to be watched most closely and enable us to use selective extraction of motors from the Fleet. Our target is to pull three back per patrol if we can. We have three missiles that went over on the SSB(N)626 and we are hoping to get them back from her.

"One problem we have discussed many times is the one existing flight failure in the A3P or A3 DASO Program, our second stage nozzle. Figure 31 shows the cumulative tests to date. In the tactical configuration, we have a graphite retaining ring with a 1010/1020 steel case, and we have observed six failures out of approximately 250 tests. It is disturbing that in static tests when we dismantle the motors we have discovered -- in addition to the six failures -- 28 more that had severe cracking in the graphite retaining ring, which we believe is indicative of the manner of failure of the six.

14P NOZZLE EXIT CONE INSERT AND NOZZLE STEEL CONE SUMMARY SHEET

NOZZLE VENDOR	1010/1020 - CS-312			1010/1020 - ATJ			1010/1020 - MHLM			4130 - ATJ			4130 - CS-312			
	SUCCESS	INCIPIENT	FAILURE	SUCCESS	INCIPIENT	FAILURE	SUCCESS	INCIPIENT	FAILURE	SUCCESS	INCIPIENT	FAILURE	SUCCESS	INCIPIENT	FAILURE	
VMC	STATIC	55	2	0	4	0	0	2	0	0	2	0	0	3	3	0
	FLIGHT	55	-	0	0	-	0	0	-	0	8	-	0	0	-	0
KAE	STATIC	29	22	3	12	0	0	0	0	0	8	0	0	0	0	0
	FLIGHT	41	-	2	0	-	0	0	-	0	0	-	0	0	-	0
TRW	STATIC	9	4	1	0	0	0	0	0	0	0	0	0	4	0	0
	FLIGHT	10	-	0	0	-	0	0	-	0	0	-	0	0	-	0
TOTAL		229	28	6	16	0	0	2	0	0	18	0	0	7	0	0

NOTES:
SUMMARY INCLUDES MOTORS THROUGH 2M-02/084.
INCIPIENT FAILURES CANNOT BE ASCERTAINED FROM FLIGHTS.

Figure 31

"In actual flight tests we have only had two failures; one was an X missile and one was a P missile. As a result, we have been attempting to qualify a backup system, namely, ATJ graphite. Originally, we were thinking of using a 4130 steel shell, but decided that perhaps it would be better to stick with the 1010/1020 steel shell.

MISSILE COMMITTEE DISCUSSION

"Figure 32 shows that there were two failures from Kaiser nozzles in flight and that Valley was completely successful in flight with most of these being R&D. Valley had two incipient failures in static test and, of course, we have no way of telling what the incipient failures might have been in flight. Kaiser had an extremely large number of incipient failures during the static firings. These incipient failures are cracks in the graphite ring discovered after it is disassembled."

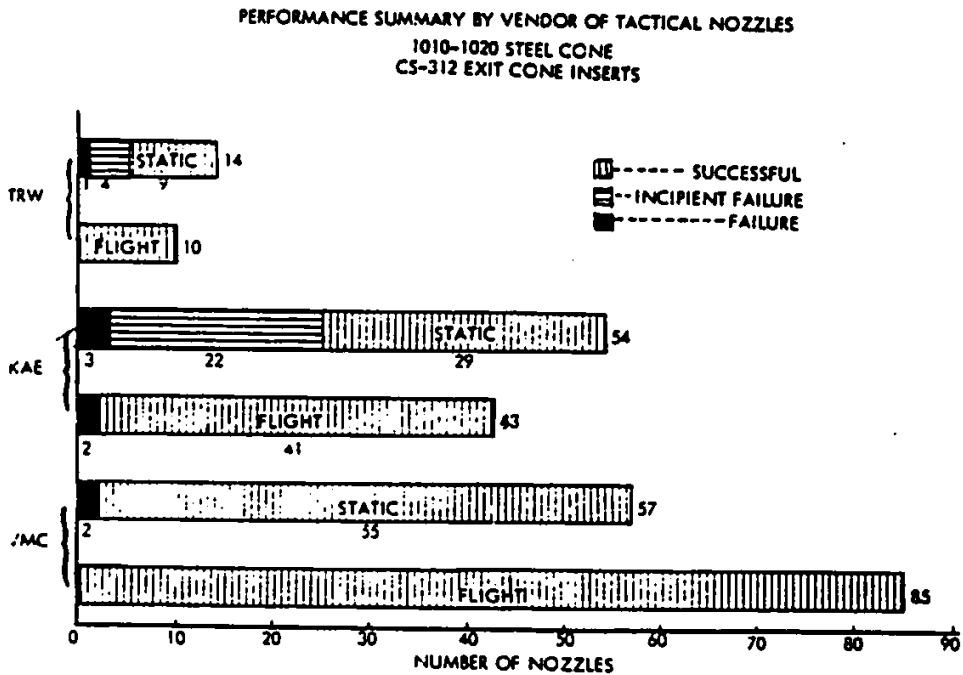


Figure 32

"It is an extruded ring," explained Mr. Stevenson, "and it is difficult to maintain density on the extrusion."

Dr. Kirchner asked if they had noticed any cracks in ATJ.

MISSILE COMMITTEE DISCUSSION

"None whatever," replied Captain Christman. "Last week four more of these were statically fired successfully; A3X-59 -- which was scheduled to go today but was postponed until Friday, because of problems on the Range -- has four of these nozzles on board as does A3X-13. Both these flights in the Pacific, if they go within the next two weeks, will give us more flight data on this particular combination.

"Because we saw this failure in the early A3X flight tests we were able to get the 4130 with ATJ into flight, but then we had some evidence that using the stronger, stiffer 4130 steel might be worse than the 1010/1020. We decided that our most likely candidate is the 1010/1020 steel with the ATJ and we simply have not had any flight tests since then to get this combination on board."

"I thought that the 4130 would give you some redundancy," said Dr. Kirchner, "since we felt the failure was a combination of incipient loading and slight deformation. The 4130 steel is much superior to our low carbon steel which is in the 1010."

"When we examined the nozzles which Kaiser was building," said Captain Christman, "using the 1010/1020 steel, it turned out that Kaiser was making a much stiffer nozzle. Apparently, they had designed the tolerances so that they were using thicker cans and actually were flexing their can much less than Valley. It appeared that if we put in the 4130 steel we would be driving the design toward duplication of the Kaiser nozzle where we were getting all of our failures.

"There appears to be adequate evidence that the 1010/1020 is fine for the purpose, and we felt from this and from other evidence, which showed that the Kaiser method seemed to be the primary cause of failure, that the 4130 was unsuitable.

"Figure 33 is a summary of ATJ nozzle performance by vendor. If we wish to catch the third buy of the A3P second stage motors, we

MISSILE COMMITTEE DISCUSSION

need to make the decision by 1 December. I plan to recommend to Admiral Smith that we introduce the ATJ on the third buy. There is essentially no impact on cost; the tooling is the same; but there might be scrapping of some graphite.

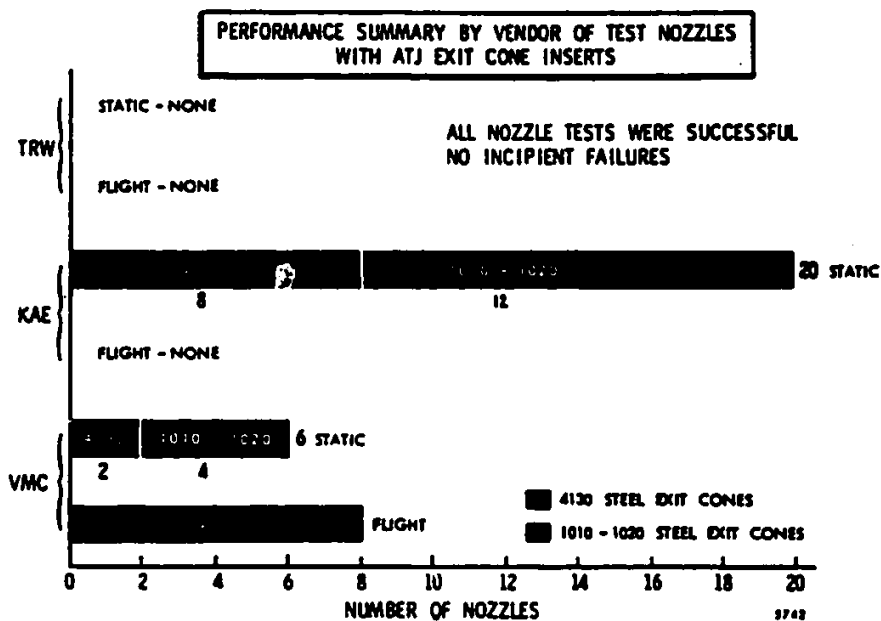


Figure 33

"In previous STG's, I have shown quite a bit of data where we are actually measuring the total strength of the retaining ring, and the Kaiser CS312 rings particularly are below the point at which we would expect them to fail on the basis of theory and test measurements of the Kaiser material."

"Graphite is a very temperamental material to begin with," said Dr. Kirchner, "and to draw any conclusion about failure or the margins of safety which you build in is a very subjective proposition. The way

to do it is to enforce a very stringent quality control on the material itself so that you are actually monitoring the particle size distribution; the ATJ from that standpoint represents a much better material."

"That is right," said Captain Christman, "but we happen to be the unfortunate partners with National Carbon who turn out tons of these graphite billets, and has no desire to set up a special facility to make CS312 for us. Apparently we are just a drop in the bucket as a user and we have had no success whatever in encouraging National Carbon to do anything; I do not think they know how. We have had no success in developing good test methods for selecting billets which are homogeneous throughout. The billets are about eight feet long and two feet in diameter. We find that if you cut off slabs of this to make rings, there is a wide variation of strength between the slabs. So this supports what you are saying. We think the ATJ is much more reproducible.

"Figure 34 simply takes as criteria the successes versus numbers of tests for the static firings, and shows that, in the number of tests we have had to date, there have been no new incipient failures at all. We have achieved a reliability superior to the existing design. Of course, if you just take flight success alone or flight success plus static success we still have not achieved that number because this number is up around 95 percent, something like that.

"We are most concerned in the Missile Branch about our production capability and retention of production capability. We are concerned about the numbers and quantities of tools we keep on hand; how to keep qualified suppliers available; how to qualify new suppliers downstream; and how to keep the technology and the information available so that as we lose suppliers we are able to educate new suppliers.

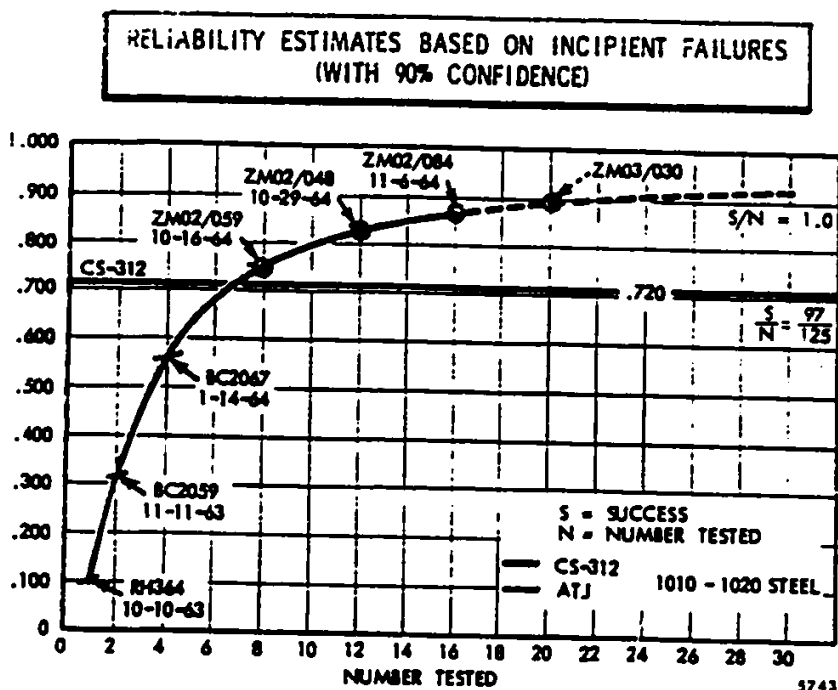


Figure 34

Figure 35 illustrates some of the parameters we have been looking at. The A1P, of course, is scheduled to phase out in late 1965, and we have been working on what we are going to do with the common components, and what we are planning to do with the excess missiles that are available. Particularly we are seeking decisions on how much of the peculiar tooling, if any, we wish to retain. Even more significant is the A2P: the last A2P missile was completed in June 1964 with a ten-year life forecast for the A2P missile. We show a SPAN requirement for 140 of these missiles at very low monthly rates through 1974, so we have the problem of retaining the various capabilities. In a couple of years we will have to face the same problem in A3P production where we go from 18 per month to 1 per month in the spring of 1967.

POLARIS MISSILE PRODUCTION CAPABILITY & RETENTION PROGRAM

BACKGROUND

A1P

1. SCHEDULED TO PHASE-OUT OF FLEET USE LATE 1965.
2. A1/A2 COMMON COMPONENTS AVAILABLE FOR FUTURE A2P PRODUCTION.
3. SOME A1P MISSILES AVAILABLE FOR BOOSTERS FOR R&D PROGRAMS.
4. RETAIN ONE EACH OR 1 SET OF A1P PECULIAR TOOLING.

A2P

1. NO PHASE-CUT OF A2P PRESENTLY SCHEDULED THRU 1974.
2. LAST A2P MISSILE COMPLETED IN JUNE 1964.
3. SPAN SHOWS REQUIREMENT OF 140 MORE A2P THRU CY 1974.
4. FUTURE PRODUCTION AT LOW MONTHLY RATES.
5. PRODUCTION CAPABILITY, TOOL RETENTION AND START-UP COSTS MUST BE CONSIDERED IN FUTURE A2P PRODUCTION.
6. AVAILABILITY OF A1P COMMON COMPONENTS REDUCES COSTS FOR EARLY PRODUCTION OF A2P.

A3P

1. NO ESSENTIAL CHANGE IN A3P REQUIREMENTS IN SPAN.
2. A3P PRODUCTION NOW SCHEDULED TO DROP FROM 18-MO. (INCLUDING BK1) IN SPRING OF 1967.

B3

1. B3P INTERGRATION AND CAD NOT FIRM.

Figure 35

"Figure 36 lists three plans with the third plan having two alternatives. If we take the straightforward A2P plan where we just manufacture to SPAN, the cost factor is 100 percent. We are concerned about the low production rate of two a month so we are looking at other plans which might call for our building ten a month downstream. We could build up our requirement for a six or eight year span so that we would concentrate on one period and pay for all of the qualification costs and flight tests which we might desire to qualify the vendors.

MISSILE COMMITTEE DISCUSSION

These costs could then be lumped together rather than spread across the two per month rate. The advantage is that of economy by a higher production rate.

SUMMARY COMPARISON CHART -- ALTERNATE PLANS

TRADE-OFFS	PLAN 1	PLAN 2	PLAN 3	PLAN 3A	PLAN 3B
1. ADD A2P TO BE PRODUCED	140	140	0	11	28
2. A2P PRODUCTION RATE	2/MO	10/MO	0	2/MO-0	2/MO-0
3. A2P UNIT COST	1077K	120-2738K 20-1326K	NA	273K	511K
4. ADD'L A3P TO BE PROCURED	0	0	140	129	112
5. A3P UNIT COST	NA	NA	842K	842K	842K
6. A2P SSB(N) POPUL. BY APR. 1969	13	13	9	9	9
7. A3P SSB(N) POPUL. BY APR. 1969	28	28	32	32	32
8. "ON SHELF" A2P RQD FOR FOT/DASO	0	28	30	19	2
9. A1P CANNIBALIZED FOR A2P	96	96	0	11	28
10. A1P AVAILABLE FOR BOOSTER	0	0	96	85	68
11. RELATIVE FLEET/MISSILE PENETRABILITY	SAME	SAME	+64 A3P -64 A2P	-64 A3P -64 A2P	+64 A3P -64 A2P
12. RELATIVE TOTAL COST -- %	100	82	74	72	71.5

Figure 36

"On the basis of the figures we used, plan 2 came out as an 82 percent cost but there is an investment here because you are pre-buying missiles. The plans 3, 3A and 3B work on a variation in item eleven. Instead of buying more A2P missiles we consider diverting A2P missiles out of existing submarines, and convert those submarines early to A3P's."

MISSILE COMMITTEE DISCUSSION

"Have you taken into account the long overhaul periods some of these ships are going to have?" asked Admiral Galantin. "Perhaps those missiles should be put back into use, and thereby decrease your additional procurement."

"We are doing this on a spares basis," replied Captain Christman. "We SPAN the number of missiles that are deployed and we only support through the various years the number of missiles that are actually at sea, and so this is entering our spares calculation."

Dr. Craven remarked that there was a problem of over-deployment, and asked if it might be wise not to deploy all the A2 boats at one time. He acknowledged that there was a need to maintain 55 percent readiness, but that they now fell below that.

"One way to resolve that is to advance the overhaul cycle of some of the boats, and another way, which may seem unattractive, is to tie up a number of boats at the pier and keep the reactors running at low speed, in a ready reserve status," Dr. Craven continued.

"This compounds the problem of getting them adequately overhauled," said Captain Gooding. "It is difficult enough on a regular basis, and if this is disrupted, the overhaul problem is even worse."

Dr. Craven stated that the overhaul at the present time was cyclic, so by taking one of these two approaches it could be smoothed out. "What is really happening," Dr. Craven said, "is that you are going through feast and famine cycles when you have a period when you are way in excess of the 55 percent on station and then you have a period in which it is almost impossible to maintain the 55 percent on station. If you look at it, you can see that you can still have boats in the ready force. If, for example, one or two of these boats went on a fast patrol, there would still be some at Holy Loch which would be ready for reserve

and would not be using up their reactors during that time period. They would still be available for any emergency or national need. Besides lying on the bottom, some of these boats could have a patrol cycle in which they were not on stations a full length of time and moved strictly at low speed to preserve the reactor time. Some of those boats could be extended over five years and it would solve the same problem."

"The approach of the Fleet is not quite so total as you are suggesting," said Captain Bayne, "but it is to operate from varying transit distances to vary the length of patrols throughout the life of the boat, so that the overhaul cycle is changed and brought into a line."

"I do not propose this as a drastic solution," said Dr. Craven. "It is highly inefficient to drag out a capability to keep producing A2's even though figure 36 says 82 percent. When you slow down the line and then speed up again there are a lot of hidden investment costs in the amount you have piled up for the 82 percent. Plan three, however, recognizes the fact that the A2 is finished or finishing."

Captain Sadler asked if producing all the required missiles in a month were worse than producing two a month on a continuous basis. It was noted that the optimum was three or four a month if 10 or 20 were to be made. If, however, 140 were needed, the optimum would be ten a month.

"We question, right now," resumed Captain Christman, "whether we are going to make our requirements to support the A3 OT and FOT next June, shown in figure 37, unless someone at the Sp 20 level decides whether we are going to have vans on the tender or store this equipment away in the tender.

"We were supposed to have a decision in October which would have enabled us to meet the June date, as shown in figures 37 and 38, and we are slipping; we have slipped past this date by 30 days, because

MISSILE COMMITTEE DISCUSSION

there is no direction to Sp 27 to change from the van concept. I assume that CNO will pass it to the Fleet Commanders, but I do not know.

TENDER REQUIREMENTS OT-FOT CHECKOUT EQUIPMENT AND TEAMS

TENDER	MONTH						
	JUN	JUL	AUG	SEP	OCT	NOV	DEC
AS-32	15 24 626		26 31 633		6 15 627 16 22 630		6 12 632
AS-31							3 9 635
AS-19		13 23 629	3 13 628			13 23 634	3 13 631

Figure 37

OT SUPPLY SCHEDULE

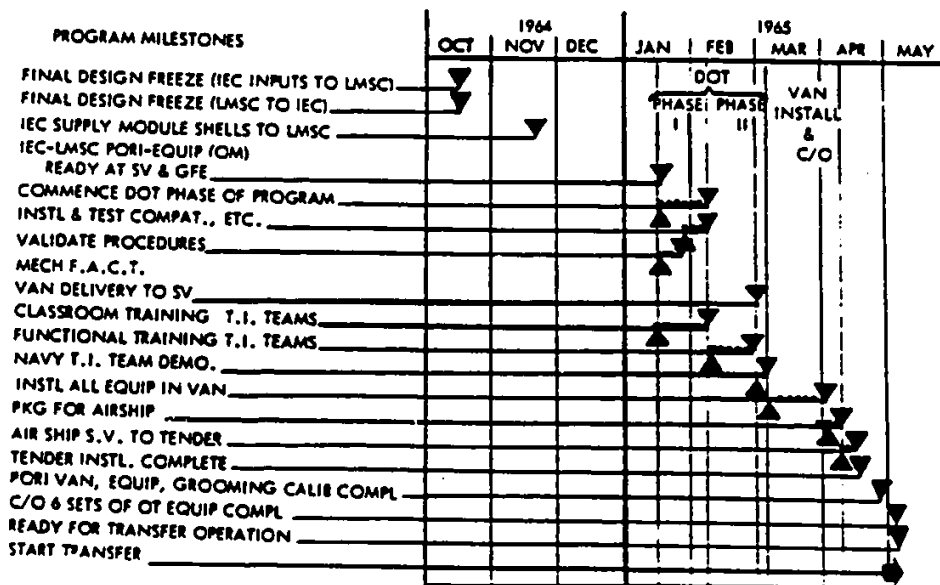


Figure 38

MISSILE COMMITTEE DISCUSSION

"Another reason we are concerned is that we are behind on the mandatory requirement to support our schedule, so we do need to raise our delivery requirement in instrumentation kits to come up to the total Cum's requirement of 51 by December 1965 where we only have 38 on order, shown in figure 39."

OT KIT IMPACT

MONTH (A)	SSB(N)	AS	CUMULATIVE NEED			CUMULATIVE AVAIL.	
			REQ'D/SSB(N)	USED (CUM)	TOTAL (CUM)	REB KITS	INST. KITS (C)
JUN	626	32	6		6	20	20
JUL	629	19	6	5	11	28	20
AUG	628	19	6	10	16	32	20
AUG	633	32	6	15	21	32	20 (B)
OCT	627	32	6	20	26	40	29
OCT	630	32	6	25	31	40	29 (B)
NOV	634	19	6	30	36	45	34 (B)
DEC	632	32	6	35	41	49	38 (B)
DEC	635	31	6	40	46	49	38 (B)
DEC	631	19	6	45	51	49 (B)	38 (B)

NOTE: (A) Kit Hardware is Delivered from LMSC 30 Days Prior to Month Shown.
 (B) Noted Hardware Impact on Present SPAN Schedule.
 (C) Does Not Include 10 Analog/Digital Kits Avail. in Aug.

Figure 39

"We are concerned about the time requirement for the first FOT," said Mr. Stevenson. "Our interest is from the standpoint of leadtime -- from the time the decision is made to when the capability will be there. We have heard that the capability is required earlier than the best time we can give; it worries us that we will not be able to keep up with the hardware in time."

"We also have some studies," continued Captain Christman, "on the probability of, one, hitting the land mass, and two, if you do hit

land mass possibly hitting someone in this area depending on the density of population. A POLARIS firing from that launch point into Midway Island is depicted in figure 40. One fired in the Atlantic into Ascension Island is shown in figure 41. The major problem is the possibility that the azimuth on the missile gets scrambled so that it does not head down in the desired trajectory but gets headed off on an odd azimuth due to some failure.

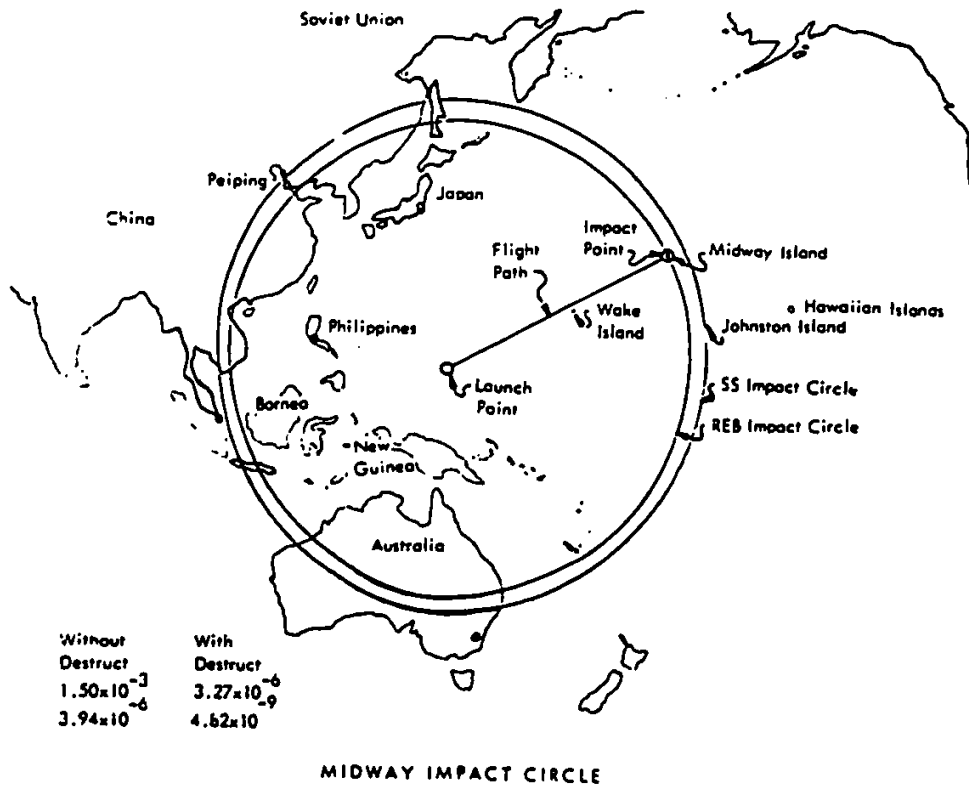


Figure 40

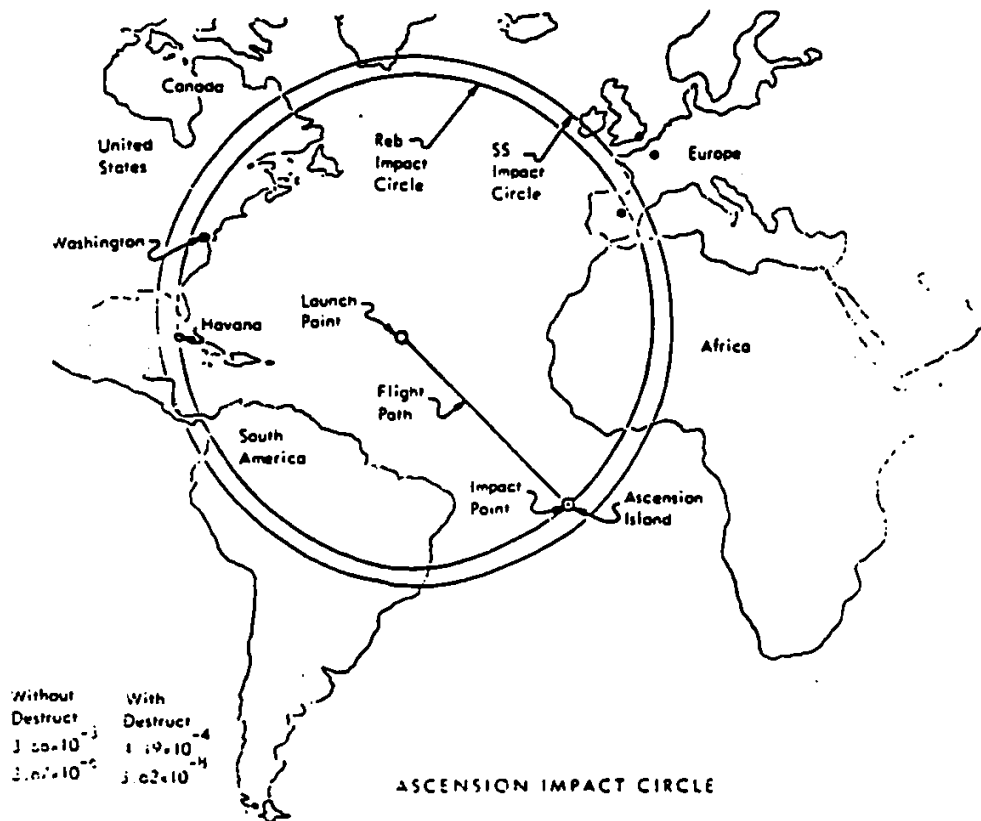


Figure 41

"We have never had a failure of this type but figure 41 shows the one case where the missile can land even in Washington, in Canada, or even hit a little bit of Ireland or Spain."

"In Op 31, we had a plan to go down south and shoot up north," remarked Admiral Galantin.

"It was initially talked about but there was a transit problem," said Captain Bayne.

"There was also another plan to move much further north," said Captain Sadler, "and shoot into a different impact point. This would provide better safety with respect to Africa and South America. Of course, it would move back into the United States and Canada if it turned around and went the other way. This plan was rejected since the Ascension Mils was available."

"Figure 42 is a summary of destruct versus no destruct kill capabilities," said Captain Christman. "We have exceeded our probability of one in a million of getting a kill using the various assumptions that we did. This study will have to be reviewed by everybody but, of course, there is a significantly higher kill probability without destruct than with it."

SUMMARY -- DESTRUCT VS NO DESTRUCT

THE PROBLEMS ASSOCIATED WITH THE DESTRUCT SYSTEMS' PRESENCE OR ABSENCE ON O.T. HAVE BEEN STUDIED. THE RESULTS OF THE STUDY SHOW THAT:

1. THE PROBABILITY OF IMPACTING ON OR KILLING INHABITANTS OF ANY LAND MASS DUE TO AN ABNORMAL FLIGHT IS

	WITHOUT DESTRUCT		WITH DESTRUCT	
	ATLANTIC	PACIFIC	ATLANTIC	PACIFIC
IMPACT	3.68×10^{-3}	1.50×10^{-3}	4.19×10^{-4}	3.27×10^{-6}
KILL	3.67×10^{-6}	3.94×10^{-6}	3.62×10^{-8}	4.82×10^{-9}

2. A DOOR MOUNTED INSTRUMENTATION PACKAGE WITHOUT DESTRUCT CAN BE DESIGNED AND SUPPLIED IN 9 MONTHS.
3. AN INDEPENDENT RAIL MOUNTED DESTRUCT SYSTEM CAN BE SUPPLIED IN 9 MONTHS.

BASED ON THESE STUDIES, LMSC RECOMMENDS THAT THE DESTRUCT SYSTEM REMAIN ON O.T. AND THAT DESTRUCT AND INSTRUMENTATION BE REPACKAGED AS INDEPENDENT SYSTEMS. THIS WOULD VIOLATE THE INTERCHANGEABILITY GROUND RULES ESTABLISHED FOR DASO AND O.T. INSTRUMENTATION SYSTEMS.

Figure 42

"We are working hard on a service life evaluation program. The major item, shown in figure 43, is that we now have given up placing life limits on items until we demonstrate that they actually have a limited life. It turns out that so far this has not gotten us into any trouble. On the A1P, we had quite the opposite; we planned to recall items at the end of two and a half to three years and were always going to put new components in. Each time we got to the decision point to bring all the missiles back, we found no data to support the thesis that we were having failures.

THE PROPOSED SERVICE LIFE EVALUATION (SLE) PROGRAM
EXCLUDES ALL RECALL PROVISIONS, BASED ON ESTIMATED
CALENDAR OR OPERATING LIFE LIMITS --

THE SLE PROGRAM WILL BE IDENTIFIED BY THREE PRINCIPAL SUB-PROGRAMS (OR MAJOR FUNCTIONAL AREAS), CONSISTING OF

1. CONTROL OF RUBBER PARTS,
2. EXPLOSIVES SURVEILLANCE & RECERTIFICATION FOR FLEET USE,
3. MAJOR MISSILE COMPONENTS (PACKAGES) SURVEILLANCE AND RECERTIFICATION FOR FLEET USE.

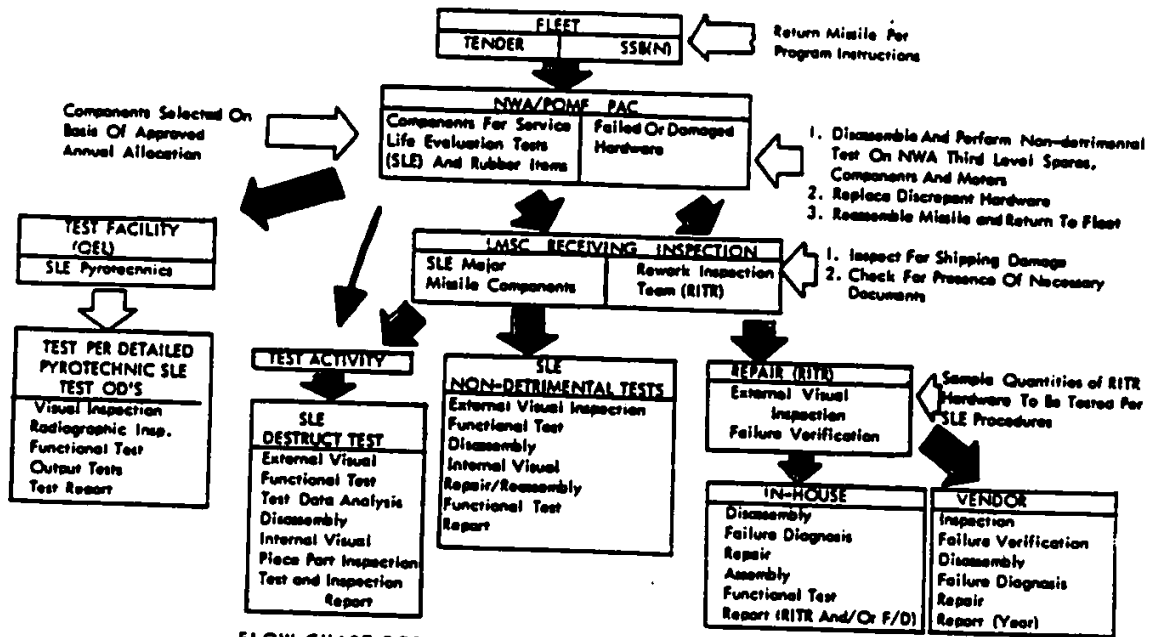
The Nature of Three Program Categories' requirements are radically different, one category from another --

CONTROLS
SURVEILLANCE
RECERTIFICATION

Figure 43

"As figure 44 illustrates, we bring the missiles back into either one of the two POLARIS ordnance missile facilities. We do some destructive testing and a number of non-detrimental tests. We run full production tests on hardware we plan to put back into service. We are trying to probe for evidence of deterioration, and also check on the repair and return cycle."

MISSILE COMMITTEE DISCUSSION



FLOW CHART FOR PROCESSING OF FLEET RETURNED HARDWARE

Figure 44

Admiral Galantin suggested a coffee break after which he took the rostrum himself.

ADMIRAL GALANTIN

When the meeting resumed, Rear Admiral Galantin spoke briefly to the STG members.

"By way of sad remembrance," began Admiral Galantin, "it is a year and two days since we had a firing for President Kennedy; some of us were there and remember that day with nostalgia. We will, I am sure, have other opportunities to demonstrate our abilities to other high level people, but I think we will all consider that shot for President Kennedy as one of the highlights of our program.

"On my recent trip to the West Coast, I had occasion to visit with Admirals Fluckey and Lowrance, COMSUBPAC and COMSUBLANT. I was greatly impressed with the spirit of cooperation existing between both their staffs and my staff and I am sure we will get quick inputs from both those sources. As the previous speaker noted, both SP's problems and the Fleet problems are converging more and more -- there is a real need for exchanged views and common understandings. For our part, we are going to have to provide those quick inputs with some rapid responses about their problems.

"I have spoken in the past about my confidence in the future of the B3 program -- I feel almost certain that the B3 program will soon become an approved system development. I cannot give you total assurance, because, for that, I must wait for the signed documents. Recent events have only strengthened my belief that we will soon be authorized to go ahead. As soon as we get the word officially, it will be passed to you.

"Concerning the 1965 funding problem -- while we have the funds in hand, we now know that the PDP for the motor development must be competitive. I doubt if this is a great surprise to our motor people, but it does make the position more firm now. It will also mean much more work here, and for our prime contractor, but the decision was thoroughly reviewed and all the pros and cons were weighed. My own arguments were heard carefully, but the contrary arguments were considered more compelling, so the motor development PDP will have to be undertaken on a competitive basis. I believe you all know who some of your competition will be. We have to issue as quickly as we can the guidelines as to whether we want them to bid on both stages or just on one stage, and similar specifics.

"We are working on these ground rules and as soon as possible we will get them out. We are taking every opportunity possible to brief the right people in the Pentagon on what the B3 offers. We have already given one presentation, and have another one coming up this Friday to a higher level group. It is important that we give these presentations because after the Sea Bed Study there was some confusion as to what these different missiles were capable of doing, what functions they were capable of performing, and what the B3 could do as opposed to the small ballistic missile. These are the kind of worries we are allaying, pointing out that these two missiles are not in conflict, that they address themselves to different time frames and to somewhat different functions.

"The Program Change Proposal to get authority for the B3 development has left the Secretary of the Navy, and is now in the hands of the office down in OSD. Although it lists six possible approaches to the problem -- six possible time scales and levels of funding -- the recommendation that went forward was the one that we favored right here -- a rather substantial first year's effort in 1966 in the motor area, with subsequent effort planned to give us an interim operational

REMARKS OF ADMIRAL GALANTIN

capability in 1971. But the levels of funding in 1972 and the following years will be determined by the PDP and by the progress made in the first year's development. I do not think we will be told that in a certain month in 1971 we must have this system at sea. Instead, we will be told that we will get funds to start its development at a certain level, and that the full system development will be reviewed in the following year's budget.

"Since our last meeting we have had two A2 operational tests. The SSB(N)617, the USS ALEXANDER HAMILTON, fired four missiles with complete success. The SSB(N)616, the USS LAFAYETTE, matched this performance and thus there were eight fully successful OT shots, all A2's.

"I was not pleased, however, with the time consumed in accomplishing these OT shots. Of course, if the submarines shoot within a two hour total time the firing is still considered successful; but they attempted to shoot one every 30 seconds and in neither case was that goal met. I do not think the Fleet knows all the reasons yet. They are probably waiting until the ship gets in to make a full report. Apparently it was the usual problem of the battery running down after being activated too soon either knowingly or unknowingly.

"This points up to me the fact that in every one of these tests, whether it is a DASO or OT, we are learning that we just cannot let our guard down at all. We have to make a very thorough analysis of each one to make sure we really know what went on, and not just relax and say it flew all right; that is only part of the story.

"Another factor that deserves serious consideration here deals with training. The present crews in these SSB(N)'s grew up with the system and certainly with the submarine. When we have problems like this with experienced crews, we can look ahead with real concern

to the days when these ships will see a steady stream of new officers and enlisted men coming aboard. Occurrences like those firings emphasize dramatically for me our need for the finest training establishments we can devise and the most realistic training that can be given.

"The box score on the A2's shows 27 successes out of 32 shots or 84.4 percent success. Now we come to the A3. Since our last meeting, the SSB(N)627, the USS JAMES MADISON, fired one and it was a success. The USS CASIMIR PULASKI fired two, and they were both successful. There have been 16 A3 DASO's and 15 of those were successful, which gives a very fine flight record -- 93.8 percent successful. As you have heard, the shots scheduled for today in the Pacific were postponed at least two days due to ground radar problems. After these there will be an additional shot in a few weeks.

"The USS PROTEUS is now enroute to Guam to await arrival of the USS DANIEL BOONE and USS TECUMSEH. The USS DANIEL BOONE will be loaded from the USS PROTEUS and will go out on patrol; the USS TECUMSEH outloaded on this coast and is enroute to Pearl Harbor. So by next month we will be on station in the Pacific.

"I have recently received an up-to-date evaluation of the UK program from Captain Murphy who is in town now, as well as information that Admiral McKenzie himself has given me. As time goes by it seems more and more apparent that there will be a UK program in some form. This does not mean that they will necessarily adhere to the existing program, which calls for five submarines. They may reduce that number; but what is encouraging is that we have been instructed to go ahead on our current schedule of procurement and training. Another significant straw in the wind is that they, themselves, have gone ahead with construction of some brick and mortar items which are peculiar to POLARIS and would not be useful for any other military purpose.

REMARKS OF ADMIRAL GALANTIN

"But, of course, the Labor Government is re-evaluating the role NATO nuclear weapons program, in order to determine their proper role in it. If they are going to have a POLARIS program, certainly this will have a bearing on their acceptance or modification of the MLF Program. They are studying now very thoroughly questions concerning the best role for their own POLARIS force -- should the command structure be buried somehow; and what should be the relationship of their POLARIS submarines to a possible MLF force.

"MLF is still alive despite the fact that more time was granted to the British to present some of their variations on that theme. I have much confidence that the British POLARIS program will continue but feel somewhat less assured about the Labour Government stand on making some part in the MLF Program.

"The other item that excited a lot of interest during my trip to the West Coast was our deep submergence program. I was delighted to see the enthusiasm for this program, not only in people whose companies are represented here -- Westinghouse, North American, Lockheed, Aerojet, etc. -- but also in representatives of companies that are entirely outside our POLARIS family. Here again you see the present trend toward competition in the phases we request proposals on.

"We are going to unveil the presently approved program next Tuesday in Washington. I know all of you have invitations and it should be a very stimulating day. Dr. Craven and his people have put in a lot of hard work and have organized the presentations very nicely. I hope your companies will be well represented and you can get an idea of what the Navy is authorizing.

"To me it seemed important that before we brief industry we talk to the Federal family. A week ago we invited the Interagency Committee on Oceanography and its Chairman, Secretary Morse, to

hear a condensed version of the deep submergence program and they received it very well. I pointed out to them that we might not necessarily be able to solve their particular problems. As I told them, we have to address ourselves to the military need which is, first of all, rescue and salvage; but at long last there is a focal point for this effort in the Navy. The Navy will have to take the lead on this on a national basis, but I wanted to keep them posted on the progress we are making. I want to be aware of their particular interests, but as I further pointed out, they will still have to fund, budget and procure for their very specialized needs. For instance, the Bureau of Fisheries or the Coast and Geodetic Survey might have some such need that I am sure that our program will help simply by gaining a solid grip on the military requirements. If we keep them informed on these requirements, it can only help them in developing their own.

"Since the last meeting Captain Bond has reported to me and is now assigned under Dr. Craven. Captain Bond, in my book at least, has contributed at least as much to undersea technology as Dr. Cousteau; hopefully we will be able to help him do even more. Commander Hazelton who used to be in ONR has reported in for duty with SPO. He is the developer of the Hazelton counter-rotating, 6 degrees of freedom, submarine propulsion system and he, too, now works under Dr. Craven.

"There was another program I wanted to discuss -- the integrated SSB(N) Defense Program. A Proposed Technical Approach has been submitted, and actually a PCP has been prepared for funding this program. Nevertheless, these are still in suspended animation in OPNAV. I have asked, that before they turn this idea down flatly and refuse to authorize its development, they ask the Type Commanders how important they consider this program. It is almost certain that this program will not get approved for funding in 1965 or even in 1966. Approval is going to depend on the level of support the Fleet gives the

REMARKS OF ADMIRAL GALANTIN

program. I do not feel we should try to push this idea home if the Fleet does not see a real need for it on this time scale.

"In Project 435, there are three TRANSIT satellites in orbit. One has been dead for some time, one is working reliably, and one is operating spasmodically. There will be another shot next month, which, hopefully, will give us two reliable satellites. The Navigation Committee Report will go into this in more detail."

"Has this one become spasmodic since the last STG meeting," Mr. Eyestone asked.

"That happened about three weeks ago," stated Captain Gooding. "Of course, we are not sure what the problem is, though most probably it is radiation damage to the components compounded by a period of high sunlight, which the satellite is just now coming out of. The internal temperature, which normally runs around 85 degrees, went up to a 105 degree fever pitch. For a while, the satellite would not accept an injection at all; then it would hold one for 36 hours and hiccup on the next pass. It still is not accepting injections reliably enough so that we feel the Fleet can navigate with it again. It will enter another period of continuous sunlight next March."

"In the area of administrative management," continued Rear Admiral Galantin, "I think all of you should be aware of the plant cognizance study that has been made. Assignments are to be made by OSD and, naturally, I was very concerned about which Service would have cognizance of the plants I am particularly interested in. It seems we will be permitted to retain our existing working relationships at Sunnyvale, as will the Air force, because of our unique dependence on Lockheed and the level of Navy effort there. This will probably be approved for an interim period of a year and then be reviewed. The two other plants that I am keenly interested in, Aerojet at Sacramento and Hercules at Bachhus, will come under Air

Force cognizance. From the criteria that were set forth for allocating this cognizance, I could not make an overriding case for continued Navy cognizance of these plants. Nevertheless, in any of these plants, not only the ones that I have named but others that do POLARIS work, we have agreements that we will control the quality assurance factors important to POLARIS. We will still maintain a direct pipeline from ourselves to our Navy plant representative. We cannot afford to have another echelon in between us and the people who work with you in assuring a good product.

"Do you have any questions or points that I have not covered?"

Mr. Eyestone asked if the mission of the B3 missile, particularly as the warhead with penetrations aids is concerned, would be more precisely defined by the PDP. Admiral Galantin replied that the PDP would not be of help in defining the mission, but certainly would set forth the various uses to be made of the extra payload. "You earlier saw a figure," continued Admiral Galantin, "about the B3 Flexi-Flyer with the alternate front ends. One of the major attractions of this proposal is the ability to take multiple targets under fire without having to depend on the missile complement on the tender or the missile loading of the submarine.

"The PDP will spell out just what is involved in cost and what CEP we can assure. When the PDP comes in, we will review it with DDR&E, who will make the choice as to the particular combination of capabilities we want in range, alternate warheads, and CEP."

Admiral Galantin turned the meeting over to Captain Gooding, who suggested that there might be further questions for Captain Christman. In response to a question by Dr. Kirchner, Captain Christman stated that beryllium would not be a prime requisite on the B3 second stage.



REMARKS OF ADMIRAL GALANTIN

"How do you feel about Class 9 versus Class 2 on the first and second stage?" Dr. Kirchner asked.

"We are very much opposed to Class 9 on the first stage," Captain Christman replied. "But, on the second stage, we already have Class 9."

At the conclusion of this discussion, Captain Gooding asked for the Missile Committee Report.

**RE-ENTRY BODY COMMITTEE
REPORT DISCUSSION**

"John Craven is not here," Commander Julian began, "but I would like to mention one item that follows his presentation this morning. This has to do with smoothing out the hills and valleys in production and replenishment.

"The Mark 47, the warhead used in the A1/A2 missiles, presented quite a challenging series of AEC refits. During the years in which this system has been in existence a large number of the warheads have been en route to or from the AEC refit plants. There were several times when, if the degree of return had been just a little bit greater, we would have found ourselves with missiles in submarines without re-entry vehicles.

"In the Mark 58 program, we did adapt all of the design features that were needed to fix the Mark 47. We hope that there will be no warhead failures, but there could be.

"It is important to remember that the A3 is quite a different system from the A1/A2. It carries three warheads, three re-entry vehicles. A very dramatic need for recalling of warheads will not mean the same thing for the A3 force as it might have for the A1/A2 force, because it is always possible to fly a one- or two-warhead A3 missile as a good strategic weapon.

"Recently, DDR&E has approved lofting capability development for the A3 missile and a compatibility test program for the Mark 12 re-entry vehicle. The lofting capability will give the A3 system and subsystems, with the exception of the re-entry system, a capability



for going to about 62 degree trajectories as opposed to the minimum 32.5 or so that exists today. The advantage here is that the subsystem modifications that will be accomplished incidentally, for example, in the Mark 84, will be those needed to provide a full range of flexible operating options to the B3. This is in addition to providing the capability for multiple missiles in a target mode with the A3/Mark 2 system. A single submarine will be able to fire up to eight missiles to arrive simultaneously, or nearly simultaneously, on target by varying the trajectory shape, and thus the time of flight. Figure 1 describes this lofting capability.

LOFTING SUMMARY

ADVANTAGES

- REDUCED ENGAGEMENT TIME
- CAPABILITY FOR MULTIPLE MISSILES ON TARGET (DEFENSE SYSTEM SATURATION)
- HIGHER RE-ENTRY BODY VELOCITIES
- HIGH RE-ENTRY ANGLES

LIMITATIONS

- MAXIMUM RANGE OF MISSILE SLIGHTLY REDUCED

SYSTEM CAPABILITY DESIRED

- LOFT ANGLE OF 42°
- MAXIMUM NUMBER OF MISSILES ON TARGET IN A 3 MINUTE LAUNCH SPAN FOR 1800 MILE RANGE
- CONTINUOUSLY VARIABLE AND SELECTABLE LOFT ANGLE

SYSTEM MODIFICATION

- MINOR CHANGES IN FIRE CONTROL, GUIDANCE, FLIGHT CONTROLS FUZING, AND PENETRATION AIDS TIMING NECESSARY

Figure 1

"A further advantage is reduced engagement time for a single missile. This does not affect the Mark 2 re-entry vehicle significantly. The down time with the maximum lofted trajectory from



170,000 feet to fuzing altitude, 10,000 feet, for the Mark 2 body is less by only 15 seconds or so. It takes approximately 45 or 50 seconds as opposed to the present 60 to 65.

"An example of dramatic improvement appears when we are using Mark 12's on B3's. Because the Mark 12 is a much faster vehicle, the higher re-entry angles lead to significantly less exposure time to any possible defense system.

"There are limitations. One is that the maximum range of the A3 at full loft capability is slightly reduced. But putting this capability in retains all of the options now available in the system. You can still fire for maximum range at the minimum energy trajectory. I will want to bring this up again when I discuss the necessary AFD modifications.

"Ground rules were set up to require configuration of the system, which is being developed specifically for the A3 with Mark 2 guidance, so that within a three minute launch interval one can fire a maximum number of missiles on target at 1800 nautical miles. This dictated a 42.8 degree angle with a continuously variable and selectable loft angle, generated in the digital geo-ballistic computer and fed in as a difference in skew angle for each shot. In addition to those shown in figure 1, there is a minor change in three of the small eject rocket motors as well as a timing change in the velocity sensor.

"Figure 2 shows the capability of getting a certain number of missiles on target simultaneously as a function of range."

"Is this variation on the loft angle being introduced by rocket motors that will be attached to the guidance system?" Dr. Kirchner asked.



MAXIMUM NUMBER OF MISSILES ON TARGET-
NEAR SIMULTANEOUS ARRIVAL

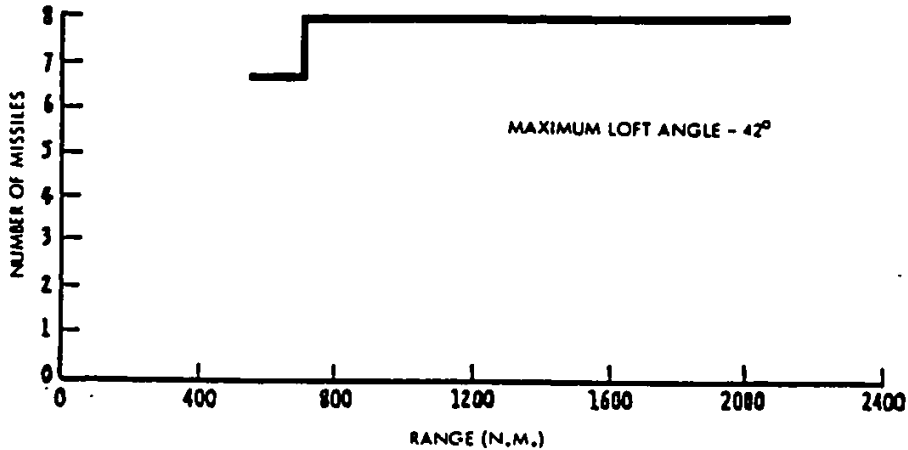


Figure 2

"The axis for calculation for the guidance system is different from the actual platform axis itself," noted Commander Julian. "This difference is minus 8.7 degrees, a fixed value in the present system. If the re-entry bodies were ejected without that skew offset, the re-entry angle, the angle at the second separation, would be 42 degrees instead of 32.8, which would not be a minimum energy trajectory. The system is capable of varying the skew between plus and minus 9.3 degrees. The skew for a given trajectory will be continuously computed during the countdown time in the three minute interval. Within this interval you can move from a plus to minus 8.7 degree skew. The first one will have the minimum skew. The last one will be at minimum energy. In other words, I have elevated the trajectory of the first shot so that it will travel over a longer path. Each successive missile travels over a shorter path. You are updating the solution continuously so you have the correct solution for firing at



-- any time within the interval and reaching the target at the same time as the preceding re-entry system. After three minutes, the first one is at a position so that you can no longer catch up with it."

How do you change the attitude of the re-entry vehicles?" Dr. Kirchner asked.

"They are separated from the missile at a different angle," Commander Julian pointed out. "The first stage drops off and then there is a constant attitude flight during the second stage. The re-entry bodies separate at some point in the powered flight sequence appropriate to the range you are looking for.

"As far as we can see, there is just one interface that may affect the British and that is the AFD with their fire set interface. They are planning to buy our AFD without change, and to design their fire set so that they will be able to interface both mechanically and electrically with it. In their system they have used two contacts in our AFD which we vacated about a year ago when we gave up the mechanical safing system. We left the contacts in and the British Ordnance Board decided that their system would be mechanically safe. They are using these two contacts to trap functional voltages into their mechanical safing system.

"In the lofted trajectory the body is going to come in faster. In the AFD we perform all of the arming functions in one timer. Figure 3 shows the minimum energy trajectory, which we use as a base point. The baro switch, which closes at about 10,500 feet, is sensitive to density and velocity, but it is not very sensitive to the trajectory.

"The baro-close point is the first point on the second timer sequence. The first timer sequence, shown above this point, boosts the warhead, starts the chopper, starts the converter and enables the

baro switch. These functions are performed well before 10,500 feet so that this non-trajectory-sensitive baro switch can close as a function of air density. Its closing point is a definite point in space, a milestone, from which the sequence B timer can time down to the actual detonation altitude, the fuzing height. In the lofted trajectory, because the body is going faster, these arming functions will occur lower in the trajectory. If the timer were not changed, they could possibly occur so low that they would not be completed before the baro switch closed at 10,500 feet, as indicated in figure 3.

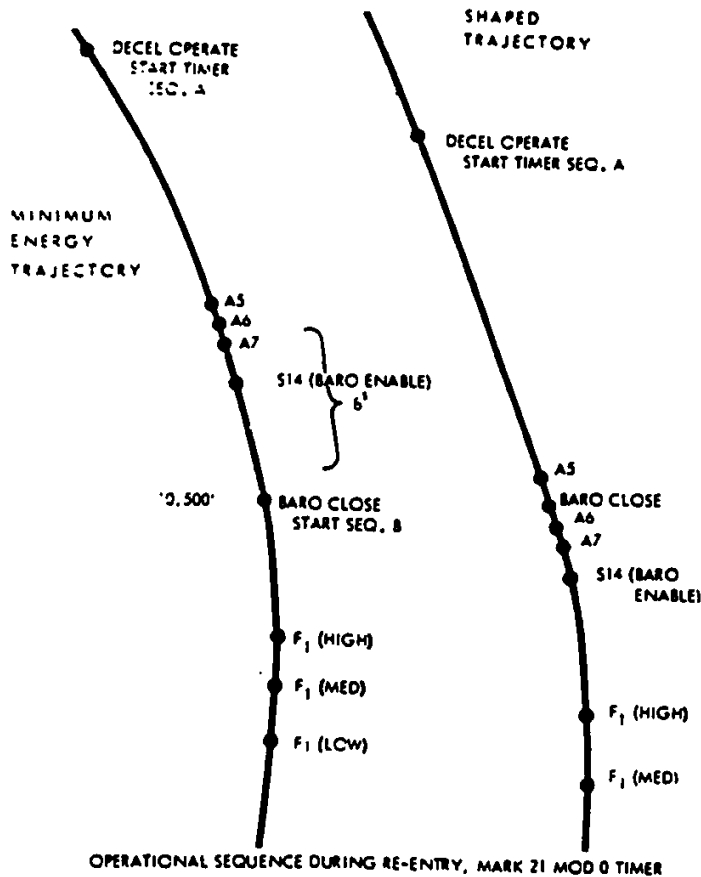


Figure 3

"The system will operate electrically whether the baro switch is enabled first or the baro switch closes and then is enabled; if the baro switch closes first, however, we have lost our reference for fuzing height. It is still possible to estimate the difference in time, but then fuze height would be very sensitive to the precise trajectory. This would be undesirable.

"By changing the timer disc that applies voltages to the contact at the points in sequence A, by advancing sequence A by 8 seconds, we solve the problem very simply. In the lofted trajectory, instead of the baro switch closing before it is enabled and the time reference being lost, we would have essentially what we had in the normal trajectory, as shown in figure 4. All it means for the normal trajectory is an additional 8 seconds or so between baro-enable and baro-close. The time reference is still valid.

"This, however, creates a problem for the British. Moving these time points up intrudes electrically into the time period when they want the contact signals. If, when we modify the timing disc, we cut two new timing slots in the disc to accommodate the UK in the interval between the Decel start and the first functional signal we need, as shown in figure 5, we can maintain both mechanical and electrical compatibility of the AFD between our fire set and their fire set. Such a modification would not affect our system. These contacts are open; voltages will be fed to them but there will be no current flow."

"Would you explain the difference in fuzing heights in figures 3 through 5?" asked Dr. Kirchner.

"All of the arming functions, A1 through A8, are activated by one timer," Commander Julian replied. "The last function stops timing action. Baro-closure is an independent action. It starts timer B,

which fires the warhead. The loft trajectory shown in figure 3 would require a trajectory-sensitive baro switch; we cannot place the height exactly. The additional points in figures 4 and 5 are based on the eight and a half second advance. The time between baro-closure and firing will be the same in both the loft and the minimum energy trajectory, but the altitudes are not quite identical, because the body is going faster. The base pressure ratio, which causes baro-closure, slips a little bit lower so that there is about a minus 300 foot difference in fuze height, but this is not significant."

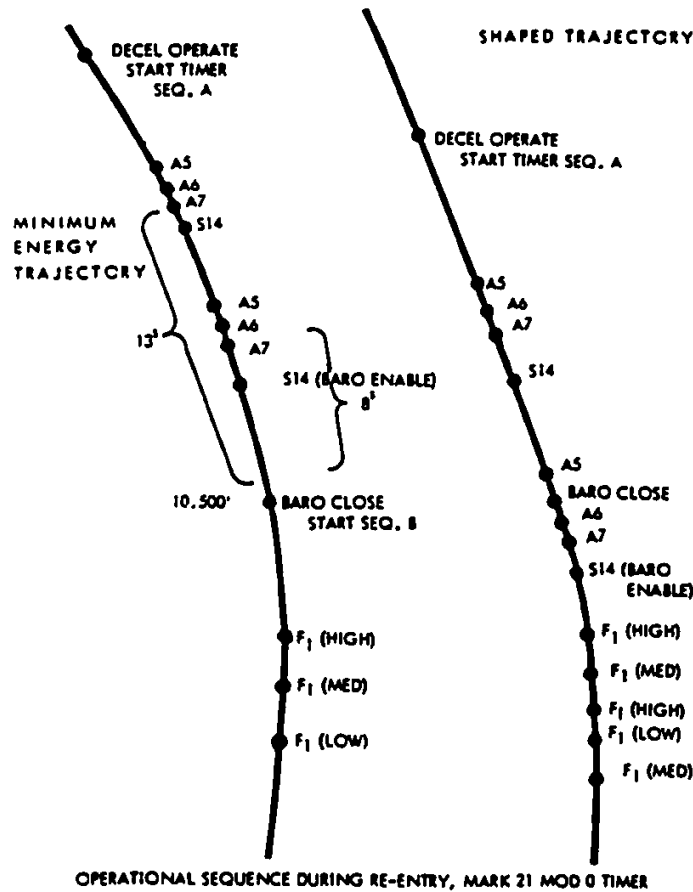


Figure 4

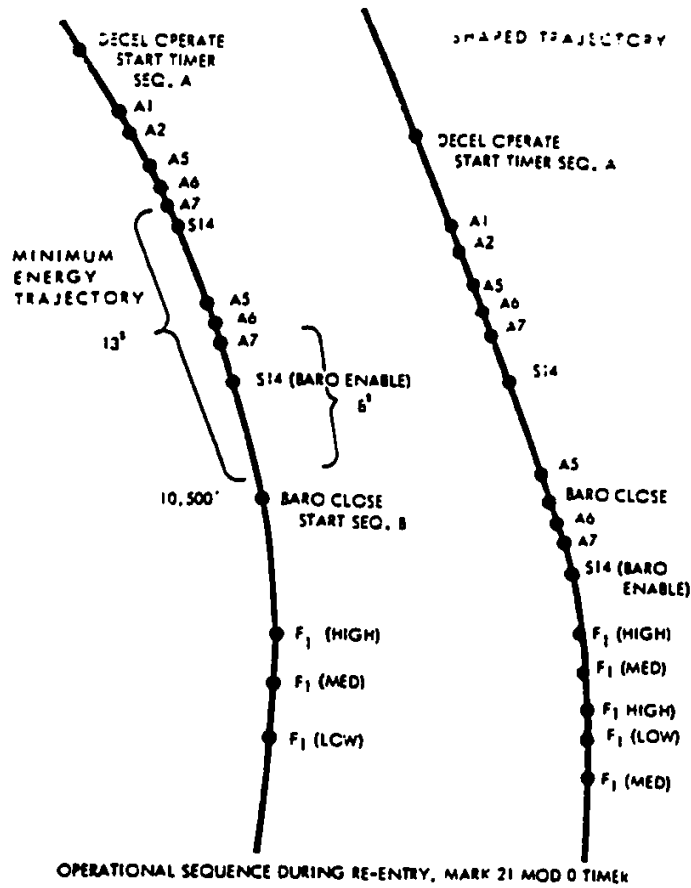


Figure 5

"This conflict does not arise with our present fuze," Captain Sadler observed. "We could supply the British requirements as part of our current production."

"This is true," Commander Julian agreed. "The modification will take approximately two years to develop. We are not at all sure



yet if we are going to get production incorporation approval; and, if we do, in the time it would take to put the change into production, the British could pre-buy their whole AFD lot. But if a problem arises we would have no trouble technically, or otherwise, in putting two more slots in the timer disc.

"Figure 6 shows the present sequence, starting at sixteen and one half seconds. We propose moving it back eight and one half seconds.

TIMER MARK 21

TIME (SEC.)	MOD 0	MOD 1	
0	•	•	START SEQ. A
4			
8		• A1 • A2,3	
12		• A4,5	
16	• A1 • A2,3	• A6 • A7	
20	• A4,5	• S14	
24	• A6 • A7		
28	• S14		

Figure 6



"The demonstration program for the Mark 12 with A1 is an attempt to prove the compatibility of the Mark 12 arming and fuzing device. In past meetings, I have mentioned that Mark 12 AFD did not function well at Mach numbers below Mach 1.8, which would be equal to a non-lofted, 900-mile trajectory. The fuzing height depends on an integrating accelerometer which is itself extremely sensitive to any difference between the predicted trajectory and the one actually flown; by our calculations, at speeds below Mach 1.8, the accelerometer will develop a zero-angle-of-attack instability. (The accelerometer derives this feature from the fact that it is extremely sensitive to the relationship of axis orientation with the drag orientation.)

"This zero-angle-of-attack instability will occasion an anomalous inertial response of the AFD integrating accelerometer and could thereby occasion large and unpredictable fuzing errors. Thus a small difference in the total accumulation of G-second product could cause the REB to impact before the fuze has functioned. It is quite important to prove that the system will work in our low speed trajectories; figure 7 shows the span of the demonstration program. It is about 22 months long. Instead of starting in July 1964, as indicated, it will probably start in March of next year. The program will consist of six A1 vehicles with Mark 12 bodies. These Mark 12's will be flight-tested bodies, built by General Electric for the Air Force, and furnished for this program by the Air Force as GFE.

"As a result of our recent conversations with General McCoy, he did submit a PCP for the \$5.2 million involved. This program works into the total flight test program somewhere between the Air Force flights at AMR and their movement to PMR.

"Recently it has been decided that the PX-2 tactical production procurement plan will be based on procurement of a total of 134 PX-2 sets. This is calculated on the basis of four and one quarter sets per boat for 20 A3 boats plus OT, FOT, and DASO requirements up through missile buy year 1966.

	1966	1965	1964	1963
MARK 12 R/V DEMONSTRATION PROGRAM	J J F A A J J A J A S O N	J J F A M A M J J A S I O N D	J J F A M A M J J A S I O N D	J J F A M A M J J A S I O N D
DESIGN STUDIES AND PRELIM. DES (WEDLOCK)				
DESIGN AND DEVELOPMENT				
DESIGN REVIEW				
DEF CONTRACT GO-AHEAD (ADEPT)				
GROUND TESTS				
FAMSCO				
DESIGN RELEASE				
PRODUCTION				
R/B MODIFICATION				
VEHICLE C/O AT SV				
AMR FLIGHT PREPARATION				
MISSILE BODY COMPATIBILITY TEST, MAKE AND E/O				
FLIGHT TESTS - FLAT PAD				
SSE - C/O EQUIP. & CHE. & MODIFICATION				
C/O BAY & PAD INSTL. COMPLETE				
TESTING OF Ground Equip. (ADEPT)				
Required at AMR for Processing 1st Veh.				

MARK-12 RE-ENTRY VEHICLE FLIGHT TEST PROGRAM PLAN
(AIP MISSILE BOOSTERS)

Figure 7

"Figure 8 shows a June OAD; we would like to lead that date somewhat in production. The cumulative total in operational service is less than the total production Cum's. This is because the chart does not show any refit, and the reason for this is that we do not really know how to refit the A3 with PX-2 in a tender availability period with the present crew. With all the other work going on, it would be very difficult. Our module concept calls for pre-assembly of an AB tray or an AC tray with the components that go on it. We make all possible electrical connections, and the result is a package out of which is hanging two cables that go to the velocity sensor. We could not store many of these on the tender. They do not have room, and certainly do not have time to refit very many missiles with PX-2 during a three-week availability.

"In addition, we have drafted a technical plan to see how long it would take to increase the production rate and completely outfit all of our boats with either PX-1 or PX-2; it would take approximately two years to reach full production.

"Figure 9 is a reminder that thorium, which is part of the radiation case material in the W58, has a daughter with a very energetic gamma ray. This is the basis for the measurements, shown in figure 10, that we made on the W58 warhead and the Mark 2 re-entry vehicle at Charleston. On the missile with an array of three warheads, the rates were high; the 16 milli-roentgens per hour shown for the surface of single re-entry body, is itself a high rate. The maximum industrial tolerance dose is 5000 or 5 REM per year times $N-18$, where N is age. We have since decided to make survey measurements on the tender. While the USS PROTEUS was at Charleston, we put nine W58's aboard on a rack and made corresponding measurements.

PX-2 KIT TACTICAL PRODUCTION
 PROPOSAL - 134 KITS
 (Based on Span Rev. 6 Dated 9-25-64)

REQUIREMENTS (OUT OF SV)	CY 1966												CY 1967											
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
1. SSBN Shipfill Rqmt. Date					645	654	600	659		656	657						659							
2. SSBN OP Suppt.					644		602										659							
3. SSBN DASO					645	654	602	656	659															
4. Shipfill Quantity					4	8	4	8	4	4	4	4					4							
5. OP Suppt.					1	1	1	1	1	1	1	1					1							
6. DASO					2		4	2	2															
7. FOT																								
8. Total/Mo					7	9	8	11	5	3	5	1					6					2	1	
9. Total/Cum					7	16	24	35	35	40	43	48					51	57	58	59	60	61	62	
PRODUCTION																								
1. Out of SV/Mo					2	4	7	8	9	8	8	8					8	9	8	9	9	9	9	
2. Out of SV/Cum					2	6	13	21	30	38	47	55					64	72	80	88	96	105	113	
USAGE																								
1. Initial Deploy Date																								
2. PX-2 Initial Shipfill/Mo																								
3. PX-2 Kits in SSBNs/Cum																								

Figure 5

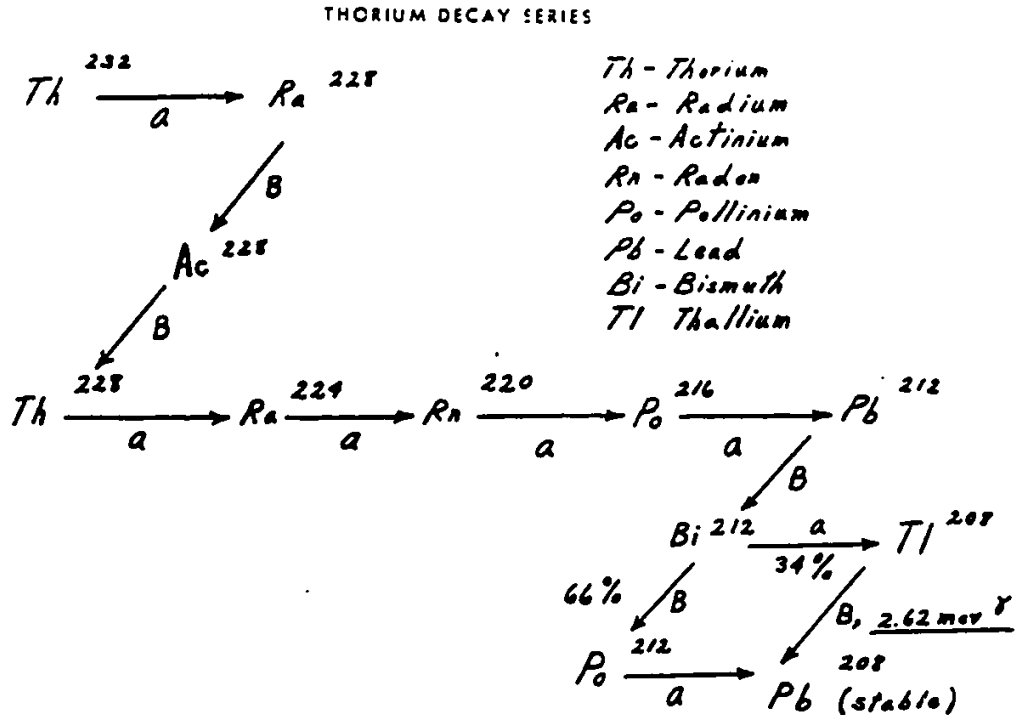


Figure 9

"Figure 11 shows a missile with a re-entry system installed, a bare body, and an array on the tender bulkhead. One MR per hour is less than the dose rate necessary to call an area a radiation area. Even in berth spaces you can have this level without any special cautions being posted; but, if a one MR per hour exists at a three-foot distance, the rate will rise very rapidly closer to the body. Of particular concern are places in the tender where the bulkhead storage sticks out into the working space. People are prone to write letters leaning on the warheads and stow hats, lines of ropes, and that sort of thing in the area. The results of the measurements are shown in the lower part of figure 10. The USS PROTEUS is different from AS-31 or AS-32 as a class, particularly in the way that the ship's spaces surround the magazines in the REB shop.

INTRINSIC RADIATION - W58 WARHEAD (CRD)

MEASUREMENTS PROGRAM -- DOSE RATE INCLUDES BOTH GAMMA NEUTRON EFFECTS

- A. SINGLE REB--NO CONTAINER AT WAIST-- SURFACE 16 mr/hr
AT 1 METER 0.82 mr/hr
AT NOSE -- AT 1 METER 0.24 mr/hr
- B. SINGLE REB--IN PALLET (H3427) AT SURFACE -- 7 mr/hr
AT 1 METER -- 0.77 mr/hr
- C. SINGLE REB--IN CONTAINER (H3387) AT SURFACE -- 2.3 mr/hr
AT 1 METER -- 0.83 mr/hr
- D. TACTICAL RE-ENTRY SYSTEM IN GEOMETRIC CENTER OF 3 REB'S -- 31 mr/hr
AT WAIST -- 1 METER 2.5 mr/hr
AT NOSE -- 1 METER 0.6 mr/hr

MAX. DOSE -- 3000 mr/CALENDAR QUARTER PROVIDED NO MORE THAN 5000(N-18) mr/yr ACCUMULATED DOSAGE

TENDER MEASUREMENTS -- USS PROTEUS (AS-19)

- A. MISSILE MAGAZINE--EYE LEVEL AT MISSILE LINER -- 4 mr/hr (TYPICAL)
IN WALKWAY -- 3 mr/hr (TYPICAL)
- B. REB SHOP -- WITH 9 REB'S STOWED ON BULKHEAD
AT NOSE -- AT 1 METER 2 mr/hr
AT WAIST -- AT 1 METER 4 mr/hr
AT 2 METERS 1 mr/hr

RECOMMENDATIONS

- A. DOSIMETRY PROCEDURES BE EMPLOYED WITHIN REB SHOP AND MISSILE MAGAZINE AREAS TO MONITOR CUMULATIVE DOSAGE RECEIVED.
- B. WHEREVER DOSAGE LEVELS EXCEED 5 mr/hr OR 100 mr/5 DAY PERIOD POST "WARNING-RADIATION AREA -- NO BUNKING OR LOITERING" SIGNS.

CONCLUSIONS

NO HAZAROUS RADIATION DOSAGE SITUATIONS EXIST AS A RESULT OF THE INTRODUCTION OF THE A3/W58, PROVIDING APPROPRIATE MONITORING PROCEDURES ARE FOLLOWED.

Figure 10

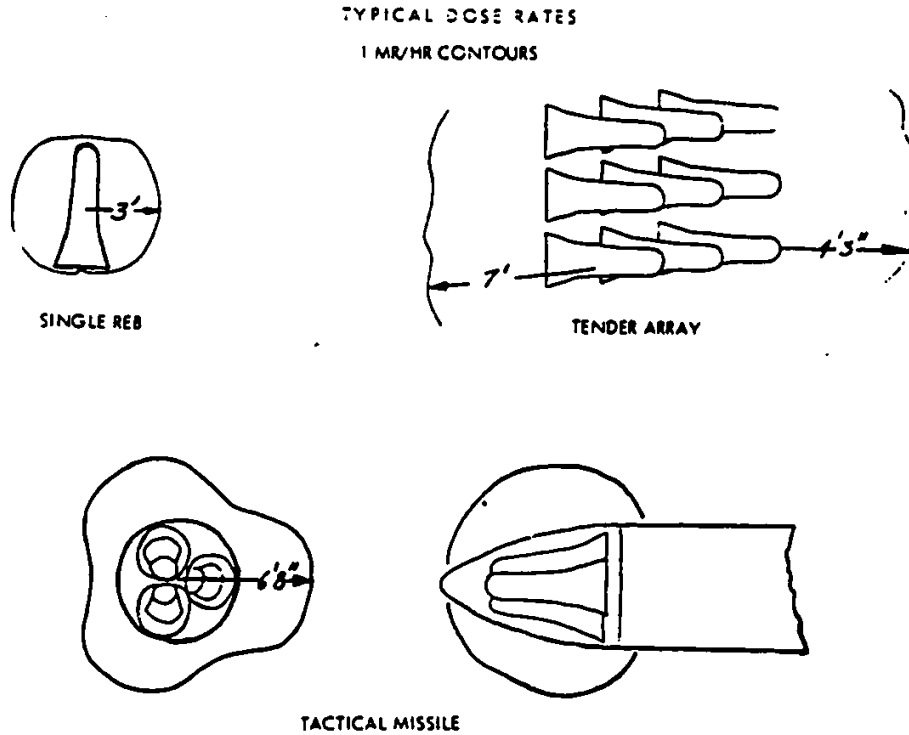


Figure 11

"Also listed in figure 10 are the BuMed recommendations, which say, basically, that the same dosimetry procedures should be employed aboard the tenders as are being employed in the REB shops, in the MAB, and handling personnel at POMFLANT and POMFPAC.

"Personnel must be monitored; it is not safe for them to work in that kind of shop without having someone review the dose that they have picked up. Wherever the dosage levels exceed five MR per hour, 100 MR for a five day working period, warning signs will go up. There is only one place on AS-19 where such signs would be needed

and that would be the space directly underneath or alongside the bulkhead storage; but no one loiters or bunks there. The situation on the other tenders is different. The backside of that bulkhead on the AS-32 is a berthing space with two bunks against the bulkhead. It may turn out that the bunks will have to be moved. BuMed has tentative plans to make a similar radiation survey on the AS-32 sometime within the next two or three weeks. They have just received their first load of the W56/Mark 2 re-entry vehicles.

"In conclusion, we can say that no hazardous radiation dosage situation exists as a result of the A3/Mark 58, provided that appropriate monitoring procedures are followed.

"We have had a fair amount of difficulty in the first few weeks of operation with the Mark 2 re-entry vehicle. The ablative shell is nylon phenolic and because of lack of care in handling, normal bouncing, and people hitting it as they go by, the shell sustains many small cracks, nicks, and dents. Most are very small, and in some cases have to be found with a magnifying glass, which the people at the POLARIS missile facilities have been using for inspection. Out of the first hundred, 21 were red-lined. Red-lining is quite a significant event. It is reported to the Field Commander, who reports it to the JCS and says the Navy does not have that weapon, it is no good. We inspected these, using earlier criteria, and found that 15 of the 21 could be accepted with repair. As a result, we drafted new criteria in order to avoid unnecessary red-lining. With these 15, people in the designing agencies might feel that they were functional weapons, but because of the lack of specificity of the criteria, the inspectors were calling them rejects.

"We wanted to widen the criteria and make it possible for the people to inspect without using magnifying glasses, to reject only the bad ones and to allow repair of all that should and could be repaired.

Figure 12 shows the new criteria, which are not very stringent. Some problems may arise with the requirement that these have to be able to be seen; this was put in deliberately so that no one would get a glass on the thing looking for cracks.

6-2.2.3.1 Defects 0.05 inch or less in depth, regardless of width, length or location are acceptable without repair. In addition, certain other defects are acceptable without repair as follows:

- A. Defects 0.008 inch or less in width and located completely within a four-inch radius circle centered at warhead nose tip regardless of depth or length.
- B. Aft edge defects that do not extend into area marked "No Defects" as shown on Sketch below.

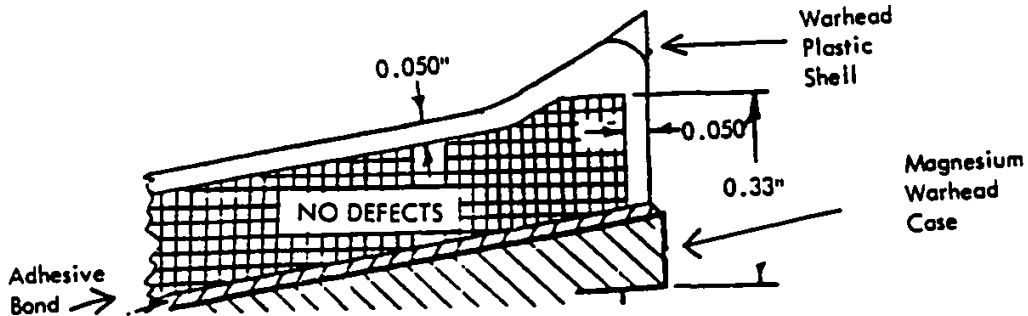


Figure 12

"Eight mils is a small crack, even if it goes down to the magnesium. The shockwave at the nose is so great and the heating so intense that the material will immediately flow to cover such cracks.

"Most of the first 21 were rejected because of aft edge defects. The vendor was making the shell in one long piece, and then cutting it to give a nice sharp corner, which chipped and cracked very easily. One SPALT we have already approved is to round the corner; this will

eliminate 90 percent of the aft edge defects. All other defects which line the white area are acceptable without repair. We are proving the repair criteria, listed in figure 13, at POMFLANT. Repair on the shell involves routing out the area of deficiency with the control routing tool, filling in with a mastic after appropriate preparation of the inside surface, sanding down the body size, and making a notation on the log chart.

6-2.2.3.2 Defects that are less than 0.100-inch in depth and less than three square inches in area may be repaired regardless of location (For repair procedures refer to para. 10-6). In addition, certain other defects may be repaired as follows: Nose defects from 0.008-inch through 0.040-inch in width that lie within a four-inch radius circle centered at warhead nose tip are repairable regardless of depth or length.

6-2.2.3.3 Unacceptable Defects - All defects in excess of limits specified above are not acceptable.

Figure 13

"The new criteria are realistic. They are based on good engineering judgement and have the concurrence of the AEC designers, the AEC production complex, and the people at PANTEX who do the final assembly.

"Captain Christman mentioned that the 17 November shot listed in figure 14 was postponed.

"Missile electronics, in fact all electronics, are sensitive to photon and particle omissions from nuclear detonations. The area for our interest is boost phase radiation sensitivity of the missile described in figure 15. Rate effect is something that has been considered only recently. Transient damage levels are those where a circuit is temporarily disabled. By hardening I mean interposing some sort of shield between these electronics and the flux so that the flux is cut down to a level where the system sees nothing. Circumvention is taking the

RE-ENTRY BODY COMMITTEE DISCUSSION

system off the air, or making it quiescent during the period of radiation, or storing the information in some fashion so that when the period of radiation is over the system comes back on and operates. At the level of permanent damage, hardening shows very little promise: it is almost impossible to stop gamma ray fluxes of one and two MEV gammas of the order of $R \times 10^9$ through $R \times 10^{11}$ per second.

MISSILE NUMBER	PLANNED FLIGHT DATA	RES CONFIGURATION	FLIGHT OBJECTIVES
AJX-13	24 November 1964	Mark 2 RES with full PX-2 and DW-19 AEC warhead test vehicle. (Nylon-phenolic, Teflon and Be special shell materials on Mark 2 Re-Entry bodies.)	A3 RES performance and penetration system effectiveness (PRIMARY). AEC warhead test unit performance and special material effects on wake observables.
AJX-59	17 November 1964 (February 1965 alternate)	Mark 2 RES with full PX-2 and ASP-3 special R/V.	A3 RES performance and penetration system effectiveness (PRIMARY). Aerodynamic power source evaluation.
AJX-61	February 1965	Mark 2 RES minus PX-2 (Teflon, nylon-phenolic, and Be special shell materials on Mark 2 Re-Entry bodies.)	Measure effects of special shell materials on wake observables. (PRIMARY)

Figure 14

POLARIS RADIATION HARDENING

MISSILE ELECTRONICS SENSITIVE TO PHOTON AND PARTICLE RADIATIONS FROM NUCLEAR DETONATIONS.

TOTAL SENSITIVITY PROBABLY FUNCTION OF BOTH INTEGRATED FLUX AND IRRADIATION RATE.

TRANSIENT "DAMAGE" LEVELS MAY BE AMENABLE TO EITHER HARDENING OR CIRCUMVENTION TECHNIQUES.

PERMANENT DAMAGE LEVELS ARE POORLY IDENTIFIED. HARDENING SHOWS LITTLE PROMISE FOR PROTECTION IN ANY CASE.

PRESENT SPECIFICATIONS SHOW EXTREME MODEL AND ENCOUNTER SENSITIVITY.

POLARIS SPECIFICATION BEING GENERATED TO BE APPLICABLE A3 AND B3 HEADS.

Figure 15

"Present specifications, including those in the B3 model specifications, the Air Force 6367 exhibit, and other papers, appeared unduly countersensitive. They are specifications for a given level of dose which could have been arrived at only by assuming a source yield, a source position, and a specific point for the encounter. We attempted to improve the specifications, which we are writing in terms of the model and countersensitivity, but I must report that we were not successful because we were required to meet certain specified conditions. In any case, we are developing a POLARIS boost phase radiation hardening specification and some of the criteria that have been proposed for it are shown in figure 16.

"For the nominal weapon, that is, today's nuclear weapon or the weapon that can be built in a few years, these criteria represent what we should be making trade-off studies against. Gamma rate is the rate at which quanta of one or two MEV gamma come out of the weapon at a given distance. As I said, we were not successful in removing model sensitivity. It is factored back in because these numbers have to come from a given condition, which in this case is an 88,000 foot atmospheric condition and a 200 kiloton source.

"Most specifications on this subject, when discussing r. or rads, almost invariably are referring to the dose equivalent in STP-air; it is not the dose, or the energy deposit in the structure, but what sits on the side of the interface. We have specified STP-air equivalent. The gamma fraction is a fraction of the total energy in the weapon. The neutron indicated is very energetic, and there is some evidence that rates this high lead to permanent damage.

"I am not sure that we will ever be able to separate neutron rate effects from gamma rate or gamma dose effects in any kind of nuclear experiment, particularly underground. The length of the tube is such that these neutrons get there about the same time as the gamma pulse

PROPOSED POLARIS RADIATION ENVIRONMENTAL CRITERIA

NOMINAL WEAPON

GAMMA-RATE ($\dot{\gamma}$): 8×10^9 r/sec

GAMMA ($\dot{\gamma}$): 80 r (STP-air)

GAMMA-FRACTION (f_{γ}): .0025

GAMMA PULSE WIDTH (τ): 1 SHAKE (10-8 Sec)

NEUTRON-RATE (\dot{n}): 2.4×10^{18} N/cm²-sec (E > 13 Mev)

NEUTRONS (n): $4.5 \times 10^{11} \frac{n}{cm^2}$ (E > 1 kev)

X-RAY (χ): 15-1.8 cal/cm² (@ 2 kw)

X-RAY ATTENUATION (χ): $\sim 10^6$ (A3-EQUIPMENT)

ENHANCED GAMMA WEAPON (Differences)

GAMMA FRACTION (f_{γ}): .03

GAMMA (γ): 800 r

GAMMA PULSE WIDTH (τ): 10 SHAKES

NEUTRONS (n): $2.25 \times 10^{11} \frac{n}{cm^2}$ (E > 1 kw)

ENHANCED X-RAY WEAPON (Differences)

X-RAY (χ): 1.8 CAL/cm² (@ 6 kev)

X-RAY ATTENUATION (χ): ~ 10 (A3-EQUIPMENT SECTION)
(CORRESPONDS TO ~ 700 r INSIDE)

Figure 16

does. This is important in boost phase radiation because the neutron rate may be a possible source of difficulty even after the dose problems are solved.

"The X-ray flux from this nominal weapon, in terms of dose, is very high indeed. In the A3, a transport calculation showed that the attenuation through 0.16 inches of the A3 equipment section wall was about a million, and that puts the flux down below a level of concern. Thorium, the high-Z material in the equipment section metal, accounted for 50 percent of the one million attenuation; it makes up three percent of the equipment section metal.

"With the enhanced emission weapons, described in figure 16, you do not get this sort of attenuation because the equivalent black body temperature is about six. Both Livermore and Los Alamos, and all the elements of the AEC seem to agree that these weapons are totally within their capability today; they could build a 6 KEV X-ray weapon, and a three percent gamma fraction weapon is possible. With this enhanced X-ray weapon, the total flux is still 1.5 calories per square centimeter, but the attenuation through the equipment section is only ten instead of a million, which, for that calorie level, gives a 700 R/STP-air equivalent inside the equipment section. In an enhanced gamma weapon, the fraction went up by a factor of 10^{12} and the dose went up to 500 r. because the pulse went to ten shakes. Neutrons are down a little bit. But the levels you get with the enhanced weapons appear to be very close to permanent damage levels. Hardening will not help very much.

"Thus, both the guidance people and the missile people should be investigating circumvention techniques. Little can be done about a very large dose. If you use appropriate circumvention techniques and there is still a residual permanent damage, nothing else could have been done.

"As a result of the DDR&E Re-entry Systems Proposal Review Meeting this fall, we were strongly solicited to submit a proposal jointly with the Army and ARPA for an IRBM signature experimental program. Our primary objectives listed in figure 17 represent both Army and Navy POLARIS penetration objectives. The re-entry bodies would be the Mark 2 and the Mark 12. The Army has proposed spheres of different materials. There will also be cones to determine scaling effects and decoys to determine the changes resulting from re-entry angle changes. The last two items are specific POLARIS penetration objectives.

ISEP PRIMARY OBJECTIVES

PROGRAM OBJECTIVE:

DETERMINE OFFENSIVE AND DEFENSIVE EFFECTIVENESS AND VALIDATE OR MODIFY HYPOTHESES AND THEORETICAL PREDICTIONS FOR THE FOLLOWING FLIGHT OBJECTIVES:

FLIGHT TEST OBJECTIVES:

DETERMINE SIGNATURES AT LOW, MEDIUM, AND HIGH IRBM RE-ENTRY VELOCITIES FOR BLUNT AND SLENDER NOSE SHAPED R B'S.

EVALUATE EFFECTS OF DIFFERENT MATERIALS ON OBSERVABLE SIGNATURES.

DETERMINE EFFECTS ON SIGNATURES RESULTING FROM γ CHANGES.

SCALE THE EFFECTS.

EVALUATE DECOYS, CHAFF, AND SPECIAL ITEMS AS RELATED TO SIGNATURE CHARACTERISTICS.

DETERMINE COMPLETE SYSTEMS OBSERVABLE SIGNATURES.

Figure 17

"This program will satisfy POLARIS penetration aid objectives. Army defense system design objectives, and ARPA re-entry research objectives. The proposal is due on 15 January, as shown in figure 18, and we will ask that DDR&E totally fund it.

ISEP PROGRAM MILESTONE CHART

INITIAL TRI-AGENCY WORKING GROUP DISCUSSION AND ASSIGNMENT OF TASKS IN RESPONSE TO DDR&E RE-ENTRY PROGRAM STUDY GROUP REPORT - 22 OCTOBER 1964

PROGRESS RE-VIEW AND FURTHER DEFINITION OF TASKS BY TRI-AGENCY WORKING GROUP - 9 NOVEMBER 1964

TRI-AGENCY WORKING GROUP REVIEW OF DRAFT PROGRAM PROPOSAL - 23 NOVEMBER 1964

FINAL DRAFT OF PROGRAM PROPOSAL COMPLETE FOR SUBMISSION TO TRI-AGENCY MANAGEMENT FOR REVIEW AND APPROVAL - 4 DECEMBER 1964

BRIEFING AND REVIEW OF PROGRAM PROPOSAL BY TRI-AGENCY MANAGEMENT - 5-31 DECEMBER 1964

SUBMISSION OF PROGRAM PROPOSAL TO DDR&E AS APPROVED BY TRI-AGENCY MANAGEMENT - 1 JANUARY 1965

FIRST FLIGHT TEST SCHEDULED WITHIN 12 MONTHS FROM APPROVAL OF FUNDING BY DDR&E.

Figure 18

"An example of the initial program that was discussed is shown in figure 19. The re-entry velocities are all within the maximum IRBM re-entry velocity. We would fire these from the EAG on some POLARIS vehicle appropriate to the velocity and the payload desired. We would have to have the range configure some sort of ship to perform range safety and tracking functions; negotiations on this are proceeding. The initial program was for 108 vehicles, a very extensive program which would cost about \$200 million. At present, the program is for 48 vehicles over a two-year period at a cost of less than \$100 million.

RE-ENTRY BODY COMMITTEE DISCUSSION

ISEP FLIGHT TEST PRIORITY MATRIX

CATEGORY	CONFIGURATION	SPHERE OR DECOY	R/E Vel. (1000'/sec)	RE-ENTRY ANGLE (DEG)	GROUP PRIORITY
SHAPES	Blunt Nose β 370 Material A	S	15	32	7
	Blunt Nose β 370 Material A	S	12	32	5
	Blunt Nose β 370 Material A	S	13	32	6
	Blunt Nose β 370 Material A	S	10	32	5
	Slender R/B β 2000 Material A	S	15	32	1
	Slender R/B β 2000 Material A	S	12	32	2
	Slender R/B β 2000 Material A	S	13	32	4
	Slender R/B β 2000 Material A	S	17	32	16
MATERIALS	Blunt Nose β 370 Material B	S	15	32	10
	Blunt Nose β 370 Material C	S	15	32	15
	Blunt Nose β 370 Material D	S	15	32	19
	Blunt Nose β 370 Material E	D-1	15	32	23
	Slender R/B β 2000 Material B	D-2	15	32	11
	Slender R/B β 2000 Material C	D-3	15	32	12
	Slender R/B β 2000 Material D	D-4	15	32	8
	Slender R/B β 2000 Material D	D-5	12	32	17
RE-ENTRY ANGLE	Blunt Nose β 370 Material A	D-8	15	60	21
	Slender R/B β 2000 Material A	D-9	15	60	20
SCALED VERSIONS	Slender R/B 1/3 Scale Material A	D-10	15	32	9
	Slender R/B 2 x Scale Material A	D-11	15	32	25
CHAFF	Exospheric Chaff + Inert R/B	-	15	32	13
	Deep Penetration + Inert R/B	-	15	32	14
	Man-O-War + Inert R/B	-	15	32	24
SYSTEMS	Blunt Nose R/B β 370 - PX Items	-	15	32	26
	Slender R/B β 2000 - PX Items	-	15	32	27

- NOTES: 1. S = 2 ea. 7-1/2 Spheres of Materials to be specified.
 2. D-1 = Physical Parameters Decoy
 D-2 = Mass-Energy Decoy
 D-3 = Combined Concepts
 D-4 = Combinations of D-1, -2, -3
 D-5 to -11 = Blunt Cone Decoys
 3. Materials: A = Be
 B = Teflon C = Refrasil
 D = Phenolic Graphite
 E = Lt. Wt. Ablator (Mark 12)
 4. Two Mile Separation Required on all Objects

Figure 19

"Why didn't this go into ABRES?" Captain Christman asked.

"I think the Army became disenchanted with ABRES," Commander Julian observed. "ARPA has money independent of ABRES that they do not want to throw into ABRES; and this is a specific investigation into the IRBM. By putting POLARIS into the program they are trying to divorce it from ABRES a little bit. But it is very easy to put it on the other side of the fence, which we do whenever we sell programs into ABRES. ABRES could be in this program but at the present time they are not."

"Is DDR&E saying that this is a test of existing hardware, or almost existing hardware, in ABRES's terms?" Captain Gooding queried.

"Not at all," Commander Julian replied. "We will have license to propose any kind of flight test vehicle. The Army is very hot for material spheres because they are shape independent. They will give good control on material differences and what they mean in terms of weight injection from flight to flight."

"I would like to mention some of our activities relating to the PENEX group. Dr. Mechlin is one of the two Navy members. We gave the first series of briefings to the Study Committee in Washington on 19 and 20 October and have since given them the other two volumes summarizing Lockheed's part of the presentation."

"There has been some question as to their credentials for access to information of greater sensitivity, particularly in the POLARIS command and control vulnerability communications area. The Study Chairman was informed that Admiral Smith had these reservations and has sent a letter to DDR&E requesting approval for access specifically to this information. I understand that the request

[REDACTED]

RE-ENTRY BODY COMMITTEE DISCUSSION

will be approved, but that he will be asked to designate certain people on the Committee for a briefing. I think that the Chairman, using systems reliability as a tie, would like to relate this briefing to the B3 follow-on briefing tentatively scheduled for 7 December. Before that date I expect to have this presentation approved through Op-31. There would be two sessions--the morning for the B3 cleanup and then the special, smaller group would hear a pre-launch vulnerability discussion.

"The first increment of the R&D hardware has been delivered to the United Kingdom. The President has signed the sales program approval and, therefore, has approved the statutory determination, a very important paper to them. It means that the AEC and DOD agree that the sale of the hardware can be conducted, and it further says that the UK can participate in a joint surveillance program and can also participate in the inspection process. The same thing is called out in Article 7 of the Sales Agreement. This participation discloses stockpiling information in this fashion. But it really does not make any difference because they already have the information or can get it from other sources.

"There is a team here this week to settle the details of the AFD fire set compatibility test program. We are discussing with them the modification we are proposing to make in the AFD timer disc. The production order for the entire five boat system is being determined. They have not yet decided whether they should try to pre-buy all of their material while our lines are operating at full capacity, or whether they will stretch out the buy at a very low rate for our producers so that they will be receiving the equipment as they need it."

At the conclusion of Commander Julian's presentation, Captain Gooding asked Captain Lieber to give the Launching Committee Report.