PART IV A-1

Interview with
Brigadier General William E. Leonhard
Deputy Commander for Facilities
Ballistic Missile Division
USAF

on 6 June 1963
at Washington D. C.

Mr. Hansen: General Leonhard, would you identify what your duties were with respect to the OSTF-2.

B/Gen W. Leonhard: During the period 1956 thru 1961 I was assigned to the Western Development Division which was redesignated the Air Force Ballistic Missile Division. I was deputy commander for facilities which included design and construction. Accordingly, with respect to OSTF-2 of Atlas, I was responsible for the over-all management and direction of this project for which detail was executed under the management of Colonel Farwell.

Mr. Hansen: Could you tell me what you feel were the specific objectives of OSTF-2?

B/Gen W. Leonhard: I guess the best definition might be found in the term itself, OSTF means Operational Suitability Test Facility. About 80% of the ICBM weapons systems are constituted in the ground environment and only about 20% of the system is airborne. The flight test programs of the ICBM missiles conducted at Cape Canaveral confine themselves only to the airborne portions of the system and the portions were not mated until they reached the operational environment at Vandenberg. The real purpose of the OSTF-2 was to enable a systems-integrated test program to be conducted to be sure that the entire system would function. It served a further purpose in terms of gaining some learning for downstream application for both construction, installation and checkout. At OSTF sites the subsystems of the total weapon systems were integrated for the first time and learning was acquired, as I said before, both in construction and in installation checkout of that equipment. Thus, we had a payoff in terms of making the jobs easier at the downstream operational sites.

Mr. Hansen: Now as I understand it, there were cost-plus-fixed-fee contracts utilized in this program in contrast to the normal bid process of other programs. Would you comment on that? Why were cost-plus-fixed-fee contracts used?

B/Gen W. Leonhard: As we have discussed before, the normal custom of the Corps of Engineers, our primary construction agent for this program, was to utilize fixed price lump sum contracts. In retrospect, I'm not sure that this was the wisest course of action to follow even at our operational sites, considering the philosophy of

concurrency that we were following in the program and recognizing that there was a good deal of research and development involved, not only in the guidance subsystem of the missile system, in the re-entry vechile and in the propulsion but also in many features of the ground environment including RPIE and other fixed elements of the system. We were researching, developing, and learning constantly through the early squadrons of each major weapon system configuration that we had, so we were prompted to recommend strongly and urge upon the Chief of Engineers that he undertake the construction of the OSTF facility for us at Vandengerg on a CPFF basis. The major advantage that we saw here was that it would give the Government, the Corps of Engineers, and the Air Force a degree of detailed management control-wise, cost-wise and quality-wise on this particular project that we would have lost had the job been attempted on a fixed-price lump-sum contract basis. I mentioned that there was considerable R&D type of work going on even at the operational sites. This condition certainly existed in the OSTF-2.

Mr. Hansen: Do you feel that the results bore out your beliefs that the CPFF would be better?

B/Gen W. Leonhard: Without question. I feel that any objective analysis of the OSTF would bear out that this was clearly the thing to do - in terms of schedule control, in terms of the contractors responsiveness to inevitable changes of direction in that time period, and in terms of assurance that we were paying costs the contractor was entitled to receive. As an example, OSTF-2 is the prototype of Atlas F. We had estimated this job - the first of its kind - at a cost of about six million dollars. When all of the bills had been paid the actual cost to us was something less than $5.6 million. Contrasted to that we had, at several of our six operational squadrons of the Atlas F configuration, major cost overrruns with one case approaching 100% above the amount that was programmed. In terms of system performance, stability of construction, schedule adherence, and cost control, we had a very fine and capable product turned in on the OSTF-2.

Mr. Hansen: I'd like to pursue this question now concerning your comparative experience with the CPFF and fixed price

contracts on projects such as these? For example, what about the Plattsburg operational sites and the types of contracts that were involved there?

B/Gen W. Leonhard: Happily, Plattsburg is not typical. At the same time it is not totally unique. The experience that we had at Plattsburg was repeated to a lesser degree in most of the construction sites that we've had in the ballistic missile program. At Plattsburg we had a 100% crossover line as measured against the value of the original contracts that were placed. I recall that in the summer of 1960 and again in the spring of 1961, meetings were called in Washington, in the summer of 1960, by the Secretary of Defense, who at that time was the Honorable Mr. Gates. The second conference was the congressional hearings conducted by Congressman Shepherd of the House Appropriations Committee in the spring of 1961. At the hearings they queried the contractors engaged in our program concerning the adequacy of the lump-sum fixed-price contracts in effect. There were a few exceptions to this statement but, by and large, they generally recommended that the work they were engaged in could better be accomplished on a cost reimburseable contract rather than attempting to do it with a fixed-price lump-sum contract. This always raised questions as to the allowable costs to be given to the contractor for changed conditions, or for new work. This led into long protracted negotiations between the contractor and the government. On the other hand, our CPFF experience on the OSTF-2 facilities at Vandenberg and fixed-price incentive experience on the first-of-a-kind Minuteman sites at Mount Sterling Montana showed that we have a much higher assurance of cost control under those conditions than we have under the fixed-price lump-sum contract. Let me site a recent, specific case that has just come to my attention. At two of our Minuteman bases now under construction, BSD had packaged some additional work in the area of site security and this was proposed to be added to the going major construction contracts. Negotiations were being conducted between the government position of $4,000,000 and the contractor position of $6,000,000. In the view of the project engineer that had drawn up this particular project, and in the view of the Air Force people at BSD, both these amounts were considered exorbitant. As a consequence, they insisted on a

condition that additional work be done on a competitive bid basis. Bids were then received. In one case, the construction contractor on the site who was negotiating from a position of $6 million, bid for this work with the Corps of Engineers for $1.6 million. He was not the low bidder and the work was awarded at $1.2 million. We feel that this condition is prevalent in our program and has contributed significantly to heavy cost overruns that we have experienced.

Mr. Hansen: How about the effect of the learning that you received through this CPFF contract on the OSTF-2? Did it or did it not carry over into later contracts, or wasn't it applicable to later contracts?

B/Gen W. Leonhard: Well, for one thing, the learning acquired there from an engineering standpoint was passed on down the line to the subsequent 73 locations that we have in the Atlas F program. The lessons learned from OSTF were applied in improved designs and drawings in specifications that were then put into effect at the operational sites. Now, its unfortunate that there was something less than an optimum amount of learning acquired in the actual construction. In the I&C work, where Convair does that I&C work for all squadrons and all launchers within a squadron, learning is acquired from the early site that is applied directly in procedures, operation, equipment installation, checkout techniques, etc. It applies downstream and they are able to do it with far less effort because they are exploring fewer dead ends. They have patented their procedures and techniques by that time, so it comes easier, quicker, and less expensively. But in a construction business where we have a different contractor group at each of our six operational squadrons there is less transfer of knowledge. We set up procedures that were designed to improve this and I expect that actually some benefit was achieved, but it was not of the hard core variety that you achieve from a weapon system contractor. We did set up regular visits by the operational site construction contractors at critical stages of construction of the OSTF at Vandenberg. We did this so they would appreciate the problems we were getting into, be able to anticipate and plan for them and also to observe solutions to the problems, good or bad, that were being applied at Vandenberg, in the hope they could adopt the better features of those plans in their

own work on the sites they had under construction.

Mr. Hansen: Would it be proper then to call OSTF-2 a pilot model and the others production models?

B/Gen W. Leonhard: Yes, I think this is true. It was in every way a prototype, a pilot model. I'm confident that there was some benefit gained, even on the construction side, that may be somewhat intangible to measure. Certainly it did exist just by the fact that people do learn by observing the actions good and bad, of others.

Mr. Hansen: Was this concept used for the Minuteman?

B/Gen W. Leonhard: Yes. But the time phasing was not as good for the Minuteman as it was for the Atlas OSTF-2. We were delayed for one reason or another in getting started with the Minuteman prototypes at Vandenberg. The work on the first operational squadron actually got ahead of the work at Vandenberg. A part of this was the result of our installation at Vandenberg having a great deal more sophistication about it. The requirements were much more comprehensive than that of our operational sites. For example, the facilities that we put in at Vandenberg were much more highly instrumented because they were going to be used for testing purposes. Additionally, while our operational sites at Malmstrom and downstream are designed for single-launch capability, those that we put in at Vandenberg had to be used for multiple-launch. We had to use them repeatedly. This caused some stretch-out in the construction timing at Vandenberg while the work at Malmstrom, where we had a very good contractor engaged, actually got ahead.

Mr. Hansen: You mentioned the incentive type contract at Malmstrom. Would you comment on how it worked out?

B/Gen W. Leonhard: I think it worked out with enormous success. Although this was a fixed price incentive, it actually was of the type that allows the government auditors to closely inspect the records of the construction contractor, billings of material, equipment delivered, all payrolls, contract work, travel expenses, communications, etc. So we knew what the actual cost to the contractor was. The incentive feature allowed him to benefit by increased

profit or fee if he kept the cost down. There was an incentive on his part to not allow his cost to escalate. I am quite satisfied that the government got a real good job for its money at Malmstrom.

Mr. Hansen: Is this approach going to be used in the future at all?

B/Gen W. Leonhard: I think that it is an approach that we ought to sponsor whenever we have a long series of facilities to be built and we need some measure of the cost. If the contractor is exercising good judgment and proper management control of the operation it gives us a standard against which we can compare the cost growth in lump-sum fixed-price contracts applied downstream. We bought Malmstrom for $80 million. Since this was first-of-a-kind there were many more problems to overcome than for example at Ellsworth or at Wightman or Minard or Grand Forks or Warren. The latter would profit by the mistakes at Malmstrom. There were many more changes incorporated at Malmstrom. The weather conditions were more adverse. The labor market was scarcer. All these conditions would tend to have you conclude that the cost at Malmstrom would be higher than the later ones. So, to me it would be inexplainable to have Ellsworth come in at a cost of $120 million. This would show total lack of responsibility.

Mr. Hansen: I'd like to examine the type of management organization that was used for OSTF-2. How would you best describe the management program?

B/Gen W. Leonhard: I would like to explain to you how it came about. We had on board the designers - architect engineers for the Atlas F - the Bechtel Corporation. After their selection as the architect engineer, consideration was given to their demonstrated capability on the construction side. By the time we got to Atlas F, we had gone through our experiences on Atlas D, Atlas E, and Titan I. If there is anything to be learned by experience, we thought we had sufficient experience to make a major departure from the customary practice that is employed in making snack bars and bowling alleys and recognize that we are engaged in the development and acquisition of total weapon system of which construction is only a part. We felt that we had to shake out, on a prototype basis, the first of the Atlas F facilities. So I wanted to have our

designer be given the job of fabricating, building, testing out etc., the prototype that he had designed. When the architect-engineer is selected in our program he is accorded associate contractor status and is brought into the weapon system program. He puts key personnel of his organization with Convair. Both Convair and Bechtel jointly prepared the concepts for this system and were jointly responsible for the configuration with review, approval, modification, verification, etc., by STL and BMD. We felt that a part of Bechtel's responsibility as the ground system developer and designer was to prove the adequacy of his product and that this could best be achieved by making him responsible for demonstrating the workability of the system in a prototype. So, while the Air Force did have authority out at BMD, derived from a Nov. 1955 decision by then Secretary of Defense Wilson, to do both its own design and construction on the ballistic missile program if we desired, I never chose to exercise the construction part of this because it would have entailed a much larger organization than the Air Force would have had to put on it. We felt we would have had adequate control, from a facilities standpoint, if we retained the responsibility for construction and exercised that directly, and then utilized either the Bureau of Yards and Docks or the Corps of Engineers as our construction agent. Coming back now to OSTF-2, we had Bechtel under contract to do the engineering work and our job was then to convince the Corps of Engineers that they should engage the same outfit to the construction for them on the same non-competitive source basis and secondly, to do this on a cost-reimburseable contract so that we could maintain an adequate day-by-day control of the details of engineering schedule adherence, and cost considerations. We were able to convince General Wilson of the Chief Engineers office that this was the thing to do and I think that it was a very useful and certainly a very profitable enterprise into which we entered. This then pointed to a three headed management group. Bechtel was the key to it because they had engineering as well as construction responsibility. BMD was a part of it because it had engineering control of the Air Force responsibility for design and the Corps of Engineers was a part of it because they were administering the contract.

So we entered into an agreement, formalized and executed between our office and the office of the district engineer in Los Angeles, that we would have this joint management group activated and would prescribe the procedures for which they would function. It called for rotating the location and chairmanship of the meetings. It called for weekly meetings of the three parties. It called for on-site inspection by all parties concerned. In retrospect it was one of the better things that we devised.

Mr. Hansen: You feel that it operated very effectively?

B/Gen W. Leonhard: Oh yes, it did beyond question. It really put Bechtel on the spot. They were responsible for execution of construction, quality product that they were claiming to give us on the engineering side, and it also short circuited what are usually very long lines of communication. If we have an engineering change to be made, the Air Force evaluates it, and then gives it to the designer. He translates this with a new instruction into different lines of words on paper. He gives it back to the Air Force. We give it to the construction agency. They in turn give it to the construction contractor, and before you know it thirty days can easily go by just transmitting papers of this type. There are questions raised; there are delays in the in-basket; it gets caught in the U. S. Mail and thirty days is not at all abnormal for such a sequence as I am describing here. But here we had a situation where, as soon as the Air Force needed the engineering judgment of the Bechtel Corporation on a change that needed to be made, they immediately had a close tie-in with the construction side. Although contractually we routed it through Bechtel, engineering to the Air Force, through the Corps of Engineers, and then to Bechtel construction, the fact of the matter was it was handed right across the door. It was a tremendous benefit in terms of dollars and time saved and avoidance of wasted motion.

Mr. Hansen: Instead of having a many-headed organization such as you had here, why couldn't you have one contractor just handle the whole thing, say Martin, Boeing or General Dynamics?

B/Gen W. Leonhard: Well, there are probably two answers to your question. One is practical - the other political. Let me cover the political side first. It is written in every appropriation bill to the Air Force that money so appropriated will be expended for Air Force construction by the Corps of Engineers of the Army or the Bureau of Yards and Docks of the Navy. This then gives them the statuatory right to do this business for us. On the practical side, maybe I should explain it this way. The Convairs, the Martins, and the Boeings are not in the construction business. They reached their point of eminence in the business world by building airplanes and now by building missiles. I really think it would be a mistake to have them become so deeply involved in mundane elements of work such as would be involved either in executing or managing facility type construction. Also, the VonNeumann committee findings in 1954, which started the Atlas program, through study of the capabilities of U. S. industry, recommended very strongly against the assignment to total systems responsibility to any single firm in this country. There were firms that were proficient in airframe development. There were other firms that had high potential and satisfactory capabilities in electronics and elements in guidance systems. There was another family of contractors who were highly proficient in propulsion and there was a totally different group that had been exploring, testing, and developing processes acquiring capabilities in the re-entry vehicle phase. The VonNeumann committee felt that to give the total job to any one contractor would so burden that company's capability (including management capability) that the total program would suffer. As a result they recommended that the Air Force manage it on an associate contractor basis giving major elements of the work to different firms and doing the integration work themselves with the help of STL. I would apply this then to the ground environment facilities. I would think that the construction industry and that the engineering fraternity that we have are best able to carry out the engineering and construction work for this program. I think we have had our problems here but, believe me, these problems would not have disappeared or been minimized had this portion of the system been turned over to Convair or Martin. This is amply demonstrated by examination of the

record in the design and construction of industrial test facilities undertaken early in the program. They had major slippages, major cost overruns, comparable with any and oftentimes exceeding the experience that we have had on the Air Force side.

Mr. Hansen: One more question on organization. As you get an arithmetic increase in the number of elements in the organization structure, you probably get an exponential increase in communication problems. Now, how did you counteract this?

B/Gen W. Leonhard: You are speaking now of a way to short-circuit the problems of communication when you put together an organization that has one job to do and all the people are involved in doing that job. I feel the management conferences minimized the communication problems and enabled us to avoid bickering, and delays that all too often occur when communicating by written correspondence. There was a minimum of misunderstanding because people who had the job to do were looking at the same problem concurrently and the solutions that were derived from these management conferences were executed by the three principals involved immediately.

Mr. Hansen: Organizational structures have effect on the attitudes of people. How about the effect of this organization structure on the attitudes of the people involved?

B/Gen W. Leonhard: From our standpoint I can speak only for two of the legs of the stool. From the Air Force ballistic missiles standpoint it was a most happy marriage. We feel that it was highly beneficial to the program and this is our primary interest. In the process, some toes may have been stepped on. I'm sure that some people's feelings got hurt because some of their jealously safeguarded preogatives were short-circuited. But no one was going to stop us if it was beneficial to the program. I consider the arrangement profitable, appropriate and desirable because it benefited the program. I think that this view also is very strongly shared by the Bechtel Corporation - the second leg of the stool. They were on the spot and by this management arrangement they had the means to fulfill their responsibilities. They were not curtailed and delayed by the administrative machinery and handling of instructions to them between the Corps of Engineers and the Air Force.

Mr. Hansen: I would like to examine possible unique design requirements of the OSTF-2. Were there any design requirements at the Atlas facility that were new to most contractors?

B/Gen W. Leonhard: Very definitely there were. Atlas F is a silo lift configuration. This is the same at Titan I. But in the Titan I program the crib containing the missile lift mechanism was considered as a part of ground support equipment. It was not furnished by the contractor nor was it funded out of military construction appropriations. The crib that we engineered and adopted in Atlas F was a greatly simplified version. In the process of simplification the cost was greatly reduced over that which was experienced in Titan I. Other elements of some uniqueness included the high speed propellant loading system, the blast closures, and the like. I guess another element of uniqueness would have to be that the work was accomplished in such a very restricted area, somewhat like building a submarine. We had a tremendous amount of equipment to be installed, hooked up, checked out and made to work. To integrate one with the other in this assembly and to schedule work space and sequence in which equipment had to be installed so that it all could be fitted together, required a great deal of imagination and planning. Perhaps, in retrospect, the most difficult part of the job was in this exercise of planning. Ordinarily, construction contractors are not faced with the problem of working in such confining, restricted, and hazardous work areas as we had in this facility.

Mr. Hansen: I would like to examine project performance now for just a moment. Sometimes in CPFF contracts there is a tendency to gold plate. Was there any evidence of this on OSTF-2?

B/Gen W. Leonhard: No there was not. I am personally confident there was none. Here we had a situation where the Bechtel Corporation was committed to the Air Force to produce an austere and economical design. They were on their metal, so to speak, in the construction phase of the OSTF-2 to prove that the estimate of cost that they had prepared for us initially was a valid one. I believe that I mentioned earlier that compared with their estimate and our verification of same at approximately $6 million level, they came

in below this estimate by some 5 or 6%.

Mr. Hansen: Would this hold true for all cases of CPFF? I think this is a rather unique example.

B/Gen W. Leonhard: I would not ordinarily favor a CPFF contract unless we had the conditions that existed in this case. I think if we want to assure ourselves of a quality product, on time, we have to provide some incentive for the contractor to meet these objectives. In the case of the OSTF, both with this one and with Parsons on Titan II, the incentive was supplied by the pride they had in their engineering work. We must look for other sources of incentive to contractors who are not motivated in the same way. For the contractors that we had at Malmstrom, profit was the incentive. Profit sharing is perhaps a better term, in that, if they were able to save money below the initially agreed contract amount, then they shared the profits from same.

Mr. Hansen: How do you feel about the quality of the original design?

B/Gen W. Leonhard: Good, although I am sure that if we had it to do over again in light of what we have learned in the last three years, there would be changes. But, I think that for responsiveness of engineering work to the weapon system requirements as were then defined in consideration of the tight schedule required, the Bechtel Company did an outstanding job.

Mr. Hansen: Was the quality of construction work up to standard?

B/Gen W. Leonhard: Yes. They are a first class outfit. They take pride in their work. I visited Vandenberg almost weekly during the time that this work was undertaken and I observed no short cuts in quality. They put highly experienced management on the job and this carried all the way down through the technician level.

Mr. Hansen: You found Bechtel to be a cooperative organization?

B/Gen W. Leonhard: They were most cooperative, in every respect.

Mr. Hansen: Do you recall any serious schedule slippages?

B/Gen W. Leonhard: This is a matter we tracked very particularly because

this facility was going to pace the entire Atlas F program. Therefore, we had a real clear understanding with the program office, Convair, Bechtel, the Corps of Engineers, and in-house that this program was going to be done on schedule. I think that the record would show an on-schedule condition throughout the entire program. There were small minor delays from time to time as measured against the earlier milestones we charted but then maybe our earlier judgments of how things would fit in, were not too well thought out. I think the "proof of the pudding" is that the construction work was completed by the time it was specified.

Mr. Hansen: You had no significant labor disputes or work stoppages?

B/Gen W. Leonhard: I recall none. If there were, it would be a matter of record with the Corps of Engineers. There was no significant stoppage from the standpoint of labor disputes. Some of the delays that they had on minor features of work were caused by late delivery of equipment that was being procured outside of the Bechtel contract, and over which they had no control in terms of assuring delivery. When that equipment arrived late, although they could work around it in part, nevertheless it did involve later-than-scheduled completion of sub-elements of the job. As a tribute to their interest in the job and as an indication of the flexibility that we derived from handling the contract as we did, they were in all cases able to cover the schedule without the government paying the price for it.

Mr. Hansen: What types of control mechanisms were used for measuring progress on time and cost?

B/Gen W. Leonhard: We had set as the first order of business in this joint management group, the detailing in as precise terms as possible, identification of the scope of the work to be done, starting with the excavation, placement of the orders for long-lead time equipment to be later installed, the fabrication, the assembly, the installation of the crib work, all of the propellant loading system, tankage, the piping and the electrical mechanical services, connections and the like. All of this was carried out in very minute detail - time phased so as to

best assure the total proficiency of the job on the date to which we had committed ourselves. Then this basic milestone chart was constantly updated to take advantage of the improvements that the field was able to accomplish; also to reschedule around delays occasioned by late delivery of equipment. You have to bear in mind that when we started the hole all we knew was that it was going to be 52 feet in diameter and 174 feet deep or some dimension like that. They started digging the hole before we had the first detail drawing off the board. All we knew at that time was the broad, general geometry. We knew what the concept called for and could visualize that there would be a need for certain cryogenic materials and high pressure vessels for the propellant loading system but at the time we didn't know exactly how many, or what capacity, or size. All these details were those that this working group addressed themselves to on a weekly or daily basis as necessary.

Mr. Hansen: What do you see as the advantages of using the PERT and related technology that seem to work well when you have interfaces and subsystems involved. Do you see any values in the use of these types of techniques?

B/Gen W. Leonhard: The term PERT is now fashionable and it will pass. I'm not saying that the techniques of PERT will pass from the scene but there will be another gimmick that will be brought in to stimulate the imagination. To me the advantage of PERT has been that it has forced planners to plan. It has forced a discipline into the process of systems acquisition. Now, good program management has always employed something like PERT and poor program managers have neglected these principles that are a part of PERT. At that time, PERT hadn't yet come upon the scene. We really didn't recognize that we had PERT. We had plotted all of the milestones ahead, closely fitted the scheduled arrival of the equipment at the site, the integration of the construction contractors work with the I&C activity closely paralleling where demonstration checks would prove out the compatibility of the two systems. All of this was very closely detailed. So we just didn't know that we actually had the PERT system in operation.

Mr. Hansen: If you had to go through it again, a similar type program, what additional things would you like to see done? Let's take the whole ballistic missile program and the relation OSTF-2 had to that program.

B/Gen W. Leonhard: Looking at our program, OSTF-2 serves as an example of a good product emerging from what could have been a real bad experience. I think if I could turn the time clock back to 1956 when we were just beginning to think about operational deployment of the ICBM force, I would have wanted to take a stronger position than I did in terms of the use of the CPFF contract for the first or prototype installation of every one of our weapons systems. We should have done it for Atlas D and Atlas E. We did do it for Atlas F. We did do it for Titan II. We did not do it for Titan I. Also, with the directive of having the engineer held responsible to actually prove out the efficiency of the performance of the system, we ought to have an architect builder aboard that engineers it, builds it and proves it out. All too often we engage an architect who completes his responsibility when he turns over a package of plans and specifications. Whereas we may get angry with him if those plans don't produce what we are looking for, nevertheless, contractually he is off the hook. I think that we can get sharp language in our contracts from now on so that the engineer-builder is held responsible for the performance and cost control that he claims exists in his plans and specification as originally submitted. I think that there is a place needed in our way of doing things for having the architect-engineer maintain this thread of responsibility from the initial concept phase of a weapons system until he has turned over to the user a system that has been demonstrated for performance. Also, I would strongly urge that we would follow the pattern that we did at Malmstrom and get the first contract that would be awarded on a competitive basis, put under an incentive-cost reimburseable-type contract where the government can be assured, on a continuing basis, what the actual costs to the contractor are and hence safeguard interests of the government during negotiations for changes. We could then develop, for each of our major systems configurations, a baseline against which we can judge the cost growth of subsequent squadrons.

Mr. Hansen: Would you like to see the people who are involved in the facilities installation, get more involved in the original design of the entire missile system or do you feel that they are close enough now?

B/Gen W. Leonhard: It probably varies between systems. I have heard from Both Convair and Bechtel that that relationship was a most profitable one to Convair. They had a tendency to think only of the airborne part of the system and were almost totally preoccupied with the missile itself. They needed someone with the reputation and the obvious capability of an outfit like Bechtel's to keep their feet on the ground, and help to not only solve problems relating to this ground environment but to suggest solutions to problems on which they had practical experience.

PART IV A-2

Interview with
Colonel Maurice A. Cristadoro
Atlas F Program Director
Ballistic Missile Division
USAF

on 6 June 1963
at Andrews Air Force Base, Washington D. C.

Mr. Hansen: What was your position in the program at the time and what were your duties?

Col Cristadoro: I had executive management responsibility for all aspects of the Atlas Weapon System acquisition. Today this position is known as the System Program Director (SPO) in accordance with the AFR 375 series. At the time that I was the executive manager of the program, the Ballistic Missile Division (BMD) of the Air Research and Development Command (ARDC) was the executive agent, and the Ballistic Missile Center (BMC) of the Air Materiel Command (AMC) provided the normal materiel command procurement and logistics support functions. With the reorganization of the ARDC and AMC to the now existing Air Force Systems Command (AFSC) and Air Force Logistics Command (AFLC), the two agencies, BMD and BMC, were integrated. As I indicated, I was responsible for the Ballistic Missile Division mission to provide program acquisition for the Atlas 107A-1 Weapon System. As executive manager, I was responsible for all aspects of this program acquisition.

Mr. Hansen: What do you feel were the specific objectives of this program?

Col Cristadoro: Recognizing some of the deficiencies that existed in the "D" Series program, we set about in the early phases of the program planning for the "F" Series to provide the vehicle and mechanisms to avoid those discrepancies. To this end, we included in our planning the OSTF/2 (Operational Suitability Test Facility) as the development test facility for the operational "F" weapon system. We had two primary objectives for that facility. The first was to serve as a pilot type operation for the entire period, from the beginning of construction to the end of the installation and checkout phase. This pilot operation was to provide the assurances that the design, engineering, validation of work effort, personnel structures, manloading, etc. were consistent with program requirements. More specifically, it was to allow for the learning necessary that the planning established for the operational buildup was consistent, that deficiencies were recognized and corrections initiated. The OSTF/2 was designed and activated as closely as possible to that of the operational facility. As a pilot operation, it provided an opportunity to define and proof test the production approaches and planning that were to apply at the operational sites. The second objective was to conduct

the development, test and evaluation of the weapon system in as near an operational environment as possible to determine deficiencies to the operational requirement, establish the "fixes" for those deficiencies, and to test those "fixes" to assure the capabilities in the operational inventory established within the Specific Operational Requirement (SOR).

Mr. Hansen: Do you feel the objectives were adequately achieved?

Col Cristadoro: Yes, I think in general this could be said to be the case, attested to by the fact that the operational sites came in on schedule as it was originally laid down. As a matter of fact in spite of the fact that the initial sites were delayed to some extent, the final activation date of the squadron was right on the date that was originally established. This, in spite of the fact that during the formulation of the planning for the "F" series program, we augmented the capability by some 33% from what it was originally established to be. We did numbers of things to improve the capabilities in the process. So, I think that the general objectives were met.

Mr. Hansen: How about major policies at the beginning of the contract contrasting to original policies? Were there any changes?

Col Cristadoro: The major policy change affected in the "F" Series and more specifically related to the OSTF/2 was the management organization conceived and utilized. This management concept recognized that the principal integrating contractor, General Dynamics/Astronautics (GD/A), and the construction contractor had a great deal of cross-correlating to accomplish, particularly in the initial design phase. Recognizing this, we worked out a management scheme whereby Bechtel, the architect and engineer for the construction program, was the prime contractor for construction, but likewise served as a subcontractor to GD/A to provide the interface between hardware equipment and construction designs. Together, these contractors provided the overall top drawings for the entire ground systems element and accordingly obviated a lot of the normal communication problems and interface difficulties that had previously existed. These were the major policy changes.

Mr. Hansen: Were the schedule requirements in the contract adequate?

Col Cristadoro: When you say in the contract, if you speak in respect to the construction contract, in my opinion they were. If you speak in respect to the other integrating contract,

I think they were also. This is of course, recognizing the flexibility that must apply in scheduling first-of-a-kind items such as this. I think that the schedules were exact enough, definitive enough.

Mr. Hansen: What I'm getting at with that question actually is to determine if the contract instruments served you well. This might have some effect on the determination of what kind of contract instrument should be used in the future.

Col Cristadoro: It is my understanding that military construction program funds require the use of a "fixed-price" type contract. There is a school of thought that this type contracting is too inflexible because of the nature and character of the type of job that was being implemented in the ballistic missile construction program. Specifically, it was allowed that facility type changes which were inevitable would be more costly in the end than what would have been under different type contracting. Not being an authority in this field, I cannot be sure of this point of view. In retrospect, however, it would appear that a "cost-plus" or a "cost-plus-incentive" contract would have provided more flexibility and may have contained costs better.

Mr. Hansen: I know pretty well what type of management organization you have. Would you like to comment on it and would you tell me how well it worked?

Col Cristadoro: At the time of the OSTF/2 and the "F" Series program, we had come a long way in the implementation of a concept which was fundamental to the prosecution of a program such as this. This concept was predicated on a team approach with the WSPO or SPO as the captain of this team, whereas earlier in the program much was left to be desired in this management scheme. By this time in the atlas program this management scheme was well understood and working rather effectively. For example, the facilities personnel of BMD, responsible for providing the facilities construction program, were physically located within the program office. Whenever matters involving facilities might impact on the program and on the installation and checkout phase, these personnel were extremely careful in correlating and coordinating their requirements and inputs with the program office to insure that proper balances were effected and impacts minimized. Of course, the program office was the final authority concerning program impacts. I think this scheme worked very well.

Mr. Hansen: In the organization you had different people from different organizations involved. What effects did this type of organization have on the attitudes of these people?

Col Cristadoro: If there are different ideas to be gotten, you ought to get them whether the organization is one scheme or another. I think that you get more expression of ideas because of the team concept perhaps than with another approach. I for one didn't experience gross differences of viewpoint which resulted in actions taken unilaterally in defiance of the decision. Nothing like this ever happened to my knowledge.

Mr. Hansen: With the team concept sometimes you have a problem in getting a decision made. Was this a problem at all?

Col Cristadoro: This problem never bothered me. I was expected to make the decisions. I was intrusted with the authority to make those decisions and I had no trouble.

Mr. Hansen: Were there any design requirements existing in the Atlas F program that were new to the contractor?

Col Cristadoro: Oh, I think the answer to that question is yes, without qualification. The fact that we were developing criteria for facilities design to live in the environment of nuclear detonations and to withstand the weapons effects of those detonations was quite unique. The lack of specific experimental data required extrapolations and the translation of these extrapolations into specific design criteria. This again represented a new requirement to the contractors. In our particular case the experiences of the Tital program served as a useful backdrop, but still the total technology was unique.

Mr. Hansen: Were there many design changes during the progress of the program?

Col Cristadoro: There were changes. The question of how many, of course, is somewhat relative. The number, however, I would consider appreciable. As I mentioned, the changes in facilities were principally the result of those brought about because of the interface requirements and progress throughout the installation and checkout of the system being integrated in the field for the first time. This is what the OSTF had been planned to considerably alleviate. However, the simulation could not be a complete one. We had provided a hard mockup for installation and checkout but this too fell short of completely configuring the final product. The

interface between the facility, the RPIE and the AGE inevitably brought changes that had to be reflected back into the facilities designs themselves. Therefore, in this context the changes were numerous.

PART IV A-3

Interview with
Colonel Robert H. Farwell
Chief, Design Branch
under Deputy Commander for Facilities
Ballistic Missile Division
USAF

on 26 February 1963
at San Bernadino, California
Norton Air Force Base

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Hansen: What was your job at the time of the development of OSTF-2?

Farwell: At the time the initial discussions and meetings were going on concerning how we were going to develop the Atlas F program and OSTF-2, I was Deputy Chief of the Atlas Design Branch under what was at that time, the Deputy Commander of Facility.

Hansen: Did you retain that position all through the project?

Farwell: No, we started design in the spring and early summer of 1959 and in the summer of 1959 Colonel Hastings, who had the Atlas office, was transferred from Omaha and I was then made Chief of the Design Branch and remained in that position throughout the remainder of all of the Atlas program including the OSTF.

Hansen: What particular role did BSD play in this project?

Farwell: Well, BSD was responsible for the deployment, and development of all of the ICBM programs at that time. As such BSD was responsible for providing the designing of facilities for the ICBM program as well as being responsible for the development and testing programs for the missile and all of its associated hardware. At that time we had an organization known as BMC or Ballistic Missile Command that performed the procurement functions. This was an Air Materiel Command office or station contiguous with the Ballistic Missile Division and was our procurement agency. Later on these organizations were combined with BSD in the reorganization of AFLC.

Hansen: I have a little problem seeing the management structure or organization at this time. I know that GDA was the integrating agency, that this agency built the missile itself, but I am trying to put together the construction agency, the integrating agency and all of these together in the management organization. Where would BSD fit in that management structure?

Farwell: BSD was the Air Force organization responsible for programming, developing and getting this weapon into the field. In order to do that we had to depend upon many other organizations. One of them was the Ballistic Missile Division under General Schreiver, which was responsible for development. Another was the Ballistic Missile Command, an AMC organization which was responsible for the procurement and which actually did the buying or contracting for BMD. Also we had Thompson-Ramo-Wooldridge, which at the time were known as R-W. It was about this time in 1959 or 1960 that they reorganized and formed a division called the Space Technology Laboratory. STL was responsible for what is known as systems engineering and technical direction. They were responsible to BMD for the

over-all systems engineering. They tied together all of inputs from the hardware manufacturers, the missile manufacturers, the guidance people and the facilities into a system. This was a management task and a technical task that they did for BMD. They provided the technical talents and the scientific skills that the Air Force didn't possess. For each of the weapons systems, the Atlas, the Thor, the Titan, etc., we ended up with different contracts. In case of the Atlas we had Convair Astronautics, now known as General Dynamics Astronautics, who were responsible for the design and production. They were the integrating contractors. Also, we had a group of associate contractors. Since he was supplying the missile the integrating contractor had responsibility for integrating the ground equipment guidance systems and the engines into a single product. He integrated them in the sense that he put them together in the field and was responsible for the direction and testing of them. Where do the facilities fit into this? The way we bought facilities in the Air Force was to identify a requirement, come up with some criteria, and give this criteria to the construction people, normally the Corps of Engineers, who then hired an architect-engineer to design it. Then it was let on a lump-sum competitive contract. The one difference was that occurring in the ballistic missile program. We had to get the criteria from the various integrating contractors to the various associates, to work up contracts with them, and then actually to provide the design which was given to the Corps of Engineers to be given to the constructor through a lump-sum-competitive contract. This is the way you produce facilities in the Defense Department.

Hansen: When you say you were responsible for the design and you contracted out for the designing, what do you mean?

Farwell: Yes, we were responsible for the design. We were responsible to the Weapons Systems Program Office, the Titan Program Office, the Atlas Program Office, etc., for obtaining the necessary information, the criteria, producing concepts and then the design. That is, the office was responsible for this but we did it also. The bulk of the work of course, was done by contract. We hired an architect-engineer to do the work and a project office who managed it.

Hansen: This was Bechtel?

Farwell: Yes, for the Atlas D and the Atlas F the Bechtel Corporation did the work. For the OSTF-2 they were the builders. To understand the management system that was used there you have to understand what we were doing before what was done before that was a very crash program - a very concurrent program. We

were designing facilities at the same time that the integrating contractor and the associate contractors were designing the missile and the hardware. In almost all of our programs we had a completed facility available about the same time that the missile that was used in this facility was launched the first time. In the Atlas D and the Atlas E programs we got the training and operational facilities at Vandenberg and they led, to a limited degree, operational squadrons. But they were never timed and built to the degree that they would give us lead information on the facility that was really useful in the follow-on programs. The Atlas F program was a very accelerated program. We felt in order to do a decent job that we should build as far in advance as the program would allow and gain some learning on this operation. There was also the desire that we eliminate, to the greatest extent possible at least in this portion of the program, the differing organizations that we had to contend with - the designer, the construction agent, a separate lump-sum contractor, then the integrating contractor taking over the facilities and hiring a different installation contractor. We felt that with the different government management and different contractors, the procedure that was not helping us in getting the maximum benefit from the OSTF. So, in conjunction with the program office and Colonel Christadoro's office and the primary contact in the ground systems area, Colonel Jack Calopy, who is now retired, we decided to have a single designer, constructor, and integrator involved. This was our objective - to have Bechtel do the designing, to have them do the construction, and to have them do the installation of the weapons systems hardware under contract to Convair. This was the system that we proposed. We had a design contract from my office, the Corps of Engineers requested and received approval, which we justified in our office for a CPFF contract, and Convair was given authority for sole source of procurement with Bechtel.

Hansen: I'd like to know more about the CPFF contracts which you let - what about the satisfaction of the contractors with normal bid-type contracts. I am speaking specifically about Plattsburg construction and the hearings that came out of it. Many of the contractors wished that they had a CPFF contract. This came out in testimony. Do you feel that the CPFF is a better type of contract for this type of project?

Farwell: I think it was the necessary type of contract for the OSTF. I don't believe that it was necessary for Plattsburg. I'll tell you the difference. When we started constructing on the OSTF November of 1959 I believe it was, we started building it at Vandenberg. We did the first part of it by lump-sum competitive contract. Digging a hole, pouring the initial

concrete - this was something that we could define on a competitive contract. It presented no problem. Then it came to installing the hardware and doing all of this in a compressed time, starting off with a facility that is not more than 2/3 designed. We didn't know what the hardware was going to look like and we still had to start the job if we were going to get any running time because we had the first operational squadron, which was Schilling, under contract in March. We had two training facilities at Vandenberg under contract in the Spring. So, we started the OSTF very early on very limited information. By the time that we got to Plattsburg, for instance, it was fairly well established. We knew by then what we wanted. There were a lot of changes though I understand the reasons for the comments for going CPFF on the constructive part. But then there is more than that.

Hansen: Would you say then that the type of contract that is let depends upon the situation?

Farwell: The only justification for a CPFF is if you can't define the scope of the job. At that time we couldn't do it.

Hansen: This has a bearing really on the objectives of the program. What were the specific objectives of the OSTF?

Farwell: The objectives of the OSTF-2 were to end up with a test facility where we could install and test out all the total components of the weapons system before or far enough in advance so that we could get some learning into the seventy-two operational facilities that we were building. We had to follow the construction very closely because of the forcing effect that the OSTF-2 had. It forced people all along the line, not only ourselves, but Convair and the other people defining their hardware and producing it and getting it out to the OSTF early. This was to give us the chance to put in the changes and see how they fit. Changes were brought before the Configuration Control Board and then installed into the system. The OSTF resulted in a great change, that of changing the weapon systems sooner and thereby saving money.

Hansen: In other words, if you had to have changes, you wanted them early.

Farwell: Yes. The sooner you make a change the less it costs.

Hansen: How do you feel about this approach?

Farwell: I think it is the right way to go. I think it was successful. Under any circumstances, at any time, I would recommend doing

the same thing where you are producing a lot of articles. When you are building many items that cost $4 or $5 million each, it is really warranted to spend a considerable amount of effort on the prototype. If you had a concurrent program that was stretched way out and you could take your time with engineering, maybe three years to build the first one before you started final production, it would be an entirely different matter. I don't see any of our weapons systems ever being in that atmosphere however. If it is an item that has a large facility base then we should get in early and expedite the design and build the article with as much lead as possible. I think everybody recognizes this.

Hansen: Were there any major policy changes during the contract itself?

Farwell: There were changes to the operational program but not to the OSTF. We ended up with a CPFF contract and one of the things that we wanted to do, we actually got. I would say that we did not have any major changes from the beginning to the end of the OSTF. There were minor changes, but the way we conceived it was the way it was built.

Hansen: Often in this business you hear comments like: "Why can't we do this in a business like way?" "What is the reason for not doing it like manufacturers in industry?" My interest in asking this question is to see if there is something different about this business and if there is, to find out what it is.

Farwell: Usually on a big project an industrial firm does not use a competitive bid approach. A selection is made based on their analysis of firms that can do the best job. If they don't consider a big firm competent, they don't use it. We in the government don't have this privilege. Then too, industrial firms have much greater flexibility on contracting methods. They may do part of the job with incentive contracting. They can negotiate the kind of contract that is most useful for the particular project. They can also identify those portions of the contract that they want to be competitive and they do it. In the areas where they want a quality article and they are convinced of just what the article is, they use sole source technique. They pick anyone they want. The justification and limitation in the government and the military over this kind of program is severe and to do anything other than open competition bidding is extremely difficult. Even to get CPFF is difficult. This doesn't leave you off the hook as far as sole source. You still must specify articles and anybody can bid on them. CPFF is just using a more versatile and flexible management technique as far as your constructor is concerned.

Still you have the problems that we had on this job of competently buying all of the other work that was done. You retain the management and that is about all. There's a lot of reasoning to be able to use a business approach. The government uses a business approach but it is dictated by the laws of the land and this is the way that industrial organizations of this country want it, at least this is the way that they tell their Congressmen they want it. That's the way we do business.

Hansen: Let's get to the management structure. Project management usually exists in a functional management environment, that is, in a functional management structure. Within the structure a project management unit competes for money and other resources and often has authority to take some kind of unilateral action which treads on the toes of existing functional authorities. Could you comment on this aspect of the program? Do you feel you had a true project management set-up here and do you see advantages or disadvantages to it?

Farwell: Well, we established and managed the OSTF construction, the design of construction, with a memo agreement that was primarily a document between the Corps of Engineers who were handling the construction and my office who had the design. In this memo we outlined the responsibility of each part. We had a coordinating committee group which met weekly and was responsible for the direction of this project. Represented on the committee were these organizations, the Coprs including the CEBMCO design office which was our primary contracting officer, the project manager of the Bechtel Company on the job, and the project engineer from Bechtel for design, and also in most cases, two AFCE organizations from Vandenourg. One meeting would be in the Los Angeles district engineers office and one in my office. We reviewed the progress made and routinely we would review construction status progresss and any items that were holding up the job. If anything were disrupting the job we would take the necessary actions. We would make a decision on who should do the work. If it was a design it was up to my office; procurement problems, for which we had an input, were handled by us. Construction proolems were the Corps' problem. We kept accurate minutes of these meetings and Bechtel would take design actions and go to the program office and the Configuration Control Board with them. We would identify from these meetings items that were of significance to the Configuration Control Board and then we would take the necessary actions, go through the CCB and get the directed changes. These would then get reflected into design for the following construction. Now, we continued this method of operating until about the time that we were having sub-systems

checkout - through the bulk of the construction, when we were down to the point where we were operating utilities systems and testing PLS systems and this kind of thing. At that time we transferred this management physically to Vandenberg. We transitioned this. We started having a meeting a month at Vandenberg of the whole committee and then we gradully transferred all the meetings to Vandenberg and then named Vandenberg counterparts. Also, we would have someone from Vandenberg go to the weekly meetings. Normally Lt Dale Strait, or now Capt Strait, would routinely attend these meetings representing my office. In the later stages of the program we transitioned this management team over to a similar management team when the I & C effort started. They actually ended up having daily meetings of the Civil Engineer people, Convair, and the program office representatives at the site, resolving facility problems, installation problems, equipment problems, across the board. This group transitioned up there right into an organization running the rest of the work.

Hansen: Would you care to compare this type of management organization and the actions that could be taken with other types of organization? I would like to have some kind of comparison between the two, in terms of ability to handle problems.

Farwell: The fundamental difference was the degree to which we worked on a problem and the amount of coordination we got with the different organizations. Unless you set up some kind of a project management group of this kind, your communications between the competing organizations just break down. You end up writing each other letters, sending telegrams. You just don't communicate fast enough with each other to resolve the problems on a program that move as fast as this one. On the earlier programs and some of the later ones where we had not used this management technique, time slipped away from us. You have to stay on top of the problem. When you have different organizations with different responsibilities, you can't let the routine means of doing business apply. It just won't do it. It takes a lot of effort. It takes a lot of people to run such an operation. You have to really staff it, but it pays off in the long run.

Hansen: Of course this gets into the delegating of authority and centralizing it. Do you think that you had quite a bit of authority to deal with problems?

Farwell: Oh, yes. We had all the authority we needed.

Hansen: How about money?

Farwell: At that time we had no problems with money. We had all the authority and we had all the money we needed. The test of the program was the ability to manage it - get information and make the right decisions. Of course, you don't get the opportunity very often to run a job of this nature, with these kind of ground rules. When we wanted to make a change, we made it. This was the first program that we really actually established close configurations for all over and in the early stages of the Atlas F program the CCB was meeting primarily on facility configurations and facility changes. I think it was a good test problem and a good training problem. It worked out real well. It gave the opportunity to let the other organizations in on what the changes and the impact on them and making sure they were adequately considered. There was no slow up on this. We worked it out so that we should have one meeting one day and we would have a daily staff problem. A meeting at Convair was scheduled a day later and then a few days later a meeting at the CCB and we would have all these staff inputs ready.

Hansen: Would you care to comment on this type of organization and the attitudes of the people who might have been trasferred from a functional or line position into a project position. Quite often project managers will cut across functional organizational lines. They have authorization over people who are answering to other people. I'm interested in finding out whether you had any bad experiences with this.

Farwell: I think we got excellent cooperation with everyone involved. Of course, the organizations we were cutting across were in the Corps of Engineers. We had to have the confidence and authority of the District Engineer of the Corps to act on the direction that we provided. This was real important. If we didn't have this we would have been totally unsuccessful. In my office I had the authority generated from General Leonhard and Colonel Christadoro also. General Leonhard was my immediate boss in the functional area and Colonel Christadoro then had a project office where he depended upon the reaction of people in different staff agencies. I was his facility man even though I had another boss. He had to look to me to do a facilities job for him. I had the authority from him to get the job done. If I had to explain all the actions to my immediate boss and to the project office to act on the Atlas F program we would have been building it today. With anything that moves this fast you just have to give the authority to a group of project people and let them go. If they don't do the job, you fire them. There isn't any other choice. Where you have a program that is fast moving and if you want speed, you have to do it this way. Otherwise, it would have taken a

month to make a decision that we made in two or three days, doing it individually with coordinated positions to the various functional offices. We had groups of people who had delegated authority for that. In other programs we didn't have this group delegation. It just takes time.

Hansen: Could we talk a little bit about design requirements that might have been new to most contractors?

Farwell: We had some new things. We were designing a single, so-called unitary structure. The over-pressure level was not new. It was the same as was used for the Titan I, so we had some basis of design. But we were using a shock mounting system at an over-pressure that had never been used before. We were building a silo deeper than had ever been built before. We were on a new frontier so to speak as far as facilities design was concerned. So the design requirements were pretty severe. Value engineering, this has gotten to be like PERT you know? If you say you use value engineering then you're all right. I think this is the same as PERT. People will say they have value engineering programs. That doesn't necessarily mean that they do value engineering. The same thing applies here. Good design has always had value engineering. You reivew alternatives, you look at different techniques of doing the job, you review the design when you are through to see that you have considered the various things, to see if you've gotten the most economical design. We do this, although in our business we don't have a value engineering department, per se. We come up with a design and somebody else makes it. The one who gets, say two hundred Minuteman sites, is the one who should have value engineering. If he can save five dollars an article, on two hundred articles this makes a lot of difference. While we didn't call it value engineering, we feel as though we used the value engineering idea all through the job.

Hansen: Were design requirements too tight? Was it necessary, in some cases to relax the requirements?

Farwell: I don't think we did. There were certain things on which we had to give deviations.

Hansen: Did you use many waivers?

Farwell: Some waivers. Most of the things we wanted were met. There were deviations along the line of the type where you end up with a different piece of hardware from what you were thinking of on a piece of paper. In most of the cases we ended up getting about what we wanted. We learned things through this,

of course, on the OSTF and the Atlas F. We've attempted to get into the other programs what we learned. It's surprising how difficult it is to get learning instilled in different programs where you have different people. It's not easy, this learning curve business. It's real difficult to get into an area like this.

Hansen: Now about the question of the ranking of the parameters of performance, time and cost in order of project importance as they existed. The using agency, the Air Force, is very much interested in getting the item on time. Would you say it was more interested in getting the item on time then it was on what it cost to get the item?

Farwell: Specifically, with respect to the OSTF-2 program, I would say we were fighting time as our number one problem. Number two was performance and number three was cost. If you look at the situation we were in at the time, I don't think that the decision could be any different. Today, in 1963, we don't look at things like we did at that time. Then we had about three missiles in operational order. There was a lot of talk about the missile gap and how far behind we were, and there was a press for us to get operational. Cost was not the object. I still think that as far as that was concerned it was the only thing we could do. Later on, perhaps with the later squadrons in the operational program, the importance of performance, time and cost could have been arranged a little bit differently. Not so as far as the OSTF-2 is concerned. We could afford to spend more money on that. It was well worth the extra cost for the benefits that you could get downstream. I think it paid off.

Hansen: How do you feel about the construction job?

Farwell: I think that we got a good construction job up there. I think that everyone was well pleased with it. We here felt that Bechtel did a good job at interpreting what was to be done, and did it in a limited period of time. I think it was a very good way of doing it.

Hansen: Do you feel as though the original quality of work was up to standard?

Farwell: It was up to standard. It was far above what we got from the other jobs because there was an incentive for the contractor to do it right.

Hansen: What was the incentive?

Farwell: Well, the incentive was that he wasn't bound by a lump-sum contract. The lump-sum contractor is constantly thinking about how he is going to come out. If he thinks he is in difficulty, he does only what the inspector might catch. The approach here was to do the job as it's called for and do it right. We were after performance and quality. This is not always true of lump-sum contracts.

Hansen: How about rework?

Farwell: There was not a lot of rework but there were a lot of changes that had to be made. We had probably more than 50% to 70% design change. A lot of things were rebuilt.

Hansen: The rework was due to design - not quality?

Farwell: It was primarily due to design in the OSTF. Where you had reached a point and there was a change you just had to do some tear-out. I don't want to give the impression that you did 50% tear-out when I say that we had 50% to 70% design. It's not the fact that we did that much but that there were design gaps because of program urgency. There was probably a 10% rework and the others were merely additions to the program somewhere along the line.

Hansen: Now that leads us into the next question. What effect did design changes have on ability to adhere to design or functional requirements? There evidentually were quite a few design changes and they must have had effect.

Farwell: This was the object of having a designer-constructor. We had a Bechtel project engineer on the job and we were in constant contact all of the time with the people on the site and with the project engineer. We had a project engineer in the Bechtel design office who did nothing but see that there was reaction quickly to requirements of the OSTF. The result was that we could go from Bechtel designer through the Corps to the Bechtel constructor in a real limited period of time. The people in the construction business knew it was going on constantly. If we didn't have this contract arrangement it would have taken much longer.

Hansen: You said before that time was of the essence. Did you get it done pretty much on time? Excluding scheduled slippages due to design changes?

Farwell: We ended up with this project, even with all of the design changes and all of the problems involved, very much on schedule. We were substantially on schedule. With the start of installation,

we had a three month joint occupancy period scheduled where we would still be working and where Bechtel, working for Convair, would be initiating installation. Convair people would be in there supervising installation of equipment and hardware.

Hansen: Did the construction agency have to go into much overtime or extra shifts?

Farwell: There was overtime and there were extra shifts. I don't recall how much. I think that Bechtel can tell you and I think perhaps that some of the Corps people can give you the idea of the extent of this.

Hansen: Are there any other items you might want to comment on?

Farwell: Well, with regard to the question of whether the design was up to the standard of design requirements. I would say that it was. We did have some problems in this area. For instance, there was a lot of government supplied equipment that we had out in other contracts that were lump-sum contracts. There were some difficulties meeting what we were after in these items. Here we learned in many cases that we were the first to get articles and the first to test them out. But having Bechtel aboard meant that we could get these things checked out and find out what was wrong.

Hansen: How about cost of the project?

Farwell: Over-all cost of the OSTF and over-all cost increases were definitely below our experience on the rest of the Atlas F or the Atlas E programs. We ended up building the OSTF in the shortest period of time. It was the most affected by changes. It had the greatest delays due to late delivery of hardware of any site, yet we built it cheaper than anything in the Atlas program. The record will show this. We know what each one of these sites cost us and the OSTF at Vandenberg was the cheapest one we built.

Hansen: Were there any labor disputes?

Farwell: I don't think that we had a problem with this. Bechtel had, of course, international agreements all the way around where we had subs. There were pretty good working relations as far as this job was concerned and since Bechtel is also the manager of the installation of the Convair hardware, we had a single manager over it all. I don't recall any labor difficulties on that job at all.

Hansen: What about the effects of concurrency?

Farwell: This was the most concurrent job that you could imagine. We were constructing before people had finished design of any of the hardware and the missile. I think that we had OSTF-2 about finished before we launched the first Atlas F. I don't think that we built anything in the whole program as concurrent as the OSTF.

Hansen: What effect did new materials and methods have on construction.

Farwell: There was nothing particularly new in this thing. We were using steel and valves and the working positions were a little bit different. Building in a hole this big is something a little new. It isn't any longer, we've built so many of these silos that people are quite fimiliar with them. There were no significant material problems. By this time we had built several silos of comparable size.

Hansen: One of the complaints of the contractors at the Plattsburg operational site was that they might get paid for a design change but it had a snowball effect so that other things in the job had to be changed and they could not get reimbursed for these other things.

Farwell: Of course they ended up getting paid for it. There was a settlement on this a few months ago. They ended up getting around $7.5 million or $11 million. They ended up getting paid for everything. The job at Plattsburg turned out costing maybe two or three times what the original bid price was. They were the last squadron in line and by no means were all the costs here due to design changes. It was just a poor job of management. Anybody that had any connection with it would affirm this. There is no question that changes did effect the job and they should have gotten paid for them. But they had problems in management too.

Hansen: You were milestoning for planning and control of delivery?

Farwell: Yes, we were using the milestone technique and we were using the management by exception. You establish milestones for certain critical dates. We used lots of them. We included in the construction contracts some twenty-six different points on which we wanted certain items to be finished at a set time.

Hansen: Did you pretty well meet them?

Farwell: Well, on the OSTF we did. This was the start of the PERT technique or at least the milestone technique of management in which we said if constructor is too far behind at this time he will not finish on time. It was used with reasonable

success. I think we used this technique to some degree in the Atlas E, and we used it more on the Atlas F Program. I think it was helpful although there was resistence to it. The normal management procedure on a contract is to tell the man what you want, when you want it, say two years later. Then, when it is a year later, he isn't due to deliver and therefore you can't make him do anything. This had been our previous experience. I've been up to some of our Atlas D sites where you could look at some of the progress of construction and you didn't have to be very smart to know that the man couldn't possibly finish on time. The position of the contracting oficer was that until the man didn't actually meet the schedule, I can't do anything about it. Wait until the man has not met his schedule and contracually, then we can do something about it. Sould we have him accelerate? This is totally unacceptable. This is the reason we put some of these interim dates in. They were used to a degree. If a contractor didn't meet one of these interim points, the contracting officer had the authority to accelerate him, that is, to tell him that he must put on additional forces to come up to schedule. The way it worked out (not on the OSTF program because it was CPFF) in the operational program, was the contractors were told they were behind and that they must increase the forces to accelerate the program. Eventually these contractors made claims against the government to the effect that, well, if they had been left to their own devices they would have met the schedule. They claimed they were forced to accelerate and therefore should be reimbursed for all extra costs. They won every case. I don't think that there was a single case where the contractor was not reimbursed for the extra cost incurred through enforced acceleration. It's not for me to say that's for the contracting officer to say. I would like to see a critical path technique that would be useful in this area. I'd like to know what it could be, I'm not smart enough to know what it should be when you have a lump-sum contract.

Hansen: Maybe that's what they are planning to do with these incentive contracts, possibly with incentive contracts with a good critical path system.

Farwell: That's the magic word today. There are a lot of contracts we're looking at right now, where you can't identify a good incentive technique. I know some contracts where we would like to use an incentive contract but, if we made it incentive, the objective of the contract would be other than to manage the job. It would be to raise the target in order to get a greater fee. You can't use an incentive contract unless you can get a real good idea of the scope - a real firm scope.

Hansen: Was the management structure adequate to control and evaluate efficiently?

Farwell: I think it was.

Hansen: Do you feel that it was quick to respond?

Farwell: Very fast to respond.

Hansen: What provisions have been made to have this learning, this ability to respond carried to new contracts?

Farwell: We carried it over to some degree. We attempted to do the Titan II job at Vandenberg with this technique. This was a CPFF contract however, it was not for a designer-constructor. We had the design contract. There was another organization that had the CPFF construction work for the Corps. We set a similar committee but it was not as effective. First of all, we did not have the designer-constructor relationship. Secondly, the way the CPFF contract was managed, almost every significant job on the Titan II at Vandenberg was operated as a lump-sum sub-contract, fixed-price. The result was that when you wanted to make a change in direction in the project you had the same disadvantage that you had if you had a fixed-price contract to begin with. All we ended up with was hiring a construction contractor to provide our management. We hung so many fixed-price subs on him that we lost a lot of benefits to be gained from the CPFF contract. We were restricted in our ability to react. It just wasn't as effective as the Atlas job.

Hansen: Finally, if you had to go through it again, what would you like to see changed?

Farwell: I can't think of anything in management that I would change. I think that the one thing that would have benefited us more is if we could have done the Atlas OSTF on the same schedule. If we had the same press of time, we could do it with pretty much the same management technique that we used, but to have had more time to get that construction experience before we had to go out with the operation program. The one thing that I would recommend in the future would be to gain a little more information, to get a little farther along with the prototype or know or define the system a little bit more than we needed to. This is in essence saying that you should just go so far on this concurrency idea. I think that we pressed it a little farther than we needed to on this job. We're trying the Minuteman and Titan II programs on this. We don't talk about them being quite so concurrent but they have the same

problems of extreme concurrency as the early Atlas. They really do and we pay for it. I don't know of any alternative.

PART IV A-4

Interview with
Lt Colonel Page Cowart
Chief, Atlas F Facilities Design Branch
under Chief of Design
Ballistic Missile Division
USAF

on 27 February 1963
at Vandenberg Air Force Base, Calif.

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Mr. Hansen: Please identify yourself.

Col. Cowart: I am Colonel Robert P. Cowart, presently Civil Engineer of the 6595th Aerospace Test Wing, Vandenberg Air Force Base, California.

Mr. Hansen: What was your position at the time you were working on OSTF-2?

Col. Cowart: During the time I was working on OSTF-2, I was Branch Chief in charge of the facility design of the Atlas F program.

Mr. Hansen: And your specific responsibility was design?

Col. Cowart Facility design as contrasted to the weapons systems design and its associated equipment development.

Mr. Hansen: Do you feel that the contract requirements were adequate and specific in schedule requirements?

Col. Cowart: I feel that the contract itself was acceptable as far as any contract could be in this type of development system. We could not reach a point of putting everything down in words because we were developing concepts, design, and weapons systems all concurrently. So you see, we could not write everything down to cover aspects of things unknown.

Mr. Hansen: Does a development contract have to be more flexible?

Col. Cowart: Definitely. It must be so flexible that you can change it daily.

Mr. Hansen: Are there any specific comments you might like to make about the contract itself? Were you inhibited in any way? Were there barriers to your actions?

Col. Cowart: I feel there were some barriers. When I speak of these barriers, I mean ones that are set up by an Air Force contracting officer working with a contracting representative of the weapons system contractor, such as Convair or General Dynamics Astronautics. This does not leave a clear line of communications between the technical personnel in the Air Force, and the architect-engineer or weapons systems companies. We attempted to develop this line of communication, but in several instances we were actually blocked by interpretations of the contract, as we were not sure if we were actually violating contract intent. This was a difficult thing to uncover.

Mr. Hansen: What effect did past experience in site construction have on the scheduling, construction, and the performance aspects of the OSTF?

Col. Cowart: We used past experience on the weapons system operation to develop criteria, schedules, and prepare our directions for architect-engineers. There was considerable effort on the part of Colonel Farwell in this area when we first started our work. Knowledge of construction problems (such as weather conditions, long-lead procurement items, labor problems, etc.) which we had encountered in construction of the earlier site, helped us to make much more realistic schedules. It must be remembered, though, that the civil engineer could only make recommendations for construction schedules, since we were only a part of a total program. This activity was not limited to the OSTF-2. It actually went into the total weapon system since we leaned very strongly towards configuration control in an attempt to make silos throughout the country practically identical. Col. Farwell pointed out early in the program that we had completed several horizontal launchers of different configuration even on the same base. We found that if minor details, such as wiring runs, location of guages, size of equipment, are not specified, each launcher will be entirely different. It was a shock to most of us to see the freedom of interpretation of plans and specifications allowed the workers of different trades with the construction industry. We attempted to change this by having the architect-engineers make construction plans with details approaching that of shop drawings. We also constructed the OSTF-11 using the Bechtel Corporation as the designer-constructor.

Mr. Hansen: Then the OSTF-2 actually served as a pilot model.

Col. Cowart: The OSTF-11 was a pilot model and we used it as such. It guided the construction of the total Atlas F program.

Mr. Hansen: Did this configuration control hold during the entire Atlas program?

Col. Cowart: Yes, it did.

Mr. Hansen: What design requirements existed that were new to most construction contractors?

Col. Cowart: The big thing was tolerances. Aircraft industries work with tolerances of 1000th to 10,000th of an inch. The construction contractors were not accustomed to working on massive steel and concrete structures with these controls, and in fact, had difficulty meeting 1/16th of an inch. They were accustomed to tolerances of $\frac{1}{4}$ inch, $\frac{1}{2}$ inch, or even larger in some cases. Living with these rigid tolerances has become something of a habit to the people here at Vandenberg. They are accustomed to this type of operation, but the Atlas F was covering the entire country where the construction people did not have this experience.

Mr. Hansen: Do you feel some of the tight tolerances were unnecessary?

Col. Cowart: Yes, I do. We attempted to block these as much as possible -- especially the ones we felt were unnecessary, but I know some did creep into the design. We could have functioned well without these. I feel a very definite improvement in the design of future weapons would be one which would allow adjustments for inter-connecting weapons systems to facility type equipment.

Mr. Hansen: Who had the responsibility for the designing of the silo?

Col. Cowart: The design of the silo was the responsibility of the Air Force Civil Engineer. This included the concrete structure itself, the tunnel from the control center, the flooring in all the areas, the major steel crib supporting the missile, the propellant loading system, the propellant tanks and support utilities such as roads, etc. All of these activities were designed and controlled by the Air Force Civil Engineer.

Mr. Hansen: In other words, you had two design agencies involved designing two systems which fit together. How is it possible to make the requirements compatible?

Col. Cowart We came to a point of terminology - "interface" - which has become second nature to us in the missile game. We use the term interface any time the design of the weapons system company matches a point of design of the facility engineer. It can be a mounting bracket, a wall plug, or an electrical outlet. It can be a connection for water lines where the weapons systems people install a cooler such as the missile air conditioner. It could be just a plane in space where we are reserving a certain area in the silo where the weapons systems engineer is to place a cabinet. Such interfaces are where the problems really have arisen between the weapons systems contractor and the Air Force design agency. This interface is very critical to us.

Mr. Hansen: Can you suggest a possible solution to this problem?

Col. Cowart: I feel that, though the problem was easily solved, we did have our differences, which was lack of communications between the technical people of the agencies involved. When I speak of technical people, I am speaking of the civil engineer types, and the Air Force weapons systems engineers who know the equipment and the requirements. But you cannot beat establishing good criteria, and actually having meetings of individuals around the table to lay out the problems for group solution. One individual cannot make all decisions for this type of facility. It has to be worked out as a group effort.

Mr. Hansen: Did you work together other than in group meetings?

Col Cowart: We did, and it was invaluable. We had an engineer from Convair-Astronautics who worked with us continually in our design section. He visited us at least once a week, and usually twice a week. He discussed the possible changes and the problems areas which could arise because of weapon system changes. He would also pass current information back to his own engineering section at Convair Astronautics. We also had continual liason between Convair Astronautics engineers, and Bechtel Corporation. People actually worked side by side on the drawing board when the problems arose. We also had Bechtel people assigned to Convair Astronautics, working in their area, working with their engineers, and also working on the mock-up which you saw in San Diego. They worked side by side in every case.

Mr. Hansen: Do you feel that this type of arrangement was more satisfactory than some other type of arrangement?

Col. Cowart: I feel that this is by far the most effective of any I have seen. We became an organization made up of individuals from numerous sections acting as one to develop an Atlas F. We had Air Force weapons systems engineers and Space Technology Laboratories people working with us. Bechtel was our designer for the Atlas F program, but we also had other architect engineers such as Black and Veatch, and Stearn Rogers. There were Air Force civil engineers, Convair civil engineers, Convair weapons systems engineers; and we became, I would say, organizationally integrated as a team.

Mr. Hansen: What were the conditions that brought this team approach about?

Col. Cowart: We were forced into this by earlier missile operations where we were having continual complaints and a shifting of blame from one agency to another. The weapons systems people, Convair Astronautics, were continually blaming everything that happened on the earlier Atlas sites on the Air Force engineers. The Air Force engineers, in turn, were blaming everything on the weapons systems people for not furnishing good criteria at the beginning of the job. We were actually fighting each other rather than working together as a team. It was a natural reaction in getting the job to run smoother and to complete it within the time span specified. It just naturally fell into place that we had to have a team concept, and no one, to my knowledge, balked at this approach to the problem.

Mr. Hansen: We've heard of the advantages of team solution of problems. Can you think of any disadvantages?

Col. Cowart: Very definitely. Any time you work with large groups, or with representatives of groups, you increase reaction time. At times, we actually lost time in making decisions, or arriving at a new approach to a problem. This in itself was costly when you realize that we were building practically all Atlas sites at one time. Any delay of reaction while making a change or decision was reflected at all sites. This became quite costly.

Mr. Hansen: Did you have a project manager?

Col. Cowart: Very definitely not that I could see from my operation in this program on the OSTF-II. We attempted to divide the tasks under the Atlas F program into a civil engineering task and one for the weapons system or the missile itself. Throughout this program, we attempted to accomplish a project-manager type operation by acting as a team; a representative of both the Civil engineering side and a representative of the Air Force BMD weapons side acting together to make decisions. This was used only if our committee or decision making group could not render a decision. This happened several times when our committees would actually come to a stalemate, and could not reach an agreement. At this time, a decision was made by a weapons system engineer and a civil engineer concurrently to determine the direction the program should go. I would say that the attitude portrayed to the civil engineers by General Leonhard was that even though the civil engineer was not responsible for other than the facility design, we should not allow anything to interrupt the continuation of the design, construction, and future installation of the missile. If decisions were not handed down in time, we were to make them to keep the program moving and on schedule.
The completion of the jobs on time was accomplished with the approval of everyone involved, and I feel they were accomplished at a very reasonable time and cost. Like anyone else, I would probably make decisions today which would differ from the decisions I made two years ago, but now that is past history.

Mr. Hansen: Would you comment on achievement as far as performance, time, and cost are concerned?

Col. Cowart: Well, in achievement of performance and time, I think the programs we have been associated with the last two years have been excellent. The area which we could not directly control and the one which seemed to cause the most trouble was cost. It very definitely varies from program to program, from site to site, location to location, and from contractor to contractor.

Mr. Hansen: Would you comment on why you think there was a great deal of cost variance and why the average cost usually comes above what is expected at the initiation of a project?

Col. Cowart: I feel that we can lay a lot of the guilt to contractor management. The contractors, in making their estimates of a job of this nature, didn't appear to tie in firm costs at the time. At least this is the way it seems to me. They lost sight of the fact that they must move fast; they must expedite; they must manage numerous sites going on concurrently. The site locations are separated by as much as 100 miles for the Atlas program. It can be as much as 400 miles for the Minuteman program. They do not allow for enough management coverage to actually maintain good cost factors. Therefore, any time a change comes up, they must cover their inadequacies of management by increasing costs. Also I feel that our architect-engineers, in making their estimates on a change order, did not have enough information available, nor did they consider close enough the cost impact a delay would cause the contractor. Our change orders could run costs up five to ten times the original estimate of time and materials. Where a contractor is faced with a large number of tasks, a small change thrown into his operation could completely throw him off pace and cause him to start a new attack. This cost had to be covered. Now, this seems to be taking the contractor's side by saying he had a reason for some of it, but overall, from the way the programs varied from base to base, I feel the contract management could have been much better.

Mr. Hansen: Let's say that I am a contractor. I know I should bid properly as far as estimates for cost, time and performance are concerned, but I know that if I do, I'm not going to get the job. What is my reaction going to be? I'll probably underbid the cost and hope that I get reimbursed.

Col. Cowart: You are absolutely right, and I would probably work the same way. I would underbid the job depending upon changes that arise, immediately overbid, or put a high cost on them to come back with my profit.

Mr. Hansen: Let's go back to the basic question then. Is the fixed-price contract the most logical type of contract for this type of operation?

Col. Cowart: I don't think so. I think the CPFF type contract would have been advantageous to us because of the numerous changes that we knew would occur under the concurrency concept.

Mr. Hansen: There are some hopes that the incentive type of contract will be proper for work such as operational site installation.

Col. Cowart: I very definitely feel that we need something in between these two types of contracts, and I think that this may be our answer because, as we mentioned earlier, the fixed-price leads us into high cost problems both on the contractor side and on the government side. Also, the CPFF can lead us into very poor management on the contractor side where the government pays for all the costs. If we had something in between where we could utilize the best of both, we would have an excellent tool for this type of work.

Mr. Hansen: As far as the OSTF-2 is concerned, do you feel that the construction was up to the standard of design requirements?

Col. Cowart: Yes, I feel it was superior.

Mr. Hansen: The constructor was Bechtel?

Col. Cowart: Yes, it was Bechtel.

Mr. Hansen: Why do you think it was superior? Do you think it was the company itself? Did they have better craftsmen or do you feel that it was due to good management?

Col. Cowart: I personally feel that here it was due to good management.

Mr. Hansen: Would you say that most of your changes were due to problems of concurrency - that is - building at the same time that you were designing?

Col. Cowart: We had numerous kinds of changes caused by concurrency. The weapon system was being developed at the same time as the facility. Not many of my colleagues would agree with me, but I believe that this was not the only problem. I feel that during the design of a facility of this nature, we were not given enough design time to evaluate all engineering problems, and this allowed the overlapping of various trades. I have found numerous occasions where the changes were caused, strictly within the facility design itself, by the overlapping of these functions. I feel this is an area for much improvement. I would like to see a very strong project level over the facilities design areas to tie the areas together in order to overcome these problems. This is one example. Early in the program, it was pointed out to me that an exhaust by-pass was needed because of heating of a certain valve. This appeared reasonable, and we approved the change with instruction that the change be implemented, and that anything associated with it be implemented. The change was designed and put into the field. Very shortly thereafter, a second change came about stating that we had forgotten to place expansion sections in this by-pass which would now cause heating at a higher rate. So that took a change within a change. Soon after this, it was found that by extending the by-pass and the expansion section, there was an interference with structural steel and several electrical items had to be relocated. Finally, after I had several harsh words with the project people at Bechtel, I discovered that we had forgotten to change insert plates in the wall. This is an example of how one change can happen right after another, and how one change causes another in cascading fashion. I feel very strong prototype activity could have overcome this. A project engineer could have overseen this and design coordination could have accomplished the job with a one-time change. In my opinion, this is a weakness in our design program.

Mr. Hansen: What types of disruptions caused either schedule slippages or added resources cost? We are getting into the area we talked about before but now I'd like to treat it specifically. Were they mainly changes in design? I know that you didn't have a schedule slippage in the entire program although you might have missed a milestone or two.

Col. Cowart: We missed milestones several times. We were worried about meeting schedules. Changes did cause much of the slippage of milestones; rather, the effect of these changes caused slippages. We had numerous delays in the change information reaching the contractor so he could start. Also, we found that the contractor would have some delays which we could not overcome. An example of this is one problem we had in the early days of Schilling when we put out a supply type contract from our Schilling contractor to American Bridge in Orange, Texas for the crib structure. They did not start this until late in the program. We had numerous changes caused by weapons systems changes or materiel changes -- things of this nature. Actually, much of this came about by a design change involving suspension supports or spring connectors. But we did make these changes, and the immediate reaction of American Bridge was that it was impossible to do this job. We attended a meeting with them, the Corps of Engineers, the Air Force people, and Bechtel designers to try to solve the problem. American Bridge was very insistent that the job could not be accomplished on schedule. Later Kaiser, steel fabricators on the West Coast, approached Bechtel and General Leonhard with the proposal that they could get the material, fabricate it, and have it delivered to the first three sites at Schilling in accordance with the original schedule. This proposal was accepted; and this arrangement gave American Bridge time to deliver the first of their nine cribs to the fourth site on schedule. These are the types of delays we had throughout the program. We also had many difficult problems with the tank fabricators. They could not get material, could not fabricate according to schedule, could not deliver. Other delays such as transporation delays, would force us to put tracers on flat cars enroute from plants on the East Coast to their destinations at the sites, and we would have to know each stop. We had a flat car which was in St Louis for a week, and no one knew where it was. With a CPFF contract, we could have worked around such slippages. We could not do this with the fixed-price contract without an additional cost. This actually occurred here at Vandenberg when a large quantity of liquid oxygen tanks were delivered later than scheduled. We had planned on delivery early in the operation so they could be lowered to the bottom of the silo before the major steel work. The tanks were held up in delivery, so we had to erect the steel work, and then find a way of very cautiously lowering a fifty-one ton tank down through the silo steel to the proper location. This job was done very efficently by the Bechtel Corporation.

Mr. Hansen: Would you care to compare the changes, disruptions, etc. with other non-defense construction jobs? Is there anything really so unique about this that it does demand a different type of approach? For example, take a great big construction job like the Hoover Dam. Would you be likely to find somewhat similar changes and somewhat similar problems?

Col. Cowart: No. Very definitely not, from what I have seen in private enterprise or in government activities. We hear people talking about spending four, five, or six years or more on design of major jobs. In fact, I understand that the Corps of Engineers is spending as much as five years on a harbor design effort, and they can follow that with a program of ten years construction. Comparing this with the dollar value of the Atlas F, we accomplished design and construction in two years in contrast to 15 years for major civil works. We were constructing sites from ocean to ocean which complicated it even more. A time schedule is the hardest thing to meet, I think. We really don't give people the time to accomplish the job as they would like to do it. This is the big difference. This was a new design area for us, especially in the liquid gas and liquid oxygen field. We estimated requirements which were beyond our technical knowledge at that time. We had to advance the state of the art as we designed.

Mr. Hansen: What management control methods were used for changes and schedules?

Col. Cowart: We used a system of bar graphs and schedule time factors. Our bar graphs showed milestones, established by our technical engineers and by Bechtel designers, which we tried to follow very closely. The graphs reflected the best estimates the engineers and designers could make. This was not very successful, as you know, since we might have a time schedule of three months to dig a silo, and the contractor might come out with special equipment, or extra people, and would finish the excavation in six weeks. Or it might go to the other way, taking five months. We ended up using the Corps of Engineers "S" chart which they persuaded the contractor to tie in with our milestones. We had differences of opinion in certain areas which we felt were critical. The "S" chart shows the percentage completion of the job. Actually, it has the dollar value on one axis against a percentage completion on the other. It is called an "S" chart because it starts out very slowly, then progress increases very rapidly, and then in the end you see it slow down again trying to complete the last per cent. So it looks like a figure "S". From observing this chart, we could see when a contractor was failing to meet his milestone for excavation, etc. At this time, we would present this to the group to determine how to get the job back on schedule, or we would call in the contractor, and point up what activity he could shorten in the future that would make up for this loss of time. It was a system of monitoring a bar chart. At the time we were working on this program, I think we should have had a good PERT chart. I feel that PERT gives us a much better control.

You asked about the control of changes. This, again, we developed in the program, and I feel it is quite unique. Every change, regardless of the magnitude, was controlled by the headquarters in Los Angeles. I say controlled because it had to go through that office for recording purposes. The request for change would be made up on a request form by the field man, the designer, Convair, or by the project office. This request would be processed through our change control at Los Angeles. We would record it, analyze it, and have our designer, Bechtel, review it to see what effect it would have on the operation, and to determine if it would change any of their designs. We would hold a meeting to discuss this change, and then it would be directed to the field. We could by-pass some of this activity by allowing certain freedom to the field offices. If problems arose which would stop work, endanger lives, or would endanger government property, the field office would immediately make a decision and run the change through. The paper work covering this change would follow later to the control office in Los Angeles for recording. This had tremendous advantages for the entire program. A change which occurred on the OSTF-II would effect practically all sites. This was immediately placed into our change control system and passed on down. Every change received a change number -- an index number. We recorded these, and kept them on record. They were cross referenced to the Corps of Engineers modification of their contract, and all of this was recorded for posterity to give us a pretty good control on the system. This system was expanded and improved, and passed on to the Titan II and the Minuteman programs. A similar type system is being used on them at the present time.

Mr. Hansen: In fact, what you did was to form a classification of critical changes that had to be done right away, and other changes that need not be done right away?

Col. Cowart: This is right. I dislike to use the word critical, because we would not approve any change unless we considered it mandatory to make the system work. Once we had established our design, we would not allow any change unless it prevented hinderance in the operation of the system.

Mr. Hansen: What I was thinking of was the control over additions to the working drawings. Did you have any problems there? While you were anticipating change or the mechanics of making a change, would they be constructing something which would have to be altered by the change you were just beginning to put into effect?

Col. Cowart: — I mentioned this earlier, I think. This was one of our problems. While changes on the OSTF-II were being studied and designed, supplies were being ordered and work was actually being accomplished at the earlier sites. This was one definite disadvantage of the change order system. If a change took too long, the contractors in the field would have accomplished work which would have to be redone. However, the advantage in the OSTF-II was, if the change was caught soon enough, it could avoid problems in the later squadrons.

Mr. Hansen: How many drawings were involved on the OSTF-2?

Col. Cowart: I think we had over 300 drawings. This is only in the civil engineering area, and does not include any of the support equipment by Convair Astronautics.

Mr. Hansen: Was there any attempt made to carry over the things that you learned on OSTF-2 to other projects? What setup did you use to gather this information and to take what is learned on the Atlas F over to the Titan? What was your mechanism for doing this?

Col. Cowart: Very definitely, and this was one great advantage we had over the separtation of the Civil engineer organization within the BMD or BSD. This organization, under General Leonhard, built the facilities for all weapons systems. Even though there were no direct relationships between the Minuteman and the Titan II, and the Atlas on the weapons side, the civil engineers were all working together under one commander, General Leonhard, at BMD. We passed the information back and forth to each other. We had one Central engineering office which reviewed the engineering work of our architect-engineers; and by reviewing the plans for all weapons systems, they naturally could compare engineering solutions. By just discussing mutual problems, and the passing of information back and forth, civil engineers would come up with solutions applicable to all weapon system facilities programs. An example of this was the change order procedure which I mentioned. This has now been accepted in all weapons systems.

Mr. Hansen: If you had it all to do over again, what things would you like to see changed?

Col. Cowart: I would like a tighter control on the change order procedure and a more stringent control by the one headquarters. This is speaking for the total weapons systems. I feel that our operations

on the CSTF-II were good, and I don't feel there should be any changes in that type of project unless we reach the point where we could have one project manager heading the program. If we had one program alone to develop, say the Atlas F, I would like to see one man at the top of it. But with several programs to develop, I feel the system we have been using is working well.

Mr. Hansen: Do you have any other comments at all on any of the things we have discussed?

Col. Cowart: No, I believe not. I think that covers nearly everything. We did establish in the Atlas F a criteria development section within civil engineering which was headed by Lt. Colonel Charles Alexander. He worked in close coordination with the Atlas program office, and with STL, who established criteria for our program. In fact, he was physically located in their office. They worked together in the beginning of the program, established criteria and passed it on to us as designers to develop it into a workable design for a construction agent. Whenever we found a problem area for which we were unable to find a solution, we would go back to Col. Alexander. He would work with the program office which handled the change orders, and would determine whether the problem area was essential. If we found a problem area which was becoming very expensive for the construction contractor, we would immediately consult with the program office to search for a middle of the road position which would be easier for both sides. This was a new procedure which was established in this program, and it worked with the two offices so close together. We have the same type of setup now. We did not have a project manager. We had a team!

I found that the experience I had on the Atlas F was invaluable when I went to the field on the Titan II. I worked on the construction of the Titan II, and found that, even though it was done by Parsons Company, the approach to design change concepts, design approach, and everything accomplished in that program were the same. I felt the job was well done. It was a very proficient design, and was one that was accomplished on schedule. Again, I must say that the people working together did a tremendous job, and I feel that any any of the architect-engineers who worked on the program should be complimented. The ones with whom I worked never criticized nor complained about any part of the work assigned to them, especially Bechtel Corporation, Parsons Company, Black and Veatch, and Stearn Rodgers. We talked earlier of the blocks in contract activity. I never saw an operation blocked between the Air Force civil engineer and the architect engineer. This became a very closely knit team, and we all worked on the problems side by side, to achieve a common goal. I consider this resulted because of the attitudes and mutual respect of all personnel working in this program.

PART IV A-5

Interview with
Lt. Colonel John Everhart
Chief of Civil Engineering
Engineering Branch
6595th Test Wing
Ballistic Missile Division
USAF

on 6 March 1963
at Edwards Air Force Base, California

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Mr. Hansen: Please introduce yourself.

Lt Col Everhart: Lt Col John W. Everhart, Chief of Civil Engineering, 6595th Air Space Test Branch.

Mr. Hansen: Would you comment on the specific objectives of the OSTF-2? What do you see as the specific objectives?

Lt Col Everhart: I think that one of our objectives in the OSTF-2 was to see that our designs were right before we moved into our operational bases. Also, it was the operational test facility for the Atlas F program.

Mr. Hansen: What type of contracts were in effect?

Lt Col Everhart: You might say we had a combination here. We had a hard dollar contract for the excavation and for the pouring of the concrete silo liner, and then a CPFF for the remaining type of facilities.

Mr. Hansen: Why?

Lt Col Everhart: We hoped to improve our design and take the bugs out. It appears to be more advantageous to the government to go CPFF except for that portion for which we have a good definitive design.

Mr. Hansen: Do you think the contractual arrangements were acceptable?

Lt Col Everhart: Yes, I do. We could have gone hard dollar contract all the way if we had a completely definitized design. This allowed us to pick up time by going hard dollar with that portion we had designed and CPFF with the rest.

Mr. Hansen: One of the other gentlemen I interviewed said that one specific objective was to provide a prototype. You could get design changes into the prototype so that you would not have to be making them on the operational sites. Is this correct?

Lt Col Everhart: This is part of what I categorized as improvement of our designs. We realized, with the operational bases coming in, that we had to have standardization. If we could put in the prototype those things that, from the design concept standpoint, appeared to be the most feasible, we could prove in the field that

it would work and not be making costly mistakes down range on the follow-on projects.

Mr. Hansen: Did it accomplish this objective pretty well?

Lt Col Everhart: I think so.

Mr. Hansen: Was the contract adequate and specific in its requirements as far as schedule, specifications and quality? Was it legally adequate?

Lt Col Everhart: Yes, I do. The construction agency Corps of Engineers might have a different idea on this. After all, the construction agency had the main responsibility for the enforcement of the contract.

Mr. Hansen: I am interested in trying to place OSTF-2 at some point in a time continuum with regard to state-of-the-art. What amount of technical know-how about site construction had we gained prior to OSTF-2 that helped us? What did we gain from OSTF-2 that helped us further?

Lt Col Everhart: Construction-wise we did have some experience in silo type constructions with OSTF-68 and TF-1. The training facility for Titan was virtually completed at Vandenberg. We could make a direct application of the knowledge gained from this in the construction of OSTF-2 because TF-1, for instance, was what was often referred to as "Hollywood Hard". In other words, it looks hard. It did not carry the inner design. The criteria for suspension, shock mounting, and ground shock were designed into OSTF-2. OSTF-2 was basically a site adaptation of the operational base which took into consideration overpressures and ground shock. So, generally speaking, we had experience digging holes and pouring concrete in them. But the design I would say for OSTF-2 was sophisticated and was a design similar to TF-1. The first operational Titan I facility at Laurie, was under construction but they were not far enough ahead of us for us to gain any information to use on OSTF-2.

Mr. Hansen: What type of management organization was used for OSTF-2?

Lt Col Everhart: Well, you have to describe it, I suppose, as a team effort, the Corps of Engineers being one member of

the team responsible for the construction and the supervision of the construction, and the Air Force, the other member, with responsibility for the design and construction surveillance. Consequently, any interface problems that came up were brought before a weekly working group. This group consisted of the Corps of Engineers, and their selected prime contractors and sub-contractors, the Air Force, who had present the airframe contractor or the associate contractor working with and for the Air Force, as well as a representative of the design agency. At these meetings, a decision was made on each and every problem based upon the time involved, the cost involved, and effect on performance. If it were the opinion of the team that it was more economical to the government to change the facility, the facility was changed. The necessary paper work was sent to the Corps of Engineers at the construction agency. By the same token, if it were more economical or feasible to change the hardware being furnished by the Air Force side of the house, the hardware was changed.

Mr. Hansen: In this OSTF-2, as in other missile programs, it appears that the using agency gets quite heavily involved in the project itself, more so than in a typical manufacturing type situation or delivery of a piece of munitions equipment, for example. You're much closer to the problem, sitting on these committees, and so forth. Could you explain why?

Lt Col Everhart: It was necessary that the using agency work quite closely with the design and construction agency because of a basic requirement in the ballistic missile program and that is the philosophy of concurrency. A schedule for the design, construction, and operation of a normal manufacturing facility would be put together by determining how long it takes to design, how long it takes to construct, and how long it takes to place the equipment and make it operational. With our ballistic missile program, in order to close-up a missile gap, we establish a mandatory end date and work back from that. This puts us behind before we start. Thus, we have to go concurrent on some items. The same philosophy was utilized in the design and construction of the ballistic missile facility. In order to have a facility to house and fire a missile at a particular date, we started with that date and worked backwards, taking so many months for installation and check out time.

This gave us an end date for the completion of construction. Backing off from that end date for the completion of the design and further, we came up with when we should start a design. Invariably, one would find that the start date had already passed. Consequently, the only way to reduce or take out 12 to 14 months, which was approximately the amount of time we were short on schedule, was to overlap various activities. For instance, when we had enough of the design completed to build a construction, construction would start. Then, when the second package was finished, design-wise, we would start construction with this. This was alos true with the installation and check-out contractor, in this instance, Convair. Convair was forced to start placing equipment, installing equipment and in many instances, checking out equipment before the construction contractor had completed his task on the facility. Thus, it was necessary to have the using agency, in this case, Convair, aboard with us. Another factor that is quite obvious to those who have worked with us, though not to those who have not, is that we were forced to go to design and even construction of this particular facility before the hardware or the equipment that was going to be placed at this facility, had been designed. Consequently, as the GSE equipment that was being furnished by the hardware contractor became definitized on the drawing board, we found that the assumption that we had made in designing our facilities were not compatible with AGE. Consequently, we had to have an almost daily feeding of information from the airframe contractor so that we would, in a timely manner, react to the design changes that were mandatory to make the complete weapon system operation.

Mr. Hansen: Authority was not properly delegated or the responsibilities were not defined properly?

Lt Col Everhart: The problem with management was getting the right representative from the various organizations with full knowledge and authority to act for that organization.

Mr. Hansen: I see. The man that was sent to the committee meeting then, was someone who really couldn't make a decision at that time?

Lt Col Everhart: This was true in some instances and this was not necessarily a shortcoming of the individual himself.

It is very hard in an airframe organization, in this particular case, Convair, to find one individual that knows all the subsystems of the weapons system. It is even more difficult to find an individual familiar with the interfaces that invariably come up with the many subsystems and the facilities. You can find an individual that is completely familiar with everything that goes with the booster, or everything that goes with the airframe, or everything that goes with the nose cone. But you cannot find an individual who can answer the questions on all of these. So the obvious schoolbook solution to this is to have a representative of each one of the subsystems and subcontractors. When you resort to this you get away from team or committee action and end up with a big conference where you don't accomplish anything. At a meeting actual items would be assigned to a particular representative to find out what the position of his organization would be.

Mr. Hansen: Well, actually how do you feel about communication between organizational units as a result of this type of structure?

Lt Col Everhart: The communication at Vandenberg at field level between the construction agency, the Air Force as a design agency, and the using agencies representation at Vandenberg was very good. There was room for definite improvement in the communications between Convair-Vandenberg and Convair-San Diego. Possibly the communications could have been improved somewhat between Air Force-Vandenberg and Air Force-Inglewood. Possibly, in some instances there could have been a little better communication between the Corps-Vandenberg and the Corps in the Los Angeles District.

Mr. Hansen: Has there been anything done since then to improve that problem?

Lt Col Everhart: Yes. Communications were definitely improved. In the case of Minuteman and some of the space programs that later followed, the Air Force delegated more authority to the field.

Mr. Hansen: What effect did this type of organization have on the attitudes of people involved in the program?

Lt Col Everhart: There is one thing that I know I learned and I am sure

that a lot of other people learned. That is that the ballistic missile program was no place for heroes. One man couldn't do it, and one organization couldn't do it. I think this was reflected in the attitude of the people that participated in the working conferences that we had. They might be very firm in their convictions on a particular point but if, to achieve this point, they would jeopardize the program and that would be giving in.

Mr. Hansen: Would you say that there was more tendency for people to stick their necks out in this project than in a less critical project?

Lt Col Everhart: I would not want to commit anyone but if people didn't have their necks stuck out we wouldn't have gotten finished.

Mr. Hansen: You agree then that there was a realization on the part of the people involved that this was a very important program and that it was bigger than any individual or organization?

Lt Col Everhart: I definitely think this is a good way of wording it. I would say that I think all agencies involved were motivated, all agencies had a cooperative attitude. What can we do to solve the problem? Not just become a part of the problem. This does not mean we did not have our differences of opinion. A different approach to the problem, but which ever approach appeared to be the most logical was followed regardless of who thought of it.

Mr. Hansen: What about the attitudes of people towards the type of organization you have?

Lt Col Everhart: Well, the management organization at Vandenberg is made up primarily of the using agency, construction agency, and the Air Force. Any individual who had an improper attitude or did not appreciate the over-all problem to the point that he was not contributing anything to the solution or to the problem was removed. There were instances where individuals had to be removed from the working committee.

Mr. Hansen: There has been quite a bit of talk about gold plating in the missile business. Value engineering is an attempt essentially to eliminate unnecessary design or gold plating and to simplify design where feasible.

Now, was there any attempt to use this approach in the design of OSTF-2, whether you call it value engineering or some other name?

Lt Col Everhart: Not value engineering, per se, as we know it today. However, by virtue of the procedure followed by the Air Force requiring preliminary and final reviews a lot of items were eliminated that did not appear essential or were of the gold plating type.

Mr. Hansen: You would say that the installation was not over-designed?

Lt Col Everhart: Generally speaking it was not over-designed.

Mr. Hansen: I know that OSTF-2 was completed on schedule and that the cost was slightly higher than estimated at the beginning of the project. What do you feel was the primary reason for the slight increase in cost?

Lt Col Everhart: The slight increase in cost was caused by many things. Concurrency hikes costs. Concurrency cost us a little more in OSTF-2 than should be expected as far as operational bases. This, we desired. The primary reason for the increase of cost in OSTF-2 was due to the changes that were ground into it. These changes were due to various things; change in criteria, change in operational philosophy, design changes necessitated in the facility because of the late design of AGE equipment, and changes that were brought about due to interfaces in equipment.

Mr. Hansen: Do you feel that construction was up to standard of design requirements?

Lt Col Everhart: Yes, in comparing OSTF-2 to previous design facilities, I think so.

Mr. Hansen: How do you feel about the utilization of work seasons, equipment, personnel and the method by the construction contractor?

Lt Col Everhart: We were fortunate in having good weather during the whole construction period. Because it was a CPFF contract the construction contractor had good equipment and good personnel. We had the best of everything on the job.

Mr. Hansen: Was the committee organization we spoke of before reasonably quick to respond to needs?

Lt Col Everhart: In most instances it responded in rapid fashion. You had a decision at the end of the meeting on problems that arose that had a possible effect on other parts of the weapon system and the decision could not be made at a meeting, usually you could have a decision in 48 hours to 72 hours. I think it was very effective.

Mr. Hansen: Col Everhart, if you had to go through it again what would you like to see changed?

Lt Col Everhart: I would like to see some concentration on improving communications - not only improving communications but the taking of necessary steps to assure that individuals in working group meeting would have full authority to commit their home offices.

PART IV B-1

Interview with
Mr. Raymond Hole
Deputy Chief, Engineering Division
Corps of Engineers
Ballistic Missile Construction Office

on 4 March 1963
at Englewood, California

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Mr. Hansen: Would you identify yourself, sir?

Mr. Hole: I am Raymond E. Hole, Corps of Engineers. I was chief of the initial small branch within the Los Angeles District which worked with the then Western Development Division of ARDC. We started off with myself and four people in May of 1956 doing close liaison with the WDD office. This small organization within the Corps was augmented and increased in size during the following years, renamed, etc., becoming the Corps of Engineers Air Force Missiles Office in 1958. In 1959 it was physically moved to the Ballistic Missiles Division complex at Inglewood and in July 1959 it was renamed and further staffed to be named the Los Angeles Field Office of the Office, Chief of Engineers. All three of these early organizations had cognizance only over design reviews of the Air Force prepared designs for the Ballistic Missile Program. In August 1960, the Los Angeles Field Office was absorbed into a renamed and augmented organization called the Corps of Engineers Ballistic Missile Construction Office (CEBMCO) which physically took over as contracting officers for all of the going missile projects and advertised, awarded and administered all subsequent ones. I have been Chief of the Engineering Division and Deputy Chief of the Engineering Division continuously from May 1956 until February 18, 1963 when I was transferred to North Pacific Division at Portland.

Mr. Hansen: As you recall OSTF-2, what do you consider to be the specific objectives?

Mr. Hole: OSTF-2 means "Operational Systems Test Facility" or "Operational Suitability Test Facility" depending on who you are talking to. The two simply means the second one at Vandenberg, but the second one only of this name because the first one was for a different missile system. The prime purpose of the facility was to provide a location for operational testing of the missile system itself in the environment and in the facility that was to be a part of the over-all Atlas F program.

Mr. Hansen: What kind of contract did you have with the construction firm?

Mr. Hole: As I recall OSTF-2, because of the urgency of it and the lack of design, we actually had three different principal contracts. The facility was not designed, although the size and shape dimensions were pretty much scoped, so the first contract was a contract for the excavation of the silo portion only. This excavation included, of course, the necessary

ring beams for support, During the time that this excavation was under way, design was continuing and upon completion of excavation either a separate contract or a continuation of the same one took care of the concrete lining. In other words, the shaft walls up to what we called the haunch elevation which was where the door top, etc., went on. In this first contract of course, were none of the interior facilities. There was the necessary imbedded piping, all the necessary reinforcing steel and concrete, of course, and a certain number of piping supports on the walls. I believe on this contract, the launch control center and the connecting tunnel was also included. Then, after this was pretty well along and the designs were available for Schilling, which was the first of the Atals F bases, the CPFF contract with Bechtel (who were the designing engineers for the Atlas F Program) was negotiated, justification being provided by the Air Force and supported by the Corps, getting necessary secretary approval for the CPFF contract. Bechtel completed the construction including all of the interior. The CPFF contract also included the installation of all the equipment that we bought under separate contracts. They were labeled "assigned service contracts" because they were destined not to be supplied as government furnished equipment, but the construction contractor was to take over administration. In this case, at Vandenberg, I believe they stayed straight government furnished and that Bechtel had nothing to do with administering the contracts because they had only one of many sets coming out of the factories

Mr. Hansen: There has been quite a bit of discussion about the merits and the deficiencies of the fixed-price contract. This isn't too important in the case we're discussing but I wonder if you would comment on the values that you see in a fixed-price contract over the CPFF or vice versa for the type of work that Bechtel is involved in. You recall the Plattsburg hearings and the comments made there. How do you feel about this?

Mr. Hole: A lump-sum contract is basically designed for the construction of a facility for which you have a fixed design. Having a fixed design, a lump-sum contract is the ideal way to run the job because it puts the incentive on the contractor where it belongs. On a CPFF contract there is no incentive whatsoever for getting the job done or for solving problems. The reason for the CPFF contract on OSTF-2 for the interior work, installation, etc., was that good plans were not available. We were told there would be myriads of changes which would be worked out and then extrapolated into the plans for the missile squadrons which then would be relatively firm jobs. This was lip service as it turned out, because this

was not the case. Had we known that the Atlas F program would have such numerous changes, a lot of them after OSTF was completed, we would have recommended strongly going to CPFF on the entire Atlas F program. There were too many changes, changes upon changes.

Mr. Hansen: It is my understanding that the Vendenberg site was supposed to serve as a pilot model, in order to iron out the changes so that changes to operational sites would be fewer.

Mr. Hole: This is true. This was supposed to be the shakedown. It was a prototype and it was designed principally for weapons system testing, but it was also supposed to serve a secondary purpose: To shake down the design and work out the bugs. Actually, there were two facilities, General Dynamics Astronautics in San Diego had in one of their hangars down there a full scale mock-up of the crib, that is, the structural steel assembly that goes into the actual missile silo, upon which nearly all of their gear was modeled. Although the Air Force was the designer through Bechtel and although The Corps of Engineers was constructing, the ability to make on the spot changes at the site and to get those back up into the designs for the follow-on-squadrons was complicated by the intermediary of GDA sitting there doing similar things to their mock-up and coming out with changes that would back up the other ones. So to get what appeared in the field to be necessary changes back up into the plans, would be a matter of weeks and weeks. This was further complicated when as soon as we got some of the initial squadrons under contract the necessary controls, Configuration Control Board, etc., on the design itself took even longer.

Mr. Hansen: As you look back, how do you feel about contract requirements, the original requirements of specifications, drawings, etc. Do you think that they were adequate, could they have been better?

Mr. Hole: The first contract which was excavation, and the continuation of the first one, which took care of the concrete lining, were completely adequate. There were no problems whatsoever. Construction went along in a very timely fashion. Because it was so early, those contracts had very very minor changes in them. The CPFF contract for the "guts" piping and wiring inside and the top, were, of course, inadequate, which was why we had a CPFF contract. That was the only justification for it. You don't know what you are going to build when you get a contract and therefore, you feed drawings to the contractor.

As a case in point, the structural steel drawings for the steel crib were not detailed completely and were changed, and changed, and changed as time went on. We did make use here of a little ruse, because the structural steel drawings were being shop-detailed in the Kaiser plant, who had the fabriacation contract. We decided that since those were going to be checked out and available and because of a horrible burden on each contractor in the squadron program to prepare and submit similiar drawings, starting with the first squadron, we would include shop-detailed drawings in the data to be furnished to the construction contractor. These we took from the OSTF contract and put out to all of the operational squadrons. This would have been fine had they been jelled at that stage, but even at that time, they weren't. So we got cribs in the hole that had to have members replaced. We had a lot of crib steel bought and then, of course, it got complicated by that 1959 steel strike.

Mr. Hansen: Did you experience a lot of waivers in the program? Or did you generally stick to the design?

Mr. Hole: Waivers weren't necessary. We stuck to the design.

Mr. Hansen: As you see it what type of management organizations were used on the OSTF-2? I'm thinking of the management structure which involved the using agency, the constructor, the integrator. What type of organizational management would you call this-committee, team effort or project management?

Mr. Hole: Well, it could probably best be categorized as a composite management organization. Over-all management concepts for all ballistic missile construction was established by WDD early in the game. There were some minor changes but the Air Force side of the family was well established at Vandenberg, the first base, a training base. This was called the BMD Liaison Office. The office title was changed, and changed, and again changed in the last year or so. Really, what this was to be was the on-site detailed contact with the facilities design office, which was the office responsible for the design, and correlation of the design with the integrator doing all of the coordination of the weapons system for the Air Force. The field office was also to control the field troops of the integrator and all of its sub-contractors or associate contractors. In the initial stage of a construction job for instance, the BMD field office

or the WDD office at that time, would be working with the resident engineer almost exclusively. As the job came along with the installation of certain inter-faces, the integrator people would be looking in and getting involved in questions, answers, etc. Then, as things got farther along, their associates got involved also. So far as the Corps is concerned, normal management associations were utilized, although a little bit different in these cases because of the closeness, not only physical but ideological. At that time our office was under the Los Angeles Field Office. We had come from the Los Angeles District and had good associations up there, so we went direct to the Los Angeles District with information, directives, etc., not going through the normal Division Office-District chain and we simply had to advise the people what we had done. We worked directly with them. Our office became involved in a management committee or special coordinating committee set up for each one of these jobs for which we had CPFF contracts. This was composed of membership of our office, of the District, and of BMD. It was to be the first sounding board for additional changes, for new requirements, for delays due to lack of decisions, or things like that. This group had no particular authority except that it was the place where the problems were brought before everybody, including the Corps, for coordinated solutions. Everybody would take their problems, hear the problems, or hear of something new like, "Would we add this to the present contract? Make a new contract out of it? Make a separate contract out of it? Can we buy this thing separately? Can we expedite the procurement of this somehow or other?" Apparently in the field, at the BMD Field Office Area Engineers Level, they were having similar meetings, in which the GDA people and the integrators were invited. They would hash over field problems in the same group atmosphere.

Mr. Hansen: Do you feel that this organization that you described had authorities and responsibilities defined adequately?

Mr. Hole: The responsibilities and authorities were defined adequately, yes. The problem was that they were limited. Over and above this was the normal WDD-BMD organization which had its own fixed channels for adoption of changes. Whatever the field committee or the local committee felt had to be done, they had to then go through this other channel of communication.

Mr. Hansen: Do you feel that this was a real limitation?

Mr. Hole: Oh, yes, definitely.

Mr. Hansen: Do you know of any other problems that might have come out of this type of management organization?

Mr. Hole: No, simply responsiveness.

Mr. Hansen: See any benefits?

Mr. Hole: Well, I think that with the complex organizations involved and with the authorities either assumed by or given to the Air Force, that this was about the only way it could have been done really. Normally in a job like this, the Corps would have complete authority to go ahead and do the job. But with controls put upon it and because this was to be the operational prototype, it had to be like the others that were coming along. The Corps, having no control over the designer being employed by the Air Force, had to go the way the Air Force wanted. We had to have the answer but we couldn't get the answer because sometimes, "it was a state-of-the-art type of thing, or the black box that GDA was to install here wasn't yet developed, or that they had the inclination that the black box was two by two by two in the original criteria." But they finally got it designed or got it built by Burroughs or somebody and it turned out to be two by two by four. So, something had to give and the change had to be uniform at all sites.

Mr. Hansen: Do you feel that the Corps could have had more input and authority in matters of approving design changes?

Mr. Hole: Well, the answer is yes, and I think that this was proven by the eventual reorganization of the Corps to have a closer control over construction. At the time that this job was done our office had no jurisdiction whatsoever over construction. We were charged with a minor amount of construction liaison, surveillance and reporting but had no direct controls. As I explained in my opening statements, the Corps in seeing and finally getting a grasp of what the entire ballistic missile program consisted, of the urgency of it, and the great impact it would have on the construction capabilities of existing Corps of Engineers districts and upon the construction industry itself, finally in 1960 the CEBMCO (Corps of Engineers Missile Construction Office) was organized and took over with jurisdiction over construction directly. This was considerable improvement over the old procedures. Although it didn't work 100% effectively, there was continuity within CEBMCO from program to program. This had not existed before.

The only place there was continuity in the program prior to this was in the Omaha district where there were early Atlas D and E types, the Titan I facilities and then the Atlas F facilities. They had all three types, so they had people who were familiar with problems etc., and knew some of the stories. We felt from the very start that our engineering division, given proper authorities, could have been of considerable assistance in the program across the board. We had been in the program from the very beginning. Without these construction authorities we couldn't do anything but attempt to convey information about problem areas to counterparts in the districts. This became much simpler, of course, when we got our own construction agency with the directorates of CEBMCO.

Mr. Hansen: Well, we have touched upon the attitudes of the people involved, how organizational structures have considerable effect on attitudes. I am sure there was considerable effect in this case. Would you comment on that?

Mr. Hole: I think in this program there was not what you would call inter-service rivalry. In fact, there was very little. There was some at the top management level. I don't know whether it was serious or whether it was of a propaganda type, but there was a constant threat hung over the head of the Corps and there still is. "Well, if you people can't do this the way we want it, we'll take it away from you and give it to the Navy or do it ourselves." Well, this doesn't make for good feelings, obviously. At the working levels the relationships were good. I use the word "good" in lieu of "excellent" here. There were cases where they were excellent; we had some very fine contacts. There were individuals, again, who could see only their way of doing things - a "we will do it our way" attitude. This caused problems. At the field working level the attitudes were good. We had a little difficulty with some of the districts relating to them the urgency of the over-all program. This was more difficult with industry I would say. This required a training program and there are still cases where it is difficult. Private business will do things the way they want to do them, you can try to hurry them all you want to, and they are still going to do it their way. There was and is a problem just categorized by the simple word "personalities." Where I think that now everybody is trying to head down the same path, there are still individuals in the Air Force and in the Corps too, who although they are working on the same weapon system only at different bases, say, "Well, we are going to do it this

way, we don't care what you guys are going to do, we are going to do it our way." This is still going on and it has caused considerable pain. I think in some cases, it helped the over-all program but it makes it extremely difficult when you go back and try to retrofit. The fact that these things must be all the same is lost sight of by some people.

Mr. Hansen: Why do you think the Corps became involved in the program?

Mr. Hole: Initially?

Mr. Hansen: Well, let's say the whole site activation problem.

Mr. Hole: Well, I think the Corps was properly involved in it. The Corps has been the construction agency stateside for military construction ever since George Washington's days. I don't think the Air Force could ever have tooled up a construction agency that could have taken care of the job; I don't think anyone but the Corps could have.

Mr. Hansen: Well, let's get into the design criteria which is probably of real concern here. What design requirements existed that were new to most contractors in site activation of the OSTF-2 specifically?

Mr. Hole: I would say there is nothing unique in the criteria. The excavation job was slightly unique with the shafts being somewhat larger in diameter than had been put down before in this country. But the problems were not severe. Generally speaking we had extremely good luck. There were spot locations where there were problems. I will still contend that most of these problems were contractor generated. Plattsburg was an example. This was just poor workmanship. We had some extreme problems of running soil at Schilling and Lincoln. With adequate planning before they started and with some thinking on the spot after they got in trouble they could have saved a lot of the problems but they didn't do it. The propellant loading system, which was a separate contract, was no great problem to construction contractors. These were not the first propellant loading systems. We had them on the Atlas D and E programs a little more complicated than on the Atlas D and E programs a little more complicated than on the Atlas F. We also had them on the Titan I. So this was not new. We had very few problems with instrumentation. The biggest problem and the newest concept here was something that most contractors lost sight of in doing the job, and it became

a real problem during the middle stages of construction when we were getting changes upon changes. The multi-level construction going on in the hole and the fact that you have so many people in such a small horizontal space makes it extremely difficult. This little aspect was one of the things that caused more problems than anything else. It is still going on in Titan holes. You have to build this crib up from the bottom. This is the way it was set up to be designed and built. You can't very well get equipment down to the lower levels while you're working upper levels of the crib because you need hoist space and there is not enough room to do work, etc. Therefore, you have to do your steel work, bring it up, hang it off on the sides with the Convair furnished hangars, then start at the bottom and do all the piping and wiring and all this sort of thing. It makes it difficult when you have to get so many people in this small area.

Mr. Hansen: Working on concurrent tasks?

Mr. Hole: Yes, on concurrent tasks. Then you plan your work in complete detail to try and do this level by level as it's coming on up and bringing up your vertical rungs as you go. You could have planned this thing down to the nth degree and had it worked out very nicely, but your plan would have been upset the minute the first change was issued. So, you're going back falling all over yourself. Suppose you have your electrical work done. Your mechanics are in there putting in piping, and equipment. For electrical changes you have to put electricians in the same place moving wires and conduits around at the same time the mechanics are trying to do their work and they've got to move their stuff, so pretty soon you've got six guys standing there saying, "What do we do next?" and "Who has priority?"

Mr. Hansen: Was there a great deal of this?

Mr. Hole: Yes, constantly.

Mr. Hansen: Well, was there an inordinate amount, considering the size of the project, the dollars involved and the complexity of the operation?

Mr. Hole: Well, you can't very well relate it to OSTF-2 because this was the way of the CPFF contract. So far as the operational squadrons were concerned - yes, there was an inordinate amount involved. I don't have the specific number of changes involved, but it doesn't mean

too much because "What is a change?" We got a certain number of change packages but these could have changed things from the LCC to the bottom or top of the hole in one change. If you want to talk about the number of times you changed the location of a light switch, or changed a conduit, I would say that there were thousands.

Mr. Hansen: Well, we touched upon this before. What other comments would you care to make about the design and spec requirements for OSTF-2? Could we have simplified designs considerably later on in the program?

Mr. Hole: No, not the design. The design was pretty well established. Just looking at this thing from a quick bird's-eye view, the facility itself is an extremely simple one. The only unique requirement here is that you have a specified hardness level. Really, all the facility is, in either the launcher or the control center, is a place in which we put the weapon system gear, plus whatever necessary pumps and water handling and electrical generating equipment you have to have. So, the facility itself is simply designed. It was ordinary concrete, a little thicker than you would normally find in a hole like this because of the hardness level required and with heavier steel. The hole inside was then tailored to fit the location where power, air, water, gas or anything like that would be required by the missile. You couldn't very well simplify this unless the missile was simplified so you had tight controls. Space controls were trying to keep this thing as small as possible, therefore, as cheap as possible to accommodate the inside. In other words, just putting a cocoon around the bird. When you start asking whether there would have been simplifications, I say yes, the propellant loading system could have been simpler. But this would have required a basic change in the thinking because at the start of the program, the oxidizer selected for these systems was liquid oxygen. Rates necessary to load the bird in the short reaction time required transfer at a rate of approximately 5,000 gallons per minute. When relating this to anything that you or I are familiar with, this is equivalent to 20 firehose streams. Well, at the time the decision was made and the planning was going on, there were no pumps available to pump Lox at this rate. There were small pumps, laboratory type and off-loading type at plants and on trucks, but they were not the large ones. The decision had been made then that we would have to go to a high pressure gas transfer system.

Well, at the time our construction was under way, pumpmanufacturers were going ahead with experimentation and there were pumps that could have done the job, a battery of them - a much simpler system than gas transfer. By this time design and construction of the pressurized system were down river to a point where you couldn't back up and change to pumps. This is the principal simplification that could have been made, but it was too late. You can always do something better after you have already done it the hard way.

Mr. Hansen: By "too late" what do you? To far along in the program?

Mr. Hole: Too far along - so many things hinged upon this. To have used pumps would have required additional power - the power being on-site power generators within the cirb itself. This might have doubled or tripled the amount of power required. There is no place for more generators on the crib so the silos would have had to have been deeper, or bigger around. Well, you couldn't do this. You can't stretch a concrete shaft. Add to this the fact that procurement contracts were out and fabrication was underway on the vessels and on the PLS valve assemblies and on the piping. There would have been cancellations across the board and re-doing of construction in places which were unthinkable because of the target dates.

Mr. Hansen: The problem of concurrency again?

Mr. Hole: This was the fault throughout the program. It was a war planning decision which I'm not qualified to criticize. But when you first choose a weapons system and decide to go with it and you decide concurrently you're going to have emplaced as of a given month of a given year, you have automatically made a decision on which you can't make any basic changes. But there is nothing unique and nothing too much that could have been changed in the Atlas program based upon Titan I experience.

Mr. Hansen: Would you care to comment on the state-of-the-art of missile system facilities?

Mr. Hole: There is not too much state-of-the-art involved in facilities. I'd say concurrency contributed to many of the problems. For one example, you decide to mount the equipment on shock mounted platforms and unless you give the contractor all the information and make him design it, you are forced to design a set of springs, we'll say, for what you think the item is going to weigh. Well, if the item you get

weighs something different you've got to pick this up immediately and redesign the springs. There were slips in this process. In fact there are still slips in the Titan II program we're going back and putting in new springs in a lot of cases.

Mr. Hansen: How do you feel about the construction itself? Was it up to standard on the OSTF-2?

Mr. Hole: I've heard very little criticism on the OSTF-2. The initial excavation and the concrete were very well done. Bectel did an excellent job on the installation. Ive heard of no problems with it.

Mr. Hansen: How about some of the other sites?

Mr. Hole: Generally speaking construction was pretty good throughout. There were problems in various spots. There were design interpretations taken which caused us serious problems at some of the Lincoln sites where for the sake of economy, the decision was made to put in a so-called "soft bottom" in the silo. It was only a six inch slab. You get a certain amount of settlement or excess pressure on the outside due to high water tables, and the slab has a tendency to raise up and crack all to pieces. But, generally speaking, the construction was good.

Mr. Hansen: I noticed that water seeps through quite a bit. Are water and moisture a problem?

Mr. Hole: Water is a problem, no matter where you go. Anytime you put a structure in water you have trouble. Theoretically, concrete is a good material if used properly: But concrete is not a water-proof material. Water will come through it. Then, if you get interrupted and get stuck in the middle, for example, and end up with a cold construction joint where you get new concrete going to old, you are going to have a parting seam. To make this thing absolutely water tight is almost impossible. There is no way, of course, with this type of construction, to put a water-proof membrane on the outside as you do with double-formed normal construction. Also, there are so many penetrations coming through, conduits and so forth, which also pick up water outside and drop it inside the hole. At the time the early jobs were done, there was no requirement to have the hole water tight. Subsequently, this was one of the strictest requirements the Air Force imposed mainly because of interpretation by individuals.

Mr. Hansen: I take it then, that you don't completely agree with these demands?

Mr. Hole: There is no apparant need for them. There are air conditioned spaces which are required, but air conditioned space is separate from the bulk space. The air conditioned space is required around the missile and for certain critical equipment, but it is not in the same atmosphere as the over-all hole. There are sump-pumps to take the water out; therefore, a small amount of leakage cannot do any harm. Concrete can be made water tight, but you have to make additional provisions over and above ordinary construction practice. In fact, at one time we had the requirement for water stops in all joints but because elimination of this requirement theoretically saved a few dollars it came out.

Mr. Hansen: Was the construction cost relatively high for OSTF-2? In order to meet schedules in this business usually cost has to suffer.

Mr. Hole: I don't recall the figures on OSTF-2, and here again I am talking strictly from memory, but as I recall the buy-out cost for the entire Atlas program was 1.8 or 1.6 of the initial contract cost.

Mr. Hansen: This is on the low end of the spectrum as far as missiles are concerned because they can go as high as 10 times the original estimate.

Mr. Hole: Well, yes, as far as the missile part itself was concerned. But as far as our part with the facilities, it was in this range someplace. And I think this was expected by everybody.

Mr. Hansen: What has been the range on other facilities?

Mr. Hole: 1.2 or 1.3 in some of the later programs. I guess Minuteman is down around 1.1 or 1.2.

Mr. Hansen: That is the low level?

Mr. Hole: Yes, and then up to 1.8 or 2.0 for the early Atlas "D" and "E". But then again, this isn't a fair comparison either, for you are comparing different things. In the early programs they weren't complete facilities as awarded, so what went into them by change were often times added to make them complete.

Mr. Hansen: How about time?

Mr. Hole: As I recall, OSTF-2 stuck pretty well to the initial time schedule. There were no time delays authorized. It was a CPFF contract to get the job done by the certain date, so there was additional cost brought on by overtime work and additional shifts.

Mr. Hansen: Were any new materials and methods introduced that construction people were not familiar with?

Mr. Hole: Not that I recall. There were, in the loading system, of course, new type gaskets and fittings and so forth that they were not familiar with, but they were recent developments and simply modifications or extensions of existing trade knowledge. The biggest thing here again, I think is the maintenance of cleanliness which is something over and above anything that has ever been done before in all of these propellant loading systems. Under field conditions, trying to install heavy piping and equipment with surgical cleanliness is pretty rough. Of course, all sorts of special measures were required - enclosures of plastic and clean clothes, nylon gloves, special spark proof tools, and all that sort of thing.

Mr. Hansen: This is a little bit aside, but I'm interested in it. On fixed-price contract where you are dealing with exotic equipment and numerous design changes, how do you verify the allowability of cost due to a change? How do you determine whether it is a justifiable cost, or too much? It would seem to me this would be a definite problem area. How do you determine this?

Mr. Hole: We in engineering had nothing to do with claims or change order negotiations. But the way it is done is this: The contractor is required to submit a proposal. The government is required to have an estimate. The difficult thing, and this is where the argument always comes in, is upon the impact. This is the great big grey area. It is not difficult at all to work up time and materials. You change your fabricating, say a change in the size of some drum heads. Many of the sizes cut in the shop you have to throw away. You have to go out and buy new material to make new ones. It takes so much additional time to refabricate these. You have a fixed dollar value, for loss and refabrication but if you are waiting for these drum heads to be assembled in the field with 77 men standing around, you've got increased costs. How much allowance is given for this standing and waiting? And this is where this accelerated schedule has effect in the paying out of claims for increased costs due to changes.

They were set up to do the job on the time scale established. They could have done the job. We changed the situation somewhat and didn't respond to their requirements more for clarification of problem areas. They had crews standing by. They had equipment standing by. They had subcontractors standing by. Their insurance went on. Their bonds went on. How much of this is the government obligated to pay? There is no question about this of course on a CPFF contract.

Mr. Hansen: Could the Corps had made the decision to let any kind of contract that it wished to make for the Atlas facilities?

Mr. Hole: No, we are limited by the ASPR's and departmental controls, to lump-sum contracts. You can go in and attempt to get authority for CPFF contracts, but this has to be approved by the Secretary of Defense. With any type of contract, whether it be CPFF, cost-plus-incentive-fee, or anything else, the problem is that you have too many other people mixed up in the job.

Mr. Hansen: Do you think that the incentive contract will prove of any benefit in the construction business.

Mr. Hole: I think that the incentive contract would be extremely misplaced as far as construction is concerned. I think it is very fine in making shoestrings or gun barrels. We have a construction job on an incentive contract. It is just about closed out. It belongs to Minuteman. If we had built the Minuteman job the way it was designed when awarded, it probably would have worked fine; but you change, and you change, and you change. Where is the incentive? You keep on throwing these changes at the contractor, so you end up by raising your ceiling price or something and you still have the argument: "I did this thing in excellent fashion. My management was good, therefore, I should not be penalized by the fact that the cost of the job grew because you made the changes in it."

Mr. Hansen: In other words, it should be pretty firmly designed?

Mr. Hole: It has to be, I think. Because you have so many fabricators, so many subcontractors, such a complex chain. I don't think incentive contracts should ever be used in construction.

Mr. Hansen: How about engineering change control. You have already commented on this. Do you feel that it was adequate in the OSTF-2: I think you mentioned that communications presented some problems.

Mr. Hole: Communication was a problem. Change control was good. Changes took too long. There was almost no way to run them through on an expedited basis. We circumvented this in some cases (in effect we were sticking our necks out) by putting out directions to the field to go ahead and make changes unilaterally. However, we used Air Force concurrence and let the change paper work catch up whenever it could. We had to do this. We didn't like to because quite often there would be something else in the mill which would have an effect on this.

Mr. Hansen: Were there instances where you had people working without drawings? What was your method for avoiding this?

Mr. Hole: Yes, this happened in a few isolated cases. It wasn't very common, but this is always a problem when you get a hundred and fifty silos in one contract and 15 control centers scattered over three thousand or four thousand square miles and changes, changes, changes, with each and every one of the changes having to get out to each site as rapidly as possible. The pure messenger service to get them there is a major operation.

Mr. Hansen: How many drawings are involved in the typical Atlas operation?

Mr. Hole: I guess that there were a couple of hundred.

Mr. Hansen: If you had it to go through again, what are some of the things you'd like to suggest. Take the experience that you had with the Atlas. If you had to go through the same thing again, just exactly what would you like to see changed?

Mr. Hole: Well, going back to the original design, I will speak the piece that I have spoken hundreds of times before in the last seven years. Spend another couple of months on design, getting the job ready in its so-called final form. Then settle back for a good review, not only by the engineers, but by the operators, the weapon systems people, and make it real clear that here is what we are going to do. If you don't like it, speak now or hold your peace in the future.

We are going to build it this way. You go through this and check out everything. When you get through with it, we will make the necessary changes. Aside from this, we are not going to make any. We could still build the job in the same over-all time that it takes us now and probably even shorten it, but you cannot make some people recognize this. A necessity is seen for shooting for a certain date. Somebody set this up on a war plan. You're back here now, but to hurry up today and get a set of plans out because this is a nice construction period is wrong. You get these plans out and then you start changing. Adequate time should be taken back here to clear the design up, to jell it, then allow a reasonable contract period. I think over-all time would be shortened this way. Also desirable is more continuity between similar systems. There is not too much similarity, for example between Minuteman and Titan II, aside from the basic excavation and silo lining. The interior is quite different. We can certainly learn about management techniques from one another.

Mr. Hansen: How about the organization? Would you like to see any changes in this?

Mr. Hole: Well, this gets into a critical type of statement, but I would say yes. The thing that I always critize about a military type organization is that there is no continuity of personnel. And this causes more problems than anything else. In a civilian type organization, which has been the strength of the Corps for years and years, you have people who have been working on a type of job in an area for many years. They've seen all of the past jobs and probably helped to plan future jobs. The way this program went in the Air Force, for instance, they would pull some people in and create the Atlas D, and E, or F shops and probably put a full Colonel in charge of it, working under a General in the design office. The Colonel gets his three years in and takes off for Wright-Patterson Air Force Base, Thule, or someplace else. Probably his replacement is not bought in until a month or so before he leaves. During this time, the Colonel is taking his month of vacation before his new assignment. So there is no cross talk here. This is a brand new man. Maybe he knows what the Atlas F systems look like, but as for detail, he doesn't and the same thing goes true for the junior officers. Well to me this is excessive military staffing. For something like this, it should be more on the civilian side. In

the case of the Corps of Engineers, when CEBMO was created, we had and have what I consider a similar problem. They brought in a bunch of officers for the principal reason that the Air Force was staffed with so many officers and there had to be paralleling of rank. They felt they could not put in civilians, therefore, all of these officers were brought in. Well, as they get their two or three years in - away they go.

Mr. Hansen: Well, of course the military in peace time is really a training organization. Don't they rotate them for training purposes?

Mr. Hole: That is right. But when you consider this program was the number one priority program in the country then there should have been some waivers made. There were in a few cases, but very positive waivers were necessary. If you are going to use officer personnel, the officer personnel should be assigned and left there until some logical conclusion of the job. Other than that, staff with civilians with officer understaffing for training purposes, but don't put them in positions of responsibility and then pull them out in a short time.

PART IV B-2

Interview with
Mr. Charles Zleizy
Project Engineer
Corps of Engineers

on 6 March 1963

at Edwards Air Force Base, Calif.

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Mr. Hansen: Please introduce yourself.

Mr. Zleizy: Charles N. Zleizy, Project Engineer, Corps of Engineers.

Mr. Hansen: Do you think the contractual arrangements were acceptable?

Mr. Zleizy: I think that it gave us additional time. We knew what the house was going to look like, the concrete liner, and the depth of the silo. It gave the Air Force additional time for designing the operating mechanism that would be installed in the house. In the meantime we gained some 120 days on the over-all program.

Mr. Hansen: Was the contract adequate and specific in its requirements as far as schedule, specifications and quality? Was it legally adequate?

Mr. Zleizy: Schedule requirements were realistic because the job was completed on schedule. The tolerances, methods and equipment used in the construction requirements, I think, were all proven to be realistic. We met them. The reason that we went CPFF was so that we could make changes in the contract and specs and only pay for the direct cost of the changes. The quality of CPFF, of course is not limited by by someone's personal opinion. Thus, the quality is probably better than the average hard dollar contract. Also, penalty clauses are completely absent.

Mr. Hensen: I am interested in trying to place OSTF-2 at some point in a time continuum with regard to state-of-the-art. What amount of technical know-how about site construction had we gained prior to OSTF-2 that helped us? What did we gain from OSTF-2 that helped us further?

Mr. Zleizy: This was the first unitary concept design where the bird along with all of its support was housed in the same silo. In the Titan I, it took three silos to house all of the support facilities and the bird. The Unitary concept made it easier to design for over-pressure. You only had to protect the one unitary silo. So, I think that was learned.

Mr. Hansen: What benefits do you think were derived from this committee form of organization?

Mr. Zleizy: I think the greatest benefit was that there was a lot of improvement needed over previous forms. Well, first you must understand that even though we had these weekly meetings, the people that had to make a final decision were not there. So, all that we could do in some cases was establish that we had a problem. I had to go to higher headquarters to find out what to do. So too, did the Air Force representative in that same meeting, have to go in some cases to higher headquarters for a final decision. Thus, the improvement that we gained was to bring either more authority into the meeting - maybe not more people, but more authority. This is certainly an improvement.

Mr. Hansen: Authority was not properly delegated or the responsibilities were not defined properly?

Mr. Zleizy: No, I think that what I really meant, was that the people that attended this meeting representing higher authority didn't have all the information necessary to make a decision.

Mr. Hansen: Has there been anything done since then to improve that problem?

Mr. Zleizy: I think it was improved in the Corps of Engineers internally, by the assigning of specific people within the district at Los Angeles to solve problems that the field level might have. Thus, there was a direct contact instead of a contact with the organization itself. There was direct contact in all departments - engineering, construction, legal, and safety. Individual people were assigned to particular positions as representatives for particular jobs.

Mr. Hansen: Let's get into the design and development area now. Were there any design requirements on the OSTF-2 and the Atlas F that were new to most contractors?

Mr. Zleizy: I think not - speaking for the Corps. Cryogenics was not new to our contractors. The silo and slip-form operations were not new to our contractors nor were the expiration shaft and rise-mining. The only thing that might have been new were the close tolerances.

Mr. Hansen: Some tolerances were relaxed though?

Mr. Zleizy: Definitely, yes.

Mr. Hansen: You would say that the installation was not over designed?

Mr. Zleizy: As a matter of fact, I think that most of the criteria that we use, especially in the cryogenic systems, are still being applied. If it were gold plating then it would certainly have been discovered by now. Some of the criteria we used in cleanliness requirements have been relaxed slightly but there has been no great change.

Mr. Hansen: Do you feel that construction was up to standard of design requirements?

Mr. Zleizy: The difference between a hard dollar contractor supervision and a cost-plus-fixed-fee contractor supervision is that the hard dollar contractor supervision has to have the ability to show that he is earning money. The CPFF contractor's supervision doesn't have to have this ability. Therefore, the quality is marked better under cost-plus-fixed fee than it is under hard dollar.

Mr. Hansen: In this matter of types of disruptions that caused added resource cost, let's consider changes. How many changes were there?

Mr. Zleizy: There were approximately 300 changes which ranged from very minor to major seriousness, and from practically no cost to very high cost. The reasons some of the changes were costly is that work that was already accomplished had to be removed and the new work re-accomplished in the same place. This would increase the cost considerably because you have the installation of the original, the removing of the original and the installation of the new work.

Mr. Hansen: Would you compare this type of project to other big non-defense construction jobs as far as the impact of changes are concerned?

Mr. Zleizy: I don't think it could be compared because here we had concurrency of facility design, facility construction, and the design of the weapon system. In non-defense construction or non-military construction, the client knows exactly what he wants, and has it well designed before the construction actually starts.

Mr. Hansen: Did you have trouble with labor disputes at all on OSTF-2?

Mr. Zleizy: There were no labor disputes and no lost time due to labor disputes.

Mr. Hansen: What kind of method did you use for scheduling and schedule control?

Mr. Zleizy: We used the Gantt method with an S curve. This is a curve that shows time vs. percent of construction. For any place on the curve you can pick off where you should be. You can put major milestones on this curve. If you are meeting these major milestones you should be in good shape. But there is no way in this system for evaluating the effect of changes. That's the bad part of it. If the scope of the work increases greatly you have to redraw the entire thing. Everytime you redraw it, you put the job back on schedule at that particular time and the next day you are behind or ahead again. If PERT planning were used there would be better evaluation very early and overtime could be utilized in the critical activities instead of crashing all jobs near the end.

Mr. Hansen: Are you starting to use PERT on Corps projects?

Mr. Zleizy: Yes.

Mr. Hansen: How will you do this on fixed-price contracts?

Mr. Zleizy: Special conditions will be made a part of the contract requiring the contractor to develop a network and, before very much construction is started, it will have to be in and approved by the construction agency.

Mr. Hansen: Will this be PERT-Cost?

Mr. Zleizy: At the present time, no. It will be just construction effort and manpower loading. Resource allocation.

Mr. Hansen: Mr. Zleizy, if you had to go through it again what would you like to see changed?

Mr. Zleizy: I would like to see some new form of scheduling and manpower loading used - a different type other than a Gantt or bar chart - possibly a critical path or PERT method including manpower loading. Also, I would like to see the facility construction agencies have more authority in the program. We had many interface problems that wouldn't have caused as much trouble if the interfacing items were both the responsibility of the same organization. In other words, I would like to see the project divided into three stages, namely facility construction as we know it now, installation, and check out and the organization that has the facility construction should also have the I & C.

PART IV C-2

Interview with
Mr. Eugene McFadden
Atlas F Project Engineer
Astronautics Division of General Dynamics

on 25 February 1963

at San Diego, California

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Mr. Hansen: Would you identify yourself, please.

Mr. McFadden: I'm Eugene McFadden presently manager of the systems engineering on Atlas Weapons Systems. At the time of the OSTF-2 development, I was project engineer for Atlas F Weapon System, which included the silo. One of the problems at the time, a problem we may never have again in this field was the mating of the large construction industry with the aerospace industry on a nation-wide basis. This was most critical in the area of developing large underground buildings using close to aircraft tolerances. This was probably the biggest growing pain that we had in any original silos. The fact that the construction industries were accustomed to normal building tolerances which are much looser than the aircraft tolerances required for missile, AGE interface. I think OSTF 2 developed for the Atlas F weapon system the methodology required for following operational bases.

Mr. Hansen: How do you feel about the quality of the original design requirements?

Mr. McFadden: Because of concurrency, the original design requirements were established prior to design proof testing and compatibility testing; therefore, some redesign was required as a result of changes in criteria after test data analysis.

Mr. Hansen: In other words, any changes that occurred in the design requirements were more in terms of state-of-the art rather than in terms of relaxing a little bit on the two parameters of cost and performance to get it on time or ahead of time actually. The reason I'm asking the question is that it seems that time has been a very important parameter in this business and that sometimes we may start out with real high reliability specifications and tend to relax them and also to relax our costs budget to meet the time requirement.

Mr. McFadden: Time is of the essence, particularly in the prototype program. In the case of OSTF-2, however, the prime requirement was test completion, since completion of the construction is really worthless unless missile, AGE compatibility can be demonstrated in time to incorporate any required changes into the operational sites. During the construction of OSTF-2, there were two program running which did in fact cause quite a number of changes in the OSTF-2 design. One of these was OSTF-1 which is the horizontal, semi-soft Atlas installation, the other was Titan I which is comparable in many respects to our Atlas F installation in that it has a silo with an elevator to bring the missile above ground prior to engine firing. During the buildup of OSTF-2, we were running missile tests on OSTF-1 and Titan was just a little ahead of us with their silo installation at Vandenberg.

Mr. Hansen: Was OSTF-2 completed on time?

Mr. McFadden: That is a loaded question, it certainly was not completed to the original schedul - that is - the schedule developed in the original design phase. It was completed within the schedule developed to support the operational bases with test data and change information. I think that the proof of this is that the other installations, the total program, came in well ahead of the original schedule. That is, the entire Atlas F AGE program and activation of the Atlas F bases.

Mr. Hansen: Do you feel that construction was up to the standard of the design requirements?

Mr. McFadden: Here again, I would like to touch on the requirements placed on the construction people by the aerospace industry. Many of the subcontractors had never worked to these types of tolerances before. I feel that by far the large majority of work was done to meet these requirements. I think that the overall construction of OSTF-2 was satisfactory. There were some problems which even the A&E could not envision at the time, and Bechtel is a leader in the field of engineering aerospace ground installation. I think these silos were unique at the time because of their size and design criteria. The relatively low failure history of this equipment since activation speaks well for the original design.

Mr. Hansen: Did you have problems in the area of the A & E design not being compatible with the design of the missile itself because of changes that were constantly occurring? Doesn't this cause a big problem? If you change the missile might it not require a change in the silo?

Mr. McFadden: That's true. There were changes in that respect. During the time that OSTF-2 was being built there were many changes to the missile. Some of them effected the design of the ground equipment to be installed in the OSTF-2 and therefore, effected the basid design of OSTF-2. However, these changes were the headache changes rather than the high cost or time consuming changes. These are the type of changes that perhaps drive the detail man on the A&E crazy but don't to a great extent effect the cost or the schedule on construction.

Mr. Hansen: Let's go back a little bit to the concept of Russian design versus U.S. design. Russian design is fairly simple and the U. S. design is somewhat more complex because of miniatureization and for other reasons. Value engineering purports to be concerned with making an item more simple by reducing the number of components, standardization or in some other way, causing the item to give more value at less cost. Was this concept used even though it might not have had this name?

Mr. McFadden: In that respect, several approaches are used here. The design criteria is compared to "off-the-shelf" hardware in order to make maximum use of available equipment to avoid the time and expense of developing and testing new design. Where a present design does not exactly match the design criteria, the designer is requested to review the available equipment and specifications to see if one or the other might be modified to make them compatible. Where "off-the-shelf" hardware is not available, we look for peculiar, but presently designed equipment within the aerospace industry; this does not save any construction time, but can save costly design and test time. A third thing, the basic design of OSTF-2 was specifically to have the capability to store a missile underground, service it, bring it up above the ground and launch it in the fastest possible time. An example of value engineering here might be the deisgn approach used to get the fuel aboard the missile. One of the original concepts was to increase by order of magnitude, the flow rate of fuel from the ground installation to the missile in order to reduce the reaction time. This design became very complex and expensive so an alternative approach was taken. This approach was to store fuel in the missile. This required minor modifications to the missile and permitted the fuel to be transferred to the missile at a very slow rate using completely "off-the-shelf" hardware. It reduced the reaction time even further than the fastest fuel loading system since fuel could be loaded prior to putting the missile on operational status. Another example was to simplify the control console to reduce the crew size to a minimum. This doesn't meet the classic example of value engineering by simplifying the hardware because to simplify the controls actually complicated the control hardware, thus increasing the cost of the original design. However, it decreased the cost in the long run by greatly reducing the number of people required on a long-term basis.

PART IV C-1

Interview with
Mr. William Van Horn
Program Director - Atlas Weapon System
Astronautics Division of General Dynamics Corp.

on 25 February 1963
at San Diego, California

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Hansen: What role did GD/A play in the OSTF Project?

Van Horn: GD/A was the integrating contractor. This is misleading in one sense. Our responsibilities for the contract called for us to prepare the criteria from which the A & E engineering design was made. In other words, we described what the actual construction should be, what it would have to do in terms of hardness, rigidity, stability, etc. The A & E contractor, Bechtel Corporation, had a prime contract with the Air Force to do the A & E work. Once they completed their drawings, we reviewed their drawings for conformance to the criteria we had established and those drawings were then given to the Corps of Engineers who actually contracted for the construction work. At the same time there were a number of associate contractors on the program; Rocketdyne for the propulsion system and the ground equipment that supports it, Arma for the inertia guidance system, General Electric for the nose cone and the re-entry system, Acoustica for the propellant utilization system. The efforts of those contractors were to be integrated by GD/A and melded into a whole. In addition to that, there was a contract for communication equipment, also a prime contract with IT & T (International Tel and Tel). Their efforts also were to be integrated by GD/A although the arrangement was a little less clear since their work was done principally during the construction phase under the Corps of Engineers rather than the phase when GD/A was prime. In addition to this effort, we had a responsibility for surveillance during the Corps of Engineers construction period. Our role in that effort was to maintain knowledgeable people at the base during the construction period and to bring to the attention of the Air Force any discrepancies that we noted between either the design or the intended design as provided to the Corps. Finally, once the construction was completed and the occupancy turned over to GD/A, we were responsible for all of the prime and the sub-contractors' efforts during what was called the "installation and checkout" phase. It was our responsibility to turn over a demonstrated weapon system to the Air Force at the conclusion of the project. These then were the things that we were responsible for. I think in retrospect you can find a couple of things that are worthy of note. Surveillance responsibility is a difficult one to discharge because there is no authority along with it. In other words; we could not stop the Corps of Engineers from doing something. We could only bring to the attention of the Air Force the actions that we felt were necessary. I think that we found no instances to my knowledge, that satisfactory action was not taken, but the lack of authority certainly lengthened the time period that these actions required. Our general relations with the Corps were very good, particularly at Vandenberg where we had worked with their people many times in the past. It was a harmonious arrangement. One thing that should be recognized, of course, is that the OSTF-2, while it was the first of the so-called silo complex configurations, was about the fiftieth launch-complex that we installed. We had already completed quite a number of operational complexes in the series "D" configuration and were working on a number in the series "E" configuration,

so we had quite a bit of background in the business to draw on in setting this up.

Hansen: Who were the designers of the missiles?

Van Horn: We designed the missile and we designed what was called the ground support equipment which is now called aerospace ground equipment. This brings up an interesting point here. The silo is a rather massive installation. The ground portion of the Weapons system, the silo and the equipment inside the silo, probably contributes something in the order of, I would guess, 90% of the total cost. The missile and its equipment contribute only about 10%, so even though the missile is the "bullet", you might say, the relatively expensive gun that this is launched from is the silo. Now in the silo there are two different kinds of equipment - real property installed equipment (RPIE), which consisted of facility-type items and which was procured under the direction of the Corps of Engineers. This would include the steel work in the silo, the propellant loading system and a number of items which are in the so-called facility category. At the same time, the silo includes a number of items which fall in the ground support equipment - that is - items like the launch control equipment, the elevator itself for example, the platform, and a number of items that are associated directly with the checkout of the missile, various pre-launch or pre-countdown checks that are conducted. These items were furnished by GD/A and the other associate contractors. Thus, you have a rather large amount of two different kinds of equipment under two different responsibilities. Therein lies one of the stories on the OSTF program and the over-all integration of those two differently managed acquisition programs.

Hansen: Would you care to comment on the joint responsibilities of Air Force and Corps of Engineers in the program?

Van Horn: The urgency for getting these silos was so great, everyone wanted them right now. Once they were approved, from then on the big cry was "when can we get them?" If you look back at the program, you find that we were scheduled to complete the first installation, which was the OSTF-2 installation at Vandenberg, in a period of time that was about four months after we were scheduled to fly the first series "F" missile. Thus we were inventing the missile and conducting an R & D test program in Florida, and simultaneously were having a major program going up at Vandenberg for the invention of the silo and its associated equipment and the installation and the demonstration of that site. And while this was going on, we were in the process of construction of silos at regular operational bases at Schilling, Lincoln and Altus. Now let me describe this silo briefly to you. It is a hole excavated in the ground 174 feet deep, plus or minus a few feet, and 52 feet in diameter. It is circular and to one side there is a tunnel that leads off to a launch control center which is

separately installed. Inside the silo is a large metal structure called a crib which extends from the top of the silo to about 10 feet above the bottom of the silo. I think the dimension is something of around 40 feet square. It, and the equipment installed on it, weighs about 3 million pounds, and it is suspended on 4 shock spring assemblies. This 3 million pounds comprises many thousands of individual installations as well as the crib steel. All of these numerous equipments had to be developed as part of this program. Not only that, but the locations of each had to be identified ahead of time. It was, in every real sense, a production-type contract. In order to reproduce repetitively you had to have a pre-planned, pre-engineered product which meant that you didn't have any liberty in the placement of equipment. I think as we look back on the program, the construction contractors who worked for the Corps of Engineers had a very difficult job since they had not, as a matter of course, been involved in a production-type program. Almost everything they had done was usually custom built. If you look at tract houses where they build 1000 houses in a sub-division from the same plan, you'll find rather marked differences one from another because the requirements are not so precise that everything must fit the way it does in an airplane, for example. But in this particular system just because of the sheer size and complexity of it, it had to fit much closer than ever before. When we got ready to install some equipment, possible a conduit had been placed in the wrong place, or a duct had been installed where you intended to place a piece of equipment. We were constantly called on to take something out and re-install it in a different way or a different place. I know that it certainly happened a number of times at OSTF-2.

Hansen: What was your specific position and responsibility with respect to OSTF-2?

Van Horn: At the time that that program took place, I was manager of our long-range planning department. The long-range planning department had several functions, the principle one of which was the over-all master scheduling for all programs in this division. All of the initial scheduling work, all of our master manufacturing and production schedules and division schedules were produced in the department I managed at that time.

Hansen: Would you care to comment on the specific objectives of OSTF-2?

Van Horn: Yes, I would like to because it has an interesting history. It was originally justified and conceived as a design tool. In the days when we first talked about it we wanted a place where we could try out and prove the design and more importantly, after we had completed it, the engineers could prove the changes

that we considered desirable or necessary to make it work better. This is the basis on which the program was established. Because of its developmental nature and aspects we had planned a test program, including launching of missiles from that installation, and we had a rather elaborate plan for how this test plan and engineering development work would be conducted. About the time that we were ready to put some of these plans in operation, during the early construction days of the program, we were directed to re-orient our thinking and use OSTF-2 as a place where we could checkout the manner and procedures of installation so that once we got in the field we would know that everything would fit. Thus, it became a sort of production tool, if you will, for a period of time. Then, as we went a little bit further down the road, it became a place where we were going to test all of the operational characteristics - the technical data, the tech manuals, the personnel sub-system aspect of the program. We were going to devise a method in which SAC would actually operate these squadrons once they were turned over the them. So it became an operational prototype.

Hansen: Did you find that any of the performance objectives were relaxed to meet time schedules during the course of the contract?

Van Horn: No, there was no substantial relaxation. What occurred was of this nature. The site has a requirement to be self-sufficient for ten days and it has a requirement that everything that operates continuously must operate for a minimum of 240 hours between failures. We found in certain instances some equipment might need more tinkering with than other, we would relax the requirements with the idea that when it was finished, we would go back and bring those items up to specification compliance. It was a very limited number of instances where this happened. In performance requirements there was no relaxation.

Hansen: In retrospect what would you change or do differently if you had the program to do over?

Van Horn: If we had to do this program over again there are several things we would like to do differently. Whether they are possible or not, I don't know. First, I would propose a much more rigid specification on the Corps of Engineers. In other words, much less ability on the part of the Corps to select required equipment from competing manufacturers. I think that we can prove conclusively that some of the equipment is just not suitable for competitive bidding. When you are pushing the state-of-the-art as we were in this program, there are a limited number of companies that can produce to the requirements that we establish. We found instances where we would have liked to have specified a single source recognizing

that they were the only ones in this country that could meet the specifications. A second is that we were responsible for maintaining surveillance during this Corps construction period, yet had no control over the Corps or its contractors. More importantly, it was impossible for us to maintain surveillance on a continuous basis on all of the things that they did. The arrangement is not as good as desirable and we would prefer to change that aspect on any future program. Another thing is to reach a common agreement earlier in the program as to what the objectives were to be - a production tool or an operational tool. Changing from one to another creates two different series of problems. From the contractor side of the program, we would want to bring in more people conversant with the construction side of the program. We were missile builders, although we had built launching equipment, etc. but we were oriented to the missile stage more than to the construction phase. As a contractor, I think more top construction talent in our organization to better understand their requirements, their activities, would have benefited to some degree. If we were going to do it over, we would go into a PERT type system also.

Hansen: Do you like PERT?

Van Horn: There are a lot of advantages. I think that it is very difficult at best to know where you stand on a major construction program. Even the construction industry itself has some pretty arbitrary measuring rules, like you're 20% complete at a certain milestone when in fact that may not be the case at all. Secondly, when you are integrating the output of several different agencies, it is difficult. Now the PERT concept gives you two inherent advantages. First, you can plan your job ahead of time in a much more detailed fashion. Whether or not you like it, nobody can quarrel that good planning gives better results. It also gives you a mechanical system that lets you quickly and mechanically calculate where you stand. I think that some of the fancier aspects of PERT, the probability factors, etc. may not contribute too much. The two basic schemes of network planning and the mechanical status collection are, I think, very desirable.

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PART IV D-1

Interview with
Mr. Robert Myers
Manager of Military Facilities Design
Bechtel Corporation
and
PART IV D-2
Interview with
Mr. S. Roy Oliver
Assistant Project Manager, OSTF-2
Bechtel Corporation

on 28 February 1963

at Vernon, California

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Mr. Hansen: Would you tell us a little about your company, Mr. Myers?

Mr. Myers: Bechtel is a company composed of a good many technical personnel. We are engineers and constructors. The bulk of our work is done under the single responsibility of designing, procuring, estimating, figuring, constructing, initially operating a project in the fields of power and industrial refinery and large heavy industrial work. We are one of the largest firms in the country from a standpoint of construction alone or of the combination engineering and construction. Our volume is in excess of $200 million a year. We specialize in difficult and complex jobs, which require ingenuity in design as well as construction. We are not interested in the run of the mill type of construction, housing developments and that sort of thing. We do heavy work where competition is probably limited to possibly a couple dozen or more firms of the necessary size and the financial capability to carry out multi-million dollar jobs. We were not involved in weapon systems work prior to 1958 but this is typical again of our company throughout the years. When a field opened up or we saw that our services could be utilized we got into the area. Typical of that would be the jump we got in nuclear power work back in 1948 when we first became interested in the field. We were part of the original team that was set up by the Atomic Energy Commission. As a result of that early entry into the field we wound up designing and constructing the bulk of the nuclear power plants in the country and we alone have probably constructed two-thirds of the plants.

Mr. Hansen: How do you manage such projects?

Mr. Myers: We put one man on top of a project, call him a project manager. He is assisted by anybody necessary in the company and takes the complete responsibility to get a job done. The same project manager is responsible from the inception to completion of a project. An example of Bechtel's flexibility in getting into new fields would be what occurred when we got our first contract with the Air Force for the Atlas weapon system. The size of the design effort was such that the Air Force had to go to a large company that had manpower resources and capability. This type of project requires approximately 200 people and to suddenly get a job of that size for design without hiring extensively is difficult to do. How we did it was to utilize the specialist resources of our refinery division in San Francisco and we managed the job here. The greatest share of personnel were in Vernon (the Bechtel office at LA), however, we managed to spread out certain

work which could be adequately defined so that the personnel in San Francisco could do it. We had, at one time, 100 people there. Thus, we could react very quickly to the problem at hand and get the job done, without excessive hiring immediately.

Mr. Hansen: What do you feel were the specific objectives of OSTF-2, Mr. Oliver?

Mr. Oliver: The specific objectives of OSTF-2 were to first, build a complex that as nearly as possible would reflect the configuration of the operational Atlas F facilities and could be used as the operational test facility for the weapon system. In conjunction with the OSTF-2, a full scale mock-up was constructed at San Diego (see Figure 11). It was planned that tooling would be developed here for hydraulic piping, cable runs, these types of things as well as the proving of space allocations. The tooling would be built in a single unit. A piece of piping spool or cable would then be fabricated from the tooling that was developed from the mock-up and would be proven at OSTF-2. This applied to the GSE which is under GDA surveillance because they have the responsibility for all the holes in the squadrons. An additional objective for OSTF-2 was to prove out the man-machine relationships, and to prove out and verify and validate the work in the technical data and systems manuals, the inspection requirements manuals, and the personnel subsystem evaluation test program that describes the task that the military people of various skills have to perform in order to operate and maintain the Atlas F system.

Mr. Hansen: Were there any changes in major policies or objectives throughout the course of the project?

Mr. Oliver: I think the basic objectives stayed the same, however, because of the lag in implementing changes to the mock-up it became necessary to rework a good part of the configured articles when they came to OSTF-2. Really, what happened in many cases is that our people who are involved in the installation of the ground support equipment made two spools, one they put in the OSTF-2 and the other they sent back to General Dynamics and this then was laid against the mock-up and against the tooling that was developed.

Mr. Hansen: We talked about the objectives of the project itself. How do you view your specific objectives with respect to the OSTF-2 program?

Mr. Myers: Our objectives were to design and build facilities for the OSTF-2 at Vandenberg and to meet a schedule that was established to fit the basic needs of the over-all weapon system.

Mr. Hansen: Do you feel that you pretty well accomplished the objective?

Mr. Myers: I think we did it in extremely good fashion. Considering all of the problems, we did meet our schedule.

Mr. Hansen: The customer (Air Force) by the way, commented on how well it was done. Mr. Myers, would you comment on the adequacy of the contract requirements?

Mr. Myers: You have to recognize the OSTF-2 is an unusual type of contract for typical government procurement - mainly because it involves an engineering and construction type of effort under a cost-plus-fixed-fee basis. Most provisions of the contract, I would have to say, were adequate and specific considering again the type of contract it was. Schedules were spelled out. This was all important. An over-all estimate of cost was made and there was cost limitation to this contract as is typically done. It was a reasonable estimate. It may have been increased slightly as work progressed. There was no problem there. You have to bear in mind that the scope of work was, by necessity, very broad to get the job done. It was not specific and could not lend itself to a specific lump-sum price without a ridiculous contingency. The only disagreement that I had in relation to the contract was this. The Corps of Engineers, in negotiating this contract, wanted a certain amount of the effort fixed. Because the definition was not made it was difficult to fix. A part of the effort, however, we did fix. This related to what you might call the home office at Vernon, in contrast to what we did at Vandenberg. All effort at Vandenberg was reimbursed. In the office, our engineering which related to as built drawings and vendor relations was a fixed amount. So also were certain procurement activities. In addition the fee was extremely low, particularly in contrast to our private work. Considering the objectives of this project it was of not too much consequence to us. We were mainly concerned with getting the job done. Again, for the amount of effort and the amount of talent tied up, my basic comment would be that it was an extremely low fee, and this could be typical of the views of a lot of contractors.

Mr. Hansen: Mr. Myers, would you comment on why Bechtel became involved

both as an architect-engineer and constructor on this project?

Mr. Myers: Yes, we were both designers and constructors. Actually, we were designers first under a separate contract to the Air Force and we continued that way through the complete design of OSTF-2 as well as the follow-on operational squadrons. The Air Force had on file several hundred qualification brochures of many architect-engineer firms throughout the country. In selection proceedings they selected Bechtel to be the prime designer for the Atlas weapon system. We were first added to the program in roughly Aug. 1958 for the horizontal configuration which was the E series Atlas built at Fairchild and Forbes as well as at Vandenberg. Later we were selected for the F series and the silo configuration of which the OSTF-2 is an example. We obtained the design contract at a late date due to a slippage of the starting time, basically because of late Department of Defense approval. The end date (operational date) did not slip, therefore, the schedules were compressed considerably. With the OSTF-2 being the first silo to be constructed it became apparent in General Leonhard's mind that the only way it could be built on schedule with a reasonable cost was to enter into a contract with Bechtel Corporation, combining design capability with construction capability and in fact coming up with an engineer-construction operation or a construction operation where a single project manager had the responsibility to see that design was accomplished piece-meal to fit the needs of the construction schedule. This type of contracting is unusual for the Corps of Engineers and I give full credit to General Leonhard and his staff of facilities officers for pushing this type of contracting through the Corps of Engineers and convincing the Corps of Engineers that this was the only way to meet their objectives.

Mr. Oliver: When we were planning on the Atlas F it was decided that an effort should be made to achieve maximum standardization of major equipment. This was based primarily on some of the troubles encountered in the Atlas E Sites. The original planning envisioned that we would go out for procurement of major equipment in early August 1959. Corps of Engineers competitive bidding procedures would then allow approval of vendor prints and would allow incorporating into the actual construction drawings the information relating to specific equipment so the construction contractors both on OSTF-2 and operation sites downstream would have the standard package which would enable the

installation and checkout to take place with a minimum of time and cost. Actually program go ahead wasn't received until after January 1960 so orders for equipment couldn't be placed until around the middle of February. This served to compress the construction schedule at OSTF-2 to a great extent. It would be impossible to meet the final completion date of OSTF-2 if the design were made to wait until vendors prints could be incorporated into the construction drawings so that the Corps of Engineers could go out and get competitive bids. This was probably the prime reason General Leonhard pushed for the contract with Bechtel Corporation on a cost-plus-fixed-fee basis. With this they could actually start construction prior to completion of the engineering drawings. Major items which could be started were the construction of steel cribs which was going to be made into a 15 story building, vessels that were scheduled for procurement by the construction contractor, and the completed piping drawings. Other equipment drawings could follow at a later date. I think this probably serves to amplify Mr. Myers statement concerning the effect the late approval of go ahead by DOD had on the OSTF-2 construction schedule.

Mr. Hansen: Would you comment on how an organization was formed to effectively manage the program?

Mr. Oliver: There was a coordinating committee set up consisting of the Corps of Engineers, the Air Force and Bechtel. The only purpose of this committee was to make certain that timely decisions were made in order to protect the schedule of the job and the design integrity. These people were empowered with the authority to jointly make decisions on the spot. If further checking were necessary it could generally be done in a 24 hour period. The committee met at least once a week and more often if it was necessary.

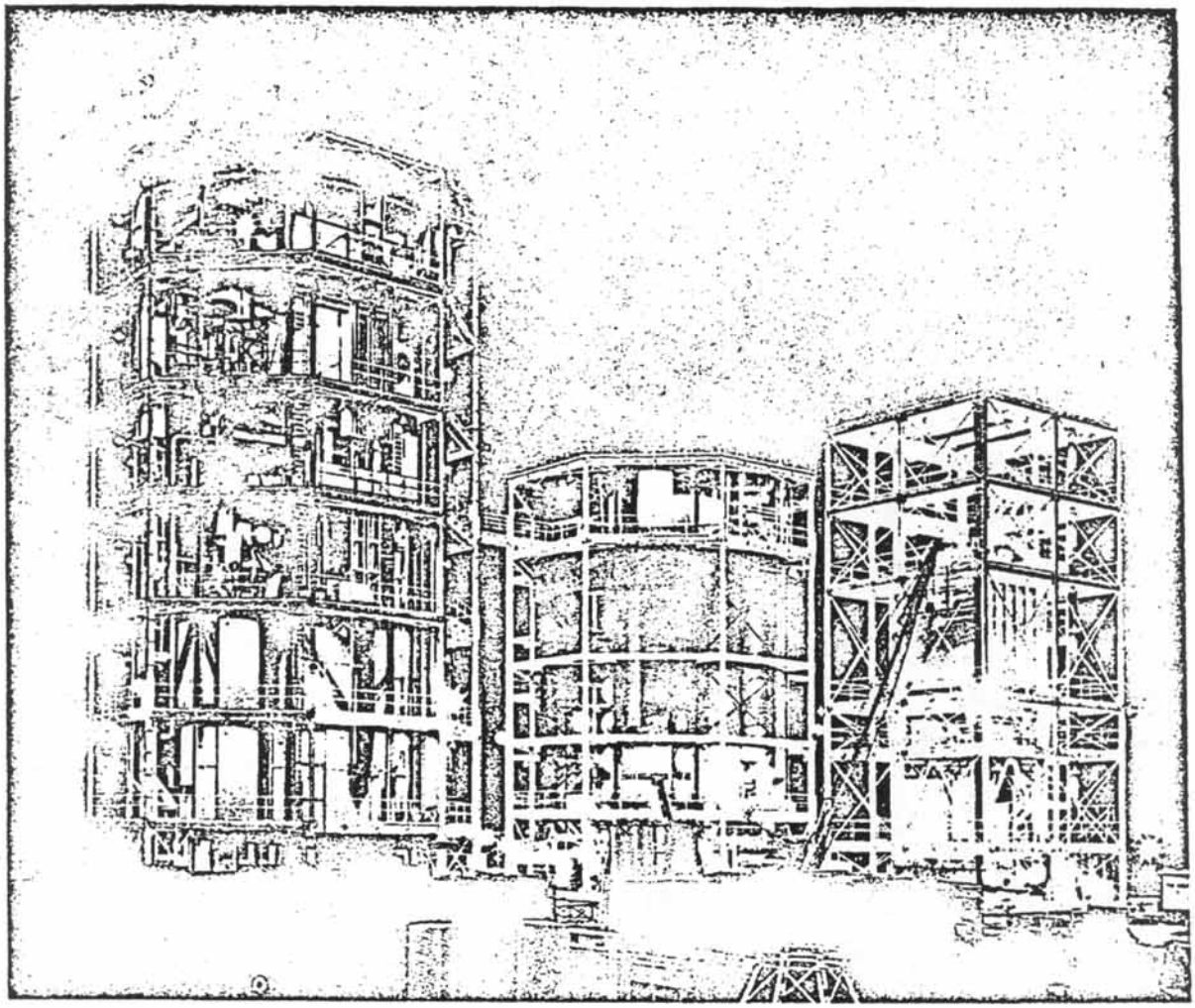
Mr. Hansen: Normally, when you have a complex organization like this involving several different parties, you have communication problems. Changes are made. Information doesn't get to the various levels, of other organizational units in time. Your reaction time is slow. Do you feel you had something here that circumvented that problem?

Mr. Oliver: Very definitely so. We had almost immediate contact by telephone and personal contacts, so we have no delays due to communication problems.

Mr. Hansen: Normally, when you have an organization which involves

different functional units, people normally reporting to one organization head, now find themselves in a position where they are, in effect, reporting to other organizational heads. This could effect the attitudes of people. Was this true in this case?

Mr. Oliver: I don't think that this happened. I think that people reported to one head, but they recognized that it was important that they support the other activity. The areas of support were well defined and the organizational interfaces were well established.



FULL-SCALE SILO MOCKUP

PART V

Interview with

Major H. B. Arnold Jr., Chief of Facilities

551st Strategic Missile Squadron
(Atlas F)
Lincoln Air Force Base, Nebraska

on 18 March 1964

at Wright Patterson Air Force Base, Dayton, Ohio.

Mr. Hansen: Would you identify yourself, please?

Maj. Arnold: Major H. B. Arnold, USAF. I was the Chief of Facilities at Lincoln AFB where the 551st Strategic Missile Squadron (Atlas F) was being constructed.

Mr. Hansen: Could you elaborate a little bit on your responsibilities in the position that you held at the operational site?

Maj. Arnold Mainly, the job for which I was responsible was facility engineering including mainly the modifications fed into the system during the Corps of Engineers' Construction Phase. In my section we had two officers, three Bechtel engineers (one civil, one mechanical and one electrical). Also, we had one GS-13 civil service engineer.

Mr. Hansen: I'd like to talk about the contract a little bit, specifically the contract requirements. First of all, do you feel that the contract was specific in the requirements for construction?

Maj. Arnold: Yes, I feel the basic contract was specific. Actually we did not have too much trouble until the many modifications started coming in as a result of the problems and work done presumably at the prototype OSTF-2. In many cases we ran into problems as a result of telling or directing the contractor how to obtain the end product rather than telling him exactly what the end product was that we desired. As an example on this, during his excavation we told him exactly how to excavate and shore things of this nature, or in detail, exactly how to dig the hole, in other words. Well, this worked out fine until we started hitting water, cave-ins and things of this nature. When he reached a problem such as these he would just flat sit down. He knew he couldn't do the job according to the plans and specs, and until the Corps of Engineer representative directed him to take a specific action on paper, for which he certainly had a claim, he would not use any ingenuity or any engineering skill on his own. And, of course, this again was after he started getting into trouble on the contract at Lincoln itself. It was estimated by various people and I more or less concurred that he was approximately ten million dollars "in the red" on his excavation alone. So, when he found himself in this bind, getting short of cash and seeing the handwriting on the wall, he just flat would not do anything without specific direction. In other words, we had to tell him how many well points to put down, we had to tell him various other things of this nature. To me there seemed to be several ways of solving the water problems to continue mining; however, he did nothing on his own. He sat there and waited for us to direct him to do something. (Us, being the Corps of Engineer representative). Everytime we directed him there was a claim. So, to me it seemed that if we had told him more or less the end product desired, rather than how to do it, we would have been better off in this case. Especially in the excavation earth work phase where you do run into many change conditions and unknowns of this nature.

Mr. Hansen: Was there a penalty clause in the contract and if so how restrictive was it?

Maj. Arnold: There was a penalty clause in the contract and it was established on various milestones or certain degrees of completion. I believe we had ten milestones which supposedly was where we could measure his progress. Some of these milestones did not have a penalty clause. However, on the ones that did have a penalty clause, the penalty itself was inconsequential in amount compared to what it would cost him to work on the weekend, put on another shift, or double time. So, it was cheaper for him just to sit there and pay the penalty than it was to speed up the job. As such he would work five days a week and wait for the Corps of Engineers to direct him to go seven days a week, 24 hours a day; and when they would do this, then he also had a piece of paper to make another claim against the government. Then the milestones, after the first couple, were rather hard to identify in that we got so damn many change clauses we couldn't identify how many days went to what change order that we had directed him to build in the system. So it got so garbled you couldn't even tell where a milestone was finally.

Mr. Hansen: Do you feel that the quality requirements in the contract were strict or of the usual sort? Could you comment on this a little bit?

Maj. Arnold: As far as the materials or the facility items which were furnished such as fuel tanks, oxygen tanks, things of this nature? The specifications were adequate I'd say. A great deal of the equipment that was to go into the hole was government furnished equipment and quite a bit of this did not arrive as promised. In several cases where the equipment arrived after the scheduled date, he was so far behind that he could not have installed it, but be this as it may this still resulted in a claim for so many days delay. In other words, if a tank, etc. showed up ten days after we said it would even though he wasn't in a position where he could have put it in, he still claimed ten days delay. As far as the tolerances themselves, the grossest one I can think of is the propellent loading system. As you know, a proportion of the PLS system was put in by the Corps contractor. In our case, Western Contracting Corporation subleased it out to Paul Hardeman, who I believe had this sub on all of the six Atlas F Squadrons. The tolerances as shown in the specs were zero. Well, hell everybody knows you can't build anything to Zero. We'd bicker around about whether a quarter of an inch could be allowed or a half inch or three inches. Usually we could get no direction in this matter from BSD. However, as a result of experience at Offutt, we knew GDA insisted on very rigid tolerances. At Lincoln, and also the construction of the D Squadron at Offutt, we would dicker over a quarter of an inch, half inch and so forth. And as we suspected, when General Dynamics came in to complete the system, they would show up with a 6, 8, 10, 12 foot flexible hose so that it didn't really make a hell of a lot of difference what the tolerance to a degree was. We understand that in a shock or blast condition that you had to have so much flexibility in the hose itself; but to show up with a 9 or 12 foot flex

for a liquid oxygen and insist on it being in one place (+ or - .01") to hook up looked rather ridiculous to us. Also, the specs themselves did not really identify exactly where these interfaces should be. At one time we thought it was from a certain point from the sides of the silo, and a little later we thought it was from a certain position on the crib itself. Of course, the crib shifted a little bit which made this point in space shift also. So obviously they were rarely the exact same place; well, it is obvious they weren't the same place in many instances. So, this brought many CDRs (Construction Discrepancy Reports) from Convair. They would come in and survey these and if they weren't where they thought they should be, they put a CDR in. Of course Convair, in this particular case, it seemed to me was building up their case for delays when they started to work. They ended up with hundreds of CDRs, as on PLS system. This was probably the main one about which we were dickering over zero tolerances --- zero tolerance from where we weren't sure --- and then when they show up with a long flex hose we thought we were whistling Dixie in Maine.

Mr. Hansen: I'm interested in the learning experience that was gained from the prototype at OSTF-2 at Vandenberg. What is your opinion of the type of information that you gained from this that was of help or possibly hindrance in the operational sites?

Maj. Arnold: Without a doubt the prototype concept was the proper concept to use. They should have furnished us with very timely and valuable mockup information. Between OSTF-2 and the three million dollar mockup crib which General Dynamics sold the government that was constructed down at San Diego, we could not see where he could have so many problems with this outlay of dough. Well, personally I feel three million dollars at San Diego was valueless though we might have got some learning for the prototype from this. However, the overall value of the prototype of OSTF-2 as it turned out was rather questionable. This I know is a change from many people's thinking. The problem as I saw it, (being the Indian down at the bottom lower rungs) was that OSTF was a cost plus a fixed-fee contract and Bechtel being a good company wanted to do it as cheaply as possible. This was commendable, but the work did not proceed as rapidly as it seemed to me it should. Had they really turned on the steam, we would have been money ahead regardless of the cost.

OSTF-2 would hit a problem and of course they would be hung up on this for several days or maybe a week or longer. All this time where we were getting good design from the prototype, we were gaining time on them. So, I would say approximately a half to two-thirds of the way through the construction at Lincoln we were practically neck and neck with OSTF-2, in fact sometimes we would hit a problem that they hadn't even faced. Of course, the Schilling Squadron was a little bit ahead of us, being the number one squadron. It seemed to me that at OSTF-2 certain parties were more interested in holding down than expediting the job and saving the other 72 missile holes money.

As I say, it seemed to me that the work was not as diligently pursued out there as it could have been; this is just my own personal opinion. I was out there a couple of times, I don't think they worked on weekends, whereas our contractor was working 24 hours a day, 7 days a week and you can see that pretty soon all the squadrons, all six of them, were practically at the same state of completion. We would hit a problem at this point, and it would hold us up as long as it held up OSTF. So, I feel that OSTF-2 would have really paid off if they had started, say several months ahead of us and had worked full bore. It seems we could have delayed the contract awarding on the operational squadrons another couple of months and we would have still finished at the same time at much cheaper cost. Of course, political pressures and things of this nature may have dictated otherwise on this; but I think we actually could have started on a later date with a better set of plans and specs and done the job in the same amount of time at a much cheaper price.

Mr. Hansen: Now, let's get back to this question that I had before. Why wasn't this particular problem of interface that you mentioned before discovered in the construction of the OSTF-2?

Maj. Arnold: Well, here again we ran into a rather hairy situation where OSTF-2 was not far enough ahead of us when they did install the PLS System. I think we did our first DPL (double propellant loading) about the same time OSTF ran one. So this gets back to not being far enough ahead of us; also Hardeman, down in in his plant in Los Angeles, prefabricated the PLS System for six squadrons and OSTF. So he was shipping these to the squadrons practically at the same time he was shipping OSTF's to them. Consequently we'd get a piece of tubing or a piping out at Lincoln and not know it would not fit because of some minor construction deficiency or change required. That would hold us back. None of the cribs hung exactly the same as they kept loading the cribs and adding materials to it and the cribs started stretching. This again created a problem with us on the PLS piping.

Mr. Hansen: Let's talk about management organization a little bit. What type of overall management organization did you have at your site?

Maj. Arnold: Well, our SATAF for the construction at the Lincoln Squadron was somewhat different from the other ones at Mead, Nebraska; we had a SATAF commander who was in charge of two squadrons simultaneously. These were the "D" Squadron at OFFUTT, and also the "F" Squadron at Lincoln. The organization was a normal SATAF organization with very little extra manning for this extra load. We did have a problem of the SATAF headquarters not being in the general vicinity of the Center of the "F" Squadron construction. In other words, it was somewhat displaced, making distance problems greater. The distance problem plus 2 squadrons under control at the same time should have been manned as 2 squadrons.

Mr. Hansen: There were other elements of the overall organization; the construction firm, the Corps of Engineers and Convair got in on it as an integrating contractor. Were there any others that were involved in the overall organization? The reason I am asking this question is to determine what problems, if any, might be ascribed to the structure of the management of the organization and the fact that there were organizational loyalties involved. Hopefully, you had a team here that would be working toward one common objective, but we realize that in project management structures, it is difficult to completely eliminate organizational loyalties. Would you care to comment on the effect of this on the project itself?

Maj. Arnold: Well, in this problem of management we certainly were like all the other SATAFS in that practically each individual members did have divided loyalties. An example was the Corps of Engineers Representative on the organizational chart for the SATAF; however, he was an Army Colonel and generally took his direction from CEBMCO in Los Angeles. We had the contracting officer in his section, this was AF contracting officer. He was working for, I believe, WCMR -- his loyalty was divided. We had, even in the blue suiters, people that were assigned to BMD (later BSD). We had people assigned to SBAMA. We had people assigned for awhile to AMC and Civilians working for the prime contractor and many subs. There was a mixture of people working for the SATAF Commander, primarily to accomplish a mission, but yet the loyalty to a degree was to whatever headquarters they happened to be a part of.

Mr. Hansen: Now it's pretty well known that communication lines increase geometrically with the addition of organizational units. Were communications a problem with this organization?

Maj. Arnold: I didn't notice too much delay in communication, in other words, if we got a facility change order it would come out of BSD in Los Angeles, and it would come directly to us in the facility section. If the Corps of Engineers got one directly out of CEBMCO it would go directly to the Corps of Engineers Representative at Lincoln. SBAMA direction and WCMR pretty well came to their counterparts or the people to whom they were assigned as a parent unit.

Mr. Hansen: In your history of construction of the Atlas Unitary Silo at Lincoln AFB, Nebraska you made a statement that there were two major problems. You state that the contractor's supervision at the individual complex consisted of one person who was supposed to supervise and coordinate the work of all crafts. Also, you state that a secondary problem was the inferior construction methods and techniques utilized during the excavation phase. Would you care to comment on these two problems?

Maj. Arnold: On the management problem the Corps Contractor never did actually, as far as I can remember, have one person in charge on the site that was responsible for that site alone. This created quite a few problems as you can imagine. The problem also was magnified in that when the contractor found he was dropping about ten million dollars on the excavation phase; he was very reluctant to let anyone do anything except on direction from the Chief Supervisor, or Chief Engineer for the construction company. All this time they were building up a big legal case, so they didn't want anyone on the site who didn't know the legal and political amplifications making any big decisions. So this certainly was a problem. The second problem was due to the contractor's being a "dirt company", rather than a mining company or mechanical company. The problem here gets back to something we spoke of earlier which was directing -- well, it was directing the contractor exactly how he would do the job. The contractor was a dirt-moving firm, primarily a dam builder -- levees, etc. As far as deep mining was concerned, they had no experience and with our telling him in the plans and specifications exactly how the job should be accomplished, we were in for trouble. True, BSD had some experts do the planning, but conditions are never the same. When he ran into any kind of a problem large or small, -- he said "well your system won't work", and he wouldn't display any initiative and try anything else until he was directed to do so.

Mr. Hansen: Were the design requirements new to most contractors?

Maj. Arnold: As far as new design requirements or extremely difficult requirements -- no, I do not feel that this necessarily was due departure from anything that hadn't been done previously. We had mined before without too great difficulty, we had poured concrete for such tube in the past, we've shut off water where we excavated or drilled in sub-surface water, and the crib steel is nothing but a skeleton of a building, more or less hung or supported on the side of the tube. It was a problem of putting together several construction techniques which had never been incorporated in one particular type building before.

Mr. Hansen: I'm interested in the general statement that's often made about "making out on changes". Could you give me your opinion why a contractor is able to make money on changes? Is it because our cost estimating is inaccurate enough that he is able to make out in this way? Just exactly what is the reason? If our estimates are correct, he really shouldn't make out. If we do a good job of estimating, all he would be able to do is to absorb overheads.

Maj. Arnold: From my experience at Lincoln, I certainly agree with you that the contractor did make money on change orders. My personal feeling is that once you make that contract, it's best to go ahead and build the thing the way you said, build it and then if necessary modify it, come back and do all the modification at one time on a separate fixed-price contract. But as to how he makes out on the changes themselves, you start garbling the contract by giving him change orders. He can dream up any number of ways a change order has "impact" on the over-all job. This impact certainly is there and has an effect on other work which he is doing, maybe he can't hire enough people in the right skills, etc.

Further, on this problem of changes and how the contractor makes out, I would like to read a little bit from my history here which is part of a TWX sent by AFBMD to AFOCE July of 1960. At this particular time we were behind anywhere from a couple of weeks up to three to four months behind on 12 individual silos there at Lincoln. This TWX pointed out the serious slippage in construction schedule at Lincoln and further stated these "conditions protend serious delay in meeting AF objectives and following the usual pattern cost increase to the AF for later acceleration justified on some possible future change order having nothing to do with the present job site inefficiency". So here we were, the contractor was way behind time, with no change orders initially. He spent much more money in his excavation phase than he thought and these changes just gave him a chance to get back his money which he had lost through his inefficiency on the excavation phase, plus a profit. This is further pointed out by the first few change orders that were given to the contractor. The proposals that he sent to the Corps of Engineers were fairly reasonable. Then they started going up rapidly. Something that looked to us like about three or four-hundred thousand dollar change order would come in for two million and it finally became outright ridiculous. The Corps of Engineers Contracting Office couldn't even attempt to negotiate, they were so ridiculous. And here he was trying to get his ten-million dollars back. In the end he finally just quit sending proposals for the modifications; he wouldn't even set an amount on them. Because of this and other problems at Lincoln, they never did settle individual modifications; they just paid him a lump sum on all the modifications, based on going through all his books, figuring out what he spent, and then paying him off plus his profit. With things so garbled this may have been the only way to do it, I don't know; but as I say, his proposals got more unreasonable until finally he just quit putting proposals in for our modifications.

On this problem of the Contractor's being so far behind on the excavation and the concrete phase, hindsight is 20-20, as everybody says. Had we had a contract for the excavation concrete tube separately, we would have had time to come in later with the drawings and spend much more. This gains you a couple of months of time to definitize your later mechanical phase better. Had we had our contractor bid this separately, this guy would have had a hard time getting his ten-million dollars back. This system was used on the Titan II missiles.

Mr. Hansen: You used Convair as an integrating contractor. Were there any organizational problems as a result of using an integrating contractor? Did you have any disputes or complaints revolving around complaints that were made by the integrating contractor?

Maj. Arnold: We did have a certain amount of trouble in this area. General Dynamics was on board practically from the day construction started performing surveillance, surveillance being all they were supposed to do. In some cases the Corps Contractor complained to us, in fact several times, that General Dynamics was getting in his way, trying to run his business, things of this nature. And of course, General Dynamics in this surveillance job was really inspecting to a large degree. This assisted us to a certain degree, but it also helped General Dynamics build up a case for extra money to complete things that weren't completed the way they wanted them. Some "deficiencies" actually met the specs as far as the Corps of Engineers was concerned, but they weren't good enough for General Dynamics. So we ran into some problems in this area. There were advantages to having GDA on board early. The Corps didn't have enough qualified people to do a good job of inspection, so GDA helped us here.

Mr. Hansen: Let's talk a little bit about modifications and the effect they have on completion of schedule and costs. Would you care to comment a little bit about this with regard to your experiences at an operational site.

Maj. Arnold: Well, this particular area is the one where I feel that OSTF-2 did not properly accomplish its mission. It seemed to me in several cases, say on something as simple as building the crib for the silo, we would take in and put out the same piece of steel three times. It just doesn't seem possible that if we had had the guidance that we should have received from OSTF-2 that things like this could have happened. In some cases, I cannot think of any specific instance, but we would get a modification and before we could even implement it we would get another one changing it. So I think you can see that contractively it's fairly difficult to even arrive at a price on something like this.

Mr. Hansen: In substance then, you feel that a better definition and more time spent on the prototype even if it meant increased costs would pay off in less modifications on operational sites?

Maj. Arnold: Well, in this particular case I don't think there is any doubt in this. You take one modification which had to be made at OSTF-2, had to be made at 72 other holes; so even a five, six, seven hundred-dollar modification multiplied by 72 gets into a pretty sizeable chunk of change. If OSTF-2 had cost 20 million dollars to expedite and get all the modifications settled before we went to contract, it would have been well worth it. Now, the idea of holding down the cost of OSTF-2 couldn't be justified in my opinion. Whatever the reasoning, it appeared to me fallacious in that any time or delay or modifications that are rung out before you actually go to contract on 72 more holes, would be money well spent.

Mr. Hansen: Would you care to comment on specific problems that you had with labor, that is delays due to walk outs, work stoppages, slowdowns, etc.?

Maj. Arnold: We had quite a bit of labor trouble at Lincoln and our construction phase. There were several reasons for this, number one, part of them were under the Omaha locals, and the rest of them were under the Lincoln locals. The Lincoln union was practically non-existent until this project came along and as such we find some people with a tremendous amount of power, which they had never experienced before. In many cases this power could have been used a little more wisely I feel. I commented earlier that another big problem we ran into was people working seven days a week, 24 hours a day. This meant for some of the laborers, 70 and 80 working hours. Of course they were drawing fabulous wages, more than many of our supervisors. These common laborers or craftsmen who were working these long hard hours had more money than they could spend, and besides they didn't really have time to spend it, they worked so much. This certainly added to the problem that these people were just completely overworked and worked out. The labor force wasn't adequate to hold down the number of hours per week by hiring additional shifts. So many times I felt the walk outs or strikes or whatever we should call them, were just a result of the laborers being so tired and overworked that they just had to have a rest. I don't think there is any doubt but what many times this was the case. They were really looking for a reason to take a few days off.

Mr. Hansen: Would you care to make some general comments then, on the overall program as you saw it and how you feel that we might make some improvements in future programs similar to this?

Maj. Arnold: On a program which is relatively new where we do have political pressure and other types of pressures, to complete the job very hastily, I feel that we should break down the contracts further. I commented earlier on having one contractor put in the concrete tube and that was his job. Had we done this, we would not have had all these facility modifications later where he could recoup his losses and so forth. For us we would have had another three to four months for OSTF-2 to complete or to progress a great deal further on their facility construction, their crib steel, the PLS system, things of this nature. This being done, the overall cost of the construction would have been at least a third less. And say at Lincoln, with a final cost of 57 or 59 million dollars after the initial contract for 25 million, you can see that the problems you actually do run into, garble the contract and double the cost. Another problem I felt was very evident at Lincoln was the quality of the supervision and Engineers and General Dynamics. This quality was lacking in many cases in that perhaps General Dynamics could not recruit enough capable people for the job; and of course they have politics in their system like we do, they're always worried about their jobs, and they have a great deal of trouble in this area. Again, their contract being cost-plus, holding down the cost, interested them very likely.

Sometimes, we would run into problems where we would practically have to direct General Dynamics to do something on our site and they would come back with the question "who is managing the job". Well, in many cases somebody should have been managing it and it was not being managed properly. They would come up against a problem which was not even fully investigated and boom, here they go -- let a contract for umpteen dollars, it doesn't cost anything. It's just the quickest and easiest way to fix it rather than actually investigating it further with an idea of saving money. Later on at Lincoln they did come under the incentive plan (which I have personally not seen), but I can see no reason it would not work, especially in a case such as the construction of the 551 SMS at Lincoln.

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