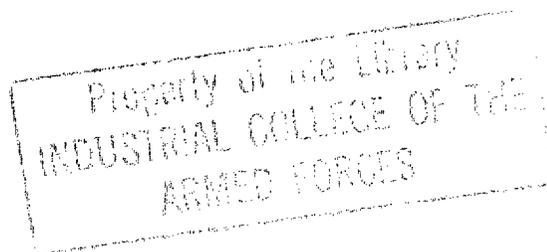




NETWORK ANALYSIS AS AN AID TO MANAGEMENT

Mr. A. William Buschman



NOTICE

This is a transcript of material presented to the resident students at the Industrial College of the Armed Forces. As such it represents the views of the author and not necessarily those of the Industrial College or the Department of Defense. Members of the College may quote it only in student reports or publications for use within the College. Other persons may not quote or extract for publication, reproduce, or otherwise copy this material without specific permission from the author and from the Commandant, ICAF, in each case.

Reviewed by Col E. J. Ingmire, USA on 25 September 1963

INDUSTRIAL COLLEGE OF THE ARMED FORCES
WASHINGTON, D. C.

NETWORK ANALYSIS AS AN AID TO MANAGEMENT

4 September 1963

CONTENTS

	<u>Page</u>
INTRODUCTION--Colonel George W. Marthens, II, USAF, Member of the Faculty, ICAF.....	1
SPEAKERS--Mr. A. William Buschman, Assistant for Industrial Management Practices, Office of Assistant Secretary of Defense, (I&L).....	2, 48
Lt. Colonel John J. Bennett, USAF, Chief, Analysis Division, Directorate of Status Analysis, DES/Comptroller, Andrews Air Force Base.....	11
Mr. Gordon D. Osborn, Chief, Management Improvement and Research Branch, Bureau of the Budget.....	33
GENERAL DISCUSSION.....	56

NOTICE

This lecture has not been edited by the speaker. It has been reproduced directly from the reporter's notes for the students and faculty for reference and study purposes.

Reporter--~~Grace Yu De Toledo~~ ~~has~~ granted access to this unedited transcript under the same restrictions imposed on lecture attendance; namely, no notes or extracts will be made and you will not discuss it other than in the conduct of official business.

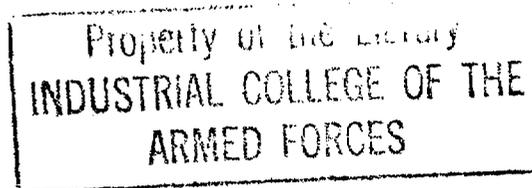
No direct quotations are to be made either in written reports or in oral presentations based on this unedited copy.

Reviewed by: COL E. J. INGHIRE, USAF Date: 25 SEPT 1963

Publication No. L64-16

INDUSTRIAL COLLEGE OF THE ARMED FORCES

Washington 25, D. C.



NETWORK ANALYSIS AS AN AID TO MANAGEMENT

4 September 1963

COLONEL MARTHENS: Admiral Rose, Gentlemen: First may I refresh your memory concerning our procedure this morning. It is a little different from the normal procedure. Each speaker will have a short question period after his presentation. Will you please relate your questions to the subject matter and keep your more general questions for the larger time period set for questions later in the morning.

We ask this since our morning speakers have kindly consented to form a panel right here on the platform at which time they will field your questions that might overlap into more than one of their areas.

Next I am sorry to inform you that we have a change in speakers listed for this morning. Mr. Fouch, the Deputy Assistant Secretary of Defense for Equipment Maintenance and Readiness, had planned for some time to be with us this morning, even though he would have had to fly here this morning from New York City to be with us. He is in New York where the DOD is putting on a program for top management in business, called the Value Symposiums. But late yesterday afternoon, he found that he would not be able to come this morning to be with us.

Mr. William Buschman, the Assistant for Industrial Management Practices of the Office of Assistant Secretary of Defense, Installation and Logistics, who will later again speak to you this morning on future programs of the PERT Coordinating Committee, has very graciously volunteered to make Mr. Fouch's presentation to us on management and networking techniques.

Gentlemen, Mr. Buschman.

MR. BUSCHMAN: Gentlemen: I have been advised a number of years ago by a speaker whom some of you may have heard at one time or another, Joe Powell, a very fine talker. He said, "Always get a symposium before you, because this enables you to check and see whether you are all zippered up before you talk."

I am going to dwell for a few moments on the motivating forces that caused us to go into networking analysis and to go into PERT, which is our basic system that has been developed for this purpose. These are the forces that are causing men such as Secretary McNamara, Secretary Head, Secretary Morris, and Harold Brown, the Director, to have tremendous interest in this program, to the extent that Morris would develop his own presentations and do it himself in this field for the Secretary.

The best example I know of to illustrate what we are seeking is a study known as the Weapons Acquisition Study by Merton and Peck of the Harvard Business School. In this study they took twelve major programs of the Department of Defense and analyzed the original bids and analyzed the final costs of these programs. They found that the average among these twelve programs of the time overrun on the programs was 1.36 against 1. This meant that they exceeded their time in effect by at least 36 percent, some of them as high as 2.3 and below .7 or an underrun in terms of time.

More striking and more costly in effect to us was the cost overrun, which was 3.2 times as an average over the original bid. These ranged from again .7 to as high as 7 times the original bids that had been submitted by industry.

This is a startling series of figures and, believe me, it is a motivating force. What does this mean to us? Now, these are not all just poor management.

Some of them are changes in the program, but changes in the program that had not been foreseen and had not been planned properly to begin with.

This is where our program, or PERT, begins to take effect. We find, of course that the original bid is not just the fault of the manufacturer. It's not just a case where he wants to bid on a program, an event. He is partly to blame, but we say we are partly to blame in not telling him what the program really is to begin with. We say that in order for the manufacturer to do a better job we must give better guidance.

As Colonel Bennett, who will follow me, will give you a networking analysis, you will be able to see how this can be improved through the network technique, through planning. We say we must enter into the picture at the time of the request for proposal. This means then that we must develop what you will see is a work breakdown structure of what the item is to do and what it is to look like, and we must give this kind of guidance to the manufacturer so that he in turn can do a better job in tipping this cost curve and this time curve instead of having it go like that from the original bit--to tip it like that. In effect it doesn't appear that we are saving money because we are raising the original bid up to where it should be.

We are attempting to cause the manager, right at the time of the request for proposal, to know more about this program that he is going to bid on and to be able to communicate better to us.

The second phase, then, that becomes very important is in the contract negotiation itself, that this same type of network analysis is used there again, a better planning tool, a better description of the program, and as a consequence a better ability to communicate to you who have been procurement officers, to you

who have been contract negotiators, so that you can communicate together and so that you can compare better.

We have some very excellent illustrations of this. When the DOD and NASA Guide was issued, we required that each service apply PERT cost to at least one major program. Now, in fact, each service applied it to more, and we have regarded all of these--TFX, Mauler, Lance, Subrock, Titan, the series of programs of the BuShips to be tests, to prove this system out and to learn from it.

Lance is an excellent case, because here we had the use or the requirement of PERT cost in the request for proposal. All the Government did was say, "Use PERT cost." About this time the DOD-NASA Guide came out and again they said, "Use the DOD-NASA Guide."

So it wasn't any true guidance. In other words, we, the Department of Defense, were not using it ourselves to give them the guidance of breaking this thing down first and defining it better so they could use it.

As a consequence, eight proposals came in from industry, and you couldn't make head nor sense of any of them. They just didn't communicate. They went into a program definition contract, and here they gave a work breakout structure. It broke this item up into its detail. It was a product-oriented work breakdown structure, going into the components, and gave some form of network for them.

For the first time clarity came out. The manufacturer knew what the Government wanted, and, as a consequence, when the bids were received, they could communicate. The contract negotiators understood and they could compare. As the Army expressed it later, "They were excited, truly excited, about the potentialities," because planning had gone into this and discipline had been exercised both on

themselves and on industry to present a uniform method of communication.

And of course the third phase is contract management. In PERT and in the networking analysis that we adopt here, we are striving for a system. We are not just giving reports to industry and saying, "Fill out these reports." We are attempting to get a system below this that the contractor uses and that will provide these data.

This is important because in this way the contractor will also use this system and he will make decisions based upon these data. We will make decisions based upon the same data. The program manager will use it and on a day-to-day, week-to-week, month-to-month operation we can both feel assured that we are looking at the same primary source of material.

This leads to another objective of the Department of Defense. That is our PERT Coordinating Group which is striving to obtain uniformity. Obviously, if the Army or the Navy each go out on separate programs and go to a contractor and they have a different system, this is going to become costly. If you add to this the Navy and if you add to this NASA or the AEC, you could have a series of systems each feeding up with different reports, each requiring different techniques, each requiring different computer programs and different language.

The first thing that would happen would be that the contractor wouldn't use any of them. He would develop his own. The second thing that would happen would be that it would be extremely costly. The overhead would go up, and we would be charged for everything, including probably NASA's and AEC's costs.

So we are striving for uniformity. We know that you are not going to get standardization as such in a system of this type. You may not get complete uniformity. But what we will avoid is disuniformity.

Why is this all important to us? Obviously, if the programs are put into effect and we don't succeed in tipping this cost and getting it to a more level effort and reducing this cost, as the program goes down the line it requires more money. At this point we say to industry, "If you had submitted a good bid and didn't come back in for this additional money"--and even in fixed-price contracts we have had to bail manufacturers out, as you all know--"the program you would have saved might have been your own."

We can say this to you, too, because coming in for more money means that some other program which has been programmed in the budget or with Congress, and so on, must suffer. As a consequence you get this tremendous machination of programs and trading off back and forth, which can be reduced. I don't say it can be eliminated, but we say it can be reduced. It can be reduced sharply. We also say that, with a proper bid in the first place, the program cost may go up but it isn't going to go up as much as it would go up if you had to make the changes as you went along.

These, then, are the motivating forces. These are the effects, the overall effects. And these are the objectives that we are attempting to achieve. As a consequence of the development of this program, recognizing that they, too, have a problem, such agencies as the Atomic Energy Commission have come in and have become a part of the PERT Coordinating Group, also NASA, FAA, and the Bureau of the Budget. You will hear a speaker from the Bureau of the Budget this morning. And, of course, we have the Army, the Navy, and the Air Force. All of these organizations

are striving to obtain this same uniformity.

We are selfish about it. We have offered them the use of a PERT Orientation and Training School that we have. It hasn't cost them a nickel so far. Why? Because we know that if they develop their own systems it will cost us in the long run. So, while we seem very gratuitous, very kind, we have selfish motives for doing this as well.

COLONEL MARTHENS: Gentlemen, Mr. Buschman will accept a few questions.

QUESTION: Just how far along is this program now? Is it in effect?

MR. BUSCHMAN: It is in effect. This is something I do want to go into later when I come up for my normal tour here of telling you exactly where the PERT Coordinating Group programs and projects are.

Let me say this: We have these ranging from six major programs to about fifteen additional programs in being. We are at a stage now where we must evaluate these tests. This memorandum has been issued by Secretary Morris causing an evaluation of this. Our crucial period begins right now, to evaluate these so that we in turn may ultimately issue a DOD Directive which broadens the actual application and establishes the criteria for the application of PERT costs to many major programs.

At the present time it is up to the service to apply it in as many more programs as it desires. We have several kinds of tests going on. The Lance test was right at the outset of the request for proposal, on program definition. The same thing is true with MMRBM, which was at least used in the program-definition phase. TFX was not used in the program-definition phase, but was set up at the initiation of the contract. PERT cost was applied to the Mauler Program when it was already 25 percent along the way. This is an important aspect of the study.

Subrock, on the other hand, was 50 percent along the way and going into production when the PERT process was applied there.

So we have these different kinds of tests which must be studied. This will take place in the next 3-month period, and at this point--plus an additional test that we have--we will be able to say, "You apply it to all these other programs."

Dr. Brown has already said that come the first of the year you will apply it to a very broad scope of programs. We want to develop more criteria for this and provide better assistance in the process.

QUESTION: Sir, will you identify specific program changes which in the past have adversely influenced cost on any particular program?

MR. BUSCHMAN: Specific program changes? In what sense?

STUDENT: You made the statement, sir, that the cost overruns were admittedly due to the program changes.

MR. BUSCHMAN: Some of them are due to program changes and some are due to mismanagement.

STUDENT: I would like you to identify for any particular program, if you can, those program changes which had an obvious adverse influence on the cost.

MR. BUSCHMAN: I can tell you one on one major program. This was the Titan III. As they went in to analyze it, they found that the vehicle that they were using, I believe in the second stage, would cost twice as much and would provide only half the payload that they had expected it to do. As a consequence, they had to change the program in the sense of moving that vehicle out completely and introducing a new vehicle at this stage. This is a startling thing. It was something which should have been known well before they got as far as they did into the program. But the important thing is that they found this out during the program-definition

stage and well before they started the development program.

QUESTION: I understand that this is applied to product research and development. Is this to be all or can it be applied to the basic information research and development, such as the many contracts with our universities and also in-house laboratories?

MR. BUSCHMAN: Let me put that this way. There is no requirement to apply it to the types of programs you describe, but PERT, or networking analysis, can be applied to any once-through, objective-oriented program. You can do this for a committee operation, for a task force. You can do it for your staff work. PERT begins the day you start the network.

We will identify our ultimate objective and work back from this, and look at it as though it were hindsight--for years we said hindsight was best--and let's assume that we have accomplished the job, we ask, "What was it that we accomplished, and what was the last thing we had to do to accomplish this?" We work backward instead of looking forward and saying, "Gee, I know just exactly what I am doing," when we are about a third of the way up the network. You stop and skip. You work it backwards on anything you do. You can build a house doing this. You can apply it to the study that you are doing or the book that you are writing or the report that you are writing.

QUESTION: How was NASA integrated into the uniformity program?

MR. BUSCHMAN: NASA is a participant. NASA has what they call PERT and companion cost. PERT and companion cost does not rely on the same system. NASA adopts our principles. NASA can use the same report. It depends on whatever cost system exists in an industry.

There is a very, very important point. They are planning upward from what

we would call the program manager on upward. We are planning our system for the program manager and later we will add the upward aspect of it to the decision making process.

I say this is important because, particularly in the development phase, we have not had a cost-accounting system in industry. Industry knows this. Our major programs were production, where you could accumulate cost on a functional basis--design engineering, manufacturing, assembling, et cetera--and you had completed units coming off all the time to define actual work being done related to that cost.

When you get into a development program or a multi-development program, the whole unit is it, and it may be 3 or 4 years long. If you accumulate costs on a functional basis, you've got a bookkeeping system and that's all.

PERT breaks that down, breaks the item down, so that the various elements of it take place. We go down into what we call work packages. The various elements of that take place at different times. As a consequence you can begin then to see actual work that is completed. You relate that to cost and you've got a cost system.

In the companion cost they rely on anything that is available. Ultimately, with the wide adoption that is taking place in industry, the whole system will back up the PERT and companion cost completely. We will have added upward and we'll have identical systems up and down the line.

This is just initiation in a different way. The principles and concepts they believe in.

Let me mention one other thing. We've had many conferences with industry at the outset of this program. I think, to put it in industry's words--Jim Hanlon of RCA and Lou Schroff of Western Electric are right now writing a report for the

DIAC, the Defense Industry Advisory Committee, on Industry-Government Relations-- if, in programs of this type, the Department of Defense will only work with industry at the outset, they will get participation, get a better program, and get better understanding, and they won't have trouble with industry.

They say that there is only one program on which this has happened. They didn't identify it in the report, but they told me it is PERT cost. We must have had four or five such conferences, at least three or four organized by Colonel Bennett here, much to his credit. It has been a help.

COLONEL MARTHENS: Gentlemen, we can come back to Mr. Buschman a little later. Thank you, Mr. Buschman, for bravely stepping in and starting off our morning on networking and PERT.

Now, gentlemen, It is my pleasure to introduce to the group Lt. Colonel John J. Bennett, who is Chief of the Analysis Division of the Air Force Systems Command at Andrews Air Force Base. He is also one of the leading experts on all aspects of the PERT system. We are fortunate indeed to have him with us today to discuss what I think is one of his most favorite subjects, Networks Systems and Analysis.

Gentlemen, Colonel Bennett.

COLONEL BENNETT: Thank you. Well, I guess you might say I am on the receiving end. This is the position you may find yourselves in when you finish school here.

There is a high level of interest in PERT and some of these new, advanced management techniques, and I have been affected. During the last fiscal year myself and two others from my office have attended 325 meetings in the Pentagon. This is more than one a day. So this to me is a high level of interest.

I think I'd like to start off and try to place PERT in perspective initially,

because it is just one of a series of new advancements in management techniques. I'd like to say that it has been primarily in the development area, but it has considerable merit for application to administrative tasks and things of this nature.

A recent survey of the Army, Navy, and Air Force shows that there are almost 800 applications of PERT in the services today. I think this is far more than I personally would have any knowledge about or would have thought existed. In the Systems Command we have over 40 major applications. This has been growing since about 1959. Some of these are small. Some are a part, and some most recently cover total major systems.

Let me start off with Chart No. 1 and tell you a little bit of how I see this fitting into the picture. What is developing really is a new organization and a new way of doing business. We are developing the Systems Command. I think you will find this in the Army Materiel Command and in some of the program project management offices in the Bureaus in the Navy now. Navy is starting to move toward program management.

We are developing a command management system. PERT is one of the aspects of this. Really, our job is systems acquisition. We are acquiring missile, space, aircraft, and electronic systems. We are really trying to produce these products and at the same time control resources. These are the two management tasks that we have.

Our particular system is just one part of an Air Force system, and these three particular management systems that are developing today all are being responsive to the Department of Defense. This is the big motivating factor within the services.

(Slide) Now, looking at the next element, the management actions that we take in the product area, this is systems management and the nonsystems management. We manage the B-70, MMRBM, TFX, and Titan III. These are our products. These non-systems are support products--personnel, equipment, aeromatics, base support, and so forth.

Resources break down into the functions. Really, in the product area, we are trying to take actions and control time, cost, and performance. And over in this area (indicating) traditionally are men, money, and materiel.

(Slide) This breaks down into the typical management process--plan, control, performance, and so forth. I have here a subsystem matrix. This is the system management cycle that you run through. I would like to blow this management cycle up on my next chart and give you more information on that.

(Chart) That's quite large. And it's about this large, really. This across here (indicating) is the cycle we run through. We have a conceptual phase. This is advance research, program indoctrination, which has been most recently developed, and then there is our conditional development, conducting, and operating phase.

These are some of the processes that we run through here. We have a top management reporting cycle. We have general conceptual program documentation. We run through a systems definition cycle, scheduling, financial, program budget, performance.

Then we get into some of the support areas here--document control, cost analysis, interface, contract administration, and inspection.

Now, I could show it on this chart, but our initial inventory shows that there are 85 new techniques developing here, all the way along. I have shown some

of these that come in here--systems of force structure, costing, new configurations, management techniques, standard PERT networks in this area, developing the plantines to support the SPO's, to improve techniques. And of course here in the scheduling is basic PERT, and it goes on over to the line of balance.

I'd like to get across to you just one point, that PERT is just one of the techniques that are developing. It fits into a total management system in the research and development area, but it's an important one. I think that is why we are here today, because it has been recognized as being important.

(Chart) What is developing in each of these processes is a building-block concept. In this particular one, in PERT, the scheduling and costing area, we have a contractor data base. In some cases we would have a functional data base, or something of this nature. Information is furnished out of the data base in the form of PERT cost for the costing area and DCPR. I am not going to touch on this. I'll just say that this is ^a defense, contractor, man report, and it gives you manpower data, financial status data of a historical nature, and it gives you cost data. This data phase is used by the program manager for day-to-day management control.

(Flip) This information feeds up the line in this particular case into a system called Whistpact. This is the computerized altarhythm system and provides you simulations of the individual programs. It answers the questions: Should we go? No go? What if we stretch it out? What if we add more money? and things of this nature.

(Flip) Lastly, this information feeds up to the Department of Defense and Air Force into a system called Prom. This is force structure costing. Again it is computerized information, looking at the individual programs, answering

questions, one as to the same data base, and looking at the total force, comparing one system to another.

This is one of the building blocks that we see developing. I will show you the one on PERT a little later on. I wanted to bring this concept to you at this particular time.

(Chart) Well, here is what we are saying we are doing. We are going into integrated management systems for program management. This is a sort of servile mechanism. We are attempting to do a better job in setting our objectives and planning, controlling time, cost, and technical performance, as I indicated before, measuring results, and manipulating resources to do a better job in this area and get a product done, hopefully, for the most effective optimum cost, and the best that we can buy.

(Chart) PERT time came along in 1958 throughout the Polaris Program, which I think is a Navy submarine. It was really the first step toward achieving this integrated management system. I'd like to run through for you some of the things PERT time has been attempting to accomplish.

(Chart) We see it as an aid to scheduled planning. As you see, you people who know more about it, PERT time gets into estimating and so forth, but it is a framework for later setting your schedules. I'll cover this a little bit more as we go along.

(Chart) We think it highlights areas for management's attention. We see it with the critical path, which I'll explain. You are able to see which of your particular milestones and your particular paths or programs are the ones that are in trouble or have a potential for being in trouble, and highlight them to the manager and people who have this information.

(Chart) We see it as aiding communication. We commit our plan to paper in a particular system, as understood by the person we are talking to, and we find that we can communicate with him much easier and faster, particularly as it pertains to changes in the program.

(Chart) We find that because we have done this planning, because we have this base line, that we can save time, again particularly in the replanning area, the communications area, and what have you, and we find with PERT that we are able to focus attention on more different actions. We are able to show the interfaces between contractors, the interfaces between contractors and government agencies, and activities of this nature.

(Chart) Here is the PERT network. I think we're going to have to get a little bit of the terminology here. It's a little bit different. A, B, C, D, E, the circles, are what we call events. These are just moments or points in time. They do not consume any resources. They are milestones. When you sign a document, for example, that is an event. Between the events we have activities, and they are called activities. These lines (indicating) represent the use of resources and they consume time. The work done in making final drawings is an activity. This is where we will do our estimating and so forth.

Overall we have here a network. This is the mark of the PERT time technique. Now, what does the network give us? By using a series of events and activities, we are able to show the dependencies and the interrelationships between the total job of work to do. It is deceptively simple to understand theory, but implementation of a large program becomes quite complicated.

The first thing, as Mr. Buschman indicated, is that we set an objective. You can work this either way, but basically it appears to be more acceptable to

work it back. I am going to accomplish something. What am I going to have to do to do that? I am going to have to do events E and F. These two parts of the job must be completed before the end objective is met. So I put these on a piece of paper and indicate the activities that must go on between these. I continue to work back. To accomplish F I must accomplish events C and D, which will be part of this activity. To accomplish E I must do activities B and C. In other words, events E and F are both constrained by C. These two events are dependent on accomplishing C. I work on back through the program until I get a starting event. I begin programs, end programs, carry out these activities, and accomplish these events.

That is the basic theory of networking.

(Overlay) The next thing that we accomplish is to indicate the time estimates, and if you are in a program that has uncertainty you can indicate three time estimates. In this case let's take final drawings, and we have estimates of 5, 7, or 9. We think that normally, if everything goes right, we will accomplish this particular task in 7 weeks. However, if we have anything go wrong, it will take 9 weeks. Under the most ideal or optimistic conditions, it will take 5 weeks. This is a three-time estimate for this part of the technique.

Now, the date of distribution we are able to compute and come up with a statistical average. In this particular case the average would be 7. In this particular case (indicating) as you can see, the average would be skewed off more toward between 7 and 14. This is usually done by a computer. In most small projects, for administrative uses and so forth, we use one time estimate. If you have a program that has some uncertainty, some unknown factors, you might use a combination of one and three time estimates. The computer, if you are using a computer, will handle one or the other.

After you have made your time estimates (Strip) and computed your statistical average for your one-time estimate, you (Strip) then go through the program and add all these facts up along the path. This particular path here is 3, 5, 8, 16 weeks to accomplish that task. This particular path here (indicating) is 4.5 and 8, 12.5, and 6.5 in 19 weeks. So you can see that this particular path through the program is longer than this path (indicating) and it happens to be longer than any other path that you might take.

This is another bit of terminology. We call this particular path the critical path, because any slip in the time along this program will be a slip in meeting this end objective. If it takes 7.5 weeks here, this objective is going to be a week late. However, on any other path, a week will not have that effect. A week on this total 16-week path may add a 17th week up there but your program will still take the time along the critical path of 19 weeks.

(Strip) Well, PERT has actually grown out of a need for showing this interdependency and this interrelationship, and has evolved out of Gant charting and out of milestoneing.

Here you see the typical milestone again--information. Let me show you what we see as advantages and disadvantages with the problems in pure milestoneing. Here, for example, we have along the product milestone the cabling drawings, the bread-board assembling, and so forth, along with systems integration and flight tests and vehicle drawings.

Let me show you this same information on a PERT network. (Strip) We take all this and show all the interrelationships and the interdependencies. Now let's take this flight test vehicle drawing. We ask ourselves the question: Is there any effect on cable drawing or bread-board assembly on a different

milestone and guess time than on the flight test vehicle drawing? Well, the normal reaction is, 'No, there isn't.' But, when you put it into the PERT network, we find that cable drawings must be completed before the flight test vehicle drawing starts, as does the bread-board assembly. Now, we can answer another question. A slip in cable drawing definitely means a slip in the flight test vehicle drawing, but it's on a path that has additional time, or a slack path, so that the probability that the total program will slip is not as great. But, if you take the slippage in the bread-board assembly component, which will have an effect on the flight test vehicle, and slip this somewhat, this particular event is on the critical path, so a slippage in this will slip the total program.

Let's go back again to the flight test vehicle and ask what the slippage in this particular event or milestone will have on some things out here (indicating) the flight test bread board assembly. We look at our PERT network. Normally if we saw this slipping we would probably want to put in overtime to expedite this. But we look at the flight test vehicle drawing and it has no effect, really, on the bread-board systems test. The bread-board systems test is on another path in the particular program. But it is critical. It is on the critical path.

Basically that's the PERT technique in use and how you would analyze to use the information.

(Chart) This gives you a sample of one of the reports that we get out of PERT. You get the same milestone information, to indicate whether we are ahead or behind on the overall plan. This particular milestone is 7.2 weeks behind. Out here (indicating) we get additional information, usually on a milestone printout. We'll get the expected time on this particular printout. It comes out of the computer. You get a barrier. You get the latest allowable time. It's expected on

this date, but the latest time that we can have this without having a slip in the program is this particular time.

Additionally it indicates the schedule, if you have one schedule. On this form a little m is added by the analyst to indicate that he feels that management action is required. Of course, with this particular chart goes a narrative analysis.

I think we all must recognize that PERT is an aid to management and not something that actually makes decisions.

(Strip) As I indicated, PERT time, the scheduling technique, has been applied since 1959. Within the last year we have seen PERT cost develop. This is what Mr. Buschman was talking about, with the major service tests going on in the Army, Navy, and Air Force. This is the latest step toward achieving/integrated management system.

(Chart) What has been our problem? I think Mr. Buschman covered it rather nicely. I'd like to repeat it: To additionally budget cost procedures and control costs by specific time periods--months, fiscal years, and things of this nature. They did not control it by work accomplished, by the products to be produced. The dollars were controlled by functional departments. The organization knew how much money it had but it worked on only part of the problem. So we were not able to obtain product costs, because we did not break down the functional department costs. Atain it was not by work accomplished. We knew the cost by project task--so many electrical engineer man hours, so many design man hours. But these again were not accounted for by the work accomplished.

We see PERT cost as providing this disciplined and orderly and systematic approach to get our budget and cost by the products of the work we are going to

accomplish.

(Chart) There ^{are} six basic concepts I would like to leave with you. The first is a work breakdown structure. The objective is set. We then divide the program into subsystems, all product oriented. The subsystems are divided into components. We break this on down to the manageable end-item subdivisions.

(Chart) The second concept: When we get to the lowest end-item subdivision, we then break the program into work packages. These are the functional work that must go in to produce this product. I'll show you this a little later on in other viewgraphs.

(Chart) The third concept is a concept of networking at this level. When PERT originated, it networked the total program without regard for how that would fit into the cost. Now we have networking being accomplished to reflect the activities to accomplish these work packages. So that you have a link between the cost in the work packages and the schedules for the actual work to be accomplished.

(Chart) In the last three concepts we estimate and report together with linkage. In other words, we plan and we have our actuals against the same baseline. We have a system in here from estimating to completion in a mathematical system, and we summarize successfully up the levels, the building-block concept.

Let me go into each of these in a little more detail.

(Chart) Here is a typical work breakdown structure. The missile weapon system is broken down into a launching vehicle, missile guidance, control, and training, and subsystems. The missile is then broken down into flight control, ballistic shell, systems engineering, and it keeps on coming on down. Then it is broken down into the nose, first stage, second stage, inner stage, equipment section. Then it

is broken on down into missile instrumentation, power, cable, assembling, and documentation.

The dollar amount and the time to accomplish this work are brought on down within the contracting plan, and we try to use the guidelines for breaking down our program so that when we get to work packages we will have to control approximately \$100,000 and 3 to 6 months of work activity.

Then the envelope of PERT activities that go into working up instrumentation is developed. Let me have the blow-up of the instrumentation and I will show you a little more of this. This is the work breakdown structure concept. As I indicated, when you get to your lowest level, end-item subdivision, you break down to the functional work packages--engineering, mechanical, manufacturing, and testing.

The activities that I have described before are the activities that make up the electrical engineering and what have you.

(Chart) These then are assigned numbers on the activities that allow the scheduling information and the cost information to be summarized into the instrumentation, and summarized on up successfully.

I'll skip the next and go on to the one after the next. (Chart) I'd like to come back here and talk about estimates to record, estimates to complete, and summarize successfully, showing you the actual report, the major report that comes out of PERT cost, and showing you these particular concepts.

(Chart) This is the management summary report. The first line indicates the total missile information. On the work performed to date, we had a contract estimate of \$31 million. Our actual, which is our fourth concept, was \$32 million. We have an overrun or an underrun. This is the projected overrun (indicating) of \$1.3 billion. Totals and completions: The total contract was \$48 million. The

latest revised estimate says \$51 million, and the projected forecast overrun is \$3.4 million.

These are projections. They did not indicate that the program would necessarily meet these, but did indicate that if some management action was not taken the possibility of having an overrun of this nature was very serious.

We additionally have our scheduling information out here (indicating). On the missile, the earliest that we can expect it is March of 1963. The latest allowable time to meet our schedule is in January. In the missile we are 8 weeks behind.

Let's break it down and take the flip off here. Where is our problem? The work breakdown structure is in the first and second levels, as you can see here. Our particular problem appears to be centered in the propulsion, which is forecast for a million-dollar overrun. It has the most delay in the schedule, 8 weeks.

(Chart) We then take a look at the propulsion. Here's the information again. (Flip) Within the propulsion we look down here and find that the major cost overrun is projected in the control area, and this is also the major schedule problem.

(Chart) The control problem is centered in the pressure transducers, and again this is the schedule slack. This is the information that comes out. I want to use it to illustrate the estimate and record on the same base, planned versus actual, the forecasting portion of it, and the successful levels of summarization. This is the major report we use in PERT cost.

(Chart) I would like to now say that PERT cost and PERT time is nearing the point where it might be called a standard operating procedure. Dr. Brown has

indicated that in January 1964 we plan to use it on most of all the new major weapon system programs.

I'd like to now just take a look at one of the additional developments, which is adding technical performance, and give you a preview of something that is on the drawing board. This particular technique follows along the same work breakdown structure.

(Flip) You can see that you have basically the same information in here-- the current contract and the total program cost area. (Flip) The schedule information has a little bit different orientation here. We picked out the major milestones that everyone recognizes. This indicates the status, whether they are scheduled, in completion, and things of this nature, with, again, the weeks ahead or behind. We have added to this some parameters in the performance area. Here we have chosen four. We have chosen range as a parameter, accuracy, reliability, and weight, and then a narrative reference.

In this particular missile the accuracy that we are asking for is 50 feet. The accuracy that we presently have is 125 feet. (Flip) Now, if we look down here we'll see that in this accuracy area 80 percent of our problem appears to be in the guidance and control. The key indicates that it is the gyro. Let me go to the guidance and control. (Flip opened up all the way) We look at the guidance and control for the same cost information and the same schedule information, using the PERT cost. We indicate here that our accuracy is 25 feet. In other words, when we get down into the components it must be greater if we are going to sum up statistically and reach our 50-foot initial accuracy.

Against 25 feet we have 100. We look down here and we find that our inertial component accounts for 100 percent of the problem in this area. Again it is the

No. 1 gyro. (Flip all the way off) In the gyro area we call for an accuracy of 20 against a guidance control of 25 feet. We have approximately 60 feet. The problem in this area--and again it is the gyro, as we have indicated-- is a weight problem. We require a .1 milorating. We have currently a 4.1. Our outlook is for a .1.

Now, how do we get this? Of course this is blown up in the narrative that comes with the report. We indicate that we must subdue the gyrogetic gyro with the unit cost increasing from \$1,000 to \$6,000 each. This is not only going to have an effect on performance but is going to have an effect on the cost and possibly on the scheduling.

This cost is reflected here. We have indicated the program increase to be approximately \$6.1 million. This is the major portion of the \$6.8 million overrun expected in the inertial components.

This is on the drawing board. We hope to test it throughout this fiscal year in one of our major programs. It's this type of concept. It is not the only technical performance technique, but it is one that ties very closely into the PERT cost concept.

(Chart) Here is your building block in the PERT area. This is strictly the PERT time area. Again you have your data base and your contractors--contractor A or B, or your government agency, or your other agency. For example, this was a DCA project. This would be either Army or Navy supporting DCA, and this could be AEC, NASA, or something like that, and the contractors.

This information is summarized up, basically by computers in large programs, into what we call an IAC condensed network. This is an integrating and check-out contractor network which has jurisdiction for all scheduling and integrating of all

the activities. This takes various events, activities, and so forth, out of the detailed events in the contractor plans and summarizes them to give you the network that the integrating contractor uses. This is summarized by selecting key and significant events out of this particular network and putting them into a program manager's network.

This is the tool that the program manager at the division or at the SPO level in the Air Force uses to manage the total program. In other words, he is not interested in every bit of detail. This is reflected in what we call a top-management network or a common-milestone network. Basically this is set in advance. We hope to have specific milestones that the commanders, such as General Schriever, in our particular case, wants knowledge of. These are designated. They are used to form the basis for the program managers' net, and this goes on down into the program.

There is a father-son relationship here. This is the father, and he would have a son, (indicating). This is the father (indicating) and he would have a son. This goes on down so that you are able to look completely down into the program if you so desire. If a problem exists in this particular event (indicating) here, you are able to go down to the events to find out the cause of some of the problems.

Basically we have had to agree with industry that we would not be involved with other than setting the structure and that we would be primarily interested in this level of detail.

Let me take a look at the next overlay. What we are really saying is that the program manager will get reports at about three levels of adventure down to the gyros you have seen. These will be summarized up so that at the command and

department level you will get two levels of report, and at the Department of Defense you will get one level. You can see that this plan is spreading this information for decision making all the way to the top.

(Chart) I'd like to talk a little bit about program definition and the use of PERT cost during this. Program definition starts before development. The way the PERT technique is laid on, before a program manager can go to industry and say, "I'd like you to give me a quotation on this particular program," he must have produced an initial program manager's network and an initial work breakdown structure. These are then issued with the request for proposal, the request for quotation, and the contractors come back in with this information in PERT and PERT cost format.

This PERT time network indicates how the contractor will carry out the program. He is allowed to change this to show serious parallel activities and things of this nature. ^{If} the subsystem breakdown in the work breakdown structure indicates a cost that he plans in each of the product areas, this then is used for the bid analysis which becomes a part of the source selection. This is called Phase 1-A. In Phase 1-A you may have 7 to 10 contractors bidding on a subsystem. In Phase 1-B of program definition, this is narrowed down to 1 or 2 contractors.

Then you go through a formal program definition. The first thing that occurs is you attempt to define your configuration requirements. This is your Spec 3. This then is used to revise your work breakdown structure. The work breakdown structure is then used for the contractor to make his detailed network. On completion of this the contractor submits his final PERT and PERT cost plan, which is used for the final selection. It must be completed before the contract is awarded.

This particular PERT cost plan is to go on up for review at the various levels on up to the Department of Defense.

(Chart) Additionally, in the cycle that I have shown you, development and production, we have the PERT techniques, with time considered implemented, cost partially implemented, and performance on the horizon. We see the requirement to develop techniques throughout the life cycle of development and production. So another big effort of the Department of Defense and the services is marrying the PERT techniques to the line of battle techniques--this is the production scheduling technique--and adding to the line of balance some form of improved costing.

(Chart) Another area I'd like to talk about is contracting. We've indicated that contract PERT management systems must be considered in the procurement or the evaluation process. This is going to have a considerable effect on the procurement techniques if this procedure is carried out. I might add at this point that we have been through various phases of program definition but have not been through a program definition where all of the new concepts were used.

The procurement people historically run a contract evaluation using the cost category or the functional information--so many engineering hours, so many design hours, so much fabrication, and so forth. This particular technique, if it is used, will force these people to utilize product information--so much money for components X, Y, and Z, and things of this nature.

What we see developing in the Air Force--and I think this is true in the services--is that we will not be eliminating, at least for 2 or 3 years, the procurement way of estimating. We will be adding to that. We will have a matrix where we will have our product information down our Y axis and our functional

information across our X axis. We will be evaluating on the product, but as the product cost might change during the negotiation, this will change the functional cost, so that we will have both product and function costs giving us the same total in the contract process.

Additionally this will change the way contracts are written. We have made some headway in this particular area. In the contracting area, the latest development effort is the use of PERT cost and PERT time for setting incentive targets, and the schedule targets. The cost point and allowance out of PERT have been used in Titan III to set the targets that will be used for the incentive marks, particularly in the Martin Denver Company. This particular effort is presently being documented and will be presented to the Department of Defense, and we anticipate that the PERT Coordinating Group in DOD will continue research and development until we get a technique that will tie PERT cost directly into incentive contracts.

(Chart) I'd like to summarize this point and indicate again, as I did in the beginning, that PERT and PERT cost is not the only thing that is available. It is one of the things we are working on. I'd like to say that this is no substitute for planning. First, planning cannot be delegated. You can't say, "Make a PERT chart on this."⁹⁰ You must set objectives. You must set subobjectives. You can't substitute PERT for it. You must carry out planning. In fact, PERT forces you to plan, which is one of its advantages.

It is no substitute for decision making. It provides information and information alone. It is an aid. It's a discipline. It's a communication device. It's a technique that gives you visibility.

It's not a substitute for management organization. Organization is being affected because of PERT, PERT cost, and technical performance development. But

you must have good organization and you must have good people in order to do the job. I believe this goes without saying.

And last, in the computerization of the PERT technique, if the information is poor, it gives you bad information faster.

I'd like to leave this thought with you. I think that in this particular area there has been a lot of overselling. There are problems in implementation here. It's a long, hard process to develop computer programs. This is evolutionary, we hope, rather than revolutionary.

Thank you.

QUESTION:Your enlightened system, I think, was an early example in the Polaris. They integrated your development and production data in it. At that time the Army was very concerned with the problem of operator and maintenance personnel. How does the Air Force incorporate the training of the users in the field when the PERT system is introduced?

COLONEL BENNETT:Nike Zeus was an early example of this type of approach. We say Atlas was prior to Polaris, and of course the Navy had one before that.

What we have tried to develop here is a particular system that can bring in all the activities that must go on through the life cycle of the system development. We have standard nets for the training command. In your case they will be your training people. They come in at the time that we are in the program definition and later on, and they develop their networks right along with our networks, so that we know when we have to have training equipment and when we have to have instructors, and so forth.

The same thing exists for the logistics, our logistics command, and generally we see evolving standard networks to do this. They have teams that come in. Additionally, each of these agencies has a liaison right in the program manager

office--1 to 5 people, particularly in logistics and training.

The user has also. On the TFX the Tack people are also developing a network that fits into this program manager's net. On one chart you saw other agencies. These are the other agencies.

QUESTION: In the case of the PERT system you have described, is this to be planned as a management-by-exception system at the very highest levels? After you have done all the work and everything is progressing and if everything continues to progress, will the detailed reports stop at a low level and forget the management?

COLONEL BENNETT: I know in our particular case General Schriever feels that management by exception is a bit misused. Actually, we manage by problem. That's our exception. When a problem comes up it becomes an exception. What we are trying to do is to develop a total bit of information. When you have the total bit then you pick out the one problem area that is highlighted here.

I think what we will see developing is that there will be certain levels of information that will go as you move up the chain of command. PERT cost I didn't mention in here because, actually, what I tried to pour into 50 minutes we try to cover in 8 hours and 40 hours. It's based on the budget code. The structure that's in the budget code defines level two, subsystems, and some parts of level three. We see this as the information that will be going up to the departmental level and the Department of Defense.

So there will be that shred-out of information. Your budget information and your progress reporting will be to that.

However, it appears that each of these agencies will have the prerogative of asking for more detailed information, on down the line. This will be a factor of

how well the program is going, how well the program manager indicates in his analysis the explanation of the problem, and the management action that he takes.

Does this answer your question?

QUESTION: With reference to the personnel resources in the services and the Department of Defense, what effect is this new management system having? I imagine it takes well qualified people. How are the services, particularly the Air Force, coping with this effect on personnel resources?

COLONEL BENNETT: Basically we are not doing a very good job. It's a bootstrap operation. We find that in the program manager's office there is a requirement for more financial analysts and more scheduling type of people. We don't have what we think are adequate resources. There's a lagging behind. This causes problems, because, no matter how much information you get, ^{if} you can't analyze and use it it's of no value to you.

We are doing a little bit better at the command levels. General Besson in the Army has quite a lot of people in the data systems, in the analyses area, and in the systems management area, working on these types of things. We do in the systems command. The Navy in the bureaus has started to move this way. As a matter of fact, I heard yesterday that they have a new agency under naval management for developing information systems and management systems.

This is an evolution that is moving this way. The type of people we find is pretty much the generalist rather than the specialist. You need a specialist. We find that you need engineering people who understand the basic problems of systems acquisition and who also have a flair for management and can understand accounting and scheduling. You see teams developing, sort of like the operation research teams, but not that long-hair type of approach.

I hope I didn't embarrass anybody.

COLONEL MARTHENS: I think we'll hold the rest of the questions for the panel, gentlemen. Colonel Bennett, I want to thank you for a real introduction to our program.

COLONEL BENNETT: Thank you.

COLONEL MARTHENS: Continuing on with our program this morning, Network Analysis as an Aid to Management, it is now my pleasure to introduce to the class Mr. Gordon D. Osborn, who is Chief of the Management Improvement and Research Branch of the Bureau of the Budget. He will describe the overall requirements and uses of PERT in government use.

Mr. Osborn.

MR. OSBORN: Thank you, gentlemen. I think I had better explain my presence here. I work in the Bureau of the Budget, and obviously I can't deny the budget process. I assume that almost everything I say will have an institutional bias, but we do have other missions in life besides chopping all of your budget requests in half.

As a matter of fact, I know of one case, and please don't ask me to cite any more, where the Bureau of the Budget coerced an agency to take some more money. Please keep this in this room, because I don't know how long I'll hold my job if the news gets back around where I work.

Let me explain this. Obviously, and I think this is very apparent from a previous speaker, the full development of PERT cost will make budgeting more realistic. If it doesn't make too much difference whether we are talking about getting the costs down to the estimates or bringing the estimates up to where they actually are going to reflect what the expenditures are going to be, and if we have better estimates to start with, it is going to make the budget process more realistic, and

we will come out a lot closer in the end to expending the amount of money that we think we are going to. This, I am sure, will be of value not only to the Congress and the Bureau of the Budget but internally in the agencies.

But, as I said, we have other missions in life. We have another interest in Pert--two others. One of them, as some of you have unfortunately come into the area of reports control know, is the function of protecting the American public from the insatiable demands of the Government for information. To carry out this function we have the Reports Control Act. This specifies that, if any government agency wants to ask more than five people, or ten people--I am not sure, I think the criterion varies--the same question, you have to come over to the Budget Bureau and get them to approve your request.

Even so, we get tremendous complaints from industry and people outside of the Government on the demands that are put on them for information from the Government, and, of course, as soon as you make PERT cost a requirement in submitting a proposal, or actually in carrying out a contract, you get involved with a considerable number of people outside of the Government. So PERT cost has become a matter of interest to these people in the Budget Bureau. Fortunately, there has been a very close liaison, and people concerned with this particular responsibility have worked very closely with the PERT Coordinating Group, and they have made arrangements for interim approvals, even as this thing has been developing or has become finalized.

When we finally get to the end of the road and we have a standard operating procedure, there won't be too much difficulty in setting this up on a formalized basis.

So this is our second interest ⁱⁿ/PERT. And we have a third one. We are charged in the Bureau of the Budget with assisting agencies in improving the management of

the Federal Government. We are not so foolish as to think that the little group of people who work in the Bureau of the Budget will do much themselves to improve the management. Obviously, management improvements are going to come from people out in the agencies, people who are responsible for getting a job done.

When we heard about PERT, this seemed like a natural. Our interest in it is to do what we can to assist in the development of this technique and this process, and to spread it as far as we can so that people all over will know about it and will apply it to their own situations.

I am completely in accord with this concept that in the military services and even in NASA we need a high degree of uniformity in PERT. When we first heard about PERT, I think the Navy was calling it PERT, the Air Force had gone down the road with it, and they decided to call it PEP, and the Army was still trying to make up its mind which way it was going to go, and I am sure that they had a new name that they were cooking up. The fact that they had different names wasn't so important as the fact that the systems were beginning to specialize and that the inputs and the outputs were becoming different. Even the various commands in the services were beginning to develop their own specialized version of it.

What was bad about this, of course, was that the poor contractor, who may have had a contract with any one or two of the services and NASA and perhaps AEC, if this were to continue, would have to develop his own system for each one of the contracts. So we would find that one company perhaps would have to develop 3, 4, 5, or any number of systems for reporting or controlling a particular contract.

So we thought it was very much in order to develop some uniformity. Our main concern was that in the interest of standardization we didn't want to go so far in

this direction that we would impede creativity in the development of something better. I think we have done fairly well in this regard.

Now, I want to say, however, that, if you are not dealing with contractors and if you are doing things in house, since PERT is a management system, I think it is perfectly reasonable and highly desirable that you tailor the thing to your own problem and to your own situation. A little later I am going to describe some applications of PERT that come out a little bit different from the unified system that we are trying to develop where we use the contractors. This thing is a management tool, and all management tools should be developed to fit the problem and needs of a particular situation.

There are certain elements, I believe, that are absolutely basic. What the actual form of them takes, the various inputs or outputs, or how you do it can vary. What I think is quite basic is that, if you are saying you are doing this networking procedure or PERT, there are certain elements that you must have.

The first one sounds very simple, and this is that you must determine and define your objectives. This must be done in meaningful terms, not just vague aspirations. All over the Government I find a great deal of confusion in people's minds between the activity that they are doing, things that they are carrying out right at the moment, and mission accomplishments. This idea of defining very clearly what the objectives are and where you want to go, and letting everybody know about it and know that this is what you are trying to accomplish, makes it possible then for them to relate their own activity to this final ambition. This is what you have to do in PERT. You can't start a PERT network without having defined what your ultimate objective is.

Another element that is quite basic is to develop a plan of action. These

things all sound simple and very obvious, and a lot of activity goes on without taking these steps. We find that in PERT a discipline is exercised and it forces people to think in detail about what they are going to do before they start.

This plan of action divides roughly into two spheres. One of them is the work breakdown structure that Colonel Bennett mentioned, which is what you are going to do, the steps involved in getting to your end objective. Every step should be mission-oriented. It should be aimed at the ultimate objective. As I say, I think this is a good discipline, and PERT requires you to go through this mental process and then record in this thing what steps you are actually going to take.

Another element of a plan of action is the question of timing. I am particularly interested in the question of sequences and concurrences. Some of the things must be done in sequence. There is just no way out of it. Before you can go to step three you must do step two. On the other hand, through working with the PERT network, you can discover that there are possible concurrences; that some of the things you can do simultaneously.

One of the big advantages of putting down a PERT network and going through all the trouble of writing one up is that the sequences and the concurrences become apparent. So you can rearrange your plan of action to take advantage of possible concurrences and become aware of necessary sequences.

The critical path, in the red line that Colonel Bennett mentioned, is very valuable. This will point out to you that, if you must shorten up the time span on your network, if you are going to make any shortening, you've got to do it on the critical path. It indicates the activities that you will be concerned with and it points out the ones where you can accomplish some time saving.

On the other hand, the activities that are not on the critical path by definition allow you some spare time. So you don't put your efforts on trying to shorten those up. Then you still have that critical path which really determines the length of the project.

one
I want to point out /thing, and I am sure this is where my institutional bias will come out. In PERT cost you notice there was no critical path mentioned. This is my own interpretation. I think every path when you work with PERT cost is a critical path. Every place you can save money, or where you have an overrun, adds up and comes out in the end. In PERT time, the only place you save time actually is on the critical path. But you can save money or lose money on any path in cost. So you will find this fundamental difference. You have no critical path put out, per se, in a PERT cost network.

The scheduling of the critical path approach to networking enables you to take some management actions. I'll give you some examples without going into detail. In one project that I heard of, one line manager kept coming into the procurement officer with emergency procurement. It was possible to get the supplies under emergency procedures, but it cost an awful lot of money. After they had developed the PERT network and they found that this particular activity was on a slack path, a path with a considerable amount of slack on it, they decided that there was no necessity for rushing out into emergency procurement each time. Because it was on the slack path they could consolidate the procurement and put it through the regular routine process, namely, competitive bids, and so on. In this way they were able to cut down on the cost.

Another example, which is quite real, is the example of a private company building a skyscraper in New York. They were interested in two things. One of

them was skilled labor, and skilled labor in New York costs like the devil. I guess it does everywhere, but particularly so there. By setting out a PERT network and determining what the sequences were and where they could make adjustments in scheduling, they were able to schedule the skilled labor so that they had an even flow of it. They didn't have tremendous peaks of, let's say, high-priced electricians or construction people. By using the network and seeing where they could do things concurrently and where they could do them in sequence, they were able to smooth this out. This was of considerable assistance to them.

Perhaps a thing that becomes more obvious is the question of building materials. If you are going to build a building in New York City, you've got a tremendous problem of where do you put the material. You've got a very limited amount of space, and if you put things out in the street it doesn't take too long before the police come along and make you move them.

By using a PERT network, they were able to schedule the building materials so that they didn't pile up a bunch of sand and gravel where they needed to put bricks, and they didn't have steel all over the place when they needed other materials. This helped them out considerably.

I just mentioned these to illustrate the kind of alternatives in management decisions that you can make when you've got this network all established. Of course, scheduling, after you get through with your network and have made your decisions, means you put some dates on them. This brings your whole plan of action down to a concrete action program.

Another thing, of course, that you get out of PERT is the system for reporting. It isn't much help just to set up a plan of action until you have also established a system for finding out how closely actual events are taking place

compared to your plan. You can get this from PERT. You can compare what you intended to do with what you are actually accomplishing.

Now, there is one other aspect of PERT that I think makes the whole thing worth while. If you have planned your work carefully and you have your PERT network and you have your reporting system going, it gives you an ability to forecast the consequences of anything that happens. First, of course, you can forecast the consequences of your original plan. If it doesn't work out right, then you can go and redo your plan. As Colonel Bennett pointed out in one point, you can put it on a computer and simulate all the different networks and situations until you get one that you like. But also it will give you the ability to forecast the consequences of any variation from this plan.

I think it was a nice example that he demonstrated. The normal thing, when you've got a crash program and you are getting behind, is to punch the panic button and speed up everything. This is a normal course of events. With a PERT network, something happens. A contractor gets a fire in one of his plants and he can then look at the PERT network and see whether you have to take some very expensive emergency action to take care of that particular situation, or whether you can ride it out and let him repair his plant and go ahead with it.

So this ability to foresee the consequences of anything that happens, or, let's say, a variation from your plan, is extremely important.

Now, getting over more to the civilian-agency side of this thing, you don't need a multi-billion-dollar-weapon-system project in order to take advantage of the PERT networking techniques. Any situation that has an end objective, is complex, has uncertainties, and is susceptible to management and there is something you can do about it is a situation that is a candidate for using PERT.

I must emphasize that the project has got to be worth the effort. There is no point in cranking up a tremendous PERT effort, with a computer program, and so on, if the project is one that is so insignificant as not to be worth this administrative type of effort. I think from this comes a lot of the talk--and we hear it all over the place--that PERT has been oversold. A lot of people have heard about PERT, and they have tried to apply it to situations that just aren't worth this kind of administrative effort. I think a lot also comes from the fact that the people who were working it really didn't understand the last fact that Colonel Bennett showed when he said it is not a substitute for planning, it is not a substitute for good organization, and so on. They thought that the system would take care of this.

Then I am sure that there is this element, too: The management consulting firms that have a sort of proprietary interest in PERT are all for it. They talk about it all the time. The management consulting firms that weren't in on it and perhaps don't even understand it too well always go around and talk about PERT's being oversold. So we have to consider the human element in evaluating this thing, as well.

I think that, with some notable exceptions, the civilian agencies of the Government will be concerned more with PERT time for some time to come than they will be with PERT cost, for the simple reason that only a few of them have these large, expensive research and development projects performed on the whole by contractors outside of the Government. Of course there are some notable exceptions. One is construction work, particularly outdoor construction, and a lot of civilian agencies are involved in this. They are finding PERT time very useful and they are beginning to learn about PERT cost. I think this will spread.

If the FAA ever gets the go-ahead to start developing the supersonic transport, I think this will be a natural for PERT time and PERT cost. I don't know whether I should call NASA a civilian agency or not, but they are heavily involved in the thing, and of course they have the same sort of problems that you have in the military services.

I wish that FAA had investigated PERT sufficiently to apply it when they were building Dulles Airport. I talked with people over there, and they were quite satisfied that the ordinary Gant chart was perfectly suitable for this type of operation. I don't know whether it was due to the lack of more sophisticated management devices, but, as you know, that airport got a couple years behind, and in the meantime the airlines had gotten accustomed to using Friendship. The Congressmen are interested in Friendship, and I think it will be quite a while before Dulles gets the traffic that they had intended for it. So I think this would have been quite helpful if they had been using it.

You have seen the network that Colonel Bennett put up and the scene of events he described. I think in my mind the most outstanding application of the type of thing that PERT does--and of course it is never used in this regard--is in French cooking. I am impressed with this, because they never take a thing and just cook it once and then bring it right to the table with everything else. They sauté this and add it to something else, and then they cook that for a while. Then that all goes on to the top of something else. So they've got all of these sequences and interdependencies. I think it's just marvelous that when the meal is ready the chef brings it in and everything is there all at once. Some of it started 5 hours before and some 3 hours before, and you've got all the interfaces and everything else. Perhaps from this came the idea of PERT. This is the type

of thing that goes on in the chef's head. He is so adept at this that he doesn't need a PERT network. I think there are a lot of cases where you don't need the PERT network, where you have been doing something and you are quite familiar with the process, or it is so simple that you can do it mentally.

But life is getting more complex all the time, and the problems that we deal with are getting more complex, and setting these things down on paper and developing a network and tasks, and so on, is a very good aid, and it will enable you to see the relationships, and it will prevent some of those very obvious goofs that the General Accounting Office loves to come along and point out and give us headlines on.

I think one of the most prevalent uses of PERT now outside of the weapon systems development is in construction. Within the Government we find agencies, such as the Bureau of Reclamation, concerned with large dams and water processes in the West. The Park Services use PERT. The Veterans' Administration uses PERT in the construction of hospitals. The General Services Administration I understand use PERT. They are responsible for constructing the U. S. exhibit, the pavilion at the World's Fair. TVA uses PERT.

In industry they are using PERT for construction on a very wide scale, or they use one of the related network techniques.

In the Bureau of the Budget itself--and this is a thought that occurred to me in listening this morning--every once in a while we employ a management consulting firm to do a particular job for us. I've noticed now in the soliciting of proposals that several of the companies will submit their proposals in the form of a PERT network. This makes it very easy to analyze. It's much easier to evaluate the different proposals that come in if you have some of them on a PERT

network. You can really see whether the contractor understands what you want and how he is prepared to go about it.

Another activity where you can use PERT is in report preparation. This doesn't sound like much of an activity, but, if you are in the Bureau of the Census, report preparation is quite a formidable task--the production of the census and the statistics. They are using PERT.

Another instance in this same regard is the Bureau of Labor Statistics. They have an enormous job in producing the kind of reports they get out. They have started using PERT to develop a system. Let me tell you a little bit about this thing. Every month the Bureau of Labor Statistics goes out and gathers some statistics on a sampling basis. They have gotten quite good at this. They have samples of up to 125,000 things that they sample. They're getting quite accurate at this, and they do it on a monthly basis. Then once a year they take some very basic statistics from the Census Bureau or possibly from the Social Security people, where they have a 100-percent return on figures coming in, and they use these as benchmarks. They relate these back to the samples they took and in some cases this shows that the sampling results have to be adjusted.

Recently they have become so expert at sampling that the adjustments are not very large. When you consider the fact of the tremendous significance of the cost of living index these days--it's the subject of labor contracts, and so on--these adjustments are important and should be made.

They developed a PERT network for this thing. Of course it's in their interest and in the whole public interest to get these adjustments out and to get their big annual reports out as soon as they can. If these statistics come out two years after the fact, they're not nearly so valuable as if they come out six months

after the fact. So they developed a PERT network and ran it through the computer, and they were shooting for 100 a year and found they had something like 424 days. They began to analyze it in the critical path to find out where the problems were. This was quite simple. They found that the majority of the time was spent within their own agency just in the communication, in their message center, and so on. So this was something they could do something about.

They ran this thing down eventually through simulation and running different networks, until they got it down to somewhere in the neighborhood of 250 days.

This became interesting. You know, this IBM Company is quite fabulous, and the whole thing was done on an IBM computer, a 1401. So IBM wrote a brochure on this particular application of PERT. I think this organization never misses a trick to advertise their own wares.

There are a lot of administrative situations that are ideal for using PERT. I took a course one time, one of these training sessions on it, and the example they gave us in the classroom was the installation of the computer. This can be a very complex activity, with all the problems of sequences, concurrences and all sorts of things, and what happens if there is a strike in the plant, and so on. It worked out very neatly. It was very helpful to use a PERT network to make our decisions.

Two agencies are going to move. The Bureau of Standards is going to move from ^{the} nice, cloistered campus they have up on 16th Street out to Gaithersburg. They are planning the move on a PERT network. FAA is going to move from the collection of buildings they are in into their own building, and this is being done on a PERT network. I was told that in the last reorganization of the Army the

actual carrying out of the reorganization was planned on a PERT network. AEC has a problem. They are turning over the whole community of Los Alamos to the people who live there. Instead of a completely government-owned community it will be a community of the people who live there. There are all sorts of problems, legal problems, administrative problems, and so on. They are planning this particular move, this turnover, on a PERT network.

When we are talking about this kind of thing, just imagine how helpful this PERT technique would have been ^{to} Project Overlord, this just fantastic problem of getting the military forces across the English Channel. I think it would have been really an ideal application.

There is a man in the National Institute of Health who is working very hard on developing a cold vaccine. I hope he makes it. They have been doing all kinds of things but they haven't done much about this yet. He is using PERT techniques in this whole research effort of trying to come up with a vaccine against colds.

Recurring maintenance is a good application of PERT, particularly in the chemical process industries. AEC is using it here. Every once in a while in the plant they have a problem. This comes on a scheduled basis. They know it happens and they anticipate it. The thing gets an accumulation of scale and deposits, and so on, and they need to shut the whole thing down and take it apart, clean everything out, and put it back together again and start it up. By using PERT networks they have been able to reduce the time that it takes to go through this operation, by a considerable amount.

There was one fellow in the Corps of Engineers who was responsible for one of the hydroplants on one of the rivers. They have this same problem. Every once in a while they have to shut down a generator and overhaul it and

put it back together. He read about PERT on his own and developed his own network, and he was able to reduce the time from 11 days down to 8, simply being able to perceive which were the concurrences and which were the sequences.

NASA, of course, uses it all over the place. I think this is an interesting thing. I ran into a military officer the other day who is assigned to NASA. He's responsible for this new installation down in Mississippi that they are working on. He told me that he was using PERT as a management device to plan and control the development of this installation. You've had questions on NASA's use. PERT time^{there}/is quite similar to what the military services are doing, and PERT cost is a little bit different. I would hate to predict, but I think eventually this will have quite a bit of uniformity all the way through.

As for PERT time and PERT cost across the Government for research and development and these large and expensive projects, we are encouraging the use of it. We think that it is going to bring estimating and financial management closer to reality and it will help people to manage.

As far as PERT time is concerned, I think this is a management tool that can help everybody. We are encouraging everybody--the military services and the civilian agencies--to go to the PERT Orientation Training Center and learn about it. We also are hopeful that we can develop some special courses in that school that will be more closely oriented to administrative-type problems that these people will be faced with.

This is all a part of the President's Program for improving the management of the Federal Government, so we are interested in helping it and are giving it a boost along to the extent we can.

Thank you.

COLONEL MARTHENS: Mr. Osborn, with your permission, I think we will hold the questions for you until we have the panel, if you don't mind. Thank you very much for telling us about the wide uses you find for PERT presently in existence.

Our next speaker, Mr. Buschman, will talk on the future programs of the PERT Coordinating Committee. I might add that Mr. Buschman is the Chairman of the group that got together and published this book which you all have received, and it was through his courtesy that we have been put on distribution for each one of you to get one of these. In fact, there were only 1,000 printed, and the College got around 250 of them. But that doesn't mean that there will not be a great deal many more printed.

As you know, this was coordinated by industry and all the government agencies. There has been an order for 25,000 of these booklets. They are for sale. Industry and everyone else are going to buy these things. There has been a great deal of interest in it. I am sure you have gone through it and scanned it, and you'll find that this is a very good booklet on the PERT network.

Therefore I'd like to introduce again to you, Mr. Buschman.

MR. BUSCHMAN: I'd like to take a few moments to emphasize to you and to give you a little bit of a picture of what this looks like. (Chart) This will lead into a few of our questions.

The PERT Coordinating Group followed the lead of the services, actually. It was formed by Secretary Morris in 1961, in the fall. We brought in at that time a series of firms, actually five firms, three associations, AIA, EIA, and AMA. We had presentations made by management firms and by the services. It was from that group that the so-called DOD-NASA Guide was ultimately developed, on a contract with both the Special Projects Office and the OSD, with Secretary

Morris. That Guide, incidentally, has sold about 35,000 to 40,000 copies right now to industry. From this effort we of course started to work on this new document, and we found that the interest was quite great. It was not just the Department of Defense, the Army, Navy, and Air Force. The Bureau of the Budget had come in right at that time, right at the outset of this program. Then Atomic Energy Commission joined us, and Federal Aviation joined us, and of course NASA has been with us, as well.

We formed several subgroups, one of which is the technical subgroup, chaired by Colonel Parker over at AEC.

This is where we get some uniformity--one of the areas, at least. This group has responsibility, for example, of evaluating the test that I mentioned earlier on Subrock, TFX, Mauler, and so on, so that we can confirm our principles and concepts and apply them on a broader basis.

We also formed at that time a training subgroup. From this we recognized--and this will answer a question asked earlier--the fact that we didn't need PERT specialists. We needed an awful lot of procurement officers, contract negotiators, and so on, who needed familiarization with PERT. We estimated this to be in the neighborhood of 12,000. We also knew that industry would come in and they would tell us about PERT every time one of these people came in. So we took our cue from the Special Projects Office.

We would sit down and spend an hour or two talking to them, and we would get nothing else done. We also had the other government agencies interested.

So from this we set up what is known as the PERT Orientation and Training Center, currently located at Bolling Field. Secretary Gilpatric recently signed a DOD Directive establishing this and designating the Department of the Air Force

to run this center and to do so for the Government as a whole. As a consequence, although it has already processed 1600 or more students, at least 200 of these are from other government agencies, and about 300 of them are from industry. The center is also authorized to provide training for them.

Secretary Morris, recognizing the experience I described a little bit earlier on Lance, realized that we needed more actual training. We came across this, too, particularly when we were out giving a presentation to a corporate organization, the Chrysler Corporation, at which time Tom Morrow said to us, "We found that the procurement people did not understand PERT." This was true. This was on Lance, on Missile B. It was too new for PERT cost. His people didn't either, because he hired a management firm to come in and do ^{this} for him. This was a real problem.

So from this evaluation already made Secretary Morris sent out a memorandum just on August 10, calling for all procurement officers and contract negotiators, and auditors--there is no sense having an auditor talk to a contract management officer and have neither one have any knowledge of PERT--to obtain a minimum of 8 hours of orientation during the next year.

We've asked the Center to establish a training seminar with the other schools in the services and with other government agencies participating in this as well, so that they can go out and provide the uniform concepts that exist here. Each school that we have all over the country will assist in this tremendous load which will run into the thousands--we have no knowledge how much. It will have to be a cycle. It will have to be a repeat.

Now, someone during intermission asked me to mention line of balance. We realize that PERT cost is a system which as originally conceived was through

an objective-oriented program. You will also realize that it is being applied to repetitive development and to production. Our original concept was that we must develop some line-of-balance concepts, which is another industrial management technique, which would have costing principles in it.

Line of balance per se is a control-type technique. Actually, what you are attempting to do is to have a series of charts for this purpose, and you can actually set up your whole inventory control system and your schedule of output and relate these two so that you don't have tremendous overinventorying in relation to the lead time that that inventory in effect is required to be used on.

It is a control technique. It doesn't measure the amount of manpower or cost that is used. This is where it gets its name. It is a line of balance, the line that balances right across to the end assembly. So we said we must apply a line-of-balance technique to PERT cost.

This was an assumption which may have been fallacious, because it was an assumption that PERT cost would not necessarily apply to repetitive development or repetitive production. The repetitive production we are talking about, of course, is truly more repetitive development, each of these items being so tremendous.

We find industry already applying PERT cost to repetitive items and still using line of balance only as a control technique and not as a cost technique. We don't know where this is going to go.

In any case we felt that we should set up a coordinating group, and as you will see there is considerable activity in this area that is being carried out with industry.

The Reports Simplification Group is no longer a part of our responsibility, but this is an area in which tremendous effort is going on.

These two (indicating) in the middle are tied together, and they work with the Industrial Management Practices Group, which is attempting to keep for the Government as a whole its horizons relatively broad.

Now let's see what we are doing at the present time in our program.

(Chart) I put this chart up because I believe it illustrates some of the opportunities which we must take advantage of if we are to make the greatest use of this. We have already put out the so-called PERT Guide for Management Use, and you have copies of that. In all of our efforts, and in the clearance we did with the PERT Guide for Management Use, we have attempted a top-down approach. So we went to presidents of corporations, 27 of them, and asked them to review a draft of this. They did, and we asked again their financial, their development, and their production vehicles to all make inputs on this, which again were very gratuitous.

We recognized from one of the comments we got on the original document, which was quite different and quite voluminous, much more so than the one you have, that we needed a document for the presidents of corporations, for the board of directors, and for the vice presidents, which was small and would be readable. That's the purpose of the PERT Orientation for Managers, which will be forthcoming. It still is not available.

Also, the Technical Evaluation Group had a job to develop uniform output reports based on the implementation teams' experience. This has been done. We have a draft of this, and we will hold a conference on the 1st and 2d of October which will be sponsored by the Pert Coordinating Group and which will be hosted

by
/AMETAG, Army Management, Engineering, and Training Groups. We will have 300 people from industry there and each will have received a copy of these reports. We will go over the entire reports with industry. Then after that we will go back to the Bureau of the Budget and review with them the extension of the reporting techniques involved here.

I mentioned the evaluation. I mentioned the DOD Directive on the PERT Orientation and Training Center. I might add that this Center has a 4-hour VIP orientation, an 8-hour orientation, and a 40-hour course.

The Technical Evaluation Subgroup has also been given responsibility for uniform input data. This is a part of the system itself. It is a very important that we ultimately achieve uniformity.

We have to know about the cost of PERT cost. Any time you have a good management technique, and this is management, you are going to have a dickens of a time trying to measure the cost of this. We have come to the conclusion that the cost of PERT cost should be treated as an overhead item, that its maximum cost is somewhere in the neighborhood of 2 percent, and that it ranges from .5 of 1 percent with one of the implementations to about 1.5 percent. We do recommend that it will be a part of overhead.

This is important because many companies--Hughes for one, General Dynamics for another--are applying PERT cost on any and all projects, whether or not the services require it as part of the contract. This I obtained directly from Mr. Highland, Executive Vice President of Hughes, and General Dynamics made the same kind of statement. Aerojet has also made a statement of this type.

This will be a relief, instead of treating it as a line item and having profits and everything else, with overhead piled on top.

We have a series of NSIA studies that have been proposed, and I am going to show you a separate chart on those. No, let's go back for a moment.

The PERT Guide for the Evaluation of Technical Uncertainties is in that network that you saw. You can define an activity that you know you have not too much of a problem about. If you can define an activity that is technically uncertain--and many of them are technically unknown--top management in submitting a bid doesn't always know this--they know that there are some there but they don't know what--and if you can interface those with other activities, we may have a whole new critical-path concept on just those.

The three-time estimate will tend to point some of these out. But they may not be on the critical path. This is an area which, having defined it, you may want to make a subnet right at the outset of the contract. This is an area that is being studied and that we will work on, the PERT Coordinating Group.

As you can see in the case of Titan III, PERT has become an invaluable tool to incentive-type contracts. I discussed this with General Bleymer. The important thing is that it works very much like the old incentive-wage contracts, in that it shows those activities that are contributing to a plus fee or, more important, a negative fee, a loss.

Immediately, it also shows the effect on other activities. As a consequence, the management within the firm and the personnel involved in other activities begin to apply it. It's an aid to the decision-making process. It is an aid to contract negotiation. These are all activities that we are involved in.

The biggest item is ultimately a DOD Directive establishing the criteria for the application of PERT cost to major programs. This must follow the

evaluation that I spoke of a little bit earlier, and so on.

Now, we do need a PERT Guide for small business, for small organizations. We are working on this. This is the time phase that I mentioned a little bit earlier.

(Chart) NSIA--and this will give you indication of some of their interests-- came to us and said, "We want to review all of your output reports." We said, "We don't believe that this is a technique. The Bureau of the Budget does have an Industry Advisory Counsel, but since you are offering to do work for us, we will be tickled to death to accept it." We've accepted it first in the field of ASPR. One of the first things that Secretary Morris asked for was, "How should ASPR be changed to accommodate PERT cost?" We found that the ASPR people didn't know about PERT and we didn't know enough about the ASPR regulations to really come up with good, tangible recommendations.

So we asked NSIA, because, after all, the two systems are impinging right on industry. They said, "Yes, fine, we'd like to do that, and we'd also like to do some of these other things." We have eight subgroup studies of the National Security Industrial Association Finance Committee, which are being headed up by a man by the name of Stanley Sjosten. He is Comptroller of Melpar. We have about 40 people from industry on these various groups. I don't have to read the gamut of them, but you can see that each of them is important subject matter, and they will represent a tremendous input to the program as a whole.

We have established quite openly liaison for them which split the job all up. We've been quite random in doing so. I believe that this gives you an indication of the type of things we still have to do, to take it down to all the opportunities that do exist here. Our greatest fear is that we will permit some of them to drop

through the cracks.

If anybody says, "Oh, PERT cost can go into effect; it's all done; things are laid out; we have beautiful guides here; it's a pity; this is the end of it," I think you can see from this that we have a lot of problems. We are going to depend upon a lot of inputs from every place that we can, including from you.

I do want to add one thought to something else that was said here. One of the basic reasons that this system is so desirable is that it has this forecast ability. I didn't mention this early, but Jack Bennett mentioned it, and you could see it in the management summary reports. That forecast ability tells you what is happening to the ultimate cost, what is happening to the ultimate time, and it makes this a very important tool, because you can forecast now that you are in trouble, now, in time to do something about it.

I think this summarizes about exactly what I want to put across at this time.

COLONEL MARTHENS: Again, with your permission, Mr. Buschman, I'd like to take a short break here while we set up the panel and hold the questions which might be directed to you for the panel. Thank you, Mr. Buschman, for the very interesting talk on the PERT Coordinating Group and its future activities. Thanks very much.

Now we've got them all together up here, and we'll try to field your questions.

Before we start--I've heard a lot about PERT and what you are doing in DOD and industry and everything, and I thought it might be interesting to our panel here to know that we here in ICAF are getting on the bandwagon of PERT and we've got a few PERT networks of our own being designed here.

Now we are ready for your questions.

QUESTION: Mr. Buschman, you indicated that there is under the PERT system

communication upward, primarily on the status and problems and then communication downward on the problems. There seems to be an insignificant amount of resistance on the part of industry in furnishing this information upward. I am wondering what the program includes for automatic feedback to the people who are working on these things, to tell them the status of the overall program.

MR. BUSCHMAN: Of course, No. 1, industry is going to have the same report that we have. This feeding upward takes place in two ways. It takes place to the vice presidents and presidents within the corporations, and the reports will feed up to them. They will be the PERT cost factor reports, and the PERT time reports. They may at that point translate them into something that the particular manager understands more or is used to. They will have the same type of reports.

Reports right now, as far as Defense is concerned, feed to the program manager. He maintains an overall master network and relationships. This is up to him. We have no requirement whereby he transmits to the contractor the program for the total system. I don't know how he could do otherwise than to have his regular briefings and discussions with these people.

Jack, you can probably answer that.

COLONEL BENNETT: There are two or three different things that occur. A lot of the actions that take place in changes require the program manager to feed back information. On the analysis that comes in with the information, the contractor will indicate some action that he plans to take, but, prior to his taking this, the program manager will feed back, indicating that he should do this or something additional.

There are other aspects to it. One is interface log, which shows all the interfaces between all the contractors, all the agencies, everyone involved. This interface log is an example of information transmitted on the particular log plan and

changes to this, so that he can see what effect changes in other contractor plants have on his particular program.

There are regular quarterly meetings and members of the teams attend, such as on the Minuteman. These all fit in to make a total control system with PERT just being part of this particular system.

QUESTION: Colonel Bennett, in your list of what PERT is not you included that it is not a safeguard against erroneous input. When you are controlling the progress status on a project, how do you go about keeping the progress fed in from your contractors?

COLONEL BENNETT: This is part of the structuring. There are several ways. Of course you have your checks and balances with your plantines, and what is developing in this plantine. We call in Accro. They do an independent analysis on this information. Then we have the plant check. The auditor goes in and does a random sampling of information to see if it is accurate, and things of this nature.

I'd say that one of the basic controls is the fact that you've got these work packages broken down into 3 months and \$100,000. He can fudge you for a certain period of time, but when he comes to that 3-month period, he's got to say, "I don't have enough money or time," or he's got to say, "It's complete," because he can't charge that account any more after that period of time. So you have that check and balance. And there are others that are built into the system.

QUESTION: I read in the Saturday Evening Post recently that the CIA had a \$3.5 billion budget. I'd like to ask Mr. Osborn if he knows whether CIA has any application for PERT .

MR. OSBORN: I'm sure I don't know whether or not the CIA has a \$3.5 billion budget. There aren't very many people in the Government who do. I don't know what

they do. Unless you have a special reason for looking into what the CIA does, you stay away from it. We have three people in the Budget Bureau who concern themselves with that agency, and I'm not one of them. So I can't tell you a thing about them.

QUESTION: Mr. Osborn, in making appropriations Congress obligates and orients, and management must watch efficiency. Meanwhile, back in the Bureau of the Budget, you are trying to sell the cost-type budget and you take into account such adjustments as inventory, depreciation, orders not delivered, and that sort of thing. And now we have PERT cost. Does this add another bookkeeping system to keep? What does it infer in terms of other management responsibilities with reference to the appropriations structure?

MR. OSBORN: In the Bureau of the Budget, we haven't required anyone to use this PERT cost up until this time, and I don't think we will. It's advantage is that it is an internal management system. If you in OEP come to the conclusion that PERT time and PERT cost are of advantage to you to use in internal management then go ahead and use it. I think it will be a long time before we will put out a requirement that this is a system that you must use.

So, if you want to call it another bookkeeping system, I don't think that PERT can be described this way. If you find it useful to use, go ahead and use it. If you use it, I think you'll find a lot of other things that you are now doing that you can eliminate. In particular the application you were talking about, in these cost-type budgets, it seems to me that the use of PERT cost is going to be extremely useful in developing the information that you need for proper cost-type budgeting, if this is your way of doing it.

MR. BUSCHMAN: Let me add one comment to that as far as we are concerned. We have taken PERT cost recently, and you can see this in the NSIA studies and also

in the studies of the ECG. We are taking PERT cost, we are taking the DCPR, which is the old Defense Contractors' Planning Report, and we are taking the 1097 and the 1177 forms, and different forms of this type and systems of this type, to attempt to see to what extent we can follow one system, one system that will provide the data we want.

The only reason I mention this is, DCPR being the old aircraft manufacturers' planning report, and missile manufacturers' planning report, we have already caused them to say, "We want to go on a work breakdown structure basis." This leads into the fact also that in contracting, as Colonel Bennett pointed out, you are going into a work breakdown structure. Many of the contract tasks will be spelled out in this manner.

Ultimately you can budget along these types of lines. In our PERT Coordinating Group, as far as the OSD participation is concerned, Secretary Morris's organization is represented by myself. Secretary Hitch's organization is represented by Ed Wood, who is now with them, through Deputy Secretary Asher. Then you have Eric Varney of DDR&E representing that corner. We are all working toward this same objective, all working in the field of PERT cost.

I haven't answered your question, but I have given you some lead or some direction that is taking place. Remember, as far as DOD is concerned, you have your financial management, logistics, comptroller, and DDR&E all participating in this thing.

As to where it will ultimately take us, we don't know the answer. We think we know. I can give you a prediction on a very nasty question thrown at me by Arthur Toner. I thought, "This man is an enemy." He asked, "Where is PERT cost going to be 5 years from today?" We told him that we thought the advantages to

industry were so great that any top management person would find it to his competitive advantage to use it. He proved himself to be a friend. He turned around and said, "I will make the prediction that every producer within 5 years will be using this system and applying it in some form to all of their programs." Arthur Toner is from Price Waterhouse, an accounting firm.

So there is a tremendous movement. We don't know fully where it is going to lead or how it will effect the budget submissions or the Congress. We get calls right now from Congressmen for the PERT Guide and the DOD-NASA Guide.

MR. OSBORN: I am going to take this a little further. I know that people in the reports control function up in the Bureau have been concerned with one thing, the same sort of question you had: "Is this just another requirement for reports?" They are interested in what can be done away with after you have fully developed PERT time and PERT cost as a reporting requirement. Of course this is from industry.

I understand that this is a closed room, so let me go a little further. In the Budget Bureau once a year we publish a publication about financial management. This is put out under the auspices of the Joint Financial Management and Improvement Group. I think this is the Budget Bureau, the Treasury Department, and the GAO. As far as I know, the GAO has had absolutely nothing to do with the development of either PERT time or PERT cost. But one of the men who are responsible for this publication came down to us yesterday and got a briefing on PERT cost, and this is going to come out in a publication when it next comes out. As far as I am concerned, this is sort of committed to GAO, since their name is on the cover, too, in that they are going along with us.

How many years it will take us to educate the General Accounting Office people

that PERT cost is a legitimate and acceptable way of developing an accounting system, your guess is probably better than mine. Until it happens the thing will be completely spontaneous on your own part.

QUESTION: By now, on the past applications of PERT, haven't we got a civilian number of similar instances of using this technique so that a library source to which others who face similar problems might go? Are there repositories for both industrial and construction types as well as military and government applications of PERT?

COLONEL BENNETT: I might take a crack at that. There is a sufficient data bank of information concerning the subject. We haven't done a complete job of distributing this, however. The Air Force just this last year has put out some 35,000 publications of all types in the area.

This is another problem, the proliferation of publications, because you don't know where to go to get the correct answer. But through the PERT Coordinating Group we are getting ready to publish an inventory of approximately 800 projects that we have, breaking them down by certain categories--administrative use, and so forth.

We have a series of five manuals that have evolved during this last fiscal year, one on Pert Time Computer Program, one on a PERT Cost Computer Program, one on the PERT Time Systems Description, one on the PERT Cost Systems Description, and one on Implementation that goes into organization, preplanning, and so forth.

We do see evolving the documentation that does provide the steps necessary to do a good job of implementing the techniques.

MR. BUSCHMAN: This leads almost to a suggestion made in the PERT Coordinating Group the other day, the fact that there is considerable latitude, and while we have prevented this many different applications, there is still room in here for

better applications and more uniform applications.

One of the services was suggesting the other day that we have some technique whereby upon implementation of the system to a major program they can get some sort of certification from the PERT Coordinating Group that this does fall within the concepts and principles and so on being adopted on a uniform basis.

But, as far as the tests on PERT cost are concerned, the types of reports that Colonel Bennett was mentioning earlier started to flow about in April, May, and June, around this time period, to the program managers. They are reworking these and so on, so that we have only just reached the point where in this evaluation that I mentioned we can begin to take those and document them. There will be this documentation of those tests. That data will be available to everybody before we are through.

QUESTION: Colonel Bennett, in determining with respect to contractors that they must include PERT cost in their bids, are there generally accepted ground rules within DOD, such as estimating cost and complexity of the overall scope of the project?

COLONEL BENNETT: Yes, these are in draft form. The first DOD document came out on the 17th of January. It set the criterion that you would have program definition. Once you have program definition this means that you do have PERT cost. It stated that this would be on operational development systems, and another category of \$25 million or more for a total program and/or \$20 million in any one year. This means that the DOD is going to direct that we have program definition which in effect directs PERT cost.

Now, the services are all in the process of coming up with program definition manuals, conceptual manuals, basically now, that hit procurement planning, systems

definition, programs and plans, and PERT and PERT cost. These are all going to be integrated into one manual on the program definition concept.

MR. BUSCHMAN: One of the most startling things about this whole program has been the willingness of one organization to adopt the techniques and the documentation of another organization. Colonel Bennett has mentioned the systems manual here, in which the Navy came along, Special Projects instituting the request, and the Navy as a whole picking it up and saying, "We would like to take your Air Force systems manual and adopt it to our use." We said, "Fine. While you are doing it, can you adopt it to the use of the Department of Defense as a whole and the Government as a whole?" They said, "Yes, we can." So Arthur Gurringer of O&M has a project right now of putting the kind of language, the more uniform language, taking away the AFS such and such and putting in DOD or what have you type of language in this manual that can later be adopted as a whole.

This is a tremendous thing and it takes place every day. It's quite startling.

QUESTION: From some of the background reading I gained the impression that PERT was more suitable to R&D projects and somewhat less suitable in certain other types of endeavor. This morning I gained the impression that PERT could be used possibly to the exclusion of other types of management techniques. Is that correct?

MR. BUSCHMAN: Not to the exclusion of other techniques, no. Let's put it this way. We, too, thought that it would be suitable only to research and development. When you have General Dynamics and firms of this type, and Douglas, saying that it is easily applied to the multi-output types of techniques--I am not talking about commercial day-to-day competitive production, I am talking about major programs here--you are quite convinced that this will take place.

Now, what happens? You must apply a learning curve, which is the DCPR-type curve, to your network in effect. Douglas has already developed a system whereby the network, with the application of the learning curve to the human resources in there, gradually closes in. They have picked out certain standard items in the network where this will actually happen, and they follow that.

So you have a big network based on the first item, or, let's say, the first group of items, perhaps 10 items. Then you have another network, and another one. And these gradually, in a period of time, with the application of the learning curve, come down into a smaller area.

There are complications here. Line of balance has to be used. We originally thought the line of balance had to have costing in it, but PERT already has the costing in it.

Army has developed and presented, and this will be/at our industry meeting in October, a PERT cost line-of-balance technique. We had them present it to us. We also had them present it also to the NSIA Group. It was quite clear that they had a PERT cost system period, and the only way they were using line of balance was as a control technique, and not as a costing technique.

So the story that is coming back to us, we realize more and more, is that the Pert cost is a management technique and that these other controls and so on will be used more as supplementary techniques to assist it.

We can get some long discussions, disagreements, and so on, in this area. I am just trying to give you a feel as to the way I see it going.

QUESTION: Mr. Buschman, are PERT techniques being adopted by any of the other nations?

MR. BUSCHMAN: Yes. There have been quite a few people who have been in to talk

to us. A man from Saud came recently and said that as far as his firm is concerned they have been using PERT time for about 3 years. He came in to obtain whatever information he could on PERT cost. From England I keep getting considerable communications from similar study groups that are going on this area, although I don't know of any big applications there. We have a man by the name of Murphy who is coming through an arrangement with the British Embassy to see us the first week of October. He is from their atomic energy group in England. We have made arrangements for him to see atomic energy here and to see the PERT Orientation and Training Center, and to go around to many of our contractors to obtain as much information as he can.

The PERT Orientation and Training Center is authorized to give its courses to foreign nationals. I'd say that we get requests for the PERT Cost Guide from Africa and different places like that and on how they can apply it.

But to give you good illustrations of actual applications, we just haven't had the time to really seek these answers out.

QUESTION: Mr. Buschman, in your opening remarks you mentioned the weapons acquisition study and the fact that it had cited cost and time overruns of a significant nature. You stated reasons for these. Could you elaborate as to what proportion of the overruns were due to such things as poor management and what proportion might be due to other factors, such as inadequate forecasting?

MR. BUSCHMAN: I can't, no. I don't truthfully know to what extent the weapons acquisition study has really dwelt on this. I haven't got through it. It's about that thick (demonstrating). I read a draft of chapters when it was being put together. This has been over a period of about 3 years during which they have been doing this study.

I can mention to you, and I think it is important for you to know, that the 12 programs were such programs as Polaris, Nike Zeus, Hercules, and so on, which were part of the program. So that it covered major programs of the Department of Defense, not small programs. Jupiter was also one of them. But I can't break this down for you.

Regardless, you hear some people say, "Oh, that was a program change that caused the cost overrun." I don't regard this as any excuse, personally. This is a form of poor management on our part and on industry's part in the original development of the program, on what the objective truly was and what it consisted of. So I blame myself and us collectively for not giving better guidance and not thinking the thing through.

This is why everybody is so interested in cost effectiveness reports, which require a complete definition. How can you possibly do a cost effectiveness report, for example, on the actual use of a program and its ultimate operational use, if the thing is going to cost so much more and there are so many program changes take place? ^{If} you don't think the thing through, you can't evaluate it. It's impossible.

That's what we are up against. That's why we need it. Maybe it should have a different name. Maybe it should be a different program. The important thing is that we need something that will forecast what the cost will be, so that we will define what the objective really is and what the program will look like, and so that we can make these analyses on what kind of weapon we really are going to use and what it will cost to operate.

There is no sense in developing 40 programs that will cost \$150 billion a year and all to be operated simultaneously, when we don't have that kind of money.

QUESTION: What is the expected effect on manpower requirements in the government agencies of the widespread use of PERT techniques in procurement contracts. Can we hope to get a reduction there?

MR. OSBORN: I think that everything that affects management, good management or bad management, affects manpower. If you start out a program and the program is basically bad because you haven't planned it properly, you are going to use up manpower that you shouldn't use. If you can employ the PERT techniques to set your objectives and to make your plan of action properly, so that you can quickly make adjustments and so on, I think that inevitably you are going to use less manpower.

I don't think this will bring about any reduction in the use of manpower, but I think we are going to get better output as a result of it. I don't think that PERT itself is going to be something you can point to and say, "We are going to reduce manpower this way." I think you are going to get better results with the same resources you have been using.

COLONEL MARTHENS: Mr. Buschman, Mr. Osborn, and Colonel Bennett, I know I speak for us all here here when I say that we are indeed grateful to you all for coming here today and giving us so generously of your time to help us understand PERT and PERT techniques. We thank you very much.