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Meeting Military Needs for Intelligence Systems
James M. Osborne

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MEETING MILITARY NEEDS FOR INTELLIGENCE SYSTEMS

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Osborne's background includes tactical development for the U.S. Army Signal Corps and 19 years with RCA, in which he rose to Vice President and General Manager of the Government Communications and Automated Systems Division. His career culminated with his Senior Vice Presidency at E-Systems, where he served as Group Executive for the company's Production Electronics Group and General Manager of the ECI Division. Thus Osborne has a wide purview over the many facets of industry's task in supplying intelligence systems to the military. I asked him to talk about what he sees as effective or ineffective in the C³I world from the supplier's vantage point.

Osborne. For about 20 of my 30 years in the electronics business, I have been involved with the design and manufacture of C³I-type systems for military and government use. Bear in mind that there are some limits to that involvement. I used to try to explain to my superiors, first at RCA and later at E-Systems, that we weren't really in the C³I business (as they were prone to tell the press and others) because we didn't have a thing to do with command; that was the exclusive domain of the military, who would likely think it presumptuous for some industry type to come in and start talking to them about command itself, about actual control of troops and people. Similarly, control is indigenous to command, and that was really not our bag either. Our strength was that we had people with the ability to understand the command and control needs of our customers when

they described them to us. Based on that understanding, we could develop communications systems and intelligence equipment suited to those needs; that's what we really did. But as a consequence of doing the communications we were exposed heavily to how people command, how people control. I think that Lee Paschall has it right when he says that C³I is not a system, but rather a group of components for management purposes.* And he makes command and control the modifier. I think that's probably correct; certainly from an industrial view that's the way it is.

It's in that context that I'd like to talk with you about several subjects. I will make some assertions to lay a foundation for discussion.

Oettinger. I think you make unnecessarily much of the debate about what C³I is. For the purposes of this course we are using it generically — talking about intelligence as external sensing, and command and control as internal execution and sensing processes or functions in a generic sort of way. I have problems with Lee Paschall when he tries to say what C³I isn't; I'm much happier when he points out that to managers command and control looks like process, while to procurement types it's programs, and to technical people it's systems. It has all those aspects. I think what you are saying in making your disclaimers is that from the E-Systems or RCA point of view, you were dealing with certain kinds of systems, perhaps as program manager yourself, perhaps responding to some program manager in the military, and trying to understand what the process requirements were if someone on the buying side was willing and able to spell them out. Have I clarified things, or muddied the waters, or what?

Student. I think you've taken "theologically" what was not intended that way. I guess I'd say, based on my years as a bureaucrat, that Jim was making plain that the contractor wasn't making policy.

Student. I got a different perception from what you were saying: that, in talking about C³I, you're not talking about applying certain defined processes to given situations. So the disclaimer is that, in RCA or wherever, if someone is talking about a C³I system, it's not something that can be defined as an absolute.

Osborne. I just wanted to make the point that my expertise, and the expertise of my colleagues and the people who worked for me, was not in the areas of command or the execution of command, but rather to provide electronic systems which permitted command and control information to flow to the proper users. That necessarily brought us into contact with people who were dealing with command and control; I don't mean to take too narrow a view. The reason I took that position was that it's very easy for

*See Lee Paschall, "C³I and the National Military Command System," *Seminar on Command, Control, Communications and Intelligence, Guest Presentations, Spring 1980*, Program on Information Resources Policy, Center for Information Research, Harvard University, Cambridge, MA, December 1980, p. 67.

industrialists to make fools of themselves by talking about things they don't know anything about — how you move and position troops, the strategic and tactical scenarios involved in military operations. I call those things command and control.

Oettinger. You can make words mean anything you want.

Student. I'd like to comment on that. As a representative of an acquisition division of the Air Force, I hear you loud and clear. Our program managers frequently try to dump all their responsibilities on the contractor, including having him give them something that their users want. Well, I think placing limitations on that is very important.

Osborne. As you'll see later on, that is one of the problems industry faces now. More and more, the government is tending to dump things in the lap of industry that I think industry doesn't know a great deal about.

Let me make several assertions and then we can debate them. From the viewpoint of an industrialist, the increasing complexities of the weapon systems are drivers to increasing complexity in C^3I systems. The C^3I systems are reactive to the weapon systems, tactics, doctrines, the military uses. As those systems become more complex, the C^3I systems become much more complex in response. The government's changing, and I think decreasing, ability to determine and articulate its needs in the C^3I area, and to prepare and manage meaningful specifications, is a very serious problem. The changing and, again, decreasing ability of the government service personnel to operate, repair and maintain the sophisticated systems which are being delivered to them is a very serious problem too, and I don't see any way out of it at the present time.

I am concerned about the lengthening lapse of time between design/development and production, as a consequence of procurement, reviews, test process, and many other things — for example, MIL-STD-781C,* which is a very elaborate test program. I call it a statistician's orgy. It has to do with the way equipment is tested after it's developed. There is a proper place for tests, no question about it. Certainly systems that have just proceeded through design and initial manufacture have to undergo exhaustive tests. But the government is applying the 781C document to the production of equipment which has been produced in large quantity over a large number of years, whose reliability is well-known, established and entirely suitable. The government, after all, pays the bill; one way or another every dime of this is charged right back to the government. And the government, according to 781C, must buy all these elaborate test machines and facilities and use them, and that, I think, is outrageous. There is greatly increased cost associated with it. And because these tests lengthen the procurement time, we're delivering systems which are semi-obsolete when the user gets them.

*MIL-STD-781C, "Reliability Design Qualification and Production Acceptance Test: Exponential Distribution," 21 October 1977.

All this has led to an increased transfer of risk to industry. That's the usual gripe, but not the most serious one. It's also led to transferring the government's rightful responsibility to industry. I think industry is ill-equipped to handle some of the things it is being asked to look at.

To digress for a moment: when I was a sophomore in engineering, I took a course in mechanisms. I was intrigued by a box that my professor had designed and built and kept on his desk, that had a crank on one side and a glass top. He had built every known movement into that box: spur gears, Geneva escapements, you name it; it was all there. When you turned the crank, you saw furious activity going on inside. One day he saw me looking at the box and said, "Jim, that thing really fascinates you, doesn't it?" I said, "Yes, it sure does." He said "Well, it shouldn't, it's not doing a damn thing."

That's been an important lesson to me. I have subsequently managed over 200 programs, run many departments, several divisions. That simple lesson has served me well: that there is a vast difference between activity and useful work. It's important to distinguish what's really happening. Just because there are a lot of people involved in doing something and spending a lot of money, that doesn't necessarily mean that anything useful should be expected to come out of it.

Another thing: I've managed a large number of programs, some of them in the billion-dollar category, but I've started only six programs in my career. It's been the same way with departments and divisions. I've not had the luxury of taking over a program whose manager had been promoted or retired and everything was proceeding smoothly. Generally the manager has been run out on a rail; the engineering wasn't coming out right, or we couldn't get manufacturing up, or we couldn't get a plant built, or whatever. (Incidentally, I should say that managers who have been replaced usually weren't stupid, or lazy, or short on dedication. It was generally a question of swamps and alligators.)

Well, it really boils down to this: what are the real needs? What is it that I really want to do? What are the alternatives associated with the needs, to serve as a framework for preparing the architecture, specifications and the like? Can I pick the alternatives that look the most promising, and from them somehow select the best course? (An endemic problem I ran across in most of the programs was that someone had forgotten to do that.) Can I develop the system specifications, subsystem specifications, equipment specifications, test specifications, in such a way that others can understand what they're supposed to do and I can measure their performance? What are the boundary conditions we're trying to work with, in terms of people, time, money, plant facilities, that sort of thing? I can't imagine that anyone in this group would think that those questions are simple in execution. The overriding consideration — at least it has been to me in managing programs — is to try and determine the forcing functions, to quantify and qualify them, to bring the important items to a level of conscious attention and hold them there. And I think that I've just stated one of the principal problems that I see in C^3I: it is exceedingly difficult to develop a focus.

In his book *The Mythical Man-Month,* Frederick P. Brooks describes the problems associated with the development of the IBM System 360. It's a series of software essays, but I found it contained many lessons that were applicable to things other than software. In fact it was required reading for my subordinates. He develops the formula

$$C = N(N-1)/2.$$

The problem in communications (C, the number of communication paths) is equal to the number of people involved times the number of people minus one over two, which of course normalizes to one if you have two people. If you have a third person, the communications problem becomes three times as great; add a fourth, and it's six times as great. That highlights the problem of committees. The whole C^3I process is riddled with committees, reviews and more reviews up and down the line, by people who don't share a common data base. Another book that I like to have my people read is Justice Cardozo's book: *The Nature of the Judicial Process.* Cardozo, who was on the Supreme Court at the same time as Oliver Wendell Holmes, was a brilliant jurist. He wrote on how a judge goes about making an objective decision, and points out that that is exceedingly difficult to do. The decision a person makes is always run through a set of filters (my words, not his). He's conditioned from birth to pick certain paths, he brings certain mores and standards to the decision process; and it is entirely possible for one judge to make an "objective" decision that is entirely different from another judge's "objective" decision on the same issue.

In the case of C^3I, people are developing needs and specifications (particularly with the current United States procurement philosophy) lacking a common data base. Indeed people in positions of authority, though they may believe they think like computers, really have their own different data bases too. And even though all these people are looking at the same facts, they reach different conclusions. As a consequence, it appears to me (and to many of my colleagues) that there is a defense mechanism — an attempt to get something sold through the next level, rather than to address the substantive issue itself.

Let me provide a little historical contrast. At the beginning of World War Two, the United States had no voice encryption for soldiers. We had facilities to encrypt data, but there was need for voice. So the government approached Bell Laboratories to develop a voice encryption system. Bell based its work on the job it had done in building a robot that spoke with a synthetic voice for the 1939 World's Fair. (I happen to know about this because I was a second lieutenant assigned to Bell Laboratories to coordinate this work for the Army.) Interestingly enough, that system was probably the most sophisticated electronic system built during World War Two. There were 20,000 vacuum tubes in it; it was a monster, I'll tell you that.

Student. I worked at Bell Labs three years ago, and they are still working on that synthetic voice. They are now using a computer and they have it sounding a little better, with diphthongs and the whole works.

Osborne. That work was started in the beginning of 1942. The first system was placed in operation in 1944, two years later. We had installations in Algiers, London, Hawaii, the Philippines. The system worked very well. Simultaneously with its development, Bell was working on a communications system called the AN/TRC-6, which worked in the then unheard-of frequency band of 4400-5000 megacycles, using a gadget called a klystron. It had an eight-channel TDM multiplexer and a voice encryption gadget of sorts, the AN/TRA-16. That work was completed in two and a half years from design to production of the equipment. Later, when I was chief of the Signal Corps Engineering Laboratories, Branch for Radio Trunk Communication between 1950 and 1956, we developed, produced and fielded the AN/TRC-3, -4, -8, -11, -12, -24, and -29, the AN/GRC-50 and -53, and a lot of ancillary devices. The average time from design to production was about two and a half to three years. The longest program I was associated with took about four years. In 1956, while at RCA, I was assigned as Program Manager on the North Atlantic Troposcatter Program for the Air Force, deploying in Labrador, Iceland, Greenland, Newfoundland. We received that contract in 1955, I took it over in 1956. We installed that equipment on the Texas towers and the other sites, and placed it in operation in 1959.

In 1959 I was pulled off that and picked up another program, a very highly classified Navy system. The Navy had determined its needs on two sheets of paper — excellently, I might add. Working with the Navy, we developed overall system and equipment specifications. We developed and manufactured 30 systems of two types, 15 of each. One of the systems consisted of 13 seven-foot racks, the other 15 racks of equipment. We installed that and placed it in operation in 15 months at 30 overseas sites. Now that one, admittedly, had the highest priority in the United States. But it was done and put together.

I was Program Manager of the communication systems for Minuteman, the sensitive command networks, support information networks and permissive action links. Five wings of Minutemen were designed with concurrent manufacture, and placed in operation within six years. I was Program Manager of Autodin, whose design was begun in 1965 and the last site signed on in 1969. But now it takes some seven to twelve years to crank out that kind of system. You can't help wondering what's happened to us in the meantime. So I'd like to go back to the assertions I spoke of.

Oettinger. Before you do, Jim, you were talking about needing to think about needs and pass on intelligible instructions, etc., etc. What's your starting point in terms of what you define as needs? Let me tell you what I'm setting you up for, so you can react. General Cushman, who will speak later this semester, argues that it's not the services that are the C^3I users, but the unified and specified commands, and they don't have anything to say about the C^3I procurement process. What is your view of how much that is expressed as "need" is possible, challengeable, arguable from your perspective as a contractor? How much latitude do you feel you had, how much latitude do you wish you had, and so on?

Osborne. I should say that I'm not speaking as an E-Systems man now. My life would have been a lot easier had the government been able to ascertain its needs and quantify them to me in such a way that I could act upon them effectively. The government used to

be able to do that, principally in the era when we were producing "black box" equipment to fit into some system. At that point in time, even though communications and the like were likely to have been afterthoughts, nonetheless I think the services did a fine job. We worked very closely with the users in determining their needs, and it was our job to put out equipment that met those needs. But there's no question about it, the user, the guy who's actually going to put this equipment to work in the field, runs into a block in the middle; and I think he has too little input as to just what the working needs really are. Someone else is articulating the needs for him, and not doing as good a job of it as he should.

Now the Army is trying to move away from that. I know we were encouraged by DARCOM to go down to the school at Fort Gordon and talk to people there, and we did that; in fact, in order to exist in this business in this day and age, you must do that, you have no choice. One of a general manager's biggest jobs is allocating his resources — just what do you bet on, what do you put your money on? You have to make certain your independent research and development programs are on real-life targets, to quantify them, qualify them, and then work with the customer to flesh them out.

Student. You say it would be really nice if the government or the military could tell you what it wanted and let you produce it. My feeling is that they don't come up with their needs in a vacuum. To a degree, technology is going to identify their needs for them. You said you went out and searched for targets. To me that sounds like an aggressive sales organization helping the government define its needs. I know the telephone company helps me define my needs. I never needed call-waiting until it was available to me at $2 a month. To what extent can you realistically expect the military to say "I need X", and to what extent are you saying to the military, "You do need X?"

Osborne. I hadn't meant to state things quite this harshly, but I will. The half-life of an engineer in the electronics business these days is about three to five years. By that I mean that, without additional training, half of what an engineer knew when he started is obsolete that quickly. Consequently, to stay in business, a company has to have a continuous training program for its engineers. Some engineers don't want to do that, and for those engineers who are unwilling or unable to continue to learn and stay up with the state of the art, I have a weapon at my disposal: I get rid of them. I assign them something they can do in a lesser occupation, if I have something else for them — or I go out and find somebody who can maintain the necessary proficiency in the state-of-the-art. It's just that cold-blooded, or rather, I don't think it's cold-blooded at all, it's just realistic.

One of the problems I got into in the government, one of the forcing functions whose lack caused me to leave the government, was that I had a couple of people I wanted to fire. I built a year's case against them (and that was back in 1956 when things were easier), and I almost got canned myself because of it. I decided I was going to work someplace where, if I had a guy who was demonstrably incompetent, I could do something about it. In industry I can. But the government civil service system does not have that kind of forcing function.

Now I don't want to sit here and say that government employees are a bunch of slobs; a lot of them are fine; but a lot of them, also, because of the lack of that economic forcing function, simply have not maintained the proficiency they should. The problem is not just, in my opinion, inability to know the state of the art, but inability to understand the needs in the first place. I can very quickly tell them whether the needs are realizable in terms of the technology that's available, and with feedback, if they had the ability to quantify those needs, I think we could have an efficient process that would develop state-of-the-art systems in a realizable timeframe.

It used to be said that we don't have a marketing system in government work — well, sure we do. But we used to have salesmen who were essentially peddlers. Not any more. If you're to exist as a government supplier now, your system must closely resemble the commercial sales system. You have to be searching out needs, going through all the programs, grinding them down, finding the ones that fit your own skill base, your asset base and the like, and betting your money on those. That means, furthermore, that you have to go out, sit with a customer and work with him on the development and articulation of his needs, and on the associated specifications architecture; if you don't, you're just flat out of the game. That costs a lot of money and takes a lot of time right in the beginning; once we didn't have to work that way, but it is necessary to do so now.

Student. I don't disagree with what you're saying, although I understand there are other ways of handling that sort of problem, by layering and so forth. But the acquisition problem is very complicated, and requirements development is bound to be iterative, and complicated by technical factors. For instance, what are the specifications of the contract you signed with the government? And what defines the quality of the deliverable product? If you are writing the contract at the same time that you're working for the government, you're in a conflict situation, so somehow you must resolve that. The government on its own has got to figure out what it wants its contractor to do, and not have him write his contract at the same time he is performing the work.

Another aspect of this that comes right from the top is OMB Circular A109,* which industry helped prepare, which says: don't tell us how to do our business, just tell us what you want and let us design our system to do it. The idea behind it is that E-Systems has one technology, RCA another, GE, TRW — they all have their own approaches to supplying the same thing, but that makes it harder for the government to specify interactive technology, which is so essential. In other words, all the government can talk about is how many people it wants to have a given piece of information on a given day by what time, or how many targets it wants to handle. It can't really look very deeply into technology opportunities.

Osborne. I'm not really talking about preparing specifications after the contract, I'm talking about specifications beforehand. I find that we are increasingly involved much earlier, long before the procurement process even starts. So that we now see things like draft specifications coming out. I think that's helpful, but from my viewpoint, just

*OMB Circular A109, "Major System Acquisition," 5 April 1976.

speaking bluntly, it's also a crutch. No question about it; in deciding how you're going to use a complex weapon system, AEGIS or whatever, you have to consider something we didn't consider before: the communications and intelligence needs, how the system is going to be glued together, just what kind of nerve fabric you're going to overlay the system with.

Those requirements are changing, and that is a problem too, because most people in the government, at least the ones I dealt with, simply aren't equipped to deal with this complexity through their own mechanisms. It frustrates them too. They don't have a mechanism to change their needs as they need to be changed. You're forced into coming up with needs, stating them and getting into a procurement process, and then even if you're wrong it's difficult as the devil to try and go back and change those needs. I think that A109 has certainly been one of the instruments that has caused that kind of problem. I understand the philosophy of A109 and why it was necessary, but I think it overlooked the practical effect, and doesn't work very well.

Student. Do you think we should throw out MIL-STD-490,* for instance? The old 490 spells out a method of acquisition, mainly for the development phase as opposed to the production phase. The high risk portion of the program frequently is in the R&D, when you don't know whether you can build something that works. Once you've got it right, you've got a first article production, as it used to be called, and then you go out and build it and that's a separate contract with its own separate problems. MIL-STD-490 is concerned with how to write a specification, go out on contract, what are the sections of the specification, how to control the configuration during development; all those acquisition problems. Well, that is a model for how acquisition should be done, but it is kind of implicit and not well described. It has to do with the fact that the user and the buyer have to write down a very detailed specification of exactly what they want. You put that in the contract with a Statement of Work which tells the contractor exactly what you want him to do and to deliver, and he reads it and goes off and builds it and gives it back to you, and it works.

Oettinger. May I pursue this point a little further. It seems to me that both of you are talking at the level of what you described as a black box that fits into things. Maybe one needs to define the detailed state of the art, but in the larger-scale major C^3I system the situation seems to me to be worse compounded. There are a lot of little pieces to deal with. DOD Directive 5000.1, 5000.2 purported to straighten things out at that level.** Could you comment on the relationship between that and what has been described in terms of OMB A109 and the MIL-STD-490 process?

*MIL-STD-490, "Specification Practices," 30 October 1968.

**DOD Directive 5000.1, 5000.2, March 19, 1980.

Osborne. First off, those documents themselves have a logical track all the way through. I think they overlook the fact that things just don't happen that way. 5000.1 and 5000.2 went through all kinds of changes before they finally came out. I remember sitting in Fort Monmouth listening to DARCOM saying what 5000.1, 5000.2 was really going to be, this was it, their version. It happened, however, that the other services didn't agree with the Army's version. The Army's version proceeded from Advanced Development through Engineering right into Production, eliminating the LRIP (Low Rate of Initial Production) and moving right into high volume production with one contractor, no breaks in between. It really didn't come out that way. In ESD I did a job — I don't want to get into identification of specific programs — that went through advanced development. We got rave notices about what a great job we'd done, and it was put out on a competitive buy for engineering development. The company that won had never been in the business. Well, maybe that system will come out one of these days and maybe it won't.

But that's a procurement itch I've got, more than a philosophy. The point is that there are all kinds of documents saying that the government establishes and quantifies needs, develops an architecture of specification, and follows a specific procurement process; but if industry were to follow that dictate literally or even approximately, it would be out of business.

Oettinger. Can you pinpoint why?

Osborne. Because somebody in industry has been working with some government agency, generally, to determine what the needs are. It's highly informal activity, but it does happen. Somebody has been in there working out the specifications for the systems and equipments. I still maintain — the government will debate me on this, and so will other people — that you can read a contractor's proposal just like you can the Bible. You can read it as a holy book or as a dirty old man's manual, whatever you like to make of it. At that stage proposals are generally cost-reimbursable instruments. Too often, if you haven't been involved in the process from the beginning (where I don't think you really should have been) you simply aren't the guy who wins the job.

Student. Are we describing a procedural breakdown? Or, given the changes in systems and technologies, is it realistic to think that someone just invents the need now, specifies it, and then puts it out for bid and gets it?

Osborne. I'm saying that, because the development of needs is now so much more difficult than ever in the past, the government usually (not just frequently) lacks the ability to do it by itself. It doesn't have people current enough in the state-of-the-art to know what can be done, or to assess what should be done.

I guess one of the most important questions any general manager can ever ask himself is, "Why am I doing this at all?" Not to debate the elements of a program until it is determined that the program is needed, and through what kind of architecture it should exist. What alternatives were explored? What matrices were developed? What cost

tradeoffs were made between the elements? How did you pick this way to go as opposed to some other? That is all in MIL-STD-490. I'll tell you right now, it is not generally done. There are some people in government who do it, but generally speaking, the government's ability to do that kind of thing is limited.

Student. In the Air Force we lost our ability to do that. Under General Bernard Schriever in the 1960s we developed a series of regulations, the AFSC-375 series, that show you exactly how to do system engineering, and who does what. We got a lot of objection from industry, we didn't tailor them well to our contracts, and we were forced to withdraw them.

Osborne. Well, you shouldn't pay so much attention to industry. I am a member of a government-industry association concerned with government procurement, and before that I was head of the Government Communications Council of the Electronic Industries Association for five years. I used to hear my colleagues bellow all the time about "best and finals." But I remember that the government didn't want to have "best and finals," it was industry that raised the big racket, and had them written in, and now it's all wrapped into DAR, to everyone's dislike. I think the government's over-reliance on procedures and inordinate concern about industry opinion leads to the kind of situation I'm talking about.

Student. Doesn't that violate your first restriction, about being involved just in the communications part, not the command and control areas? Now you're saying that you have to get involved in those too.

Osborne. Exactly right; it brings us in whether we like it or not. I think it's bringing us into an area where we shouldn't be. Lots of guys on my side of the fence think they know all about how to fight a war, just as some civilians in government do who'd take over from the military in a crisis situation, with whatever results. Yes, we are in there, but I don't think we should be.

Student. It's interesting that you are talking about having no forcing functions to cause you to optimize and support your procurement procedures. Such functions do exist in a couple of operational areas, where special project offices (SPOs), for example in the Air Force, end-run almost every normal channel and procurement practice, sole-sourcing nearly everything; they do work with their own engineers in private companies, and it's almost like your description of how things were done back in the '40s and '50s. From that kind of project offices have come certain technologies that were designed 20 years ago, yet are still the state of the art. It is interesting that, in the areas where there are very critical operational needs, that old system still works.

Osborne. Another good example of that is NSA, which doesn't work under the same kind of requirements that are laid on the Army, Air Force and Navy. They can develop and produce their equipment and systems in a different way. As a consequence, some of the best developments I have seen have come out of NSA.

Student. Well, just reading the DOD directives, my mind gets boggled trying to visualize how I would draw the charts, who has to sign off on what. It seems to me that part of the problem you are talking about is not only the failure to update the training of people who have to develop the specifications and that sort of thing, but the very detail of what has to be done, and who has to sign off, and how things have to be developed and tested and implemented, all of which has to take place before you can go into production. It seems that there are some gaps — that, unless the knowledgeable outsider, a technological expert, intervenes, the process is going to fall by the wayside. Could you comment on that?

Osborne. I don't know how to. I'm a great believer in the saying that there's just no substitute for smart people. You can have regulations and procurement procedures that span whatever range you wish them to span, but without trained, intelligent people, your procedures don't make a lot of difference. We can spend a lot of time talking about the procurement process, just in terms of DOD Directive 5000.1 and 5000.2, and all its ramifications. But rather than talk about the mechanics of the directives, I think we should focus on their consequences: that it is taking much longer to develop systems than it used to take, much longer than it should take. That it's costing a great deal more to produce these systems than it used to take or should take. That the capability of the people to operate and maintain the systems after they get them is questionable.

Student. In most of these areas you seem to be identifying people with deficient training. Decision-makers in government aren't well enough trained, or current enough, to identify their needs or explain them in the way that gets the product out. Do you see any other factors besides training deficiency that might contribute?

Osborne. I said earlier there's no substitute for smart people. Every company likes to go around spouting that people are the most important element, yappity yappity yap. A lot of them don't really believe that; then they get to be my age and they find out they were telling the truth all along and didn't know it. I guess I feel that with intelligent people on both sides of the fence — trained, intelligent people — the specifications issues and so forth can be resolved. Excessive procedures get to be a problem too; they tend to act as an alternative to intelligent action, and can end up as a straightjacket. For example: in one case I was working with an intelligent DCA group and things moved smoothly, both on the contract side of the house and on the technical side. In another case, on a program where AFSCM-375-5* was invoked, the program was nitpicked to death. I remember that one only too well. I made a film for the Air Force at the end of the program; they hadn't asked for it. It wasn't in their budget. It ran for 33 minutes, it didn't even have a sound track. All it was was a series of forklift trucks going across the screen piled with data, and dumping it into an incinerator. There was a little clock down in the corner registering the millions of dollars that had been poured into the program. It caused quite a furor in the Air Force.

Student. You look at MIL-STD-490 and you say, okay, well, there is system engineering and we're going to do this, but what do you write down on a piece of paper? I gave a copy

*AFSCM 375-5, "Systems Engineering Management Procedures", 10 March 1966 (withdrawn c. 1972).

of AFSCM-375-5 to some of our younger contractors who didn't know the answer, and it opened their eyes. Maybe you don't want to put out a contractor requirement for all that data, because you're not going to read it, nobody's going to read it. But somebody has got to know what the process is.

Oettinger. Wait a minute, let me try to articulate something to see if I've understood what's been going on. You've got a problem: bits and pieces aren't procurable, so you want to consolidate, you want to go through a logical process. To address that problem, you create guidance documents like 5000.1. That carries a high overhead; mainly you generate all this paper, which then is taken in all your forklift trucks. Worse than the overhead, it really gets in the way of doing the job. So you not only pay lip service by generating all that costly paper, you also have to subvert the very process. If I hear you correctly, except in a few instances (maybe in some of the "black box" programs or something), the subversions aren't even very successful.

Osborne. Correct, we're so preoccupied with killing alligators, we're not draining swamps. I would dread being on the government side of the house trying to take a program through all its needed approval cycles before they can even let a contract. And God knows whether they get the system they wanted. Maybe their needs change in the meantime. You try to change something, and you're met with a group of congressional staffers who apparently are free to run rampant through the laboratories, saying "You are giving money away." So you end up not changing things that need to be changed because you're going to get into another approval cycle. I don't know where we developed the philosophy that people have to be prophets, but we have. That's imbedded in a lot of our procurement philosophy now. It doesn't permit change to happen when it needs to.

Student. Or it allows us change when it absolutely should not happen. We build a contract specification and get halfway through full-scale development and somebody decides he wants to change the whole system — the data base, for instance — and goes in for an engineering change proposal that has enormous impact on what's already been done, essentially setting the contract back to the beginning and throwing away all the dollars that have been expended up to then. And this happens twice a year. I think it goes back to the fact that people on the government side really don't understand the contracts they let, quite frequently. We say on our contracts "All provisions of MIL-STD-490 (or -483) will apply" without having opened that document and realized how generalized it is. We decide what data we want to have by citing every contract data requirements list (CDRL) item. As long as you have every number in your contract, you're safe. That's the forklift problem. Well, somebody has to understand this process and tailor it to the specific situation, and that is what is not happening.

Student. I think it may go back even further than that. What I was getting at is that there are other processes — the selection process itself, the procurement process, the bidding process — and once the needs are defined, and all the bidders have come in with their own stories, you pick the team that can do the job best. You move away from the selection process. Suppose you have promised delivery of seven planes per month. You get into

something that looks like a budget perspective. The Secretary and one of his advisors say "I'm not going to decide between another missile, another airplane, or ship; I'm going to let you all have what you want to have, and we're going to stretch out procurement processes." Now the plant investment by the team that was bidding for a particular piece of the job has changed; so have the initial source selection criteria. And the schedule is considerably different. Costs, risk, and the technology all change as a result of those outside factors.

Osborne. Is it your assertion that that's bad? Now, I wonder about that — if the system needs change you have to do things differently. You know, that's the whole crux of long range planning in any corporation. I've had a fair amount of experience with that. I never expected divisions to be able to tell me permanently what it is they will wish to do five or ten years out, only what they will wish then as seen now. A plan is a living thing. If the circumstances change, the plans change. Don't do your planning just once a year, do it as it happens; maintaining currency is super important. But the government process doesn't really permit that to happen. They don't have enough people who, if you wish to have it happen, could do it anyhow.

Oettinger. Let me try to rephrase this. Suppose you express a need for a system delivery — say, AEGIS — years too early. You get turned down. Is it a bad idea because you wanted it too early? On the other hand, maybe the Secretary of the Air Force and the Secretary of Defense are right, maybe it is too early, and it is desirable to stretch out the R&D, or at least the development phase, in order to go further down the road before you cross the decision point. You have avoided having the wrong thing earlier, which may be a plus. What I hear you saying is that, in the government, the formalization of a lot of these processes makes it so that it is damn hard to have either a rational stretch-out or a forced march with an abrupt cutoff, no further changes, and delivery in 12 or 15 months. You imply a great deal, from the less constrained industrial side, how — between avoiding the mistake of committing too early to something that is going to be dumb in somebody's judgment, and the mistake of dragging out too long something that you bloody well need tomorrow — how that gets screwed up in the government. Could you draw now strictly on the industrial side? If you had your druthers, as General Manager, how would you most comfortably strike the balance between avoiding committing too soon to the wrong thing and dragging your feet too long on something even if it's not perfect? One of General Cushman's statements was that it is better to have something than nothing, and in some circumstances even if it's not perfect you want it tomorrow. I think you were starting to talk about that. Forget about the government for the moment; as a manager, a principal, how do you balance that?

Osborne. Well, let's say this. You can't fight a war with things that are on the drawing board. You fight a war with things that are in your hand. You can't run a plant with things that you're planning to do sometime in the future. You run a plant with the things you have now. So you need to have the capability at any given point in time that's sufficient to

meet at least your minimum needs. But that's a process that doesn't happen by itself. It takes a great deal of planning to be sure that you're probably postured as well as you can be at any given point in time. I don't think that's answering your question very well, Tony, but I don't know how to put it better. I guess one of the things I feel is death, from the industry side, is to lock yourself in concrete by choosing a course that you refuse to change — even though there's a need to change.

For example, I started an LSI facility. It was a large-scale, integrated array facility that developed innovative circuits, and we had chosen a certain complement of equipment to go in there — we had budgeted for it and bought it. But another group of equipment came out that was far better, that would speed the process up, give us greater accuracies, better resolution in our lines, and the like. The Board was horrified when I went to them right after this stuff was delivered and put it on the block to sell it, to buy something else. But they went along, and we put in a facility that really did what we wanted it to do. In the near term it looked like a bad decision because we had spent more money in that period than we'd planned to spend. In the long term (after all, that's the thing we were aiming at) it made and saved a lot of money for us. But the government system now has gotten so complex in its needs analyses, specifications analyses, justification and quantification of programs — there are so many levels — that things do get locked in concrete; it's almost impossible to change them. As a consequence, we have systems which are less capable than they should be, and it takes longer to get them.

Oettinger. If I was one of your subordinates walking into your office and saying "Here, I've got a problem" — what would your thought process be on striking the balance? You're saying they get locked in too early and therefore the fielded capability is not what it should be. A moment ago you said it takes planning to assure that at any given point in time you have a pretty good capability. That sounds contradictory; it really isn't, though, because you're striking some kind of balance there. Maybe you can dredge out of your experience a particularly vivid case, or cases, where you have had to live with a decision. Say, one case in which it turned out right — the thing was timely and did the job — and another case in which it went sour. Maybe you can articulate the difference between having something that was not timely but had reasonable performance specs, and having something that got there on time but didn't do the job, or, indeed, something that never got there, waiting forever to do the job right.

Osborne. Well, in one division that I led long ago, we decided that the government would probably need optical devices: laser systems for surveying, lots of other stuff. So we committed to a very large optical capability long before the government saw that it had those needs and was willing to buy those products. As a consequence, we had a system that was available for thirteen years before one item ever left the loading dock. That was a bad decision, premature. The right decision was the one I just mentioned, to convert the LSI facility when the need was there. There are always boundary conditions: what do my resources permit me to do? I want planning to take place, I want people to use their imaginations; that is the right thing to do — that is what I want. Eventually, though, I

have to be bound by my capability to do something that has now been proposed. Even though I agree that it's the right thing to do, I may have to reject it because my resources at that point in time simply don't permit it to happen. Or I may need to get on with the program I now have under contract, using the resources I have or can get now, not things I'd like to have later.

For example, on a contract not long ago I would very much like to have used automatic insertion equipment in the manufacture. I'd like to have redesigned the boards and gone into scope-type soldering where you don't drill the boards, but lay the components on the traces and the like. It would have speeded up manufacture and cost a lot less money considering the amount of product involved; but it was impossible to do that, because I had to deliver the system long before I could bring all that stuff on line. So, even though it was the right thing to have done for the long range, it simply couldn't be done because of the boundary conditions that existed in that particular contract.

Student. Isn't it really a function, from the business side, of risk and return? If you come out too early with something, you have made a risk tradeoff trying to get higher returns by being the first person in and having it when the government needed it. In that case you make great returns — you probably get the contract, production, etc. But if you're too early, you've got to sit on some inventory for a while, or the technology may change and you'll have to repeat the whole thing. But that was a risk, you bet your resources. You took a hundred-to-one shot, instead of a two-to-one shot — which would be waiting until the government asks you to do something and then coming in and knowing it will only double your money.

Osborne. Yes, I think things like that happen all the time. You see certain programs coming up that you feel are going to be necessary, so you plan the capability for that thing when it happens, and then sometimes it doesn't.

Student. From the business side it's easy to just look at it in terms of betting, risking returns and things, but the government and national security can't afford to have all those independent players out there with poker chips. So should the government step in and control certain R&D functions, and possibly even certain businesses and suppliers, so that it can take risks which any individual couldn't, but society dictates?

Osborne. You could do it by placing a contract with industry on something other than a fixed price basis. It's very difficult to place cost reimbursable contracts these days.

Oettinger. Earlier you set great store on your notion of smart people. But it seems to me that even smart people are not omniscient, so would you be willing to buy, as a second important principle, that risk-taking ability, either in the government or the private sector, is essential? Or wouldn't you go that far?

Osborne. I certainly would. I think, though, that I would certainly rather take my risk using smart people than stupid people.

Student. You have to assume that there are smart people on both sides of the fence all the time, and that all these regulations and procedures are simply means of focusing already smart people.

Student. One thing you need before you take risks is objective evaluation criteria, such as you have in business. If you get the smart people you want, then they will take the risks to get the returns that they can be evaluated on. And the second thing that I think is essential that you don't have in government — I'm asking if you agree with me or not — is decentralized decision-making, where you vest in the person, the decision-maker, the ability to take a risk, and make clear what he or she is going to be evaluated on; the smarter the people you get, the better they are at doing that. My feeling is that, in government, you may have smart people — and there are many — but you don't have either objective evaluation criteria or decentralized decision-making. Would you agree with that?

Osborne. Yes. Incidentally, in *The Mythical Man-Month* Frederick Brooks points out that when a software program gets in trouble, the general tendency is to throw a lot more people on it. Unfortunately that usually lengthens, not shortens the time, and certainly drives the cost up. You can't do it that way. You've got to practice management philosophy somewhat like a surgeon. The man in charge has to determine what it is that he wants. A surgeon has a lot of experts around him, but it's not a committee thing when you're operating on a human being. Somebody must be in charge, setting up the overall architecture of things to be done and where other intelligent people can fit into it.

Planning in a corporation is exactly like that. What is it that I want to do, in some broad sense? What are the various alternatives that I've looked at, and what are the matrices associated with them? And does that in turn justify my doing this thing? Having determined that, what are the various elements I need to do it? What capability do I have now? What are the things I'm lacking, and what is my plan to acquire them so I can put them in and do what I have chosen to do?

Now, government specifications theoretically try to map out that planning process. But they don't put any one person in control; the process runs through a whole series of bodies who are entirely different, who have their own ideas about things. I've prepared a lot of these presentations for, or in concert with, my government colleagues to take them through these steps. The name of the game is to get through the gate. And you're sometimes willing to sacrifice some of the more substantive things in order to get it through. And once you've got it through, for Christ's sake don't change it, because you'll have to start the whole thing all over again.

McLaughlin. I'm feeling a certain frustration with this. I think we can all agree that smart people are better than dumb people, and that traditionally the rules and regulations got written as a substitute for smart people, or for fear of dishonest people. And I'm wondering, are we talking about the sort of traditional, simple, institutional fixes where you hire smarter people, and you pay better to keep them? Instead of relying so much on

the rules and regulations, you lean more on firing people when they fail. There's a whole literature of this, a litany of government going back to the Roman Empire. But are we talking about something more basic or different? Are you really saying that maybe building a World-Wide Military Command and Control System is so incredibly more complex today because it is connected with so many complicated weapons systems that it takes you six years to get it through, regardless of the kind of people you have?

Oettinger. Jim, I think John's question would be an admirable takeoff point for you to review, in light of your several propositions, whether it's the inherent complexity of global systems as opposed to some simple-minded World War II radio, or whether it's this age-old problem.

Osborne. All right, let's see what we can do with that. There's another element in the equation we haven't talked about: the people who operate, repair and maintain the system. There's an excellent piece by Melvin Laird pointing out that all services are continuously having to lower their requirements for the people who are coming on board. So as our weapons systems and our command, control and intelligence systems are becoming more complex, the capability of the people who are actually operating, maintaining and repairing them is going just the other way.* In turn that makes the systems even more complex, because now you have to build things into them to replace the intelligence you'd normally expect to find in the human being. That lengthens development time. Sure, things are getting more complex. We now have to put much more capability in the same size box. We are constrained in size, weight and power, yet the functions to be performed are much more complex, so the equipment is more complex. Determining just how all this threads together is obviously more complex. Being more complex, it takes longer. Because we don't have people who are maintained at the needed proficiency, it takes a lot longer than it should.

Admittedly it's going to take a lot longer in any event, right from the beginning of the process. Engineering the systems takes longer, intrinsically; it's more complex stuff. Manufacturing takes longer. Because it takes longer it costs more. But it takes much longer to engineer and manufacture, and costs a lot more, because we're not applying all the intelligence we could and should to the process. Finally we deliver the equipment to our customers — late, and at an exorbitant price. We hand it over to people who don't have the capability to operate, repair, maintain it, so in the end the intended use of the equipment is subverted. It's just not what we want. Somehow, despite all this, we just have to change.

Oettinger. Now how would you interpret your propositions, in terms of what you'd want to change?

Osborne. The complexity of the system is not going to change. Indeed, it will get more complex. Since that's so, we have to look at how we can assess the needs of the system in a much different way, and with smarter people. The government, as I said, is less and less

*The point is further pursued in the discussions in this volume by B. R. Inman and Congressman Charles Rose.

able to articulate those needs in the form of specifications. That is going to continue to be a problem. Those specifications are going to continue to be complex, even more complex than they are now. We have to come up with a means of obtaining the best product, and a mechanism to expedite changes when changes are needed. The procurement process, the testing process and the like, by their very nature, cause things to take longer and cost more money. And although I can understand theoretically why these things have been done the way they have — to keep out crooks and so forth — nonetheless it is a fact that things are taking much longer than we can afford to have them take. They're costing more than we can afford to have them cost; we've got to do something about that.

Oettinger. Some years ago Alvin Weinberg, whenever cornered with something like that, would say, there'll be a technological fix and the problem will disappear, and I used to think that was a crock. But let me try this out on you. Both of the points you've made take for granted that complexity will continue to increase. Is that an inexorable effect? Let me give you what I think is a counterexample. In the early days when I was involved with computers, designing a flip-flop or designing a couple of stages of an arithmetic unit was something of a big damn mess. Once we had students here who'd put together computers, but then for a period it got completely out of hand and making a computer was not something you did in academe. It required the best men, industrial facilities, etc., etc. Well, now lots of folks all over the place are putting together computers again; you buy yourself a passel of chips, each of which has inside it an enormous amount of 1940 or '50 status complexity. Any kid can put together a computer in a university lab and it can work, because the building blocks are simpler. Can this be applied to the development process? Or is that nonsense? Do you see any way in which the assertion 'complexity is bound to increase' might be overcome by technological fixes or by organizational genius?

Osborne. First off, it's true that we're now using components the size of a pinhead, where we used to need a rack of equipment. We can say, yes, it's less complex because it's in a nice package that I can install somewhere. Manufacturing a device might be less of a problem, because I can now take a whole bunch of circuitry that's been hammered out, hammer it into boards with automatic machines and automatically test it, and I can repair it by pulling out a whole chunk of circuitry and throwing it away. In that sense it's less complex. But that doesn't change the point that someone had to decide what you wish the device to do. Someone had to design all the stuff that goes inside the chips, and that is a much more complex thing.

The next thing that's important — especially in the LSI and VLSI type of circuit — is that once you have decided that a device will be used to do a specific something, it's very difficult and very expensive to change that later on, because now its function is embedded. For example, I once developed a PABX system — Private Automatic Branch Exchange equipment. It was all solid state. The decision was that we would put it all into LSI circuitry. It was a beautiful system, with automatic wake-up, call-back, all sorts of cueing. It was the sexiest thing you ever saw — except that nobody would buy it because, when I told them how much it was going to cost and how big it would have to be, they simply didn't have that much money or room in the motel or hotel to fit it in. It was

suggested that we take the features out. But you can't do that; they're embedded in the finished system. Therefore, it is super important, since you're going to be building things this way, to make sure you start off with the best evidence: what is it that I really want to do? What are the needs? It's important to spend enough time qualifying and quantifying these things to the point where you can say with reasonable accuracy, "That does represent what I want." But we just aren't doing as good a job of that as we need to. It's because we don't have the people to do it, or we have processes which make it impossible.

McLaughlin. Does it make sense, then, to talk about solutions? It seems to me you've spent a lot of time describing problems. If someone from the Carter administration were sitting here he could say, well, we have recognized these problems in the last few years, and we have substituted a career executive service; we put in General Jones' new form of fitness reports, so we're forcing change and forcing efficiency. I'm not sure I know anyone affected by those systems who believes that's actually true, but apparently that was one attempt at an institutional fix. If that doesn't work, what do you do as the next step?

Osborne. Remember the Kung Fu series, when someone was asking David Carradine "What do I do?" He said, "I don't know, I have enough of a problem understanding the questions; I don't have any answers."

One general area I think needs to be improved: a hard look needs to be taken at the entire civil service system, which does not have any built-in forcing function to maintain people at high proficiency and to attract smart people on a continuing basis. Granted there are a lot of smart people in the system now, and I think a lot of smart people continue to enter the system, but it is insufficient to the need. Second, I think our procurement process needs to be gone over from one end to the other, to see whether contracts are really being placed and monitored so that we're getting things when we need them, not whenever they're delivered to us, and at a price that is budgetable and affordable, not something that comes out at any old figure at a distant point in the future. We have to recognize that, after we've gone through the whole process, and assuming it's all perfect, these systems are going to be handed over to a group of people with decreasing ability to use them. That has to be worked out too.

Student. From different things you've said, I find myself questioning whether you think business should be active or totally reactive to the government. On the one hand you've talked about risk-taking and your own experience from the business point of view. On the other hand, you've pointed to the problems of more detailed government directives, more skilled government people, the need to try to anticipate where things are going in order to try not to fall behind. There must be some middle ground between business that is totally reactive to government procurement systems, and business that is active.

Osborne. Oh, I think it's going to have to be a joint effort. It's nice to sit back and say somebody else is going to generate all the needs and the complete architecture, and will then hand it to an industry guy and he's going to go out and design the stuff and crank it

out of a factory. Logically, though, it's not going to work that way. It's got to be an iterative process with a real partnership between government and industry if it's going to work right. Of course that's frowned on these days. The government-industry complex somehow or other got to be a dirty word — I don't know why, but it did. Yet I think we're going to have to go back to a lot more of that kind of collaboration. The development of the whole semiconductor business wasn't done in the military; it was done on the commercial side. The fact that you can get all this stuff on chips now wasn't a consequence of government work, it was the competitive force in the commercial marketplace that caused it to happen. I think that, like it or not, there has to be a degree of partnership between industry and the government.

Student. I would just like to say that our laboratory did give RCA seed money to do advanced semiconductor development.

Osborne. Oh, absolutely. And the Army gave RCA lots of money for the micromodule project. And the Army and the Air Force put a multimillion dollar hybrid facility in the Burlington plant. I'm well aware of all that. But, taken all together, that's still pretty small compared to some of the money that's been poured into semiconductors in the private sector — even in RCA.

Student. I'd just like to make a remark on complexity. Complexity is a moving boundary, and military systems are always working against its limits. JTIDS is an example, where we want a computer that's variably estimated in an airborne configuration to work at six to ten mega-ops per second (MOPS) in a ten pound package which draws no more than 100 watts. It's beyond our capability to put that in an airplane today, although five years from now maybe we can do it with VLSI. But no matter what we achieve in five years, our requirements are always going to be demanding beyond that boundary.

Oettinger. That may be at the heart of the matter, but I wonder how much of the problem is an absolute, and how much of it is perception. A tire is one hell of a complicated thing to fabricate, but any bloody idiot can change a tire on a truck. By the time it gets to the end consumption point, it has to be operable. The internal complexity may be increased, but still you have to design the truck so that the bolts can be unscrewed and somebody can use any old wrench; and you have to think about whether it's desirable to require a specialized wrench, and so forth. Maybe some of the problems are not as much the diminishing capabilities of people, or the increasing complexities of systems, but the need for more attention to making sure things are operable by human beings. You may have to take five or ten year intervals between major changes so that things are engineered at a level where people at a particular time can use them effectively, as they would a tire. Now, is that nonsense, or is there a germ of something sensible in it?

Student. It's not responsive to today's demands, but it's perfectly true. For instance, the Air Force has problems not only with internal complexity, as reflected by computer programs and designs, but with external complexity, as reflected in the interfaces of what

you're building today with the other systems that are already in place or, worse, with those that are already being simultaneously developed without the communications view. This problem is going to exist until those systems are fielded and they somehow come together. For example, we wanted to build an automated TACC — this is one of our disasters — an automated tactical air control center; and it was pointed out to us that current technology will support multi-processing — that is, several computers which can share jobs. That's fairly complicated. Well, one company said yes, our computers can do it, and we've got an operating system that works, and another company said we'll build the applications systems if you'll give us a specification of how the operating system performs. Another company said, well, uh, we're the system integrators, and if those computer programs work on that computer, then we can make the system work. But it didn't work, and you've got fingers pointing all over the place. Now was that all complexity, or poor management? It's very hard to distill lessons learned out of disasters. You can draw almost any conclusion you want, but I think complexity was certainly a factor.

Oettinger. Well, it's easier to manage simpler things with dumber people than it is to manage complex things with even smart people. I wish I could put my finger more effectively on this question of tradeoff between the rate at which you increase complexity and the rate at which you keep things manageable and fieldable and doctrinable so that you get something that's not just like that box with a lot of stuff going in it, whirring around but doing nothing. I'm surprised you didn't say anything else about doctrine, because I think it is related to what the guy at the end of the line does.

Osborne. I've got that noted down here, but I decided it gets to be too darn hairy.

Oettinger. Okay, we'll leave that as an angle for some of the speakers later on in the semester; I think this whole question of doctrine relates to who's out there at the other end and how they react, with "Oh, it's too complex," or "Oh, another one of those." That reaction depends on what you are expecting, and what you are expecting has something to do with what the doctrine is and whether something is routine or entirely out of the realm of what you've been trained for or what you expect.

Osborne. I remember a group of people coming in to the Navy, describing a system to us. We began to ask some questions about it. They took great offense at the questions and we finally had to point out in one syllable language that, hey, we're on your side. These are questions that somebody else is going to ask you somewhere along the line — why not raise them now? There is a tendency to get walled into these systems; it's not challengeable; it really isn't. The guy in charge of that program started out as a commander, and now he's an admiral in the same system. And it's the system that did it for him.

Oettinger. He forgot why he went into the swamp.

Osborne. Yeah, he sure did.

Student. That wouldn't happen in the Air Force, because the tours would be four years at most, and the guy who started would be long gone before the boat sank.

Osborne. Well, I'll tell you, it happens in the Air Force too. Over in Minuteman, we had a problem with the cable systems. Invariably some farmer using a posthole digger would punch a hole in the cable; and gophers, it turned out, loved to eat lead, they'd eat holes in the stuff. So we developed a system to pinpoint where the leaks had occurred with great accuracy — within 50 feet. That saved the Air Force an enormous amount, having this handy little gadget on the link that would tell them right away there was a leak; all they needed to do was go out and dig a hole there and fix it. But then we had to pull that gadget out — it wasn't to Minuteman standards. As a consequence, the Minuteman system is operating without that device now. It just wasn't in the game plan.