

INCIDENTAL PAPER

**Seminar on Intelligence, Command,
and Control**

**The Emergence of Data Systems: Cost
and Technical Change in Military Systems
Barry M. Horowitz**

Guest Presentations, Spring 1993

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August 1994

Program on Information Resources Policy



Center for Information Policy Research



Harvard University

The Program on Information Resources Policy is jointly sponsored by
Harvard University and the Center for Information Policy Research.

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E-mail: pirp@deas.harvard.edu URL: <http://www.pirp.harvard.edu>
ISBN 1-879716-12-7 I-94-5

The Emergence of Data Systems: Cost and Technical Change in Military Systems

Barry M. Horowitz

Dr. Barry M. Horowitz has been MITRE's president and chief executive officer since 1990, and a member of MITRE's Board of Trustees since February 1989. His previous MITRE positions include: Executive Vice President and Chief Operating Officer, Group Vice President and General Manager of Company Operations in Bedford, MA, and Director of Special Studies. Dr. Horowitz is a national authority on software development and techniques for managing engineering programs. Before coming to Bedford, Dr. Horowitz held several positions at MITRE's Washington Center from technical staff to department head. Most of his effort was devoted to air traffic control in support of the Federal Aviation Administration. During this period, Dr. Horowitz became a recognized leader in the aviation community on the design of new collision avoidance systems. Dr. Horowitz received his BS in Electrical Engineering from City College of New York, and his MS and PhD in Electrical Engineering from New York University. Dr. Horowitz's professional activities and awards include membership in the Eta Kappa Nu and Tau Beta Pi engineering honor societies; the Air Force Exceptional Service Award; the Gold Medal Award for Engineering presented by Nova Chapter, Armed Forces Communications and Electronics Association.

Oettinger: It's a delight to have as our first speaker here today Dr. Barry Horowitz, president of The MITRE Corporation. I won't bore you or titillate you with the full details of Barry's biography. You've all had a chance to read it. Let me merely say that he's seen the subject that we're dealing with from such a wide variety of viewpoints, both civilian and military, that I can think of few others who can open things up with as broad a scope as well as sharp a focus, wherever he wants to focus, as Barry. He has agreed in conversations prior to class to be interruptible with questions and discussion as he goes along, so please don't hesitate. I will moderate if necessary. And so saying, it's all yours, Barry.

Horowitz: Can you remind me of the title of my talk?

Oettinger: It was command and control — your thinking about it in any way you want it. That's the general ballpark.

Horowitz: Okay, I just wanted to be sure. What I thought I'd like to do is go through what I see as the pressures that will undoubtedly lead to some important new directions and emphasis in the command, control, communications, and intelligence operations in the military, and then highlight some areas that people are not talking about that I think are significant for some of the desires that are often expected to come true. I'll be glad to change the subject, to talk about anything, as long as I know about the subject.

Everybody knows that probably the most significant factor in changing the direction of the military force structure, as well as the C³I, is that we no

longer consider the Soviet Union, or the Russian states, as the prime issue of military contention. That raises a whole question of rethinking what is and how do you situate yourself so that you have the ability to do whatever you have to do over the next number of years. In parallel with that, there is the question of what do you do about all of the investment that has been made in the command and control of our strategic force structure, given that it's not likely to be either the same size or to be used in anything like the context of the prior theoretical exercises.

A second very important thing is the money situation. Going along with the change in mission that the military has to consider is that their budgets and their size are being reduced. Any organization, whether it's a military organization or a private organization, that has to make changes knows that change costs money, and the worst time to make changes is when you have no money. So they are having to deal with the subject of, "Well, what do I want to do and how do I finance the shift from what I was doing to what I am going to do?" That's a big complexity.

A third factor, that's perhaps unique to the command, control, and communications area, is that there's commercial technology that is certainly as capable as military technology, moves faster than military technology. There's just the general question of how does function that relies on a commercial world stay in sync with the commercial world, both from the viewpoint of taking advantage of it and, when doing that, just having the administrative and budget support to stay in sync with it? Anybody who has bought large commercial systems knows that there's a turnover rate that's pretty fast in terms of life cycle, and this requires a concept of a depreciation in investment, which is something that is not traditional in the Defense Department.

Finally, we fought, and I think we won, Desert Storm, and a lot of lessons were taken out of that. The issue of the interoperability of systems and services, the access to intelligence information for the operational forces, is a big issue that General Schwarzkopf chose to raise as primary. We saw that GPS (Global Positioning System), the navigation capability, became a commercial thing and was proliferated, and great use was made out of just knowing where people are at low cost. That has created a whole new wave of thinking about how we take advantage of things like that. We saw that you can't move the whole U.S. infrastructure abroad in a short period of time. We had a six-month build-up

period, and even after six months, people were not fully secure that we were so-called "ready." I think this gave a lot of credence to the notion that wars in the future will have to have part of the infrastructure support existing in places other than where the actual crisis activity might occur.

So, Desert Storm illustrated problems of that sort. The Army saw that its rate of movement of the Army was unimpeded and they moved very quickly, and the ability for their short-range communication assets to be moved as quickly as the Army moved on the battlefield actually created disruption in terms of continuous communication with a fast-moving force. They never contemplated in their theoretical exercises that they could move at the speeds that they ended up moving across the battlefield in Iraq. So, people took those experiences home and what has occurred, I think, over the last year or two is a few key directions have emerged. I'll highlight what I think those are. I'll probably leave some out by accident, but I'll be glad to talk about them if you want to raise them.

One is the Joint Chiefs came up with *C4I for the Warrior*. How many of you have seen or read that? Any of you? That's a pamphlet that Colin Powell personally released that presents the new military concept for command and control. It essentially says that it will be a highly mobile force, part of whose infrastructure support is coming remotely, and that information will flow on the battlefield from all sources to all recipients who need it, no matter what rank. So weapons that need data would get data, and generals who need data will get data. So the basic idea is what I call a massive information system that will have part of its sources in theater, part of its sources being national assets, intelligence assets, and part of its sources being resident perhaps in the United States or other places where we have convenient access to knowledge and information.

Oettinger: Let me just, if I might, at this point, interject that that's a neat opening for our concluding session when Admiral Tuttle will be here, because implicit in what Barry has said is that there's a tremendous problem of realizing that ambition that the Chairman of the Joint Chiefs has outlined. Admiral Tuttle has been engaged in the creation and development and conceptualization of a Navy system called by the acronym SEW, Space and Electronic Warfare, which is one of a number of ambitious attempts to put something under that concept. The concept, as far as I understand it, is kind of a wish list, and the question is how you do

it. It's still wide open, and we'd welcome any other comments you might have, but I wanted to alert the class to the fact that this is a large topic of which we'll hear more later from one of the "horses' mouths."

Horowitz: Yes, I will talk about what I think are some of the things that I see going on to try to achieve this. But I'll also talk about some of the things that *aren't* going on that probably are necessary to achieve this. I think people have accepted that space really matters. That is, resources in space are essential, because the ability to collect global data is obviously better done from space on a steady-state basis than other ways — there's less risk, physical risk for sure — and the ability to pipe data from places to places at very far distances is obviously best done through space. So we see that space is an important part of the puzzle. I'll say more about that. If we're going to achieve interoperability, things have to be done to achieve it, since in fact, whatever we haven't achieved, the current planning and development methods haven't produced. So, let me take those topics and say what I think some of the ideas are that are going on and some of the things that I think are crucial that aren't going on.

First, the idea of a big information system that gives everybody the data they need, when they need it, for whatever purpose, is a great idea! You really can't be against that idea of everybody gets what they need, when they need it, for whatever purpose. If you go to each service, they will draw a diagram of all the sources with lightning bolts between the source and whoever you decide a recipient might be. There are these big complicated diagrams of sources and receivers. In fact, they have programs that have traditionally been funded to develop things in the field, which are those sources, those lightning bolts, and in some cases, those recipients. Every military service will have a diagram of what they currently have and what they're going to have that fills some need to get the data distributed. But one of the observations that I have made is that implied in the concept are some things that aren't on the lightning bolts and aren't in the systems themselves. Implied is that there's an assurance that if somebody thinks they're supposed to get data, they'll get it, and systems individually developed in lightning bolts and boxes don't create an assurance of that sort, unless there's a method of assurance. We don't currently have methods of assurance.

Second, implied in that diagram is that the data has integrity. If one were to ask, "What are the

standards of integrity for all of these users? Who is in charge of assuring that kind of integrity? And will all the users be satisfied with the same level of integrity for the data?", a simple mind exercise will probably tell you that depending on what you're using it for, there's certainly a different level of integrity demanded. If you're going to shoot down an airplane, you want to be darn sure about whatever it is you want to know, compared to if you are making some observation to someone about whether someone is flying through a particular air space.

Student: Can you separate integrity from accuracy?

Horowitz: I would include it as a subset of integrity.

Student: Okay, so you're talking about multiple . . .

Horowitz: I mean all of the factors that would make the person who receives it get what he thinks he's supposed to be getting. So implied in that diagram is that the data has integrity. Otherwise, we know those people don't want it, however they define the integrity they demand.

Also implied in that diagram is that we have sufficient capacity to send all the data that we want to send. In fact, there's a big R&D program being formulated in the DOD called Global Grid, which has the idea of exploiting such technologies as fiber optics and making more use of space technology and setting up a grid around the world so that you can imagine wherever you go there's a plug. You plug in and you can get access to all the information that the United States has about whatever it is you want to know. This implies one of two things. We will have sufficient capacity that there's no limit to the amount of data we can send to any place, or more realistically, that there's some way of judging, given what amount of capacity you have, what you'll send and what you won't send, that's compatible with the earlier topics of assurance and integrity.

Also implied in that diagram is that should things fail . . . you know, the wars go on and things could happen, so should things fail for natural or unnatural reasons, there's some sensible process of re-managing those resources so that under the circumstances at hand, they are being best utilized.

In fact, if you assumed all those things and other such things were going to occur and had to occur in a large information system, and then asked, "Well, where is it?", you'd find that there is no such thing

or such place in the government that does that. You'd find that DISA, the Defense Information Systems Agency, formerly the Defense Communications Agency, does have responsibility that common, shared communications resources will be on the air and that the channels will be shared in some way that the generals agree to, and they'll manage that. Then you have Space Command, which assures people that the satellites that provide communications will, in fact, be utilized as the generals — or the upper management, they're not only generals — decide to use them. So that's a far cry from them either knowing what's being sent, assuring that it's good stuff, and having any information responsibilities. Their responsibilities are really access and control.

Oettinger: They're kind of the military's phone company, period. I think it's important to underscore that because you can get mad at the phone company if you can't get from here to there, but if where you get to doesn't want to talk to you, or has nothing to say, or gives you misinformation, that's not the phone company's responsibility.

Horowitz: . . . and no one holds them responsible for that. But the military really has no experience with setting up communications channels. They do that pair-wise today. They do that maybe even three-wise today when they get complicated. But if one truly imagines all sources can get to all receivers, you can't use hand-shake methods. You have to have some system for doing that, and the country lacks both a designated person or place or authority to deal with that subject and the systems to enable that person to do the job.

Oettinger: Can I try to lead you down a path here by giving you a leading question because that's an ancient problem and my nose and brain, both, tell me that where there's an ancient problem, there are probably underlying causes beyond technological feasibility. And so, perhaps if you could dwell on that a bit I'd be grateful.

Horowitz: Well, I think that here's a case where historically my experience has shown that the military has felt that voice communications gives them the assurance, and the integrity, the reliability, the management of supply and demand to deal with the capacity, and that voice deals with all of that. There are the override buttons that make sure that generals get access when generals need access, and they've lived in a world of voice. Out of Desert

Storm, they all saw that data is in. That was a big observation — data is in. I would say that prior to that some people *thought* data was in, but everybody *felt* that voice was it. So I think that that's really the change, that Desert Storm really illuminated the importance of data compared to any other time. Voice does not have the same demands as data because voice can get by with just a phone company — *people* become the method for providing information.

Student: Sir, could you expand on that because, as a military kind of guy, that doesn't automatically make sense to me. I mean, I know there are advantages in which you get your data, but could you expand on it for me?

Horowitz: About how I saw data help them compared to voice?

Student: Right.

Horowitz: Well, for example, in Desert Storm JSTARS (Joint Surveillance Target Attack Radar System) was put into that activity. Do you know what JSTARS is? That's an airplane that has a radar on it that can see moving ground vehicles. There were two of those, still under development, that were sent to Iraq under the terms of the war. So they weren't even at complete capability. But they could provide surveillance that enabled the leadership to see the battlefield movement to the rear. That is, they could see the motion of the reinforcements, the supply, and that there were no giant tank colonies, but if there were, they saw the retreats. So the generals got a picture. But in addition, the data from JSTARS was used to cue pilots about what they could do, and that was done by voice, but it really was a voice system that was set up to emulate a data system, that is, a quick turnaround, and all they told them was data by voice, or absence of data link. Everyone could see what they needed to see. The generals could use it in a broad context, and the weaponeers could use it in a narrow context — same system, same data — if filtered properly, but the capacity of the system was greatly limited by the fact that voice links rather than data links were the method.

AWACS (Airborne Warning and Control System) was up there mainly to do air traffic control. There were no air battles going on. But even air traffic control was a very complicated subject. We had thousands of sorties and there were a few near mid-air collisions even with AWACS doing air traffic

control. That was again done by voice, even though AWACS had all the digital data, and there were some close calls. I think people could see that if the pilots had had direct access to some of the information, that, in fact, could have been helpful. So I think that the information on the digital platforms, imagery, but I can't say too much about . . .

Student: Can you tell me this? I see that what you're getting at is an intelligence function through data as opposed to a command function from voice. And you don't get . . .

Horowitz: I know, but voice is used today to both provide information as well as command. I think the basic idea of *C²I for the Warrior* is that if the weapon has the information, it doesn't need command. It needs general instructions. It doesn't need particle-by-particle command. In the way they had to run the war, they needed particle-by-particle commands, since, in fact, the weapons didn't have the data.

Oettinger: I need to respond to that in a slightly different way to see if you agree or want to disagree or expand on it. It seems to me that underlying what you're saying is a deeper problem both of in-service roles and organization, and interservice, or inter-agency collaboration. Inside of service, I hear what you're saying, that's calling into question the role of, let's say, the fighter pilot or bomber pilot, because if a data link can see what he sees and can bring back what might be commands, then the question of whether the pilot is necessary in an era of remote pilotless vehicles becomes kind of nasty. Then about data integrity, et cetera, et cetera, there's an assumption implicit in what you say that folks are willing to share it and that there's only a technical problem in sharing it, and it's not clear that everybody's willing to share data . . . never mind with the enemy, but with one's friendly colleagues.

Horowitz: I agree. Those are both management problems that will end up determining the degree to which information is promoted into the battlefield, but the things I raised are to this point: that even if you decided to send a certain amount, they don't have a system for sending it. The Navy would claim that one of their missions in the future and in Desert Storm, was do early interdiction. They're sitting on the shore, there are targets there, somebody giving them target information, they can do the interdiction. The Air Force owns all the surveillance platforms for doing that sort of thing by nature of the fact that they have that mission in the norm. The

fact that the Navy needs that data is quite clear, and it's not likely that they'll buy themselves a JSTARS or another AWACS or anything like that. So I think the idea that the sensors can provide things to the weaponeers was seen. Their high-fidelity data added that edge. In addition, the generals need the aggregated data to make command decisions and so flow of data I think is recognized as important. The thing Tony raises is that there was some data to the effect that people were disappointed about our ability to do bomb damage assessment, and that there may have been some data available that could have helped, but it wasn't fully accessible, therefore there were long delay times and stuff like that.

That's another degree that gets into that topic of whether anyone wants to give it to them anyhow. But, even if they did, what would be the method? I think there is no such method today. So if you go to each of the services, you'll find there's a three-star general who would be in charge of information systems, and he sort of goes around that service just figuring out what people need and all that, but he's not an operational general. He's a planner. So there's really nobody who would say he's the information officer of the Air Force, or the information officer of the Army. His job is to figure out what that service needs, to provide it, to assure it, to make sure it's viable and useful, and to understand its costs and its benefits. I think that's going to be a necessary condition and a hard thing for them to gravitate to since they've never had to think about it.

Oettinger: If I might, I'd like to underscore that point for the class, because you'll be reading Tom Coakley's book* for critique. In connection with Dr. Horowitz's comment, I urge you to read the preface to that book, which is by Bob Herres, who, when Coakley wrote the book, was Vice Chairman of the Joint Chiefs, essentially making and reinforcing the same point: that there is no military specialty that would see to it that the things are in place for the operational commander. That's what I think Dr. Horowitz is talking about, and it might shock you to hear not only a responsible civilian, but also a high-ranking military officer say that, as of two or three years ago, such a thing does not exist, when it might strike you as self-evident that it should. The question of why it doesn't is something that may be worth somebody's term paper.

Horowitz: Well, again, I believe it's because voice was the answer. There's not a real belief in data.

*Thomas P. Coakley, *Command and Control in Peace and War*. Washington, D.C.: National Defense University Press, 1991.

Student: Do you think there might be some sort of purposeful reason why people aren't attuned to that? I know in a lot of corporations when data or information systems are brought in, the entire structure changes. Instead of needing a whole bunch of middle managers, you can eliminate a whole central part of your organization, and the whole hierarchical structure of military organizations naturally tends to go against any taking away, as Professor Oettinger was saying, of roles for each of these people anywhere.

Horowitz: I think it's deeper than that. Maybe there is that aspect, but I think it's very hard for any organization to make a new technology a running part of the way that it does business. It's just very hard to do. There's no company that could honestly tell you that it was doing business by method one and then decided to do it by method two, went out and bought whatever method two was, installed it, and then everybody went about their business and it was all 30 percent better business. No company can tell you that. There are a lot of people, a lot of different ideas, a lot of training, a lot of undoing, the customers all expect a different thing, you've got to train your customers, so it's just a hard thing to do. I think that until Desert Storm, data was not considered to be of great importance and, therefore, the change of control and orientation did not seem to be warranted based on earlier experience.

Oettinger: It's hard to overstate the importance of the point that Barry is making, because even in the Navy, where it seems to me there's a greater reliance historically on data than in the other services, eventually the amount of data that could be transmitted has always been relatively low because of a long-standing and perfectly rational tradition that ships at sea did not need to communicate. They couldn't, and they have always organized themselves on the basis that once you're out of port, you're out of touch. Last year we had in the seminar a rather poignant testimony from one member of the class, who had been on a ship in Desert Storm, recounting the actual withdrawal symptoms that he felt when he went from shore back on ship and the ship left the dock, from having access to this enormous panoply of data and then, within a few hundred yards offshore, being on cotton wool.

McLaughlin: Part of that was that he didn't have his STU-III anymore. That was the story.

Oettinger: So these things go very deep into all organizations and organizational problems, but also

into strange — until you start looking at them — cultural kinds of historical phenomena.

McLaughlin: And without crediting them as long as it may be Dr. Horowitz's story. We never had a war where we had so much data. In conventional targets and theory, we talk about, "Yes, we're going to take care of this bridge or this building," and in this particular case, we had the architect's plans, the builder saying, "Well, this is the span of the bridge that you want to bomb." That's fairly rare in history, and the ability to do targeting plans and handle the body of data involved was enormous compared to some historical examples. Lots of people felt the acute shortage of data when they . . .

Horowitz: Let me amplify on that point. People for years have talked about a thing called fusion, which has been a word to mean that if you could combine two data points, you might end up with a better answer than if you only had one. There have been many attempts, still in progress in some cases, that jump to combining everything you can think of in some statistical or other way to come up with some conclusive statement. I think that we saw in this war clear examples where combining different data sources truly provided great enhancement value. I really can't say too much about this subject other than to say that you could get information that would tell you where to strike something because it was weakest there. You could get information about where that was in the geographical sense, as well as on the structure itself. You could find out about the current state of affairs in that region in terms of defense. These, all coming from different places, get together a whole picture that says this is a good time to do it, this is how you do it, and if you're going to do it, you have the precision weapons that can do it, or that you don't need precision weapons to do it. So I think fusion was another one of these factors that is implied. I don't really think people are thinking that every weaponeer should receive all the data and fuse it. Maybe they are, but it's very likely that somebody would have to do some of the precombining and since these data come from different places, it's not likely that one of the existing resources will be the ones who will do it. So there's an implication of another place and there is no tradition of another place to do this. So I think that's another missing ingredient on that list of information management versus communications management — it's a different ball game.

Oettinger: That's a double whammy because, as Dr. Horowitz points out, some of this has to be

invented because it's nowhere. It's kind of a positive element. There's also a negative one. I'll draw on banking as an example. I don't think there's a bank yet in the world that has a full picture of its relationships with its customers; that is, if somebody has a checking account and a trust account, and does some currency trading, and so on, and I am the bank manager, I want to know what am I in for, what are my hooks into this customer? By and large, you can't tell. After 35 years of bank automation, you sort of wonder, how come? Well, aside from its having to be invented, there's a great deal of resistance from the trust department, and from the loan department, and from the other departments about sharing it. I mean, my job depends on having control over this, and you're not going to make it available to everybody who needs me, that kind of thing. That takes a while to erode. The earlier comment about flattening organizations indicates that yes, when it does happen, it does lead to considerable dislocation, so it's not paranoia.

In the services and in the intelligence realm there is also that tension, which in your reading last week and in your critiques you've made plain you saw, between operational security and operational effectiveness. If you let all the data come in one place together, you could get all of it compromised together. And so, people who are responsible for the integrity of information and the "protection of sources and methods," which is language out of a statute, say that if you don't protect sources and methods, you're violating Article VIII or Section 18 of the U.S. Code or something, and so it's your duty to protect sources and methods, and one of the ways you protect it is make sure that nobody gets it, I mean even your buddies. What Dr. Horowitz has raised here is a very complicated problem.

Horowitz: Let me say that I think most of the military believes that creating this C⁴I for the Warrior is a management problem — just deciding to do it and doing it. In fact, it would probably be the most complex information system the world has known because the sources are very different and very sophisticated in some cases, the information fusion is very complicated, the communications mechanisms are diverse and complicated, and catastrophic failures are much more likely than in normal systems. So it would be, in my opinion, one of the most complicated, if not the most complicated information structure anyone ever tried to build. That's one of the major concerns I have. People talk about it like it's just a thing you decide to do, and then if we all agree, you go and do it. Then they

view doing it within the context of the programs they currently have, which means, "Okay, so we'll connect this arrow to that arrow and now there's an information flow." So I think that's got to be changed.

The second point I want to make is, let's assume we really want data to go to weapons or at a lower level to the warrior, whoever the warrior is. This assumes that the warrior can afford to receive the data. We've assumed that space is going to be an important aspect of communications because of its global coverage, because of its convenience — at least it's served as a mechanism for communications that are immune to being shot at for the moment. If one looks at the military satellite program, a satellite terminal costs a lot of money. A Milstar terminal costs more than \$1 million. I don't think every weaponeer will be buying a million-dollar receiver. A DSCS (Defense Satellite Communications System) terminal, that's an SHF satellite terminal, costs hundreds of thousands of dollars. I don't think every weaponeer will be buying that. People are buying UHF satellite equipment that is commercially available and that costs in the low thousands of dollars. That's a good thing.

The only problem is we're saturated at the UHF frequency. There are so many people sending so much data and receiving so much data that it's a saturated communications band. So I believe that this is one problem: that the idea that everyone's receiving implies that the cost of receipt is low and, in fact, that it's probably a commodity system that's receiving, like your cellular phone; it's cheap. Today there is no available technology to do that, and there's no activity to create the technology to do that. And in the communication bands we are saturated in the area where you can do it, and unaffordable in the areas where there is still available bandwidth.

Also there's an irony. If you look at the commercial world, people say, "Let's use commercial satellites." It's a good thing to do. But I ask myself, as a U.S. citizen, let's say you're sitting home one day and you heard on the TV that some weapon shot down some target, whatever it was, and killed some people and it was sent over the satellite you happened to be talking to your mother on at the same time. It just wouldn't sound right to me or feel right that the weapon data and target data would be going over our phone system like any other piece of data. If anything, I would really feel that that kind of information should be on a military-dedicated system, whether it was protected or not. It just shouldn't be shared with commercial phone calls.

Oettinger: I agree that there's an overwhelming problem in the continental United States, but that's curious because that's exactly what happens.

Horowitz: Well, we haven't shot anybody down in the continental United States in a long time.

Oettinger: No, I suppose not. True. But that becomes kind of a metaphorical thing, I mean, how far at the end does a long-handled screwdriver get . . . ?

Horowitz: On the other hand, my personal opinion is that I could imagine generals talking on the phone to each other from the United States to Iraq on the same phones that I'm talking about. What do I care when I want to make a phone call?

Oettinger: You have a strange thing then about one end of the screwdriver as opposed to the other.

Horowitz: That's correct. Yet, the way I see the communications going, the generals will get the military-dedicated satellite service and, if anything, if the weapons are going to be serviced with commodity receivers, it will probably be over commercial satellites, unless the military develops its own satellite system with its own commodity receivers.

McLaughlin: Well, that may be an advantage in terms of technological generations as the weapons will actually be ahead of the general circuits.

Horowitz: They will. That's right.

McLaughlin: There will also be the availability of redundancy of them competing for available bandwidth.

Horowitz: I agree, those are good features. But I just wonder whether our public — and it's just a question I raise to myself — could accept the fact that Mother Bell is running a phone system that is killing people, and how people would feel about that.

McLaughlin: The GPO in Britain did that to the Luftwaffe during World War II. I mean . . .

Horowitz: I just threw that out into the air as a subject. But the more important subject, without doubt, is that if we are going to have the warrior receiving information, the prices have to be warrior-level prices, and when the military generates a system, they are generally not commodity type systems and you're so market-driven. One might argue, if the Secretary of Defense decides that the national security is threatened, he can decide to pay whatever price it costs.

Oettinger: In a flush era . . .

Horowitz: That is exactly right. I just think that is not in keeping with the pressures of today. So I think that the space program should be asking themselves, "Is there a family of commodity receivers that can receive all of this interesting information?" If the answer is "no," knock off C⁴I for the Warrior. The warriors will not be receiving this kind of information. But if the answer is "maybe," then they ought to start to create the programs to answer that question.

That raises a corollary . . . and I'll let you interrupt me. Military people have traditionally submitted that their systems have to be antijam; they have to be covert, secure, with different levels of security. Can we have designs that do that in commodity prices? I don't know. I'll say some more about that after I give Tony a chance, but I think that's a fundamental question. C⁴I for the Warrior, done at a price the warrior can afford, implies it's an unprotected system, but nonetheless, built for the warrior. Now that should not make someone crazy. GPS was an unprotected system to the warrior. They bought it like crazy! They loved it! In another war, maybe they couldn't have gotten a lot of advantage out of it. But in this war, they built it, and they buy it like crazy. So the idea of an unprotected system at warrior prices may be perfectly acceptable. If it's not, then we should not talk about C⁴I for the Warrior until we can prove that we can provide military kinds of security into systems at warrior prices. I'll talk about some ideas about how we might do that in a minute. But I don't feel that anyone has talked about that. It's not even a subject that has been discussed. They're consumed with the question, "can we disseminate information?" and haven't asked the price of receiving it and the security implied in the receipt to make it doable at a price. So this means a total change in outlook from "What do I want?" to "How much money do I have and what can I get?"

Oettinger: This may be either a straight-man question or off mark and you can treat it accordingly. But, as you were talking for the last three or four minutes, my mind says, look, I am cognizant of a lot of hullabaloo in the private sector about so-called personal communications networks — fixed, mobile, et cetera, et cetera. Now, let's say that this happens and that it becomes prevalent in the civilian community and you then have one of those over some area and only one of the expensive antennas, and so on. I can visualize intermediate ground

where the military, instead of paying for it all, stimulates and accelerates a piece of that civilian initiative. You know, you now have a dual-use technology kind of an asset or liability and so on. Is that something that you want to see or are you derailed?

Horowitz: I can see a possibility, but I think that once you enter that door of these different types of security, you have a big danger of getting trapped and destroyed by it because it's very hard for the communities. This is not a negative remark about NSA, but NSA is the gatekeeper for security. They don't worry about costs of security, they worry about security. And, I'd say, as a rule, they are viewed by the services as being unrealistic about how much security is necessary. If NSA weren't there, there'd probably be no security because costs might be the only issue. So, it's not that you don't want a gatekeeper, but once you enter the arena and set up structures, you end up with gatekeepers and people who don't care, and it's just hard to come to intermediary solutions that are sensible. It's not undoable, but hard. But I think the first issue is the military has got to put cost at the start and then ask "What can I do?" rather than "What do I want?" and "Let's go do it," because the services all learn that once they say what they want, then you figure out what they can afford and you are optimistically driven to say you can do it, and that is a nonlivable paradigm for the budgets that they're going to have.

Student: I agree with you about not being the gatekeeper and probably pushing things far more than the services would ever be willing to go if it wasn't for something else. But there were a couple of things there — somewhat in where Tony was going and somewhat where you were going to commodities. The STU-III was designed as much as possible to be a commodity security device, granted, strategically versus tactically, but question one: do you see that that is working as a good idea?

Horowitz: Yes. I think that that is generally the kind of idea that's needed.

Student: And the second one is a few security initiatives that they were trying to do, which is very much "let's get everybody to just go to them as separate . . . into their commercial systems and then everybody buys it and no one . . ."

Horowitz: They're screwing that up. That's screwed up. You should not put that on the same table with the Stingray. Let me say what the problem is with the commercial security ideas that NSA

has, and I've said this to all the bosses at NSA, so it's not a private comment. The commercial world changes its operating systems and its control mechanisms at the rate at which its customers demand change in functional capability in the operating systems that supports them. They have to. NSA would evaluate the changes as part of assuring security, not an unreasonable position from the security management point. The process of evaluation is longer than the turnaround time of customer satisfaction. As a result, they have an absolutely nonviable method of matching commercial rate of change with assurance of security, and the suppliers who might care have yet to see the commercial market care enough to make that matter. They all tell me I ought to set MITRE up as a nonprofit foundation to support all the computer manufacturers in setting up security standards, and a go-between between NSA and the commercial vendors that could do it at a turnaround rate consistent with commercial rates versus government rates.

This commercial demand will happen somewhere in the next 10 years. But commercial vendors are willing to invest epsilon to preempt its happening in its own right, unless someone gets a distinct advantage before they do it. So there's no great desire to undertake anything that's a high risk, high quantity of money investment in this area. Essentially NSA is hoping that that's there. It's not there!

Finally, I made some comments at lunch that this subject fell into. If you had standards for security in all the systems, across all the computer vendors that made good security, it would lose differentiation in product. And remember I told you, you'd rather have no market with differentiation, than a giant market with no differentiation. So they will grab it and go with their own solution, see what happens, let it all play itself out, and maybe they'll win the market. Yes, but what market? Well, who knows? Maybe a bank will get robbed or something then there will be a market. Who knows? So I think that falls into that category. NSA has the wrong paradigm that there's a desire for excellence out there, and if they can slow down, we need to respond to customers differently than with the STU-III. STU-IIIs are the right thing.

Student: Would you say a word about the STU-III, because I am not familiar with that.

Horowitz: The STU-III is a secure telephone unit, and they went to a keying system that made it practical for you; you are your own operator. In the old days, if you wanted to make a secure call, it took

a long time to get somebody to set it up for you and all that stuff. They made you your own operator, they gave you a little key, you went zip, there's a voice authentication, and it's all built into the phone. They disseminated it widely, not at commercial prices, but pretty low for government — \$4,000, \$3,000, or something like that for the phone.

Student: Thirty-five hundred.

Horowitz: \$3,500? So I'd say on the scale of a million dollars for a Milstar terminal, it's a commodity price. That was a good thing, and they had the great advantage of a large aggregated market to share the development costs across. That is, there are thousands and thousands, maybe millions, of STU-IIIs. Do you know how many STU-IIIs there are? Probably hundreds of thousands.

Student: Hundreds of thousands. The agency's got in the neighborhood of 30,000.

Horowitz: Thirty thousand, but not over 100,000? Okay, so when you take that kind of aggregation, you can divide out the one-time cost per unit. It would turn out to be pretty low. Take JTIDS (Joint Tactical Information Distribution System), which is the air-to-air, air-to-ground data link for the Air Force. They bought 45 of them and they divide \$80 million of development costs by 45 units. Now that gets pretty darned expensive. If they could divide that \$80 million by 30,000 instead of 45 it seems a bit more tolerable. You know, \$80 million divided by one thousand is \$80,000, divided by another 30 is \$2,500. They can afford \$2,500. They can't afford \$4 million. And that's a big problem — getting the aggregations.

That's an encouraging thing about the warrior. There are lots of warriors and they can decide to aggregate a market that can create a commodity product, but they have to bring in commodity development companies — AT&T did the STU-III. Usually, they don't bring in a commodity company to do the job. If you look at the communications companies that service the military, they are not commodity companies. They are custom-design, big-number companies. So they have the wrong thing.

Now, I just recently saw a briefing out on the West Coast on the space division of the future. It says, "Well, everyone wants information. Check! And everyone needs to receive it; therefore, they need communications. Check! So we have to have data collectors and communications in space. Check! Here's our vision of the future: this kind of

collector, this kind, and this kind. And there's this communicator, this communicator, and this communicator, and there are arrows to the ground. That's our vision of the future." I asked the basic question of who's receiving it. It's not in the vision. You see, it's a supplier view, and that's a big cultural change. The military is a supplier unit. You said you need information, here's the balls that give you information. You need a communicator? Here are the ones who do that. Where's the receiver? Well, the receiver is a warrior. He's a sergeant. The suppliers are generals. So it's opposite to a free market way and I don't think you can afford that in warrior communications. So I'd highlight that as a second major issue: how they're going to get low-cost receipt and turn themselves around to say, "Don't supply it if I can't receive it." Forget those! First, we'll figure out what we can afford to receive, then we'll figure out the supplier.

McLaughlin: Barry, in this same zone between the monopolistic military and commercial something or other, is there a counterpart? It would make sense to have a counterpart in the communications world: a simple reserve air fleet, people who were putting up commercial things where you pay them for a certain amount of capabilities on the chance that you need them, like the wide doors in jet freighters?

Horowitz: That's one idea. Another idea is the military could decide to pay the ones who put those up, to put up one dedicated to them at comparable cost. But there's a big issue about all this that caps these two topics I talked about — how do you control the information and assure it, and how do you afford it — which is: how often do you get to use it anyhow?

Student: I think that's why a civil reserve air fleet . . .

Horowitz: That's right. That's what that's for — how long do you get to use it anyhow? When you get the civil reserve, you can get to use that. How often do you get to use it anyhow, it's even less with that. A big motivator to spending money on information is using it. Any company that has an information system, boy, it costs a lot of money, and any president of that company will say, "Gee, what the hell are we doing with this information anyway all the time?" We usually don't get very good answers, but at least we get told that it's disseminated. If the warrior is not even getting it disseminated, it will be disheartening, I think, unless we get into a frequency of value that's high. That could be more

disheartening. I don't know. So I just think that they'll always have that problem of reasking themselves, "Why did we do this anyway?" Implied in all this is standards; implied in all this is the services working together so that commodities can be commonly designed.

This has led to the third thing I want to raise, which is, well, maybe we need centralized C³I, not more service unique C³I. They now build their own C³I. No more separate intelligence agencies doing their own "I". We really need to have some way of integrating it all and various proposals have been on the table, taken off, changed, and all that. Smacking things together has been put on the table; it's been taken off. Congressmen talk about putting things together. My own view is that this is not going to go away as a topic, no matter what the current state of affairs is at any time. This condition will continue to be raised. Every time someone sees something that doesn't work together, they'll say "Why do we have two instead of one?" Every time they hear that someone spent money to do X, and someone spent similar money to do Y, and X and Y sounded awfully close, why do we pay twice? Those questions will continue to arise and continue to tempt the issue of consolidation.

Now, in the DOD, what has happened is that to the defense information system . . . Let me explain the structure for those of you who don't understand it. There's the Office of the Secretary of Defense, who has an assistant secretary for command, control, communications, and intelligence. That person is in charge of policies related to assuring that we have coherent programs to achieve the objectives, like C⁴I for the Warrior. We have the JCS, who are the people who represent the military and say this is what we, as the military, need. The standard process is the JCS says, "Here's what we need." It's confirmed if it's joint; if it's separate and the service does its own thing, it goes up to the Joint Chiefs anyway, and they confronted that. Then the assistant secretary is responsive to that in terms of creating the systems that presumably will respond at a cost that's presumably affordable, and then he relegates out to the services the job to go develop those systems and install them, and hone them, and all that stuff.

Traditionally, each service does its own thing, and the Air Force has probably done the most joint development. So if you look at Milstar, the Air Force is doing the development of Milstar. If you look at JTIDS, the Joint Tactical Information Distribution System, which became MIDS, which

the Navy did, the Air Force was doing JTIDS. You can look at almost anything with a J. The Air Force is doing JSTARS; that's the Army-Air Force sharing this moving vehicle surveillance. But the Air Force decided, "We're paying for the other services' things. Now we don't want to do that anymore. Why are we using our budget to help everybody? We want to help the Air Force. We're going broke here!" And not an unreasonable position for our Air Force to take. The other guys are not raising their hands volunteering: "I'll tell you what. We'll pick up the cost." In fact, the Army and Navy are big advocates of Milstar today. Why? The way they look at it is that the Air Force is paying and they're using it. Great! Never heard of a better idea! The Air Force is saying, "Let's cancel Milstar." So the whole issue of how joint programs are funded and managed is up in the air because the services are wondering about their own integrity, let alone these joint things.

So the idea comes up, "Well, maybe we ought to have a joint agency, DISA, do these things. After all, they have been providing common-user communications. Maybe they can do common command, control, communications, and intelligence." Immediately, the services go crazy. "What do you mean? Some third party is going to tell me how to manage my force? This is bonkers!" It is bonkers, but that's sort of what's being parleyed around. Then this is exacerbated by the fact that acquisition, after all, is expensive, development is expensive, and why are we doing it three times? Let's have one organization. By the way, what do military guys know about this subject anyway? Maybe it ought to be a civilian organization. Maybe we ought to have a joint civilian organization do all the acquisition for everything. (Well, okay, maybe "everything" is a bit extreme.) C³I is joint by its very nature. Maybe we ought to do that for C³I. All these ideas are worrying around the Washington scene, and they each have their moment in time and get squashed, get up again and get squashed. Defense directors come and go. In fact, Deputy Secretary Atwood, upon leaving, said he thought the most important thing that could be done is to form a joint acquisition agency that does all the acquisition of developments and procurement for the services and stop this service thing.

There is a law that deals with the proficiency of people in the acquisition business that's been passed and Nick Mavroules, formerly a congressman from up here, sponsored it. It was a big thing of saying you have to meet certain skill requirements to head a program, and they were set up in such a way that a

military person would have to make a very early career decision to be in procurement in order to conceivably meet those requirements. When you're a captain or have just been made a major, if you haven't decided to devote yourself to procurement, you're out. You can't meet the requirements any longer in terms of years of training, years of experience to become a program manager, and many people felt that was Mavroules' way of assuring a civilian would always have control. You know, he might deny that, and say he was just trying to get a better military system.

But whatever he was trying to do, the vectors say things like this should be pressing over the next few years. On the one hand, the military does not like spending the money on doing things like this, and on the other hand, they don't like the idea of somebody else doing it for them. And so, when someone doesn't like doing it themselves, and they don't like someone else doing it for them, it's very hard to predict how it will come out. But I believe that C⁴I for the Warrior will have a big impact on how this comes out. That is, if C⁴I for the Warrior is serious, then the idea of an information officer, the idea of commodity products, will force things to have to be more joint.

Oettinger: Can I comment on that? Because "forcing" used like that is a little strong.

Horowitz: Okay, I should say philosophically will force the issue because they'll be unsuccessful if they don't act jointly. They could go ahead and operate unsuccessfully, but I think that . . .

Oettinger: Let me just spell out what this argument is about. The statutes of the United States put on the military services a responsibility for fielding and procuring, et cetera, et cetera. The Secretary of Defense and the Joint Chiefs have a certain amount of authority, but given the support of the Congress for the statutory status quo, the idea of forcing something on somebody who controls the budget is a little bit like the idea of the president of this university making a deal with the business school or the dean of the faculty of arts and sciences do something, because as in the case of the military, the money at Harvard resides with the deans, not with the president. In the military, because the Congress says so in the law, the services own the money. Yes, there are exceptions to that, but I think by and large the Secretary of Defense can exercise a great deal more of persuasion and one thing or another, and ultimately the services have the budget.

One of the reasons why they do, and why I think this is a very difficult problem, is that the arguments cut both ways. I don't want to use up more of your time to go into that, but I call to your attention the reading in Allard,* who examines in detail this theme of why do we need services anyway? Why the hell wouldn't you glom it all together, because it is more efficient in theory? And he, having been an Army guy (he still is in the Army), started off with the notion that, "Yes, together is good." Army folks tend to think that way. The Navy and Air Force tend to be more separatist. And then he convinces himself of the opposite. You can see that in the book — little by little, why there is a justification for the existence of separate services. So you have a situation where, yes, lots of things get done poorly because they're not joint and that's one of the reasons why the Goldwater-Nichols Act of 1986 put a little more teeth into the folks who are responsible for jointness. But the reason why, as Barry stated quite correctly, this is a perennial problem, is that quite aside from the status quo at any moment, there is in the philosophical underpinnings of things again a tension here between what you do well with services, and what you do well with a unified approach. So I just wanted to alert you to delve more deeply into this in the reading as you go along.

McLaughlin: Tony, let me take issue with you for a moment. I think you are replaying your traditional argument, and we can debate whether or not the balance of power is shifting there. I think the services are losing suasion over time for a whole host of social and political reasons, but I think Barry was making a more important point: that changes in the underlying technology influence how this game is played. In the early 1960s I was in the budget office at FAA's research and development organization. The new Kennedy administration had launched an outside review of plans for the future air traffic control system. This outside group, Project Beacon, or the Hough Commission, came back and said, "You are spending half of your R&D budget building an air traffic control computer. Thousands of people out in the commercial world know more about building computers than FAA ever will. FAA should rely on the commercial market for computers." What I hear Dr. Horowitz saying is, "If you go this warrior way, in a world where communications and computers are becoming commodities, there will be heavy budget pressures to do things differ-

*C. Kenneth Allard, *Command, Control, and the Common Defense*. New Haven: Yale University Press, 1990.

ently in terms of procuring some systems." Even if the services don't like it, the market is changing. Look at Iridium, the Motorola satellite system, going out there. Assuming their gallium arsenide chips work, it is another whole new world of communications. The services may want to continue to do it in the traditional way, but the budget cuts won't let them.

Horowitz: Let me just say that my own judgment is that we'll see the JCS take on a more important role, and that they will manage this issue of the service integrity versus things that need to be joint. But I think that in order to aggregate the largest quantities and get the closest approximation to commercial in an area that is essentially commercial in its orientation, but military special in its avocation, they're going to have to do something. So I think there will be a change. I just think it's hard to predict when it will occur. My own judgment is that when the budgets get cut enough to where the services say, "Why am I arguing so hard to hold onto my own C³I development and acquisitions budget, my own organizations?", they'll start to wonder why they're fighting it so hard and maybe start to relent a bit, but with great caution because I think they will be afraid that the technology could end up dictating how they control their forces. They will not want to give that up, ever. I mean nobody would ever want to give that up. I just think that will play itself out in a fairly unpredictable way, but I predict it will end up that they're going to back off the strong position they have.

One of the things that happened two years ago is that they were told they had to give up their business management systems, their information resource management stuff, you know, how they take attendance, how they keep track of their stock, and stuff like that, and have to combine them. And while there's a lot of noise and a lot of aggravation, that's all been agreed to. Many thousands of workers have been transferred to DISA to do that. DISA is unqualified to do it, but . . .

Oettinger: And their orders from Strassmann were lunatic.

Horowitz: Right. They were crazy orders, but nonetheless, unless they take back all those transfers, it's done, and there will be another method of dealing with that subject. Even there, they didn't like the idea. I don't blame them for not liking the idea. You know, you like your own business management things, but they conceded, "Hey look, they really wanted to take away my C³I. I'll let them take

away my business management, but don't you think that you're taking away the C³I," and I think that's an evolution. Five years ago, if someone came in and said, "We're taking away your business management," they would have gotten bazooked. That would have been the end of that subject. So I do think there's been a change in society's outlook on these matters and the military understands it has to concede the point.

McLaughlin: Well, 10 or 11 years ago, each of the services was still trying to build their own desktop PC, their laptop PC, and it was taking years to do. Meanwhile, the market went along and the unique requirements will only specify that, you know, well it had to be hardened for this or that and ruggedized and at the same time, people like Apple would say, "Listen, people drop the boxes in the airport all the time, and we have a strong commercial incentive to ruggedize these things regardless of what the military wants."

Oettinger: Yes, but in fairness, as the underlying sort of network or computers have become commoditized, the software that makes them usable by particular users has become a larger and larger proportion of the cost and has become increasingly particularized. And so again you've got . . .

Horowitz: I disagree. I would say I'm a student of this topic and I'll give you a portrait of it. In the 1960s, computers cost a fortune, and fortunately they couldn't deal with a lot of software. So software costs, but much less than the computers because the computers had no capacity to use a lot of different software. And system engineering cost what it cost; system engineering addresses the integration issues and the combining of hardware and software.

In the 1970s, the computers' capacities went up and their prices started coming down, and they became capable of absorbing lots of software. The cost of software really went up, that's your point, while system engineering stayed the same. In the 1980s, we started to see computers go to zero, and they're really heading toward dead zero. But the emergence of commodity software started. Nobody was developing their own operating systems anymore, hardly anyone would develop a customized database management system anymore, and things like spreadsheets and other support type stuff were coming into general use. And system engineering stayed the same.

I look at the 1990s and I predict that we're going to see commodity software go through the type of

revolution that we saw computer hardware go through, and in the year 2000, a new system will have mostly commodity software, and some particularized software, but much less. We will see software approaching zero and hardware approaching zero, and the only remaining cost being system engineers. And system engineers, I believe, are living a mythical vision that they give such value added that it doesn't matter what they charge, but I believe that that's the next thing to go. It's only a matter of time for either their productivity to go way up, or the market to decide it doesn't need all that innovation, or their wages to be cut, or some combination of all those things, because they're going to be forced on the productivity line. And I think . . .

Student: New vendors will emerge . . .

Horowitz: That's right. There will be a different type of market: for products that are system engineering products, rather than people who provide the service. Now when I talk about the information manager, today the military would say, "Well, I'll hire 100 people who are the equivalent of system managers to do that." In the year 2000, there will be products that do it — you'll just buy it — and then there will be 10 people who might integrate them into a usable thing. I really see that all occurring as a natural pressure of the marketplace and the prices of hardware and software. That's off on a tangent.

Let me make some technology points. I just want to make the point that I think you'll see DISA and the intelligence community press toward taking on more things in an integrated fashion. To the degree that the services and the intelligence community step up voluntarily and demonstrate methods of integrating themselves and show progress in doing that, in milestones, their lives will go a hell of a lot more smoothly than with them each being in their own corner and people observing that it doesn't look terribly integrated and deciding for them that they're integrated by fiat. I really think that if the military and the intelligence agencies are smart, that's what they'll do; they'll self-integrate and create some consortia that are viable consortia. I don't know what the likelihood of that occurrence is. I am personally trying to inspire some of that. MITRE has created an intelligence integration panel out of high-level people in the intelligence community. We are bringing to them, on a regular basis, all areas that we think are or could be interoperable that are not, or all developments that are going on concurrently that we know of that could be combined. That's the first time such a panel has ever existed

and hopefully, that will be a consortium voluntarily conceived. There is no such thing in the C³I world.

Student: My impression was that the military has been moving in that direction. What the main intelligence nodes have become — JICPAC (Joint Intelligence Center, Pacific Command) and JICLANT (Joint Intelligence Center, Atlantic Command) and all — is that an attempt at coordination as opposed to true integration?

Horowitz: I think that that has gone on at the exploitation side, not at the supply side. If you go to a JIC, a joint intelligence center, you'll find N receiving terminals to get all the different suppliers' data, and one could ask a simple question: "Why isn't there one receiving terminal? Two at the most?", but there isn't. The JICs have integrated the sharing of power, buildings, and people — important things to share. They have yet to say, "Why are there N computers doing exploitation, rather than one?" Well, one of the main reasons is that they own all the software and it would cost a fortune to redo it all. So you've got a big problem of legacy software. But nonetheless, the integration has been more people, buildings, power, and . . .

Student: Do you think there are relevant issues of the redundancy and diversification as far as security goes? Or is that not really a security issue, but it's these other things you're talking about, like protecting turf?

Horowitz: I don't know. It's complicated. Everything is complicated.

Oettinger: But again, it's a tension, isn't it? I mean you have had buildings for decades, where two different, similar looking operations are side-by-side and they're walled off resolutely because somebody has made a judgment that unless they are similar actors and have the same power, et cetera, et cetera, he'd rather not have them talk to one another. And, you know, that doesn't go away. MacArthur's cutting himself off from the commander in chief by pretending his teletype wasn't working remains an option. So all these things do is shift. I don't disagree with what Barry has said. I think that the presumptions are shifting toward more commodity-like things at various levels, but that doesn't mean that the countervailing forces are dead.

Horowitz: That's true.

McLaughlin: But I also say that going back 10 or 12 years ago, if you walked onto the trading floor of

any financial institution, you had this proliferation of terminals — Dun & Bradstreet or Standard & Poor Blue Line, LEXIS or NEXIS, all had a dedicated terminal that came with their information system. Now, you walk in and they're all the same, running on some workstation. However, that's happened for a whole bunch of reasons, but people were tracing the same kind of . . .

Oettinger: Evolution, sure.

Horowitz: I'm going to make some technology observations. These are free ideas that are probably worth what they're priced.

I talked about commodity hardware for communications earlier, with military protection. Is that possible at a commodity price? That's a question. I don't know if you're familiar with the subject of what people call flexible manufacturing, but the basic concept of flexible manufacturing is you can go to a factory that makes electronics, and robots and computers do most of the work. These robots have profiles; that is, they can put N different parts on a board as long as the board is of dimensions X to Y — no bigger than X, no smaller than Y — and the accuracy of the placement doesn't have to be greater than Z. The selection of parts could be anywhere from the size of the rack of parts it reaches for, no bigger than nine inches wide, and the smallest part can be no smaller than this and no bigger than its profile, and it can put them in a case that has no more than N slots and no fewer than Y slots. Any company today that's viably making commodity products is building a plant like that. Interestingly, the design of a robotic plant takes system engineers and system engineers cost a lot of money — a lot more than robots and a lot more than the workers who check the plant.

In fact, I visited Motorola's cellular phone plant in Plantation, Florida, and the annual cost of the hardware in the plant that makes the robots and computers is about \$3 to \$4 million. The annual wages of the entire work force that works in the plant is about \$1.5 million. So my estimate is that it's \$4.5 million a year for that whole factory that puts out 500,000 widgets a year. That's \$9 a widget plus parts. But the system engineers, the ones who continue to redefine the accuracy of the parts, and how many different kinds, cost \$6 million a year. But what they've done is they now make something like 23 different products, in any order, in any volume, at the same price, except for parts, on that line. So all they have to do is push the right button. The robot doesn't care if it's three of those and two

of these and nine of these. It just does whatever it is they tell it to do within the profile. So the key job now at Motorola is to figure out what flexibility they need in the plant that will give them the ability to produce the products they have to produce, and the future ones they want to produce in the same plant, and aggregate as many plants as possible down to one to share those system engineering costs, which are big, bigger than the plant. And that's the definition of flexible manufacturing.

Well, I raise the problem the other way. Is it possible that, if we understood the profiles of these plants, the military could design its systems to do the best military job it could imagine within the profiles of flexible manufacturing? And then, is it conceivable that you can get one of these plants to decide to want to use itself to help the military? Now I went to Motorola and they said, "Forget it! We're too busy making money. We don't want to screw around with Uncle Sam. The DOD, they're crazier than the rest of the government, they do the ridiculous. It's the last thing I'd do here to make money."

Okay, maybe it would be hard to get a commercial company to do that, but it might not be hard to replicate a commercial factory and to make your own flexible plant. So, one of the things MITRE is looking at* is what is the state of flexible manufacturing in the United States? What will its state be in the next few years? And what range of military capabilities can reasonably be expected to fit the profiles of these plants? A Milstar terminal? Forget it! It's too complicated. Scope Shield is a walkie-talkie. There's no doubt in my mind that that could have been done in a flexible manufacturing plant. The government is paying I think something like \$9,000 or \$10,000 for a walkie-talkie that's military-unique. They probably could have gotten one of those for about \$600, if they designed it to fit an existing factory rather than write its requirements in the abstract, and then paid whatever it cost to get them custom-manufactured.

So, we're going to look at that and see where that takes us. I believe that's one outlet for dealing with getting commodities with special military capabilities. The answer to that might be, "Sorry," and MITRE engineers always think the answer will be "Sorry." So they predict that it's likely not to pan out. If it doesn't, then it means warriors will not

*Dr. Horowitz's ideas on this subject are developed further in: Horowitz, Barry M., *Strategic Buying for the Future: Opportunities for Innovation in Government Electronics System Acquisition*, Washington, D.C.: Libey Publishing, 1993.

have effective information, or they will not be warriors who have information. And it will be like the GPS situation. Or, hopefully, it might go the other way. We'll find some opportunity there and see if a new style can be developed.

We have two major problems in software. C³ is dominated by a lot of software, unfortunately, and the two problems are (1) that software changes all the time and (2) we don't design systems so that they have a low cost in change. In fact, the way the military buys systems is they specify requirements, and then they test the system to prove it meets the requirements, and then they buy it. It's bought. They have a contract to do these things — test it and buy it, and whether the design is a good design or a bad design is an ethereal question. In fact, we don't know what a good design means or a bad design means. We just say, "Did it meet the requirements — yes or no?" If it does, buy it; if it doesn't, throw it out. And yet, the design is what dictates the cost of owning it for the rest of your life. If it's a crummy design, it's a disaster to change. If it's a well-organized design, it's hopefully not a disaster to change.

So we are starting to ask the question of how you design systems so that, in fact, the system is constructed in a way that permits the design to be better understood and changed over the system's life. How do you preserve the features of the design by order of the management and technical procedures for assuring good design is maintained? How do you know you have a good design anyhow? How do you evaluate one? The government, if it's going to buy design, is going to have a test to say it's a good design or a bad design. The government does not do anything abstractly. It's either in the contract or you don't get it. So how do you contract for a good design without telling someone what the design is? The government should not do that. So MITRE has developed a whole bunch of ideas in this regard here. We have four or five real projects that are actually using some of these ideas and I'm hoping that out of this emerges a new style of buying software that recognizes that two-thirds of the cost of software occurs after the initial delivery. But, of that, some of it's just debugging old things and stuff like that, but a good half of the cost is changing it, and now you're poor. You have no money, but you've got to change.

What do you do about all that software? It's very hard. I consider this the sucker sale of the 1990s — someone coming in and saying they have an answer for you on that problem and you're so desirous of

answering that, that you'll pay him because your choices are very onerous throughout the system — either we redo it or stop using it. If the answer would find the one magical part you could fix and then everything is good, that's a well-designed piece of software. You don't ever want to throw that out. You've got a really good piece of software. So the usual thing is either you've got to throw it out or live with it, and those are both really very bad choices.

Nonetheless, one of the things we are looking at is a whole bunch of software tools that are emerging in the marketplace for understanding what is inherent in the existing software package as it is designed. What are the linkages, what are the flows, what are the technical characteristics? That would at least enable someone who wants to make a change to understand what the package he has does, and supplant documentation, which doesn't help someone to do that. Or, I shouldn't say that. Studies show that 80 percent of the software maintainer's time is spent trying to understand what he's trying to change; not what the change is, but how do you change it. If you could get at that, you might at least get some benefit for productivity. I do not hold out a giant hope there, but I consider this a big problem. Software has a special onerous characteristic in that if one soldier exists who needs that package, you've got to pay to maintain the entire software package. Whereas, if you get down to one soldier, he'll only need one piece of hardware. So hardware goes down somewhat linearly in its ownership costs as this force structure goes down, whereas software does not.

One last comment on technology concerns the turnover rate of electronics in everybody's life. We've all learned you don't repair old stuff. Is there anyone here who has a TV from the 1960s that still gets repaired? Call me up if anyone does that. Or a transistor radio that still gets repaired? Why would you do that? Well, it's stupid to do. In fact, you wouldn't have anyplace to go to if you wanted to. Well, the military still does that, and they do have a place to go — a self-funded place that repairs very old stuff. That's got to go. There's got to be a whole new method of turning over electronics at a rate consistent with the technology rate, which is five to eight years.

Student: But it's not as simple as that. In systems that are so complicated, so integrated — and it takes years and years to integrate all these systems you're getting — you can't just say, "That radio's broken;

don't take it and isolate the broken dial or resistor and replace it, just buy a new radio." It just isn't that simple.

Horowitz: Right. I agree. It's a very complicated thing. So I personally look at this subject and some of the things I recommend are as follows: (1) You don't have to buy the same radio. You could go to engineers and say, "Look, I've got a radio. I hate it. Here's the original spec. Here are the tests we ran. Give me your closest replication to it, that's a commercially relevant thing. Tell me what it costs!"

Student: Tell me what it costs to train my 4,000 or 8,000 people to fix it.

Horowitz: No, I'll tell you what. Let's do what we did on the cellular phone system that the Army bought. I'll give the designer/developer a 15-year life cycle contract at a fixed price to sustain the contract. The contractor pays all the costs of retraining and maintaining because new electronics hardly need maintenance. How many times have you had your radio fixed at home? Yes, these are more complicated radios, I'll grant that, but the reliability of solid-state equipment has gone up something like 11 orders of magnitude in 20 years, not because of design, but because of the inherent reliability of the components.

Student: I just think it's much more difficult for the military to adapt and to keep up with that high turnover rate than it is for private companies.

Horowitz: I grant that, but it's also very expensive not to. So the real question has got to be, "If I can't afford not to, what do I do?" Because they claim that they cannot afford to keep what they own. Now I've gone to the high levels of the Defense Department (I don't want to throw names out), and said, "Gee, you're buying something new . . . and you're shrinking. Do you know what everything you own is worth? What is the depreciation rate? Or, you just bought something new and added it to your inventory. Are you taking anything out of your inventory that's depreciating at a comparable rate as the new things you're putting in, so at least the capital structure is staying constant? Or maybe it's going down at the rate that the force structure is going down?" Well, whoever manages a company where you keep on putting things in the company and you don't know their value, you don't know the rate at which it depreciates, the cost to keep its value, the things you're adding, and the company's going down in size and you keep on adding into the bin

and have no records to tell you anything about it? There's absolutely nothing! So, my feeling is the first thing they should say to themselves is, "Okay, you know, businesses in America are forced to have a depreciation schedule for tax reasons. You've got to show what your company is currently valued at, which means you've got to say, 'Well, if things are worth X today' . . ." You have to do that by law. The government does not do that. As a result, the government doesn't know what it's worth, doesn't know what it costs to keep its worth, and doesn't know what it's adding to the cost to keep its worth, by virtue of the new things it does. And any business that's reducing in size has to reduce its infrastructure accordingly.

Student: I agree that money is a factor, but it's not the only bottom line. See, I don't look in terms of money every time I say, "Gee, we can combine A and B and make C. C will do the job of A and B and cost a lot less money." Now I'm the end user out there in the field, as are the soldier and the sailor on the ship, and I don't care if it costs less. What I care about is the quality of information, the quality of intelligence, and that's my bottom line.

Horowitz: I understand that. Then let me say something. I believe this is the fundamental point: that the military's orientation is requirements first and cost second. The rest of the world, almost without exception, deals with cost and requirements concurrently.

Oettinger: Barry, before you blow their minds, let me just make this point. I completely agree with what Barry said, but let me take the sting out of it in one way. I think what he said is true of all professions. I mean, think about it. In medical care, we have the same argument by the medical care providers as well as the medical care users: "We don't care about the costs." "I'm ill; I want the best service." "I am dedicated to saving lives; I want the best technology," et cetera, et cetera. You heard the President last night. We're going broke on health care. It's the same thing with universities. Look at our productivity. I like to teach small seminars because it's very effective and so on. We are under enormous pressures to knock this kind of stuff off because, "What the hell do you mean, it's more effective? Who knows, you could be replaced by a robot and a videotape and these students sitting out there would probably be better off and we could make it bigger and cheaper." I can make it a very impassioned, professional argument. All professions, all activities

in a period of declining wealth are under great pressure to readjust those priorities.

Student: But just as you implied, I don't understand his concept and I don't understand your concept. I can say that you don't understand mine, and you don't understand where I'm coming from.

Horowitz: No, no, I do.

Student: Let me illustrate, which is why I think cost doesn't have any impact on the requirement. Fifteen years ago, the design concept for the SINCGARS (Single-Channel Ground and Air Radio System) handset was a piece of equipment that was going to cost \$17. That's what people were proposing. If something was wrong with the receiver on the ground or someone stomped it so it couldn't be reused, or whatever, you issued another one, or picked up another. You carried three, like emergency radios. Now, the procurement response was a 10-foot specification, 85 percent of which had to do with maintaining and repairing those at Army radio depots. And the vendor said, "Forget about the depot. Just throw the damn things away!" As a user, do you care about the institutional requirement? Wouldn't you rather have the best, the most modern radio, and if it didn't work, throw it away and pick up a new one? Now the people who ran the radio repair depots had a very huge vested interest in having a handset that required repairs. And that's why 85 percent of the specs had to do with that, as opposed to your requirements as a user in the field.

Horowitz: Let me just take this a little bit further. You say you're in the Navy and been on ships? Is that a ship with a DSCS (Defense Satellite Communication System) terminal on it?

Student: No.

Horowitz: That's an SHF satellite. They have cryogenic coolers, because they have to have very low-noise receivers, and therefore, . . .

Student: What are cryogenic coolers?

Horowitz: It's a refrigerator, and this is because they're not solid-state receivers. They're tubes and they get hot and they require cooling; otherwise the noise level goes up and the signal's integrity is inadequate for the design of the system. So the Navy is buying cryogenic coolers and there's nobody, I mean nobody, that sells them, because there's no market. You have your own market. You're buying tubes for which there's no market. You're paying for all that in order to have that DSCS terminal.

Analyses have been done that say you could buy a solid-state terminal that's just as good, the same performance, just do it again with modern technology and throw it out. There's a front-end cost that pays itself off in two-and-a-half years. The Navy says no, no, no! Why? Because they don't want to put up the front-end money. They just throw it in the closet, because the back end never happens in their world. I think that's what really has to change.

So I don't say that we ought to lessen capability to spite ourselves and all that. I'd say, if we have to lessen capability, we have to. But I think there's a lot to be made in terms of improving capability by recognizing the back end is going to happen. In fact, I've gone around telling commanders that, "Hey, look, you're the richest you're going to be, right now, for a long time. You're rich. You feel poor because you're worse off than you were years ago, but you're going to be worse. You're rich! If you can't afford to make an investment now that lowers your cost a few years from now, you're going to feel even poorer." And that's what's happening.

My feeling is that we've got to get a program to do that, but the new management in Defense feel they're going to force you to all commercial stuff. I don't feel that's the right answer. I feel it has a part in the answer, but that's not the right answer. But, their feeling is the way you really get this down to zero is you go to all commercial stuff, and they're going to push it to the wall on that topic. And when they're told, "Oh, no, military stuff needs to be militarized," they're going to say, "I don't understand. We've got computers in the engine of a car. What's not rugged about that?" There are legitimate questions that are going to be raised and that people are going to push to the wall on that topic.

I don't think that's really the right answer in the entirety, but I think the change is that cost and need have to be dealt with concurrently. They can't be dealt with sequentially. The current requirements process deals with them sequentially. The user first simply specifies needs, and then the product divisions say what it costs, and the product divisions are terribly prone to being supportive of what the user needs for the price that they think is available. Then the product development stretches out, delaying the recognition that you can't get what you thought you'd get for as long as it can, so that the sum costs are tragic. That's my model of the current system and it goes up the chain. That is, OSD does not like telling Congress it's got problems in its programs. It delays telling it, so that some costs get greater. The services don't like telling the Secretary of Defense

because they don't want him to tear up the program. The product divisions don't like telling the service chiefs. The SPO (system program office) chiefs don't like telling the commander, and the contractors don't like telling the SPO chiefs. You've got a string, 10 long, of people who are delaying revealing that they can't do what they were asked to do, which they knew the first day, but are revealing it now that it's 100 percent certain and maximizing some costs. That's an unacceptable system.

Instead, the system, in my opinion, has to be one that says we can only afford what we can afford. This is what we think we can afford. Our activities are going to continue to ask the question, "Is that what we can afford still?" Or, change it, and we're not ashamed to change it. And you don't fire anyone for changing it. But we emphasize let's get what we can afford. That's not the kind of system we have. And I think the support part of that is a big part of the problem.

Oettinger: I think you just heard a prediction, which I think is an accurate one. But having come from a riches of meeting needs without regard to cost, I heard Horowitz say that we're going to go to cost without regard to need and it will take a while before it bounces back the other way because the kind of rationality that he's implied by way of a cost-related specification of needs and so on, is at the moment fairly unlikely. I don't want to be cynical about it.

Horowitz: It's more than fairly unlikely and I would be shocked if it occurred, in fact. But if we take the case of integrating business management systems, people said that we will save \$13 billion by integrating management systems. That's \$13 billion out of the budget — no investment! Someone gave a speech, \$13 billion will be saved — great!

Oettinger: Yes, by the way, if you want to know how that's been done, read the books by Paul Strassmann,* which sort of lay out the theory of how this is done.

Student: Who was that?

Horowitz: He was an executive in the Defense Department, previously from Xerox.

Oettinger: Paul Strassmann — there are several books. You'll find his name and books in the reading list. He worked for Duane Andrews in C³ in the OSD.

Horowitz: He's a bright man and he had some good ideas, but he didn't have any feeling of how to manage those into being.

Oettinger: There's a good term paper there that could be written there on an electro-political failure.

McLaughlin: You're also illustrating, though, references from a number of speakers a number of years back. They talked about some basic rules for how Congress reacts to these things; that is, if two services are funding something, neither shall get the money. The sure way to eliminate your funds in Congress is to make sure both of you have any budget. I think this illustration of taking of \$13 billion because somebody says they can do it without anyone providing any investments is in keeping with good Washington tradition.

Horowitz: So I think we're going to stagger a bit over the next few years, going from requirements first and cost second to cost first and requirements second, but I think the real thing is to do them concurrently, which really means having the requirements process include in it people who understand costs, and do those at the same time, with the same group, with equal importance. That is, the general can't say to the guy who knows about cost, "You don't matter." Similarly, the guy who knows about cost can't tell the general he doesn't matter. They both matter and how those meld, I don't know. There have been some proposals to make the requirements process a shared one between the JCS and the Undersecretary of Defense for Acquisition. That's one way to deal with that subject. I don't know if that will be a good way to deal with it, but that's the first discussion in which anyone's ever even brought up that it can't be done anymore just by military people. They don't deal with costs. So I think there will be some changes. I don't know what they will be, but there will be some changes.

Oettinger: Let me, if I may, just comment on this in the light of some other concerns of the course. First of all, I want to thank you, Barry, for an absolutely fantastic talk. If I had tried to dream it up, I couldn't have ginned up a better first discussion, because I think you've taken us through the whole gamut from the technical to the political and put it in context of the course. We haven't gone over each of the questions that Dr. Horowitz opened up. There's

*Paul A. Strassmann, *Information Payoff: The Transformation of Work in the Electronic Age*. New York: The Free Press, 1985.

Paul A. Strassmann, *The Business Value of Computers*. New Canaan, CT: Information Economics Press, 1990.

just volumes. But he sketched it, as I hoped he would, from being an observer, you know, somewhat outside and somewhat above of the whole panorama that involves . . . and he's a lot closer to it on a day-to-day basis than I am, sitting in the university. So you've gotten a very good picture of how the various pieces fit together . . . not the ultimate resolution, but it's a wonderful introduction to the course.

The last couple of comments I want to make, about this procurement where the money for doing what you're doing now disappears before the replacement occurs, go to the heart of something a number of you have taken me to task on in your critiques of the reading for last week, namely, my little acerbic attack about seeking perfection. Well, you ought to seek perfection because if you don't seek perfection, you're just looking for a margin and you may be blindsided, et cetera, et cetera. Yes, there was a little bit of straw man, and I admitted it to one of you in my critique that I'd set up something of a straw man using the Defense Science Board as a whipping boy, but the real situation is one where the scale of errors is the kind of thing that Dr. Horowitz has illustrated. That scale of error, thank goodness, is not limited to the U.S. alone, and it does not take a tremendous amount of deep and careful intelligence to know that Bosnia is not likely to be a serious military enemy when they are self-destructing to a degree that makes peccadillos like \$12 million taken away before you got a substitute look like nothing. So what one can afford in that kind of situation, and just getting better at something like that, means that raising the margins may be good enough; you don't have to be perfect. You just have to get better on some of the most egregious things and then, yes, another margin, yes, graded, but the notion that one should set oneself up as a goal of perfection when there are so many egregious errors that need to be righted and are in our power to remedy is a good one. You don't need deep intelligence about the enemy to straighten out your own internal workings, and since you know that the other guy, your competitor in the marketplace, is likely to be as screwed up as you are, then dealing with your own errors . . . I don't think you uttered the word "threat" once during the whole session. I mean, it's the old Pogoism, "we have met the enemy and he is

us," which I think was the theme, and certainly not in malice. By doing our own thing better, we've gotten a lot of margin to cover and there's no intelligence about the threat required. I don't want to saddle you with those remarks, but I appreciate your setting it up for them. But you're our guest, so any closing words?

Horowitz: No, nothing more. I'd say that probably the one thing is I really have a very positive outlook, so I believe that in the end the military will figure out how to make the most of what is left to them. Of the two things that I think that the military is best at, the best is their very high regard for their work force. I think it's higher than most companies have, and that's an important attribute when all the conditions are changing. They really care about their workers. The military gets very high marks in that. Second, they're very idealistic. Idealistic people sometimes make a lot of mistakes, but also the times have changed, and they'll be driven by honest, idealistic objectives, and I think I am, in that sense, going to be able to make a lot of changes. I really don't buy a lot of the commentary about being stuck in the mud. I think they're very idealistic. They have this tension between their own service and the joint service, but even that is idealistic rather than negative.

Oettinger: I can't resist piggybacking on that because it couldn't be a better introduction — at the risk of biasing your critiques — to FMFM1, the Marine Corps doctrine manual. One of the reasons why I'm asking you to read it for next time is that it is by far the best manual for *adaptability* that I've seen anywhere in the literature. There is nothing that the Harvard Business School or Stanford Business School or all the business schools combined have put out that, in my mind, is as good a manual for how to adapt to a changing world as is the Marine Corps manual that General Gray's people put out. So, yes, I very much agree with Dr. Horowitz. And, so saying, let me thank him for a wonderful session.

McLaughlin: Barry, you don't get away without our traditional token of appreciation.

Horowitz: A tie!

Oettinger: A Kennedy School tie. Enjoy!



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ISBN-1-879716-12-7