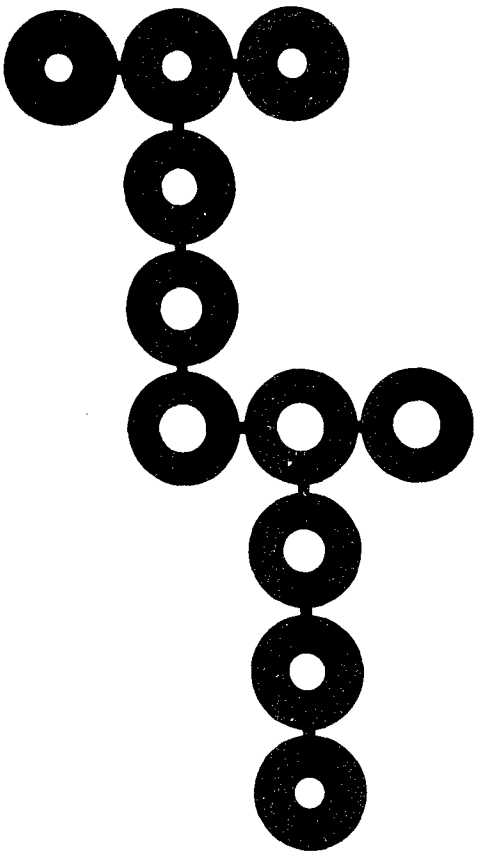

TECHNOLOGY TRANSFER: A THINK TANK APPROACH TO MANAGING INNOVATION IN THE PUBLIC SECTOR

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INTRODUCTION
J. W. Creighton

During 1983, I was privileged to work with the USDA Forest Service on a project to enhance the utilization of research results and new technologies through improved effectiveness of their technology transfer efforts. I was doubly fortunate in that their objectives were nearly parallel to those of my Navy research sponsors. The objectives of the two organizations dovetailed nicely.

The Forest Service mission statement for the project was quite general, affording me freedom to direct effort toward goals I considered to have high potential. I interpreted the openness of the mission to mean that part of my task was to determine if some of the results of ongoing technology transfer research sponsored by the Navy Material Command and the Naval Facilities Engineering Command might be useful to the Forest Service. My participation in this research was not the only factor contributing to the credibility of my assignment. Among my credits are a bachelor of science degree in forestry, extensive experience in wood-using industry, and prior work with the Forest Service on technology transfer projects.

My immediate objectives were as follows:

- To make a general evaluation of Forest Service technology transfer effectiveness as compared to that of other public sector organizations;
- To identify factors which might enhance the speed and effectiveness of technological information transfer into and within the Forest Service;
- To suggest organizational incentives for the movement of appropriate technologies;
- To improve technological transfer between the Forest Service, other public sector organizations, and the private sector, and to search for successes from other organizations which might apply;
- Last, and perhaps most important, to determine how technology transfer efforts can assist the Forest Service toward becoming a lead agency in this endeavor.

A Forest Service committee was established to provide counsel, consisting of Dick Schafer (Chairman), Paul Johnson, Phillip Haug, George Moeller, with Hal Marx serving as the liaison agent. I was also fortunate to receive guidance and support from John Vance, Director of the Forest Service Area Planning and Development Staff; Martin Pearl, Naval Material Command; Milon Essoglou, Naval Facilities Engineering

Command; Jim Jolly, California State University, Sacramento; Jack Kolb, Army Material Command; and Steve Laner, Pacific Southwest Experiment Station. Dr. Timothy O'Keefe, representing California Polytechnic University, took care of symposium arrangements.

I began by interviewing Forest Service personnel in positions ranging from Regional Forester to ranger district laborers. There were also discussions with individuals from experiment stations with state and local forestry employees, and with people in industry. Topically parallel interviews were conducted with Naval Civil Engineering officers and civilians.

During the interview period, I also conducted a survey among Naval Facilities Engineering Command employees to evaluate the degree of impediment or facilitation to the transfer of technology imposed by Naval procedural requirements and directives. Topics discussed with the Naval personnel were also raised with Forest Service people and vice versa. It was extremely interesting that for every point, negative or positive, made by a Forest Service employee, a similar one surfaced from a Navy officer or civilian. I therefore came to the conclusion that the issues and concerns experienced in the course of the interviews were typical for public sector organizations.

As a result, I experienced a change of thought on project objectives. Although I had no feeling of secure knowledge, I felt that I had come to understand the reasons for the Forest Service's ways of doing things. In spite of a few obvious shortcomings, the Forest Service appeared to me as at least equal, if not superior, to any other federal organization with which I was familiar in its efforts to enhance the utilization of appropriate technologies.

I was greatly impressed by the dedication of the people interviewed, the pride in their work, their desire to do well, and the belief that they were giving their best. High levels of competence literally oozed from these people, generating confidence that if requested and rewarded, technological innovations would be readily adopted and implemented. Professional competency extends beyond the doing of tasks to the understanding of action consequences and the nature of reward. When, time and again, the opinion is voiced that career progress can end with a single mistake, a long finger points toward the need for attention to managing change and managing innovative people.

My thought evolution was supported in a meeting with my advisory committee, when it was decided that the project should culminate in a symposium with mid-to-upper level managers to treat the subjects which had surfaced from the interviews as those being most likely to provide benefit to the Forest Service organization. It was further decided that the symposium should concentrate on the emergence of technology and its transition into use, rather than on specific channels which a variety of technologies had taken. Further, because of the diversity of individuals, technologies, personnel, and regions, it was determined that the symposium should attempt to provide managers

within the Forest Service with food for thought on the management of innovation rather than how-to prescriptions.

The list of agenda items generated by the interviews included the following:

- Provide a better understanding of response and non-response to reward systems;
- Treat the subject of response to change, recognizing that while people respond to change, systems tend not to, and may actually act as barriers;
- Illustrate how flat organizations tend to produce more innovations than those with multiple responsibility tiers;
- Illustrate the delicacy of risk-reward interactions;
- Provide explanation for the premise that opportunity generates innovation, and respond to the question of how value is generated and how it is recognized;
- Relate the concept: "each day is a small dose of the future, yet the acts of the day are judged by standards of the past" to the managerial acts and policies of each of us and our organizations;
- Illustrate how observance of the concept "people in an organization, their work-related goals, and their qualities become what you reward them for being" can encourage innovation;
- Relate Forest Service objectives and responsibilities to the needs of Forest Service customers. Like it or not, those you service determine your future;
- Affirm the proposition that within an effective organization, goals are pervasive and congruous, and that rewards which foster technological change tend to be those which have benefits for an entire organization;
- Provide a deeper and more widespread understanding of the many obstacles confronting an emerging technology.

All of the above subject areas received some treatment in the talks by the speakers in the symposium, although they were not specifically identified. No speaker addressed only one area, and many addressed most of the topics, explicitly or implicitly.

The keynote address, entitled "Managing for Change," was delivered by Dr. P. A. Phelps, currently Vice-President for Research of Bechtel National, Inc. Dr. Phelps is a retired Navy captain with a long record of

successful innovation during his Navy career. At the time he retired from the Navy in 1974, he was Deputy Commander for Research and Facilities Acquisition for the Naval Facilities Engineering Command, Washington, D.C. It was under his direction and that of Milon Essoglou that much of my technology transfer work was conducted. Dr. Phelps is well known in the Navy and the Bechtel Corporation for his skill in managing innovative people and managing for change.

Managers are not expected to predict the future but are expected to be able to respond effectively when tomorrows become todays. While they tend to thrive in a world of uncertainty, effective managers do not like to be caught by surprise. They constantly strive for insight to avoid surprise.

Two of the Navy and three of the Forest Service interviewees expressed the opinion that the only economist who could make an accurate prediction of future events was Murphy of the famous law. Ross Whaley, whose topic was "Focus on the Future," is well known as a Forest Economist. A review of some of his work causes me to believe that he is not a provider of economics bait for Murphy. His unusual insight and understanding of demographics, culture, and the nature of man open the door to the application of the principles of economics to the more effective management of resources.

Dr. Whaley was, until recently, Director of Economics Research, Forest Service, Washington, D.C., and is now President of the College of Environmental Science and Forestry, State College of New York, Syracuse.

Retired Navy captain Richard Fay, who comes from a mixed educational background of engineering and management, spoke on "Managing More With Less." Dick Fay is famous in Navy circles for his ability to manage major Naval systems acquisition contracts without exceeding budget, for his efficient management of Navy shipyards, and for generating managerial environments which cause people to reach the goals of the organization. Since retiring from the Navy, he has been Executive Vice-President, Scientific Management Associates, Landover, Maryland, specializing in marine system design and project support.

Dick Fay's record of community support and participation in community activities are evidence of his ability to interact with people at all levels of society. His counsel is widely sought, for he is a master in the art of taking advantage of opportunity and transfer of technology.

A common feeling among those interviewed was that they were always expected to do more in spite of being provided with decreased resources. Dick Fay was asked to share some of his thoughts on this subject with us.

There are many definitions of technology transfer, some specific, some quite general. A common definition implies the new use of a technology or information, or the use by a new group or individual. Utilization seems to be

the key to technology transfer definitions. For this reason, many do not consider education to be part of the field of technology transfer. If we consider factors essential to the transfer of technology to include willingness to perform, capability to perform or to transmit knowledge, and the credibility of interacting with people, the contributions of education must be considered. We depend upon our universities to prepare people to perform needed services and to enhance the level of capability of already-competent people through advanced knowledge of fundamentals and understanding of applicability.

Art Wilcox is an example of university professors who can balance the theoretical and the practical by effective application. Dr. Wilcox has been a Metropolitan Park Director, for 32 years the Department Head for Park and Recreation Administration at Michigan State University, then at Colorado State University. He has combined classroom teaching and university-based research with extensive consulting and continuing education activity. Because of his past successes in Park and Recreation consulting, and his ability to apply the things he teaches, he was asked to address the symposium audience on "Potential Contributions of Education to Technology Transfer."

The advisory committee did not wish to fill the symposium with examples of emerging technologies. On the other hand, the subject of emergence pitfalls was considered to be of prime importance. Of great interest, not only to foresters but to people from all fields, is the subject of genetic engineering. Dr. Stanley S. Krugman is neither a geneticist nor an engineer by education, but he does have extensive experience in working with biological scientists. Currently Director of Timber Management Research, U.S. Forest Service, Washington, D.C., he carries the responsibility for research in genetic engineering in the field of biotechnology within the Forest Service, and was thus eminently qualified to speak on "Emerging Innovations: Considerations For Implementation."

It is commonly believed that the management of technology emergence differs greatly between the public and private sectors. While there may be differences, the committee felt that there might be much to learn regarding principles of transfer from the private sector. The Hewlett Packard Corporation is a prime industrial example of effective technology management. We were therefore fortunate to have Bob Frankenberg, the General Manager of Hewlett Packard's Computer Systems Division, Roseville Operations, with us to discuss Hewlett Packard policies and techniques under the title, "Matching Technology to Customer Needs."

Bob Frankenberg is responsible for the low cost and mid-range of the HP-3000, Hewlett Packard's commercial computer system. In his 17 years in the computer business, he has developed over 25 commercially successful computer systems. Most of his background is in product research and development, but he also has experience in product market-

ing, computer manufacturing, and radar and computer systems field services. In addition to his work at Hewlett Packard, he has extensive consulting experience and has published widely on computer technology and management topics.

A viewpoint often expressed by people in government is that managerial policies and techniques which work for the management of technology in industry will not work in the public sector. Comparison between successes adduced by Bob Frankenburg and those described by Milon Essoglou in his address on "Technology Transfer for Enhanced RDT&E Effectiveness" reveal a great deal in common.

As a former Naval officer and civil engineer, Milon was in charge of construction on various projects, but has held his present position as Director of Research for the Naval Facilities Engineering Command, Washington, D.C., for many years. His enduring interest in and involvement with managing the transition of research results into use dates back more than twenty years.

Milon is a strong believer that even in government, the research organization must be responsive to the needs of the working engineer. When he began his work on transferring the results of research into use, he encountered an organization which neither asked for, nor expected, applicable technological advice from the Navy Civil Engineering Laboratory. Field engineers hardly considered the laboratory as a useful and dependable source of technology.

Since that time, there has been a great change in the civil engineer environment. Approximately 60% of civil engineering officers currently report that they have requested information from the laboratory and have used it. At the laboratory itself, there has been an ever-increasing sense of responsibility to provide technical assistance to the field engineer–the customer.

MANAGEMENT FOR CHANGE

P. A. Phelps

I was delighted when Wally invited me to meet with you, and I would like to express, from the beginning, my deep pleasure in being able to join you. I have found that some of the more interesting stimuli and thoughts that have come to me have come from talking to people totally out of my field. At first I was going to question Wally about why in the name of heaven people in the forest business would have any interest in hearing anything from someone with my background. After giving it a little thought, however, I was able to rationalize that if I can learn something from Forest Service people, maybe the converse is also true. Moreover, I get a bit jaded with the same daily office routine in San Francisco.

Orginally, Wally invited me to talk to you about the management of creative people. A good subject, because I like to manage people and believe that all people are creative to one degree or another. Although I've given this talk for Wally before, I was all prepared to update and redo my talk on management of creative people. However, when the advance program reached me, I learned that I was scheduled to talk about "Management for Change." I stopped my word processor, stopped my thinking process, and contemplated shifting gears to talk about a different topic. In fact, my confusion about the topic made me concerned that my memory was going, so I decided to talk to a psychiatrist friend about it. The psychiatrist friend said he didn't really think my problem was serious. To set my mind at ease, he told me about a patient he had seen earlier in the day, and who he thought did have a problem worthy of his attention. The patient, a woman, had come to see him because her husband thought he was a chicken and was roosting all about the house. He made nests, cackled a lot, and really was comporting himself in a way that caused her a lot of concern. My psychiatrist friend asked her how long this had been going on, and she said about two years. "Why didn't you come to see me sooner?" he asked her.

"Well, it was so nice having a fresh supply of eggs all the time."

I also want to mention that it was sort of fun to talk to a couple of fellows outside tonight who hail from the south. I mentioned that for some reason the Army seems to produce almost all of its officers from the Deep South. Perhaps, I suggested, they join the Army to escape from Alabama and Texas and other such places. Also, I observe them to be full of Aggie and Tulane stories. One such story I remember about Tulane is about the fellow who hurried into a store during one of the football games. He rushed up to the counter and asked for two orders of that famous southern barbecue, a large order of cole slaw, and three cokes. The man behind the counter said, "You must be from Tulane, young man."

"That's right, and just how did you know?"

To which the man behind the counter replied, "Because this is a hardware store, son."

The use of stories in management of people is to loosen us up a little bit and make us a bit more manageable. I used to teach Midshipmen at one time, and loosening them up often posed quite a problem. There was another professor teaching physics with me who had a system, so to speak. "You know," he said to me, "people's minds are pretty well set, and need to be prepared in order to receive knowledge." He visualized Midshipmen's minds to be like closed oysters. He'd tell them an off-color story, and as he did, he'd visualize the oyster shells opening up. Then he would tell another story and they'd open up a little bit more. Finally, when he felt that he really had them ready and could get some knowledge thrust into them, he'd shout at the top of his lungs, "F equals M A!" The oyster-shell minds would all quickly snap shut again, and he'd start all over.

The management of creative people is just a part of the management of change. Of course, management of change includes the management of other resources in addition to people. I really don't know much about your technical field and the management of your other resources, so I decided to stick to the people part. As I said, I have come more and more to believe that everyone is creative, and that our job as managers is to extract that creativity and employ it constructively. If you manage people well, I believe you will usually find that the management of things will take place in due course. That may be heresy to some management school people, but my experience has been that there are more people who know how to manage things than know how to manage people. If you invest a little trust in people and go ahead with the hope that they know something, it is surprising how seldom they will let you down. That doesn't mean we shouldn't pay attention to "thing" management, but that "thing" management comes easier if one gets people management done well first.

I'd like to show you a short videotape of a project that I've been working on. The relevance of this videotape is that the best service I can perform for you as a practitioner of management is to discuss some of the things about managing creative people that have been successful for me in conducting a real project: a project for developing a method of egressing from a deep underground base. One of the possible methods for deploying ICBMs that does not get much publicity is an underground base several thousand feet deep. It's a very intriguing project which opens up a lot of opportunities for ingenuity. During the course of the work, I have drawn from a lot of fields with which I have been involved.

Our task was to design an egress system which would provide a route to the surface so that missiles stored in the deep base could be launched after an enemy attack. We were awarded the contract for this job on August 1, 1982. The initial work was to design a piece of

equipment and use it to demonstrate the feasibility of egressing through the rubble at the surface above an underground base after a nuclear attack. We designed a 12 foot diameter hole-boring machine, manufactured it, tested it, took it to Nevada, then employed it to egress through a large pit from a cavern which had been prepared underneath it. At the test site, we first had to dig the cavern, then bore vertically upward through the intact ground above the roof of the cavern, then traverse 50 feet further through a prepared pit. This pit contained large boulders of the sort that might exist after a nuclear weapon had exploded at the surface. In just over eight months after being awarded the contract, with no prior design or machinery, we successfully came out of the ground with a real piece of equipment in April, 1983.

It is not simple to look back and analyze the reasons for our success on this demanding project. Partly it was luck, partly it was management, partly it was forethought, partly it was good subcontractors, partly it was just sheer determination to go ahead and do it! In large part, though, it was, I am convinced, the fine people working on the job. It's about some of these people that I want to talk to you. But first, let's look at the videotape.

> (The videotape showed the machine designed to bore upward the 12 foot diameter egress hole. Pictures show it while boring, and included the operation of the materials handling equipment as it removed tailing from the boring operation.)

That's the background for something which had never been done before, an undertaking that required putting a team of people together, figuring out how to do the job, and getting on with the solution. The field work was paralleled by engineering in the home office throughout this first phase of the project.

I would like to talk about two of the key people who worked on the project: the deputy program manager who ran the field test operations, whom I'll refer to as Roy Watson, though that was not his real name, and likewise, for the deputy program manager heading the home office engineering work whom I'll call Charles Buss. Both of these people are absolutely superb managers who have made my job easy. They demonstrate one of the first things about putting a project like this together, which is to get the right people the first time around. By this, I don't necessarily mean just getting good people, but also matching them to the requirements of the jobs.

Roy Watson, in charge of the field effort, was relatively young but had previously held positions with significant responsibilities. When I identified and proposed Roy for the job, I was told that I didn't need a man this good. When this sort of denial happens, you sometimes have to hold your ground and insist, "If you want this thing done, I need the right people. We cannot go out and do demanding things with people who don't

have qualifications." I got Roy Watson.

I'd like to point out a couple of things which turned out to be important that Roy Watson did early in the job when we mobilized at the Nevada Test Site. The U.S. Air Force was our client but the Department of Energy owned the test site. I'm not at all sure the Department of Energy really wanted the Air Force down there, mucking around making holes in their test site. In addition to our three principal subcontractors, other participants included the long-established contractor who provided site services, the local labor unions, a construction company out of Chicago, an equipment manufacturer from Seattle, and a major aerospace company. Roy began the task of fitting people together to make sure we were in good communication with the other players. We put an experienced field manager on the job quite early, and we had him make calls on and drink coffee with all of the people involved to find out what they were worried about. We wanted to know which oxen might be worried about being gored by our operations. Any one of those groups, the labor unions, the resident contractor, the Department of Energy, etc., could have prevented us from succeeding had they chose not to cooperate. If we had not established the right relationships, it is probable that we would have failed.

One of the things that Roy pulled was new to me. He said, "I want to have dinner for the construction crew." The crew eventually consisted of about 50 tradesmen from a variety of unions who were to do jobs which did not always fit union jurisdictional rules. We had everything from electricians to a couple of iron workers from Detroit. Roy said, "I want that dinner for these guys so I can explain what's going to happen. I want to have it at a real fancy restaurant down in Las Vegas, with an open bar and so forth. Can you hack that out of your non-reimbursable budget?" The Air Force didn't pay for that sort of thing, obviously, but agreed to give it a try.

We rented a hall, prepared a slide show, and had a sit-down dinner with an open bar. All of us in management roles were able to enjoy a rather rare occasion of spending the evening with our crew-to-be in a non-work environment. It went well. The crew was informed and pleased, and some were surprised to find out that several of our managers had been electricians or equipment operators in their own time.

Management in the construction business is quite often remote. Our managers sometimes think they're communicating when they put out printed flyers to inform the workers. Roy's approach was to sit down, drink, and have dinner, then show the crew slides about the project plan. An old military dogma proclaims that officers don't "fraternize" with troops and this still tends to color our thinking. Among other things, it leaves out of account that everyone's safety on a construction job depends on what people know about what each of them is going to do. The dinner created a favorable climate for us to be able to bring up the touchy point that some jobs normally performed by

union workers would not be because the job was a test operation. The crew not only accepted this, but came up with some pretty good suggestions of their own. There is a lot of competition among construction people to meet deadlines, to do things, and to succeed. We told them that we were probably going to have to go on three shifts, to bring other miners in, and so on.

There is no doubt in my mind that Roy's idea of having that dinner made a big difference. Thereafter, there was a camaraderie on the job that is not often seen. Everybody knew who our management people were, and no one loafed. When we actually began the work, there were members of several labor unions working in the same area. The jurisdictional rules called for miners to move dirt and electricians to put wires together, but these guys didn't fuss about that. In one case I saw an electrician furiously clearing dirt away with his arms.

Another thing Roy pushed was that we print decals that you stick on your hard hat. I'm sure you've seen them if you've seen a construction worker. Some workers have decals all over their hard hats just like medals. They are proud of them. The decals say who they're with and makes them distinct. We got our stickers printed early so everybody could identify with our job right from the beginning. Everyone pasted the decals on their hats. They loved them. They ate them up. We all did!

But the thing Roy asked for which I figured was really going to break the bank was "some sort of a memento for this job." So we created a watch fob, cast in bronze, with a nice looking picture of our machine coming out of the ground. On the reverse it had the names of all the organizations involved: our Air Force client organization, the Department of Energy, the site contractor, and all our subcontractors. This little bit of bronze was worth its weight in gold. In fact, the dinner, the stickers, the watch fobs, and a few other items couldn't have cost more than a couple of thousand dollars on a job which had a value in the neighborhood of $15 million. Yet so many managers just don't think about things like that. If Roy Watson hadn't come to me and urged me, I probably wouldn't have given the salesman of such wares the time of day. I'm that much wiser now.

My friend, Charlie Buss, slugging away back in the home office, did an equally fine job. He had a different crew to work with. Unlike Roy in the field, who was dealing with hardhats, Charlie was back in the office managing a crew of PhDs who think they know how to do everything, but usually have never done anything in the field. Hardhats, by the way, are pretty smart. Even though they don't come equipped with a lot of degrees, they can often show you things that are real eye-openers. With a hybrid background like mine, I have to hide the fact that I have this oppressive PhD degree when I am out there. Sometimes I think that it must be harder to manage people frustrated by being cooped up in the home office than it is to manage field personnel. There's something subtler about managing in the office.

I believe that my home office manager's success stemmed from his thorough understanding of the job and of the need of each work task. Charlie Buss fully perceived the rationale behind the need for the machines, and their design, manufacture, and operation. He did his homework well, developing a firm mental construction that enabled him to guide the work in great detail and with complete confidence. He was also able to influence other contractors, who were doing their own thing, to mesh with us. He could quickly spot where the client was wrong and demonstrate why and could present difficult technical questions so that the client could provide guidance to allow us to do a sensible job.

The second thing that Charlie did is very mundane but highly creative. It's something that I don't think I personnally do very well. Charlie prepared a well-organized and highly detailed engineering plan and schedule--a work planning document. We had specialists who helped him with this, of course, but he supplied the logic, the thought, and the insight which made the difference between a mechanical plan and a true blueprint for the project structure.

I'd like to spend a few minutes now to look at some of the personality traits and management techniques of these two managers. Both differences and the similarities are instructive.

Roy Watson is an ebullient, short, feisty guy who gets out there with the men and is always full of words and jokes. Charlie Buss is rather reserved and tends to be a chin stroker. Watson is a loquacious fellow who sometimes doesn't consider his words carefully. In contrast, Buss does choose his words. I tend to listen to him more carefully because I can be pretty sure that he has thought through what he says. Watson makes friends quickly, and people tend to like him quickly. On the other hand, you have to know Charlie for a few months before you realize what an effective manager he is.

The qualities they have in common may be even more enlightening as reasons behind their success. Both are willing to assume risk, not to the point where they will lose their jobs nor lose money for the company, but rather in the sense of moving out of the ordinary. Both are unsatisfied people, and each always has an eye for the next innovation. Both are intense and able to focus on whatever is at hand at a given time, which is sometimes very difficult to do. We all know "butterfly" people who don't ever manage to concentrate on one thing, but who forever hop from one thing to another. Roy and Charlie are not that way; they keep on an issue, and they ride it through to the finish.

They are what I call functional starters, and I sort of envy people like that. By functional starters, I mean that they're able to get themselves up and going to accomplish things. It's a lot of fun to talk about why you can't do a job, and justify procrastination by such statements as: "If only our management were more enlightened," or "If only they'd give us more money," or "If they'd stop giving us those turkeys they sent us as employees." There are always lots of

reasons why something can't be done. But functional starters get going and keep going on a job. They don't seem to require an external application of force to get them underway. They're not easily discouraged, and in Abraham Maslow's hierarchy, they seem to qualify as self-actualizers.

Both managers have perceptivity and very sharp sensitivities. They "smell" out situations, people, and trouble before it begins. In many cases I've had one of them come to me and in effect say, "I think that the client doesn't know it, our company doesn't know it, but that something is not going to happen right." This has happened both on the administrative side and on the technical side.

Finally, concerning similiarities, both managers are intelligent in more than an academic way. They know where their limits are and when to ask for help. They are "survivors," a term which I use in a non-pejorative sense. There are some interesting accountings of people who are actual survivors of such things as combat situations and major disasters, who seem instinctively to know how to maintain themselves in a "win" situation, or to keep their "spiral" going up. I like to think of continuing success as something which feeds all of us, and makes us think that we can do things that we wouldn't undertake without prior experience in success. If you get people on that upward spiral of adding new wins to their records, they will feel that they can handle tough jobs and very often do.

As I said, I'm a practitioner not a professor of management, but I have abstracted a few thoughts from my personal litany of management ideas for what they are worth, and I'll try to convey some of them to you in this talk tonight. I've cribbed a few of them, adapted a few of them, and originated a few of them, and I'll call them Selected Rules for Managing Creativity. I re-jigger this list every once in a while, and if you're interested in it, you're welcome to a copy.

I've already mentioned rule number One, which is that each one of us is a creative person. Quite frankly, the management of creative people is not so different from the management of people that one doesn't think of as being creative. Theodore Levitt wrote an article some years ago about the fact that we can only stand so many creative people shoveling stuff out of their ivory towers upon those of us who have to clean it up and deal with it. Well, this is not the only concept of creativity. You don't have to put up with these bloody nuisances. Such people can be useful, but I have to agree with Levitt that we can only take them in small doses. In another view, creativity is the simple ability to make something that isn't.

One thing you should do at the very beginning of any job is to assess your management situation and decide what you want. Some of the things that you might want are production, ideas, mutual stimulation, interaction, compliance with rules, and so on. If you're going to manage a situation where creativity is required, then it is imperative to determine carefully what these

management objectives are to be.

Another rule is fundamental in anything we do with people, and that's to let the troops know what is going on and what the objectives are. There are a variety of ways to do this. In the project I've described to you, we are now back in the engineering stage. I've gotten back into the business of staff conferences, but can't say that I'm exactly satisfied with these as a communications medium. We need more of a "milling" occasion such as a coffee klatch where the more junior people can stick in their "two bits" without the intimidation present at formal meetings.

A rule that I believe in is to manage in a way that enables people to do whatever they were hired for in the first place. You know, very often we hire people but then don't really create an environment in which they can effectively do their thing. If you hire people, have the courage to let them do what they can do well without interference. Experienced managers are more comfortable than inexperienced ones with this idea. A new manager who has been in a non-supervisory position for ten years, and who suddenly comes into a position where he figures that his neck depends on what somebody else does, is often very reluctant to allow an individual under this supervision to do his thing. You may have to actively train this tendency out of your managers and supervisors. Make them take a chance on their employees.

An example of this is the use of microcomputers on my current job. I ordered two microcomputers with no formal justification, a tactic which really antagonizes the budget people. Of course, I produced a justification, but in all honesty I wasn't really sure how we were going to use the equipment, except that I knew that several of our new hires were supposed to be adept in computer applications. We gave these employees their head, kept them informed of our project objectives, and the results were miraculous. We now have all of our financial tracking and reporting, project tracking and control, personnel records, document tracking, project cost estimating, and a number of other things up and running on the micros in a very cost-effective operation.

Match people to the jobs. I'm going to say two seemingly contradictory things in this regard. One is to match people to the job, and the other is to look for opportunities to work people out of their specialties. Both courses of action can be very rewarding. Roy Watson is a natural at running things in the field. Because he does such a superb job of it, he may never get a chance to get out of the field. Charlie Buss has the ability to visualize the whole job and to structure it for development. They are both well matched to their job requirements, but we just do not know their full potential.

As an example of working people out of their ratings or known skills areas, I have an employee who is skilled in operations research disciplines. He left our company for a while to work in the computer industry but is back with us again. He is an intriguing fellow and computer buff, and arrived on the job with his own personal computer setup.

At the time we were looking for an electrical engineer with control systems experience to do some work on our concepts for automating the boring equipment. It occurred to me that our computer man with the operations research background could perhaps help us develop the concepts for automating the equipment we needed. So we put him to work, and I have every indication that he will succeed at the automation tasks, with some innovative ideas as dividends.

When putting teams of people together, aim to get a complementary mix. You need so many visionaries, so many traditionalists, and so many catalysts. You really shouldn't have all of one kind. If I were to look at the case at hand, I would say that my field man is a catalyst and that the engineering manager is a combination of visionary and traditionalist. The fit to team needs is rather good in each case. Mixtures of types of people also lead to conflicts. These, strangely enough, can be most rewarding if managed well. Where a genuine destructive conflict exists on a job, one obviously has to keep it from sapping energies and destroying morale. Beyond this, however, conflict can play a stimulating and useful role if the manager engages people in a constructive manner, listens carefully, and seeks to prevent job related differences from turning into personal animosities.

The need for ambiguity in management is one of my strong beliefs. This may not sound very good to many management professors. Clearly defined organizations we can agree upon as a necessity, but personally I think that you never should have an organization where you must depend entirely upon one route in order to get something done. You've got to have a little ambiguity to provide alternatives and a bit of healthy competition.

I'm sure all of you have had occasion to deal with superstars. The superstar is like the guy in the ivory tower who shovels stuff out for all of the rest of us to clean up. The superstar leaves such a trail of debris that we wish we could wall him up somewhere, anywhere, except on our job! I guess I tend to feel this way as much as anyone, and yet, one of the largest jobs my company has ever won, valued at some ten billions of dollars, was won largely through the efforts of such a superstar. Superstars may be difficult but their energy and flair may at times be exactly what a situation demands.

Another rule is pretty straightforward, and that is, for heaven's sake, develop people and don't hoard them! In our business, chief engineers are famous for hoarding their best people. They will keep a good engineer in the same position for ten years, unless he dies or moves on to some other company or becomes completely demoralized. It is our responsibility as managers to try to move people along, not to let them burn out and fade. People often don't know what there is to do besides what they are doing. Most of us have little opportunity to become aware of jobs which might represent a better fit to our talents. It is an important managerial responsibility to help subordinates in this search.

When you hire people don't repli-

cate. We have a certain tendency to hire anyone who is like ourselves. If you do that you'll probably get what you deserve, and you may not learn much that you didn't know already. It is often better to look for someone who complements you. For example, I don't enjoy many aspects of financial management very much, though I try to understand enough not to go to jail. Because of this, I like to employ somebody who compensates for that deficiency in my own makeup.

Myths and absolute knowledge comprise a suspect category of management lore. I know a person who has a superb command of absolute knowledge about work breakdown structures, job planning, and execution technique favored by the defense and aerospace industries. My friend can do anything with work breakdown structures down to the fifth and sixth levels. Paper flies around, meetings are held, clients are soothed, but often nothing really seems to happen. Work breakdown structures are fine management tools, but none of them have ever done the work.

When really pressed against the wall, it is amazing how some people can be motivated. Push people beyond their abilities from time to time. This works well when you take the time to find out what it is that really stimulates an individual, and then find a craft or tough task to take advantage of whatever that favorite stimulus may be. Of course, there are as many routes to motivation as there are people. The microcomputer gives some people room to exercise their ingenuity and can create both motivation and dedication. Professional participation and papers at meetings such as this provide another avenue for motivation. Be wary, however, of the professional meeting-goer.

The last thing that I had in my Phelps rules for managing creativity was to reflect on the fact that the path leading to most great inventions often becomes manifest only in retrospect. Insights of scientists often defy logic simply because the process of creating, of innovating, is not necessarily logical.

QUESTIONS AND ANSWERS

Q: After you have all of these good managerial characteristics, and you still want to get better, do you have a contingency policy which works if everything else fails? Is there something you have hidden in your agenda that you haven't told us yet?

A: There's one person I remember from a long time ago who had a way with people in a military setting. He used to take people who were on the brink of discharge due to intractable behavior or because they would not fit. He was a Seabee company commander who had come out of the east side of New York City, very quiet-spoken, who never used force to achieve his aims. He was able to convert these supposed incorrigibles and to reclaim them. I think he did it by relating to them and finding what was causing them to behave as they did. I don't know exactly what his secret was, nor how to emulate him, but I think if you can somehow relate to people on their own ground, you might reach them. That seemed to be how he succeeded. I

think about him as a person who was able to do that more effectively than most of us. I may not have the patience.

Q: I think you're saying personalize the relationship. I think that's the way, I honestly do. Being an old Navy man myself, I agree with you one hundred percent.

A: It's a matter of chemistry. With some people I find that I can talk until I'm purple yet never get anywhere. If I can get these same people into someone else's domain, and they can personalize the relationship, then maybe they can succeed where I haven't been able to.

Q: And therein lies the most difficult challenge of all, especially if you don't like the individual.

A: That happens. I remember a young lady who was a pretty heavy women's rights type of person. I had avoided having a confrontation with her because she worked two or three levels down from my position in the organization. Then one day she came to see me. I knew enough about her reputation for aggressive tactics that I didn't want to become entangled in any argument. I promised myself beforehand that I was just going to sit behind my desk when she came in, and would be very nice and pleasant. In spite of my resolution, she had hardly walked into my office before she got my dander up. To this day I can't explain it to myself.

Q: Can you say more about upward spirals and downward spirals?

A: It seems to me that you want to make people winners not losers. You want to give them something that they will be a winner at, and then tell them that they were a winner and give them the next step--something within their reach. I think of a series of wins as an upward spiral with momentum built at every turn. Conversely, a string of losses can lead to downward momentum and a self-fulfilling expectancy of further losses. The spiral phenomenon happens among our friends and our families as well as among our employees. You need to help people to believe that they can do shaking out all those reasons why they're not succeeding. Reasons not to succeed can be anything from illness to "I'm not smart enough." I don't know that I have anything to prescribe that hasn't been written about, such as setting targets that are going to allow people to succeed. Success gives us a psychological boost and allows us to put the next foot out.

Q: As a functional starter, if you have a procedural kind of a thing, you can always create something and say, "Tomorrow morning we'll do this." I've got to have a plan for that. That gets the juices flowing.

A: I agree with Milon on this. There are quite a lot of people who sort of stand back and tell everybody else how they're doing it wrong, but who never do things themselves. If you throw them in at the deep end and push them a bit, you may be able to bring some of them around to acting instead of criticizing.

Q: You have to get people like that to make a commitment of time and energy, and show them how best to spend their resources which are limited just like your own.

A: I had a case like that recently where

I put someone into a situation with a big challenge and thought he might make it. He worked very hard and turned out a very neat but incomplete piece of work. It just wasn't in him to accomplish a 100% success. He sort of temporized and I think he enjoyed it. I think he felt enriched and happy that he got a shot at a tough assignment, but it wasn't within his ability to do all that needed to be done. As for myself, I could not bring up the energy to try to get a better performance from him. As you said, my own resources are limited, too.

Q: You may not want to comment about the size of the organization because you had a pretty small staff in charge of field activities and even in the headquarters work. That doesn't give you much maneuvering room. Does it help to have a fairly large organization with a lot of openness and opportunities to create projects and move them around?

A: Small is helpful. I think with less than a hundred people you can get morale going and can keep track of what is going on. When you begin to get into the two hundred to five hundred people range, it's very hard to keep track. The sense of intimacy on a personalized basis erodes when you have a much larger organization.

It must be at least midnight in Washington, and I know that some of you started the day on Washington time. I'll get a chance to know some of you a bit more tomorrow. Again, thank you very much for having me here.

A FOCUS ON THE FUTURE

Ross Whaley

I must offer a great deal of thanks to Pap Phelps for his stimulating keynote address last night. He caused me to have an absolutely rotten night's sleep thinking about what he said. On the other hand, it was a very exciting evening in that I was trying to relate the questions which were asked and sent to us initially. The questions, which we all received in our invitations, were: What are the factors that might affect the speed and direction of emerging innovation? What will be the impact on people, budgets, accomplishments? What are the key policy decisions?

I heard Dr. Phelps talk about people--the management of creative people. Here I am to talk about external environments to that process. And last night I was trying to think how these things come together and what they have in common. Pap was talking about creative people and their management, the output being that of change. I, too, will be talking about change, but from a different angle.

One of the problems is getting change to the people who are the implementers, those who ultimately deliver something to a customer. In *In Search of Excellence*, Peters and Waterman discuss it, and then there is the futurist literature including such things as *The Third Wave* by Alvin Toffler, Marvin Cetron's *Encounters with the Future*, and John Naisbitt's *Megatrends*. All of them look at the external environment in which change takes place. As I listened to Pap talking, it suddenly struck me that much of the focus in the technology transfer area is wrong. If we have a product, we think about the process of getting that product from one group of folks into the minds of others. Yet, Pap didn't talk about that process. He talked about people.

When you ask people to accept change, you're asking them to do things differently from the ways they have been doing them. Pap mentioned that the first thing one might consider about kinds of people to hire in a company are people who are willing to take a risk. Most of us are not. It's risky business to take a risk and to hire people who are willing to do likewise. So it seems to me that the kinds of things that Pap was saying last night and the kinds of things I'd like to talk about, external environments and how they influence people to make change, are perhaps more important than the arrows that prescribe specific processes.

I'm not going to talk about predicting change. Nor am I going to make any predictions. I don't know that much about the future and I don't think of myself as a futurist in any sense at all. I think of myself as a planner. A manager of plans, if you will. I am a consumer of the material we read about external environment. I got interested in the

future because of my interest in forecasting. Being an economist, and involved in trying to take a long term look at resource supplies and demands, I began by thinking that these were very critical parts of the manager's job. How does one think in terms of the long term? I was unhappy with the job we were doing in forecasting and started to raise the question, "How do you make better forecasts?"

I will begin with my conclusion. The first lesson I learned was that I was asking the wrong question. The real question is, "How do you make decisions under uncertainty?" It took me some time to become convinced that we in the Forest Service, in our assessment activities, do the best job of forecasting done anywhere. The problem is that when we are asked to look forward 50 years, all of our stuff is wrong.

The second lesson I learned is that in our agency at least all of our forecasting efforts have been devoted to looking at resource programs and asking questions such as, "How much more or less of this or that should we supply or do?" Never did we take our forecasts and use them to examine ourselves in terms of our own organizations and our people. We have Assessments, RPA Programs, and land management projects. But who is stepping back and saying that the world might be different five or ten years from now, and what are the implications for the way we manage things and the way we're organized?

I shall illustrate the third lesson by paraphrasing a futurist colleague, a Washington consultant by the name of Joe Coats. Frequently, I argue and debate with Joe Coats, but in this instance I think Joe said something that has been very helpful to me. To paraphrase Coats, individuals tend to look at the future in three ways: (1) the future is the enemy--change is something to be avoided. By all means maintain the status quo: oh, for the good old days; (2) the future holds change, but not on my watch. Yes, I recognize that change is occurring all around us. I am told that the rate of change may be accelerating. I read some of the current bestsellers related to the future. But I do not change my behavior because I assume that these changes are around the corner and will not affect me personally--maybe my children and maybe my successors, but not me; (3) the future is ripe with opportunity. Those of us who subscribe to this view of the future realize that we can know enough about it to be useful. We can influence the future, and though we will be living in a world of continuing change, there is potential for all of us to be better off as we respond to it.

Many fall into the first group. Most of us, I suspect, fall into the second. We'll acknowledge that change is coming, but that it is around the corner. How many of us have read the books of Toffler, Cetron, and Naisbitt and know about the anatomy of change, but don't change the way we behave individually, and don't change our organization nor think it has any impact in our particular part of an operation.

Few are the people in the third group who have the outlook that the future is pregnant with possibilities.

Although you can't forecast it, you can know enough about it to influence it. The materials I have put together and talked about over the last six months have been oriented toward trying to move people and organizations from that second group to the third group.

I shall start by considering how by looking at the future we might improve our decision making. I shall examine a few trends into the future and then some strategic issues. Figure 1 outlines what we do well in assessing the future renewable resources. We do as good a job at forecasting the future as anybody in the world. But I would also argue that the answers we produce are all wrong.

Figure 2 suggests areas where we fall short. In the Forest Service, assessment refers to a document which portrays our long term forecasts. One of the things that is wrong with it, I think, is the implication of precision. In all our forecasts, we insert all the caveats about uncertainty, and admit that we really don't know what the world is going to look like in fifty years. And then we go ahead and assume we do know. If you examine Forest Service assessments and look at the graphics, you will find that they are all drawn with a 4H pencil. It struck me that we offer precision not because we believe in the precision of our forecasts, but because as managers we

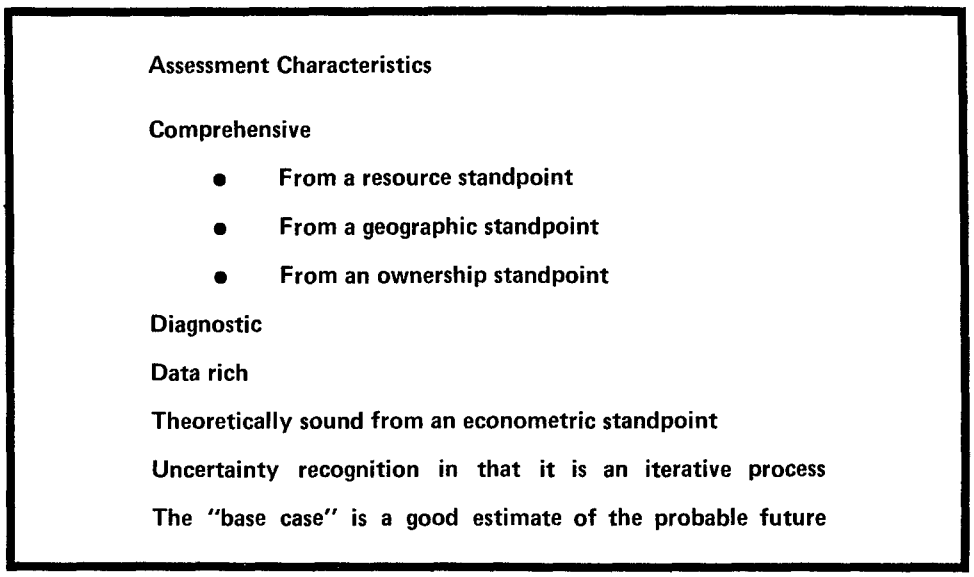

Figure 1. What Do We Do Well in Assessing the Future Renewable Resources Situation in the U.S.

abhor uncertainty. I'm absolutely convinced that managers would rather have information that is precisely wrong than approximately right. Examples of this are common, and relate to risk and uncertainty and our willingness to deal with them.

Problems Facing Government Strategic Planners

My next consideration in strategic planning, after examining the way we do forecasts in a government enterprise, is to search for things that influence us that might be different from the corporate

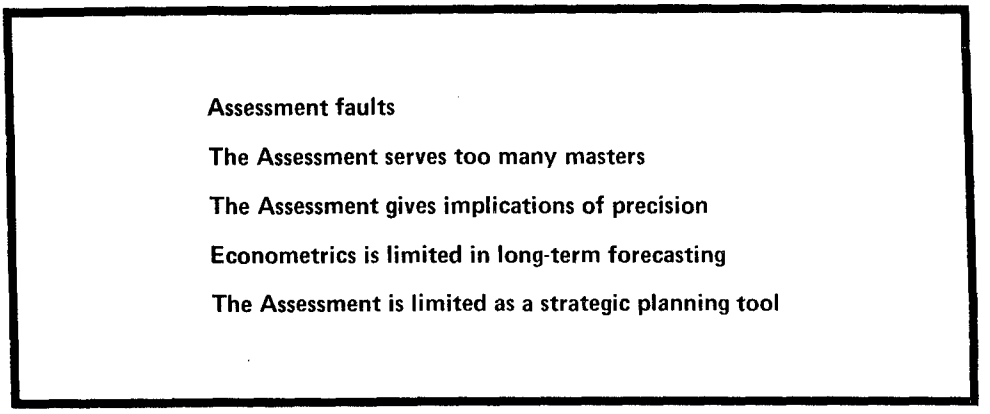

Figure 2. Where We Fall Short in Assessing the Future Renewable Resources Situation in the U.S.

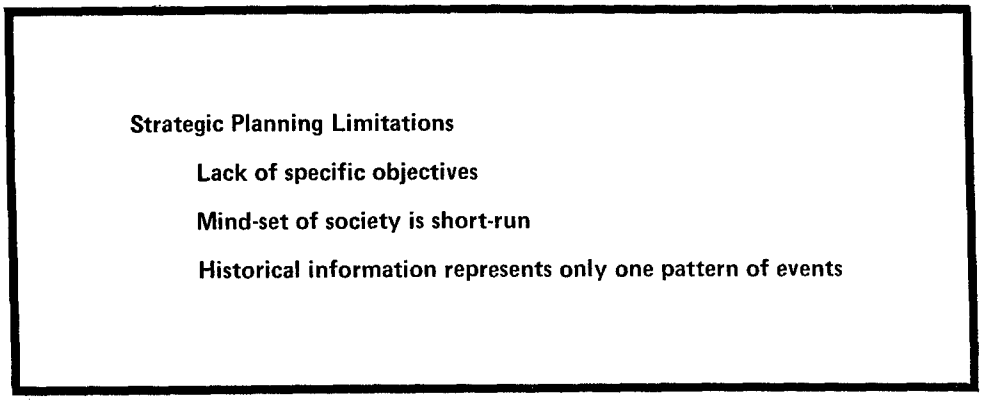

Figure 3. Problems Facing the Strategic Planners in Government.

sector or the rest of the world. Part of the rationale for the existence of government is the ability to take a long term view. Figure 3 indicates some of the problems we face in taking that long term view. One of the difficulties of decision making in government, I propose, is the lack of specific objectives. Usually when I mention this point somebody in the audience wants to debate with me. The argument is brought up that we have laws, and there is a whole set of laws, manuals, policies, and handbooks, all of which provide us with specific objectives. Let me explain why I came to the conclusion that, in fact, we lack specific objectives.

In our early efforts to look at long term planning, some of our industrial colleagues said, "Why don't you look at what we do in industry?" So I talked to people at Champion International, Royal Dutch Shell, MacDonald's Hamburgers, and an array of others trying to find out what they do in planning and how it is different from government. There are some interesting differences. First of all, in those firms where planning is done well, the planning organization sits at the right hand of the Chief Executive Officer. Why is that important? Because the planners know where the Chief Executive Officer is coming from. They know that in addition to the stated objective of the firm to make money, the Chief Executive has a whole bunch of other objectives.

For example, the planning organization knows that the Chief Executive Officer wants that firm to be the most responsible environmental organization in their industry. Or conversely, they know that the CEO doesn't care about the environment–not really. Or they know that the Chief Executive Officer wants that firm to be a leader in civil rights, affirmative action. Or conversely, no, the CEO doesn't care. Most of the forecasting activities are done on the back of an envelope. The presentations are about one page long and they deal with the specific objectives of that Chief Executive Officer. Let me provide an example. It's a small one but it surely drove the point home to me. I was having lunch with Bill Ashley, who was then in charge of strategic issues for MacDonald's Hamburgers. At the time I didn't have the foggiest notion of what Bill Ashley and Ross Whaley would have in common. It took about five minutes to find out. We got into the subject of red meat consumption by the American public.

I know about red meat consumption by the American public. In our assessment, we have a whole chapter that deals with livestock grazing. When you're examining 50 years of livestock grazing, you just start those computers whirring and they forecast *ad nauseam*. From historical profiles of red meat consumption, you learn the relationships between age and income. Consumption peaked at 118 pounds per capita per year around 1978, then declined and if past trends continue, it could grow to 140 pounds per capita. Bill Ashley doesn't use a computer. He scratches his head and says, "You know, Ross, our firm has a major concern. There's a lot of faddism, we think, in the consumption of food. Relationships like that of food to cancer, concerns for cholesterol, nitrite in

bacon, and such things are probably going to reduce red meat consumption. In addition, the demographers tell us that the average age of the population is rising, and we know that older people tend to eat less red meat than young people." He believes that red meat consumption could drop to 70 pounds per capita.

Now what does Bill Ashley do with that information? He simply gives it to the Chief Executive Officer of the firm and McDonald's responds with a product called Chicken McNuggets. In contrast to that, when I prepare a forecast, I don't even know who the Chief Executive Officer is. Is it the chief of the Forest Service? I'm led to believe that occasionally he and the Assistant Secretary of Agriculture differ. I'm also led to believe that the office of Management and Budget and the Assistant Secretary often do not see eye to eye. I know for a fact that Congress disagrees with all of them. So who is my Chief Executive Officer? And what does Ross Whaley do when he gets into the forecasting business? I do not know whether we have ever influenced a decision in our lives with our forecasts. As a result, the measure of the success of the forecast is the elegance of the analysis, and not its influence on decisions. We behave as if our clients are the academic community. That is one of the impacts, I think, of not knowing the specific objectives of the top decision maker of the organization.

Let us consider the second item in Figure 3: the mind-set of society. People are aware that the mind-sets are short run. People are aware of Congressmen being elected for two years and senators for six years, and that their time horizon focuses on getting re-elected. It is we, you know, who jam them into a situation where they must perform for us within the context of two years or six years, or else we're not going to elect the scoundrels again.

Let me give you another example of the short term mind-set of society. About four years ago, I was on an accreditation visit at Rutgers University. As an examiner, you tend to be on the campus for two or three days and you spend your time in successive interviews with students, faculty, deans and others, one hour at a time, all through the day. This particular accreditation happened on the day of the attempted assassination of President Reagan. I was in a meeting, had an interview, came out, and the secretary said, "Oh my God, the President has been assassinated." I went into another interview, trying to have an hour's discussion after having heard that the President had been assassinated. Obviously, it wasn't a very successful interview. When I came out, I found that, no, that's not what had happened. There had been an attempted assassination of the President. The next time I came from an interview I found that that information was not exactly right either. There had been an attempted assassination of the President and he had indeed been shot. He was at George Washington University and the prognosis looked pretty good. I found that interesting because my assumption had been that this was the rumor mill at work. But this was not what had happened. The woman who had told us of the shooting had a radio on her

desk. It suddenly struck me that even our media behaves in a way where the premium is on being first and fast, and not on being right. It seems that the mind-set of all segments of our society is crammed with short-term thinking.

When we consider the length of time involved in the research process, starting with developing a concept and proceeding to the implementation of innovation, as ranging from seven to twenty-three years and averaging about thirteen, we ought to be much more aware than we are that most of the work on the drawing boards in our research institutions is not usable until several years from now. In spite of this, we are asking our research people to do some development that will come to fruition in an environment and a social context they haven't even begun to think about. We're asking our people to be innovators when they are not primed to think in terms of longer time horizons.

Alternative Long Term Strategic Scenarios

Let me suggest an alternative approach. Consider Figure 4. I suggest that traditionally we try to look at the center. We want to know what the most probable future is going to be. As a matter of fact, I began to draw my lines with a 4H pencil in terms of a likely world in the year 2020, and expressly included the array of possible futures that we may have to deal with. But I think it's extremely important to look at those things which might cause deviations from the foreseeable future, even though I do not know how to put probability values on them.

I would argue that it is equally important to look at the preferred future. What is the preferred future? What do we want our organization to be in the future? Here we come right back to Joe Coats and that third group of people. There are a lot of opportunities and you can't forecast them. But just by visualizing and targeting them, you can influence many an outcome. That's surely something to think about.

Let's then consider some possible futures. Figures 5 and 6 show some trends. Don't pay any attention to individual terms on the list. They are examples. If we were to go around this room and itemize the trends that may influence us, we would come up with a different list. As a matter of fact, I'd come up with a different list than when I prepared these. What I'd like you to do is to consider the list as mapping a thought process.

As you see, Figure 5 contains some fairly certain trends and Figure 6 some less certain trends. As I mentioned earlier, I cannot put probability statements on them. The important thing is to force oneself into a frame of mind that says, "Here are some things that I am very certain are going to happen. If they do, what? Do they have any effect on me or my organization? If they don't, I'll ignore them." Next, look at those which are less certain. If they're going to have a major impact on the organization, by golly, then don't ignore them. That, then, is the second general comment about the trends. First, the set is only a list of examples. Second is the question

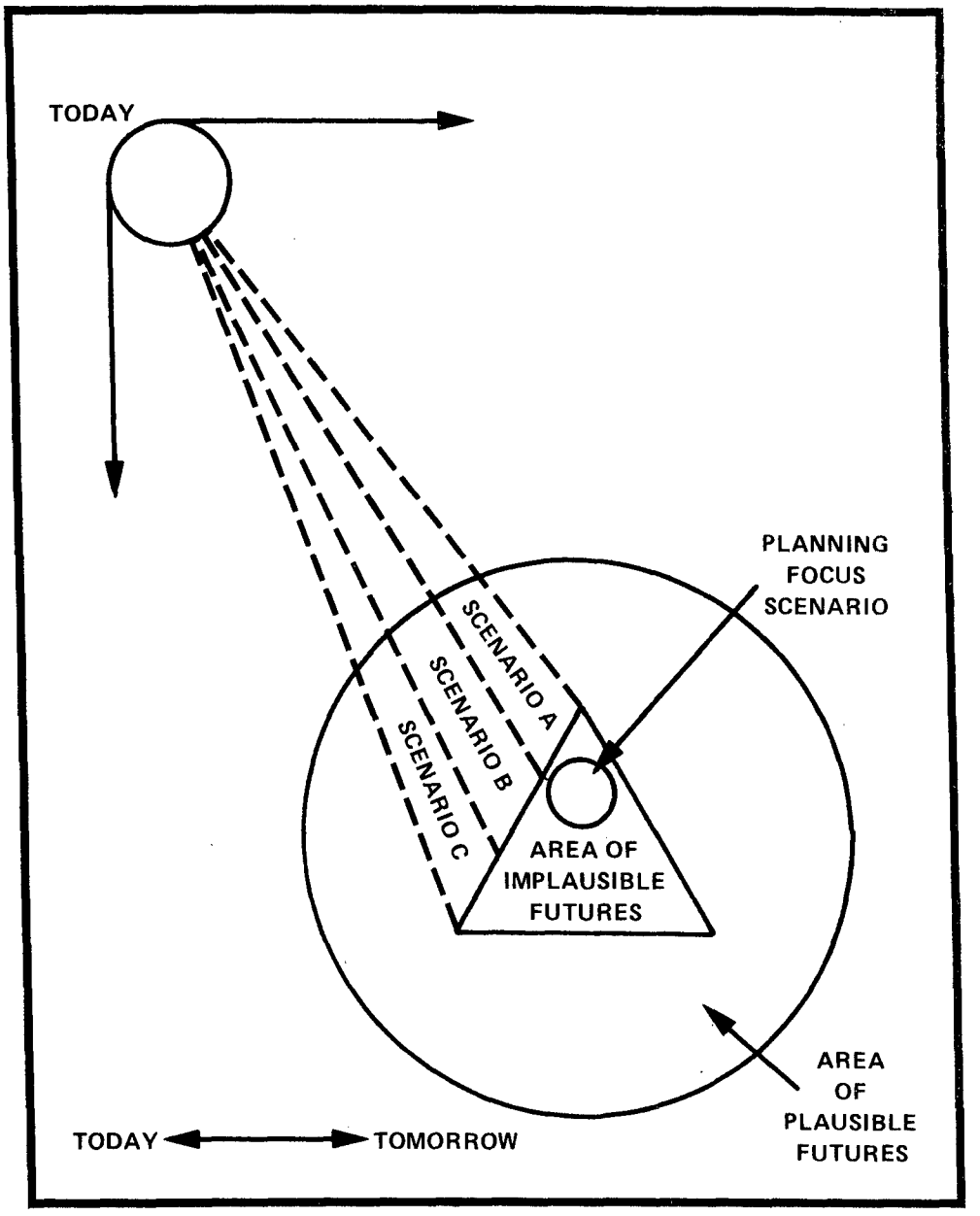

Figure 4. Alternative Long Term Strategic Scenarios.

Social/Political/Demographic

1. Aging of the baby-boom cohort of the population combined with improved health will result in a population with a higher average age, but healthier.
2. Move to the Sunbelt will continue but at a slower pace than the '70s due to water shortages and other urban development barriers.
3. Maldistribution of resources relative to the location of population on a global level will increase international interdependency.
4. Increasing concern over health combined with an aging population will have significant impact on attitudes toward diet and food preferences.
5. The increasing importance of immigration as a portion of population growth will result in significant changes in cultural and political attitudes.

Resource

6. The combination of agricultural exports, shortages of irrigation water, and mining on public lands in the West will cause a faster conversion of southern forest lands to other uses than heretofore anticipated.
7. There will be economic disruptions caused by temporary energy shocks of varying duration and some locations will have absolute shortages.

Technological

8. Advances in telematics, including telecommunications and robotics, may cause a major decentralization of business manufacturing and education in the U.S.

Figure 5. Examples of Fairly Certain Trends.

Social/Demographic/Political

An increasing economic gap between the "have" and "have-not" nations, combined with a shift in international political power may increase the potential for international terrorism and give a strong incentive for expanding domestic capability for producing energy and strategic minerals.

Technological

Advances in telecommunications and robotics accompanied by increased population may lead to "work" comprising a significantly smaller share of our lifetime.

Biotechnological advances may produce trees with combinations of characteristics heretofore unprecedented.

Figure 6. Examples of Less Certain Trends.

of certain and less certain events.

The third move I would like you to make is rare in this kind of exercise. More important than any individual trend that we might have on this list (or any list that you might come up with), it is the coincidence of trends. We continually make the mistake of looking only at changes in technological kinds of things today. Tomorrow we talk about demographic kinds of changes. Then, next day, we talk about political changes. Individually, those trends aren't particularly important. But start matching them up and look at the coincidences of changes in technology with changes in demographic characteristics, or changes in the political scene, and then you'll find big consequences.

A general comment I would make before we go into any particular concern is that of the forecaster's humility. Some of the items in Figure 5 are demographic changes. Predicting demographic changes, by the way, are what we do best. Forecasting demographics is the easy stuff. Why is that true? If you're looking at fifteen to twenty years in the future, most of the people who are going to be alive then are alive today. So we can count them--by sex, by race, by ethnic background, and all you have to do is age them by twenty years. You then make some assumptions about death rates, assumptions about birth rates and immigration, and by and large, you won't

be far out.

Now that I have said that, look at the projects made in 1970 by the Bureau of Census and look at the 1980 Census. What really happened? In 1970 the statement was made that the average population age would be up. It happened. But it was underestimated by several years. The tremendous health gains during the '70s caused the average age of the population to rise substantially more than was predicted. Again, in 1970 a continuation of the movement from the North and East of the U.S. to the South and West was predicted. That part was right, but it was underestimated several-fold. In 1970, it was predicted that there would be a continuation of the immigration from rural to urban communities. That was absolutely wrong. The trend reversed itself. I don't know if the reversal will continue, or whether it was a flash in the pan and what will happen in the next decade. The point is that even those things we do best in the forecast business are subject to all kinds of errors.

Now let's look at Figure 5 again and pick a couple of trends that are particularly relevant to technological change to illustrate the process. Let us consider trends 2 and 5 in combination. The second one says something about the continuing movement to the Sunbelt. This trend is particularly relevant for the Forest Service. We manage large segments of land in the southwestern part of the United States. The migration is extremely meaningful to us. Be careful, however, in projecting it too far. It may dampen. And why may it dampen? Why do people move from the Northeast to the Southwest? Part of it was due to the weather. Part of it because of the hold of unions on the Northeast. Part of it due to the crime rate. Part to the congestion. The point is how long will it take until the combination of the shortage of water in the Southwest, combined with the change in the social climate which will make the cities in the Southwest very much like those the people were escaping from because of congestion, unionization, and crime reverses the trend? The migration is almost sure to slow down and reverse itself. But it is almost certain to continue for a while.

Another thing of interest results from a combination of item 5 in Figure 5, immigration, with the trend of movement to the Sunbelt. These two items have, I think, a great deal to do with each other. If you consider the demographic projections for the next 10 to 15 years, about 25% of our population increase will come from immigration. This country originated from immigration. What's the change? I believe it is a substantial change. Immigration in earlier years of the Irish, Italians, Poles, and Germans was to ghetto settlements in the Northeast. You will still find remnants of the Italian ghetto, the Irish ghetto, the Polish ghetto, and so on, in renovated Northeastern cities. In the ghetto, people need the comfort of being with others of their own kind. When "junior" came home from school, reverting to the family Italian, mother would say, "We're American now, speak English." The immigrants flew American flags on Flag Day and wanted to get Americanized.

We don't even know the magnitude of the current great crush of inflow of newcomers because of illegal immigration, but it is estimated at somewhere between 500,000 to 1,000,000 people a year. The immigration occurring now seems to be different from earlier immigration. There are pressures to maintain and perpepuate culture, to maintain and perpepuate language. Look at the bilingual education provided in southern California, New Mexico, Arizona and Texas. By the way, I am not in any way trying to suggest that the form of immigration taking place today is any worse or any better. I have yet to form an opinion about that. I am simply trying to point out that it is different, and that we must therefore expect different impact.

On the positive side, we may see New Mexico, Arizona, and southern California culturally enriched. Another possibility is that the area will become the Quebec of the United States. Texas is currently 24% Hispanic. New Mexico is, I think, 37% Hispanic. I don't know what the percentage is for southern California, but I suspect it is of the general magnitude of Texas and New Mexico. In any case, there is no question but that single largest political block in the southwestern United States is Hispanic.

I mention the demographic shifts to suggest that the management of our organizations, how we deal with innovations, indeed, the whole context in which we are going to operate is going to be different. I predict that it will not take 30 to 40 years, but will be different 10 years from now.

Let me mention another trend, one that will enable me to make a linkage here between a fairly certain event and one that I am less certain about. It also has to do with the way we organize our agency and deal with innovations. I am referring to the maldistribution of resources internationally. In terms of thinking about the future for this agency, I would argue that historically we have ignored the rest of the world. Oh yes, we have an international forestry organization, but I think we ignore the rest of the world in managing our forests. Is that all right? So far it seems to have stood us in pretty good stead. There hasn't been a problem with it. Is there going to be a change? I have a terrible time dealing with that question. The reason that I have a terrible time dealing with it is that I can cite you all kinds of documents, some 15 to 20 years old, some quite new, all of which come to the conclusion that resource scarcities on the international front are going to be so severe that they're going to have major impacts on the world. I can even show you documents that say that the decade of the '80s is going to be pivotal in this respect. In fact, by the end of the '80s, we're going to see a whole new perspective on resources, dictated dominantly by international shortages.

There is a dilemma, however. For every one of those publications, I can find you another one that says, "No sweat." For every Dennis Meadows and his *Limits to Growth*, I can find a Herman Kahn who says that it's not a problem. For the Global 2000 Report put out under the Carter Administration, there is *The Global 2000 Revisited*

coming from the American Heritage Foundation. In it Julian Simon says that if you look at the statistics in the developing world you will find that people are living longer and better than they have ever lived. The literacy rates are better than they've ever been, the caloric intake is better than it's ever been, the average income is better than it's ever been. And there is no indication that those curves are dipping.

What can I and other forecasters do to deal with this paradox? One conclusion which we all will agree with is that there is going to be a maldistribution problem. What do I mean by that? If you take the most optimistic view of population growth, very little, and the most optimistic view of resource availability, great gobs, you are still left with the problem that the people and the resources are not in the same location. Consequently, you are going to find an uneven pattern of economic scarcity. That has all kinds of implications for a nation that has the resources. By the way, if you look at statistics presented by Julian Simon, you will probably agree that he is absolutely right in terms of the growth and the improvement in the developing world. It's interesting, however, to compare the growth in the developed and the developing worlds. You find that the gap between them is getting greater and greater and greater. As well as the developing nations are doing, the developed world is doing better. And so the issue of maldistribution, in terms of claims on the world's resources, is getting larger and larger.

Two more things should be considered. One of these is technological change which will give us highly sophisticated communication links. The Forest Service is now getting geared up to adapt to it. By the time we have adapted it and are reasonably comfortable with it, it will be obsolete. What are some of the things coming down the pike? Well, one of them is the use of cables in the homes. What are the implications of that? Some estimates say that by 1990, 85% of the homes in the U.S. will be on cable. About half of those will be on two-way cable with interactive capabilities. What does that mean if it happens? Simply that in addition to having the choice of switching to 150 different channels and seeing dirty movies at night, there will also be machines that will allow you to find out what's on the menu at the local restaurants, what's at the local shows, what's happening on the stock reports, what's happening with sports, and whatever else it is you want to know. You will be able to query the machine and get an answer.

Is this technology far off? Of course not. The Midland Hotel in Chicago has already equipped 300 rooms with computers. A new subdivision just outside of Sacramento, California, is hooked up with two-way cable to the local school system. Does this mean the students are going to stop going to school? Of course it doesn't. What it does mean is that they can query that school at any time of the day through audiovisual channels.

What are the implications of such systems for us? One of the implications, it seems to me, is of major importance for

those of us involved in the environmental impact process. It is reasonable to assume that in 10 years we will not put together another Environmental Impact Statement the way we do today. Why? Well, we're already seeing evidence that the ubiquity of the computer is such that nobody wants to see our analysis. They'd rather see our data. They'll analyze it themselves. That's one impact from the proliferation of computers.

The second thing I'd like to bring up concerns the possibility for instant referenda on our environmental impact. Suppose we go to Channel 127 on an evening and conduct an hour presentation on the alternatives for management of a particular piece of land. Those who think that Number 3 is best, punch Number 3. Those who think Number 2 is best, punch Number 2. I don't know, of course, if this will come to pass, but I'm absolutely certain that within 10 years the public input process is going to be vastly different from what it is today.

Another example is a little bit more fanciful. It is about talking to computers. You know, we're greatly concerned with training people for the use of computers as typewriters, even though there are executive types who have not used them at all and are afraid of keyboards and those sorts of things. What is the possibility that we will, instead, talk to the computer and do away with the keyboard? Part of the problem is that verbal communication with the computer is very, very difficult. Accents differ, the uses of grammatical forms differ, and vocabulary differs between individuals. These differences give the machine absolute fits. People with "you knows" and that sort of thing drive the computer bats. The computer doesn't know how to handle three "you knows" in a row. Now that I have said that, let me tell you that we are led to believe that the National Security Agency already has a machine which listens to foreign radio broadcasts, translates them, and analyzes and interprets them. The results are not good yet. But the fact remains that the machine does it.

It is interesting that if you dial 411 in certain parts of New York City, a voice will come on and ask you for the name and the street of the person you're trying to locate. If you provide it, the machine will come again and tell you that the telephone number of that individual is such and such. The point about this technology is that there is no recording on the other end. There is no person on the other end. But there is a computer on the other end with a computer-generated voice that performs a search, and then gives you the number. Talking to a machine is not too far away.

Just how far away is it? I take public transportation in Washington. Occasionally, one of the car pools is short somebody. In Washington, they have fast lanes where you must have three or four people, so when a driver is short a person I can get a choice ride. I periodically go back and forth to work in car pools short a rider. A man in one of the car pools usually has a reserved parking slot, which he accesses by speaking into a little receiver. In the receiver is a computerized voice print. And although everybody says the same thing, the computer can

differentiate between voices. If you tried to say the same thing as the "owner" of the slot, your voice would not give you access to the parking place. The chip that performs this will handle up to sixteen words. The price of that chip is $13.

Let us consider an issue among the less certain trends. Consider the case of maldistribution of resources on an international front from a political perspective. Is there any reason to believe that the gap between the have and have-not nations, which is increasing, could be the very thing that prompts international dissension. Is it not true that the developing world is gaining in political clout? I could cite several pieces of evidence. One of the most obvious is that of the United Nations. It commenced with 28 signatories and now there are 154. Outside of the Security Council, the United Nations is run by the developing nations. Consider the programs of FAO and the World Health Organization and UNDP, and others, and you will see that they do what the developing world wants them to do. I'm not sure that is necessarily wrong, but it certainly illustrates a change in the political clout within that organization. Consider also that countries like Iran can bring the world's most powerful nation to its knees through terrorist tactics. My technological friends here from the Defense Department probably know much better than I that the potential for development and use of small-scale nuclear weapons is not farfetched at all. In fact, I am led to believe that a reasonably well-educated PhD student in nuclear physics is able to put together a small-scale nuclear weapon.

I am making no prediction that international terrorism is going to be a major problem. I don't know. I am saying, however, that if I am right in my concerns over the maldistribution of resources, if there is a relationship between terrorism and people's claims on the resources of the world, the growing power of the developing nations through terrorism or through political clout is something that even organizations like the U.S. Forest Service can ignore only at their peril. We may never have thought of ourselves as being in any kind of international political arena, yet I am sure we will be impacted by it.

If I had the time, I would next discuss the question of "so what?" Figure 7 deals with strategic issues. I tried to look at the trends, and from there, attempted to identify what the trends mean to an organization in terms of change of management style, in terms of the way we treat people, or the way we deal with innovations. We are in the midst of transitions to which we will have to respond. What trends we accept, and what we reject will affect how we operate. I am going to stop now and entertain questions. But feel free to challenge, rebut, debate, or make any kind of comment you choose.

QUESTIONS AND ANSWERS

Q: Why did you say that you don't want to predict that terrorism is going to be worse than it already is?

A: Rather than say that we as an agency are going to have to deal with terrorism as is happening in the Middle East by 1992, I would prefer to stick

to some things I am fairly sure of. I'm not sure where it will be. I'm not sure who the actors are going to be. I'm only fairly confident that it will have a major impact on this agency. I would argue that in some of these forecasts, the degree of uncertainty may have more of an impact on management decisions than the absolute level of the forecast. I refer back to Bill Ashley and the MacDonald's Hamburger. He doesn't know what's going to happen to red meat consumption. But there are certain management strategies that can cover consequences in either direction.

Q: Isn't the trend toward no middle class majority in the United States, and more and more people with money going to cause more division so that the preservationists are going to be stronger and stronger?

A: Let me make two comments. First, about the environmentalist thrust. Some of us who have seen the heyday of the environmental movement in the late '60s and early '70s may have come to the conclusion that the thrust has weakened. I would say nonsense. A good share of those people who were carrying placards in the early '70s now wear pinstripe suits and are in the halls of Congress and in business. Although perhaps more subtle, the thrust is now much stronger.

Second, about the issue of the middle class. There are some things about it that worry me a great deal, although I will admit I haven't thought it through. Along with the changing technologies, society is becoming more and more sophisticated. If you discuss unemployment in the era of telecommunication, somehow the implication is that jobs are going to be there, but they're going to be different, certainly more sophisticated than putting hubcaps on Fords by hand. If that is true, then I think I see another thing coming. There have been three major reports during the last year which talk about the quality of education in this country. All say that it's dismal, and the elementary and secondary levels are getting worse. I've heard that some of those studies are bad. Nevertheless, there seems to be agreement among those studies showing that the overall quality of education is poor. It is interesting to me that if I look at my kids and their friends, they strike me as being brighter than I was when I got out of school. In math, in science, in political affairs, and in any other dimension, they are much more sophisticated than I was at their age. Now when I checked with my colleagues about their kids, everyone, without exception, told me that very same thing. If that is true about one subset of society and if the observations about the deteriorating quality of education are right, it seems that the other side must have a bunch of unfortunate kids who can't add or can't write. And who apparently can't balance a checkbook. That makes me nervous.

Q: You're mixing a couple of things here. You're talking about standards of quality. When you were a child, you were exposed to "X" amount of information. Knowing your ability now, you probably absorbed a large amount of that. For your children, the amount of the information provided is "X plus a great deal." The studies you referred to

are reporting the percentage of that information your kids are absorbing. Our youngsters are certainly exposed to a lot more information and may even be absorbing more, but still a very small percentage of the total information. It's all relative.

A: I agree with you. But I contend that even if the studies that have been done of the educational system are right in assessing the ability of these students in very rudimentary skills, I would still make my same case.

Q: The skills you referred to put a certain value on reading, writing, and arithmetic, and being able to speak. My youngster may not be able to do anything else, but he can run a computer. What value do you put on running a computer? What are the skills that will serve these young people best? There is a gap but we've always had that gap. Our concern is that there are more people in the lower end of the distribution than there were when you and I were in school.

A: Okay, your analysis, I think, is better than mine. The conclusion, however, is the same.

Q: I'm not arguing that. The demands for jobs by that segment of society are going to be very large. When the President says that there are 90 pages of want ads so there is no reason for unemployment, is he really talking about the tail end of the curve? There could be 200 pages of jobs which these people are not going to be able to qualify for.

A: A better analysis, an interesting spectre is still before us, relating to the distribution between education and income, and what is happening to the middle class. Is there any reason why it's flattening out?

Q: Statistically, what have we defined as the middle class? We have just redefined what poverty is. Also, consider that it is much better to be poor than it used to be, and that the motivation to get away from the lower tail of the curve is therefore not what it used to be. People are not so likely to die when staying at the tail end. Also, in some ways it is more difficult to escape.

May I change the slant of this discussion? You said that kids are getting brighter. They're definitely more informed. There's a lot more information. But also the world is getting far more complex and requires a lot more bits and pieces of information. Perhaps the ratio of information required to information absorbed in the formative years isn't much different for the generation today than it was for our generation. I wanted to question you on your opening statement. Do you see the role of people like yourself in your organization increasing? I am perfectly content to see a simple-minded linear extrapolation of the past become the standard thinking pattern of the average employee. But it should happen at that level before we get more involved with all of the econometrics that you amuse yourself with.

A: I will make two comments about that. First, regarding the quality of the forecasts: one group of people, more than any other, have entered the forecasting business. They are the economists. They do a very simple-minded thing. They discern a relationship between some dependent and several independent varia-

bles, make some assumptions, calibrate them over historical data, then say that between these driving variables and this resultant variable, these types of things tend to happen. The easiest way to make a forecast is for the next four to five years. People don't like to change. We institute by laws a whole bunch of things that are going to reinforce the status quo. The problem is that you then make the mistake of taking that information and extrapolating out another forty years. And that's absolute nonsense. Unfortunately, there are all these screwballs called futurists who are telling us how to do it. I think about 85% of that material is garbage. To me, the key to the whole thing lies with the people that Pap talks about--risk takers. I don't like some of the material in Peters and Waterman's book, but one thing was very, very good. They made the point about people not being interested or willing to take risk. Don't expect anybody to take risks. None of us want to. The successful firms are not simply lucky in having on board a bunch of risk takers. Rather, the managements of these firms have turned it around by making it risky not to take risk. In other words, there is a payoff from being a gambler.

Recommended Readings
Introduction to Future's Analysis

General

Meadows, Donella H. and Dennis L., et. al. *Limits to Growth*. (Potomac Associates. Washington, D.C. 1972)

Bell, Daniel. *The Coming of Post-Industrial Society: A Venture in Social Forecasting*. (Basic Books. New York. 1973)

Henderson, Hazel. *Creating Alternative Futures: The End of Economics*. (Berkeley Windhover. New York. 1978)

Toffler, Alvin. *The Third Wave*. (Bantam Books. New York. 1980)

Cetron, Marvin. *Encounters with the Future: A Forecast of Life into the 21st Century*. (McGraw-Hill. New York. 1982)

Naisbitt, John. *Megatrends: New Directions Transforming Our Lives*.

Methods

Meadows, Donella, et. al. *Groping in the Dark: The First Decade of Global Modeling*. (John Wiley & Sons. New York. 1982)

Ayers, Robert. *Technological Forecasting and Long Range Planning*. (McGraw-Hill. New York. 1969)

Armstrong, J. Scott. *Long-Range Forecasting: From Crystall Ball to Computers*. (Wiley & Sons. New York. 1978)

GETTING MORE DONE WITH LESS

Richard C. Fay

I enjoyed the talks by Pap Phelps and Ross Whaley. It's difficult to follow two talks which were so impressive.

Once I had the opportunity to make an ad-lib speech. We had to draw cards for the subject. It was a day like today where speakers had taken more than their share of time. I was the last speaker and had to give a speech on the subject mentioned on the card. I looked at the card which had only one word on it--sex. I said to the audience, "Ladies and gentlemen, it's a great pleasure." The room erupted into applause and that was the end of the speech.

When I was approached about making a presentation to this group, I thought that we would be talking about something like the "Small Business Innovator," or "Project Management," or "How to Get Things Done Quickly," or "What Does It Take To Be a Capitalist When You Don't Have Anything To Start With?" Subjects that I know something about. Then I received the program from John Vance. It said, "How to Accomplish More with Less." I thought, "My goodness, if you stand in front of a group of government people and talk about how to do more with less, that's got to be the most offensive thing anyone could do!" This is just a terrible topic. But it is a challenging one and it is one that I know something about.

Ross Whaley made some points about demographic and technological trends and I propose to return to a couple of them. I cannot quantify them because I'm not in that business, but would like to consider some of the things that are going on. Let's talk about feeding an enormous new world population. How big is that population? Over the next 10 to 20 years, we're talking about feeding more additional numbers than the entire population of the world just prior to World War II. Not only are we talking about doing more in terms of feeding all these people, but we're talking about doing it with substantially less. We have fewer available chemical fertilizers, fewer biological agents and insecticides. We're talking about doing it in a tremendously more difficult way because of social restrictions.

In the next 5 or 10 years, we will probably produce twice as much from our national resources than we have in the last 100 years. But we must do it with less contaminant wastes. We are talking about raising the living standard of the world without having a war over the allocation of resources. We're talking about providing jobs without having inflation. In everything we do, we are compelled to take account of the consequences of the action.

Doing more with less is not just a topic of interest for this group of people. It is not a contemporary subject for foresters or any other individual group. It is a contemporary subject for the entire

world. It is what the world is about today: doing more with less. The people who can do more with less are going to be the people who are on the cutting edge.

Generally, these people have names. We've heard of some of the names in the preceding talks--innovators, entrepreneurs, self-starters, go-getters, doers. People who do more with less all have such names. What they do is of great value. Creativity is the enhancement of value. Entrepreneurship is the creation of value. Innovation is the identification and establishment of value. All of them have to do with creativity. I would like to emphasize the issue of creativity a little stronger than Pap Phelps. Creativity is something that everybody has because it is right at the heart of the human being. The creative process is the central identity of the human being. In my opinion, the most important thing in the creative process, more important than people, more important than management systems, and more important than style, is the ethical conviction of the person: the ability of human beings to look at themselves, come to grips with the ethical issues in life, and classify what will be done and what won't be done according to central convictions. Ethical performance must be something that people can live with, that they can be proud of. That they can reconcile for themselves. The ethical conduct of the individual is more important than anything else.

I certainly don't want to presume on anybody's religious beliefs or anybody's ethical concepts. I want to lay out, simply, something that seems to appear in most philosophical systems. There seems to be a concept of feedback attached to most philosophical thought. Such things as a stress on creative life and living guidelines provide examples. There is stress toward being reborn, toward feeding forward. Among all people there is stress on creativity because it is the central part of the human experience. The ethical concepts that support the creative process are the most important things that can be presented to anybody in considering creativity.

One could speak at some length on the stimulators for creativity. I have jotted some of them down. The daily dose of risk, independence of life, respect for details, self-confidence, respect for priorities. At the heart of the creative process, the very central point of the creative process, is the identification of opportunity.

The Identification of Opportunity

Let me say at the outset that I retired from the Federal service in 1973. I entered the Federal service in 1941 and spent approximately 33 years working for the Government. Since then, I have spent 10 years as a private capitalist. My most salient observation of the government services is that nowhere are there more committed people. Nowhere are the people more uniformly honest. Nowhere are the people more trustworthy in terms of their careers, their professional vocations. Public service is characterized by commitment, trust, and integrity. It deserves to be recognized that way and described that way.

On the other hand, we have industry. We have laws. We have legislatures

and a judicial system, and we have resource limitations and taxes. We also have government agencies which may be limitors or stimulators.

All of these contribute to the environment for creativity. Consider Figure 1, The Environment for Creativity. Consider the crowd over on the left made up of industry and the business community. It has a fairly simple role and is specialized to enhance production, identify opportunities, capitalize on them, and make them profitable. The group as a whole exists to make a profit. Specializing tends to enhance production.

In the upper center, the legislative-judicial group is generally concerned with the codification process with which to describe our ways of life and the distribution of risks which are created when individual entrepreneurs or capitalists operate. They provide the constraints. And one of the constraints is to obtain from all of the people the money to provide for the common defense to ensure the general welfare to provide for domestic tranquility, and to ensure the blessings of prosperity upon the whole.

The lower part of the central segment in Figure 1 is occupied by

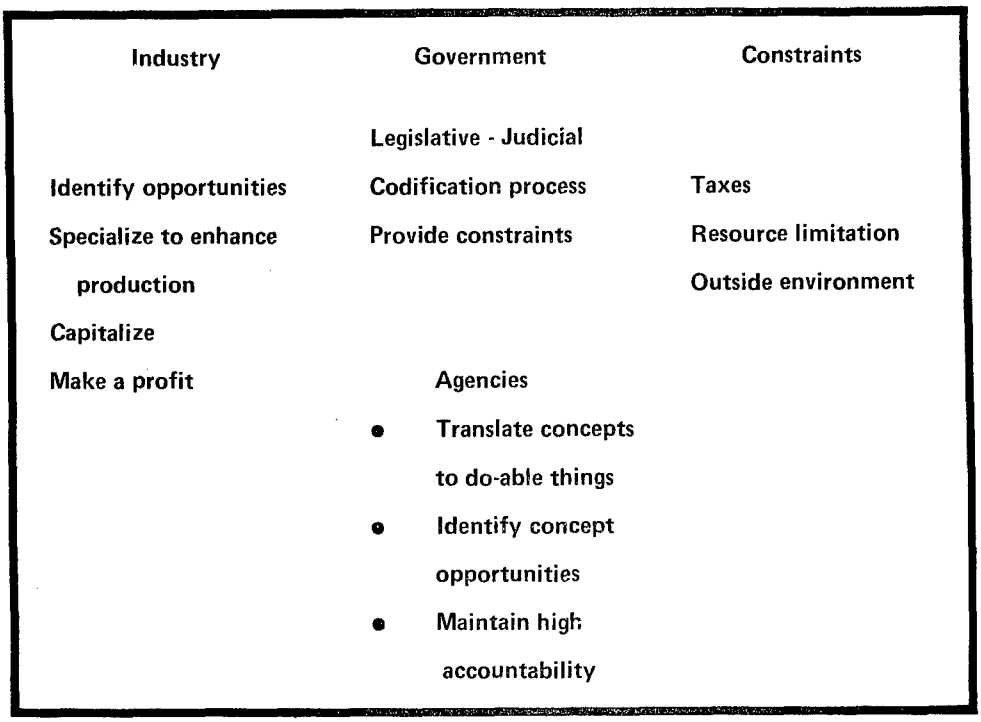

Figure 1. Environment for Creativity.

government agencies. Government agencies are generally involved in taking fairly high-level systems and concepts and translating them into performance-centered do-able things. When something is contracted out to industry, it is usually contracted out as something to buy or as a service to be rendered. The creative process of providing the integrative design between the requirements of the people and the performance centers, principally industry, is based on the excellence of the government agency system design. For instance, the government buys electronic warning systems. The military organizations then use them to provide for the common defense.

In identifying opportunities, government agencies have vertical budget lines and very high financial and operational vertical accountability. Why must the vertical accountability be high? Because the most important characteristic of many of the government functions is the trusteeship for the people. The government agency acts as a trustee. People who are trustees are good at scorekeeping. They are good at accounting. They are good at explaining. They are good at keeping track of things. They are good at allocating, if they know in which direction to allocate. Trusteeship is a very special and important function.

On the other hand, government agencies are expected to accomplish a mission. Mission statements are often across organizational levels. At each crossing, the interaction is a place where an opportunity might occur. Consider Figure 2, Opportunities for Creativity. After the leaders or the charter of the law have laid out the mission statement, which crosses every organizational element, the trustees enter into dialogue about the allocation of resources at every one of the crossing points. The dialogue, heavily oriented up and down along with accountability, is normally very restrictive. This causes it to be very difficult to do things horizontally, to go from one accountability crossing to the next, and to start in on mission accomplishment. It does not matter what is being moved across the vertical lines, whether it's a new forestry product, a new academic or teaching device, or a new tool or machine. At each node there is conflict. And because there is conflict, these cross points become opportunites. Those who live on the cross points, and that really means everybody in a organization, have an opportunity to be creative, to assist the flow, to contribute change or contribute in any one of a number of other ways to help in the mission accomplishment.

A problem arises, then, as to how goals should be identified and established. The organization sends the mission statement across the organization. The Chief announces all the mission statements so that in a hierarchically established organization, goals are normally quite heavily oriented from the top down. The Chief says, "Do this." Everybody breaks it up into pieces and says, "I'll do this." And things become quite countable and visible because they are the basis of grade determinations, promotions, and everything else. On the other hand, if the Chief should say, "The major mission accomplishment is so-and-so, and

everybody here has an opportunity to contribute," then the goal process shifts to a more democratic base. That democratic base is much more likely to increase the identity of individual goals and provide an individual creative opportunity. The top-down goal setting process will usually produce countable performance oriented goals. The bottom-up goal origination process will produce creative opportunities and innovation probabilities.

The greater the depth of the organization, the more rigid and procedural the vertical accountability lines become. For this reason, there is less likelihood that the creative process will emerge. The trustee force in very deep organizations tends to be so constraining that funding will not be available or will be eaten up by controls. Funding for opportunity will be less available for the creative goals coming from the bottom up. From a managerial point of view, one should insist on the trustee-type of operation when

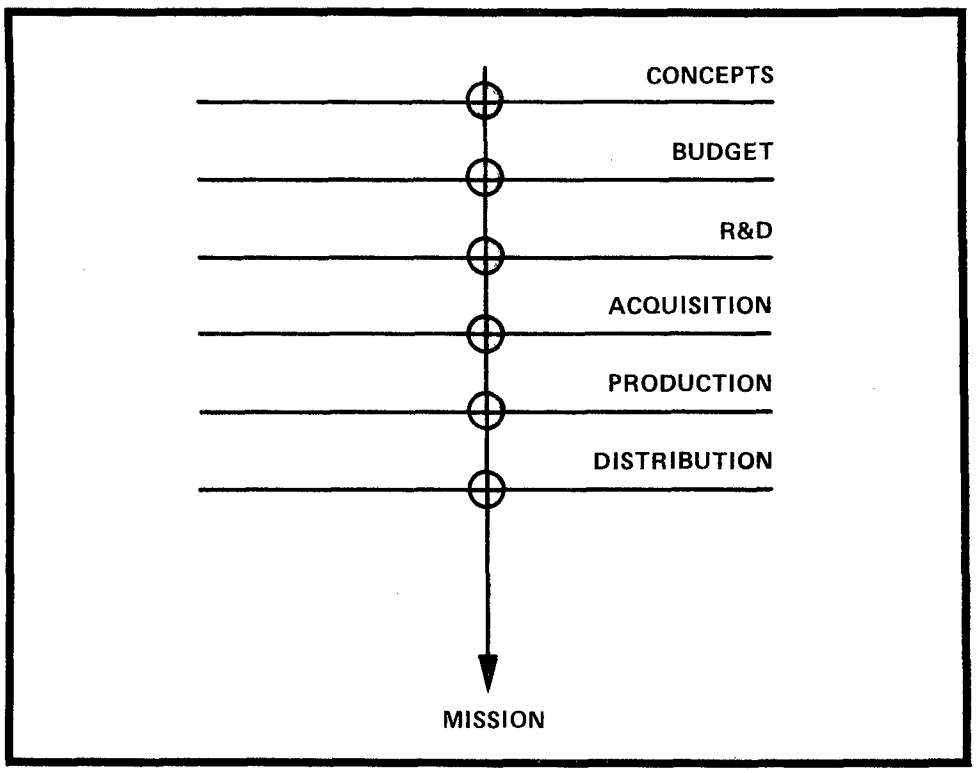

Figure 2. Opportunities for Creativity.

engaged in controlled, repetitive operations. In the private sector, we refer to things like that as "cash-out" when we're stripping the operation. As you increase the performance requirement, you tend to level the money, for as the performance goes up, you draw out the cash. In such a case, whenever you want a source of cash, you set up the operation, make sure that everybody has a defined job, that they do it, make sure that they have speed-up goals, and make sure you take the money from the organization.

On the other hand, if you want innovation, you flatten the organization. Flatten it as far as you can. Innovative organizations are characterized by being flat. There's the boss and there are the doers, and all kinds of organizational variations. There are matrix variations. There are economists and planning agencies that report to the Chief. But everybody in an innovative organization, a creative organization, is operating in an environment where the leaders and doers are not far apart.

Now let us consider Figure 3 with the two organization charts. Over here on the (A) side there is a boss, and very close to him you have many people. Now over here on the (B) side, most people are isolated from him. On the (A) side, you have creativity. With an organization chart characterized by few specific responsibilities, people are changed around. You take dollars and performance objectives and move them from people to people and take advantage of the characteristics of the individual people to do diverse things. When the various things that they are engaged in become do-able, manageable, repeatable, you move back over to the (B) type of organization.

Now in Figure 4, let us consider risk in terms of time and development costs. At the start, development costs are high and risk is high. As the system moves over, risk becomes more and more calculable, and unless you have some sort of mechanism for managing it, you get into trouble quickly. Most businesses need to have a risk assessment process. Once the goal identification has occurred somewhere in the organization, the procedures systems must be identified and described. Then a risk assessment ought to be made. One step is to establish some event probability and another is to establish event consequence.

In most situations, government or business, and particularly in small business, the most important risk that needs to be assessed is the financial overrun. In mature organizations, you can only milk the cash so much as you move over toward the more vertical type of organization. Normally there's a bleed when you do it, because of things called take-home pay, fringe benefits, tax-reduction necessities, and so on. Overruns are scary. And they must be assessed. The innovative manager must pay particular attention to the probability of an overrun.

You can have overruns in time, in schedule, in costs, and in quality. Most managers, particularly those managing innovations, are very likely to optimize the schedule (costs, time, and quality) in favor of the project. In such a case, quality reductions, schedule aberration, dollar overrun, and time threats must be

guarded against with great care. A manager is sitting on a time bomb if these things get out of hand.

Now suppose the probability of performance on schedule, plus or minus six months, is 0.8. If you want to raise it from 0.8 to 0.95, you are fundamentally talking about a resource allocation. That resource allocation may be in terms of other people, it may be in terms of dollars, it may be in procedural exceptions, or it may be in terms of almost anything that you can quantify. This process of risk adjustment leading to risk quantification is the absolute central part of managing creative people. The product of risk analysis is goal modification. These modifications can go up and they can go down. The result of the goal modification and the risk analysis is a highly focused opportunity. Failure to take advantage of this focused opportunity can cause heads to roll.

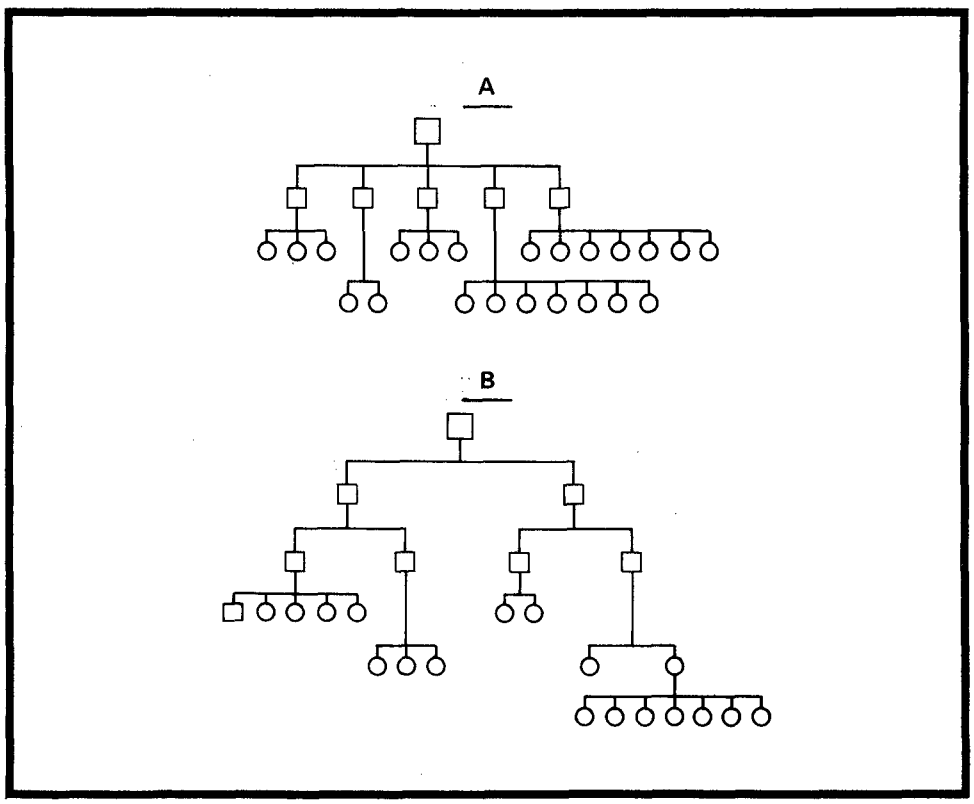

Figure 3. Organizational Creativity.

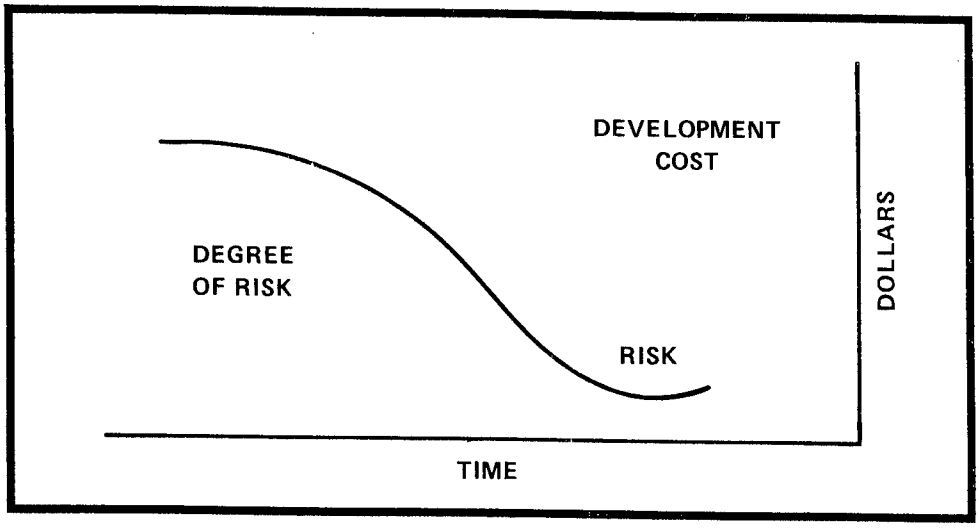

Figure 4. Risk Management.

But still, the most important characteristic of innovative organizations is that they have a clear view of their own ethical standards. They have sharp perceptions of the goals that they are trying to achieve, and they are being managed by somebody who understands the processes and production of creative work. In order to get things done, consideration of the quality of life is perhaps the most important thing.

How do you assess the quality of life? If filling out the forms that you have to fill out to get a $10,000 capital purchase is harder to do than to give an in-step increase to an employee, then you have an organization which is really screwed up in terms of quality of life. If you can't help the people get the tools to get the jobs done which they are required to do, you aren't going to get anything accomplished.

People today are interested in the quality of life and we are operating on an assumption that there's an unlimited supply of people. Somebody has told us that the war babies are having children now and that there are lots of people available for organizations. Well, the fact is we're only about five years away from old people selling hamburgers at MacDonald's instead of young people because there isn't going to be a high continued input into the work force.

Another consideration when thinking about the innovative process is that in 1981 and 1982, the number of small business failures was probably the highest the country has ever known because of the recession and difficult times. Many of the innovative people, the doers, the

system for instantaneous correction of any forest devastation.

QUESTIONS AND ANSWERS

Q: I have a question concerning the point 0.8 or 0.95 probability you referred to earlier. Is this a product of human judgment or does it result from a study of time and motion and previous events so that the precise variation can be determined?

A: It can come from the assessment process, however you have designed it. The assessment process can be based on interviews, judgments, on statistical experience, or almost anything. It's a product of your risk assessment analysis by whatever method you use. It could be, for instance, the MacDonald's hamburger manager acknowledging the existence of a problem, and the subsequent decision to start selling chicken. Or it can be a very detailed analysis of data. Smaller businesses mostly do it by the seat-of-the-pants. In a small business, you can tell that your risk assessment process is deficient when the banker calls and wants your car, besides your house, on the line.

entrepreneurs, fled into stable organizations. With just a little bit of an upturn in the economy, those entrepreneurially innovative, creative men and women are going to migrate the other way. They want to be in charge. They want to have their own businesses and do their own thing. They want the ultimate flat organization.

Innovative, high-result organizations are going to come up with some tremendously exciting ideas. One type of organization right now is the so-called RDLPM (Resource and Development, Limited Partnership). This is fundamentally the concept of the general partner, limited partner, and producing organization working together. Such organizations working with big organizations, such as the government, through participative agreements, advisory agreements, and grants can greatly increase the probability for creative requirement identification and creative accomplishment.

To bring this down to basic terms, somebody like me, who fundamentally designs electronic warfare systems, missile control systems, and things of that kind, will now be able to come to you with the design of the satellite blight recognition

POTENTIAL CONTRIBUTIONS OF EDUCATION TO TECHNOLOGY TRANSFER

Arthur Wilcox

The potential contribution of education to emerging innovations must center around a university's primary mission in the American scene. That mission is to bring order to produce the best possible future leaders of our world.

We are, in fact, in the technology transfer business, prime agents in passing on to the future the best values of the past and present. One of our major contributions to innovation is to refine new knowledge and make it more efficient. To paraphrase Matthew Arnold, it is carrying from one end of society to the other, the best knowledge, the best ideas of our time; to divest knowledge of all that is harsh, abstract, professional and exclusive; to humanize it and make it efficient outside the clique of the learned, yet remain the best knowledge of the time. Hopefully, universities are in the forefront in developing new innovations in communications to an ever broader spectrum of our society. We do have problems, however.

Universities, like other institutions in America, are in constant turmoil trying to meet the challenge of the greatest knowledge explosion in history, and concurrently, the greatest technology explosion in history. We find ourselves grasping for the right straws in a sea of new knowledge that demands to be recognized as a necessary part of university education, both liberal and professional. The challenge is confounded by dramatic changes in the whole area of technology transfer; communications between the university and its clients.

We have the same problems as do business and government in making changes. There is the tendency to go slowly and be too conservative because risk is more difficult to handle than keeping the status quo. Few people look forward to change unless change is comfortable, and this is seldom the case. There is the problem of buying expensive hardware to keep on the "leading edge" of new technology, only to find it obsolete at a time when funding for higher education is at one of its lowest points in our history. We are subject to the pressures of cyclic politics in spite of the myth that education should be detached from fads and mundane pressures.

How, then, do universities contribute to our interests? I suggest two areas for consideration: First is the traditional university campus-centered program. Second is the rapidly growing area of off-campus extension programs, "outreach education."

Traditional Education

Perhaps we will never solve the academic conflict between those who maintain that a university's role is to provide a broad liberal education and those who insist that professional competence in some narrow field is an essential requirement of university education.

We try to do both. And in both areas, the "essentials" become more numerous and increasingly complex. To many of us in the professional schools, our challenge is to strive continually to define the fundamental principles that affect our professions and refine the great mass of knowledge we have at our fingertips into the most effective teaching package. "Back to basics" is a popular expression that goes far past the three Rs. Perhaps better, we strive to go forward with fundamentals.

In this environment, there are many problems where you as field professionals have an interest. One of the most worrisome is a tendency to neglect history as a basis for training future managers. In an effort to be up-to-date and on the "cutting edge" of our times, we forget the role of historical perspective in successful management and mature leadership.

For those who aspire to become broadly based resource managers, we are sadly lacking in time to contemplate, to bring together the many snips of knowledge gleaned from brief exposure to many disciplines. We are only now beginning to put the computer into proper perspective as a tool of management and science rather than an all-pervasive subject for study. We are continually concerned with balancing the needs of huge organizations like yours against the multitude of smaller organizations whose resources, and therefore needs, may be much different from yours.

We are concerned; are we training technicians at the expense of educated citizens? Can we do both?

To what degree do we study in depth such political waves as private involvement in public service, or current but ever-changing management practices?

Is there some merit in emphasizing the American rather than English language? If writing is important, how about drafting and graphic skills?

There is no question that our students today are smarter than their predecessors. Are they more intelligent? They have infinitely more varied backgrounds. Some have superb training in science and computer skills; others have little. Can we analyze these changes from the past and change our own work accordingly?

In our professional theater, three changes seem most important although the success of change varies greatly. The most obvious is competence in modern technology for field application. This ranges from computer skills at several levels, from office records to multiple resource decision management and computer mapping, for example. Especially important to the natural resources field, where public involvement has become a major fact of life, is more emphasis on public relations, communication skills, political science, psychology, and sociology.

Finally, there is a realization that the modern resource manager can ill afford to be egocentric in the midst of a multitude of sophisticated professions. The importance of understanding the role, if not the content of many speciality areas, makes personal information storage and retrieval systems an integral part of management training, and a major unify-

ing force in training.

Universities have another role in putting new ideas and innovations into the field. That, of course, is research. Cooperative research is very much part of your game plan and its value has been demonstrated for years. At the risk of talking to those who seem to have (or had) the unlimited resources of big government, universities in America ideally combine the broadest range of interdisciplinary skills with the innovative potential of academic freedom and the huge investments in high technology equipment necessary to make major advances in innovative technology.

University Continuing Education Programs

The second broad area of university activity, and one that has more direct value to the professional fields we serve, is off-campus continuing education.

One of the most significant changes in American education, brought about by our massive growth in knowledge and technology, is the idea of lifetime learning as an essential part of American life. State universities have had extension programs since their beginnings over a century ago. A wide variety of continuing education courses, short courses, and intensive post-graduate training courses have been common in many places for many years. One of their greatest values has been to maintain close communication between the university and society in general. All of these programs are expanding at a tremendous rate in response to demand and the opportunity to use new and innovative communications technology to reach more people more effectively.

For many institutions, this growth in decentralized education to try to serve every nook and cranny of society has been the largest area of growth in the last decade. All kinds of new techniques for getting the message out are being tried. Some are now an integral and stable part of modern educational communication. Occasionally, we seem to have made a cult out of the method for its own sake. A well worn and proven example is the use of standard slides for audio-visual for the amateur and professional alike. They have all the characteristics required to get a message through: uncomplicated procedures, standard equipment, appeal to several senses, low cost, and relatively foolproof operation.

Yet recently, I saw two examples of enthusiasm for the medium carried too far. Both were twelve-screen slide presentations. In one case a simple error in projector adjustment effectively ruined the show. In another, a minor breakdown closed a public information center visited by hundreds of people for several days until an expert could be brought to the scene. In one case, our office developed a complex audiocassette training unit. We found that the people we were serving would much prefer scanning the written word to listening to a long tape. Then, only a short time later, the videotape made this procedure almost obsolete.

One of our biggest challenges is to capture the right technology for our use. In this we tend to be followers rather than leaders, and depend on industry-

funded research to come up with new ways to get our message out to a bewildering array of potential customers. In our own situation, we have had a substantial menu of technology transfer methods from which to choose. Most of them are useful in solving specific problems. Many of them are rapidly making it possible for consortiums of educational institutions to combine their resources.

1. Audiocassettes. Already a bit old fashioned, though inexpensive, they use only the spoken word, and lack the glamour of new methods. Many users prefer the time-efficiency of the written word. Few will argue that newer methods fortify the old saying that one picture is indeed worth one thousand words.
2. Videodiscs and video cassettes. Availability of playback equipment is rapidly ceasing to be a problem. These are relatively inexpensive and easy to get to the user.
3. Computer-aided instruction. This use of computer-generated instruction is widespread. Over 100 engineering colleges use the PLATO courses for undergraduates.
4. Telephone and audio-teleconferencing. The University of Wisconsin is known for its program. We use teletips, a simple telephone call which brings information about any available subject. Hospitals use this method to good advantage.
5. Cable television. A combination of live broadcast and purchased printed material, needs a large audience and broad subject matter to be efficient.
6. Slow-scan television combined with two-way telephone. The University of Idaho uses television signals with 30 second pictures via telephone.
7. Instructional fixed system television. This microwave transmission between fixed points is used by Stanford University to bring engineering instruction to 160 high-technology firms in the San Francisco area.
8. Satellite delivery. This is particularly significant with regard to multiple university teleconferencing.
9. Computer communications. Computer conferencing or electronic mail is efficient where terminals, screens, and phone connections are available.

There are vast differences in both costs and effectiveness depending on the kind of training desired, nature of the audience, access to equipment, whether one-time or on-going, and whether various forms of permanent record keeping, feedback, and monitoring are required. Most important in a tight

university economy is the way rapid changes affect long-range, low budget planning and capital investment. Your agency illustrates some of the constraints that limit application of these methods. Your personnel work is widely scattered, your locations are often isolated, and you have a wide variety of educational requirements for a limited clientele.

Not all new programs are dominated by glamour technology. Three examples may serve to illustrate some interesting developments in our own university.

State Cooperative Extension

State extension programs have a long and effective history of helping agriculture and home economics at the grass roots level. Some states have expanded their extension work into many related areas. Extension programs in land grant universities could have a very significant value to your organization. In effect, the resources of the state university are at the call of extension agents in every county of the state. It seems that larger agencies take little advantage of this service.

Teletypes are a "primitive" but very effective service of our extension office. A phone call elicits short two-minute answers to specific questions. We are working with local parks on maintenance and operations data and with the tourist industry on hospitality tips for tourist service people--your "Host" program on a local level. A committee of the National Park and Recreation Association is investigating the practicability of making park maintenance information, indexed into your Famulus language, available in the ever-improving extension computer network.

The New Zealand Experience

New Zealand has a highly regarded national park system. The service was distinguished by excellent leadership and high morale, but an obvious lack of advanced technical field competence that made uniform high performance difficult. In the early '70s, a decision was made to upgrade field personnel training in cooperation with Lincoln College, a down-to-earth agricultural school. This decision caused considerable concern on the part of field personnel who had varied technical and academic backgrounds:

1. Uncertainty on the part of field personnel about their activity to handle academic requirements, compounded by the fear of being bypassed by "bright young college kids."
2. Distrust of academically trained people.
3. Apprehension about what unknown duties would be forthcoming.
4. A general fear of change that affects traditional lifestyles.

It was my good fortune to be invited to analyze the situation and assist in developing a training program. I was able to visit with practically all senior field personnel in their parks and work with them to determine how training might be accomplished. Because the major concern of many experienced and practical field men was that they

might not be able to meet academic requirements, it was essential that field men not be put at a disadvantage in the academic setting. A major personal objective of many was to be able to work smoothly with other professionals: engineers, architects, and scientists.

Study resulted in a program consisting of a ten-year series of six-week block courses taught at Lincoln College. This series was made available with full government support to all qualified field personnel. The curriculum emphasized areas of weakness, professional awareness and purpose, public contact, professional associations, personnel management, and field engineering. It was to be directed by a man with long park experience and enjoying the respect of field personnel.

Initially there was some resistance to leaving home and the job, but ultimately the classical "line of influence" as opposed to the "line of authority" made the program work.

Ten years later it was my good fortune to return and see the results. The evidence of success were especially apparent after this long absence. It showed up in many ways:

High morale and esprit de corps.

Efficient use of manpower and materials.

Greatly improved quality of environmental management.

Close cooperation with attorneys, local governments, engineers, and scientists.

Quality interpretation as a standard function of management.

Good communications skills.

To my knowledge, this is the only instance of an all-out joint government/ educational institution effort to upgrade the training of field personnel. The New Zealanders are now preparing a long-range plan to make directed lifetime learning a continuing part of parks operation.

A Recreation Management Correspondence Course

A final example of innovative use of university resources is the recreation management correspondence course being developed by Dan Williams on assignment to our college from the Forest Service Regional office in Denver.

The need for field personnel became apparent from your program reviews. Many Forest Service employees at both District and Forest level are not aware of the recreation mission or the current state of the art in management, planning, or research. Further, many do not know how to find information and have no incentive to search for it. Resource material on recreation is sometimes hard to find within the Forest Service. In some cases it never gets to the District level, in others it is lost in the files or distribution is haphazard.

In places there are indications that experts "do their own things" without concern for national perspective. In other cases, there are regional pressures to deviate from national policy positions.

The target population for the course includes professionals and technicians at GS levels 4 to 9. A correspondence-course format was developed to overcome severe travel limitations and to provide flexible coverage of a rather amorphous and rapidly changing subject.

Course content includes policies, legal implications of management, organizational barriers between District Forest and Region, uniform understanding of FORNET and study groups in landscape management, cultural resources, facilities, off-road vehicles, trails, and operation and maintenance standards. In developing course content, the importance of having a leader with long practical field experience was clearly in evidence.

The best people in each specialty area were chosen as authors and field reviewers, and where controversy occurred, every effort was made to protect authorship.

The project has generated real frustrations, largely centered on "too many cooks spoiling the broth" and occasional personality and ego problems. Its success had been largely due to having a Forest Service regional level director in charge. He is able to work directly at the national office level and can break through the many hold ups and bureaucratic road blocks.

In several cases, there were strong regional guidelines but no national standards. Winter recreation, fee estimations, and cultural resources are examples. The course should go far in developing uniform practices in these areas.

Weak areas include law enforcement where two philosophies, moderate hardnose and soft protection of the visitor experience, compete. Trail maintenance information is twenty to thirty years old and fails to recognize some important changes in equipment and machinery. Better understanding of the RIM system at the field level is also required.

The hardest area to organize has been the administration of special uses where uniformity on the district level is most important. This program unit may be the most valuable in the long run.

There have been problems of bucking tradition in developing a new training technique, and serious issues may have been bypassed because of current politics.

The final problem has been to put field-originated materials into a university educational format to be recognized for academic credit.

This project has already received recognition by other agencies. It would have been very difficult to develop as a contract without direction by a recognized field authority. For the university, it has sensitized faculty to field operations in a way traditional research work could never do.

For your agency, I believe, it represents innovation at its best and may well open up the way to increased training efficiency in many other areas. For our university, it provides another opportunity to adjust traditional practices to meet changing economic and professional needs.

EMERGING INNOVATIONS: CONSIDERATIONS FOR IMPLEMENTATION

S. Krugman and J. W. Creighton

In science, there periodically appears a major breakthrough--a major innovation. Such innovations often have a substantial impact on a given scientific field. They force a rethinking of goals, priorities, and direction. An example is the microchip which has given us video games as well as mini- and micro-computers. In this case, virtually all of science was affected. Recently, genetic engineering has provided the biological sciences with a unique set of tools for use in overcoming a conventional biological constraint, i.e., the sexual process. The new science which is evolving is commonly called the new biotechnology, or genetic engineering.

As in the case of other major innovations, biotechnology has evolved from an already existing technological field. Foresters have long been practicing biotechnology, as have all participants in the life sciences. However, genetic engineering is new in the biotechnological field because it outflanks natural processes. Genetic engineering, at least in theory, finally provides a set of working tools for identifying, isolating, and transferring single or complex genetic units from one organism to a closely-related or even a non-related organism. Cell factories can be formulated for the purpose of producing useful chemicals, vaccines, disease cures, and even more productive plants. Wood content and its quality can now be influenced as never before.

The new science of biotechnology is actually many different sciences focused on a set of common problems. It includes biochemistry, plant physiology, botany, genetics, and even forestry. Its roots were planted over a hundred years ago, but it has flowered only in the past nine years. It now offers the greatest single-known biological process for growth productivity enhancement ever known by providing a mechanism for introducing single, positive genetic traits without necessarily disrupting desirable existing features. Its high risk is counterbalanced by very high payoff potential. There are, however, some disadvantages in that the process is species specific, requires multilaboratory treatment, and progresses in time cycles that are unpredictable. In addition, it raises major public relations problems.

The process breaks down into three basic phases. First is the identification and isolation of desirable genetic traits, then the transfer of such traits, and finally the cloning of desirable plants having the new traits. In forestry, it is anticipated that biotechnical research will focus on the following: disease resistance, gene locators, physiological stress, nitrogen fixation, photosynthesis, and denitrification. The basic techniques that need to be improved or developed include cell fusion, direct DNA transfer, and single cell selection (somaclonal).

The Forest Service is currently conducting exploratory research in each of these areas. Emphasis has been placed on the initial development of appropriate techniques for use with trees. In addition, the existing botanical, genetic, scientific base for a forestry biotechnology effort is being expanded. The research is currently concentrated in two centers, and these are supported by an aggressive extramural program. The scientific staff is multi-disciplinary and is being continually strengthened by additional skills. The effort is very different from traditional Forest Service programs and there is no guarantee of success. If it succeeds, the ability to respond to biological as well as technical changes will be greatly increased. Potentially, genetic engineering could add at least $18 billion to agricultural productivity by the year 2000. A more modest productivity increase can be expected in forestry, but the potential for gain is greater since the genetic improvement is not as advanced as it is in agriculture.

A common meaning of technology transfer is the adaptation of existing knowledge or technology to serve a new purpose, or its adoption and use by a new group of people. An extension of this meaning by a manager might be,"Let's find out what all our resources are and then put them to more effective use." This, and related meanings, are the foundation for most of the Federal Government technology transfer effort. Technology transfer programs tend to be built around the idea of sharing the knowledge or resources for the benefit of the total population.

It is all too easy to lose sight of technology transfer needs as an idea or concept works its way from a dream to a usable product. Each of us tends to think of technology transfer in a narrow way, especially when we consider our own specialized fields. We think of it as the direct movement of our newly generated information or methodologies to someone who will put it to use. Even though we may spend a great deal of time acquiring knowledge and learning how to apply it, we do not think of this as technology transfer. Of course it is. We tend to forget that usable products have been derived from basic concepts and ideas which have progressed through many transfer steps.

Evolutionary transfer steps are taking place right now. To the dreamers, the specialized scientists, the adopters, adapters, and finally the users, the steps must take place as a technology emerges. As a technology becomes useful, particularly after it has been embodied in a useful product, failures along the way tend to be forgotten. We look for successes and we transfer successes. However, during the early stages of the emergence of a technology failures are as important as successes. To the scientist who tries an experiment which produces negative results, the result is just as much a part of the knowledge of the field as are positive results. What does this mean to the research and development organization manager, and to the managers of the various organizations which constitute the marketplace for the research and development organization? While it is imperative for the R&D manager that he

produce something which may be used by somebody else, it is equally important to give attention to the process of generating knowledge which has resulted in those useful products.

We are indebted to Lowell Steele for pointing to seven misconceptions managers harbor about technology . His formulations are pertinent to all managers who are concerned with innovation, and are particularly relevant at policy making levels in organizations. Using the example of the development of biotechnology in the Forest Service, we shall illustrate these misconceptions in terms of kinds of barriers confronting an emerging technology.

Misconception 1: The criterion for determining the implementation of a technology should be "best possible," not "good enough."

As Steele states, "Much of what R&D does is develop solutions which are less than technically elegant, but that reflect the value for which customers are willing to pay." The development of methods as well as products from forestry genetic engineering has a time lag which is perhaps longer than for other products. The length of this lag depends on whether genetic-caused modifications are to be induced in the characteristics and quality of fiber, or whether the intent is to produce higher quality, lower cost, saw-log products. Since the time needed to develop the characteristics desired will be lengthy for either purpose, continued support from taxpayers for research carried on by a public organization is difficult to maintain. Successful applications, even though not perfectly developed, may be needed to ensure continuing support to permit later refinements for a private sector timber company. It is thus mandatory that any genetic modification program be oriented toward "good enough" to bring a recognizable benefit. Otherwise, long range genetic research may die for lack of support.

Producing faster-growing trees and higher quality wood are certainly objectives of the genetic engineering effort. But there are also short range goals that could provide immediate and useful benefit. The development of new methods for the identification and selection of disease resistant trees could have immediate application, and the benefits would be measureable in a relatively short period of time. The increased production of selected and known silvichemicals by the new biotechnology is also a current goal.

It must be emphasized here that in general, there is a great difference between the time required for developing modifications in many plants with which the Forest Service deals, as compared with agricultural products. Of course, the possibility exists for quick results from forage plant modifications, and there is also the possibility that genetic engineering could fairly soon bring about a shift in the production of cellulose fiber from pulp wood to some other kind of plant.

If either of these possibilities were to be realized, the economic consequences--costs savings and benefits--would be more decisive in influencing managers' attitudes toward genetic engineering R&D in the Forest Service than any number of

specific discoveries from the sciences.

Misconception 2: "Good enough" is determined by careful rational choice, not by what consumers accept or expect.

Researchers are apt to disregard the fact that it is the consumer who ultimately cracks the whip. In the private sector, the research manager who is not aware of existing or potential consumer demand is not likely to survive. In the public sector, it is often difficult to identify the consumer. Typically, the consumer is not the sponsor who provides the funds. The sponsor is only the intermediary between the ultimate public user cohort, which includes private sector business establishments. Because the linkage between the researcher and the ultimate user is not close, the urge is strong to do what we want to do rather than what the ultimate consumer is likely to support.

Like forestry genetic engineering, NASA was confronted with the imperative of maintaining public support of space programs. The agency had to expend considerable resources developing and publicizing spinoff. The Forest Service might be well advised to follow NASA's example and alert the public to the benefits, actual and potential, of its genetic engineering programs.

The foundations for such a campaign have already been laid. For many years the forest genetic research programs have identified priority problems jointly with the various groups. This joint priority-setting procedure is now well established.

Misconception 3: Most innovations are successful.

As noted by Steele, "This distorted perception arises to some extent from the natural tendency of both companies and individual managers to publicize successes while allowing failures to die quietly. In addition, the data needed to analyze a failure even for an internal study are usually skimpy and difficult to assemble.

In reality, the failure rate of innovations is high. This fact reflects the intricacy and interdependence of advances in technology. Any attempt to introduce a technical capability must demonstrate that the capability really does offer substantial advantages. Most of the time, however, a new technology either is not enough of an improvement over the old to warrant the effort and the risk it entails, or it has problems and deficiencies that were not apparent initially."

The excitement and enthusiasm which often accompany a new technology are almost certain to prevent some of the deficiencies from being recognized early. It takes managers of some experience to be aware that unforeseen consequences will arise. They need to be cautious, and stick to the axiom familiar to every manufacturing executive: "If you're not sure--don't."

The need for caution is a stimulus for effective evaluation in product introduction planning. Under threat from innovative techniques, existing technologies are not infrequently modified to bring them up to scratch, and the upgrading actions may be so extreme and thoroughgoing as to constitute a new

technology. This may not apply extensively to genetic engineering research, but almost every R&D manager has seen it occur in the applied research field.

There is, furthermore, the question of who determines if an innovation is successful? Researchers may feel that anything that contributes to the knowledge and the subject area is *ipso facto* successful. The administrator charged with turning out products that really offer substantial advantages cannot afford to take such a cavalier position.

Misconception 4: What you do not know about a new technological advance is probably good: Murphy's Law rarely applies.

Every manager is aware of Murphy's Law or its variants:

- If something can go wrong, it will.
- If there's no way it can go wrong, it will anyhow.
- There's never time to do it right, but there's always time to do it over.
- Nature always sides with the hidden flaw.

All of us know of others. It is not possible to know everything about a new technology when it is introduced. On the other hand, it is possible that well-directed research efforts can reduce the number of Murphy-type snafus.

Because of Murphy, when a decision is made to go ahead with the new technology, there will be doubts. But in case of doubt, make the case for adopting a new technology sound convincing. You may get away with it.

We, too, have our doubts and deep concerns about the likely success of a new biotechnology as applied to forestry. But then, we had similar concerns when conventional genetic practices were applied to forest trees. If we take each step one at a time, and not forget our previous experiences, we should be able to eliminate many negative impacts of Murphy's Law on the program.

Misconception 5: In most instances, radically new technology will turn out to be more desirable than advances and extensions of conventional technology.

The evidence is overwhelming that most technological advances are of a developmental nature and originate in the private sector. The research departments of many corporations are confined to efforts of design modification to, or part-by-part changes in the product. As a matter of policy, basic research and work on drastic innovations is left to others. Many industrial leaders frankly admit that "it's much less expensive to buy, borrow, or steal than it is to maintain basic research facilities." The Japanese government has traditionally concentrated on promoting the transfer of successful existing technologies rather than investing in new ones. This, it has been suggested, may have been a factor in their losing World War II, but there is still some questions as to who is winning the peacetime competition.

The place of genetic engineering modifications in forestry has yet to be proven. Possibilities for application are so exciting as to make investment worth-

while. Some successes are already on the horizon, but so are some attendant questions. For instance, will genetic changes to increase disease resistance be able to surpass the efforts of an already well-developed industry devoted to the control or prevention of plant diseases?

Questions such as this are prompting us to move in the direction of incorporating the new technology with existing proven genetics programs. Managed in this way, the new technology will be seen as a logical but needed extension of current forest genetic development.

Misconception 6: The success of a new technology rarely depends on the adequacy of available infrastructure.

Again we quote from Steele: "A good practice is to assume complete technical success and then ask the question, 'Now what has to happen to get this technology widely adopted?' "

For each field which may be impacted by genetic engineering, there will be infrastructure questions to be addressed before widespread adoption becomes possible. For instance,

- What additional education and training will be required before the technology can become useful?
- What existing technologies and support fields are in a position to lend support?
- What existing institutions or groups can be expected to oppose?
- What is to be done to prepare the public for innovations resulting from genetic engineering?
- What sorts of legislative barriers are likely to be put up?
- How can potential opposing vested interests be influenced against initiating or supporting such barriers?
- What are the long-term biological consequences of the new technology, and in particular, what impact is it likely to have on natural systems?

Many of these issues cannot be addressed until we can screen and test products of the new biotechnology. But they must be kept under review, even as we develop this program. At this time, we are putting effort into exploring concerns about the potential impact on an array of social, legal, and even moral questions. We are also looking into the education and training needs of the current, as well as the next generation of scientists.

Misconception 7: Making a technology effective doesn't involve developing routines and standards, achieving greater precision, and working under constraints.

When considering innovation, we tend to look at the gold and disregard the acid, to think that something is so good that the flaws in it will work themselves out. Millions of dollars have been lost by consumers because of the unwillingness of the computer industry to standardize and modularize both hardware and software. Convinced that computers are

here to stay, many firms in the industry have acted on the precept, "Let the customer adapt to what I am producing." Some have paid the price.

Genetic engineering has yet to develop experimental and testing procedures for predicting replications and standardizing results, for establishing standards and thinking through enforcing practices to the point where they can be applied, and for structuring the management of the new technology.

Where Do We Go From Here?

We have been discussing the seven misconceptions in terms of the evolution of genetic engineering. But the principles presented apply to all technology emergence. Both in managing emergence and in managing resulting technological resources, an understanding of the entire change process can result in vast economic gain.

Those in research fields tend to be impatient with users for failing to take early advantage of new technologies, frequently not understanding that the experience of the user supports beliefs in the high rate of innovation failure and the adage, "If you don't know–don't." On the other hand, the user community tends to be impatient with researchers for failing to devote sufficient resources and effort toward the "real" needs of those in producing segments of organizations.

Neither deserves blame, for the incentives generated by professional and organization peers not only tolerate but encourage such views.

It is the function of managers in the total organization to bridge the gaps between technology generators and users with incentives which cause researchers to seek active participation by users in their research and development work, which cause users to demand from researchers beneficial results, and which cause both to feel rewarded from acceptance of change contributions wherever generated.

People in organizations respond to perceived reward. If primary rewards are established as incentives for researchers and users to cooperate, to introduce, adapt and adopt economically beneficial innovations from whatever source, managers will see the process of innovation accurately and not as colored by various misconceptions. We return to Steele: "Although the odds are very high that any given innovation attempt will fail, companies must innovate in order to survive. The benefits of the occasional successes are enormous--not only in direct rewards to the innovator and gains to society, but also in the ripple effects generated by the process itself. It goads conventional technology into improvement, stimulates adaptability to change, leads a company toward greater self-awareness of its strengths and weaknesses, and responds to one of the most powerful human drives--the urge to try something new."

Lowell Steele, "Manager's Misconceptions About Technology," *Harvard Business Review*, November-December 1983, pp. 133-140.

MATCHING TECHNOLOGY TO CUSTOMERS' NEEDS

Bob Frankenberg

I regret that I was unable to attend the earlier parts of this symposium. I arrived yesterday evening just in time to have dinner with two of your speakers, Milon Essoglou and Dick Fay, and your chairman, Wally Creighton. From the evening's discussion, I gained some knowledge of preceding parts of this symposium and hope that what I am about to introduce to you will fit nicely into the symposium's objectives.

I understand that Ross Whaley referred to Peters and Waterman's book, *In Search of Excellence*, and their contention that the environment in some companies makes it risky not to take risks. Perhaps that is the perception of some, but I believe that at Hewlett Packard risk is not thought about very much. Rather, there is a widespread understanding that the health of the company and the well-being of the employees depends, to a great extent, on being leaders in the industry. To maintain that leadership, Hewlett Packard must be aggressively innovative.

This aggressive pursuit of innovative solutions to problems is not precisely spelled out in the objective statements of the corporation, but the environment for it is certainly encouraged as you can see from the following framework statement for the Hewlett Packard corporate objectives:

"The achievements of an organization are the result of the combined efforts of each individual in the organization working toward common objectives. These objectives should be realistic, should be clearly understood by everyone in the organization, and should reflect the organization's basic character and personality.

If the organization is to fulfill its objectives, it should strive to meet certain other fundamental requirements.

First, there should be clearly capable innovative people throughout the organization. Moreover, these people should have the opportunity through continuing programs of training and education to upgrade their skills and capabilities. This is especially important in a technical business where the rate of progress is rapid. Techniques that are good today will be outdated in the future and the people should always be looking for new and better ways to do their work.

Second, the organization should have objectives and leadership which generate enthusiasm at all levels. People in important management positions should not only be enthusiastic themselves, they should be selected for their ability to engender enthusiasm among their associates. There can be no place, especially among the people charged with management responsiblity, for half-hearted interest or half-hearted effort.

Third, the organization should conduct its affairs with uncompromising

honesty and integrity. People at every level should be expected to adhere to standards of business ethics, and to understand that anything less is totally unacceptable. As a practical matter, ethical conduct cannot be assured by written policies or codes. It must be an integral part of the organization, a deeply ingrained tradition that is passed from one generation of employees to another.

Fourth, even though an organization is made up of people who fully meet the first three requirements, all levels should work in unison toward common objectives, recognizing that it is only through effective, cooperative effort that the ultimate in efficiency and achievement can be obtained.

It has not been our policy at HP to have a tight military-type organization, but rather to have overall objectives which are clearly stated and agreed upon, and to give people the freedom to work toward those goals in ways they determine best for their own areas of responsibility.

Our HP objectives were initially published in 1957. Since then they have been modified from time to time, reflecting the changing nature of our business and social environment. This booklet represents the latest updating of our objectives. We hope you find them informative and useful."

DAVID PACKARD
Chairman of the Board

WILLIAM HEWLETT
Vice-Chairman of the Board

JOHN YOUNG
President and Chief Executive Officer

The above might appear as an objective statement, but it is not the statement of HP objectives. I will present the corporate objectives to you later if there is interest and time permits. First, however, I would like to discuss some of the things we do at HP to aggressively pursue innovative solutions to customers' problems.

I am the general manager responsible for the low-cost and midrange portion of HP's Commercial Computer System product line, the HP-3000. This product line accounts for roughly 25% of HP's total revenues and is the second most popular general-purpose business system in the world. All of the systems available in this product line were introduced within the last two-and-a-half years. Within the next two years, all current systems will be replaced by newer, more powerful and less expensive systems. We have been doing this since the inception of the product line and see no end in sight to the need to continue this rate of innovation while providing compatible upward growth for our customers. To say that innovation is our life blood is absolutely true.

I understand that Dick Fay stressed the flattening of an organization to encourage innovation, and that the fewer the steps between the individual contributors and the top manager the greater the chances for innovative approaches. Hewlett Packard is in complete agreement with Dick Fay on this point. We are well

aware of the studies that show that the majority of the innovations which become successful in the market come from small companies. You might ask, then, how it happens that HP is well known for its innovations when, with sales over $4.5 billion, it can hardly be considered small.

Hewlett Packard's policies toward growth have strongly emphasized maintenance of the "small" atmosphere through the creation of divisions. When a division reaches a critical size (greater than 1,000 to 1,200 people), it is encouraged to split into two smaller entities. It is this process that has created over 50 divisions and operations in HP. Each division or operation concentrates on a particular market, product, or technology area, with the objective to provide the very best solution to customers' problems within its chartered area. Each entity is like a small company with product development, marketing, manufacturing, personnel, finance and quality assurance functions, and is free to pursue its charter with a high degree of autonomy.

This does, occasionally, result in conflicts between divisions which are resolved either by the division managers involved, or by group and corporate management. These rare conflicts are a small price to pay to retain the small team atmosphere so essential to a healthy, innovative environment. By charging a small group of very capable people with the full responsiblity for a product line's success, one creates an environment where an individual or small team can make a big difference, and people know they are the only ones who can make it happen.

There's nothing quite like necessity to spur invention. I might add that it's really quite exhilarating to see this in action. There is no finer feeling for an engineer than to see his or her work result in a successful product and see that product make a real difference in the success of a business. This is much more likely to happen and be noticed in a division with sales of $100 million per year than in a company that does $4.5 billion per year.

Let us now turn our attention to the process of creating innovative solutions to customers' problems. If you allow me to define a customer as anyone who spends something of value to "buy" a service or product from you, we arrive at quite a different view from the conventional definitions. In this sense, each of you is my customer at this moment, spending a very valuable resource--your time--for my service information. For me to provide you with a good service, I need to know what problems you would like to solve and how my information might be applied to those problems. That is, I need to have close contact with my customers' needs, ideally understanding them as well or better than my customer does. Everyone in this room has customers in this sense, and everyone in this room is a customer for many services on the job and, of course, as an individual consumer. Often the resource expended is quite intangible.

Examples of intangible, dear resources include reputation, trust, career, health, and ability to respond to other demands. Putting these intangible but clearly vital "resources" at risk for

another's service or product is a trade-off we all make every day. HP believes that only by truly understanding our customers' problems can we create products and services that solve these problems, and earn us the priviledge of having those customers spend their tangible and intangible resources for our solutions. This definition of a customer applies internally as well as externally. The person on an HP production line is the customer of the person before, and the next person on the line is his or her customer. With each person striving to please the customer in better and more effective ways, we create an atmosphere where each person is striving to innovate, and where each person is an important part of the overall process and not just a worker collecting a paycheck.

When HP developed products only for use by engineers, learning about the customers' needs was relatively simple. You talked to the engineer at the "next bench." He or she had measurement and instrument control problems that could not be solved without a new instrument, controller feature, or entirely new system. This "next bench syndrome" combined with occasional trips to visit outside customers (e.g., when a new product was introduced, or casual meetings at trade shows) gave design engineers excellent insight into the needs of customers. As we have expanded into products that serve business, government and consumers, our "next bench syndrome" had to be enlarged to include new ways for our designers to learn about customer needs, likes, and dislikes. Let me give you some examples of these methods:

1. Attending user group meetings and presenting a paper, or sitting in on an informal session with users, learning about their concerns.

2. Visiting customers and interviewing users, managers and system administrators. One of our divisions does 100 such visits before completing the initial or investigation stage of a development project.

3. Customer surveys. Our Computer Service Division, for example, surveys all customers who have service contracts each year and shares the results with the product divisions.

4. Personal visits. I spend approximately 15% of my time with customers.

5. Inviting customers to our factories to visit with our Research and Development (R&D) and Marketing teams and discuss their requirements.

Using these and many other methods, we search continuously for customer problems that need to be solved, improvements that need to be made, and problems for which there are no solutions today but could be tomorrow. The results of these searches are cataloged and used to guide our research and development efforts so that they are "doing the right things." We believe that it is every bit as important to have R&D do the right things as it is to have R&D do things right. Doing the right things right means solving the problems your customers need to have solved. Doing things right means providing a high quality solution.

I'd like to share with you a process that we apply to a wide range of prob-

lems, including selecting products to develop. We call this process "TQC" which stands for total quality control. Quality in this sense means "fitness for use," and includes all aspects of the product or process, not just reliability.

As you can see from this diagram, TQC starts with the definition of an issue. The second step is to figure out how to measure the important aspects of the issue using what we call PPM, or Process Performance Measures. The process that generates this issue is defined in sufficient detail to permit understanding, but not in so much detail that one can't see the overall flow on one piece of paper. A team of people who are involved in the process or have learned a great deal about it (e.g., from customer visits, etc.) get together in an informal session and brainstorm what this process might be if it were perfect; what's inhibiting this process from performing better; and what might accelerate it to better performance as measured by the PPM? I call this "imagineering," an idea and a term I borrowed from Bill Conway, former CEO of the Nashua Corporation.

Accelerators and inhibitors are classified into major categories and arranged on a "fishbone" diagram showing major categories as trunks, and subclasses as branches. Data gathered to support or deny the hypothesis of the brainstorming session is stratified and looked at in many different ways to ensure that all aspects of the issue are examined. Often this results in a sub-issue being defined, and the process is repeated. This goes on until one gets down to the verified basis of the problem (there may be several) that can be acted upon.

When TQC is applied to product development, it often yields surprising results. Frequently, the problem is not what you initially thought it was. Had you acted on the original issue, you would have created a product or service no one really needed. But TQC has also been successfully applied to research projects, development projects, management processes, service products (yielding the best service for computer systems in the industry according to Data Pro and several other surveys), production processes, and in a host of other areas. I hope I have tweaked your interest sufficiently for you to want to apply it in your agency.

QUESTIONS AND ANSWERS

Q: How do you measure the performance of your scientists and engineers?

A: This is very difficult to do correctly and objectively. We have a formal evaluation of performance annually for all employees, including engineers and scientists. The key overall criterion applied is contribution to the success of the project being worked on. Specific areas evaluated include demonstrated technical results, judgment, creativity, ability to work in a team, perseverance, willingness to extend oneself, and keeping commitments. There are several other aspects that are evaluated which don't spring to mind right now. If you'd like, I'll have that information forwarded to you. We also apply a grading system to projects. One that is done on time and right gets an "A," one that is right but late gets a

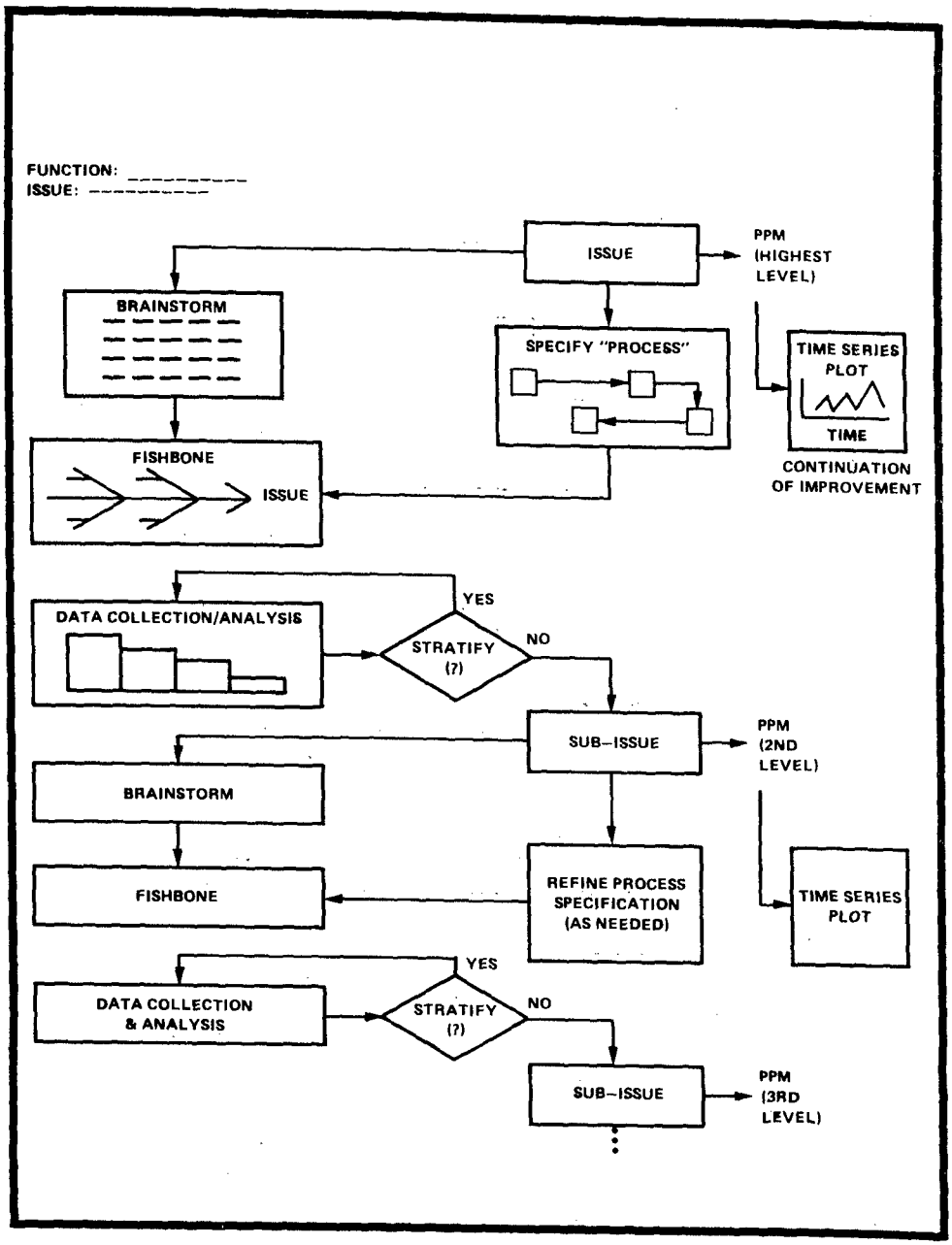

Figure 1. TQC Methodology.

"B," and one that is wrong and early or late an "F."

Q: What types of educational assistance are available to scientists?

A: HP pays all fees, books, tuition, etc., for all classes that relate to a person's job. Many people join HP right out of college with a bachelor's degree. These people are strongly encouraged to pursue a master's degree either through Honors co-op programs, attending local universities, or by taking videotaped or video-teleconferenced courses offered in all HP plants. These are also paid for by HP. HP also lets people know that we realize that the half-life of an engineering education is about four to five years, and that employees are expected to take advantage of the educational opportunities provided to keep current. We also provide a research fellowship program to which engineers can apply. If selected, they attend school full time (usually to pursue an advanced degree or to cross-train into a new career area), receiving 75% of full pay, and all school costs. One of our more innovative programs allows technicians and production workers to pursue a four-year degree in Engineering or Computer Science. If selected for the program, the individual can work as little as half time and receive full pay if carrying 12 or more semester hours and maintaining a B average or better. Selection for the program is based on current job performance, school grades in classes taken on their own time, and appropriateness of the chosen curricula. This program is only offered in one division of HP at this time.

Q: What other ways are used to develop people?

A: We encourage engineers to work in several different areas during the early part of their career. It is not unusual to be hired as an R&D engineer, work in R&D for several years, move into Manufacturing, Marketing, Product Assurance, or Management Information Systems for several years, then come back into R&D. We believe that this makes an engineer much more well rounded, gives a better understanding of what makes a product reliable, supportable, manufacturable, and useful to the customer. It also affords the opportunities to get to know people in these areas, and to become more effective in getting things done in cooperation with these other teams. We have begun a similar program of exchange with our central research labs (HP Labs) to give people in product divisions the chance to do more research-oriented work, and the people in our central labs to learn what it takes to make successful end products.

Probably the most important way in which we develop people is with one-on-one counseling and mentoring. All new engineers hired are assigned a mentor who shows them the ropes, helps them to learn the tools and "tricks of the trade," and acts as a sounding board for technical ideas and problems. The most vital link in the development process is the first line supervisor. For engineers, this is the project manager. A great deal of the project manager's time is spent in scheduling training, reviewing individual progress in informal one-on-one sessions, and setting personal development objectives as well as job objectives.

Another key, I believe, to developing engineers to their fullest is to give them complete responsibility for a product over its entire life cycle. Ideally, the engineer who does the original design keeps responsibility for it as it is developed, debugged, introduced into manufacturing, introduced to the market, manufactured in volume, and eventually "obsoleted." This philosophy helps ensure that the right things are done at all stages, as there is no "fence" to throw an incomplete job over for someone else to fix. This is not always possible, as people get promoted, transferred, or change career fields, but we try to do this with every engineer.

Q: What do you look for when interviewing college candidates?

A: The main things I look for are intelligence, enthusiasm, and the ability to get things done. Intelligence measures are relatively easy to obtain from a combination of grades and questions related to the individual's major. I gauge enthusiasm by the person's demeanor, preparation for the interview, and the kinds of projects the person would like to do if given the opportunity. The ability to get things done well is gauged by the person's performance in things they have chosen to do.

Q: You've mentioned informality a number of times. What are some of the things you do to encourage it, and why is it so important?

A: We believe that informality is a key element of good communication, and that good communication is an essential element of success in everything we do. Informality is encouraged in many ways. Everyone uses first names even with top managers. Bill Hewlett and Dave Packard are known to everyone as Bill and Dave, and so it is with all other managers. If you walk around an HP facility, you'll find office spaces separated only by low partitions. I challenged a visitor once to find the general manager's office by the appearance of that office. He wasn't able to do it. The "office" he chose turned out to be a conference room arranged to look like an executive's office for a sales training film we were shooting at the time. The offices are set up this way to encourage people to communicate easily without the barrier of a secretary guarding a closed door. Another form of informal HP communication that has become quite well known is MBWA (Management by Wandering Around). Managers walk around in a facility and stop by an area to chat with people to see how things are going. It's amazing how much you can learn just by talking with the people who are doing the work!

Q: Do you allow people to work at home?

A: Yes, we do, although not as a general rule. At times it is more productive to work at home especially when the task demands complete concentration and is harmed by interruption. I think the basic attitude at HP on this question for engineers and other professionals is that as long as you are meeting the objectives we have agreed on we aren't going to keep track of how many hours you work, what time you come to work, and what time you leave. We offer flex time to nearly all our employees. This makes it easier for people to deal with commuting,

personal preferences, and other concerns. The basic message in these policies, and many others at HP is: "We trust you." We believe that people want to do a good job, work hard, and be successful. I have found that this trust is rarely misplaced, and that giving people the freedom to work their own hours usually results in people working more hours than if you held them to a rigid time schedule. Everyone is, of course, expected to be present at meetings, participate in project reviews, and meet deadlines.

I think that we have taken a significant step towards increasing the ability of people to work at home. For a high percentage of the engineers in HP's computer group, we have provided personal computers and modems that permit working on projects at home, learning how to use these new tools, and linking into our internal data processing systems, data communications, and electronic mail network. Homework of this kind has resulted in a significant increase in productivity on two projects I've been heavily involved in, and, I'm sure, on many others thoughout our computer divisions.

Q: How do you go about making sure that people do the right things right?

A: Let me see if I can illustrate the approach by giving you a sample of the things we do.

It starts with selecting good people, which gets us back to an earlier question about recruiting. Getting the right people with the appropriate skills, experience, and interest is absolutely vital to success. The next step is setting objectives. This is an iterative process that incorporates the business objectives, project objectives, product objectives derived from customer requirements discussed earlier, and the individual's abilities and personal objectives.

Once the objectives are agreed upon, the next step is making sure the tools and methods are in place to do the job properly. For engineers in the computer area, this might include good development systems, appropriate instrumentation, simulators, test facilities, and so on. Properly equipped engineers are far more likely to do things right. For example, by methods I mean derating methods for electronics components to assure reliability, documentation standards to ensure that the design information is correctly captured and understandable to others, coding standards to ensure that software is properly designed for future enhancement and maintenance, etc. By employing the best tools and methods, our aim is always to do it right. As this does not always work, we test the product exhaustively. For hardware, this means grueling environmental tests beyond the specifications we certify to customers.

Many divisions in HP have adopted a concept which we refer to as "strife testing." In this type of test, the product is, for example, subjected to higher and higher temperatures until a failure occurs. This failure is then analyzed, corrections are made to the design or part, and the process is repeated on corrected versions of the product until the margin in that particular parameter is well beyond specification.

For software the process is more

difficult. Here we employ peer-group design reviews, certification tests, and system reliability tests. We are constantly experimenting with ways to improve both hardware and software testing effectiveness. Whenever we find a problem, we ask ourselves what caused it, and how it could be avoided in the next product. This information is used to improve the design methodologies with the goal of doing it right.

Following are the Hewlett Packard corporate objectives:

1. Profit. To achieve sufficient profit to finance our company growth and to provide the resources we need to achieve our other corporate objectives.

In our economic system, the profit we generate from our operations is the ultimate source of the funds we need to prosper and grow. It is the one absolutely essential measure of our corporate performance over the long term. Only if we continue to meet our profit objective can we achieve our other corporate objectives.

Our long-standing policy has been to reinvest most of our profits and to depend on this reinvestment, plus funds from employee stock purchases and other cash flow items, to finance our growth.

Profits vary from year to year, of course, reflecting changing economic conditions and varying demands for our products. Our needs for capital also vary, and we depend on short-term loans to meet those needs when profits or other cash sources are inadequate. However, loans are costly and must be repaid. Thus, our objective is to rely on reinvested profits as our main source of capital.

Meeting our profit objective requires that we design and develop each and every product so that it is considered a good value by our customers, yet is priced to include an adequate profit. Maintaining this competitiveness in the marketplace also requires that we perform our manufacturing, marketing, and administrative functions as economically as possible.

Profit is not something that can be put off until tomorrow; it must be achieved today. It means that myriad jobs be done correctly and efficiently. The day-to-day performance of each individual adds to--or subtracts from--our profit. Profit is the responsibility of all.

2. Customers. To provide products and services of the highest quality and the greatest possible value to our customers, thereby gaining and holding their respect and loyalty.

The continued growth and success of our company will be assured only if we offer our customers innovative products that fill real needs and provide lasting value, and that are supported by a wide variety of useful services, both before and after sale.

Satisfying customer needs requires the active participation of everyone in the company. It demands a total commitment to quality, a commitment that begins in the laboratory and extends into every phase of our operations. Products must be designed to provide superior performance and long, trouble-free service. Once in production, these products must be manufactured at a

reasonable cost and with superior workmanship.

Careful attention to quality not only enables us to meet or exceed customer expectations, but it also has a direct and substantial effect on our operating costs and profitability. Doing a job right the first time, and doing it consistently sharply reduces costs and contributes significantly to higher productivity and profits.

Once a quality product is delivered to the customer, it must be supported with prompt, efficient services of the same high quality.

Good communications are essential to an effective field sales effort. Because of our broad and growing line of products, very often several sales teams will be working with a single customer. These teams must work closely to assure that the products recommended best fulfill the customer's overall, long-term needs. Moreover, HP customers must feel that they are dealing with one company, a company with common policies and services, and one that has a clear understanding of their needs and a genuine interest in providing proper, effective solutions to their problems.

3. Fields of Interest. To build on our strengths in the company's traditional fields of interest, and to enter new fields only when it is consistent with the basic purpose of our business and when we can assure ourselves of making a needed and profitable contribution to the field.

Our company's growth has been generated by a strong commitment to research and development, and has been accomplished in two ways: first, by providing a steady flow of new products to markets in which we are already well established, and second, by expanding our technology into fields that are new but related to our traditional ones. The evolution of the HP product line is a reflection of this two-dimensional growth.

Our first products were electronic measuring instruments used primarily by engineers and scientists. In time, we extended our range of products to include solid-state components and instrumentation for the fields of medicine and chemical analysis. Recognizing our customers' needs to gather and assimilate large quantities of measurement data, we developed a family of computers to complement HP measuring devices. By linking measurement and computational technologies, we gained added strength in our traditional, technically-oriented markets and began to serve the broader needs of business and industry.

Today, the interactive capabilities of Hewlett Packard instruments and systems enable our customers--decision makers in business as well as in technical fields--to gain ready access to essential information, to put it into meaningful form, and to use it effectively in improving the productivity of themselves and their organizations. Helping these customers achieve better results is the unifying purpose of our business. The areas we serve build on each other to add strength to our company and provide additional values to our customers. This guides our interests, our organization, and our marketing philosophy.

The broad scope of HP technology often provides opportunities for our company to expand into new fields. Before entering a new field, however, we must satisfy ourselves that it is consistent with our business purpose and that it affords us the opportunity to make a significant contribution. This requires that we have not only the technology to create truly innovative and needed products, but that we also have the capability to manufacture and market them effectively and at a reasonable profit.

4. Growth. To let our growth be limited only by our profits and our ability to develop and produce innovative products that satisfy real customer needs.

How large should a company become? Some people feel that when it has reached a certain size there is no point in letting it grow further. Others feel that a large-sized business is an objective in itself. We do not believe that large size is important for its own sake; however, for at least two basic reasons, continuous growth in sales and profits is essential for us to achieve our other objectives.

In the first place, we serve a dynamic and rapidly growing segment of our technological society. To remain static would be to lose ground. We cannot maintain a position of strength and leadership in our fields without sustained and profitable growth.

In the second place, growth is important in order to attract and hold high-caliber people. These individuals will align their future only with a company that offers them considerable opportunity for personal progress. Opportunities are greater and more challenging in a growing company.

5. Our People. To help HP people share in the company's success which they make possible; to provide job security based on their performance; to insure them a safe and pleasant work environment; to recognize their individual achievements; and to help them gain a sense of satisfaction and accomplishments from their work.

We are proud of the people we have in our organization, their performance, and their attitude toward their jobs and toward the company. The company has been built around the individual, the personal dignity of each, and the recognition of personal achievements.

Relationships within the company depend upon a spirit of cooperation among individuals and groups, and an attitude of trust and understanding on the part of managers toward their people. These relationships will be good only if employees have faith in the motives and integrity of their peers, supervisors, and the company itself.

On occasion, situations will arise where people have personal problems which temporarily affect their performance or attitude, and it is important that people in such circumstances be treated with sympathy and understanding while the problems are being resolved.

Job security is an important HP objective. Over the years, the company has achieved a steady growth in employment by consistently developing good new products, and by avoiding the

type of contract business that requires hiring many people, then terminating them when the contract expires. The company wants HP people to have stable, long-term careers–dependent, of course, upon satisfactory job performance.

Another objective of HP's personnel policies is to enable people to share in the company's success. This is reflected in a pay policy and in employee benefit programs that place us among the leaders in our industry.

There is also a strong commitment at HP to the concept of equal opportunity and affirmative action, not only in hiring but also in providing opportunities for advancement. Advancement is based solely upon individual initiative, ability, and demonstrated accomplishment. Since we promote from within whenever possible, managers at all levels must concern themselves with the proper development of their people, and should give them ample opportunity through continuing programs of training and education to broaden their capabilities and prepare themselves for more responsible jobs.

The physical well-being of our people has been another important concern of HP's since the company's founding. With the growing complexity and diversity of our research and manufacturing processes, we must be especially vigilant in maintaining a safe and healthful work environment.

We want people to enjoy their work at HP and to be proud of their accomplishments. This means we must make sure that each person receives the recognition he or she needs and deserves. In the final analysis, people at all levels determine the character and strength of our company.

6. Management. To foster initiative and creativity by allowing the individual great freedom of action in attaining well-defined objectives.

In discussing HP operating policies, we often refer to the concept of "management by objective." By this we mean that insofar as possible, each individual at each level in the organization should make his or her own plans to achieve company objectives and goals. After receiving supervisory approval, each individual should be given a wide degree of freedom to work within the limitations imposed by these plans, and by our general corporate policies. Finally, each person's performance should be judged on the basis of how well these individually established goals have been achieved.

The successful practice of "management by objective" is a two-way street. Management must be sure that each individual understands the immediate objectives, as well as corporate goals and policies. Thus, a primary HP management responsibility is communication and mutual understanding. Conversely, employees must take sufficient interest in their work to want to plan it, to propose new solutions to old problems, to stick their necks out when they have something to contribute. "Management by objective," as opposed to management by directive, offers opportunity for individual freedom and contribution; it also imposes an obligation for everyone to exercise initiative and enthusiasm.

In this atmosphere, it is

important to recognize that cooperation between individuals and between operating units is essential to our growth and success. Although our operations are decentralized, we are a single company whose overall strength is derived from mutually helpful relationships and frequent interaction among our dispersed but interdependent units.

It is important, as well, for everyone to recognize that there are some policies which must be established and maintained on a company-wide basis. We welcome recommendations on these company-wide policies from all levels, but we expect adherence to them at all times.

7. Citizenship. To honor our obligations to society by being an economic, intellectual, and social asset to each nation and each community in which we operate.

All of us should strive to improve the environment in which we live. As a corporation operating in many different communities throughout the world, we must make sure that each of these communities is better for our presence. This means identifying our interests with those of the community; it means applying the highest standards of honesty and integrity to all our relationships with individuals and groups; it means enhancing and protecting the physical environment, building attractive plants and offices of which the community can be proud; it means contributing talent, time and financial support to worthwhile community projects.

Each community has its particular set of social problems. Our company must help to solve these problems. As a major step in this direction, we must strive to provide worthwhile employment opportunities for people of widely different backgrounds. Among other things, this requires positive action to seek out and employ members of disadvantaged groups, and to encourage and guide their progress toward full participation at all position levels.

As citizens of their community, there is much that HP people can and should do to improve it--either working as individuals or through such groups as churches, schools, civic, or charitable organizations. In a broader sense, HP's "community" also includes a number of business and professional organizations, such as engineering and scientific societies whose interests are closely identified with those of the company and its individual employees. These, too, are deserving of our support and participation. In all cases, supervisors should encourage HP people to fulfill their personal goals and aspirations in the community as well as attain their individual objectives within HP.

At a national level, it is essential that the company be a good corporate citizen of each country in which it operates. Moreover, as individuals our employees should be encouraged to help in finding solutions to national problems by contributing their knowledge and talents.

The improvement of our society is not a job to be left to a few; it is a responsibility to be shared by all.

TECHNOLOGY TRANSFER FOR ENHANCED RESEARCH DEVELOPMENT TEST AND EVALUATION EFFECTIVENESS

Milon E. Essoglou

This talk will be divided into two parts. First, I wish to discuss a shortfall in our present philosophy and system for rewarding individuals. We do not reward them for transferring technology. Rather, we reward them for the opposite. The second part is our Naval Facilities Engineering Command case history of designing and implementing a system to manage research, development, test, and evaluation aimed at improving the odds for effective transfer of our laboratories' results.

Our organizations exist in a state of competition with one another because our society is competitive. We assume that a purpose for RDT&E is to produce technologies which may be used. Yet we have models and notions about technology transfer and the accomplishment of creative endeavor that are not in tune with the real reward systems for individuals in our organizations. If we truly want to improve our RDT&E effectiveness and enhance the level of our transfer of technology into use, we need to revise our reward systems for those accountable for the transfer of the technology in our organizations.

Research and Development Management: Production Stimulation Through Technology Transfer

PUTTING RESEARCH AND DEVELOPMENT TO WORK

- Technology flow
- Transfer
- Diffusion
- Utilization
- Implementation

Our organizations, indeed, the entire industrial society, cannot function without the flow of technology. It must flow just as money must flow. Many terms have been used by academicians and practitioners to differentiate various forms of technology flow. These are extensively defined in the literature. Irrespective of terminology, we are interested in flows because the forces behind them provide the stimulus for putting technology to work. Investment economics dictates that we increase the rate of effective transfer through application or implementation.

BRAINS, NOT PAPER

- Technology is not reports
- Technology is knowledge
- Reports do not work
- People work
- Work output is the only measure of technology transfer
- Not the paper or words distributed

Even while acknowledging the abundant contrary evidence in the literature, we continue to act on the misconception that technology consists of reports. This is shown by organizational activities. For example, we are obsessed with ensuring wide distribution

of reports, but at the same time curtail travel essential to meeting people involved in the production and application of new technology. While we are quick to acknowledge that technology is knowledge within an individual, our actions don't show this nearly often enough.

We seem to forget that technology transfer occurs when people do work. Transfer does not occur when reports are distributed or received. Unless there is evidence from the work output of people, there is no good measure of how much technology has been transferred. While it may be essential to make distribution counts of paper and reports, these counts are only a measure of the effectiveness of our shipping system. The movement of individual knowledge cannot be ascertained unless reflected in use, or better yet, unless the receiver or user tells us of improvement benefits. Today's information channels are so many and complex that we must have the user's cooperation to learn which channel was the effective one. This is important to us in the technology production business because it is we who must account to corporate or congressional management for the application effectiveness of our RDT&E expenditures.

The Effect of Competition on Technology Transfer

COMPETITION AND TECHNOLOGY TRANSFER

- Competitive edge requires one not to give away knowledge/ideas
- Technology Transfer requires disclosure and communication
- Can technology transfer coexist with competition in our society?

As members of an industrial society based on survival through competition, we are severely handicapped in the use of communication necessary to promote technology transfer and report on its effectiveness. In many environments, ideas and knowledge must not and cannot be shared freely if a competitive edge is to be maintained. Technology flows can occur only within the market exchange context. The owner of technology need not sell until the price is right. Similarly, individuals within an organization will not give away their knowledge, which they regard as their intellectual property, without assurance that they will obtain some benefit, such as pay, security, power, prestige, and so forth. They cannot, furthermore, admit that their output owes too much to the work of others because they are rewarded primarily for their own creativity and innovation.

Technology Transfer Differences Between Industry and Government

TECHNOLOGY TRANSFER MODELS DIFFERENTIATION

- Industry
  Model of technology transfer in a competitive (for sale and for profit) world
- Government
  Model of technology transfer for public good

Individual and organization value

systems in industry are quite different from those in government. Of course, there are affinities but we will disregard those for the moment.

In industry the transfer of technology is obviously tied to the profit orientation of the organization. Money is the medium for inducing or obstructing technology movement. For the right price, technology is bought and sold routinely.

In the public sector on the other hand, technology transfer occurs, at least in theory, when the "public good" warrants it. This is greatly different from the situation in industry. Public servants are expected to engage in activity promoting technology transfer because it is presumed to be in the public's interest. It is their legal duty to do so because their technology has been generated with public funds.

Obviously the reward and motivation structures are not alike. Government has a duty to disclose; industry has a duty to sell and make a profit. The difference does not simply derive from the competitive nature of industry, for the competitive forces have also penetrated government bureaucracies. Fierce competition within and among public agencies and various power games of considerable complexity lead to various forms of secrecy, withholding or delaying of technology. The organizational climate discourages and in many cases forbids acknowledgement of knowledge having been imported from another group with which the organization may be having jurisdictional disputes. Unlike industry, government does not have an accepted price concept for transferring completely or partially developed technology as in a sales contract. Frequently, the only reward for the government employee or organization producing a new technology is the documentation recorded in technical reports and professional journals.

Risks of Non-Transfer

TECHNOLOGY TRANSFER OCCURS WHEN THE RISKS OF NON-TRANSFER ARE GREATER THAN THE RISKS OF TRANSFER

- Laboratory to operations
- Laboratory to laboratory
- Operations to operations

Transfer occurs when the consequences of not using a technology are apparent to source and/or the user. Consider the following three source combinations in user transfer patterns associated with risk:

1. Laboratory to laboratory: Transfer may be inhibited by individual or organizational competition. The competition may be for power, security, or some other need.
2. Transfer from a laboratory: source to user. This form is usually less burdened by professional jealousy because of relatively clean demarcation lines between the roles of the personnel involved. There is less likelihood that competition survival considerations will inhibit flow. Users seeking security tend not to inhibit adoption of unfamiliar technology unless they perceive a threat to their com-

petitive posture. The desire and need to import technology which is new to the importing organization are probably driven by competitive pressures. Willingness to take the risks inherent in adopting a new technology is likely to increase when the competitive threat has grown great enough. However, the tendency will be to look for a technology producer who can be trusted.

3. User-to-user transfer: Transfer occurs when a potential user chooses to accept a technology from an actual user from within or outside. The most celebrated innovations seem to occur when a technology has crossed industrial lines. Depending on the institutional setting, technologies can be stolen, purchased, or acquired through competitive transfer agreement.

Reward considerations cause a strong bias against acknowledging the importation of technology in favor of overstating locally conceived innovative contributions. Perhaps the only exception to this occurs when technology acquisitions are conducted in an explicit policy climate that opts for the acquisition of technology from outside rather than creating it from within. When practiced by groups, this is called "product development strategy"; when practiced by individuals, "specialization."

Conditions Needed for Cooperation

ESSENTIAL CONDITIONS FOR COOPERATION IN GOVERNMENT

- Only between persons or organizations of complementary/equal stature
- When risk for non-cooperation is greater than the risks of coordination for transfer

IN INDUSTRY

- Contractual/monetary conditions must be mutually acceptable
- Other conditions are secondary

In government organizations, transfer which is openly acknowledged is most likely to occur between those of equal or complementary position. When the source is somewhat more powerful, the weaker, less prestigious user is likely to find a way to reject the innovation or seek to take credit for it. Most systems of rewarding innovation which control a multitude of individuals and group actions tend to suppress efficient importation. Not only are these reward systems extremely complex, but they are often not sufficiently explicit to be recognized.

As previously postulated, the transfer process in industry seems to be a straightforward function of contractual and monetary conditions. If the importation of a technology is seen as more profitable than local innovation, it most likely will occur. Provided the product is a winner, the individual and the team will be rewarded for keeping costs down. Re-

wards are derived from any technology, whether locally generated or imported, as long as it results in products which uniquely please customers. More than flat-out importation is usually involved; the imported technology is modified and sprinkled with innovations in an attempt to beat the competitor's product.

Characteristics of Technology Flow Patterns in Government and Industry

TECHNOLOGY TRANSFER
GOVERNMENT/INDUSTRY

Industry

Market Competition

- Achieve
- Lead
- Secrecy

Public Welfare

Incompatible

Government

Market Competition

Incompatible

Public Welfare

- Openness
- Cooperation
- Tech Transfer

The forces toward achievement, market leadership, and secrecy prevailing in the industrial world of competition are in sharp contrast to those for openness, cooperation, and transfer, characterizing the expected role of government organizations as they work for the public good. Because this is something of an overgeneralization, it is doubly important to be sensitive to the danger of applying government-derived recommendations to private sector situations and vice versa. When all is said and done, incentives for transfer in the private sector are governed by the need to keep innovations secret until they can be converted into profit. On the other hand, public sector technology is likely to be freely disseminated at the public's total or partial expense.

The Transfer Role of Operating Managers

OPERATING MANAGERS AND
TECHNOLOGY TRANSFER

- Management by: results and objectives
- State what but not how!
- Technology transfer function must always be subordinated to profit center's objective (cost, schedule, and performance)

Operating managers must apply technology transfer considerations as integral elements of their daily activities. Technology transfer is frequently talked about, especially in settings and among individuals seeking to promote it as if it existed all by itself and outside the real operating world. We recognize that managers drive for results. All managers, whether in the private or public sector, try to reach objectives. This is what they are there for. Any attempt to superimpose technology transfer management as a separate entity on top of the manager's already-existing burden is therefore bound to fail.

Faced with a dynamic and risky situation, operating managers are impelled to stabilize their activities as much as they can. If technology input is a source of instability, they may choose to shut it off or at least control it. Thus, any technology from whatever source must provide a benefit within recognized

missions and established schedules. Operating people have too much to deal with to add yet another activity dubbed "technology transfer." On the other hand, when exporting technology is part of an operating manager's explicit mission, the connected activities are commonly incorporated in functional entities called systems. Production, distribution, marketing, and selling systems are many times components of the technology transfer effort even though this is not reflected in their labels.

Aspirations and Realities in Managing Technology Transfer

ASPIRATIONS AND REALITIES OF MANAGING TECHNOLOGY TRANSFER

Ideally we want to:

- Control
- Direct
- Assure coupling
- Feedback

Realistically we settle for:

- Distribution of paper
- Opportune talk
- Diffusion

The management of technology flow is one of the many "other" jobs of the technical manager. The managerial control function, often considered the essence of management, seems to have dominated thinking regarding technology transfer. Perhaps the belief in the need for close control is also attributable to the usually deterministic engineering background of technical managers. As engineers, we would ideally like to control, direct, couple, and obtain feedback from our efforts to move technology. It is normal and natural to try to control something for which you are accountable. However, managers must often settle for controlling the distribution of paper reports, seizing opportunities to promote the product whenever possible, and hoping for diffusion to reach deep and wide within the world of potential users. There is a gulf between directed and controlled transfer and unmanaged diffusion. But it need not necessarily be frightening.

The great burden of transfer and accounting for it has been placed on the producers of technology, at least in the public sector. Since these producers spend the bulk of research and development dollars, potential users frequently perceive the expenditures as questionable investments, placing the burden of proof of need for research on the producers. Measuring the effectiveness of transfer has been tried by many. It is at once a formidable and a hopeless task.

Precisely because of the difficulty and insistence of top managers to measure transfer effectiveness as a price for getting R&D dollars, we must try yet another approach: asking the technology user to freely report which of all the technology "messages" sent have been "received" in the sense of effecting actual adoption. I believe that reports by individual users are the only real and affordable way to measure effective technology transfer. In sum, only the "using" individual can tell us just how much of all the information transmitted has resulted in the use of a particular product or problem-solving event.

The Effect of Value Systems on Transfer Measurement

MEASUREMENT OF TECHNOLOGY TRANSFER IMPEDED BY OUR VALUES

- Work output measures one's worth
- Utility model: useful problems, solved efficiently
- Aesthetic model: Creativity, originality
- Hybrid model: creative problem solving
- To acknowledge technology transfer is to risk reward for originality
- We do not reward "copying"

Measurement of technology transfer is dependent on value systems. In our society, a worker's worth is generally associated with his/her output. This output must be useful. For an engineer, the measurement is of efficiency in problem solving. Creativity and originality are also expected, not only because they contribute to efficiency and effectiveness, but also for aesthetic reasons. They, too, are elements of our culture.

As previously emphasized, it is risky for someone working in our competitive society which rewards originality and creative problem solving to acknowledge technology import or indebtedness to others. Copying, importing, and adapting, even if done efficiently and in a timely manner, are honored less than innovating or creating. As long as our rewards are so heavily bound up with innovation, only an individual with a strong professional ethic, secure in pay and recognition, and with a good sense of fair play can be counted on for honest feedback on transferred technology. This is very crucial to us, the technology-producing community, for as producers and exporters of technology, we are constantly asked to show how much of and how effectively our technology was transferred into productive utilization. It appears that top management has burdened the wrong side to produce objective measurement for technology transferred, at least in government. Virtually all technology transfer studies have been directed and undertaken by R&D people when, in fact, they should have been undertaken by engineering, design, production, construction, marketing, and sales people. We are forced to pay from our R&D accounts for the measurement and reporting of the ultimate net worth of our product to the enterprise, when that enterprise is run by operators and users rather than technology producers. Does top management realize this? If they do, should they not adjust organizational value systems to reward transfer activities?

How Can Transfer Effectiveness Be Enhanced?

THE ULTIMATE AND OFTEN THE ONLY MEASURE OF TECHNOLOGY TRANSFER IS TO OPENLY ACKNOWLEDGE THE INFLUENCE OF ANOTHER PERSON'S WORK.

But this is a matter of:

- One's professional ethic
- One's sense of security, pay, and recognition
- One's sense of fairplay
- (Or back to Maslow?!)

I suggest that there are four propositions which may open the door to opportunities for managers concerned with the enhancement of research effectiveness through technology transfer.

1. Openly recognize technology transfer activity in government to be as legitimate as marketing is in industry. Provide professional and organizational status with budget and responsibility definitions.
2. Either financially support or abandon demands on the technology producer for evidence of technology transfer. Too much burden now exists on the generator or exporter of research and development results, and not enough on the importer or user.
3. Reward problem solving directed to modifying and adapting a technology for transfer at least as much as that connected with creating or inventing a technological innovation.
4. Reward those who voluntarily acknowledge the extent of their dependence on ideas and technology created by others in adapting a technology for use.

Management of RDT&D for Effective Transfer in a Public Agency: A Case History

Over a period going a long way back, the Assistant Commander for RDT&E of the Naval Facilities Engineering Command has persistently promoted research on technology transfer concepts, theories, methods, and practices to help develop fundamentally sound RDT&E management goals. We now believe that we have succeeded in creating a formal management structure based on technology transfer principles. While our system is still a bureacracy, all of our procedures have been realigned and rationalized so as to promote involvement of the customer. In particular, delivery of information to the customer is in a form such that upon completion, we in RDT&E can count on effective transfer and implementation.

Technology Transfer History of the Naval Facilities Engineering Command

Our command's traceable concern for research effectiveness through better utilization is summarized in Figure 1. The periods of intense activity coincided with active military leadership by individuals with a great deal of perception and commitment to technology transfer. During these periods, we were fortunate to have effective leadership from the Assistant Commander for RDT&E at our Washington headquarters and from Commanding Officers of the Naval Civil Engineering Laboratory in California. The apparent slackening of activity in the mid-to-late '70s is primarily attributable to a shift of focus toward building new RDT&E programs to meet demands for growth.

One of our initiatives in 1970 was to commission the Naval Postgraduate School at Monterey, California, to perform research on the technology

1962	RDT&E Assistance
1964	RDT&E Utilization
1965	Mandatory Task Proposals
1966	Technology Transfer
	A. Applications Division
	B. RDT&E Liaison at Field Level
1967	NCEL Report Utilization
1970	Naval Post Graduate School (NPS)
1970	NPS Technology Transfer Study
1971	Technical Data Sheet
1971	NCEL Field Engineering Support office
1971	RDT&E Assistance Doubles - $100K to $200K
1974	NCEL/NAVFAC Workshop
1981	Advanced RDT&E Transition Planning
1982	NAVFAC RDT&E Management Instruction
1983	Increased NCEL Field Liaison Program
1985	Briefings to Industry

Figure 1. Chronology of NAVFAC's Technology Transfer Efforts.

transfer process specifically applicable to our Navy Facilities world. We are all enjoying the fruits of that undertaking here today. By far the most significant contribution to our research management is the Linker Model, which neatly structured conditions whose fulfillment determines the extent of effective information transfer from a source to a user. It applies to lateral transfers, laboratory to laboratory, and user to user, as well as to vertical transfers from laboratory to user and vice versa. This model is shown in Figure 2. We consider the Linker Model as the cornerstone of our technology transfer model embodied in our NAVFAC RDT&E management process. This model will be shown later.

We have integrated the principles and experiences reported in technology transfer literature into the mainstream of RDT&E management. Our effort to transfer technology from the laboratory to the operating world does not start

- Selection of Project
- Information Documentation
- Information Distribution
- Technical Credibility
  - Linker (Source and/or User)
    (User Oriented)
    - Formal Organization
    - Capacity of Individual
    - Reward/Penalty
    - Willingness to Receive and Transmit

NOTE: The user may also be a source of information which the researcher may need for his work.

SOURCE: Creighton, J.W., J.A. Jolly, and S.A. Denning. *Enhancement of Research and Development Output Utilization Efficiences; Linker Concept Methologies in the Technology Transfer Process.* U.S. Naval Postgraduate School, Monterey, CA. June, 1972.

Figure 2. The Linker Model.

upon completion of a research task. We have instituted a process that gives the ultimate user ownership of the project from the very start of research. We put our customer-users in the driver's seat by asking them to "approve" and "specify" at critical points of research activity, as shown in Figure 3. Our management philosophy for RDT&E execution is based upon this user-producer dialogue. Most important is the customer's approval of the initiation decision report, Figure 4, and the Test and Evaluation master plan, Figure 5. As the titles suggest, these important documents give potential users of our research active control over the direction, the duration, the goals to be pursued, and the reports to be produced. They can keep informed of progress and participate in decisions at intervals in the development process.

We have also redesigned our RDT&E documentation practice. Our output has traditionally been a laboratory technical report, primarily intended to document the RDT&E technical activity. These reports were written for technical peers and the R&D community, and to

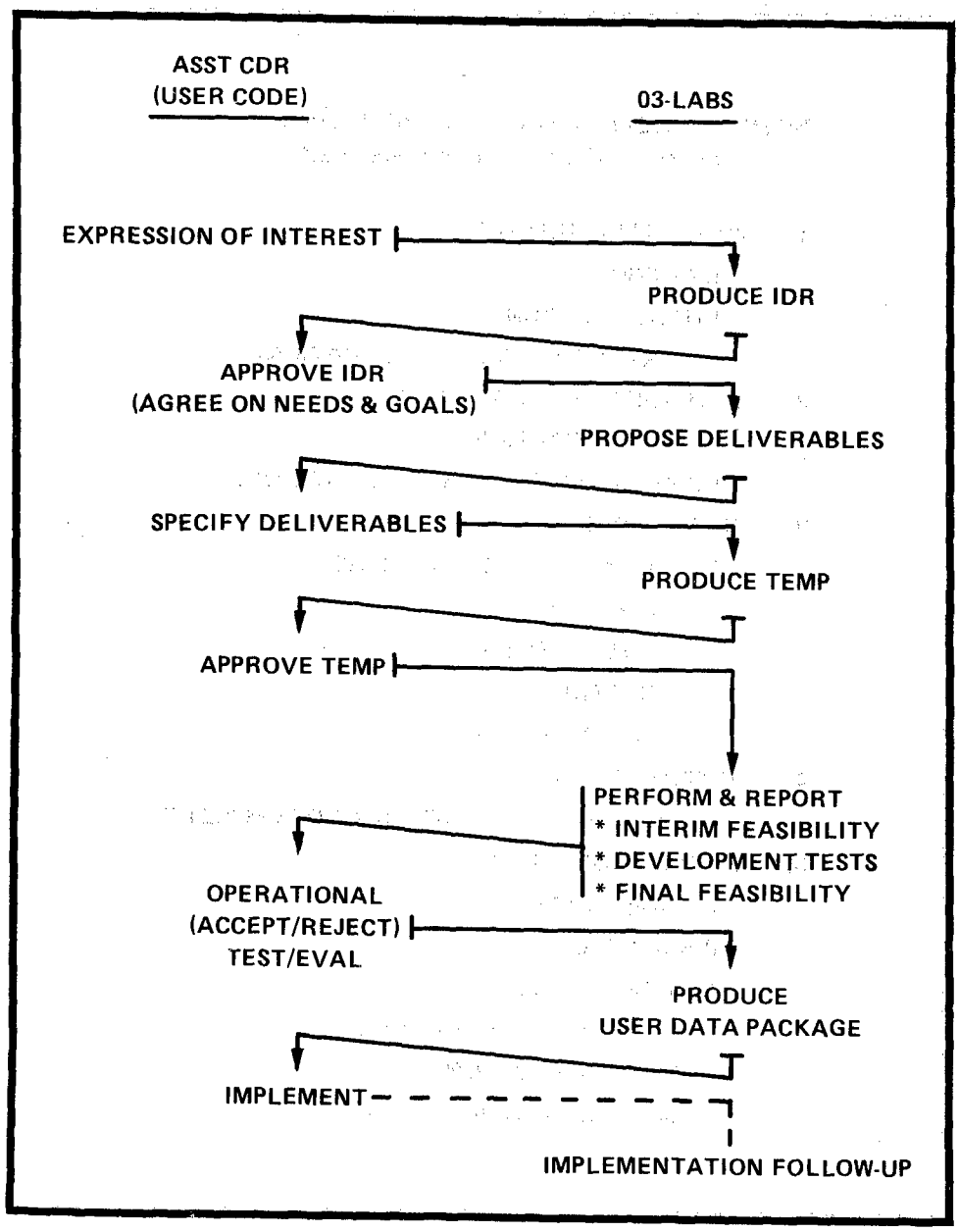

Figure 3. NAVFAC User/Producer Dialogue for RDT&E.

NOTE: Primarily for Problem-Driven 03 Research Initiatives with Active User Involvement.

1. PROBLEM DEFINITION
   - EVIDENCE
   - QUANTIFICATION
     - (EXTENT, FREQUENCY, DURATION)
2. STATE-OF-THE-ART ASSESSMENT
   - CURRENT PRACTICE
   - COMMERCIALLY AVAILABLE TECHNOLOGY
3. TECHNOLOGICAL PROJECTIONS
   - IDENTIFY TECHNOLOGY AREAS
   - TRACK RDT&E BY OTHERS
     - LEVEL OF INTEREST
     - DIRECTION
     - RATE OF CHANGE
4. ALTERNATIVES
   - (RISK, PAY-OFF, COST, TIME TO COMPLETE)
5. TECHNOLOGY GOALS
   - DEFINE TARGET
6. CAPABILITY GOALS
   - INTEGRATED R&D TASKS
     - TECHNOLOGY IMPROVEMENT
     - SYSTEMS DEVELOPMENT
     - COMPONENT DEVELOPMENT

Figure 4. Initiation Decision Report (IDR).

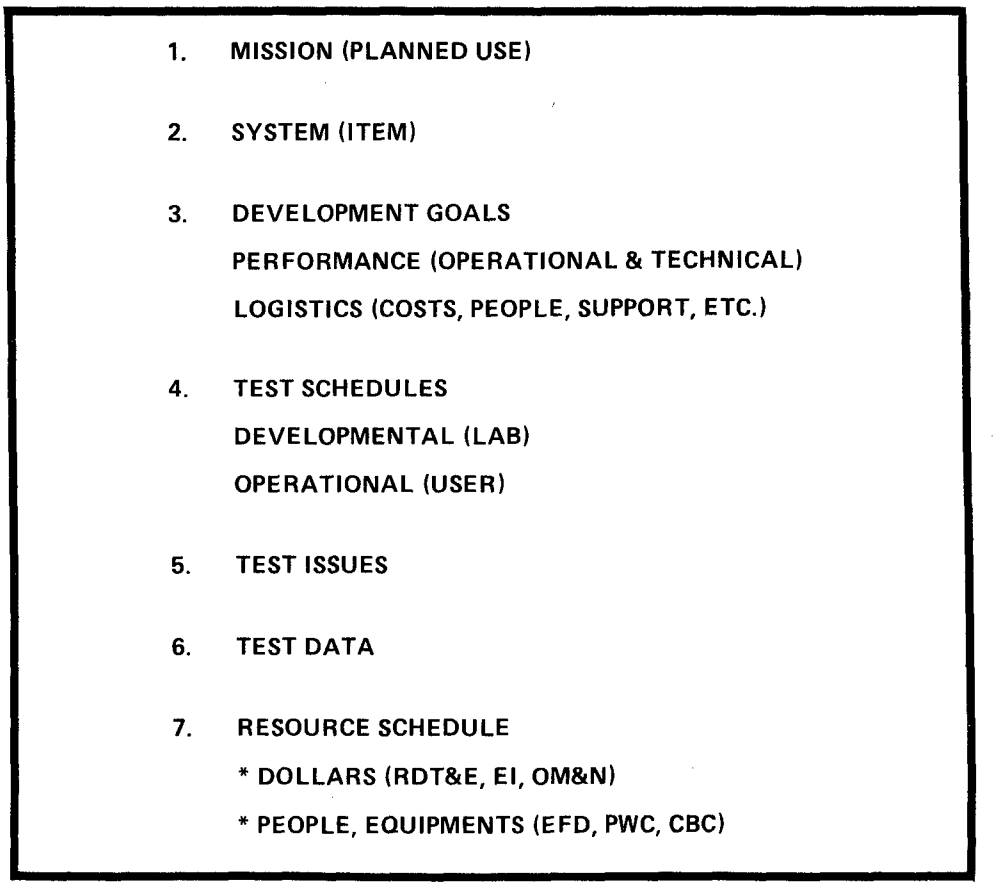

Figure 5. Test and Evaluation Master Plan (TEMP).

account for the money expended. Over the years we have tried to orient the reports toward the needs of those who would be responsible for application, and to have the reports written in language clear for the user. Unfortunately, this resulted in downgrading the apparent quality of the report in the eyes of other researchers, and did not really increase technology transfer effectiveness. Another reading, analysis, interpretation, and writing cycle was necessary to transform R&D reports into effective operating publications suitable as planning, design, construction, and maintenance engineering documents. These are now designated as the command's approved publications, and serve as the basis for updating specifications for actual construction or repair projects. The preparation of these criteria publications, known as guides, manuals, specifications, and so

forth, has been increasingly contracted out to architect and engineer firms for periodic update. This, however, reduced the likelihood that the laboratories' technical report message would ever get into the command's operation publications, let alone reach the designers and specifiers who formulate the actual projects where benefits from R&D may be reaped.

To eliminate this "loss-link," we decided that in addition to "peer-destined" laboratory reports we would produce specific user-oriented publications. Figure 6 provides an outline for our user data package. It includes specifi-

1. GENERAL OVERVIEW
2. PLANNING
   - P-80
   - OTHER
3. DESIGN
   - DM
   - OTHER
4. SPECIFICATIONS
   - NFGS, MILSPEC, ETC.
   - OTHER
5. CONSTRUCTION/PRODUCTION
   - INSP & QUAL ASSURANCE
   - OTHER
6. MAINTENANCE OPERATIONS
   - MO
   - OTHER

Figure 6. Outline for User Data Package.

cally phrased recommendations for revising old specifications or writing new ones, criteria, standards, and so forth. Notice that the outline is functionally arranged. The risk and cost to users and their architect-engineer contractors of having to translate RDT&E reports has been removed.

The user data package delivers recommendations for revising specifications, criteria, and manuals for every phase of the project's life cycle, such as planning, design, construction, and maintenance. This was done deliberately and insures that our development projects are not narrowly focused but instead address the concerns of the various functional groups in all our organizations. Previously, implementation would be delayed if one aspect of a project was not sufficiently addressed. Pressure for the generation of the user data package came from the following sources:

1. For many years the Department of Defense has emphasized that the logistics support aspects of a project be addressed with as much thoroughness as the development of the project itself. Many a good development project failed or took too long to implement because we had neglected to develop it within support constraints.
2. Similarly, within our command many an accomplishment was never implemented because its maintenance and operation had not been considered along with the development of design criteria.
3. Jurisdictional disputes between planners, designers, and constructors, and the maintenance and operating factions of our organization were often disrupting, for each might sponsor research in its own functional area with resulting incongruence. The data package enables us to define the end product for all RDT&E investments so as to include all work required to meet performance improvements and life cycle logistic support. When all of this information is in one report, it makes it easier for our functionally fragmented and geographically scattered user community to implement.

The Management and Mode for Technology Transfer

Our management system conforms to the Creighton-Jolly technology transfer model which is simply a list of factors identified as necessary for the movement of technology. The four formal factors contained in the list are:

1. Project selection;
2. Documentation of information;
3. Distribution of information;
4. The formal organization.

The five informal factors are:

5. Credibility of persons involved;
6. Capability or capacity to perform;

7. Willingness to perform;
8. The linking function;
9. Reward.

We have attempted to take advantage of each function in the model in the following ways:

(1) Project Selection. Involvement of potential users in project selection considerations throughout the life cycle of the project is assured by the requirement for their approval of the initiation decision report.

(2) Information Documentation. This function consists of the descriptive format.

(3) Information Distribution. Adequacy of information documentation and distribution is assured through the deliverables agreement which itemizes the stream of deliverables and the users' contributions in specifications for the user data package. Each R&D program manager is required to keep current on progress of programs and projects, and is responsible for directing the distribution of reports through the user community.

(4) Formal Organization. The responsibilities and barriers imposed by the Navy's formal organizations have been factored into the design of the user data package. This package recognizes the Navy-user as a matrix of organizations and people.

(5) Credibility. Technical credibility of the source is ultimately assured by the users' independent operational test and evaluation for acceptance or rejection of the R&D product. Credibility buildup starts with the initiation decision report, and continues as the researcher and potential user keep each other informed during development.

(6) Willingness. The users' willingness to receive an end product is cultivated and developed by involving them from the time of decision to initiate to their decision to accept. Approval of the test evaluation master plan puts users under obligation to accept, at least for trial, unless their needs have changed. Cooperation between the researcher and the product user develops willingness on the part of both to transmit information needed by the other for effective design of a master plan, and for establishment of test criteria. The need for willingness, both to receive and to transmit, is extremely important if test evaluation master plans are to be effective.

(7) Technical Capacity. Capacity is closely related to willingness, for without technical

capacity to transmit and understand evolving technological changes, an individual is likely to refrain from contact with others involved in the technology. The initiation decision report, the documentation agreement, the test and evaluation master plan, the test and evaluation plan, and the user data package must all be understood. The requirement to get involved in all of these is a strong incentive toward constant update of capacity.

(8) Linker. Without some form of linkage, a new technology cannot find a use-sponsor. All of the methods and procedures developed to encourage the movement and procedures developed to encourage the movement of R&D products into use are formulated with linkage in mind. The various systems which have been devised with the common intent to bring producers and users of technology together so that natural linkages can be established and extended. Without linkage, there can be no success in the program.

(9) Reward. Systems for rewarding or penalizing users for accepting and implementing newly emerged technologies or failing to do so are beyond the responsibilities of our R&D managers. It is my specific proposal in this talk to move forward, altering the reward/penalty structure so as to create the largest possible scope for technology transfer. Such a departure from prevailing practice is also badly needed to obtain a measure of the effectiveness of the transfer process. We must encourage, rather than drive underground–in the name of original thinking or local adaptation--the cheerful admission that a good idea taken from a source, whether from an R&D lab or elsewhere, was put to good use. The stigma attached to adapting or copying successful technologies must be removed.

The Management Transfer Matrix

As we designed the NAVFAC RDT&E management process, we attempted to relate the various steps to the Creighton-Jolly transfer model. The matrix shown in Figure 7 indicates those steps in which the transfer elements are most important.

The need for linking is pervasive throughout the management process, for the identification of early adopters and negotiations for transfer are crucial at each step in the movement of innovations from concept to use.

Of course, the need to reward individuals is ever present and is exercised in each segment of the R&D organization

NAVFAC RDT&E EVALUATION STEPS		TECHNOLOGY TRANSFER FACTORS								
		Linker Mediation	Project Selection	Information Documentation	Information Distribution	Technical Credibility	Formal Organization	Technical Capacity	Reward-Penalty	Willingness to Receive
Initiation Decision Report	IDR	X	XX					X		
Documentation Deliverable Agreement	DEL	X		X	X			X		X
Test and Evaluation Master Plan	TEMP	X					X			XX
Operational Test and Evaluation	OTE	X				XX		XX		
User Data Package	UDP	X		XX	XX				O	X
Post-Delivery Appraisal of Implementation by R&D	APP	X							X	

X Important Technology Transfer factor attention points.

XX Areas of extreme importance. Special effort is made at these points to assure avoidance of deficiencies which might impede project progress.

O The reward/penalty system of technology users is outside the jurisdiction of the RDT&E process. Successful and beneficial results from use of the project UDP constitute reward for the user. Reward for the RDT&E systems results from the acceptance of the UDP by users and post-delivery appraisal of implementation.

Figure 7. Technical Transfer Factors (Creighton-Jolly Model) Principally Involved at Each Stage of the NAVFAC RDT&E Management Process.

as warranted. However, reward for the RDT&E system as a whole results from acceptance of the UDP, trial, and successful implementation.

A better system is needed to reward those in engineering operations who import technology efficiently and openly. Today's reward practices, geared heavily and mainly towards local innovation, would seem to discourage adopting good proven technology in favor of "local ingenuity." And when technology is adopted there is a disinclination to credit the source.

Conclusion

In conclusion, I ask that you study the propositions presented in the first part of this paper. We need to improve operational productivity and avoid the high cost of locally innovated marginal pursuits. We must transfer technology quickly and reward those who do so quickly and efficiently. Our obsession with rewarding original thinking is blocking us from ready measurement of technology transfer. As an R&D manager, my productivity will increase if I don't have to squander my resources trying to chase around and report on how well my technology was transferred and implemented. It is ironic that the senior executives who ask R&D management to measure and report on the effectiveness of transfer efforts are more often than not from the operating sector or the user environment. Could it be that they know first hand how little corporate R&D has helped them, so that now, from their position of authority, they can make the R&D community squirm? Could it be that they are protective of their own kind in the mainstream of operations? Could it be that they simply have not thought through alternative processes for the management of R&D as I have tried to do and illustrate in this talk? I suggest that top management ask the users to account for implementation and payoff from new technologies by rewarding them for and acknowledging the source of innovations in their reports.

Creighton, J.W., J.A. Jolly, and S.A. Denning. *Enhancement of Research and Development Output Utilization Efficiencies; Linker Concept Methodologies in the Technology Transfer Process.* U.S. Naval Postgraduate School, Monterey, CA. June, 1972.