Office Memorandum • UNITED STATES GOVERNMENT

TO : Mr. W. F. Friedman DATE: 8 April 1955

FROM : Mr. A. B. Clark

SUBJECT: Talk Given at IRE Convention

You may be interested in the attached which is a slightly revised edition of a talk which I presented before the IRE on March 22. The occasion was a panel discussion of the subject - "Operations Research a Tool of Management", chairmaned by Mr. C. M. Jansky, Jr.

It occurs to me that this might be appropriate for an article in the proposed NSA Technical Journal, which I understand you are in the process of creating.

A. B. CLARK

Incl:
Cy of "The Scientific Enterpriser"

4 April 1955

THE SCIENTIFIC ENTERPRISER

Our genial Chairman, Mr. Jansky, has asked this question: "Are terms such as 'operations research', 'operational research', 'operations analysis', 'operations evaluation', 'systems engineering', etc., synonymous? If not, how should we differentiate between them?"

It does not seem to me that these terms are synonymous, the first four terms being much narrower than the last, which is "Systems Engineering". "Systems Engineering" is a very broad term meaning many things to different people. A different title has, therefore, been chosen for my remarks. "The Development Planner," would perhaps have been equally appropriate but was not chosen because it did not emphasize the very important idea of "enterprise".

The job of the "Scientific Enterpriser", or group of Scientific Enterprisers, is easily defined. In the civilian world, it is simply to make plans for increasing profits. In the military world, it is to make plans for increasing the destruction which we wish to inflict on our enemies, while at the same time keeping our own expenditures in men and materials at a minimum. So I believe that the subject fits well both to peace and war.

In order to achieve success, the Scientific Enterpriser needs two essential ingredients.

One, an exceedingly good understanding of the field of operations to which his plans are to be applied.

Two, an imaginative understanding of the possibilities afforded by advances in science.

Since the "Scientific Enterpriser" cannot be expected to encompass all of this understanding himself, he must have free access to other scientists working in the fields of interest to his plans. Thus, these other scientists will add their own dreams of future possibilities to his own.

With these two essential ingredients in hand; ideas will, in many cases, be forthcoming almost automatically. The "Scientific Enterpriser" will naturally originate some of these ideas. However, he should encourage the generation of ideas by others, the users in particular. He should take pains to give all ideas equal weight, whatever their source. In other words, he should have no "pride of authorship" with respect to ideas.

As to the making of plans, I can suggest no fixed pattern. Sometimes, and particularly so if the field in which the plan is to be applied has not already been well plowed over by planners ahead of him, the essentials of a good plan may be immediately evident. Then work on a more detailed plan can immediately proceed.

In general, however, it will be found that gaps in understanding exist which must be filled in before even the outline of a good plan can be produced.

Maybe there is a gap in knowledge of the field of operations. A frequently encountered gap is knowledge of "user preference". The new plan may aim to produce a product with which the user is unfamiliar. Then special trials are necessary to find out if the new product would really serve him well.

Or the gap in knowledge may lie somewhere in the physical world. Then a special research or development exploration will be indicated.

Lest this discussion become too abstract, I will give you illustrations, from my past experience, of how gaps in understanding have been filled in.

1. When nationwide customer dialing was proposed, one requirement was that the customer must dial ten digits. Would he like this? Would he make too many mistakes? To answer these questions a big trial was made at Englewood, New Jersey in 1951. This showed that the customers really liked this service and really made few mistakes. So the grand plan for nationwide dialing proceeded.

2. When the application of telephone carrier to fine wire cables was first proposed back in 1928, it was evident that this would involve thousands of vacuum tubes in tandem with amplifiers spaced only about 17 miles apart. Would the cumulative distortion introduced by these vacuum tubes present a serious problem and, if so, how could it be overcome?

This led to a trial within the laboratories of a lot of vacuum tubes in cascade which demonstrated that the distortion would not be serious.

Another question raised at that time was whether adequate stability of a carrier system, several thousands of miles long and with hundreds of amplifiers in tandem could be achieved, in spite of the large transmission variations to be expected in the conductors due to temperature changes and the large number of amplifiers in tandem, in which changes in amplification were anticipated due to aging of tubes and variations in power supply voltages.

Inventions were soon forthcoming to take care of these things. The invention of the negative feed-back principle went a long way toward eliminating the amplification variations. The invention of several forms of automatic transmission regulators took care of the variations in the lines and of the small variations remaining in the amplifiers.

Thus these several gaps were filled in and the plan for applying carrier to fine wire cables could proceed.

I will say just a few more words about the making of plans after the gaps in understanding have been filled in.

I do not believe that it is possible to set up a method of planning which can be applied, slavishly, as routine applicable in all situations.

Some plans offer large and evident possibilities of great savings. Under such circumstances, precision in estimates of savings to determine the worthwhileness of the project are unnecessary. Also it is unnecessary to go into much detail in the planning.

In fields which have already reached a high state of development, however, a much more detailed plan is necessary and a much more accurate cost study, to determine the probable worthwhileness of the project.

Where a detailed plan is necessary, close cooperation with both development engineers and researchers is a prime requirement. A new plan usually involves an assemblage of elements. Some of these may already exist as concrete things while others exist only in the imagination of the planner.

The development engineers and research men can help a lot in assessing the possibilities, sometimes in estimating performance characteristics of the imagined element and sometimes, simply, in estimating what its cost is likely to be. If there is great uncertainty as to whether one of the imagined elements can in fact be created, some exploratory research may be necessary. In some cases the imagined element may occupy so prominent a place in the system that its cost will be controlling. Then it may be necessary to actually build a model of the proposed new element to better assess its probable cost.

Finally, after the list of required elements for the plan is complete and the operating characteristics and probable cost of each element has been obtained or estimated, it is a straightforward matter to estimate the over-all performance and cost of the whole system. Then, these costs are compared with the benefits to be obtained. Thus an assessment is made of the worthwhileness of the project.

Right here, if he has not been forehanded, the planner may bump into an unanswered question as to whether or not the new system would really

serve the user well. However, this would be a poor time to run into this question of user acceptance, because an adverse answer might wreck the whole plan.

It will be assumed, therefore, that user preference studies will have already been made, using human "guinea pigs" and some sort of dummy system whose over-all performance simulated that of the system envisaged in the plan.

Even if some user preference studies have been made, it is usually desirable to construct a "breadboard model" of the new system and try its performance on actual users as the last step in planning, preparatory to the initiation of development for manufacture.

I am sure that all of these necessary steps in planning will sound very simple as in fact they are. In my experience, the major difficulties will be found in obtaining the two essential ingredients already mentioned, which must be in hand before an effective job of planning can even be started. Good understanding of the field of operations wherein the plan is to be applied is one of these. The other is possession of a good imaginative understanding of the possibilities reasonable to expect from advances in science.

To create a group of individuals possessing these two essential ingredients is the really tough job. Evidently this group must be composed of gifted people. They should also possess the qualities of self-effacement, tact, and sympathetic understanding.

In closing I would like to add the thought that "The Scientific Enterpriser" is not a recently created type of human being. Rather, he is thousands of years old. To illustrate, Archimedes was such a man. History tells us that, about 200 years before Christ, he devised plans for and had constructed engines of war which terrified the Romans.

What is perhaps new about "The Scientific Enterpriser" or "Development Planner" is that he has become a specialist or group of specialists. He is most easily identifiable in an institution large enough to have a separate organization devoted to research and development.

A. B. CLARK