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## HOPS - The HARVEST Operational System

### 1. Introduction

The National Security Agency is expecting to install the HARVEST computing system late in 1960, and to begin shifting much of its data processing effort to the new equipment during 1961. This system is considerably faster than currently operating computers, but it is correspondingly more complex both to program and to operate.

The potential contribution of the new system to Agency problems is large. To insure that the complexities of HARVEST do not hinder this potential, MPRO will have to change its way of working in some important respects. It is the purpose of this paper to explain the changes in operation, and to indicate why they are necessary.

Present plans for HARVEST call for it to take over much of the work now being handled by the different general purpose equipments in MPRO. Therefore, in designing the system of operation the principal attention must be given to doing present types of work better than is now being done. The use of HARVEST to handle problems which are too big to go on present equipment is secondary in importance to the improvement of current operations.

### 2. Goals for HARVEST

The high-speed digital computer has had a revolutionary impact on the work of the Agency. Nevertheless, there is no room for complacency about what we have done. It takes much too long to program a job of any complexity. Even worse, the elapsed time to get a problem done by a program which is operational is much too great.

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It must be recognized that with the great bulk of Agency applications, the time a problem spends on the computer is a small part of the elapsed time. If the great speed of HARVEST can be used only to reduce this small part a little further, the potential contribution of HARVEST will not be realized.

It is also clear that MPRO cannot hope to deal with the greater complexity of HARVEST, both in programming and in operating, by a large overall increase in staff. Therefore, it must go over to methods of programming and operating that are more efficient in their use of people, and especially of the people with the scarcest skills.

A new operational system is required. This system must accomplish the following three goals:

- a) It must considerably reduce the time necessary to prepare a valid program initially.
- b) It must aim for quicker service on operational programs - overnight results on all but the largest problems.
- c) It must standardize and simplify the work so that these improvements can be realized without a large permanent increase in the size of the MPRO staff.

These goals imply that there must be a considerable increase in productivity, even though the MPRO staff is already working as hard and as loyally as it can within the present-day system. The greater efficiency of the new system will be based on a clearer understanding of the complex processes involved in getting work done successfully on the computer, so that steps wasteful of time or effort can be eliminated or rearranged. Also, the new system will require increased cooperation and improved problem definition from the sponsoring offices, in order to make possible a greatly improved service to them.

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It should be emphasized that these goals are established not merely because MPRO desires to improve its output and increase its achievements. The new system is required if NSA (and in particular PROD) is to keep up with the technological advances affecting the capability of NSA to accomplish its mission. The HARVEST equipment is very complicated to program and to operate. With present methods of operation manual compilation of HARVEST program instructions would take much longer than is now required for existing computers, and a substantial increase in programming staff would be necessary. Operation with present methods would result in little improvement except in the ability to run somewhat longer problems. To use the machine in this way would mean a tragic waste of its capabilities.

The system being developed in order to attain the stated goals is called HOPS - The HARVEST Operational System. The remainder of the paper will be devoted to an explanation of the system and of its relation to the three goals. It must be emphasized that HOPS is little more than an outline at present, and that a great deal of planning and development will be required to expand this outline into the desired smoothly-running system.

### 3. Programming of New Problems

The first aspect of HOPS is its use of an autoprogramming system called ALPHA (Advanced Language Processor for HARVEST) in order to shorten the time required to write new programs. It is intended that all new programs be written first in ALPHA. The resulting programs will inevitably have poor efficiency in terms of running time. However, this inefficiency will be of trivial weight in comparison to the saving in elapsed time, for three reasons:

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a) The majority of programs are modified substantially after they have completed one or two valid runs.

b) For most programs, the total savings in running time, through more efficient programming than would be possible with ALPHA, will not justify the extra time and effort of such programming.

c) The decision that a program does justify reprogramming for running-time efficiency can be made after a valid run has been obtained. This procedure will not involve any waste in effort. In fact, the deferring of the investigation of special programming techniques until the problem has been firmly defined by some preliminary runs is likely to be the most economical way to use the scarce skills of the expert programmer.

In addition to the advanced language, there will also be a symbolic language using HAP (HARVEST Assembly Program). This will be used primarily to extend and improve ALPHA, and also for reprogramming problems where these warrant the effort to improve running time.

The complexities of programming for HARVEST have made it necessary to include a supervisory program HASP (HARVEST Supervisory Program) in the programming system. This is intended to simplify certain aspects of the programmer's job that are common to most or all programs.

#### 4. Running Programmed Problems

The objective of overnight service has been mentioned for work using operational programs. For this to be possible, job requests and data must be dealt with in a completely new way.

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There are two completely distinct parts to a job involving an existing program. First, the data input to the problem must be assembled in correct form and made accessible to the computer. Second, the program must be applied to the data in the actual computer run. Under present operations if the sponsor properly anticipates his needs and gets the data preparation largely completed before the formal job request is submitted, elapsed time is likely to be short. If he does not, and the job request initiates the data preparation, elapsed time is almost certain to be long.

Under HOPS, data preparation must be completed by the time the formal job request is made. However, a special system of handling data will make it relatively easy to get ready ahead of time. This will involve the establishment of a set of active files on TRACTOR tape, "TRACTOR" referring to the high-speed tape system which is subject to the control of the HARVEST computer.

During production runs on HARVEST, all data must be located in the TRACTOR files. If the necessary information is not on TRACTOR tape when a production run is desired, a file preparation run will be made before the production run can proceed.

This system will have some important advantages for the sponsor and for MPRO:

- a) It will make overnight service possible by encouraging accurate data preparation in advance.
- b) It will reduce the volume of data processing by eliminating the need for multiple forms of the same data.
- c) It will make record-keeping and routine analysis of data much simpler and more systematic.

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5. Standardizing Operations

If HARVEST is to take over the work now handled by a diversity of present equipments, a considerable simplification of procedures, data formats, operating rules, etc. will be possible. This standardization will at the same time be vitally necessary in order to permit efficient, largely automatic operation.

The name "turnpike concept" has been given to the operational procedure which is planned. This name refers to a limited-access type of operation, in which problems are prepared in batches and fed in to the computer at standard intervals; meanwhile, the computer continues to run using the data and programs stored in its internally controlled TRACTOR files. Console direction of operations occurs only during breakdowns or other emergency situations.

The standard interval of operation would be broken up into several periods, each handling a separate type of work. For example, one period might do all straight processing of data, another might compile programs and assemble data for the production period, which might constitute the third period, and a fourth might be set aside for program debugging; these would follow automatically in turn. Results obtained might feed out continuously, or be held for the next data-processing period, as appropriate.

6. System Improvement and Evaluation

A system as complex and many-sided as HOPS will require much time and effort in order to bring it to a stage of smooth and satisfactory performance. Initially some elements of the system will be in a preliminary or interim form; the ALPHA programming system in particular will require expansion and improvement. Defects in planning will have to be spotted and corrected.

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A means of evaluating and improving performance must therefore be considered an essential part of HOPS. A systems engineering staff will be responsible for approving and instituting all changes to HOPS. Evaluation will be provided on a continuing basis through a regular review of work done on HARVEST as well as of programming for HARVEST.

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