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ANNEX F

COINS MASTER PLAN

PART I

U N I T E D S T A T E S I N T E L L I G E N C E B O A R D

INTELLIGENCE INFORMATION HANDLING COMMITTEE

C O I N S

Community On-line INtelligence System Experiment

Test and Analysis Panel

PLAN FOR GATHERING, ANALYZING AND PRESENTING DATA ON PERFORMANCE AND USE OF COINS

IHC-D-113.4/11
31 May 1968

STAT

ABSTRACT

This plan provides for the collection, analysis, and compact presentation of statistics and other information on the performance and use of the experimental COINS data transfer system; and allows for forecasts of the demand for the system and of its response times under different conditions of load. If the system is judged a failure, the proposed analysis should suffice to determine the cause. But if it is judged a success, performance and use data will not suffice to show that the system is worth the cost. Determination of the value of such a transfer system would have to be part of a comprehensive analysis of the intelligence system.

In order to obtain the needed data on performance, use, and user reaction, the following actions will be required of agencies participating in COINS:

Use in COINS messages of an identification number that uniquely identifies both the particular query and the user/analyst.

Weekly submission to DIA of the COINS User Log Forms completed by analysts at each COINS terminal.

A monthly exogenic queries report on internal queries that compete with COINS queries from other agencies.

Interviewing of COINS users in accordance with the COINS Evaluation Interview Guide; and the monthly reporting of interview results.

A one-time COINS environmental report as of 31 January 1969 covering location of terminals, means employed to interest analysts in COINS, and training.

CONTENTS

I. Introduction

A. Panel's Tasks and Rationale

A memorandum for the record, issued 30 January 1968 by the chairman of the COINS committee, set forth the tasks and responsibilities of the panel as follows:

1. Develop and present to the COINS Committee for approval a plan for acquiring, analyzing and presenting data on:

   (a) System utilization,
   (b) System performance, and
   (c) User reaction to the system.

   This plan is to be submitted no later than 1 June.

2. Oversee and coordinate execution of the approved plan.

3. Recommend such other data acquisition and analysis as in the Panel's judgment is necessary or desirable in connection with system evaluation.

The panel was pleased to have its responsibilities spelled out in this way, because they are both realistic and well suited to the nature of the COINS experiment. It is clear from the documentation on COINS that "experiment" has been used from the beginning in the sense of "trial". The COINS system was developed as a means of allowing analysts in participating agencies to access information in the files of other agencies directly; and it was to be subjected to trial in order to determine how it performed and how users responded to it.

The panel believes that, given the nature of the COINS experiment, "evaluation" should be understood to mean "learning as much as can be learned from the COINS experiment, or trial" in order to determine whether this is a promising approach to a community information system and to decide on the next steps. In this context, evaluation is not to be understood in the narrower sense of measuring the performance or use of the system against some standard, or base line, or set of evaluative criteria, for these have not been, and cannot readily be, developed. The principle goals, therefore, of this data gathering and analysis plan are (1) the presentation of statistics on the actual performance and use of the system; (2) the forecasting of demand and of performance under different conditions of load; and (3) the presentation and discussion of other, primarily non-quantitative information that will help to develop an understanding of the factors that affect

performance and that account for differences in levels of use, users' reactions, and views as to the potential utility of such a system.

The data and information to be presented should be thought of as indicators of the effectiveness and potential of such a system. In the last analysis, use is the best indicator of the value, or utility, of an information system, but as of now there is no basis for saying how much use must occur before the COINS system has demonstrated its utility. Statistics on use must be treated with considerable care. Even if a new kind of information system has reached the operational stage, and COINS has not, it still might take quite a long while for the community of users it serves to learn to make effective use of it and to adjust their work habits to it.

The panel expects that conclusions from the COINS experiment and decisions as to the next steps toward a useful community system will have to be products of informed judgment; and hopes that the data resulting from the proposed plan will serve to inform those who must draw conclusions and make decisions. If the COINS experiment is judged a failure, the data on use and performance should suffice to determine the cause. But if it is judged a success, such data will not suffice to show that the system is worth the cost. In order to reach this conclusion, estimates of the reduced labor cost, of the cash equivalent of more timely reporting, and of the costs of the system would be required. Such an analysis of the value of an information transfer system would have to be part of a comprehensive analysis of the intelligence system.

B. Definition of the COINS System.

COINS is a sub-system, specifically the transfer component, of an intelligence data system. The data in COINS files constitute a data base for the use of intelligence analysts, but are a small part of the data needed for the production of intelligence. The purpose of COINS is to make some of the files in certain agencies accessible to analysts in other participating agencies. The designers of COINS created an interagency linkage of several agency data storage and retrieval systems; and did not address such questions as the value of the tasks upon which the potential users were engaged, their competence to perform them, the content of the files, means of updating them, or the efficiency of the retrieval systems. Hence, COINS is not a complete information system as this term is usually defined, but rather the transfer component of such a system.

This transfer system is a standard on-line duplex store-and-forward system. Queries filed at a teletype terminal are transmitted (practically instantaneously) to a central computer which stores the query until the line to the addressee becomes free. After the line becomes free, the query is then transmitted to the addressee where it

enters the queue for the file called. Here the query waits its turn. When this turn arrives, the file is searched and an answer is transmitted automatically to the central computer. Here it is stored until the line to the originator becomes free and then transmitted to him. A complete description of COINS can be found in the DIA COINS Test Facilities and Implementation Guide, Technical Report No. RADC TR-67-665, March 1968.

C. Scope of the Panel's Plan

The plan, which is spelled out in detail in Section II of this report, is focussed on the three aspects of the COINS system that the panel was asked to cover, namely, system performance, system utilization, and user reaction. The plan contains the following principal parts:

1. Statistical analysis of performance and of minimal data on utilization and user reaction

The principal sources of data will be: the switch log, which will automatically maintain records of all interagency traffic through the system; and user log forms which have been designed to gather from a user at a terminal certain minimal information on his identity, his office, the times at which queries are entered and responses received at the terminal, the user's satisfaction or dissatisfaction with the response, the principle reason(s) for dissatisfaction, and ease of use. The data from these user log forms will be coded and , together with the data from the switch log, will be analyzed in order to obtain statistics on, for example, total use of the system, use of each file, response times, reasons for delays, non-responses and reasons for them, and user reactions. To obtain performance statistics, certain data will be required on operational readiness of the agencies' systems and on internal queries of their COINS files that compete with COINS queries from other agencies and that are not recorded by the COINS system.

2. Intensive analysis of utilization and user reaction

An interview guide has been developed for in-depth interviews of users in order to learn more about the circumstances of use, with attention to both favorable and unfavorable experiences with the system, and to obtain user's views on deficiencies, needed improvements, training, potential use of such a system, and alternatives to COINS.

3. Description of environmental conditions affecting use

In order that the data on use and user reaction may be properly understood, each participating agency will be requested to prepare a

report describing the environmental conditions in each agency that may affect use of COINS, such as training, assistance provided, steps taken to interest potential users in the system, and locations of terminals in relation to potential users.

Some comments on certain kinds of data not covered by the present plan may be in order. The panel has not planned any economic analysis of the COINS system because, in its original recommendation that resulted in the COINS effort, the President's Foreign Intelligence Advisory Board indicated that the system should be regarded as experimental and "there should be no attempt to insure that in its experimental form its operation can be economically justified." Moreover, it is the panel's impression that the costs of developing the experimental COINS system are inextricably intertwined with the cost of developing formatted files, query languages and hardware/software complexes for agency systems; and that no records have been maintained of the man-hours devoted to COINS committee and panel activities during the system design and developmental period.

The panel has not made plans for the gathering and analysis of data on security aspects of COINS for a number of reasons. Secure communication channels for the system have been approved by the proper authorities. COINS I will operate at a single level of security only, and will therefore not present the special problems of a multilevel security information network. A secure environment has been assumed for the COINS terminals, and therefore no authentication procedures have been included in COINS I. As for protection of the files against unauthorized modification, those responsible for each agency system and its component files can guarantee that users will not have access to procedures that could be used at a console to make changes in the files. The panel believes that multilevel security arrangements are likely to be included in any future COINS system and that the problems they present must be given careful study by a highly qualified group, such as the DOD/ARPA committee on security chaired by Willis Ware. We believe it would be advisable for the COINS community to look to that committee for guidance on security requirements and test procedures.

Even though it can be assumed that the organization of the formatted files in the COINS system and the query languages and search techniques used in querying the files will have an effect on performance, the panel has not made plans for the technical analysis of file organization, query languages, or search tactics. The plan encompasses data on the extent to which slow response times are caused by "retrieval" time, as well as users' comments on difficulties with query languages and search limitations. Such data and comments may indicate the need for further attention to file organization, query languages, and/or search tactics. If so, these matters should be the subject of study in connection with any continuing design and development work on COINS I or its successors.

The panel has not made any plans for a technical analysis of the software in the COINS system because it is understood that this task is within the purview of the Computer and Communications Interface Panel.

D. Schedule of data gathering, analysis and presentation

The earliest date on which it will be possible to begin to gather data on the performance and use of the total COINS system is not yet known, for it is not clear when the links among all participating agencies will have been established. As soon as the total system is considered to be operationally ready, data gathering can begin. The end of the data-gathering period on the COINS experiment must be no later than 30 June 1969 because of the need to draw conclusions and reach decisions on follow-on actions by September 1969. The panel proposes to gather and analyze data for the entire period from implementation of the total system, whenever that may be, to 30 June 1969.

The experimental COINS system will continue to evolve during this test period as equipment changes are made and as software is improved in order to achieve better performance; and as files are added to or withdrawn from the system. In addition, users' actions and attitudes should also change as they learn from both training courses and experience in using the system. It is important, therefore, to gather data over an extended period of time so that trends will be discernible and the effects of changes in the system and of user learning can be determined. The present plan is to obtain user reaction for each query submitted, but this requirement may be relaxed after sufficient data have been collected.

It should be noted that the data on the last few months of the period will be the significant data from the standpoint of evaluation, because the first portion of the period will be more in the nature of a "shakedown cruise" during which many adjustments will probably be made in the system software and users will be gaining knowledge of the system and experience in its use.

Summary statistical reports covering each four-week period will be prepared for submission to the COINS Manager.

In-depth interviews of users will begin three months after the start of the test period and will continue to the end of the period. The results of the interviews will be summarized monthly.

The agencies' reports describing environmental conditions will be due in February 1969, so that the use data gathered during the last few months of the test period can be understood in the light of up-to-date descriptions of terminal locations, training of users, etc.

A final report on the use and performance of COINS during the test period and on the views of the user community will be scheduled for completion by 1 August 1969.

II. Plan for Data Gathering, Analysis and Presentation

A. Statistical Analysis of Usage and Performance

A distinction is made between the effectiveness and the utility of the COINS system. The utility of the system depends not only on the effectiveness of the system but also on the content of the files and on the needs and skills of the users; the effectiveness of the system - in standard engineering terminology - depends only on the performance characteristics of the system itself. And, while the effectiveness of the system can be measured, its utility cannot.

Certain questions, however, about the use which has been made of the system and about the reactions of the users can be answered. The demand and the degree of customer satisfaction can be determined; and responses which are unsatisfactory because of the performance of the system itself can be discriminated from those which are unsatisfactory for other reasons.

1. Data Collection

The statistical data required for this purpose are to come from four sources:

(a) The User Log Forms

These log forms (Appendix I-A) are to contain the name of the user, his identification number, his section and agency and the name and agency of the file queried, the identification of the query, the date and time the query was filed and the time the answer, if any, was received, and the user's expressions of satisfaction or dissatisfaction. Copies of the log form will be available at each COINS terminal for the use of persons submitting queries during the test. Although it is presently considered essential to obtain user reaction for each query submitted, this requirement may be relaxed after sufficient data have been collected. The log forms are to be filled out at each terminal and forwarded to DIA at the end of each week for key-punching.

(b) The Switch Log

This log contains the designation of the computer system originating the message, the system (and file) addressed, the identification of the query involved (and the priority), the time at which the message was received or sent, and the count of parity errors. This log is maintained automatically by the switch at DIA.

(c) The Operational Readiness Report

This report is to contain the date and time period during which each computer system was down for preventive maintenance or due to malfunction of a described type or was withdrawn from the COINS system by the sponsor. This report is to be prepared weekly by DIA.

(d) The Exogenic Queries Report

This report is to contain the number of queries during each hour which compete with the COINS queries and which are not recorded by the COINS system, together with the priority of each query. This report is to be prepared monthly by each agency covering each of its COINS files.

2. Data Analysis

The analysis of these data is to consist of three major parts:

(a) The preparation of a single evaluation record

As soon as possible, all of the basic information about each query in the user log and in the switch log is to be consolidated in a single record (Appendix I-B).

(b) The analysis of the demand for the service

Queries will be counted in order to provide data on system usage; and to forecast the total demand and the workload for different computer systems.

(c) The analysis of the response of the system

The plan is to tabulate the records of down time by hour of the day and by computer system, compute the percentage of queries lost and queries with parity errors, and determine the effect on response time of COINS system error. In addition, the response time will be displayed as a function of workload. If consolidation does not produce a significant loss of information, detailed distributions of the time required to perform each function for each originator and addressee will be eliminated after the initial runs have been examined.

For a more detailed discussion of the proposed data analysis, see Appendix II.

3. Statistical Presentation

The results of the statistical analysis are to be presented in two sections ... one on system usage, the other on system effectiveness. The section on system usage will consist of a short summary of the statistics on over-all usage and user reaction and of detailed breakdowns by user and file and by date, day of the week and hour of the day; the section on system effectiveness will consist of a short summary of the values of the elements of system effectiveness and of performance curves for transmission and retrieval time.

(a) The Summary of System Usage Data

The summary of system usage is designed to answer some management questions ... in particular, questions about the demand for the service and the degree of expressed customer satisfaction. To present these data, the following form is suggested:

Current Demand

During the four-week period ending _____, _____ analysts submitted _____ queries to the system. Of these _____ percent were answered satisfactorily, _____ percent were deemed unsatisfactory due to the content of the reply, and _____ percent were deemed unsatisfactory due to the performance of the system. However, _____ percent of the queries answered satisfactorily could have been answered without the use of COINS as soon as was required.

Ease of Use

Of the _____ analysts who used the system, _____ reported the system as easy to use, _____ as somewhat difficult, and _____ as so difficult to discourage further use.

Degree of Interest

In addition to the _____ analysts who filed queries to gain information, _____ analysts filed queries to familiarize themselves with the system. Of these _____ analysts, _____ reported that the system was easy to use and produced satisfactory results.

(b) The Summary of System Effectiveness Data

The summary of system effectiveness is designed to answer the three operational questions: the proportion of the time during which the system is operational, the proportion of the messages transmitted correctly (while it is operational), and the speed of the response. To present these data, the following form is suggested:

Operational Readiness

All components were operational _____ percent of the time.

System Reliability

Due to lost messages, _____ percent of the queries were unanswered.

Due to line noise, _____ percent of the queries contained parity errors.

System Response Time

When no delays occurred, the average time required to transmit each dialogue was _____ minutes and the average time required to retrieve a reply was _____ minutes.

With an average input of_____ queries per hour, the average delay in transmission for each dialogue was _____ minutes and the average delay in retrieval was _____ hours.

For a more detailed discussion of the proposed statistical presentation, see Appendix II.

B. In-Depth Interviews of Users

User reaction to COINS will be determined in more detail by means of in-depth interviews. These interviews will be conducted initially with users of any of the 10 files selected by the IHC files panel but may be expanded to users of other files when activity statistics show that a better insight into COINS can be obtained from such an expansion of the interviews. The purpose of the interviews will be to collect data on the circumstances of use, favorable and unfavorable experiences with the system, training and prior experience, deficiencies, strengths, potentials of a COINS-type system, and possible alternatives thereto.

Procedures:

1. Under the direction of the COINS Manager and with a view to achieving comparability among interviews in different locations, the COINS managers in the respective agencies will: develop detailed schedules of interview topics and questions for the use of the interviewers; explore by means of trials the utility of having the text of the users' queries and responses available to the interviewers; and select and train personnel to conduct interviews of COINS users in their agencies in accordance with the COINS Evaluation Interview Guide. (Appendix I-C).

2. Interviewers will interview all users of the files designated by the IHC Files Panel at least once, beginning three months after the start of the test period. Interviewing will continue to the end of the test period. Periodical follow-up interviews of continuing users will be made according to a plan to be worked but by the COINS managers. The first three months of interviewing should be viewed as a period allowing for refinement of the interview techniques and further training of the interviewers. Interviews should be conducted if possible within five days after a particular instance of use. While interviews will normally be conducted in the office of the user, attempts should be made to conduct some interviews immediately following use.

3. Immediately after each interview, the interviewer will complete an Interview Report Form (Appendix I-D) and turn the report in to the agency's COINS manager. The manager will review these reports and determine if and when follow-up interviews are to be made.

4. Agency COINS managers will summarize interview findings at the end of each month in a narrative report to the COINS Manager, commenting on favorable and unfavorable aspects of user reaction and indicating corrective action taken when required (e.g. when training is criticized consistently, what has been done to improve the situation).

Copies of all Interview Report Forms will be attached to these monthly summaries.

5. Three months after the start of the interviews, all COINS managers, in consultation with the COINS Test and Analysis Panel, will review these procedures and determine if changes and adjustments are necessary. Consideration will be given to interviewing non-users (e.g. individuals who have received training but have not used the system), and interviewing individuals who are users of files other than the 10 designated for the test.

C. Environmental Conditions That May Affect Use

In order to understand the data gathered on the use of the COINS system, a variety of factors affecting its use must be examined. Past experience, even though somewhat limited, indicates that the location, and the noise, of remote consoles has a definite effect on the use of a remoted system. Other factors affecting use include the training or lack of training in how best to use the system, the provision of assistance to users, and measures taken to interest analysts in the system.

Each agency participating in COINS is requested to prepare a one-time COINS Environmental Report as of 31 January 1969. Each report is to consist of :

A completed Console Location Form (Appendix I-E) for all COINS consoles in the agency.

Any additional descriptive information considered relevant to an understanding of the physical location of consoles in relation to potential analyst users.

A description of the effect of noisy teletypes on nearby personnnel, if any, and actions required to abate the noise.

A description of means employed by the agency to interest analysts in the use of COINS.

A tabulation of training given to analysts in the agency. Give analysts' specialties, course names or numbers, and files trained on.

A brief description of each training course (duration, topics covered, classroom or individual instruction, etc.).

III. Other Data Gathering and Analysis Efforts

The panel was asked to "recommend such other data acquisition and analysis as in the panel's judgment is necessary or desirable in connection with system evaluation." The panel has given careful consideration to this part of its assignment and has decided against recommending any other data-gathering and analysis efforts at this time. It is the panel's view that, given the nature of the COINS Experiment, the data on performance, use, and user reaction that will result from the plan outlined in Section II will most probably be sufficient for judging the success or failure of the Experiment. The panel's rationale for this view is given in Section I.A.

APPENDIX I

FORMS TO BE USED IN RECORDING, REPORTING, AND ANALYZING DATA ON PERFORMANCE AND USE OF COINS

A. COINS User Log Form

B. COINS Evaluation Record Form

C. COINS Evaluation Interview Guide

D. COINS Interview Report Form

E. COINS Console Location Form

APPENDIX I-A

COINS USER LOG FORM

To be completed by analyst for each interrogation of a file in another agency

Analyst Name or name code_____ Assigned User Number_____ Organizational Component_____

Name of query technician or reference specialist, if any_____ Terminal_____ Name of File Queried_____

Date_____ Time Query Completed_____ Time Response Completed_____ Query Reference Number_____

1. The interrogation was made primarily: (check one)
   - ☐ (a) To obtain data in connection with an actual intelligence task
   - ☐ (b) To gain knowledge of the COINS system or files

2. If you judge response to be satisfactory, indicate whether the information could have been obtained without the use of COINS soon enough for your purposes
   - ☐ (a) Yes
   - ☐ (b) No

3. If you judge response to be unsatisfactory, check reason(s):
   - ☐ (a) Inaccurate or questionable information
   - ☐ (b) Outdated information
   - ☐ (c) Incomplete information
   - ☐ (d) Negative response when a positive response was expected
   - ☐ (e) Response not pertinent to query
   - ☐ (f) Response took too long
   - ☐ (g) No response at all
   - ☐ (h) Other (please specify)_____

4. Indicate present impression of ease of using COINS:
   - ☐ (a) Easy to use
   - ☐ (b) Somewhat difficult or troublesome to use
   - ☐ (c) Sufficiently difficult to discourage further use

5. Any explanatory comments on any of your answers will be welcome, as well an any suggestions for improving the file interrogated:

COINS EVALUATION RECORD

APPENDIX I-B

Reference Identification NUMBER	MESSAGE TYPE	PRIORITY	FILE NAME	Originating Agency & Office
1 2 3 4 5 6 7 8 9 10	11 12 13 14 15 16 17 18 19 20	21	22 23 24 25 26	27 28 29 30 31 32 33 34 35

Continuation below

Query File	Transmission Completion Times					Message Length	Answers to Questions			PARITY
							1	2	3	4
YY MM DD DTIME	Query to Switch	Query from Switch	Answer to Switch	Answer from Switch	Answer to User				a b c d e f g h	
36 37 38 39 40 41 42 43 44 45	46 47 48 49	50 51 52 53	54 55 56 57	58 59 60 61	62 63 64 65	66 67 68 69	70	71 72 73 74 75 76 77 78	79	80

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ANNEX F/19

APPENDIX I-C

COINS EVALUATION INTERVIEW GUIDE

A. PURPOSE

The purpose of conducting in-depth interviews with the users of COINS is to determine:

1. Adequacy of service
2. User requirements
3. User reaction to the system

B. INTERVIEW GUIDE

In order to determine the above, users will be interviewed along the following lines:

1. Job Analysis

This phase will focus attention on the job duties and specific tasks which require the use of a COINS type system. The tasks will be explored sufficiently to develop logical requirements for the system.

2. Favorable Experiences

Users will be asked to focus attention on the last time they had a favorable experience with COINS. The reasons for the favorable experience will be determined (e.g. short response time). (The interviewer will differentiate between a general positive attitude toward COINS and a specific experience). The next series of questions will focus on other times the user had favorable experiences with COINS. The interviewer will attempt to elicit specific details as above.

3. Unfavorable Experiences

Users will be asked to describe in detail the last unfavorable experience and state specific reasons for the failure. They will then be asked to relate details about other unfavorable experiences

4. Changed Performance Resulting from COINS

Users will be asked to identify tasks which require the use of an information system. They will then be asked to describe the steps taken in performing the tasks before and after COINS

5. Training and Experience

The user will be asked to indicate prior experience with similar on-line systems; and to describe the training received in the use of the COINS system and give details concerning the adequacy. He will be asked to make specific recommendations regarding desired changes in training.

6. Deficiencies (These may be covered by the interviewer in connection with other questions, or separately as the situation demands).

a. Are there any problems with user language?

b. Adequacy of response time (distinguish between need and "nice to have")

c. Files in the system (What information should be in the system vs. what is?)

d. Data Elements (Are the data elements in the files actually used adequate for the performance of the task?)

e. Any other suggestions that will improve the system?

7. Alternative to COINS

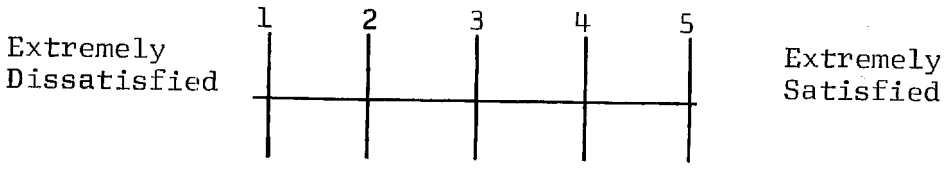
If there were no COINS how, and how efficiently, would the tasks be performed?

8. Continued Use

Under what conditions (different files, more data elements, shorter response time, etc.) will you continue to use the system?

9. Overall Rating

Have the user rate the system on this scale



APPENDIX I-D

COINS INTERVIEW REPORT FORM

(To be completed by interviewer immediately after each interview)

1. Name of User
2. Organization
3. File Queried
4. Specific language of the query (if available)
5. Duties of the user
6. Favorable experiences with COINS
7. Unfavorable experiences with COINS
8. Changes in user's performance resulting from use of COINS
9. Training received, its adequacy, and prior experience
10. Deficiencies:
    a. User languages
    b. Response time
    c. Files
    d. Data Elements
    e. Other, including
11. Alternatives to COINS
12. Conditions under which user will continue to use COINS
13. Overall rating
14. Other comments

APPENDIX I-E

COINS Console Location Form

TTY* Number	TTY Make	Normal** Access (Yes or No)	Separate Room (Check One)	Machine Room (Check One)	People Room (Check One)	Sound Proof Booth (Check One)	Operators On Duty (Yes or No)

* If more than one TTY is at one location, list all numbers in one box. If an agency number is not available, use simple sequence numbers, one through n.

** If within 200 ft., same level or one floor removed, of 80 percent of the users, access is considered normal.

APPENDIX II

DETAILS OF THE STATISTICAL ANALYSIS AND PRESENTATION

This appendix contains a more detailed discussion of the Data Analysis portion (II.A.2) and of the Statistical Presentation portion (II.A.3) of the plan.

Data Analysis

(a) The preparation of a single evaluation record

The evaluation record (Appendix I-B) will be prepared from the user log form and the message log maintained by the switch. Each user log is to contain a user number and a query identification number, each message is to contain the reference identification number which is to identify the individual user and the query uniquely.

The record will be prepared at DIA by keypunching a record for each user log and by extracting the time at which each action was completed from the switch log, accepting the errors introduced by lack of perfect synchronization of the different clocks.

The work record will then include:

The identification of the user and of the file.

The user's expression of satisfaction or dissatisfaction.

The time relevant to each operation required to answer the query.

The date and time of the query.

These evaluation records, sorted by agency, section, analyst name and date, will be used as a basis for the in-depth interviews and for the analysis of the demand for service and of the response of the system.

(b) The analysis of the demand for service

The first step of the demand analysis will be to make the counts required for the display of actual system usage, which are specified in detail in Sections (a) and (b) of the following Statistical Presentation section. The depth of additional analysis will depend on the volume of data.

When sufficient data are available, counts will be made of the number of analysts who filed one, two, three and so on queries during each week. In addition, these data will be broken down according to the section of the user and the file addressed, the expression of satisfaction or dissatisfaction and the number of the analysts who also filed one, two, three, and so on queries during the past week. If sufficient data are not available to justify a refinement of the statistics, counts will be consolidated until there are at least five items in each cell.

The data will then be used to make textbook short-term forecasts. For example, given a series of counts of the total number of queries per week, the forecast for the next week will be taken as the weighted average of the predicted number of queries for the last week and of the number observed, the weights having been selected to minimize the forecasting error.

The total number of queries filed can be broken down as described above and this same technique applied to forecast the number of queries in each cell; and the totals added to determine the forecast of the total demand. For example, queries might be classified according to the analyst's evaluation of the answer or as queries from old or new customers.

Then, if the breakdown does not improve the accuracy of the forecasts, the collection of the data which has been shown to be non-predictive can be stopped or at least reduced to the collection of data to that required by higher authority.

To determine the distribution of the workload in time, tabulations will be made of:

the number of queries filed during each hour of the day and day of the week in a 7 x 24 matrix, and tested to see whether the daily cycle differs significantly for different workdays;

the number of queries filed during each day of the week and each week, and tested to see whether the weekly cycle differs significantly from one week to the next and whether there is a significant change in total demand from one week to the next;

the number of queries filed during the period before and after each major change in the system, in the files, or in the training of the analysts and test to see whether significant differences in demand can be detected;

(c) The analysis of the response of the system

If actual usage fails to exercise the system sufficiently, the data obtained from operational use will be supplemented by experimental data. Specifically, the system will be queried during slack periods until sufficient information is obtained to allow predictions of the response time of the transmission system under the range of possible workloads for each pair of computer systems. It is not, however, planned to collect experimental data on retrieval time and it is not planned to collect the experimental data on transmission time until the data obtained from operational use have been examined.

The analysis of the data on operational readiness will amount to computing the percentage of the calendar time during which all computer systems are operational and the same percentage for each computer system. Similarly, the analysis of system reliability will amount to computing the percentage of queries unanswered and the percentage with parity errors.

The analysis of response time is more complex. The first step of the analysis will be to compute:

The times required to transmit the query (including waiting and service time) from the originator to the switch and from the switch to the addressee.

The retrieval time for the answer from the viewpoint of the switch (the time from the receipt of the query by the addressee to the receipt of the answer by the switch). The time from the addressee to the switch is included with the retrieval time since the time to traverse the communication line is negligible and the instant at which the answer is filed is not available at the switch.

The time required to transmit the answer (including waiting time and service time) from the switch to the originator).

In the analysis of retrieval time, the queries received by the file during each hour on each date will be counted and sorted in increasing order. All time periods for which the number of arrivals is the same will be defined as periods of the same type. If the number of observations is sufficient, the cumulated probability distribution of the retrieval time will be estimated as a function of the arrival rate by merely computing the percentages of retrievals which occurred during a given time. If not, retrievals which occurred during hours when the difference between arrivals was not statistically significant will be considered as arrivals of the same type; the observed number

of arrivals will be replaced by the average number; and the cumulated probability distribution will be computed as before.

These distributions will either conform to a standard probability distribution or they will not. If a standard probability distribution (hopefully a gamma function) is an acceptable approximation, the distribution point by point (as above) will not need to be laboriously computed after it has been done once. But if it is not, this procedure will have to be repeated until enough data have been accumulated for determination of the proportion of the queries which will be retrieved within a given time as a function of the arrival rate.

For the purpose of exposition, the question of priorities has been ignored. To take this into account, each distribution will be estimated on the basis of a classification of hours in accordance with the number of queries of the same priority or a higher priority.

To estimate the distributions of the four phases of the transmission time, the same procedure will be repeated, taking into account the originator and addressee. In the fortunate case, the distribution of the transmission time as a function of the number of queries will conform to a standard probability distribution and will predict the percentage of responses transmitted within a specified time as well as the distributions of the separate phases.

Statistical Presentation

(a) The detailed analysis of system usage data

The detailed analysis is designed to allow forecasts of demand. It is expected that the average demand will be a function of the user and the file used and that it will vary by day of the week and hour of the day and from one week to the next during a given month. In addition, there will be sudden changes in demand due to the addition of new files and changes in intelligence requirements. And it is hoped that there will be a long-term growth in the use of the system.

(1) In order to show progress, the summary statistics will be tabulated for all periods up to and including the current period. And, if demand can be forecasted with sufficient accuracy, a forecast of demand will be compared with the current demand.

(2) In order to forecast the demand, it is necessary to determine:

the distribution of queries filed during each week by each user against each file;

the distribution of the queries by day of the week and by hour of the day;

the distribution of the queries by week during the year;

the long term growth in the use of the system by each agency and the maximum demand.

(3) During the developmental period the work will be confined to presenting actual counts as follows:

the total number of queries filed during the four week period by each section (summarized by agency) against each file;

the total number filed during each day of the week during each hour of the day (7 x 24 matrix);

the total number of queries filed each week, during the current four week period and during all previous weeks.

In addition, counts will be summarized over the appropriate time periods before and after each major change in the system and, if the forecasts are sufficiently accurate, a comparison of next period forecasts and actual demand will be made.

(4) Prior to January 1, 1968 this plan will be reviewed and, if the data warrant the effort, it will be revised so that the required distribution can be obtained.

(b) The detailed analysis of system effectiveness data

The effectiveness of the COINS system is defined as the probability that the system will deliver the proper reply to a proper query within an acceptable time under a normal load. Since it is not known what time is acceptable and what workload is normal, families of curves will be developed to show the distribution of response time for workloads from one query up to saturation.

These curves will be divided into curves for transmission time and curves for retrieval time. The curves for transmission time (together with the plots of the available data) will display the performance of the switch and the computer systems; the curves for retrieval time (together with the plots of the available data) will display the performance of the retrieval systems.

(1) The distribution(s) of transmission time

If it is at all possible, data on the transmission time for the dialogues will be condensed into a single set of curves. This set of curves is to show the percentage of queries which would be answered within a specified number of minutes (if the retrieval time were zero) as a function of the apparent input rate.

To do this, the apparent input rate will be defined as the average number of queries filed per hour divided by the probability that no error in a query will be detected, thus taking into account both the workload and the reliability of the system.

Since the transmission time is relatively small, it is reasonable to hope that the transmission time between any pair of computer systems will not differ significantly from that between any other pair. More precisely, one would expect that the apparent arrival rate and the average length of the answer would be sufficient statistics for each pair of computer systems and that, although the error in predicting the response time for the transmission system might be statistically significant for computer systems which differ in the average length of an answer, this difference would not be operationally significant.

Initially, the observed distributions will be presented for each pair of terminals and for each phase of the transmission in addition to the consolidated data. In subsequent reports, these data will be eliminated whenever the subdivision has no predictive value and may be eliminated when the predictive value is deemed negligible.

(2) The distributions of retrieval time

For the purposes of this report, retrieval time will be measured from the viewpoint of the switch; it will be the difference between the time at which the transfer of the query to the addressee is completed and the time at which the transfer of the answer to the switch is completed.

A set of curves for each file addressed will be determined. The first curve will show the distribution of the service time ... that is, the proportion of the queries which will be answered within a given time after the start of the search. The remaining curves will show the distribution of the response time (waiting time plus service time) for queries of each priority in terms of the total number of queries (exogenic and endogenic) addressed to the file.

APPENDIX III

MATHEMATICAL APPENDIX

This appendix contains two short notes intended to convey to the non-mathematician some notion of the mathematical basis of this plan:

A. The Technique of Short Term Demand Forecasting

B. The Determination of the Response Time

A complete exposition of the basis is given in references 1 through 4.

APPENDIX III

A. The Technique of Short Term Demand Forecasting

The simplest technique for routine demand forecasting is to forecast that the demand for the next period will be the same as that for the previous one. And it is clear that, when the demand is constant, this rule is both necessary and sufficient. When, however, the demand is subject to random fluctuations, the error will evidently be decreased if the average demand is used rather than the demand for the previous period. The use of average demand, of course, has the disadvantage that remote experience has the same weight as recent experience so that, if non-random fluctuations occur, the error may become large.

One widely-used (and easily-computed) compromise is to use a weighted average of the observed and predicted demand for the current period to predict the demand for the next one. In terms of a formula,

$$m_{t+1} = p\, n_t + (1-p)\, m_t = m_t + p\,(n_t - m_t)$$

where p is a weight between 0 and 1

n is the number of queries filed during period t

m is the number of queries predicted.

Here p can be interpreted as the probability that the observed error was due to random fluctuation and - in the absence of data - can be taken as .25.

As more data become available, the use of more elaborate predictors can be justified. In fact their use can be extended indefinitely by taking into account the differences between the number of queries filed for one period and the next (the linear growth), then the differences of the differences, and so on indefinitely. Such predictors are fully treated in the literature.

The forecasts can perhaps be improved by using the distribution of queries rather than the total count. In other words, if the numbers of analysts who filed no, one, two and so on queries during each week are known, it is possible that use of the exponential formula to predict the number of analysts who will file no, one, two, and so on queries during the next week will yield more accurate forecasts of the total number of queries filed than estimates merely made from the total counts.

The forecasting routine can be elaborated indefinitely. For example, the transition matrix for this distribution can be determined; in other words, the number of analysts who filed given numbers of queries in two successive weeks. And whether or not expressed satisfaction

significantly influenced behavior can be determined. If sufficient data are available, therefore, routine forecasting of the total load on the system will be feasible.

Such forecasts are based on the assumption that no radical change in demand occurs and are, of course, probabilistic. It is unfortunate that some confusion may result; however, useful and well-known techniques cannot be ignored merely because they are not universally understood.

In this particular case, it is desirable to forecast demand for three reasons. First, such forecasts serve as a check on the accuracy and value of the data. Second, they serve to summarize past experience. Third, they permit determination of the impact of a radical change in the overall system (an effective sales program, the inclusion of a useful file, or an increase in timely service) on the critical factor for success. Hence, forecasts will be made whenever sufficient data are available.

B. The Determination of Response Time

In order to simplify the analysis, the transmission system will be treated as a black box, if possible. If so, the transmission time for a dialogue could be predicted from a single family of curves; if not, the model will have to be elaborated.

1. Discussion of the Model

In the model to be used, it is presumed:

(a) that the average number of queries filed during each hour for each pair of systems is a known parameter.

(b) that the actual number of queries filed is Poisson-distributed, and

(c) that the service time is a known arbitrary function of the pair of systems.

In point of fact, the system is quite complex. Queries can queue up at the input terminal waiting for a line to become free and, after transmission has been completed, can be delayed waiting for the receipt to arrive over the input line to the terminal. Hence, the holding time for a queue depends not only on the length of the query itself but also on the load on the input line.

In addition to the queue at the input terminal to the switch, there is a queue in the switch at the output to the addressee. Hence, this is a two-node tandem net and it is known that for such nets the times between arrivals and the lengths of adjacent messages are not independent.

The workload induced by a query is not simply a function of the query itself. Each query will generate service messages and will almost always generate an input to the system after some delay. Hence, the service for a query is not as simple as the service in standard queuing models.

Moreover, queries will not arrive completely at random within a given hour.

The above axioms, therefore, do not describe the system accurately, and it must be determined by experience whether these errors matter.

2. The Distribution of the Waiting Time

(a) It can be proved (Saaty[2], p. 109) that for this simple model

$$F(z) = (1-r)/[1-(a/z)(1-K(z)]$$

where: the Laplace transform of the waiting time $F(z) = \int_0^\infty f(w)\, e^{-zw}\, dw$ (the Laplace transform of the service time $K(z) = \int_0^\infty k(s)\, e^{-zs}\, ds$) (the input-output ratio* $r = a\,\bar{s}$, a is the arrival rate and $\bar{s}$ the average service time). Hence one may be able to determine the distribution of the waiting time from that of the service time.

For example, where $k(s) = be^{-bs}$, $K(s) = b/(z+b)$

so $F(z) = (1-r)\,(1+a/[z+b-a])$ so $f(w) = (1-r)$ where $w=0$

$= r\,(b-a)\, e^{-(b-a)\,w}$ where w is greater than 0. Hence $r = a/b$.

(b) For more general service distributions, the waiting time distribution is quite complicated.

where $k(s) = [(bs)^{k-1} / (k-1)!]\,[be^{-bs}]$

For example, $K(s) = [b/(z+b)]^k$

so $F(z) = (1-r) / [1-(a/z)\,(1-[b/(z+b)]^k)]$

However, it can be proved (Syski[3], p. 321) that

$P(w) = 1 + \sum_{i=1}^{i=k} A_i\, e^{-B_i\, W}$ where

$A_i = (1-r) / (1-k\,[\frac{a + B_i}{b - B_i}])$

* the ratio of the rate at which messages are filed to the rate at which they are transmitted.

$$- \text{SUM}_{i=1}^{i=k} A_i = r$$

$$r = k\ (a/b)$$

and the B_i are the roots of the equation

$$\left(\frac{b}{b-B}\right)^K \left(\frac{a}{a+B}\right) = 1,\ (a+B)\ (b-B)^k = (b)^k\ a$$

3. Expected Value of the Waiting Time

The form of these solutions suggests that it is very unlikely that simple expressions will be obtained for the probability of a reply within a prescribed time. Hence determination of the effect of variable service time, of detected errors, and of a priority system on average response time will be attempted.

(a) The Effect of Variable Service Time

If it is considered that queries are filed at random within any given hour of the day at any given station, then the average response time $\overline{x}$ will be equal to $\overline{x} = \overline{W} + \overline{s}$ where it can be proved (Bailey[4], p. 140) that:

$$\overline{W} = 1/2\ (1+ (d^2/\overline{S}^2))\ \left(\frac{r}{1-r}\right)\ (\overline{S})$$

where $r = a\ \overline{S}$ = the input-output ratio

$\overline{S}$ = the average service time (in the absence of delays)

d^2 = the variance of the service time (in the absence of delays)

a = the average number of queries filed

(b) The Effect of Detected Errors

The effect of detected errors in transmission will be to multiply the average delay in transmission (the waiting time) by a factor which depends on the chance that no error will be detected and the input-output ratio.

$$\overline{W}' = [\ (1-r)\ /\ (p'-r)]\ \overline{W}$$

where $\overline{W}$ is the expected waiting time in the absence of error

$\overline{W}'$ is the expected waiting time in the presence of error

p' is the percentage of messages filed for which no error is detected.

r is the input-output ratio.

Proof

Under certain assumptions, this equation is easily proved. Messages to be transmitted are considered to be filed at random. Now, if each time a message is found to be incorrect, it is retransmitted and if the chance of error at each transmission p' is the same, the effect of error will be to increase the load on the system by the factor 1/p'.

For it is well known that under these assumptions,

$P(n) = p' (1-p')^n$ and $E(n) = (1-p')/(p')$ and $E(n) + 1 = 1/p'$

where n is the number of retransmissions

So that $a' = a/p'$ and $r' = a/b = r/p'$

where a' is the apparent arrival rate (including retransmissions)

and r' is the apparent input-output ratio.

So since the expected waiting times are

$$\bar{W} = \frac{1}{2} (1+(d^2/\bar{S}^2)) (\frac{r}{1-r}) \bar{S}$$

and $$\bar{W}' = \frac{1}{2} (1+ (d^2/\bar{S}^2)) (\frac{r'}{1-r'}) \bar{S}$$

$$\bar{W}'/\bar{W} = [\frac{r'}{1-r'}] / [\frac{r}{1-r}]$$

$$\bar{W}' = [(\frac{r}{p'-r}) / (\frac{r}{1-r})] \bar{W}$$

$$\text{so } \bar{W}' = (\frac{[1-r]}{p'-r}) \bar{W}$$

(c) The Effect of the Priority System

As one would expect, the introduction of a priority system will not change the average waiting time for all messages. Under rather general conditions, it can be proved (Saaty[2], p. 231) that

$$\bar{W} = \text{SUM}_{i=1}^{i=n} (a_i/A) \bar{W}_i$$

and $$\bar{W}_k = [(1-R)/(1-R_k) (1-R_{k-1})] \bar{W}$$

where a_i is the arrival rate for messages of the i^{th} priority

$A = \text{SUM}_{i=1}^{i=n} a_i$ the arrival rate for all messages

$R = A/b$ the input-output ratio for all messages

A_{k-1} = the arrival rate for all messages of higher priority

$R_{k-1} = A_{k-1}/b$ where b is the processing rate for all messages

$A_k = A_{k-1} + a_k$

$R_k = A_k/b$

where $\bar{W}_k$ is the average waiting time for messages of the k priority

4. Need for further research

The basis summarized here is adequate for the investigation. If the average response time is acceptable as a measure of the over-all effectiveness of the system, no further mathematics will be required; if it is not, the mathematics required will be unintelligible and expensive. Moreover, general experience suggests that it is advisable to resort to simulation when simple models are inadequate.

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