

**DESIGNING COMPUTER SOFTWARE PACKAGE
FOR SOLVING APER PROBLEMS AND ANOVA**

BY

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CERTIFICATION

This is to certify to the best of my knowledge that this work has been carried out by me, ONYIA, PIUS EJKEME under the supervision of PROF. K. R. ADEBOYE in the Department of Mathematics and Computer Science, Federal University of Technology, Minna.

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DATE

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DATE

EXTERNAL EXAMINER

DATE

DEDICATION

This project is dedicated to the memory of my late daughter EZINNE
UNO-OMA ONYIA who passed on on the 22nd July, 1996

ACKNOWLEDGEMENT

It is my singular honour to thank the Almighty God the most beneficent and merciful for his blessings in seeing me through the programme.

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ABSTRACT

This project "Designing computer Software Package for solving Aperi Problems and ANOVA" discusses the widespread use of questionnaire in survey, coupled with that of digital computers in recent years by most establishments and individual is as important as the study of orthogonal polynomials in the approximate solutions of differential equations .

This study is a concise presentation of the basic concepts of questionnaire analysis with special emphasis on the development of computer software and computational algorithms for Basic statistical and applicable analysis inferred from well designed questionnaire referred to as "Cross-Classification having ordered categories "typical of the type used by most ministries and parastatals in their Annual Performance Evaluation Report Score (APER SCORE).

The approach is to ensure conceptual understanding of questionnaire design, coding, measurement and interpretation, and to provide very efficient analysis of questionnaire particularly for non-statistician users. Result sort include among others, averages or percentage performance score for any record or factors, presentation of best overall performance and of course finding the significant best performed individuals or records where the test of hypothesis fails to show equal performance or mean effect of factors or treatment by use of Analysis of Variance (ANOVA) method. Results are interpreted.

The interpretation and references made on these relationship are also discussed here.

CHAPTER ONE

GENERAL INTRODUCTION

1.1 THE MOTIVATION

The title of the study "Designing Computer Software Packages for Solving APER Problems & ANOVA" is aimed at developing simple and common statistical analysis software package for the analysis of "Annual Performance Evaluate Report" scores. "Analysis of variance" (ANOVA) is the technique used to analyse data from a designed experiment. Statistical analysis here refers to the application of modern statistical tools and tests that seek a logical way to quickly arrive at some definite, precise conclusions during decision making in the face of uncertainty. Statistical analysis software, therefore refers to computer applications program developed from some common statistical analysis techniques commonly used in evaluation analysis, with reference to analysis of variance.

Following the topic of the project, one may require to define computer as a complex system of electronics which will accept data and process them by obeying a set of given institutions (Sequence of processes) such as store, manipulate, and retrieve data, and if directed, sends the raw or processed data to an output device usually a printer. It usually performs these complicated tasks in the shortest possible time as compared to the amount of time it would ordinarily take a human being to accomplish the same task. All these the machine can handle effectively

without any human intervention or interruption. With this definition above, Designing Computer Software for Solving APER Problems and ANOVA in this study, refers to the application of computers or the development and use of statistical software programs for the statistical analysis (Analysis of variance in particular) of most commonly used and well designed questionnaire.

It is not an over statement to say that statistics and statistical concepts and methods are widely applied in many areas of human activity. They are extensively used in the physical, natural and social sciences, in business and public administration, and many other fields. In the sciences, the applications are far-ranging, extending from the design and analysis of experiments, to the testing of new and competing hypothesis.

One may then define statistics as a scientific methods for collecting, organising, summarizing, presenting and analysing data, as well as drawing valid conclusions and making reasonable decision on the basis of such analysis. Similarly, it is concerned with data that are subjected to uncertainty, the uncertainty being due to sampling, experimental errors, or due to intrinsic randomness in the phenomenon under investigation.

This branch of statistics is referred to as inferential statistics or inductive statistics. Presently the world is in a state of flux and experiencing quantitative evolution. Days of guess work approach to problem solving are or less over. There is the modern quest for objective bases for all kinds

of decisions. Decision concept therefore involves all activities that generate conditions and action. Condition known as decision variable refers to the possible steps of an entity. Actions on the other hand are alternatives that an individual may decide to take when confronted with a set of conditions.

Again, statistical analysis is useful whenever a problem can be defined in such a way that data of some kind, when properly collected and analysed, lead to it's solution.

Although this study concern itself with questionnaire analysis, it does not intend to provide a panacea for all forms of questionnaire design or all quantitative questionnaire analysis. For simplicity and suitability of "Analysis of variance" in this topic, the type of questionnaire format to be used in this study is typical of the questionnaire format in table 2. 1 below referred to, by Leo A. Goodman as "Cross-Classification having ordered categories".

Typical practical example of questionnaire, discussed here are those used by various ministries and parastatals particularly NYSC 1997 Promotion Examination in their Annual performance Evaluation Report Scores known and called APER SCORES. As a result, analysis should involve manual coding and compilation of data, paper presentations or Annual Performance Evaluation Report handouts of some topics and statistical tests analysis and decision making (computerized). Details of the

limitations of this study, including the format or kind of questionnaire covered are included in section 1.5

Historically, there has existed a major communication gap between Computer Scientists, System Programmers, and designers on one hand, and Statisticians on the other. As a result, statistical design and analysis of experiments is rarely applied to computer studies. "The consequences", as indicated by Schatzoff Martin (1981) "may include unnecessary expense, undue time delays, loss of information, misinformation and incorrect conclusion"¹.

Therefore, in this study, some of the basic ideas underlying the statistical design of experiments will be illustrated by means of real examples drawn from computer performance evaluation work. Also guidelines to good questionnaire design, coding methods and measurement techniques most suitable for analysis of variance, method of analysis coupled with justifications for their use are explained.

In this study, we confine our attention to the design that allows internal scale measurements techniques which allows for all forms of arithmetical computations and statistical analysis like ANOVA, which is chiefly employed here.

Two models of ANOVA are applicable namely Completely randomized design (one-way analysis of variance) and randomized complete block design (two-way analysis of variance). The assumptions

required for these models and their equations are included for guidance in chapter 2. Given the form of the model, the design of experiment is concerned with procedures which will enable us estimate the parameters efficiently and draw statistically valid conclusions, while minimizing or eliminating the effects of extraneous factors that may be beyond our control. Thus, the entire study also is illustrative of the scientific method of testing hypothesis of no difference in factor effects, and possibly identifying significantly different means where the null hypothesis is rejected (i.e. where difference in mean exists).

In spite of the fact that much of experimental and survey work have been done on statistical software packages and computerization, little is known about Designing Computer software Package for Solving APER problems and ANOVA discussion. It is my understanding, and fervent feeling that in my humble capacity as a statistician/system analysis, that this study will provide an even greater productivity for full fledged statisticians or those who have acquired enough knowledge in statistical methods.

1.2 PURPOSE OF STUDY (AIMS AND OBJECTIVES)

Techniques of statistical design of experiments have been successfully employed for many decades in a variety of applications in industry, Agriculture, Medicine, Psychology and other physical and social science. Their aim has been to provide scientific and efficient means of

studying the effects, on one or more variables of interest of varying multiple controllable factors in an experiment.

These techniques have not been widely used in the study of computer systems, although they can potentially have as large impact as they have had in other fields. The purpose of this study is to review some of the basic concepts underlying the statistical design of "Cross Classification having ordered categories" type of questionnaire, their coding and appropriate measurement techniques, and the application of ANOVA techniques using the computer systems.

The aims and objectives of the study are as follows:-

- (a) To present in a practical and rational manner, the fundamental coding and measurement techniques for classical statistical questionnaire analysis, particularly for data resulting from "Cross-Classification having ordered categories", type of questionnaire.
- (b) Develop statistical software programs based on sound statistical assumption and techniques for the study in question, with a view to removing or minimizing abuse of the use of statistical assumptions and analysis by non- statisticians.
- (c) To develop computer-aided computations of basic statistics such as averages, percentages, ratios, including statistical tests of hypothesis on these statistics, particularly analysis of variance tests, on any questionnaire that satisfies the questionnaire format

illustrated in chapter 2 coupled with the legitimate assumptions indicated therein:

1.3 RESEARCH METHODOLOGY.

Consultations were made from the following libraries.

- (a) Federal University of Technology, Minna
- (b) National Mathematical Center, Abuja.
- (c) NYSC Directorate Headquarters, Statistics Section.
- (d) Enugu State University of Technology, Enugu.
- (e) Onyia's Family Library.

These were coupled with personnel interview particularly with my project adviser. Prof. K. R. ADEBOYE.

Following a vast literature review, a variety of questionnaire designs were studied and appropriate questionnaire type or style christened "Cross-Classification having ordered categories" by Goodman², was chosen for study. This inturn, led to data collection in terms of interview, study of documents, and methods of analysis. Typically the annual performance evaluation score (APER SCORE) was selected as a model for study.

The results of these preliminary studies coupled with the associated problems and flaws, formed the foundation on which systems design and analysis were conducted. Also accompanying these are file specification, program specification, etc. dBase IV version was used in coding the program.

1.4 DEFINITION OF TERMS

QUESTIONNAIRE: Questionnaire as defined by the dictionary of statistical terms is "a group or sequence of questions designed to elicit information upon a subject, or sequence of subjects from an informant³".

STATISTICAL ANALYSIS: Statistical analysis here refers to the application of modern statistical tools and tests that seek a logical way to quickly arrive at some definite precise conclusion during decision making in the face of uncertainty.

STATISTICS: This is the study of the philosophies underlying the methods of collection and of analysis of numerical data. It is a tool for decision making in the light of uncertainty. Statistics therefore seeks a logical way to quickly arrive at some definite precise conclusions.

QUESTIONNAIRE ANALYSIS: Questionnaire analysis shall include appropriate statement of problems (aims and objectives of the survey), good choice of sample design and method of data collection, appropriate statistical analysis and test and reasonable inference or decision making.

COMPUTER: Computer is a fast and sophisticated electronic calculating machine which has been carefully assembled to handle any given task, be it in area of Engineering, statistics, mathematics,

general science, etc. and usually performs these complicated tasks in the shortest possible time as compare to the amount of time it would ordinarily take a human being to accomplish the same task, all these the machine can handle effectively without any human intervention or interruption.

ANALYSIS OF VARIANCE (ANOVA): "The total variation displayed by a set of observations, as measured by the sum of square" of deviations from the mean, may in certain circumstances be separated into components associated with defined sources of variation used as criteria of classification for observations. Such an analysis is called an analysis of variance, although in the strict sense it is an analysis of sums of squares. Many standard situation can be reduced to the variance form⁴".

$$\text{Sum of Squares (Total)} \Rightarrow \text{SST} = \sum_{i=1}^r \sum_{j=1}^c x_{ij}^2 - \frac{T^2}{rc}$$

$$\text{Sum of squares (Column Means)} \Rightarrow \text{SSC} = \frac{\sum_{j=1}^c T_{.j}^2}{r} - \frac{T^2}{rc}$$

$$\text{Sum of squares (Row means)} \Rightarrow \text{SSR} = \frac{\sum_{i=1}^r T_i^2}{c} - \frac{T^2}{rc}$$

$$\text{Sum of squares (Error)} \Rightarrow \text{SSE} = \text{SST} - \text{SSR} - \text{SSC}$$

TREATMENT: "In experimentation, a stimulus which is applied to observe the effect on the experimental situation, or to compare its effect with those of other treatments. In practice, "treatment" may refer to a physical substance, a procedure or anything which is capable of controlled application according to the requirements of the experiment⁵".

COMPLETELY RANDOMISED DESIGN: A very simple form of experimental design in which the treatments are allocated to the experimental units purely on a chance basis. Leads to one-way analysis of variance.

ONE-WAY CLASSIFICATION: When a set of variate can be classified according to the K Classes of a single factor. Such a classification is termed a 'one way' classification and forms the basis for the simplest case of variance analysis.

EXPERT SYSTEM: An expert system (also called a knowledge based system) is a very special class of information system that effectively captures and uses the knowledge of an expert for solving a particular problem experienced in an organization.

RANDOMISED BLOCK DESIGN: Any experimental design in which each BLOCK contains a complete replication of treatments, which are allocated to the various units within the BLOCKS in a random manner and hence allow unbiased estimates of error to be

constructed. Design leads to two-way Analysis of variance.

TWO-WAY CLASSIFICATION: The classification of a set observations according to two criteria of classification as, for example, in a double dichotomy or a correlation.

FACTOR: Used to denote a quantity under examination in an experiment as a possible cause of variation.

NOMINAL SCALE: This is a scale used only to categorize individuals in the population. For each category a number is assigned so that two different categories will be identified by distinct number. e.g. If individuals are classified by sex, then we can assign letters M and F, 1 and 2 to the two categories.

ORDINAL SCALE: In addition to categorising individuals in the population, this scale orders the categories. For each category we assign distinct numerals so that the order of the numerals corresponds to the order of the categories, thus if we assign numbers to the categories then the categories are in numerical order; if we assign letters to the categories then they are in alphabetical order, if we assign words to the words, e.g. we may wish to classify individuals into one of the three socio-economic classes; low, average and high. If we chose to order these categories from low to high then we may assign the numbers 1 = low, 2 = average, 3 = high etc. The structure of the ordinal

scale is undistorted under any one-to-one substitution which preserve the order.

INTERNAL SCALE: This scale not only categories and orders individuals, but also quantifies the comparison between categories. Thus we can determine how much more one category is than another. To make such comparison we need a unit of measurement and an arbitrary zero point"⁶.

POWER TEST: "Power is defined as the probability of rejecting the null hypothesis when it is false"⁷.

ROBUST TEST: " A test is called robust if inferences based on it remain valid despite the violation of one or more of the basic assumption necessary for the theoretical development of the procedure"⁸.

VALID TEST: " A test is called valid at a particular level α if the probability of a type 1 error does not exceed α for all null hypothesis. Type 1 error is the error committed when we reject a null hypothesis"⁹.

1.5 LIMITATION

The essence of questionnaire design and analysis is for the solution of the investigator's problem. However a well designed questionnaire, if perfectly analysed, may produce nonsensical or invalid results if the philosophies underlying the methods of its distribution and collection

(sample design) are not properly done. Similarly, no amount of statistical analysis will produce results better than the original or raw data. Thus if data are poorly collected, application of perfect computerized statistical package based on sound statistical and language principles will definitely produce result poorer than the raw data collect.

As Moser puts it, no survey can be better than its questionnaire, a cliché which well expresses the truth that no matter how efficient the sample design or sophisticated the analysis, ambiguous questions will produce non comparable answer leading questions biased answer and vague questions vague answers"¹⁰.

Again, statistical analysis is useful whenever a problem can be defined in such a way that data of some kind, when properly collected and analysis, lead to its solution.

However, this study does not guarantee the elimination and minimization of errors due to:-

- (a) Errors as a result of wrong or poor specification of objectives in relation to questionnaire design.
- (b) Errors due to wrong sampling namely methods of questionnaire distribution and collection. This include errors due to poor coverage of survey area.
- (c) Measurement errors in putting down the answer (i.e. response errors), interviewer bias errors etc.

- (d) Wrong question wording resulting in poor understanding of the intended meaning, the question is supposed to convey.
- (e) Respond and non-response errors. The factors or treatments or item under considerations at any one analysis are limited to a maximum of (20). Where factors are more than twenty, analysis may be made in two or more stages. The main statistical test here is analysis of variance (ANOVA). ANOVA tests are restricted to one-way and two-way classification with single observations per cell.

1.6 STUDY FORMAT

Chapter one of this project, general introduction embraces the motivation, purpose of study (aims and objectives), research methodology, definition of terms and limitations.

Chapter two examines the relevant of software package and system design literatures.

Chapter three discusses the present system, problems of the present system, need to improve on the present system and the effect on non-staticians.

Chapter four discusses the systems review and design with regard to system flowchart, system file, output and input specifications, programming, analysis and design..

In Chapter 5 we review implementation plans (involving training, testing, and system running), and discuss results of our achievements.

CHAPTER TWO

LITERATURE REVIEW

2.1 NEED FOR COMPUTERISED QUESTIONNAIRE ANALYSIS

In section 1.1 we saw our motivating factors to include among others, the rapid growth awareness and application of computers in virtually all facets of life. There is large volume of data to be analysed, and of course possible abuse of application of statistical assumption and methods in analysis of data involved.

The processing complexities involved require the use of computers.

As Bolanle Sodamade (1988) puts it, "The nation can no longer live in ignorance about computers and their relevance to its national development while its impact has continued to improve the standard of living in computer developed countries"¹¹. Thus the justification for computerised questionnaire analysis cannot be over stressed. According to Sanders, "A computer application is justified when processing complexities, permit no alternative or when the tangible and intangible benefits to be gained are greater than comparable benefits received from other processing alternative"¹².

2.2 CHOICE OF QUESTIONABLE FORMAT

The result of any survey is directly dependent on its questionnaire design and philosophies underlying its distribution and collection. There is therefore the need for a standardized question format in a situation like ours, that is, questions of standard and generally accepted format for an efficient and general software applications. Based on a vast literature, including works by A. N. Oppenheim (1992)¹³, N. M. Grunbohers (1990)¹⁴, Moser C. and Kalton G. (1991)¹⁵, Agubashim F. C. (1990)¹⁶, it was noted that question wording in questionnaires generally fall into any of the following categories:

- i. Choosing one and only one option (factor) from a mutually exclusive options as is the case of one choosing the material status or sex option,
- ii. Choosing one or more factors from independent options as is the case of choosing factors or reasons responsible for some phenomenon,
- iii. Selecting one and only one condition or category out of a^N categories for each of the N factors or treatments under study. Such questions or questionnaire have the following format.

**TABLE 2.1 QUESTIONNAIRE FORMAT FOR
COMPUTERIZATION**

S/No.	TREATMENT OR FACTORS	OUTSTANDING	VERY GOOD	GOOD	SATISFACTORY	FAIR	POOR
1.							
2.							
3.							
4.							
.							
.							
.							
N							

Therefore, this category of questionnaire shown in table 2.1 above is the type to be discussed and analyzed throughout our discussion in this study.

Further, process in this chapter will explain other reason behind this choice.

Typical practical examples of questionnaire type are those used by various Ministries and Extra-Ministerial Departments in their Annual Performance Evaluation Report Score popularly called 'APER' Score. This type of questionnaire has been given the name "Cross - Classification having ordered categories" in earlier chapter. Moser C., Kalton G. (1991)¹⁷ refereed to this form of questionnaire as "check list".

2.3 LEGITIMATE MEASUREMENT AND CODING TECHNIQUE FOR APPLICATION OF ANOVA

Another very important aspect of questionnaire analysis that has been mostly neglected and poorly handled particularly among the non-professionals, is measurement and coding of attributes.

The type of questionnaire under consideration (see Table 2 .1) does not involve the case where respondent is asked to decide just whether he agrees or disagrees with an item, but rather to choose between several response categories, indicating various strengths of agreement or disagreement. The categories are assigned scores and respondents attribute is measured by his total score, which is the sum of the scores of the categories endorsed for each of the items. In assigning scores, "INTERVAL SCALE METHOD" was adopted and most suitable in preference to other scaling methods like "NORMAL SCALE" and "ORDINAL SCALE" for the following reasons as indicated by AFITI A. A. and AZENI S. P. (1992)¹⁸.

- a. "The scale of measurement determines the type of arithmetic operations that can be performed on the data".
- b. "In a Norminal scale (see definition of terms), arithmetic operations are not meaningful. Hence the median and mean are no meaningful measures of central tendency.

tendency. The only appropriate statistic is the mode".

- c. "For the ordinal scale (see definition of terms) arithmetic operations are not meaningful for this scale so that an appropriate statistic for central tendency is one not dependent on the value of the numeral such as mode and median".
- d. "In the interval scale, arithmetic operations are meaningful so that the mean as well as the median and mode are appropriate measures of central tendency. Therefore, for the interval scale, all available statistical methodology, analysis of variance (ANOVA) in particular are applicable". This is our justification for the use of ANOVA in this study.

For the purpose of coding our questionnaire we shall use what Moser C. and Kalton C. (1991)¹⁹ called Likert scaling techniques, a technique which operates with the interval scale principles. The scales are referred to as SUMMATED OR SUMMATED RATING scales. In this technique, six categories are normally employed, and shall be adopted here (see table 2.1). The usual description for the six categories are:

Outstanding:- An exceptionally valuable member of the staff. Performance is well above

- Very Good:-** Displays good all-round level of effectiveness; performance meet requirements in all important tasks.
- Good:-** A competent member of the staff, generally achieves the standards required.
- Satisfactory:-** Completes all assignment satisfactorily within agreed date.
- Fair:-** Performance does not always reach the required standard. However, there is room for improvement.
- Poor:-** Performance does not meet the required standard.

Although, more complex scoring has been attempted, we shall, for the purpose of simplicity apply Likerts scaling principles and assign scores of 6, 5, 4, 3, 2 and 1. This is called coding. Therefore, to make a total score meaningful, items must be scored in order.

The individuals attitude or performance in terms of any factor under consideration, is measured by his total score - which is the sum of the scores of the categories he has endorsed for each of the items or factors or treatments. There is the problem of classifying respondents overall performance as outstanding, very good, good, satisfactory, fair and poor.

To achieve this, the respondents average score is computed. Average scores here means the total score obtained by an individual divided by the number of factors sum endorsed. Thus the average score is expected to range from 1 to 6 inclusive or 18% to 100% inclusive. There is therefore the need to classify the values 1 to 6 on a class interval of 6 classes capable of describing the individuals overall performance as "Outstanding", "Very Good", "Good", "Satisfactory", "Fair", and "Poor".

In other to achieve this measurement technique, overall performance was measured by employing partly what Michael N. Gronobery called "Cornell Job Description Index (JDI)¹⁹ and partly Likerts Scaling Techniques (LST).

The following assumptions were made:

1. the items of factors namely F1, F2, F3,....FN carry equal weights and measure the same thing namely performance.
2. The quantifying factors (performance) can be represented on a straight line interval scale.
3. The size of the rank interval is known and likely to be equal.

These assumptions are made for convenience. There are as proof (though they could be explained), however, that these assumptions are necessary correct though they do make things easier for measurement

purposes as M. Gronobery indicated in trying to place a worker's attitude on a live scale or linear continuum in such a way that he be described as "very satisfied", "moderately satisfied" and "not satisfied" preferably in terms of a numerical score or by means of ranking.

In any case, it is worth noting that when these properties are assumed, in order to place respondents score on a linear continuum, they could be regarded as being analogous to the assumptions made for classical or prior probabilities. For instance, when one states that the probability of obtaining a head when a coin is tossed is $1/2$, according to MOODGRAYBILL and BOES

(1994)²⁰, he has arrived at this result purely by deductive reasoning. The result does not require that any coin be tossed or even be at hand. We say that if the coin is fair, the probability of a head is $1/2$, but this is little more than saying the same thing in two different ways. As MOOD (1994) has it, nothing is said about how one can determine whether or not a particular coin is fair. The fact that we shall deal with ideal objects in developing a theory of probability will not trouble us because that is a common requirement of mathematical systems. Geometry for instance, deals with conceptual perfect circles, lines with zero width etc, but it is a useful branch of knowledge, which can be applied to diverse practical problems as ours. Therefore, then we believe that the average performance score ranging from 1 to 6 inclusive or 18% to 100% inclusive

can be grouped into six categories and individuals overall performance classified as follows:

TABLE 2.2 AVERAGE SCORE (ACTUAL) AND CLASSIFICATION OF PERFORMANCES

AVERAGE SCORE (ACTUAL)	CLASSIFICATION OF PERFORMANCE
1 - 1.8	Poor
1.9 - 2.7	Fair
2.8 - 3.6	Satisfactory
3.7 - 4.5	Good
4.6 - 5.4	Very Good
5.5 - 6.0	Outstanding

TABLE 2.3 AVERAGE SCORE (PERCENTAGE) AND CLASSIFICATION OF PERFORMANCES

AVERAGE SCORE (PERCENTAGE)	CLASSIFICATION OF PERFORMANCE
18 - 31	Poor
32 - 45	Fair
46 - 59	Satisfactory
60 - 73	Good
74 - 87	Very Good
88 - 100	Outstanding

Throughout this study, average percentage score shall be used in determining or classifying the overall performance in the factors or treatments.

2.4 JUSTIFICATION FOR USE OF ANOVA TECHNIQUES

The choice of statistical analysis test are known to be dependent among other factors, on the type of sample design, type of data collected, coding and measurement techniques and result expected. In section 2.8 we will see the justification for applying or using ANOVA technique since our coding and measurement techniques approve all available statistical methodology, particularly ANOVA. Although there is a legitimate controversy concerning the relative merits among these ANOVA, based tests, according to Barlet and kudell (1976)²¹, Brown and Forsythe (1984)²², Gartside (1984)²³ and Layard (1993)²⁴, "the consensus is that ANOVA tests are much more robust to distributional form than to the traditional normal theory procedures". As Giblons, J. O. has it " the most powerful tests are those that are based on the most stringent assumptions. On the other hand, the most rubost tests are by definition those with the weakest assumption" ²⁵. Thus, ANOVA is both powerful and robust (see definition of term). Thus apart from simple tests like computation of mean scores, percentage scores the major test of interest here is the test of analysis of variance (ANOVA).

2.5 ASSUMPTION FOR THE USE OF ANOVA

The main data to be analysed in this study involves tests either on the factors or treatments that affects the individuals performance. In this situation, there is the need to test for equality of several means simultaneously. According to R. N. Walpole (1974)²⁶ "a technique called analysis of variance is required. The analysis of variance is a method for splitting the total variation of our data into meaningful components that measure different source of variation. The precise steps in carrying out the analysis will depend on the experimental design used to generate the data ²⁷. If the experimental design involved the completely randomized design" that is, a design in which the treatments or factors are randomly arranged over the whole of the experimental material for example, if samples are taken and the entries or score for the factors F1, F2,FN of table 2.1 are got by chance, then the design falls into the completely randomized design and this design leads to one-way analysis of variance techniques. Continuing, Walpole, R. E. said "that the completely randomised design is very easy to lay out and the analysis is simple to perform, it should be used only when the number of factors is small and the experimental material is homogenous".

The model for the one-way classification is given as follows:

$$X_{ij} = \mu + \alpha_i + \epsilon_{ij} \dots \dots \dots 2.1$$

where $i = 1, 2, \dots, N$, factors or treatments

$j = 1, 2, \dots, N$:records.

where X_{ij} represents the score made in factor i recorded for individual in the j^{th} record.

μ represents the overall population mean.

α_i stands for the mean effect or contribution of the i^{th} factor to the scores made in the various records.

ϵ_{ij} represents the derivations of the individual scores X_{ij} from the overall mean \bar{x} .

Another experimental design taken into consideration here is called "randomised complete block design". Here the experimental material is divided into groups or blocks such that the units making up a particular block are homogeneous. Each block (in our case either factors or individuals or group of individuals) constitute a replication of the treatment. Thus in a randomized complete block design, there is homogeneity within individuals or departments and randomization restricted within. The design according to Walpole R. E. leads to two-way analysis of variance.

The model for this design is:

$$X_{ij} = m + a_i + b_j + t_{ij} \dots\dots\dots(2.2)$$

where $i = 1, 2, \dots, t$ factors or treatment

$j = 1, 2, \dots, b$ individuals or records

where X_{ij} represents the score recorded by the j^{th} individual or record for

the i^{th} factor or treatment

\bar{m} represents the overall population mean

a_i stands for the mean effects of the i^{th} factor to the scores made in the various records.

b_j stands for the mean effects of the j^{th} record on the scores made for the various factors and $\sum_i a_i = \sum_j b_j = 0 \dots \dots \dots (2.3)$

ϵ_{ij} represents the deviation of the individual scores X_{ij} from the overall mean \bar{x} .

The applications of the two models are based on the following assumptions:

- i. The effects (factors and records) are additive. That is, we are assuming that differences in the effect between any two factors is the same in all records.
- ii. The error term t_{ij} or ϵ_{ij} are independent random variable, normally distributed with mean 0 and variance σ^2 i.e. $t_{ij} \sim n(0, \sigma^2)$.
- iii. The random variables X_{ij} are independently normally distributed.
- iv. The random sample of size is drawn from each of the b_t population.
- v. The variances of each of the b_t populations are equal.

Based on a vast literature including works by Snedecor and Cochran (1974)²⁸ and Zar (1984)²⁹ and David L. Silla (1978)³⁰, it was noted that when these assumptions are not met for the data under study, the result of the statistical analysis may be very misleading. The notes indicated that when the error variances are heterogeneous the f - test tends to give too many significant results. In addition, there is loss of efficiency in the analysis because when errors are non-normal, for instance, the mean of the observed value for a treatment is, in general, not the most accurate estimate of the corresponding population mean for that treatment.

However, minor failures do not generally disturb the conclusions drawn from the standard analysis.

In fact, Snedecor, Cochran on page 321 referred to these assumptions as ideal conditions that are unlikely to be ever exactly realised in practice.

Therefore, efforts will not be wasted in testing for these assumptions: rather the user of this package is advised to apply strictly the analysis of variance method (notably one-way or two-way) in relation to his sampling design.

2.6 SIMILAR PACKAGES AND ASSOCIATED ERRORS

Although the formulae both for the parameters and the associated significance tests of the general linear model are well documented in a large variety of econometrics and statistical texts, particular tests such as regression through the origin and Analysis of Variance (ANOVA) are largely ignored

or casually discussed. According to H. A. Gordon (1988)²¹, in one text on applied statistics which devote several pages to the subject, R^2 are not mentioned, the formula for the regression sum of squares was incorrect and the total degrees of freedom misspecified continuing Gordon H. A. noted that the principal reason for the errors in the specification of the R^2 and the analysis of variance estimate is from erroneous definition of the "variance" to be analysed. According to him, if the software package for ANOVA is operating correctly, the total sum of squares for the "regression through the origin" and its ANOVA from least square equation should be the same. The degrees of freedom should be identical as well. Thus for correct output package, R^2 should be calculated as

$$R^2 = 1 - \frac{\text{Residual sum of squares}}{\text{Total sum of squares}} \dots\dots\dots(2.4)$$

While the degree of freedom should be taken from the ordinary least square output.

2.7 OUTPUT FORMAT FOR ANALYSIS OF VARIANCE (ANOVA) PROGRAM

Cramer, Elliot. N. (1986) in his publication "A non-orthogonal analysis of variance program" described the output format, computational procedures and accuracy of a general computer program for univariate and multivariate non-orthogonal analysis of variance program he developed and called "Coroline" and later called "MANOVA". In trying to explain, he

maintains that the criticism on the accuracy of computer ANOVA programs by one Francis was unwarranted, claimed that with an accuracy of $R = 54.493$ i.e. accuracy to the fifth significant figure a reasonable result for a 32 bit computer, and sufficiently accurate for any practical purpose. In his contribution he said Francis suggested an accuracy up to 5 decimal places. Thus a three decimal place format was recommended as sufficiently accurate for the computations of sum of squares, mean sum of squares, F- ratio, etc in the computation of ANOVA. According to Cramer, Elliot M. the three decimal digit format are sufficiently accurate when compared with numerous textbook, examples and other computer programs. According to him, computer programs are more accurate than hand computations. Thus Cramer (1986) summarized as follows:

"This suggests that users concerned about errors in computer programs should probably be more concerned with errors in hand computation".

2.8 SYSTEM STUDY APPROACH

Prince Badmus (1997) suggested a procedure for solving problems with computer (system analysis & design) which we adopt as a guideline for a problem situation such as ours.

His suggestion caption "procedure for solving problems with computer" is shown in Fig. 2.1 below:

Thus the programming process, begins with a broad systems specifications. The programmer analyzes these specification in terms of:

- a. The output solution needed
- b. The operations and procedures required to achieve the necessary output, and
- c. The input data that are necessary to realize or produce the output.

Once the analysis is completed, the next step is the preparation of written instructions that will control the computer during the processing.

FIG 2.1 PROCEDURE FOR SOLVING PROBLEMS WITH COMPUTER

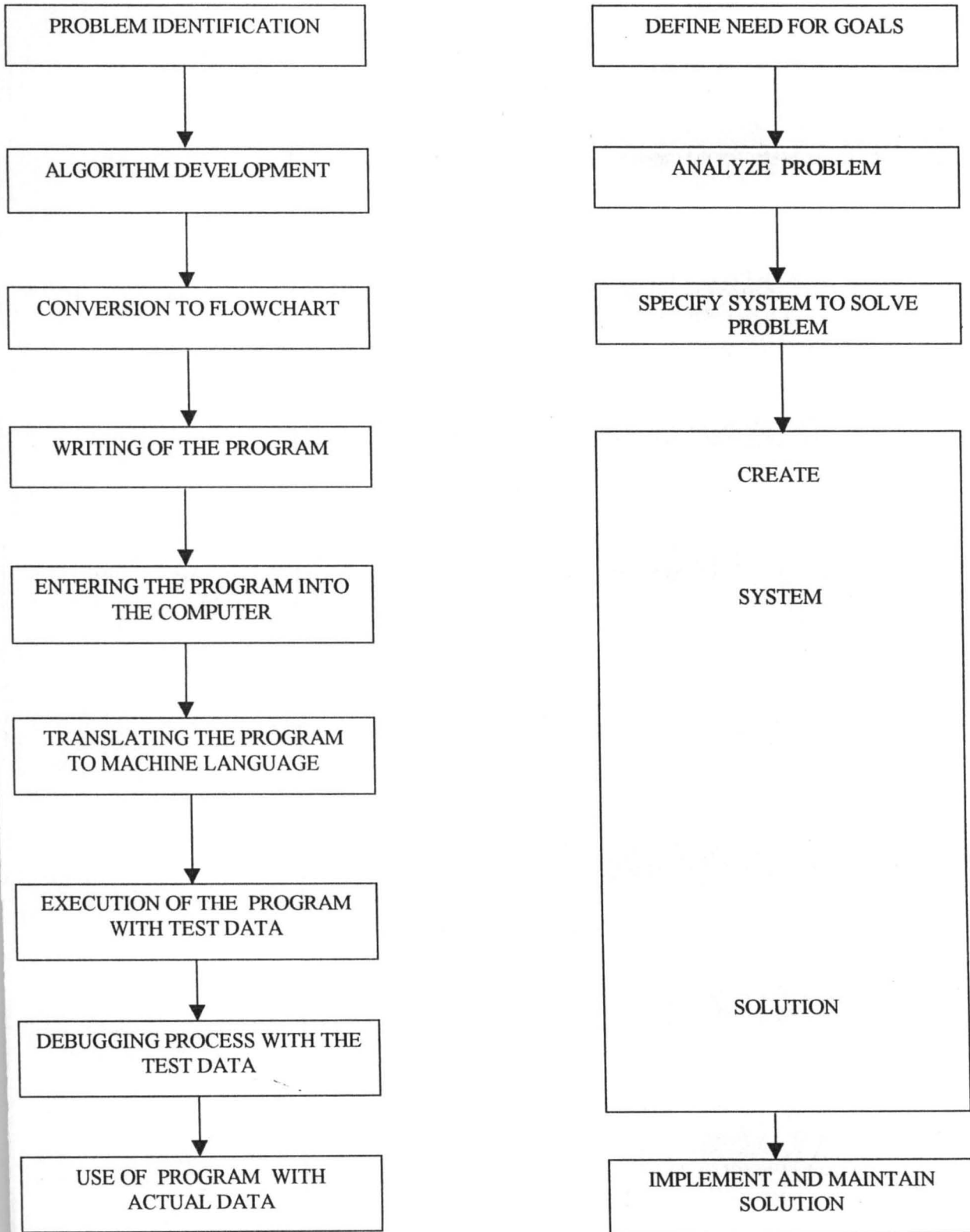
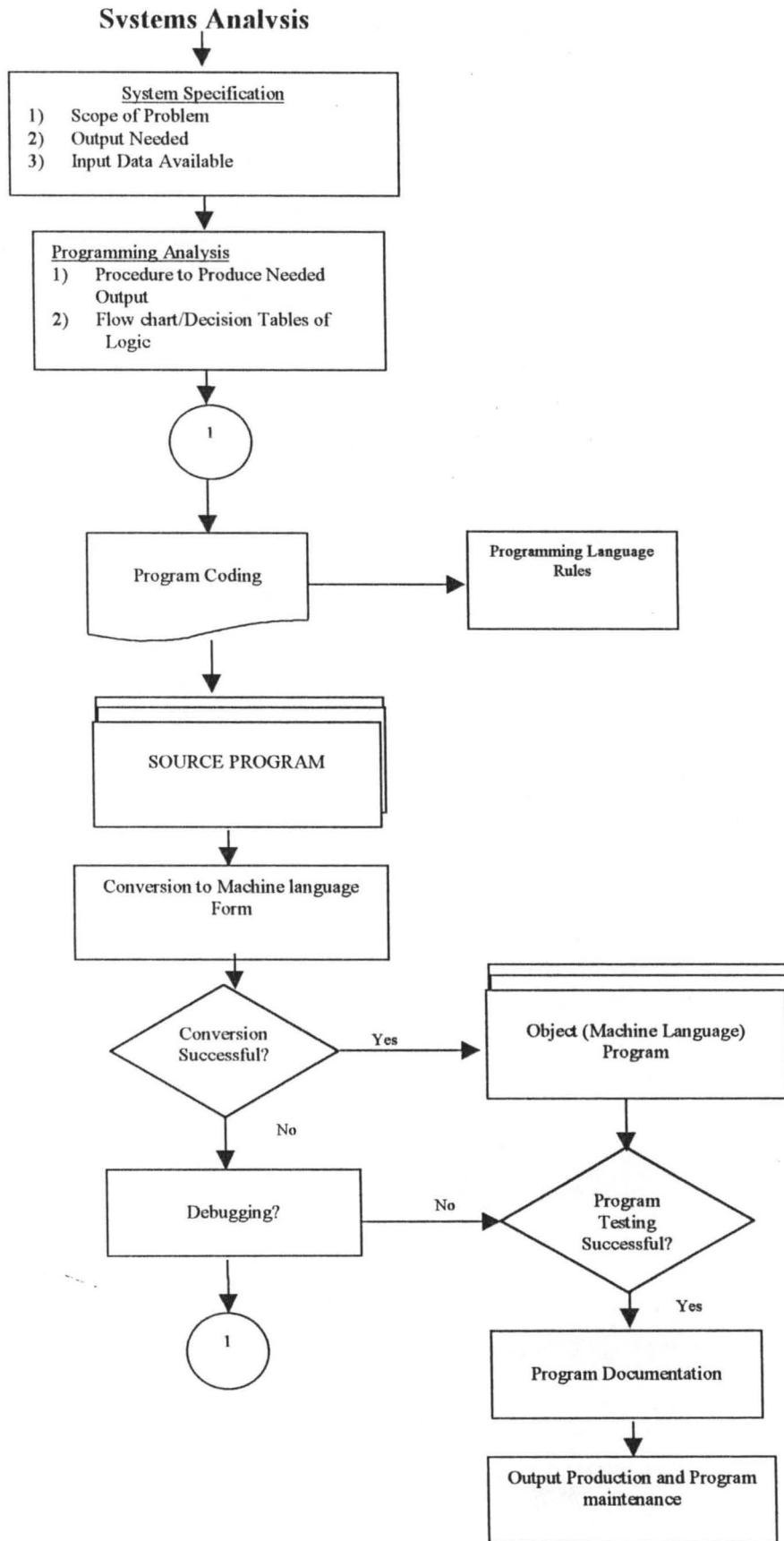


FIG. 2.2

PROGRAMMING PROCESS



CHAPTER THREE

PRESENT SYSTEM

3.1 DESCRIPTION OF PRESENT SYSTEM

The present system involves manual analysis of questionnaire. In section 1.5 questionnaire analysis was defined to include appropriate statement of problems, good choice of sample design and method of data collection, appropriate statistical analysis and test, and reasonable inference and decision making. Though the study of the present system involves questionnaire analysis and methods of analysis, the objective of the new system , if designed is not to provide a panacea for all forms of questionnaire design. Thus the form of questionnaire used by most ministries in their annual performance evaluation score was used as a reference point. These types of questionnaire have been shown in Appendix A, while their form or format has been exemplified in table 2.1. The present system involves sets of questionnaire containing chiefly, the personal data of respondents and the main "treatments" or "factors" to be measured.

In the present system, questionnaire or forms are usually distributed for completion by the appropriate individuals. It is usually an annual event used to measure the performance of the staff concerned. Method of distribution of questionnaire, in this case involves complete enumeration

sampling technique since forms are given to every staff. No formal Data collection methods was adopted.

However, for research purposes, copies of the questionnaire are usually distributed at the required period. However, there may be problems of inappropriate data collection methods when the distribution is done by non-statistician investigators.

The questionnaire is coded usually by the reporting officer (any officer superior to the officer filling part I of the Aper Score format) and performance measured in terms of percentage scores. Thus the inputs to the present system included among others names, Ministry/Extra-Ministerial Department, Personal particulars/qualifications held etc. (See Appendix A) and the score computed.

The analysis of the system usually involve the computation of the treatment scores and subsequent association of these measured scores to the respondents attributes like, Name, Registration Number, Sex, Marital Status etc. where applicable.

For some questionnaire used in research work, statistical analysis are performed and results associated with the respondents attributes. These tests range from statistical test of independence, test of association, correlation, regression, analysis of variance, or even computation of simple averages and ratios.

In the case of "APER SCORE" format, analysis involved just the computation of the "APER SCORE" usually measured in percentage. These computations and analysis are done manually and results are stored as filled or computed on the questionnaire form.

During promotion, confirmation or lateral conversion exercises, the APER SCORE are extracted and decision for promotion based on subjective analysis of these scores in relation to other inputs as may be deemed necessary by the Senior Staff Committee.

3.2 PROBLEMS OF PRESENT SYSTEM

The problems of the present system form the motivating background of this study (see section 1.1).

The problems can be enumerated as follows:

1. There are no clearly specified objectives of the system. The calculation of the "APER SCORE" is simply necessary but not sufficient for any decision to be made as regards promotability of any staff. The degree of association of this score in relation to other attributes like years of service, age, salary grade level, previous score etcetera, is not clearly defined. Decisions seemed to be based on subjective analysis. In some cases what determines a 'pass' score is left to the discretion of the particular selection board on a particular meeting for a particular situation.

2. Another problem is that of coding. Coding is not done properly due to poorly designed questionnaire (for questionnaire other than APER SCORE questionnaire). Methods of measurement of scores were not standardized. For instance, the 'APER SCORE' computed for any officer, which normally serves as the officer's measure of performance is not done on uniform measurement continuum or technique. This is because, an officer scoring for instance 86% may have his overall performance described as 'outstanding' while another officer scoring 86% may be classified by another reporting officer as "Very Good". In some cases, the same erroneous classification may be made by the same reporting officer if classification are done at different times. For other questionnaire meeting the format for study, there may be poor measurement techniques as observed in some students research work.

3. The analysis of data in the 'APER SCORE' questionnaire does not go beyond computation of 'APER SCORE' possible extracting the annual performance score as and when required. Strictly speaking, it can be said that no analyses is being made on the scores.

No effort or plan is made in terms of comparative analysis either for the same questionnaire over the years or for various individuals. The scores are redundantly stored in the secret files waiting for a promotion exercise. Where analysis is carried out on this type of questionnaire, there is often wrong application of statistical tests based on wrong assumptions. In some other cases, particularly where this type of questionnaire is used in research work, there is often disregard for statistical assumptions.

4. Yet another problem of the present system is the volume of work required. For large volume of data, for example, data demanding the generation of performance evaluation scores (say test performed staff) for all the employees in a scheme like NYSC or Ministry in a state or country, manual analysis is particularly difficult, if not impossible.
5. Finally, there is the problem of identifying and acknowledging the problems of the present system. It is said that "problem identified is half solved". The users of the system are aware of the associated problems but require a convincing note or appeal to disabuse their mind of bureaucracy and red-tapism associated with accepting

changes generally even when immediate solutions are provided. The documentation here, it is hoped, will provide convincing solutions to the problems sited above by non-statistician investors.

3.3 NEED TO IMPROVE ON THE PRESENT SYSTEM

In a result oriented organizational setting, there is constant need to ensure that resources including men, money, material, methods and time are employed and combined in a favourable proportions for attainment of efficiency, effectiveness, economy and ultimately higher productivity. In this direction, it is crucial to assess the performance of "men" the most important factor of production on how he uses these resources in consonance with the pre-determined objectives of the organization conducted usually on the principle of child - father - grandfather. Where the child represents officer reported on or reportee, father represent reporting officer while grandfather stands for countersigning officer.

Today the world is in a state of flux and experiencing quantitative revolution. The present system of solving APER problems are rapidly becoming out model and unscientific hence the need to involve computer in aiding the analysis and computation.

1. The most basic function of a computer in this direction is to compute or calculate and that is its greatest assets as it can do it so fast and accurately that an observer would think that the computer is a magician.
2. It can also take decision very fast by comparing data or information.
3. In the development of a theory or hypothesis, a researcher is often confronted with masses of data he wants to theorize on. If he has access to computer, he can store the data somewhere in the computer and make use of the high speed of computation offered by the computer to examine as many hypothesis as are possible on the data.
4. Statistical analysis of data derived from experiments can be very tedious and cumbersome especially when the quantity of data involved is very large and many variables/factors/treatments are involved in the analysis. The procedures for analyzing these data are standardized. In most cases, a manual analysis would involve hours and possibly days of computational efforts due to care that needs be taken for accurate results to be obtained and margin of errors that must be achieved.

3.4 THE EFFECT ON NON-STATISTICIANS

Statistics as concerned in this text refers to a body of theory and methods of analysis. It is very broad extending from the planning and design of experiments, survey and other studies which generates data to the collection, analysis, presentation and interpretation of data. It then means that numerical data constitute the raw material of this project.

Since the essence of modern statistics is the theory and methodology for drawing of inferences which extend beyond the particular set of data examined and for the making of decision based on appropriate analysis of such data a non-statistician may not be appropriate in the setting.

From the above, one may wonder its clear difference from the expert system which is a new type of information system that is mostly used nowadays to support managerial decision making. It is an organized collection of people, procedures, data bases and devices used to generate expert advice or suggest a decision in an area or discipline. These computer systems are like a human specialist who has many years of experience in a field.

Non-statistician cannot contribute to the quantitative techniques and procedures whose purpose is to aid and improve management decisions.

However, it is the brief that we are in the era of modern technology backed by scientific assumptions and proves. Lack of statistical knowledge will make an individual out of place. A non-statistician here is like a round peg in a square hole.

CHAPTER FOUR

SYSTEM DESIGN

4.1 OVERVIEW

This project was introduced to provide legitimate statistical analysis technique particularly ANOVA for the type of questionnaire format in table 2.1. Questionnaire analysis here starts from the coding stages. However, the philosophies underlying the design, and methods of distribution and collection of questionnaire are left to the field enumerators or investigators, and are not covered by the system (see section 1.4).

The functional specifications and the design concept is based on preliminary investigations made on several questionnaire formats and their methods of analysis.

The different data processing steps that were carefully examined include:

- A. The information gathering techniques adopted by sampling several questionnaire formats coupled with their analysis techniques. Having decided on the questionnaire format to be analysed, a thorough review of the forms of the adopted questionnaire were carried out. Interviews were carried out in methods of coding and analysis.

The general findings were as follows:

Coding was not properly done due to poorly designed questionnaires.

There was no standardized method of measurement of scores. For instance the "APER SCORES" computed for each officer was noted and regarded as the main aim of evaluation, but sadly, classification of the officers overall performance based on his 'APER SCORES' was not done on inform measurement continuum or technique. An officer scoring 86% may have his overall performance classified as 'outstanding', while the same officer, scoring 86% may be classified by reporting officer as 'Very Good'.

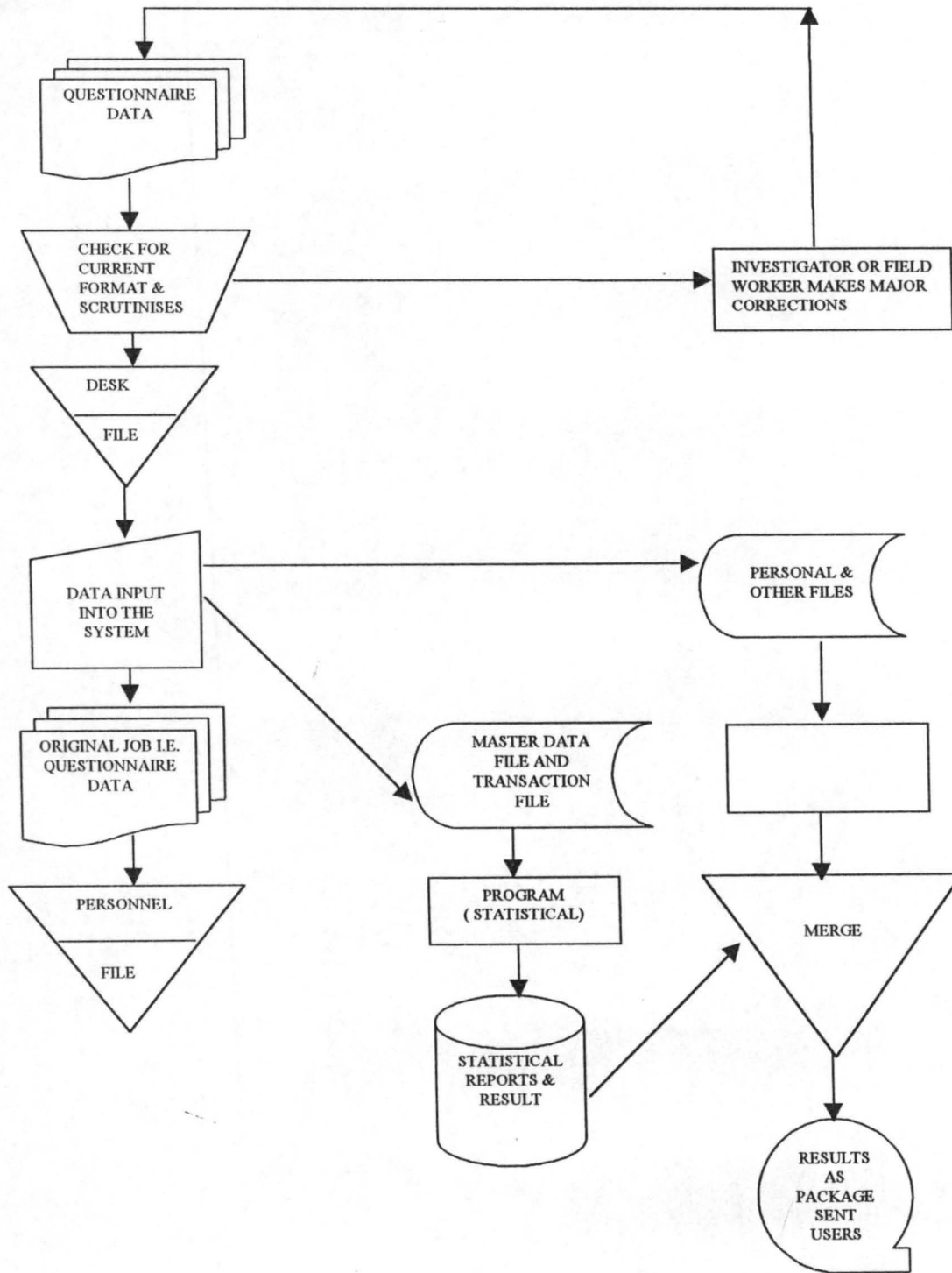
The job of the system therefore is expected to start with manual scrutiny and coding of questionnaire assumed to have been distributed and collected by legitimate statistical sampling methods.

In some cases, particularly the "APER SCORE FORM" analysis does not go beyond extracting the annual performance score. No effort or plan is made in terms of comparative analysis either for the same individual over the years or for various individuals. In cases where questionnaire are used for research work there is often disregard of statistical assumptions, use of inappropriate statistical methods or application, of appropriate methods improperly.

- B. DATA ENTRY AND VALIDATION:** Scores of questionnaires that meet the specified format are entered and validated after scrutinizing and coding. Validation is done at different levels throughout the system.
- C.** Pull - Down Menu including basis assumptions and guideline on sampling designs and their associated analytic techniques are included as guides.
- D. FILE MANAGEMENT AND MAINTENANCE:** With due consideration to faster accessing as far as statistical ANOVA and test of hypothesis are concerned.
- E.** Volume management techniques to reduce constant exchange of disc.
- F.** Results of analysis are related to the personal data respondent.

**CONCEPTUAL DESIGN AND FUNCTIONAL
FLOW OF THE SYSTEM**

4.2.1 FLOW CHART

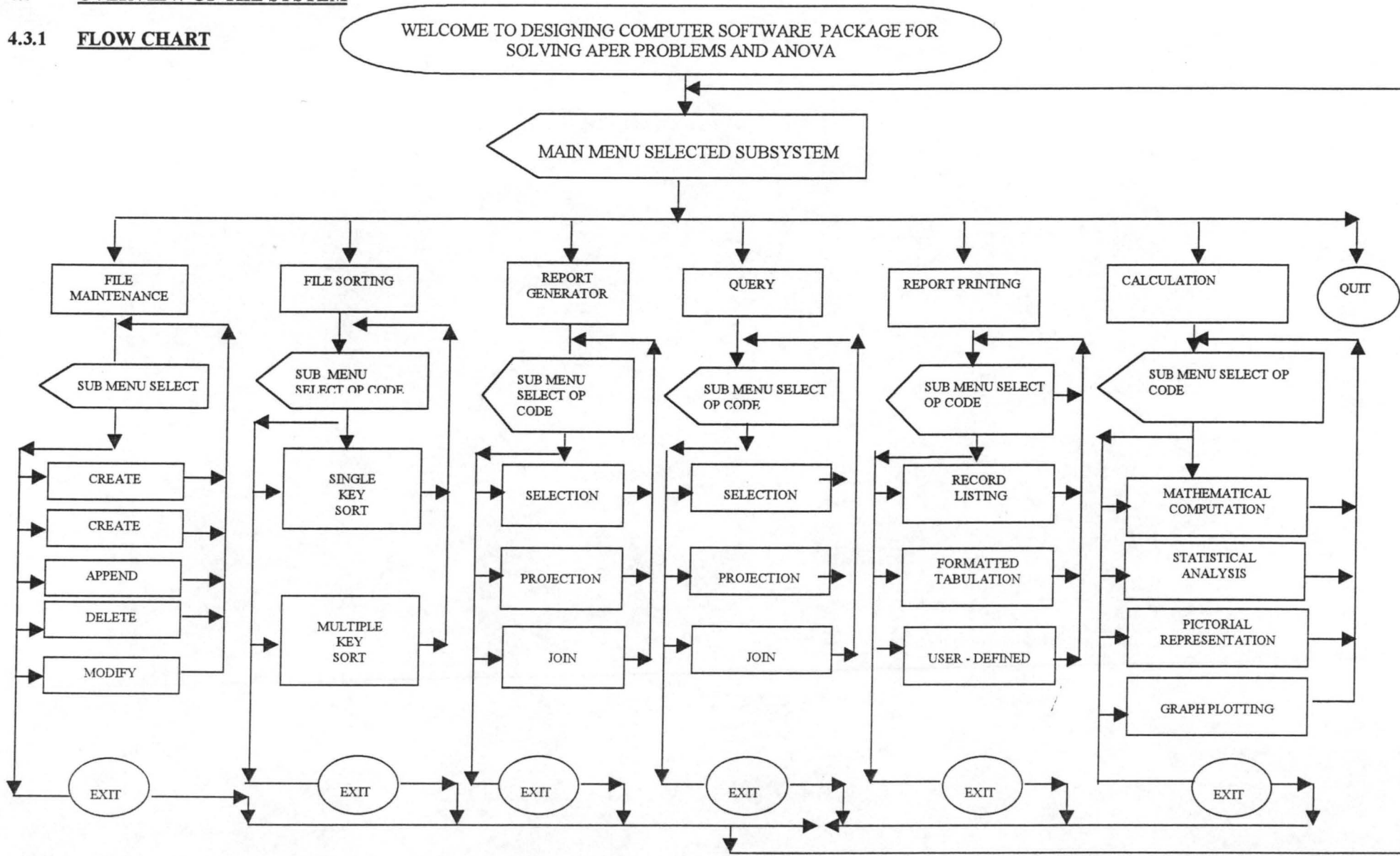


4.2.2 WRITTEN NARRATIVE

- (1) Completed questionnaire are received from the field or the investigator.
- (2) The questionnaire is first checked for correct format, then scrutinized and coded accordingly. This process is done manually. Major errors are sent back to the field or investigator for correction and subsequent transfer to the computer section for processing.
- (3) Validated questionnaire or job is stored on desk files.
- (4) Data from this questionnaire are keyed into the computer. The main data, containing the factors are stored differently from the personnel data after validation.
- (5) After computer storage of data, the original or application job are stored on a desk file.
- (6) The computer performs operations on data e.g. sorting, display, printing etc, to produce some reports particularly statistical reports.
- (7) These results are stored as requested.
- (8) We can update the database as necessary.
- (9) Maintenance of systems data.

4.3 OVERVIEW OF THE SYSTEM

4.3.1 FLOW CHART



4.3.2 Written Narrative

The database management system is menu driven. The first thing which the program has to present to the user is the introductory note namely:

WELCOME TO DESIGNING COMPUTER
SOFTWARE PACKAGE TO SOLVE APER
PROBLEMS AND ANOVA
BY
ONYIA PIUS EJKEME

This is followed by the main menu with the pressing of any key.

The main menu comprised:

- (i) File maintenance subsystem
- (ii) File sorting "
- (iii) Report generator "
- (iv) Query "
- (v) Report printing "
- (vi) Calculation printing "

and (vii) a default (additional choice) namely quit to enable the user back track from the present level.

The sub-systems are available to the user and the codes representing them. Subsequently, the user is prompted to input a code corresponding to the subsystem of interest. For the subsystem, the user

is given the option to input either the operation code or the first character of the desired operation's name.

Fig 4.2 above, was given for convenience and to show all possible options as regards this study.

However, not all the sub-systems or operations are applicable in this study. Thus, where an operation is not applicable e.g. "graph plotting" in the calculation sub-menu, a message "NOT APPLICABLE" is given and the user is expected to follow next instruction in order to continue. They are, however, included to create room for expansion and further development of the entire system.

4.4 SYSTEMS FLOWCHART

4.4.1 Written Narratives

Here, we provide a broad overview of the processing operations that are to be accomplished (and/or that should be performed), with primary emphasis placed on data flow.

(a) The questionnaire is checked for appropriate format and specification. This process is done manually. Major errors are sent back to the field or the investigator for correction or redesign of questionnaire as the case may be. The job file contains details of all the contents of the questionnaire stored in different files.

The questionnaire forms or application job are stored on a disc file.

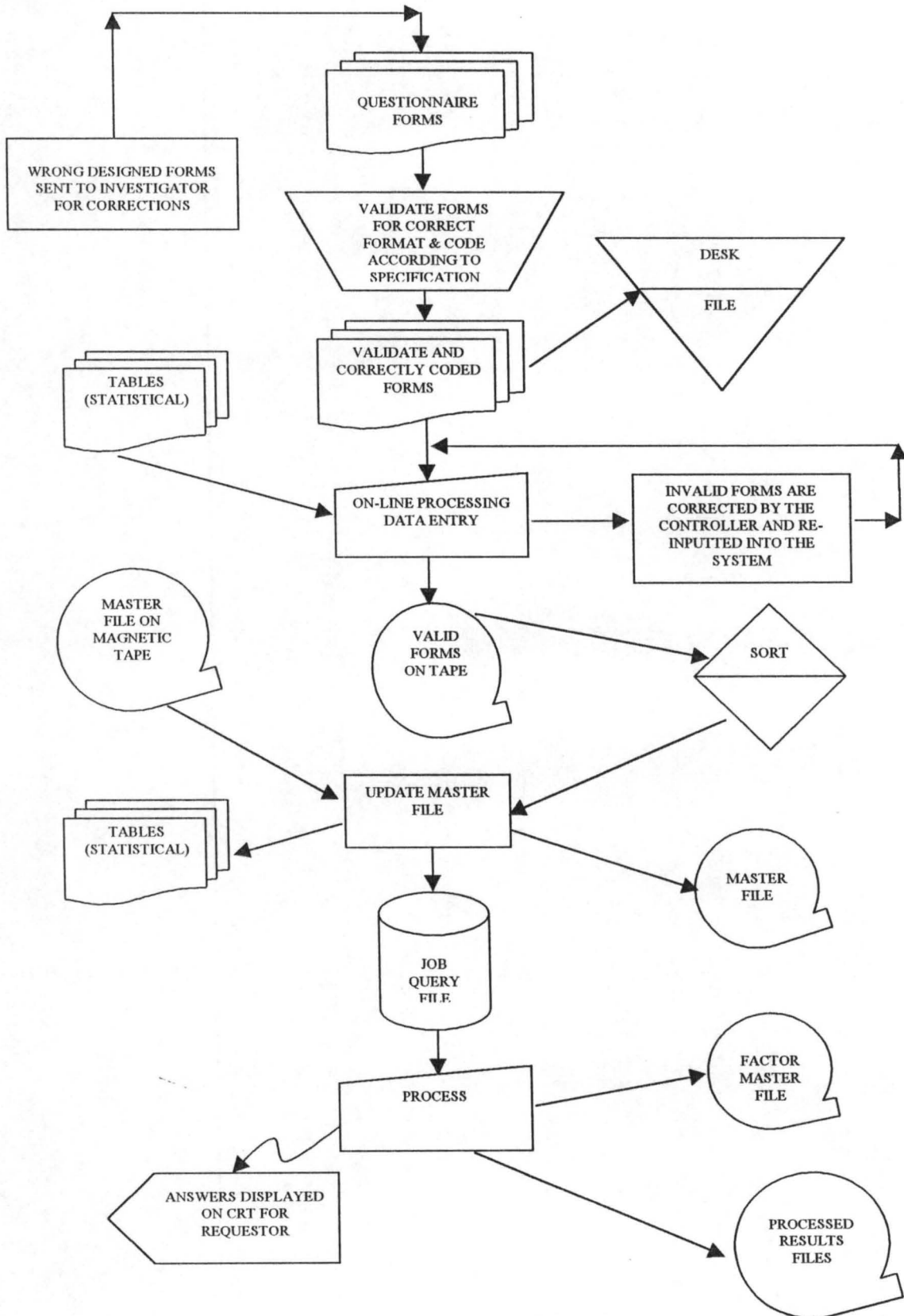
(b) Invalid records or data are corrected by the controller and re-inputed

into the system or where it contains major errors, sent back to the field. The magnetic disc file is used to update the job file.

- (c) During the update, statistical analysis and computations are performed on the job file, jobs which have been fully completed are made and printed out while those only being completed are held in magnetic disc. The query reports are produced from the job query file.

FIG. 4.4.2

QUESTIONNAIRE ANALYSIS SYSTEM FLOW CHART



4.5 SYSTEM SPECIFICATIONS

Each file in this format shall be described in respect of the purpose and program that will utilize it as well as volume, frequency of use, source from which the file is obtained, description of fields, layout and samples.

4.5.1 Scope of Problem

The "factor file" serves as the main data or input storage for analysis. Hence the arrangement of questions to serve as input to "factor" file would conform to the format given in table 2.1. The factors are to be assigned scores 1, 2, 3, 4, 5, and 6 or 6, 5, 4, 3, 2, and 1. The choice would be dependent on whether "strong agreed", "favourable" or "unfavourable" attitude.

Among other tests results sort, like sum, average and percentables, analysis of variance test is the main test provided. The ANOVA test is restricted to one-way and two-way ANOVA tests only, with one observation per cell.

The scope of problem has also been highlighted in chapter 2, section 1.2

4.5.2 System Files

The system files are maintained by the database manager and are the first files to be created.

They include the following:-

(a) **NORMALISED FILE**

This file contains all fields in all the files created for the system according to field name. That is, it contains the field names of all the files serially numbered. The fields for the normalised file are, serial number, field name, field length, field type and program field name. The detail layout and sample is shown in the appendix. (Table B 14 of Appendix B)

(b) **RECORD INDEX FILE**

This file has all the file names created as its field name. In other words, any program file to be created is first of all included as a record in the record index file. The fields for the record index file are; serial number, file name, record length, number of fields per record, and cumulative index. The cumulative index shows the starting point in the normalised file for the fields to be included in a given file. The length is the sum of the field lengths plus 1 in any record (see Appendix for the layout).

(c) **FIELD INDEX FILE**

Field index file indicates the location in the normalised file where the selection of appropriate field names for a given file is to start. Once the exact number of fields are obtained, the system displays the field of given file. The fields for this file are serial number, and location in the normalised file.

These files namely; normalised file, record index file and field index file are manipulated by the system to provide the record holder for any file to be created.

4.5.3 Output Specification

In this section, we shall illustrate the printed output reports which the system is expected to generate. These reports will be produced at various points during the data processing cycle, that is after data entry, validation and statistical analysis (processing) of the questionnaire.

The reports contain data or scores obtained from the questionnaire it also contain data or scores obtained at the points of coding and measurement, until the actual production of statistical results and decisions base on associated tests of hypothesis.

The following table contains a description of each report produced by the system, the nature of the report, contents, format, number of fields and the necessary information contained. Here the frequency of generation of output is coded as follows:

- A/R → As Required
- DTH → During Test of Hypothesis
- WNRR → When Null Hypothesis for Record Effects is Rejected
- WNFR → When Null Hypothesis for Factor Effects is Rejected

TABLE 4.1 DESCRIPTION OF REPORT PRODUCED BY THE SYSTEM

S/N	REPORT	TITLE AND DESCRIPTION	FREQUENCY
1	RECRPOT I	<p>RECORD SCORES</p> <p>This is the report showing the highest rating score and lowest rating score used for the factors. It's fields also include the total score, average score and percentage score for each record or individual or questionnaire. It also bears the questionnaire number as a key.</p>	A/R
2.	FACRPOT I	<p>FACTOR OR TREATMENT SCORES</p> <p>This is a report showing the factor name or treatment name, and their respective total score, average score and percentage score. This report shows the performance of the various factors or treatments under consideration in terms of total, average and percentage scores recorded.</p>	A/R
3.	R HSCORE	<p>RECORD SCORES IN ORDER OF MAGNITUDE (RECORD PERFORMANCE)</p> <p>This is a file of record of the scores for each record sorted in order of magnitude (descending order) . It shows the name of individual and/or questionnaire number but, usually after "RECRPOT I" have been produced with their respective scores. The scores are sorted in order of magnitude (descending order i.e. highest score on top), and serves as the pointer or key.</p>	A/R

4.	FHSCORE	<p>FACTOR SCORES IN ORDER OF MAGNITUDE (FACTOR PERFORMANCE)</p> <p>This record shows the performance of each of the factors or treatment under study by using the scores made for the various factors. Thus, the record contains the factor code, its name and scores arranged or sorted in descending order of magnitude.</p>	A/R
5.	R ANOVA I	<p>ONE - WAY ANALYSIS OF VARIANCE TEST FOR RECORDS</p> <p>This report produces the ANOVA TABLE for a one - way classification for the records effects. The table include the source of variation, sum of squares, degrees of freedom, mean square and computed F.</p>	DTH
6.	F ANOVA I	<p>ONE - WAY ANOVA TEST FOR FACTORS OR TREATMENT EFFECTS</p> <p>This report produces the ANOVA table for a one-way test for the factors. The table include the source of variation among factors, and sum of squares, degree of freedom, mean square for column means, error and total, and computed F for the column means.</p>	DTH

7.	ANOVA 2	<p>TWO - WAY ANOVA TABLE RESULTS</p> <p>This is a tabular report showing the result of the two-way analysis of variance computations of the record and factor effects. Contents of report include source of variation, sum of squares, degree of freedom, mean square and computed F, for the following:</p> <ul style="list-style-type: none"> a. Row (record) means b. Column (factor) means c. Error d. Total <p>The computed F is applicable for the row and column effects only.</p>	
8.	HRANOVA I	<p>TEST OF HYPOTHESIS FOR ONE - WAY ANOVA ON RECORD EFFECTS, (Equality)</p> <p>This is a comprehensive report on the test of hypothesis for equality of record scores showing the null hypothesis, level of significance (α) critical region, computed F and conclusions. The record occupies a page.</p>	A/R
9.	HFANOVA I	<p>TEST OF HYPOTHESIS FOR ONE - WAY ANOVA ON FACTOR EFFECTS (Equality)</p> <p>This is a comprehensive report on the test of hypothesis (one - way ANOVA) for equality of Factor Scores, showing the null hypothesis, the alternative hypothesis level of significance (α) critical region, computed F and conclusions.</p>	A/R

10.	HANOVA 2	<p>TEST OF HYPOTHESIS FOR TWO - WAY ANOVA ON RECORD AND FACTOR EFFECTS</p> <p>This report produces a concise account of the two - way ANOVA test of hypothesis for no difference of factor and record effects. Items include statement of null hypothesis, alternative hypothesis, level of significance, critical regions, computed F values and conclusions.</p>	A/R
11.	SIGDMR I	<p>SIGNIFICANTLY DIFFERENT RECORDS MEANS OR SCORES</p> <p>This report is generated whenever the null hypothesis tested in report HRANOVA I is rejected. This report shows the significantly different means of record scores since we have rejected the null hypothesis of no difference in mean scores. This report shows. The questionnaire number, name of respondent or individual associated with the significantly different record scores.</p>	WNRR

12.	SIGDMF I	<p>SIGNIFICANTLY DIFFERENT FACTOR MEANS</p> <p>This report is generated whenever the Hull hypothesis tested in report HFANOVA, is rejected. This report shows the significantly different means or factor scores since we have rejected the null hypothesis of no difference in factor mean scores. The report shows simply those factors whose scores are significantly different. That is to say, best performed factors.</p>	
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4.5.4 Input Specifications

This is the primary file where all data containing the respondents personal records are logged. It contains in addition, the questionnaire number which serves as the key used in accessing this file. Records on this file are transferred to disc and used to relate inferences drawn from the computations made on other files. Thus, the "personal" file contains a field into which is printed a unique alphanumeric value which will always identify the record or respondent and his/her scores afterwards. This is questionnaire number. The layout is thus:

TABLE 4.2 PERSONAL - INPUT SPECIFICATION

FILE NAME	FILED NAME	CONTENT
PERSONAL	QUESTIONNAIRE TITLE	This is the name of the job or the title of the job. It differentiates one job from the other.
	QUESTIONNAIRE NUMBER	A uniquely generated number used to identify each questionnaire and other records associated or attributed to the questionnaire.
	NAME	The name of the respondent or holder with the surname first then other names or initials of other names and appropriate title.
	NAME OF ESTABLISHMENT	The name of establishment of the respondent.
	DEPARTMENT	Department of the respondent to include section of the division.
	STAFF NUMBER	The employee file number where applicable.
	SEX	Sex of the holder or respondent which is either male or female.
	MARITAL STATUS	The marital status of the respondent.
	DATE OF FIRST APPOINTMENT	The date of first appointment into the service. In some other cases e.g. questionnaire involving students, this field could be used to record date of entrance into the institution.

	PRESENT SUBSTANTIVE POST	The respondents present designation or substantive grade.
	DATE PROMOTED LAST	Date the respondent or staff was last promoted.
	SALARY G/L.	The holder's salary grade level. For other cases this could be taken as year of study also.
	JOB EXPERIENCE	Number of years of experience since appointed.
	DATE OF BIRTH	Date which respondent was born

"FACTORS" FILE

This master file contains approved and validated measurement scores of the treatments or factors under study. The sum of scores across the factors is a measure of the individual's performance while the sum across the records gives the factor score and measures the performance of the factors. The contents of this file forms an array of scores used for the statistical analysis, ANOVA in particular. From this file a copy is made that forms the transaction on which all computational analyses are based.

The key used in accessing this file or relating the result of analysis from this file to other data, particularly the personal data, is the questionnaire number. See layout as bellow:

TABLE 4.3 "FACTORS" - INPUT SPECIFICATION

FILE NAME	FIELD NAME	CONTENT
FACTORS	QUESTIONNAIRE NUMBER	A uniquely generated number used to identify each questionnaire and other records associated or attributed to the questionnaire.
	F1 F2 F3 . . . F20	Factors F1 to F20, are codes for the factors whose meaning are given (below) in the look - up table. They contain the scores made by the respondents in a particular factor. Number of factors are limited to twenty (20) in any one analysis.

(C) "LOOK - UP F"- FILE.

The factors occurring in the factors master file are coded. Again these factors are usually updated whenever new or different questionnaires are to be analysed. Therefore the Look-up table provides the meaning of the codes used as factors, so that after analysis, the meaning of the code used against the factors are found from the Look-up file. The layout is as follows.

TABLE 4.4 LOOK-UP F - INPUT SPECIFICATION

FILE NAME	FIELD NAME	CONTENT
LOOK - UP F	CODE	The code for all the factors under consideration namely F1, F2, F3,..... F20.
	MEANING	The respective meaning for each of the coded factors or treatment e.g. USING ANNUAL PERFORMANCE EVALUATION form, the first factor coded F1 means how well he/she understands, organises and does his/her job F2 means how well he/she applied his/her professional tech./admin or any other acquired knowledge etc.

(D) "F-TABLE" FILE

This file contains the statistical F-table values that must be referenced during statistical test of hypothesis involving analysis of variance. The value from this file or table, when appropriately compared with the computed F value, serves as a criterion for rejecting or not, the null hypothesis. It is a look up file of V_1 and V_2 table, where V_1 is the degrees of freedom for the factor effects and V_2 is the degrees of freedom for the error effects, V_1 and V_2 each can assume values from one (1) to infinity.

4.5.5 File Organization

In trying to access respondents records here, questionnaire number is used as the primary key. During and after data analysis, results are related to the personal data or records e.g. Age, Name, Sex etc, through the questionnaire as the key of linking field for most record files.

The master control file contains parameters necessary for faster processing and reporting. It also contains analysis, data and information relating to the system (main data for analysis).

Mention must be made of the password protection of data and software package at various levels to prevent unauthorized access (Other securities have also been identified in corporation at the development state such as protection, to prevent unauthorized access to processing or usage of the development package.

CHAPTER FIVE

PROGRAM DESIGN AND IMPLEMENTATION

5.1 PROGRAMMING ANALYSIS

The common tool used for programming analysis here is the program flowchart. This is used to represent detailed graphical representation of steps to be performed within the machine to produce the needed output.

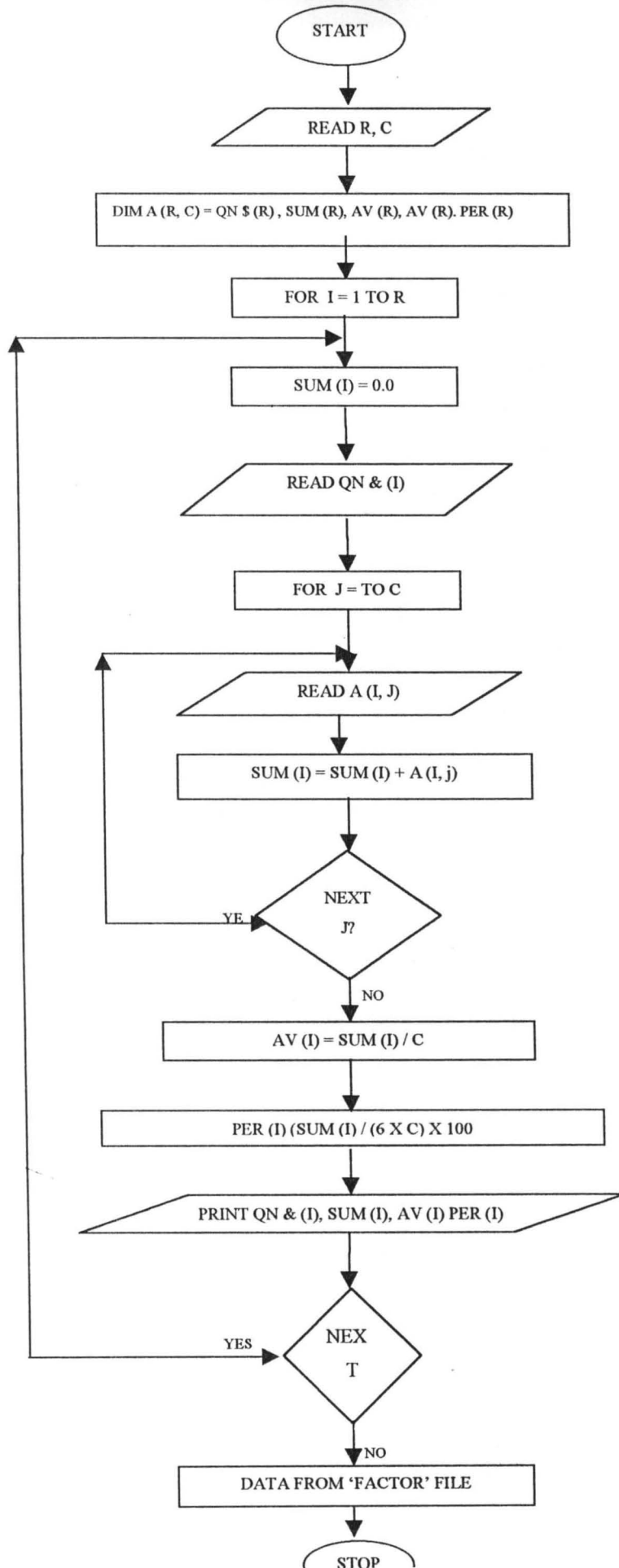
Therefore our program flow chart evolves from the system charts.

In section 4.5.3, the following reports are generated, namely;

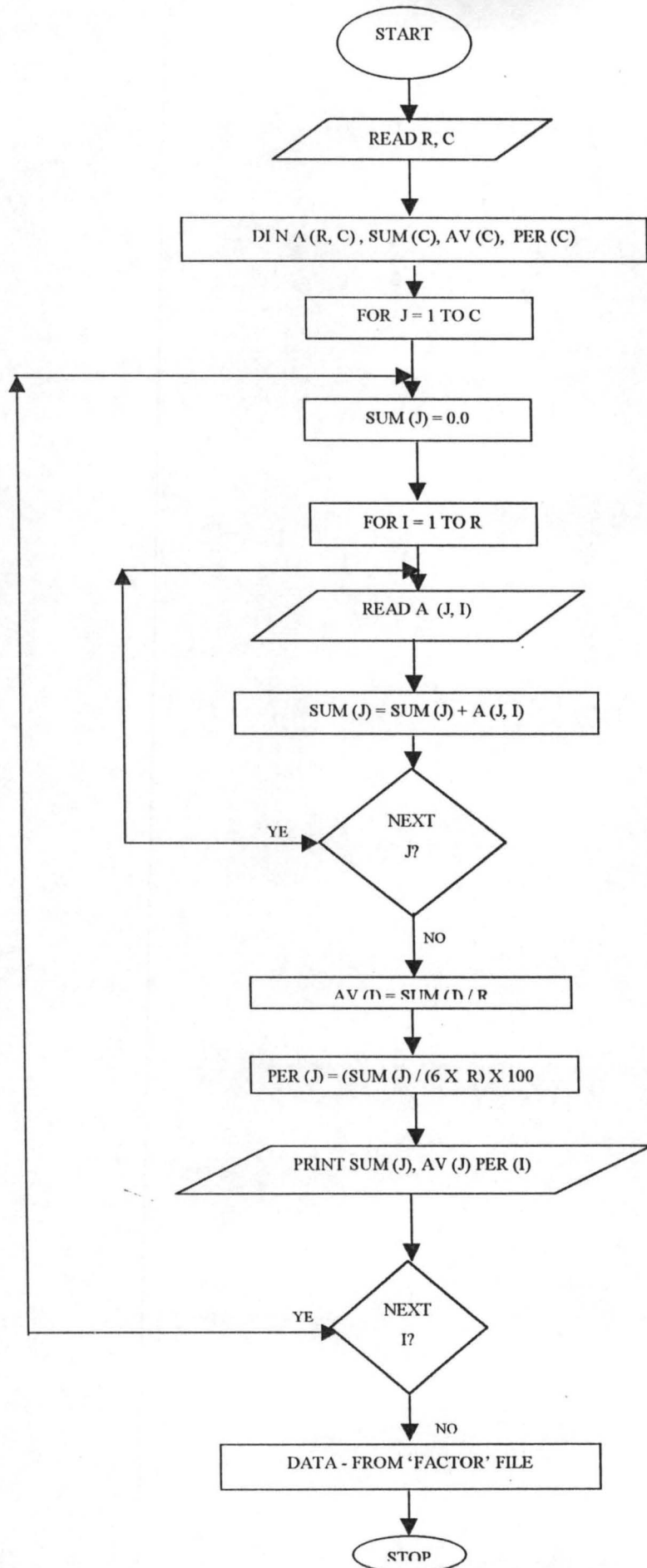
- | | |
|---------------|---------------|
| (a) RECRPOT 1 | (b) FACRPOT 1 |
| (c) RHSCORE | (d) FHSCORE |
| (e) RANOVA 1 | (f) FANOVA 1 |
| (g) ANOVA 2 | (h) HRANOVA 1 |
| (i) HFANOVA 1 | (j) HANOVA 2 |
| (k) SIGDMR 1 | (l) SIGDMR 1 |

The flowcharts and algorithms to realise the above reports are shown in the diagram that follow:

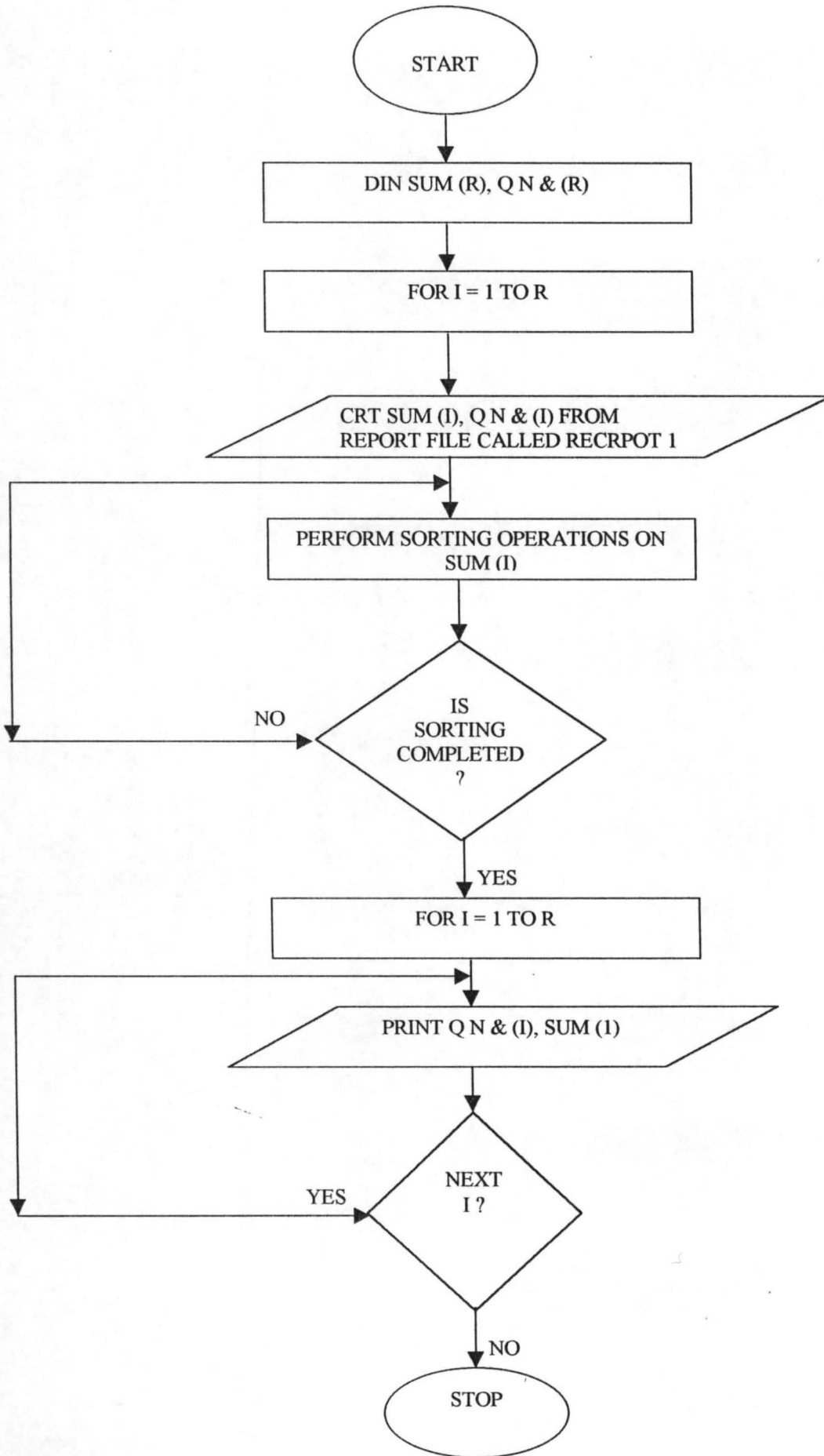
5.1.1 FLOWCHART FOR REALIZATION OF 'RECRPOT 1' FILES



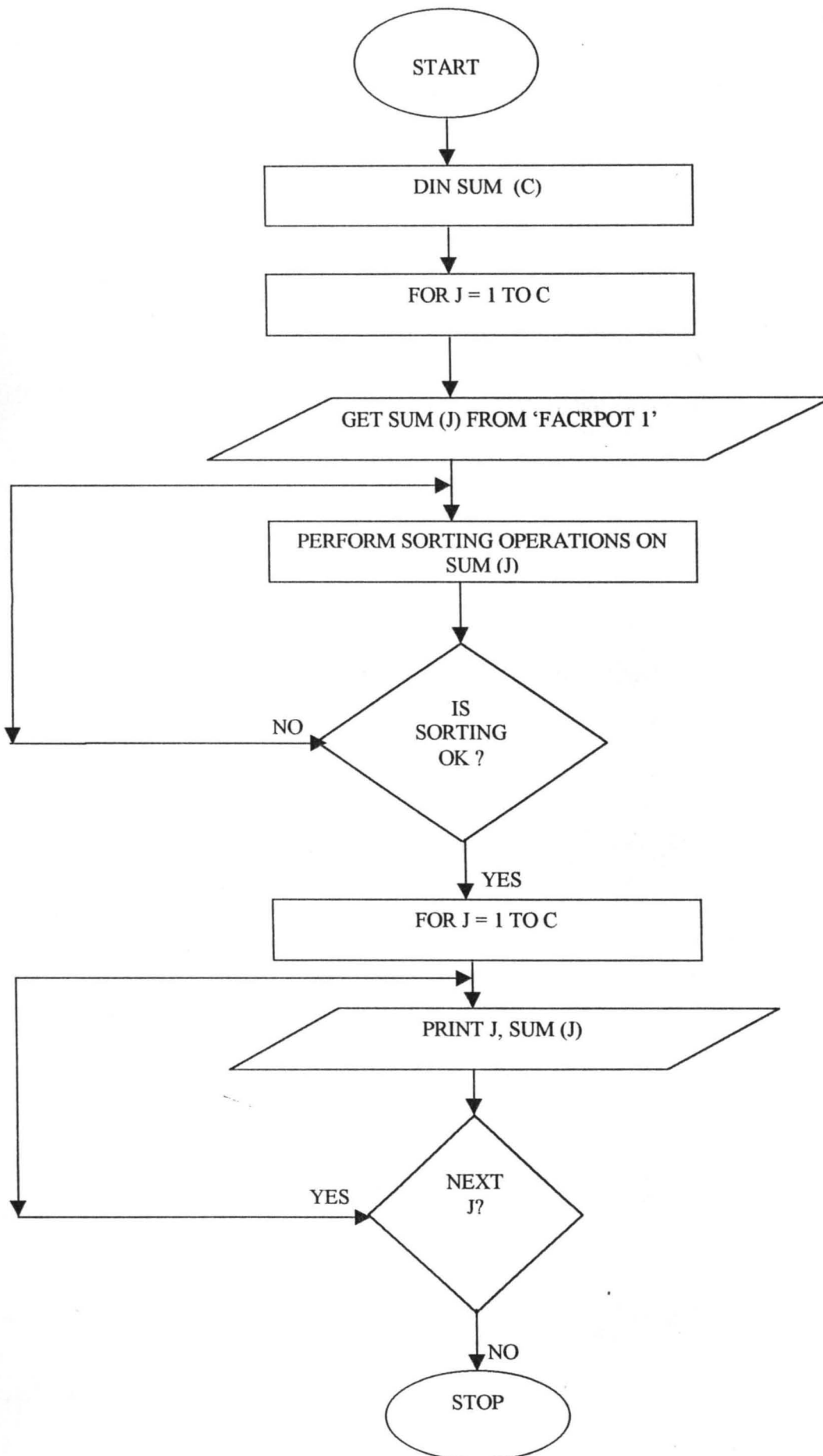
5.1.2 FLOWCHART FOR REALIZATION OF 'FACRPOT 1'



5.1.3 FLOWCHART FOR REALIZATION OF 'RH SCORE'



5.1.4 FLOWCHART FOR REALIZATION OF 'FH SCORE'



5.1.5 Algorithm for Realization of ANOVA Table Reports

A set of well defined rules or processes for the realization of the expected reports in a finite number of steps is provided. The emphasis here is to give a step-by-step method of how the reports are generated.

The inputs to the report files after the analysis of variance computations, whether for factor effects record effects or even both (two-way analysis of variance) Involves similar sequence of operations.

- (a) 'HRANOVA I'- report file on Record effects for a one-way analysis of variance table
- (b) 'HFANOVA I'- report file on factor effects for a one-way analysis of variance table.
- (c) 'ANOVA 2'-report file for both factor and record effects for a two-way analysis of variance table.

The reports generated here namely 'HRANOVA I', 'HFANOVA I' and 'ANOVA 2' are necessary inputs in the form of computational tables during the statistical test of hypotheses for the appropriate treatment effects.

Though the programs to realize each of the reports

(a) to (c) above are written separately, a unique sequence of operations (logic flow of operation) can be used to express the logic of operations for realizing the report files.

These sequence of operation can be expressed as follows:

- 1 Open the appropriate data file.
- 2 Select appropriate data inputs.
- 3 Compute total sum of squares (SST).
- 4 Compute column sum of squares (SSC) for the treatment of interest (i.e. record or factor for one-way).
- 5 Compute row sum of squares (SSR) (for two-way analysis only).
- 6 Compute error sum of squares SSE.
 - (i) For one-way ANOVA, $SSE = SST - SSR - SSC$.
 - (ii) For Two-way ANOVA, $SSE = SST - SSR - SSC$.
- 7 Compute degrees of freedom for SSR, SSC and SSE.
- 8 Compute mean square for SSR, SSC, SSE.
- 9 Compute ANOVA F values (FC).
- 10 Store results or values in appropriate fields of appropriate report file.
- 11 Store report file and print as required.

TABLE 5.1 ANALYSIS OF VARIANCE FOR THE ONE - WAY CLASSIFICATION

SOURCE OF VARIANCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE	COMPUTED F
Column Means	SSC	K - 1	$S_1^2 = \frac{SSC}{K - 1}$	$\frac{S_1^2}{S_2^2}$
Error	SSE	K (n - 1)	$S_2^2 = \frac{SSE}{K (n - 1)}$	
Total	SST	n k - 1		

TABLE 5.2 ANALYSIS OF VARIANCE FOR THE TWO-WAY CLASSIFICATION WITH A SINGLE OBSERVATION PER CELL

SOURCE OF VARIANCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE	COMPUTED F
Row Means	SSR	r - 1	$S_1^2 = \frac{SSR}{r - 1}$	$f_1 = \frac{S_1^2}{S_2^2}$
Column Means	SSC	c - 1	$S_2^2 = \frac{SSC}{c - 1}$	
Error	SSE	(r - 1) (c - 1)	$S_3^2 = \frac{SSE}{(r - 1)(c - 1)}$	
Total	SST	r c - 1		

5.1.6 Algorithm for Realization of "HRANOVA I" and "HFANOVA I" Reports

The sequence of operations for the two reports namely:

HRANOVA I - Test of hypothesis report for equality of the records on the factors.

HFANOVA I - Test of hypothesis report for equality of mean effects of factors on the records or individuals performance; follow the same sequence even though the programs are separate and distinct.

The Sequence of operation can be expressed as follows:

1. State the null hypothesis, which is either
 - a. $H_0: a_i = 0$, that is the null hypothesis that the mean effects of the records of the factors on individuals or records are the same (for HFANOVA I report).

or

- b. $H_0: a_i = 0$, that is the null hypothesis that the mean effects of the records on the factors are the same (for HRANOVA 1 report)

2. State the alternative hypothesis

$$H_1: a_i < > a_{i'} \text{ for some } i \text{ and } i', i < > i'$$

That at least two of the means are not equal that is at least two of these factors differ in their mean effect (H F ANOVA 1) or At least two of these records differ in their mean effect (for HRANOVA report),

3. State critical value (select choice from menu option $\alpha = 0.05$ or 0.011).
4. State critical regions
5. Produce ANOVA TABLES
 - a) For HFANOVA 1, Produce FANOVA1), and
 - b) For HRANOVA 1, Produce RANOVA 1)
6. State conclusions
7. Store results and print as required

5.1.7 Algorithm for Realization of "HANOVA 2" Report

HANOVA 2 is a report file for a two-way analysis of variance (ANOVA) test of hypothesis. The algorithm for the generation of this report files is similar to those described in section 4.1.6 except for steps one two which involves the statements of hypothesis.

These steps are as follows:

Step 1. State the null hypothesis

$$H_o : a_1 = a_2 = a_3 = \dots, a_c = 0 \text{ (Factor effects are zero)}$$

$$H_o : B_1 = B_2 = B_3 = \dots, B_R = 0 \text{ (Record effects are zero)}$$

Step 2. State the alternative hypothesis

$$H_i : \text{At least one of the } a_i \text{ is not equal to zero}$$

$$H_i : \text{At least one of the } B_i \text{ not equal to zero.}$$

For Step 5. Produce ANOVA TABLES after computations is produce

ANOVA 2 report.

Other steps are same as in section 4.1.6

5.1.8 Algorithm for "SIGDMR 1" and "SIGDMF 1" Report

The "SIGDMR 1" is a report file required to output the significantly different records whenever the null hypothesis of equal performance of records is rejected. In other words, when we test the null hypothesis of equal record effects or record means and conclude that at least two of the record effects differ, efforts must be made to identify the significantly different means, because according to Ronald E. Walpole (1974) "the analysis of a contingency table must never conclude with the rejection of the null hypothesis"⁴⁶.

The report file 'SIGDMF 1' outputs the significantly different factor means whenever the null hypothesis of equal factor means is rejected.

Algorithm for the report are as follows:

STEP 1 : Open appropriate file

"FACRPO 1" For factor means, and

"RECRPO 1" For Record means

STEP 2 : Arrange the means in ascending order of magnitude

STEP 3 : Compute appropriately appropriate test statistics namely:

$$T = t(\alpha, v) = S_e \sqrt{2/b}$$

Where:

α = level of significance

V = degrees of freedom for the error sum of square.

S_e^2 = error mean square and

b = number of treatments not being considered for significant effect.

Step 4 : Compare the means. The mean, such that the highest minus the second largest, is greater or equal to T is declared significantly different.

STEP 5 : Store significant means in appropriate report file.

STEP 6 : Print as required.

5.2 TOP-DOWN DESIGN

The design technique for this study focuses first on "higher-level" (overall controlling) functions which the program must carry out, and treats "lower-level" (specific, detailed) functions last.

The programs that list or display the main menu must be carried out first for appropriate menu to be selected. Each of the main menu calls her sub-menu. In each of the sub-menu, specific programs are written to achieve the desired objective. Therefore then, Top-Down Design approach was adopted. Thus, each of the sub-menus form program modules, each of which carries out one well-defined function and can be coded separately and independently.

Therefore, the design with its associated flowcharts and sequence of logics are converted into codes (computer program of instructions).

Coding is done in modules in line with the system design so that the menu-driven system has each unit basically controlled by a single program.

5.3 MENUS AND SUB-MENUS

The program design for this study covers all the menus and sub-menus as shows in Fig 4.2. Thus the system driven routine covers all the menus and sub-menus as shown in figure 4.2. This was implemented in the program design for convenience and to allow all possible options in a database management system. However not all the subsystems are applicable in this study. For instance in the calculation-menu, the sub-menus namely 'pictorial representation' and 'graph plotting' were not implemented, same were applicable to 'User designed' and 'Formatted tabulation' sub-menus of the reporting printing menu.

Therefore, for these operations that are not applicable, a message 'NOT APPLICABLE" is displayed on the CRT, and user is expected to follow next instruction displayed in order to continue.

These non-executed or non-implementated sub-menus are however include in the database system to create room from future expansion and further development of the entire system.

5.4 THE SYSTEM DRIVEN ROUTINE

The system designed is menu-driven. This is a program implementation techniques where by the desired function or items is executed or displayed on the CRT screen by picking or keying the buttons

against the function or item required.

The appropriate package is loaded and the package of program loaded with the name 'ANOVAP'. This must be done on IBM compatible computers that accept 3.5" diskettes. Programs are written in dBase IV. Thus the insertion of the program diskette is followed by the dBase IV command load "ANOVAP". This is followed by the command 'RUN'.

The command 'RUN' prompts or displays the following introduction note.

"WELCOME TO DESIGNING COMPUTER SOFTWARE PACKAGE
FOR SOLVING APER PROBLEMS AND ANOVA".

AUTHOR : ONYIA, PIUS EJKEME

SUPERVISOR : PROF. K. R. ADEBOYE

REG. NO. : PGD / MCS / 243 /96

This is followed by the display of the of the main menu with a press of any key. With the display of the main menu, the user has the option of keying either the numerical codes or the letter-codes to select the desired main menu. The system also provide an additional option namely QUIT, to enable the user back track from the present level. It also provides for error messages in the event of wrong choice of options (that is, choice of options that are out of range), such as "wrong choice, please try again".

The system provide for single instructions on basic assumptions or justifications for the application of certain tests (statistical in the system

for example, to apply the two-way analysis of variance test, the system routine reminds the user of the need for the sampling design to be 'Randomized complete block design' for two-way analysis of variance to be applicable. It also provides guides on certain input specifications informing the user of the range of values for the inputted data in the 'FACTOR' file.

Again for the systems files, the file 'system' is called up and run. Here the systems files are create if need be. This is done before the user program 'ANOVAP' is run. The data here is maintained by the base administrator. The system therefore check for unauthorised modification of files here. Programs here are also menu-driven.

5.5 SUB SYSTEM IMPLEMENTATION.

The first step in establishing an effective system control in our case is scrutinizing and batching of source documents. That is checking the source documents (questionnaire) for current format, errors and subsequent coding. As the popular adage goes "gabbage in gabbage out".

Also questionnaire is numbered manually before processing, during scrutiny programs are written in dBase IV programming language. Some of the single flowcharts in section 5.1 that are too complex for one program are, split into sub-programs using subroutines. Other aspects of the program design included the following:

Input controls are also established to ensure that data from the input forms (questionnaires) are complete and accurately converted to machine readable form for entry into the computer. This is achieved through coding techniques. Where processing is done at high or large scales, it may be necessary to input original data twice for error detection, editing and validation. Automated controls to be provided in the system include the provision of validation program, to check data for the following:-

- (a) Ensure that fields which must contain only numeric or only alphanumeric or alphabetic entries are maintained.
- (b) Entries in one record for all the fields (i.e. mandatory fields must be completed) are completed before entering the next record.
- (c) Wrong choice of options or proper choice are responded to appropriately. There are limit checks on the inputted scores to make sure the values are within acceptable limits. For example, if the score for factor is 4 and erroneously 8 is keyed in, the system should be able to send out an error message or prevent the cursor from moving to the next record unless the correct data (which must lie between 1 and 6 inclusive) are entered before entries are accepted by the system. During processing runs, record counts and control totals

generated during the processing will be compared against some values in the control records on the files.

Finally provisions are made for proper storage, updating and backing up of files at appropriate intervals.

In section 2.2, we observed that the highest and least rating scores to be 6 and 1 respectively. Again the average score was computed by summing the score across the factors and dividing by six items the number of factors under consideration (6x number of factors). Thus the average computed will not be reliable if any recorded score is higher than 6 or less than 1. The same situation holds for scores that are non integer values or out of the range 1 to 6 inclusive.

Therefore, a major control whether manual or automated will be in:

- (a) Ensuring the accuracy and validity of all data stored on the system,
- (b) Preventing unauthorized access or modification in the data particularly the system files,
- (c) Preventing wrong application of statistical assumptions and methods to the statistical tests provided by the system,
- (d) Safeguarding records through back-ups and careful handling and storage.

Again, the input file "Factors" that contains data or the main data for virtually all the mathematical analysis is usually copied before analysis and the subsequent result of analysis stored in the appropriate report file. As a result, each run is complete without tempering with entries in the old file (Factor File). Thus if any of the of the copied data file is corrupted, the update can be used to re-create the transaction file for analysis. Finally back-up storage is used for all entries and reports on diskettes.

5.6 SOFTWARE TESTING AND INTEGRATION

In this section, we discuss the following aspects:

5.6.1 Training

In this particular study the importance of training as an aspect of implementation plan is very necessary.

Non-Statistician users of this package may encounter serious difficulties, if there is lack of sufficient training or briefing on the system, particularly the questionnaire format, coding techniques used, assumptions underlying the analysis and terms of hypotheses, the limitations involved, and contents of files and file structure. These are therefore required to have a very clear understanding of how the system will operate and the contribution expected from them for the system to be successful. They should have knowledge of the input forms, the output format and reports and be able to read and interpret the output from the system.

5.6.2 Test Plan and Test Data

Before bringing the "statistical package" into use it is of vital importance that it is both comprehensive within its intended limits and fully current, even though programs have been written according to specifications. The key tasks associated with program testing, identified here, include developing a test plan and a test data.

In testing, and as far as this study is concerned, the major task is to be certain that the programs developed, particularly for the computation of averages. Analysis of variance (ANOVA) tables and Tests of hypotheses are perfectly working well. To achieve this plan, it is expected that standard test book data whose means, and ANOVA analysis have been concluded will be used as our test data so that if similar results are got, then the program is perfect.

But in this study, this was made difficult, if not impossible because most text book data have figures above 6. Recall that our input data were of scores ranging from 1 to 6 inclusive. As a result the system will refuse to accept such text book data let alone analysing them. In view of the above, hand computations were made on appropriate survey data and where result got from hand computation are the same with that from the system then one may claim convincing that the system functions well in this regard. Therefore test data specifically designed to address every aspect of the system was generated and used. The test data included

known incorrect data such as input data having scores less than 1 or greater than 6 or non-integer values, etc. in order to test for validity and control procedures.

Having validated the system particularly the ANOVA tests and computations by comparing the results got from hand computations with result got from the system for some test data, confirming effective running of the system. Direct change-over procedure was recommended. Therefore users of the systems are expected to switch over to the package since its functions have been adequately validated.

The test data for 10 records and 10 factors are as follows:

TABLE 5.3 TEST DATA

S/NO	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10
1	6	6	6	6	6	5	6	6	5	5
2	6	5	5	5	6	5	5	5	5	5
3	4	5	5	4	5	4	5	5	4	4
4	6	6	6	6	6	6	6	5	5	5
5	5	5	5	5	5	5	6	5	5	5
6	5	5	5	5	6	4	5	5	4	5
7	5	4	4	5	4	5	6	5	5	5
8	6	5	5	5	5	5	5	5	5	5
9	5	4	5	5	5	5	5	4	4	5
10	6	5	5	5	6	5	5	6	5	5

5.7 TEST RESULTS

Here we shall present results from hand computations given below, and results from software package (Computerized result) given in appendix B to check for effectiveness of the system.

Where they produce identical results, then the system is declared reliable and perfect.

TABLE 5.4 (A) RECRPOT 1 (HAND COMPUTATIONS)

S/NO	HR	LR	TRS	RAS	RPS
1	6	5	57	5.7	95.0
2	6	5	52	5.2	86.7
3	5	4	45	4.5	75.0
4	6	5	57	5.7	95.0
5	6	5	51	5.1	85.0
6	6	4	49	4.9	81.7
7	6	4	48	4.8	80.0
8	6	5	51	5.1	85.0
9	5	4	47	4.7	78.3
10	6	4	53	5.3	88.3

(See Appendix B for the field Names)

TABLE 5.5 FACRPOT (HAND COMPUTATIONS)

FACTORS	FTS	FAS	FPS
F1	54	5.4	90.0
F2	50	5.0	83.3
F3	51	5.1	85.0
F4	51	5.1	85.0
F5	54	5.4	90.0
F6	49	4.9	81.7
F7	54	5.4	90.0
F8	51	5.1	85.0
F9	47	4.7	78.3
F10	49	4.9	81.7

TABLE 5.6 (C) RHSCORE (HAND COMPUTATIONS)

S/NO	RPS
1	95.0
4	95.0
10	88.3
2	86.7
5	85.0
8	85.0
6	81.7
7	80.0
9	78.3
3	75.0

TABLE 5.7 (D) FHSCORE (HAND COMPUTATIONS)

FACTORS	FPS
F1	90.0
F5	90.0
F7	90.0
F3	85.0
F4	85.0
F8	85.0
F2	83.3
F6	81.7
F10	81.7
F9	78.3

From the test data for 10 records and 10 factors on table 5.3 above, we obtained the following :

$$(i) \quad SST = 6^2 + 6^2 + 4^2 + \dots + 5^2 + 5^2 + 5^2 - \frac{510^2}{100}$$

$$= 2636 - 2601 = 35$$

$$(ii) \quad SSC = \frac{54^2 + 25^2 + 51^2 + 51^2 + 54^2 + 49^2 + 54^2 + 51^2 + 47^2 + 49^2}{10} - \frac{510}{100}$$

$$= 2606.2 - 2601 = 5.2$$

$$(iii) \quad SSR = \frac{57^2 + 52^2 + 49^2 + 57^2 + 51^2 + 49^2 + 48^2 + 51^2 + 47^2 + 53^2}{10} - \frac{510^2}{100}$$

$$= 2615.2 - 2601 = 14.2$$

$$(iv) \quad SSE = 35 - 5.2 - 14.2 = 15.6 \text{ (ANOVA 2)}$$

TABLE 5.8 RANOVA 1 (HAND COMPUTATION)

SOURCE OF VARIATION	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE	COMPUTED F.
Record Means	14.2	9	1.578	6.83
Error	20.8	90	0.23	
Total	35	99		

TABLE 5.9 FANOVA 1 (HAND COMPUTATIONS)

SOURCE OF VARIATION	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE	COMPUTED F.
Factor Means	5.2	9	0.578	1.75
Error	29.8	90	0.331	
Total	35	99		

TABLE 5.10 ANOVA 2 (HAND COMPUTATION)

SOURCE OF VARIATION	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE	COMPUTED F.
Factor Means	5.2	9	0.578	0.37
Record Mean	14.2	9	1.578	8.31
Error	15.6	81	0.19	
Total	35	99		

5.8 SUMMARY

The test results with hand computations are compared with results from the system. Having validated the system therefore, particularly the ANOVA tests and computations, by comparing the results got from hand computations with results got from the system for the same test data (See table 5.3), the effectiveness of the system is confirmed or validated. Direct change over procedure is therefore recommended, since the functions of the system have been adequately validated.

5.9 REVIEW OF ACHIEVEMENTS

Before this stage in the system development, adequate program testing and system test have been done; files have been created and documents scrutinized and understood by users. But no matter how good the programs are, the system will not be useful if data does not flow smoothly. There is therefore smooth system running which included the smooth transportation of the questionnaire (scrutinized) from the field enumerators, to the data processing department. It also includes the smooth distribution of files and output reports within the system.

The menu - driven system is performing according to specifications. There is a good link between the system file and the program files. The validation and major controls whether manual or automated were achieved namely:

- (i) Ensuring the accuracy and validity of all data stored in the system,
- (ii) Preventing unauthorized access or modification in the data, particularly the system files,
- (iii) Preventing wrong application of statistical assumptions and methods to the statistical tests provided by the system,
- (iv) Safeguarding records through back-ups and careful handling storage.

Based on the objectives of this study and the proceeding analysis including figures and algorithms carefully analysed, the following can be said.

Fundamental and classical coding and measurement techniques for classical statistical questionnaire analysis, particularly for data resulted from "cross-classification having ordered categories" type of questionnaire have been provided.

Great efforts have been made to produce statistical software package for ANOVA in particular with appropriate statistical assumptions as menu-driven guides capable of removing or minimizing abuse of the use of statistical assumptions and analysis.

5.10 SUGGESTIONS FOR FURTHER IMPROVEMENT

The following addition, findings and improvements that can be made on the study are suggested for those who may wish to take the topic further.

These are:

- (i) Developing the submenus namely, graph plotting representation
- (ii) Attempts should be made to include other statistical tests like chi-square test of independent and association thus expanding the topic of this study.

Chi-square test could test.

- a) That factor performance is not associated with sex, age, marital status, etc.
 - b) factor and Record performance are independent
- (iii) Other tests could include regression and correlation analysis test between factors totals and record totals with a view to identifying any variable associated or predicted from the other.

In addition, efforts should be made to make comparative analysis of scores by one officer (in the case of APER SCORE) over some years, or by a given ministry extra-ministerial department over some period. The program design allows for these modifications and expansion.

5.11 CONCLUSION

Since the factors or treatments are measured for some desired objectives e.g. determining the staff performance (in the case of APER SCORE), it must be noted here that though much of such deductions are true, suffice it to say that since some of these factors are affected by some personal characteristics like age, marital status, etc. results obtained can be the combined effect of all these factors, much better deductions will be obtained when due considerations are given to all possible factors affecting staff performance or factor/treatment performance under study.

Finally it is hoped that this study provides a good analysis techniques for researchers in general and government in particular.

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APPENDIX I (SCREEN DESIGN AND PROGRAM OUTPUT)

ANOVA PACKAGE	
A	DATA ENTRY
B	CALCULATION
C	REPORT
D	EXIT
PICK CHOICE:	

DATA ENTRY SCREEN

r number of Rows: 4

r number of Columns: 3

1	64.0	72.0	74.0
2	55.0	57.0	47.0
3	59.0	66.0	58.0
4	58.0	57.0	53.0

ENTRY IS COMPLETED, PRESS ANY KEY TO CONTINUE

ANOVA RESULT

=====

SQUARE OF VARIATION	SUM OF SQUARES	DEGREE OF FREEDOM	MEAN SQUARE	COMPUTED F
Row means	498.00	3	166.00	9.22
Column means	56.00	2	28.00	1.56
Error	108.00	6	18.00	
TOTAL	662.00	11		

ANOVA.PRG

set talk off

set stat off

set scor off

set safe off

do while .t.

clear

@ 3,23 to 21,56 double

@ 5,33 say 'ANOVA PACKAGE'

@ 7,24 to 7,55 double

@ 9,28 say 'A DATA ENTRY'

@ 11,28 say 'B CALCULATION'

@ 13,28 say 'C REPORT'

@ 15,28 say 'D EXIT'

@ 17,24 to 17,55 double

do while .t.

ch = ''

@ 19,33 say 'PICK CHOICE:' get ch picture '!'

read

if ch \$ "ABCD"

exit

endif

```
endd
do case
  case ch = 'A'
    do entry
  case ch = 'B'
    do calc
  case ch = 'C'
    do rep
  othe
  exit
```

```
endc
```

```
endd
```

```
clea
```

```
retu
```

CALC.PRG

```
use data
```

```
nc = column
```

```
nr = row
```

```
sumts = 0
```

```
sumt = 0
```

```
r = 1
```

```
declare sumc[nc],sumr[nr],data[nr,nc]
```



```
do while r <= nr
  c = 1
  do while c <= nc
    data[r,c] = element
    c = c + 1
  skip
enddo
r = r + 1
enddo

c = 1
do while c <= nc
  sumc[c] = 0
  c = c + 1
enddo

r = 1
do while r <= nr
  sumr[r] = 0
  c = 1
  do while c <= nc
    sumts = sumts + data[r,c]^2
    sumt = sumt + data[r,c]
    sumr[r] = sumr[r] + data[r,c]
    sumc[c] = sumc[c] + data[r,c]
```

```

    c = c + 1
endd
r = r + 1
endd
sst = sumts - (sumt^2 / (nr * nc))
sumrs = 0
r = 1
do while r <= nr
    sumrs = sumrs + (sumr[r]^2)
    r = r + 1
endd
ssr = (sumrs / nc) - (sumt^2 / (nr * nc))
sumcs = 0
c = 1
do while c <= nc
    sumcs = sumcs + (sumc[c]^2)
    c = c + 1
endd
ssc = sumcs / nr - (sumt^2 / (nr * nc))
sse = sst - ssr - ssc
msr = ssr / (nr - 1)
msc = ssc / (nc - 1)
mse = sse / ((nr - 1) * (nc - 1))

```

```
cf1 = msr/mse
cf2 = msc/mse
wait
use result
if .not. eof()
  zap
endi
appe blan
repl sov with 'Row means'
repl sos with ssr
repl dof with (nr-1)
repl ms with msr
repl cf with cf1
appe blan
repl sov with 'Column means'
repl sos with ssc
repl dof with (nc-1)
repl ms with msc
repl cf with cf2
appe blan
repl sov with 'Error'
repl sos with sse
repl dof with ((nc-1)*(nr-1))
```

repl ms with mse

retu

REP.PRG

clea

set devi to prin

@ 2,34 say 'ANOVA RESULT'

@ 3,34 say repl('=',12)

@ 4,6 say repl('-',69)

@ 5,6 say '|'

@ 5,9 say 'SQUARE OF'

@ 5,23 say '|'

@ 5,26 say 'SUM OF'

@ 5,35 say '|'

@ 5,38 say 'DEGREE OF'

@ 5,49 say '|'

@ 5,53 say 'MEAN'

@ 5,61 say '|'

@ 5,64 say 'COMPUTED'

@ 5,74 say '|'

@ 6,6 say '|'

@ 6,9 say 'VARIATION'

@ 6,23 say '|'

@ 6,26 say 'SQUARES'

@ 6,35 say '|'

@ 6,38 say ' FREEDOM'

@ 6,49 say '|'

@ 6,53 say 'SQUARE'

@ 6,61 say '|'

@ 6,64 say ' F'

@ 6,74 say '|'

@ 7,6 say '|-----|-----|-----'

@ 7,49 say '|-----|-----|'

r = 7

tot1 = 0

tot2 = 0

use result

do while .not. eof()

 r = r + 1

 msov = sov

 msos = sos

 mdof = dof

 mms = ms

 mcf = cf

 @ r,6 say '|'

 @ r,9 say msov

```

@ r,23 say '|'
@ r,26 say msos pict '9999.99'
@ r,35 say '|'
@ r,41 say mdof pict '99'
@ r,49 say '|'
@ r,53 say mms pict '9999.99'
@ r,61 say '|'
if mcf < > 0
    @ r,64 say mcf pict '9999.99'
endi
@ r,74 say '|'
tot1 = tot1 + msos
tot2 = tot2 + mdof
skip
endd
r = r + 1
@ r,6 say '|-----|-----|-----'
@ r,49 say '|-----|-----|'
r = r + 1
@ r,6 say '|'
@ r,9 say 'TOTAL'
@ r,23 say '|'
@ r,26 say tot1 pict '9999.99'

```

@ r,35 say '|'

@ r,38 say tot2 pict '99'

@ r,49 say '|'

@ r,61 say '|'

@ r,74 say '|'

r=r+1

@ r,6 say repl('-',69)

set devi to scre

wait

use

retu